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THE *CULICOIDES* OF SOUTHEAST ASIA (DIPTERA: CERATOPOGONIDAE)

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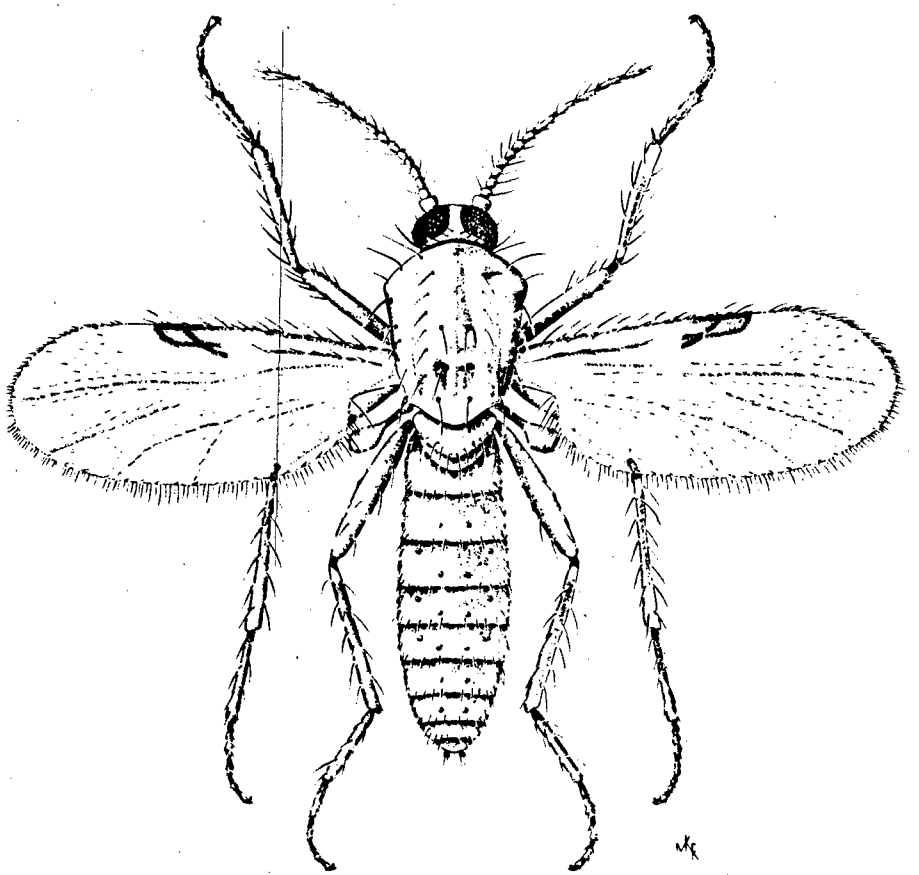

Fig. 1. *Culicoides arakawae* (Arakawa), female (drawing by Molly K. Ryan).

THE *CULICOIDES* OF SOUTHEAST ASIA (DIPTERA: CERATOPOGONIDAE)

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ABSTRACT. One-hundred and sixty-eight species of *Culicoides* are recorded from Southeast Asia, a region comprising the countries of Burma, Cambodia, Indonesia, Laos, Malaysia, Singapore, the Philippines, Thailand, and Vietnam. A taxonomic key is given for the identification of adults (based mainly on females), and an atlas of wing photographs is arranged in taxonomic sequence. For each species there is a complete synonymy, description, distribution, Southeast Asia locality records, and a summary of what is known of the biology and taxonomic importance. The following 53 NEW SPECIES are described: *acanthostomus*, *agas*, *allantothecus*, *bigeminus*, *brinchangensis*, *calcaratus*, *carpophilus*, *cylindripalpis*, *delfinadoae*, *divisus*, *dungunensis*, *flaviscutellaris*, *fordae*, *garciai*, *gouldi*, *griffithi*, *halonostictus*, *hoffmanioides*, *kelantanensis*, *kepongensis*, *kinabaluensis*, *luteolus*, *maai*, *macclurei*, *manikumari*, *mellipes*, *minimus*, *minipalpis*, *murrayi*, *nigripes*, *niphanae*, *orestes*, *palpisimilis*, *pangkorensis*, *parabarnetti*, *parabucalus*, *parahumeralis*, *paramalayae*, *pendleburyi*, *pictilis*, *prolixipalpis*, *pseudocordiger*, *pseudopalpalis*, *quatei*, *rugulithecus*, *selangorensis*, *siamensis*, *subpalpifer*, *tawauensis*, *tenuifasciatus*, *thurmanae*, *trimaculipennis*, and *uncistylus*. *Culicoides mcdonaldi* NEW NAME is proposed for *C. pulicaris monticolus* McDonald and Lu, preoccupied by *C. monticola* Wirth and Lee. The following NEW SYNONYMY is proposed: *C. assimilis* Delfinado, synonym of *sumatrae* Macfie; *bifasciatus* Tokunaga, synonym of *geminus* Macfie; *candidus* Sen and Das Gupta, synonym of *clavipalpis* Mukerji; *denmeadi* Causey, synonym of *homotomus* Keiffer; *ejercitoi* Delfinado, synonym of *peliliouensis* Tokunaga; *fortis* Sen and Das Gupta, synonym of *shortti* Smith and Swaminath; *lingensis* Tokunaga, synonym of *yasumatsui* Tokunaga; *multinotatae* Tokunaga, synonym of *perornatus* Delfinado; *papuae* Tokunaga, synonym of *notatus* Delfinado; *praesignis* Delfinado, synonym of *circumbasalis* Tokunaga; *quadratus* Tokunaga, synonym of *peregrinus* Kieffer; *subflavescens* Wirth and Hubert, synonym of *flavescens* Edwards; and *suborientalis* Tokunaga, synonym of *maculatus* (Shiraki). A NEOTYPE is designated for *brevitarsis* Kieffer, and LECTOTYPES are designated for *andrewsi* Causey, *flumineus* Macfie, *gentilis* Macfie, *gymnopterus* Edwards, *indianus* Macfie, *klossi* Edwards, and *maculipennis* Macfie.

INTRODUCTION

The need for taxonomic understanding and the ability to identify bloodsucking disease vectors is too often taken for granted by medical and veterinary officers directing efforts in disease control. The problem cannot be stated more aptly than in the following passage from a review paper presented at an Australian veterinary conference by Murray and Dyce (1970):

"Overseas experience has shown that an essential for all epidemiological studies is a good taxonomic knowledge of the organisms under study, whether they be the vectors or the infective agents. Such studies are not fashionable at present in certain disciplines even though resolutions are passed regularly at all international congresses on zoological topics, such as entomology, to emphasize the shortage of taxonomists and the basic necessity of such studies to those on ecology (epidemiology)."

"Australia is no different from elsewhere in the world, in that there are very few people in the country who are competent in the identification of the various groups of blood-sucking insects, and the immediate outlook for the future is grim. Consequently workers whose interests are ecological and epidemiological are forced into detailed and time-consuming taxonomic studies initially, as has been our experience."

There has never been a comprehensive taxonomic publication on the Oriental *Culicoides*, although there are two good accounts of the species occurring in one country. Delfinado's (1961) review of the Philippine *Culicoides* was the first comprehensive work in this region to use *Culicoides* characters and taxonomy as currently practiced. Howarth's (1985) publication on "Biosystematics of the *Culicoides* of Laos" is an outstanding example of up-to-date *Culicoides* systematics. Chu (1986) presented a key and a review of the Cambodian *Culicoides* that included only 14 species from one coastal locality.

Tokunaga's series of publications (1959, 1962b, 1963b, 1963c, 1976) on the New Guinea species are an excellent and necessary adjunct to a study of the Oriental *Culicoides*. Causey's (1938) *Culicoides* of Siam and Sen and Das Gupta's (1959b) review of the Indian *Culicoides* were too limited in scope and taxonomic treatment to be of much assistance. McDonald and Lu (1972) and McDonald et al. (1973) reviewed the *Culicoides* of Taiwan and Okinawa, respectively, but treated only the females. Kitaoka (1985a, 1985b) gave an excellent review of the Japanese species that includes many Oriental species with distributions including Southeast Asia. Most of the taxonomic literature on the Southeast Asian *Culicoides*, however, consists of a multitude of scattered papers of limited taxonomic and geographic scope.

Starting in 1957, we began gathering the taxonomic material in preparation for writing a comprehensive monographic treatment of the taxonomy of the species of *Culicoides* occurring in all of Southeast Asia. Up to that time only 41 species were known from the area. Delfinado (1961) added 21 species from the Philippines and Howarth (1985) added 16 from Laos. In contrast, the present work includes 168 species of which 53 are described as new. Between 1957 and the

present there have been many scattered published records and descriptions of new species from Southeast Asia; these have been incorporated in the present work.

HISTORICAL AND ACKNOWLEDGMENTS

Malaysia. The first collections from Southeast Asia that we studied were made by H.C. Barnett in 1955 while he was stationed with the U.S. Army Medical Research Unit, Institute for Medical Research, Kuala Lumpur, Malaya (now Malaysia). When our project was formally established in 1957 as an activity of the Walter Reed Army Institute of Research (WRAIR), Lieutenant Colonel Robert Traub, commanding officer of the Kuala Lumpur unit, set up a sustained and systematic program for surveying Southeast Asian *Culicoides*. Through the efforts of R. Traub, H. Elliott McClure, R.H. Wharton, and the junior author, study materials were submitted to the U.S. National Museum for a nine-year period from 1958 to 1967. We are especially indebted to Drs. Traub and Barnett for their efforts in instigating our *Culicoides* project and setting it up on a good-working regional basis. As a response to our request through Dr. Barnett and WRAIR, Donald R. Johnson, Entomologist, Public Health Division, International Cooperation Administration (ICA), Washington, D.C., set up a *Culicoides* collection program in 1958 with malaria control personnel of the ICA in Southeast Asia. We would like to express our appreciation to Mr. Johnson and his organization for their assistance.

Donald H. Colless, then working at the Department of Parasitology, University of Malaya, Singapore, collected ceratopogonids extensively in North Borneo (now Sabah), Sarawak, and Singapore from 1948 until 1958 in connection with his research on mosquitoes, hoping some day to study them taxonomically. Upon learning of our interest in Southeast Asian ceratopogonids, Dr. Colless made his entire collection available to us for study in 1958, and this collection formed the nucleus of our Borneo material. The Borneo specimens collected by J.L. Gressitt, L.W. Quate, C. Yoshimoto, and others, and sent to us much later by the Bishop Museum, have supplemented Colless' basic collections.

We are also greatly indebted to R.H. Wharton, formerly of the Division of Entomology, Institute for Medical Research, Kuala Lumpur, for the light trap collections he furnished us through the U.S. Army Kuala Lumpur Research Unit. Albert Rudnick, Richard Garcia, and John Jeffery of the Hooper Foundation, University of California, and the Faculty of Medicine, University of Malaya, Kuala Lumpur, also furnished us valuable specimens and biological data on Malaysian *Culicoides*. These have constituted an important part of our study materials.

Shigeo Kitaoka of the National Institute of Animal Health, Ibaraki, Japan, kindly sent us samples of the *Culicoides* he collected in Malaysia during a joint research project with the Veterinary Institute, Ipoh, Malaysia, in 1978. Kitaoka (1983) described five new Malaysian species from these collections, but unfortunately their descriptions came too late and specimens were not available to be studied and incorporated in the present revision. The numerical characters of these species are listed in the tables under the appropriate group headings, and a short diagnosis is made of each of these species in the section on species descriptions.

Thailand. Our first Thai material was received from Robert E. Elbel, Malaria Control Advisor to Northeast Thailand, who collected in Loei Province from September to November 1954. This was an area of primary forest at approximately 1,780 m elevation (Taylor and Elbel, 1958). Later, we received specimens from Deed C. and Ernestine B. Thurman, Malaria Control Advisors from the Division of International Health, U.S. Public Health Service, assigned to the Thailand Mission, Foreign Operations Administration, Chiang Mai.

We are grateful to Melvin E. Griffith, Chief Malaria Advisor to the United States Operations Mission to Thailand, International Cooperation Administration (ICA), Bangkok, and Udaya Sandhinand, Director of the Division of Malaria and Filariasis Control, Thailand Ministry of Public Health, for arranging the extensive collecting trips by Manop Rathpradith in 1959. John E. Scanlon sent us extensive collections made in the vicinity of Bangkok in 1962 while he was Chief, Department of Entomology, U.S. Component, SEATO Medical Research Laboratory, in Bangkok. Keizo Yasumatsu also sent us *Culicoides* specimens from Thailand rice paddies, which he collected in 1977-79 during his investigations on the biological control of rice pests (Yasumatsu et al. 1980).

Laos. Special acknowledgment is due Francis G. Howarth of the Bernice P. Bishop Museum in Honolulu, who worked closely with us in his study of the Laotian *Culicoides* (Howarth 1974, 1985). Dr. Howarth collected in Laos in 1967 and 1968 while stationed there with the International Voluntary Services and brought the number of reported Laotian species from nil up to 62, describing 16 species as new to science. He emphasized the study of larval breeding sites and was able to rear 25 species, 18 for the first time, and from this material he described the pupal stage of 17 species, 14 of which had not hitherto been described. Dr. Howarth made his material available to us for study from the start, and our work was coordinated in time to allow for the publication of his new species so that we could include them in this manual.

Philippines. Our primary collections of *Culicoides* from the Philippines came from the Division of Malaria, Philippine Department of Health, all collected from carabao-baited traps and light traps designed for mosquito collections. Delfinado (1961) based her revisionary study of the Philippine *Culicoides* primarily upon this collection.

Rupert L. Wenzel, Chicago Natural History Museum, kindly loaned us the extensive collection of ceratopogonids obtained by D. Heyneman, H. Hoogstraal, and F.G. Werner during the Chicago Natural History Museum Philippine Zoological Expedition in 1946 and 1947, from which Delfinado obtained records of 26 species for her revision. We also received extensive ceratopogonid material collected by T.C. Maa, L.W. Quate, and C. Yoshimoto during the 1957 and 1959 expeditions of the Bishop Museum in Honolulu under the direction of J.L. Gressitt.

Through the courtesy of Torben Wolff and Leif Lyneborg we were also privileged to study the ceratopogonids collected during the 1961-62 Danish Noona Dan Expedition of the University of Copenhagan and National Museum. Their Philippine material included important collections from Mindanao, Palawan, and Tawi Tawi (Petersen 1966; Wolff 1966) from which 22 species of *Culicoides* were identified.

Indonesia. R. Tandjung Adiwinata, Central Animal Diseases Institute, Institute for Parasitology and Pathology, Bogor, Indonesia, sent us our first Indonesian collections, made by light trap on the Institute grounds. He wrote us in 1959: "My own interest in this matter is from epizootologic point of view in connection with a helminthic animal (mostly in cattle) skin disease known here as cascado, with a morbidity rate up to 90% in some parts of Indonesia. Insects are long since suspected as the possible transmitters of cascado and representatives of the family Ceratopogonidae, especially *Culicoides* species, are under my particular suspicion, such in analogy to onchocerciasis and filariasis (while trying to elucidate the life cycle of *Stephanofilaria dedoesi* as the recognized cause of cascado)."

T. Kurihara, Department of Parasitology, Institute of Medical Science, Tokyo University, provided us with Indonesian specimens of *Culicoides agas* n. sp., and notes on the habits of this man-biting species. M.D. Murray, CSIRO McMaster Laboratory, Sydney, Australia, sent us a rich collection made by D.G. Nicholls in 1969 in Bali, Lombok, Sumba, and Sumbawa.

Vernon H. Lee carried on an intensive program for the collection and study of Indonesian *Culicoides* when he was assigned to the U.S. Naval Medical Research Unit no. 2 in Jakarta from 1977 to 1983. We have confirmed Dr. Lee's identifications and added his locality records to our publication. A voucher collection of Indonesian *Culicoides* will be deposited in the Museum Bogoriense.

Burma. One of our greatest disappointments during this study was our inability to set up a large-scale collection program in Burma. However, we did receive small collections from the following persons:

W. Büttiker, Division of Malaria Eradication, World Health Organization, Geneva, Switzerland, and P.F. Beals, Technical Assistant, Advisory Team on Malaria Eradication no. 3, sent us *Culicoides* that were attached to *Anopheles* mosquitoes in the Mandalay region of Burma in 1957.

R.R. Griffiths, FAO Veterinarian for the Far East, Food and Agriculture Organization of the United Nations, Rome, sent us *Culicoides* specimens collected from *Leucocytozoon*-infected chickens in Burma.

Special Acknowledgments. The "*Culicoides* of Southeast Asia" project was inaugurated by the Department of Entomology, Walter Reed Army Institute of Research, in 1957 under Herbert C. Barnett and has received their financial and logistical support for more than 30 years. We are especially grateful to the Commanding General, U.S. Army Medical Research and Development Command, Bruce A. Harrison, E.L. Peyton, and Ronald A. Ward, Walter Reed Biosystematics Unit, Smithsonian Institution, for financial and administrative assistance in preparing our manuscript for publication. The cost of publication was subsidized by the Department of Entomology, Walter Reed Army Institute of Research, Washington, D. C.

Most of the species illustrations were prepared by artists of the former 406th Medical Laboratory, U.S. Army, Camp Zama, Japan, under the direction of Wallace P. Murdoch (1958-60), Gordon Field (1960-62), Hugh L. Keegan (1963-65), Vernon J. Tipton (1966-68), Alexander A. Hubert (1968-73), and Edward S. Saugstad (1973-74). The Laotian *Culicoides* collected by Howarth were illustrated by Biruta Akerberg of the Smithsonian Institution. For the photographs

of the *Culicoides* wings we are especially indebted to Ian Roper of the McMaster Laboratory, CSIRO Division of Animal Health, Sydney, Australia, under the supervision of Alan L. Dyce.

In 1985 the senior author spent three months in Sydney working with Alan L. Dyce on the taxonomy of Australasian and Oriental *Culicoides* under a grant from the Division of Tropical Animal Science, CSIRO, Brisbane, Australia, under the administrative direction of H.A. Standfast, T.D. St. George, D.F. Mahoney, and K.C. Bremner. This period of study was critical to the successful completion of our manuscript.

The senior author is also indebted to David J. Lee of the School of Public Health and Tropical Medicine, University of Sydney, for the opportunity to collect and study related Australian *Culicoides* while working under a Fulbright Research Fellowship at his laboratory in 1956-57. We also wish to thank Margaret L. Debenham of the same laboratory for constant assistance, especially from her compilation of a marvelously complete catalog (1978) of the ceratopogonid literature of Australia and the Pacific Islands.

LOCATION OF TYPES

Unless otherwise specified, holotypes and allotypes of our new species are deposited in the U.S. National Museum of Natural History (USNM) in Washington. Primary types of the extensive collection borrowed for study from the Bernice P. Bishop Museum (BISH) are deposited in Honolulu. A number of new species were described from the excellent Indonesian collection sent us by M.D. Murray of the CSIRO McMaster Laboratory in Sydney, Australia; these types are deposited in the Australian National Insect Collection (ANIC) in Canberra.

Some explanation should be given regarding Delfinado's (1961) types from her fine study of the Philippine *Culicoides*. Her work was based primarily on her own collections while working in the Philippine Department of Health and on a large collection which was borrowed by Wirth from the Chicago Natural History Museum [now the Field Museum of Natural History] (CNHM). Delfinado returned her types and other specimens to Wirth who labeled the types and divided and sorted the material for deposit in the museums specified. Holotypes of 11 of Delfinado's species were deposited in the Field Museum. A portion of the types destined for the Philippine Department of Health in Manila was retained by us for illustration and description in the present study; these types are now deposited in the USNM. The remainder was returned to Manila. Recent inquiries indicate that the Manila *Culicoides* collection no longer exists, and we have made notes under the appropriate species regarding the whereabouts of Delfinado's type material.

Primary types of 7 species of the subgenus *Avaritia* described from India by Sen and Das Gupta (1959b) and Das Gupta (1962a,b, 1963a,b) were studied by Dyce and Wirth (1983) in connection with this revision. At present they are held in the personal collection of Das Gupta (personal communication), but eventually will be deposited in the collection of the Zoological Survey of India (ZSI) in Calcutta.

ECONOMIC IMPORTANCE

ANNOYANCE

By their annoying attacks in tremendous numbers, *Culicoides* midges can make life almost unbearable in some areas. These small gnats are called by many names in many places: "punkies" and "no-see-um's" in the United States and Canada; "moose-flies" in Alaska; "sandflies" on the Atlantic and Gulf coasts of the United States, in the West Indies, and on the coasts of Australia; "jejenes" in Spanish-speaking Latin America; "maruins" in Brazil; "no-no's" in Polynesia; "makunagi" or "nukaka" in Japan; "agas" in Malaysia and Indonesia, and "nyung noi" or little mosquitoes in Laos.

Reye (1964) wrote most aptly: "Most people know the Ceratopogonid midges as the 'sandflies' met with on the seaside holiday or fishing trip. The abrupt fall in morale and the strong desire to be elsewhere which they engender are difficult to convey to those who have not experienced them"; as Kettle (1962) puts is briefly, "one midge is an entomological curiosity, a thousand can be hell!"

One of the earliest accounts by naturalists in Southeast Asia was given by Alfred Russell Wallace (1869), writing of the Aru Islands: "Ever since leaving Dobbo I had suffered terribly from insects, who seemed here bent upon revenging my long-continued persecution of their race. At our first stopping-place sand-flies were very abundant at night, penetrating to every part of the body, and producing a more lasting irritation than mosquitoes. My feet and ankles especially suffered and were completely covered with little red swollen specks, which tormented me horribly."

Meijere (1909) gave one of the earliest accounts of ceratopogonid annoyance in Indonesia. The following is a very rough attempt to translate his remarks:

"According to Jacobson the small midges (*Phlebotomus*, *Ceratopogon*) are called 'agas' in Malayan; he did not ascertain the Javan common name. In the Sunda Islands the 'agas' and 'meroetoe' (chloropid eye gnats) are lumped together with many other small Diptera under the name 'remetoek.'"

"According to Dr. Salm in Sumatra the name 'ages' as well as 'merotoe' was used for the small *Ceratopogon* collected by him. (Salm's remarks apparently applied to the day-biting *Lasiohelea* spp.)."

"Jacobson took a number of *Ceratopogon* (*Culicoides*) *guttifer* Meij. at night in the bed. They penetrate through the mosquito netting. Their bite is painless and causes no itching, except perhaps with persons with sensitive skin."

"Jacobson found them numerous in chicken coops, where they were present in thousands and gave the fowls no rest the whole night through. The fowls continually shook their head and picked at their feet, while they were plagued by these ghostly tormentors that crawled between their feathers and there sucked blood. Jacobson saw white chickens with their feathers covered with small drops of blood due to crushing the midges. He sought to relieve the fowls by kindling a smoldering fire near the coops so that the midges would be in the smoke. The midges were found then only 'dann und wann.' Jacobson observed them only in April, May and June 1909, yet he thought this might coincide with the amount of rainfall; 1909 was a very wet year. This species appears only at night; they do not especially prefer any certain part of the body."

In Indonesia at about the same time Salm (1914) reported that the biting midges are collectively called in Malayan "Agas" or "Merutu." He gave notes for distinguishing three common species, two species of *Forcipomyia* subgenus *Lasiohelea*, and *Culicoides pungens* (Meijere). Holz and Adiwinata (1958) figured and gave descriptive notes on two sand flies which they collected in Indonesia: a species of *Forcipomyia* (*Lasiohelea*) from Bogor, West Java, and a species of *Culicoides* from Menado, Celebes. It is not possible to make a more exact specific determination from their description and figures. Their taxonomic and biological notes were taken for the most parts from the papers by Meijere and Salm cited above.

The earliest account from the Philippines that we could find was made by Banks (1919), in a general review of the bloodsucking insects of the Philippines. "The midges (Chironomidae) are abundant in the Philippines, where the genus *Culicoides*, represented by *C. judicandus* Bezzi, is one of the commonest and most annoying pests in provincial regions. It is very persistent at certain times of the year, especially in Los Banos, where the mountain streams undoubtedly supply its breeding places . . . the year 1917 was unusually rainy, and these little pests were extremely abundant at that time. Their small size and mottled wings serve as a protection when they alight on the bare arm or leg of a person, and they readily enter mosquito nets where, like the nicnic [*Phlebotomus*], they congregate in the upper corners when replete with the blood of their victims. Their bite is as painful as that of the nicnic, but the effects last longer and the redness of a bitten spot will remain for two or three days, while the slightest irritation will cause it to begin itching again."

Pendlebury and Chasen (1932) in their introductory account of the 1929 Zoological Expedition to Mt. Kinabalu, North Borneo, complained that at Lumu Lumu (elev. 1,650 m), "at night we were assailed by minute midges (Ceratopogonidae) against which even our fine-mesh sand-fly curtains were of no avail. . . . The ground on which our tents were pitched was moss covered and in fact every tree and leaf was festooned with mossy growths, the whole locality being kept continually damp by mists and rain. . . . We both agreed that Lumu Lumu was the most unpleasant place we had ever camped on."

In World War II during the decade of the 1940s military campaigns were waged by both adversaries at the ends of long and tenuous supply lines thousands of miles from the home countries. Troops were forced to live, fight, and travel in jungle areas and were constantly subjected to the attacks of mosquitoes and other biting insects that were vectors of malaria and other tropical diseases.

Sen and Fletcher (1962) in their textbook of "Veterinary Entomology and Acarology for India," quoted extensively from manuscript notes written by P.G. Patel circa 1922 concerning the biting habits and larval habitats of *Culicoides* in India: "In Assam and Bengal some species of *Culicoides* are very common more or less throughout the year. In Assam, the number of these noticed during July and August 1906 was so great as to greatly worry animals. Their bite is not confined to any hour of the day or night but they are especially a nuisance during the evening hours. During the hot hours of the day they are generally seen attacking in

species of *Culicoides* are in the habit of drawing more blood than they can cope with. I have marked several species of *Culicoides* at Belgachia, Calcutta, alighting upon a bull which was tied in the open air during the evening hours in September, and entering straight into the hairs to suck blood. After taking their fill, which is generally accomplished within 3 to 10 minutes, they were observed to emerge from the hairs. Many of the flies had so much blood in their abdomen that each of them looked like a small droplet of blood. Several of these gluttonous flies after the meal were seen falling down in their attempt to fly." Patel found *Culicoides* breeding in the following situations: algal growths near edge of stagnant water, manure pits and reservoirs containing urine of cattle or washings from stables; rotten rags of cloth, sap of trees, and collection of rain water in holes of trees.

Sen and Fletcher list references reporting on 27 species of *Culicoides* from India. They also describe *Culicoides* control measures reported in manuscript by Patel: "In Assam, cultivators tie burning cowdung sticks on the waist at the time of planting or transplanting rice in the fields in order to protect themselves with smoke from the bites of these flies, which are known there by the vernacular name of *kuiki*. He also states that men plying bullock carts between Gambati and Shillong likewise use ignited dung sticks as a preventive against these flies."

Howarth (1974) reported that in Laos persons working outside are occasionally severely bitten by *Culicoides*. "The Lao keep smoky fires burning near working areas outside in the evening and at night mostly to repel the biting flies of several families. They call biting midges . . . 'nyung noi' or 'little mosquitoes.' . . . Cattle were often noted with visible clouds of midges swarming around them at dusk. A few of the swarms were swept with a net and the species noted. The most common species in the swarms were *C. schultzei*, *C. shortti*, *C. peregrinus* Kieffer, and *C. orientalis* Macfie. . . . In man, the bites of many species are characterized by an intense immediate burning sensation, similar to being struck by a burning ash. Many species also burrow into the hair on the scalp to bite and cause considerable annoyance. This latter biting habit makes it difficult to correlate the specimen collected with the bite. Many species are attracted to lights in houses and once there will bite."

ALLERGIC DERMATITIS

Severe and repeated biting attacks by *Culicoides* may give rise to allergic reactions and secondary infections in humans severe enough to be a medical problem (Hase, 1934). Wongsathuaythong et al. (1977) described skin eruptions due to *Culicoides* bites on humans visiting an allergy clinic in Bangkok, Thailand.

Horses in widely separated regions are subject to a chronic, seasonally recurring, irritating, superficial dermatitis of the withers, tail, mane, and ears. At times it is associated with onchocerciasis infections, but it usually occurs without any trace of etiological agent. As early as 1934 Underwood reported "Dhobie Itch" in horses in the Philippines. Riek (1953) first attributed this allergic dermatitis to the bites of *Culicoides*, and more recent workers (see above) are in general agreement. Horses commonly bite at the attack sites and break the skin with their

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include pasturing horses away from areas subject to midge attacks, stabling the animals at night or other periods of greatest midge activity, sprays or shampoos of midge repellent materials, and injections of anti-histamines.

DISEASE TRANSMISSION

All blood-sucking arthropods must be suspect as potential vectors of disease agents. Experimental transmission work with ceratopogonids as disease vectors has been seriously hindered and delayed because of the small size of the insects and difficulty of their colonization. Nevertheless, important discoveries in recent years are steadily incriminating *Culicoides* as vectors of pathogens of man and wild and domestic animals. Important review articles on the medical and veterinary importance of *Culicoides* have been published by Kettle (1965) and Braverman and Galun (1973). More recently the literature on disease transmission has been expanding so rapidly that the subject is difficult to review. Only reports of disease transmission by *Culicoides* in Southeast Asia will be included here.

Protozoa. Special attention must be called to the publication by McClure et al. (1978), "Haematozoa in the Birds of Eastern and Southern Asia." This volume gives a systematic list of the birds sampled and a list and discussion of the blood parasites found in each species. Nine important localities are discussed in detail with summaries of the infected bird species and possible vectors. Companion volumes summarize seven years of activity by the Migratory Animal Pathological Survey in Asia: McClure and Ratanaworabhan (1973), "Some Ectoparasites of the Birds of Asia"; and McClure (1974), "Migration and Survival of the Birds of Asia."

1. *Haemoproteus*. Fallis and Wood (1957) were the first to incriminate *Culicoides* as vectors of protozoan blood parasites of birds, when they discovered the development of *Haemoproteus nettionis*, a malaria parasite of ducks, in an unidentified species of *Culicoides* in Ontario. The vector was later named *C. downesi* Wirth and Hubert. Bennett et al. (1965) split the genus *Haemoproteus*, retaining the name for those species transmitted by hippoboscid flies and erecting *Parahaemoproteus* for those species transmitted by *Culicoides*. Miltgen et al. (1981) described *Parahaemoproteus desseri* from *Psittacula roseata* from Thailand and obtained experimental sporogony in *Culicoides nubeculosus* (Meigen).

2. *Hepatocystis*. Garnham et al. (1961) worked with a *Plasmodium*-like malaria parasite of *Cercopithecus* monkeys in Kenya, *Hepatocystis kochi*. They traced its development in *Culicoides adersi* Ingram and Macfie, where the sporocyst (= oocyte) lies free in the haemocoel and is not attached to the gut wall of the insect as in most malaria parasites, including other species of *Hepatocystis*. Miltgen et al. (1976) were able to transmit *Hepatocystis brayi*, a Malaysian parasite of squirrels, by feeding of *Culicoides nubeculosus* (Meigen) and *C. variipennis* (Coquillett) from laboratory colonies. Fyles and Warren (1963) recorded

oocysts on the gut-walls of *Culicoides* captured in Darjeeling, northern India, while investigating the possible vector of a malarial parasite of a flying squirrel. It was not possible to identify the species of *Culicoides* or the parasite.

3. *Leucocytozoon*. Mathis and Leger (1909) described *Leucocytozoon caulleryi* from domestic fowl in Tonkin (Viet Nam). Campbell (1954) first reported an acute haemorrhagic disease of chickens in Thailand which he called "Bangkok haemorrhagic disease." Akiba et al. (1958) reported *L. caulleryi* from chickens in Japan in which they first observed this disease in 1954; they considered Campbell's Bangkok disease to be identical. Akiba (1960) reported the vector in Japan to be *Culicoides arakawae* (Arakawa) and later (1970, 1975) reviewed in detail all aspects of the etiology, pathology, and control of this important poultry disease. It was not possible to control the disease in Japan by midge suppression, but administration of the drugs pyrimethamine and sulfadimethoxine in chicken feed or drinking water was effective until resistance developed in the parasite.

Griffiths (1963) reported observations on poultry leucocytozoonosis in Burma, where around Rangoon it affected young birds nearing laying time, with mortality rates sometimes exceeding 20% of the affected flocks. Fadzil and Cheah (1974, 1975) reported that leucocytozoonosis was prevalent in chickens at Ipoh, peninsular Malaysia, and trapping in poultry houses yielded abundant *Culicoides arakawae* infected with *L. caulleryi*. The seriousness of this *Culicoides*-transmitted poultry disease in Malaysia is indicated by the report of Fujisaki (1983) (fig. 2) who reported that up to 92% of the chickens sampled at Ipoh at from 10 to 500 days of age were positive for antibodies against *L. caulleryi* by the immunodiffusion test.

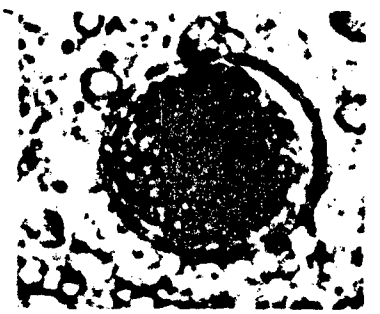


Fig. 2. Photomicrograph of schizont detected in a crush preparation from liver of a chicken 203 days after sporozoite inoculation of the Malaysian strain of *Leucocytozoon caulleryi* (from Fujisaki 1983).

Kitaoka and Cheah (1983) trapped *Culicoides* for 33 nights during a one-year period at Ipoh and found nearly equal numbers of blood-fed *Culicoides arakawae* and *C. guttifer*, both species with sporozoites of *Leucocytozoon caulleryi* in their salivary glands, indicating a high vector potential for these species.

4. *Trypanosoma*. Bennett (1961, 1970) noted developing stages of trypanosomes in *Culicoides* midges fed on infected birds, but did not consider this insect to be the important vector in Ontario. However, Miltgen and Landau (1982) were able to obtain experimental transmission of *Trypanosoma bakeri* Miltgen and Landau of the parrot *Psittacula roseata* Biswar from Thailand by laboratory experiments involving *Culicoides nubeculosus* (Meigen).

Filarial Worms. Schacher (1973) presented a valuable review of the life-cycle patterns of filarial parasites. The following adaptation of his table lists species having ceratopogonids as the intermediate host of species in the family Onchocercidae:

Filaria	Definitive Host	Intermediate Host
Subfamily Icosiellinae		
Icosiellia neglecta	frog	*Forcipomyia velox*
Subfamily Dirofilariinae		
Macacanema formosana	Taiwan monkey	*Culicoides sumatrae*
Subfamily Onchocercinae		
Tetrapetalonema perstans	man	*Culicoides grahamii*, *C. inornatipennis*
T. streptocerca	man	*C. austeni*
T. marmosetae	squirrel monkey	*Culicoides* spp.
T. llewellyni	racoon	*C. hollensis*
Mansonella ozzardi	man	*Culicoides* spp.
Onchocerca cervicalis	horse	*Culicoides* spp.
O. reticulata	horse	*Culicoides* spp.
O. gibsoni	cattle	*Culicoides* spp.
O. gutturosa	cattle	*Culicoides* spp.
O. sweetae	water buffalo	*Culicoides* spp.
Subfamily Splendidofilariinae		
Splendidofilaria californiensis	quail	*Culicoides multidentatus*
S. picacardina	magpie	*C. crepuscularis*
Chandlerella quiscali	grackle	*C. crepuscularis*
C. striatospicula	magpie	*C. haematopotus*
Subfamily Eufilariinae		
Eufilaria longicaudata	magpie	*C. crepuscularis*, *C. haematopotus*
E. kalifai	magpie	*C. nubeculosus*
Unclassified		
Filaria undet.	starling	*C. crepuscularis*

Fig. 3. Development of *Macacanema formosa* larvae in *Culicoides sumatrae*; A. "sausage stage" larva in thorax at 6 days after infective blood meal from *Macaca cyclopies*; B. second stage larva in thorax at 6 days; C. motile third stage larva in haemocoel at 22 days; D. motile third stage in head at 16 days; E. infective larva in head at 21 days; F. motile larva emerged from proboscis at 22 days (from Bergner and Jachowski 1968).

1. *Subfamily Dirofilariinae.* Bergner and Jachowski (1968) studied the development of the filarial worm *Macacanema formosana* Schad and Anderson of Taiwan monkeys (fig. 3). After experimental feedings, development of the microfilariae was completed in 16 days in *Culicoides sumatrae* Macfie (as *C. amamiensis* Tokunaga), the midge most prevalent in the natural habitat of the monkey.

2. *Subfamily Onchocercinae.* Buckley (1938) studied the possible vectors of *Onchocerca gibsoni* (Cleland and Johnston) in cattle in Malaya (fig. 4). This worm causes large nodules to form on the brisket and flanks of cattle. Of 20 species of *Culicoides* collected on cattle, *C. actoni* Smith (as *pungens* (Meijere))

microfilariae was very low, being 0.3% in nature and rising to only 1% after feeding on infected cattle. According to Supperer (1966) this parasite attacks cattle and buffalo in India, Sri Lanka, Malaysia, northern Australia, and South Africa.

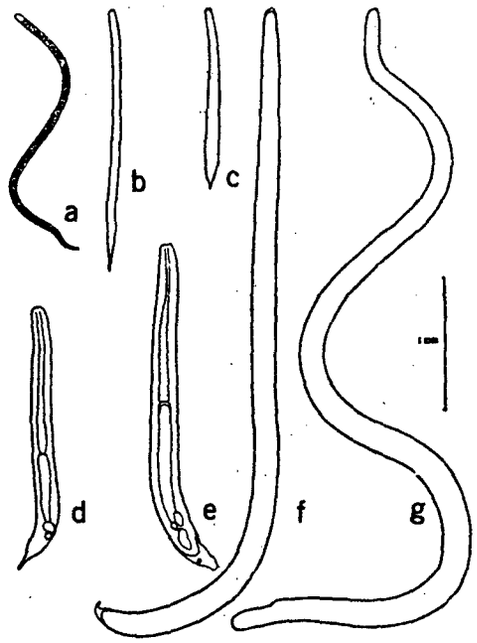


Fig. 4. Development of *Onchocerca gibsoni* in *Culicoides actoni*; A. microfilaria in blood of cattle; B,C. early stages 4 days after infective blood meal; D,E. post-"sausage stages" 4 days and 52 hours after infective blood meal; F. pre-infective stage 5 days after infective blood meal; G. mature larva from head (from Buckley 1938).

Viruses. The list of viruses transmitted by *Culicoides* is a rapidly growing one. At this time the economic importance of *Culicoides* as a vector of viral agents stems mostly from their association with bluetongue of sheep and cattle and Oropouche virus disease of humans. The implication of *Culicoides imicola* Kieffer as the vector of bluetongue in South Africa was accomplished by du Toit as early as 1944. But it was not until 1981 that Pinheiro et al. determined that *C. paraensis* (Goeldi) was the primary vector of Oropouche virus in Brazil. As pointed out in a review article by Linley et al. (1983), "the proven association of *Culicoides paraensis* with transmission of Oropouche virus elevates the medical importance of biting midges to a new level."

1. *Bluetongue Virus* (BTV) (Orbivirus--Bluetongue Group). Bluetongue is a chronic disease endemic to cattle and wild ruminants in Africa, where the greatest number of host animals, vectors, and virus strains have been identified. It was first recognized in cattle and sheep (figs. 5, 6) in South Africa in the early 1930s and has spread nearly worldwide; it was reported from Cyprus in 1943, Israel in 1951, U.S.A. in 1954, Portugal in 1956, Spain in 1957, and Australia in 1974. The extent of Bluetongue infections in domestic and wild ruminants in Southeast Asia is unknown, but its actual and potential occurrence there is a matter of serious concern. Jones et al. (1981) gave an excellent summary of our knowledge of the etiology, transmission, and control of Bluetongue disease.

Fig. 5. Sheep with Bluetongue. A. typical stance when coronitis is severe; B. severely inflamed coronary band on hoof; C. casting fleece at 50 days after infection; D. break line where wool has grown a quarter inch and is less dense (from Bowne et al. 1964, with permission of J. Am. Vet. Med. Assoc.).

The primary host of BTV is cattle and the endemic cycle is congenital from either parent. In cattle acute disease symptoms are found only in the fetus, and if the calf survives to become an apparently healthy adult it will remain infective for life. An insect vector is not concerned in the endemic cycle but occurs only in an epizootic situation where a *Culicoides* midge takes blood from an infective animal. After an incubation and multiplication period, the midge becomes infective to any wild or domestic ruminant that it will feed on, whether sheep, goat, cattle, deer,

epizootic cycle may go on repeatedly from year to year. Among the ruminant hosts morbidity and mortality is nil in goats, inapparent to very low in cattle, variable from moderate to high in sheep, and extremely high in deer.

Fig. 6. Shorthorn heifer with acute symptoms of Bluetongue--swollen muzzle and lips, thick saliva, and swollen, protruding tongue (from Bowne et al. 1968, with permission of J. Am. Vet. Med. Assoc.).

The economics of Bluetongue disease has changed greatly in recent years. For several decades the primary concern was to avoid the losses from epizootics in sheep, and these were brought under control by a widespread immunization program. When serological tests showed that BTV was becoming widespread in cattle, it was further discovered that the virus was the cause of many of the abortions, stillbirths, and deformed or brain-damaged calves causing losses in the

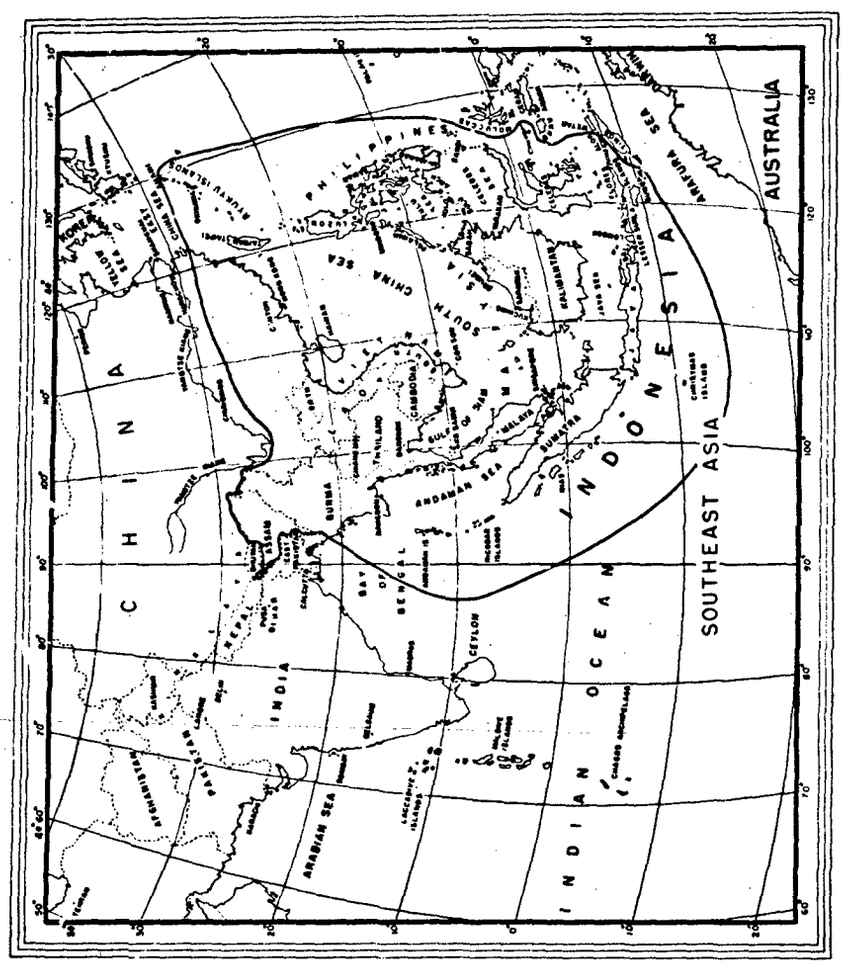
cattle industry, especially in dairy herds. The most serious problem has arisen in the international shipments of semen from highly productive and prized breeding animals to be used for herd improvement at relatively low cost in underdeveloped countries. Becuase no method has yet been devised to eliminate BTV from sperm from infected animals, all breeding herds must be kept in strict quarantine. In areas such as Kenya where the presence of up to 19 antigenic types of Bluetongue virus complicates the effectiveness of polyvalent vaccines usually containing 6 serotypes (Davies 1978), the use of vaccines is of doubtful value. Because Bluetongue vaccines in present use may possibly release active virus into herds of cattle and thus act as a source of infection, immunization as a form of Bluetongue control is now discouraged and animal breeders must turn to insect vector control to stop the epizootic cycle.

2. *Akabane Disease* (Simbu Group virus). A disease of cattle, known as arthrogyroposis-hydraencephaly (AH) syndrome, was known in Japan since 1947 and has also been reported in cattle, sheep, horses, and goats in Australia, Israel, and Kenya. Inaba et al. (1975) proposed for it the name Akabane Disease. Akabane antibodies have also been found in pigs and monkeys in Indonesia, monkeys in Malaysia and the Philippines, pigs in Taiwan, horses in Thailand, and cattle and sheep in Cyprus (Matumoto and Inaba 1980). The disease causes epizootic abortion, premature birth, stillbirth, and congenital malformations in newborn calves and lambs. The virus was first isolated from *Aedes* and *Culex* mosquitoes in Japan in 1959 and later from *Anopheles* mosquitoes in Kenya. Doherty et al. (1972) isolated Akabane virus, along with two other viruses, from *Culicoides brevitarsis* Kieffer collected in Queensland in 1968. St. George et al. (1978a) isolated Akabane virus repeatedly from cattle in Queensland and made three isolations from *C. brevitarsis* collected nearby in the same period. They concluded that this midge is the vector in Australia. Akabane virus is closely related to Bluetongue and its effects are much like those of Bluetongue in cattle.

3. *Fowl Pox Virus* (FPV). *Culicoides arakawae* (Arakawa) has been reported as a severe pest of domestic fowls and turkeys in Japan as early as 1913 (Shiraki 1913, Tokunaga 1937). Tokunaga (1937) and Kitaoka et al. (1965) suggested that *Culicoides* midges might act as vectors of fowl pox, although mosquitoes were known to be the principal vectors. Fukuda et al. (1979) eventually succeeded in showing that fowl pox could be transmitted experimentally from chicken to chicken using female *C. arakawae*. Becuase of the far larger numbers of *Culicoides* midges than of *Culex* mosquitoes attacking chickens, these authors believed that keen attention should be paid to *C. arakawae* by poultry growers.

GEOGRAPHY OF SOUTHEAST ASIA

Southeast Asia is usually considered to include Burma, the Indochinese Peninsula, the Malay Peninsula, and the islands of Indonesia and the Philippines. By this definition Southeast Asia occupies a region almost 2,400 km in radius from a point off the mouth of the Mekong River. It extends from north of the Tropic of Cancer in upper Burma to 11° south of the Equator in the Lesser Sunda Islands (Map 1).



Map 1. Southeast Asia, political divisions.

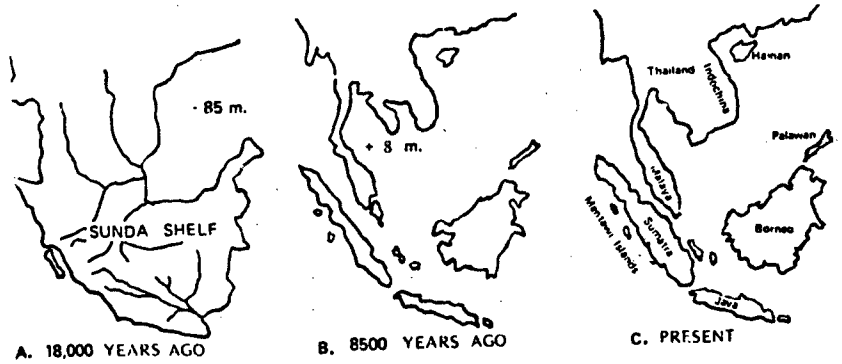
In our geographical discussions we find it most convenient to speak rather loosely of political subdivisions and boundaries. Accordingly, we will often refer to Peninsular Malaysia as Malaya; the combined states of Brunei, Sabah, Sarawak and Kalimantan as Borneo; the combined states of Cambodia, Laos, and Viet Nam as Indochina; and of Indonesia to exclude the New Guinea state of West Irian.

Because we were unsuccessful in obtaining significant *Culicoides* collections from Burma, and to save space, we have omitted detailed discussion of the terrain and climate of Burma. This happened in spite of our conviction that faunisti-

cally Burma would have been one of the most interesting and important geographic areas to study. We hope that someone may fill this gap in the near future.

Limitations in publication funds prevented us from including a detailed discussion of the geography of individual countries and of the biogeography of Southeast Asia and biogeographical discussion of the *Culicoides* fauna. We hope to have the opportunity to present the latter in a separate publication at a future date. We will limit ourselves here to a general discussion of Southeast Asian geography which we have prepared from the personal observations of the junior author, and from reference to a number of published sources.

Excellent treatises on Southeast Asian geography have been published by Wallace (1869, 1876), Zeuner (1941), Dobby (1954), Lewis and Ho (1965), Bingham (1968), Macnae (1968), and Lekagul and McNeely (1978). Recent interpretations of the geological history of this area were published by Wilson (1972), McKenzie and Sclater (1973), and Molnar and Tapponier (1975). Our sources for the recognition of plant formations are Richards (1936, 1952), Vidal (1960), Ogawa et al. (1961), Wyatt Smith (1964), Neal (1967), and Robbins (1968). Good accounts of the biogeography of individual countries can be found in Smythies (1953) for Burma; Gressitt (1970) for Laos; Corbet (1941), Corbet and Pendlebury (1956), Pendlebury and Chasen (1932), Delacour (1947), and Wyatt Smith (1964) for Malaysia; Delacour and Mayr (1946) for the Philippines; and Deignan (1945) and Lekagul and McNeely (1978) for Thailand.

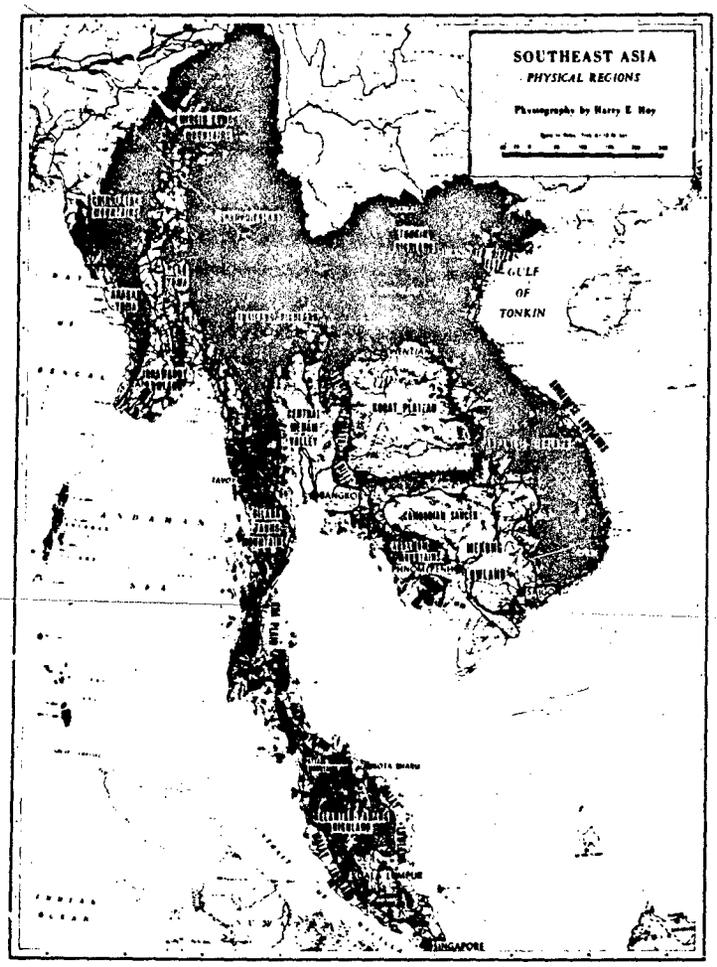


Map 2. Southeast Asia during Pleistocene sea level changes. A. 18,000 years ago, when sea level was 85 m lower than at present; B. 8,500 years ago, when sea level was up to 8 m higher than at present; C. present configuration (from Lekagul and McNeeley 1978).

THE SUNDA SHELF

The southern part of Indochina, the Malay Peninsula, the eastern half of Sumatra, the north shore of Java, and all of Borneo lie on what is called the Sunda Shelf (Map 2). On this, the world's largest continental shelf, the mean depth of the sea is 30 fathoms, with a maximum of 45 fathoms. The surface of the entire shelf was above sea level during the Quaternary ice ages and was submerged again at

the close of this period. Underwater maps show drowned river valleys of two systems: one draining eastern Sumatra and western Borneo, and the other draining the southeastern tip of Sumatra, northern Java, and southern Borneo. The existence of many common species in the fresh water fauna of eastern Sumatra and western Borneo attests to the former land connection.



Map 3. Southeast Asia, physical regions (from Bingham, 1968).

MOUNTAIN AND ISLAND SYSTEMS

The line of Himalayan mountain formations which extends eastward across South China towards the China Sea delimits Southeast Asia geologically from the rest of Asia. Mountain ranges to the south through Indochina and the Malay Peninsula have a roughly north-south orientation (Map 3). Fault and fold systems outside of the Sunda Shelf are complex, but a number of mountain arcs can be recognized, the higher parts of which emerge from the sea as islands. The most important of these starts in the Arakan Yoma of Burma appears as the Andaman and Nicobar Islands and then continues in the mountains of western Sumatra, southern Java, and eastward through the Lesser Sunda Islands, finally curving back on itself in the Banda Sea. This is paralleled seaward in the Indian Ocean by a deep trough and then by a ridge showing in the Nias-Mentawei Islands west of Sumatra. After a gap of 2,000 km an arc rises in Sumba and Timor and continues through Tenimbar, Kei, Ceram, Amboina, and Buru. The mountains of Borneo trend southwest to northeast. The northern range is probably continued as Palawan and into Luzon in the Philippines. Another connection between Borneo and the Philippines may be through the Sulu Archipelago to Mindanao. Two lines of volcanoes in the Philippines reach Halmahera and Sulawesi, respectively. Most of the 300 volcanoes found in Indonesia occur in a line of active volcanism extending along western Sumatra, central Java, and the Lesser Sunda Islands to Flores and beyond.

DRAINAGE

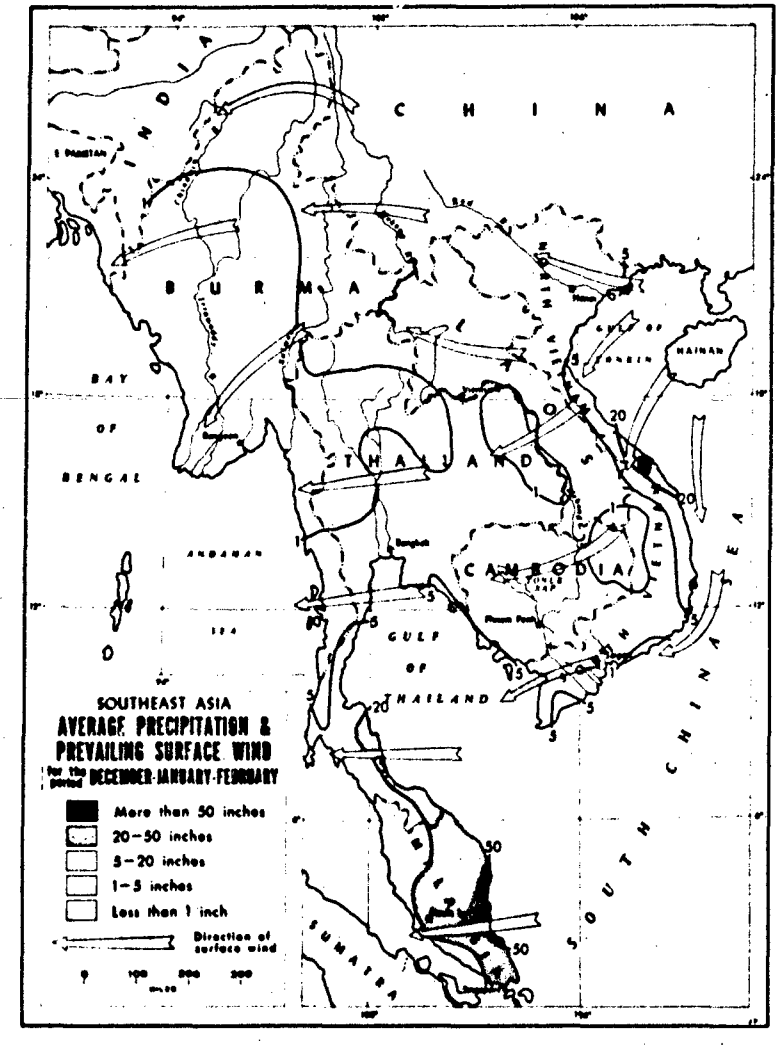
The principal rivers of Southeast Asia are the Irrawaddy, the Salween, the Chao Praya, and the Mekong (Map 4). Of these, the Salween and Mekong are remarkable for their great length in a region where rivers are generally short. The high rainfall often comes in torrential downpours, causing great fluctuations in stream level within a short period of time. These rainstorms have powerful erosive effects, especially on cultivated land. The soil rapidly washes away, and this muddy run-off creates a heavy silt load in the streams. Under natural conditions the forest protects the soil by breaking the force of the rain and reducing the run-off. The heavy load carried by the rivers reduces the surface of the drainage basins over most of their area and causes the build-up of estuaries where they empty into the sea.

CLIMATE

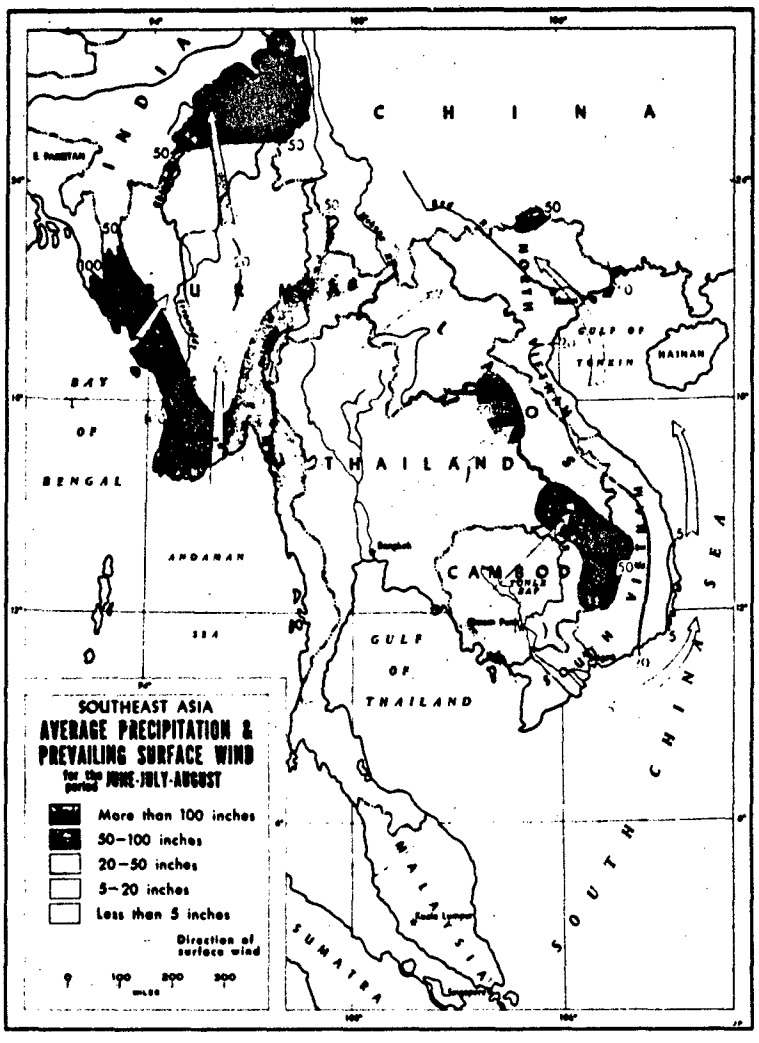
The climate of Southeast Asia is characterized by regional uniformity of temperature and little temperature fluctuation due to seasonal change. Apart from local variations due to altitude or to continental influences from Tibet, the average monthly temperatures remain within 10 degrees of 80°F throughout the year.

The seasonal distribution of rainfall is dependent upon the movement of air masses. There are two tropical air masses, one normally moving toward the Equator from the north as the northeast trade winds (Map 4), and the other moving toward the Equator from the south as the southeast trades (Map 5). The line along which these two physically similar air masses meet may be termed the

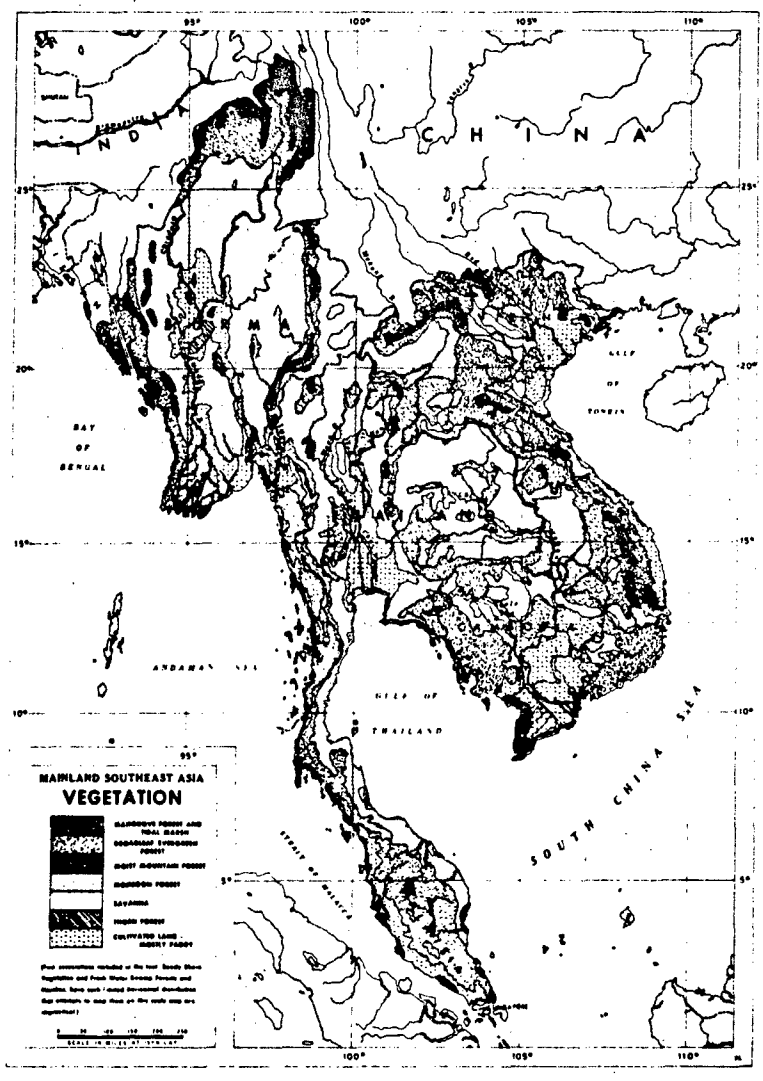
"intertropical front." This front is pulled above the Equator during the northern hemisphere summer and south of the Equator during the southern hemisphere summer by the annual migration of the sun. When the trade winds cross the Equator they are bent so that the northeast trades blow from the northwest and the southeast trades blow from the southwest. The position of the intertropical front is further influenced by the low pressures developing over the Asian continental land mass and over Australia during the northern and southern hemisphere summers, respectively.



The northeast and southwest trade winds, which are called "monsoons" in southern Asia, produce rainy or dry weather in different areas, depending on the geographic relationship to land masses, seas, and mountain ranges. On the continent the northeast monsoon brings dry weather to Burma, Laos, Thailand north of the Kra Isthmus, inland portions of Vietnam, and most of Cambodia.



Map 5. Mainland Southeast Asia, wind and rainfall June-August (from Bingham 1968).



Map 6. Mainland Southeast Asia, vegetation (from Bingham 1968).

It brings heavy rains to the Cardamom Mountains in Cambodia, the eastern flank of the Annamite Mountains in Vietnam, peninsular Thailand, and all of Malaya. During the southwest monsoon conditions are pretty much reversed, the continent north of the Kra Isthmus receiving rain, while less falls in Malaya, which has no distinct dry season. Total annual rainfall is moderate to heavy over most of this region. A striking exception is the dry zone of central Burma, parts of which receive less than 630 mm of rain. The climate of Sumatra, Borneo, and Java is much like that of Malaya. The islands of eastern Indonesia are subjected to an extended dry season, some stations on Sumba and Timor receiving less than 76 mm of rain during the 6 months from May through October. The seasonal rainfall pattern in the Philippines is rather complicated, with many local variations.

VEGETATION (Map 6)

Southeast Asia has the richest flora of any biogeographic region, there being an estimated 35,000 species of plants. Woody plants predominate, and 15% of the species are trees whose mature trunks are over 40 cm in diameter. The proportion of woodland to other types varies from less than 30% to over 70%. The climate, the soil, and the work of man are chiefly responsible for the present-day distribution of vegetation types, i.e., Coastal Vegetation, Lowland Forest, and Mountain Forest.

Coastal Vegetation. The Coastal Vegetation may be divided into two general types: Mangrove Forests and Beach Woodland.

Fig. 7. Morib, 32 km S. Klang, Selangor, Malaysia, mangrove habitat (photo A.A. Hubert

1. *Mangrove Forests* (fig. 7) are widely distributed along sedimenting shores throughout Southeast Asia. In Malaya, mangrove occupies most of the west coast, which is sheltered from effects of the northeast monsoon. Along the mostly sandy and exposed east coast, it is restricted by the rougher water to the shelter of river mouths. The entire west coast of Thailand is mangrove wherever coasts are muddy. There are scattered patches along the east coast of peninsular Thailand, and a more continuous formation borders the Bight of Bangkok and coastal Southeast Thailand. In Burma, mangrove is characteristic of some Arakan Islands and of southern Arakan, the Irrawaddy delta, and large portions of Mergui in southern Tenasserim. Mangrove in Indochina is concentrated in three areas: a discontinuous coastal fringe in Tonkin; extensive forests at the mouths of the Song Be and Saigon Rivers, the Mekong delta, and the west coast of the Camau Peninsula in Cochin China; and the northern portion of the Cambodian coast. In the Philippines, the mangrove forest is discontinuous and varies in breadth, depending on the coastal soils and exposure of the different islands. In Indonesia, mangrove forms an almost continuous belt on the northeast coast of Sumatra and the east and south coasts of Borneo. It is also common in Sarawak and Sabah, the Bornean states of Malaysia. Whereas heavy surf inhibits mangrove development on the southwest coast of Sumatra and the south side of Java, the more sheltered Java Sea coast of the latter island has considerable mangrove towards the west. The Lesser Sunda Islands have little mangrove except for sheltered locations in southwest Timor, where suitable edaphic conditions offset the semi-arid climate.

The mangrove formation is remarkably uniform in structure and species composition throughout Southeast Asia (Macnae 1968). This is a single-story forest of evergreen trees sometimes reaching a height of 12-24 m at maturity with little or no ground cover of shrubs or herbs. The component species, which are relatively few, have various adaptations enabling them to withstand the drying effects of bright sunshine and wind and to survive partial inundation with salt water. There is a strong tendency towards vivipary in several families, the embryo undergoing partial or complete development while still attached to the parent tree. In *Rhizophora* and related genera the hypocotyl grows out of the apex of the fruit, permitting the young seedling to take root rapidly when it drops to the mud. Floating seedlings are the means of dispersal for this group. *Rhizophora* can easily be recognized by its propping stilt roots, while the genera *Sonneratia*, *Avicennia*, *Bruguiera*, and *Xylocarpus* have roots with knee-shaped or asparagus-like pneumatophores protruding from the mud, presumably to enhance respiration. Root systems are shallow and tend to radiate out from each tree to provide better support in the unstable substrate.

Environmental factors governing the occurrence and distribution of species within the mangrove are the nature of the soil, which ranges from sand through silt to clay, the frequency and length of tidal inundation, the saltiness of the water, the strength of the tides, and the degree of exposure or shelter. As can readily be seen in aerial photographs, some of the mangrove species are arranged in regular zones according to the factors listed above. The pioneer species in exposed situations or on stiff clay belong to the genus *Avicennia*. In more sheltered places on soft mud the pioneers are *Avicennia* and *Sonneratia*.

a belt just inland from the pioneers. The main part of the mangrove is occupied by *Rhizophora apiculata* Bl., sometimes mixed with *Bruguiera parviflora* W. & A. The other stilt-rooted mangrove species, *Rhizophora mucronata* Lmk., is mostly confined to the banks of waterways. The drier and slightly higher margins of the mangrove forest beyond the reach of the tides are elevated not only by the deposition of soil but by the mound-building activities of the burrowing prawn *Thalassina*. Characteristic of this zone are two or three additional species of *Bruguiera*, other trees of such genera as *Intsia*, *Heritiera*, and *Xylocarpus*, the large fern *Acrostichum aureum* L., spiny-leaved *Acanthus* bushes, and the spiny-trunked *Oncosperma* palm. At the mouths of rivers where the water is brackish, the banks are often thickly lined with the stemless palm *Nipa* (or *Nypa*) *fruticans* Wurmb.

Fig. 8. Morib, 32 km S Klang, Selangor, Malaysia, beach strand forest (photo A.A. Hubert 1973).

2. *Beach Woodland*. Beach or strand forest, also known as the *Terminalia-Barringtonia* formation, is found along sandy or gravelly shores, where conditions are unfavorable for development of mangrove. This is one of the most uniform and widespread of tropical forest types, the same species occurring along all suitable mainland and island coasts in the tropical western Pacific and Indian Oceans (fig. 8). Several of the important trees in this association, such as *Barringtonia asiatica* Kunz. and *Terminalia catappa* L., are characterized by floating fruits, which are resistant to salt water and can be carried great distances by ocean currents. Another, *Hibiscus tileaceus* L., which is pantropical in distribution, sometimes extends inland along the banks of streams. The beach formation is usually a narrow strip 18 to 36 m wide. Along sandy coasts the outermost fringe facing the sea is often comprised of the feathery *Casuarina equisetifolia* L. Other common representatives of this association are *Calophyllum*, *Cerberra*, *Desmodium*, *Hernandia*, and *Thespesia*. The shrub *Scaevola* and the sprawling [illegible] both occur on the beach between the tree line and the high

Lowland Open Country Zone. Corbet and Pendlebury (1956) interpolate a man-made zone in the lowlands of Malaya between the Coastal Forest and the Lowland Forest to include in its widest sense all cleared areas such as gardens, coconut plantations, rubber estates, roadsides, and deserted clearings reverting to secondary forest (fig. 9). When cleared land is abandoned in Malaya it first reverts to a high coarse grass [*Imperata cylindrica* (L.) Beauv.] called "lalang." Next, the lalang is gradually replaced by other grasses and low-growing shrubs with leguminous plants prominent, as well as introductions from other tropical regions. The reversion of cleared land to true primary forest is estimated to take at least 250 years. In other parts of Southeast Asia the practice of clear-and-burn or shifting cultivation has also taken place to a significant extent at higher elevations, paving the way for introductions of subtropical and temperate plants.

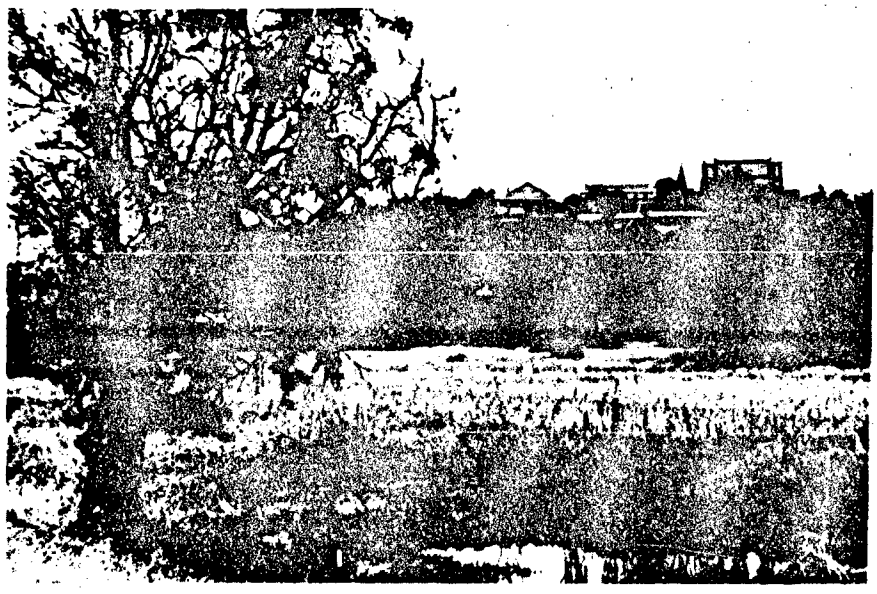


Fig. 9. Open sunny marsh in disturbed habitat near Rathburi, central Thailand (photo A.A. Hubert 1966).

Lowland Forest. Lowland Forest may be of several types, but for the purpose of simplicity can be classified into Tropical Evergreen Rain Forest and Monsoon Forest.

1. *Tropical Evergreen Rain Forest* occurs in Southeast Asia from sea level to as high as 1,200 m in regions of high rainfall without a distinct dry season, wherever

forest has been classified based on altitude into lowland, hill, and upper dipterocarp forest, but these distinctions will not be made here. Freshwater swamp and peat swamp forests will also be considered as part of this formation. Evergreen rain forest as herein defined is characterized by the predominance of the family Dipterocarpaceae in the canopy-forming and emergent trees.

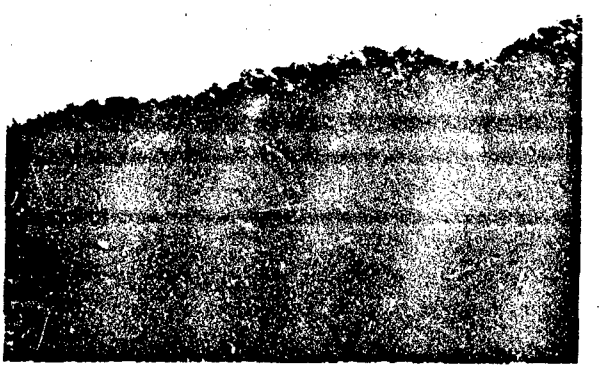


Fig. 10. Ulu Gombak Forest Reserve, Selangor, Malaysia; hill dipterocarp forest at 600 m in Genting Sempah Jungle Reserve (photo A.A. Hubert 1973).

Trees in tropical evergreen rain forest are typically tall and straight-boled with the first limb about 25 m above the ground. Many species have plank-like buttresses for support at the base of the trunk. A profusion of climbers, including thick-stemmed woody lianas festoon the branches of adjacent trees, linking them inseparably together. The dense canopy of intertwined limbs and dark green leaves prevents most sunshine from reaching the ground. Consequently, the ground cover of herbs and shrubs is relatively sparse and open, except where a stream course or occasional fallen tree admits more light. Epiphytes are less abundant in Malaya than they are farther north in Thailand and Burma.

The rain forest formation has a three-storied structure (fig. 11). Uppermost is an emergent layer with spreading crowns reaching 36 to 45 m or more above the forest floor. This discontinuous layer is comprised largely of the families Dipterocarpaceae and Leguminosae. The main layer, 21 to 30 m in height, forms an unbroken canopy except directly under the emergent trees. This story is represented by species of Bursuraceae, Sapotaceae, Guttiferae, Myristicaceae, and Rubiaceae, as well as younger trees of the emergent layer. The understory consists of saplings of the upper two layers plus representatives of the families Euphorbiaceae, Annonaceae, Flacourtiaceae, and Rubiaceae. The understory and shrub layers also include a variety of palms (figs. 12-15).

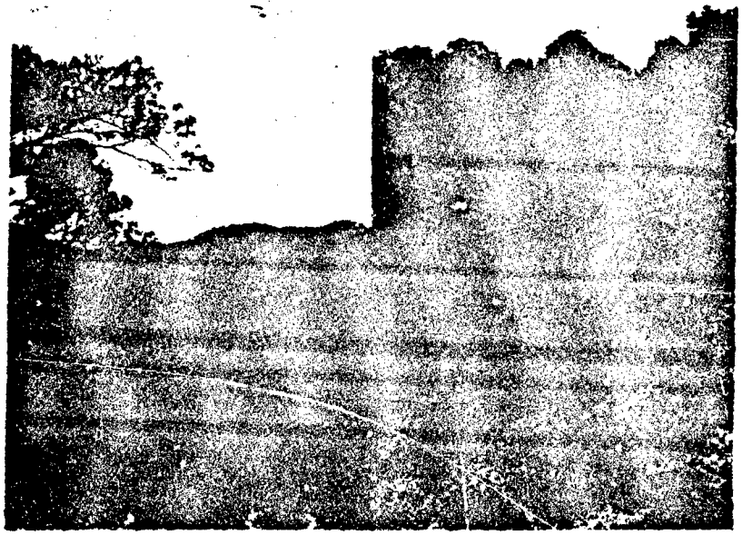


Fig. 11. Ampang Reservoir, 11 km E Kuala Lumpur, Selangor, Malaysia; virgin forest at 150 m elevation (photo A.A. Hubert 1962).

Fig. 12. Sungei Buloh Forest Reserve, 16 km NW Kuala Lumpur, Selangor, Malaysia (photo A.A. Hubert 1962).

Fig. 13. Kuala Langat, Selangor, Malaysia, peat swamp forest (photo A.A. Hubert 1973).

Fig. 14. Ampang Reservoir, 11 km E Kuala Lumpur, Selangor, Malaysia, virgin forest at 150 m elevation (photo A.A. Hubert 1962).

Fig. 15. Bukit Lanjan, Selangor, Malaysia; lowland secondary forest (photo A.A. Hubert 1973).

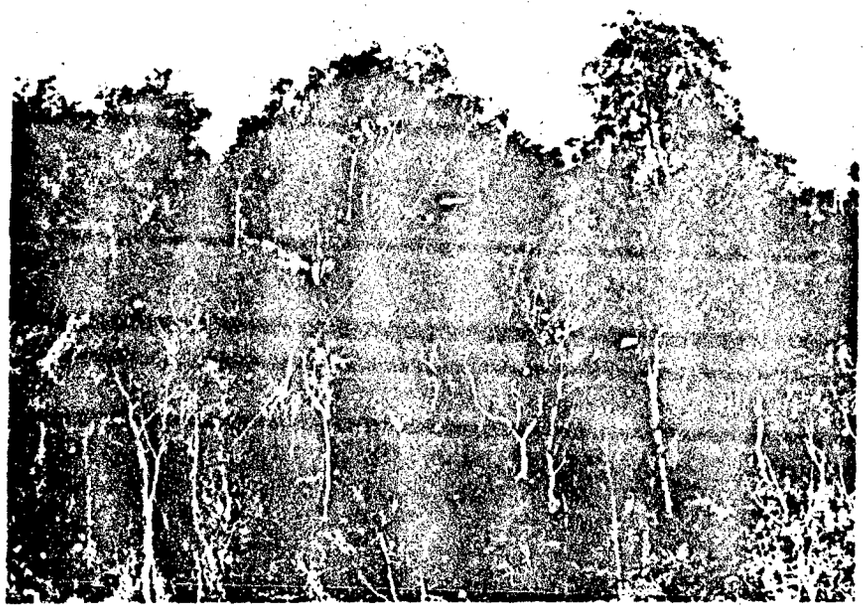


Fig. 16. Pak Chong, Thailand, semi-deciduous monsoon forest (photo A.A. Hubert 1973).

2. *Monsoon Forest* occurs in Burma, Thailand, Indochina, eastern Java, and the Sunda Islands. During the prolonged dry season nearly all of the trees shed their leaves (fig. 16). Monsoon forest is mostly of mixed species but sometimes a single species dominates, possibly as a result of selection through repeated burning. Of these, teak forests (*Tectona grandis* L.) are characteristic and important commercially. Among the trees, *Acacia* and other Leguminosae are conspicuous, as are smaller members of the family Dipterocarpaceae, including *Pentacme* and a few species of *Shorea* and *Dipterocarpus*. Extensive areas are covered by bamboo.

Mountain Forest. In Mountain Forest (fig. 18) the families Dipterocarpaceae, Leguminosae, Burseraceae, Sapotaceae, etc., gradually are replaced with increase in altitude by members of the Lauraceae, Fagaceae, and in certain regions, conifers. Among the Fagaceae, *Castanopsis* and *Quercus* are most important. Above 1,500 m trees become gnarled and dwarfed, and the ground becomes buried under a thick layer of mosses, liverworts, and ferns. Epiphytes are also abundant in this so-called Oak-moss Forest (fig. 17).

Fig. 17. Cameron Highlands, Pahang, Malaysia, oak-moss forest (photo A.A. Hubert 1973).

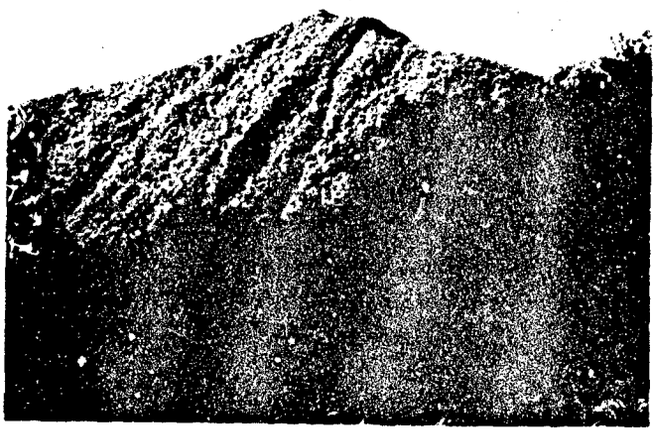


Fig. 18. Mt. Brinchang, 2,000 m, Cameron Highlands, Pahang, Malaysia (photo A.A. Hubert 1973).

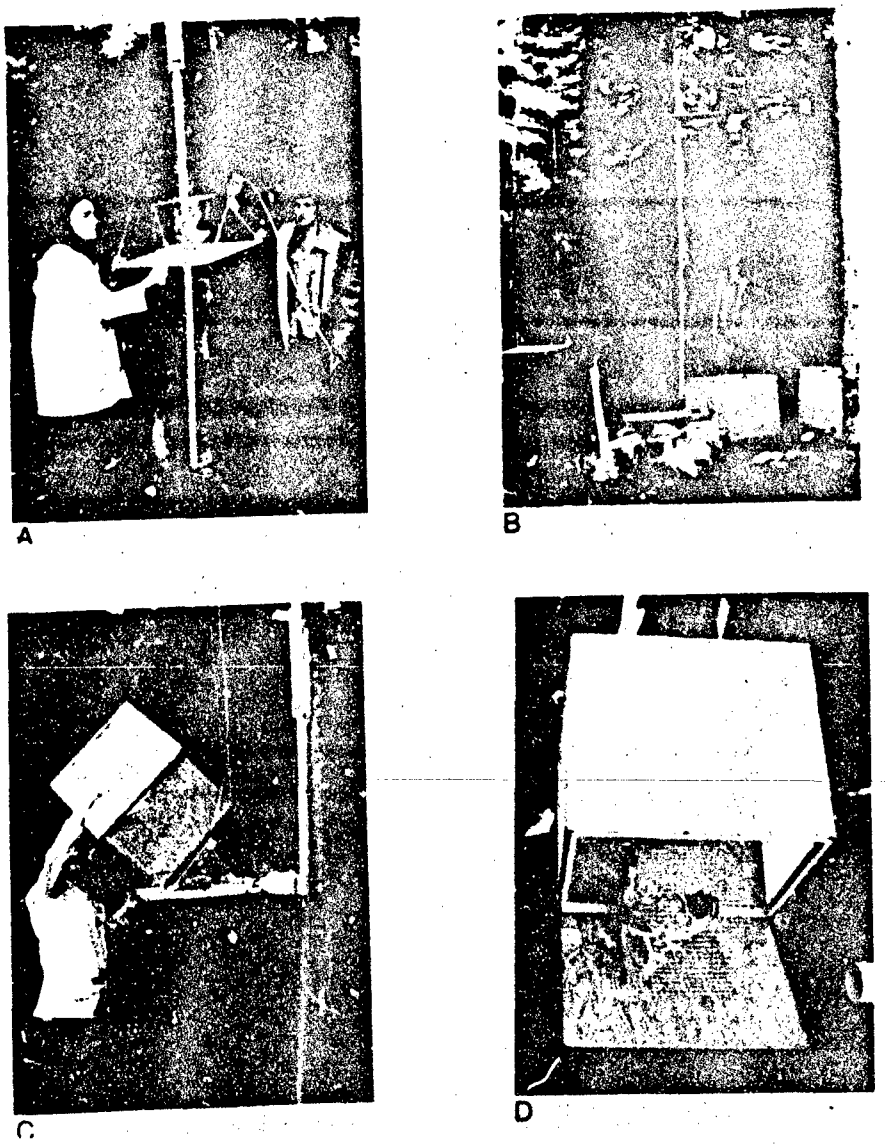


Fig. 19. Bennett trap in operation in Newfoundland; A. initial uncovering of bait fowl; B. hoisting of uncovered bait to tree canopy; C. final covering of exposed bait preparatory to collection of biting midges through sleeve cage; D. close-up of bait fowl in restraining cage on platform board and of sleeve cage.

METHODS OF COLLECTION AND STUDY

ADULT SURVEYS

Females may be collected while feeding on man and animals by touching them lightly with a finger, forceps, or brush moistened with alcohol, by aspirator, or by a fine-mesh insect net. Bait traps are not very satisfactory since *Culicoides* are reluctant to enter an enclosed space. Bennett (1960) and Schmidtmann et al. (1981) have had good success with drop traps (figs. 19, 20). Bidlingmayer (1961)

Fig. 20. Drop trap for collecting *Culicoides* attracted to tethered calves (from Schmidtmann et al. 1981).

in Florida, Sommerman and Simmet (1965) in Alaska, and Dyce et al. (1972) in Australia (fig. 21) made excellent collections of *Culicoides* using an interception trap mounted on a vehicle which patrolled roadways during hours of adult activity. The most satisfactory method to determine incidence and relative abundance of *Culicoides* species in a general area is by means of light traps. We have had steady success with standard New Jersey mosquito traps (fig. 22) (Mulhern 1953), particularly if the hood is designed to allow the light to shine at least slightly above the horizon. A small portable AC generator may be used for operation in

habitats not provided with electric power. A suction fan greatly increases the efficiency of any light trap in collecting these small midges, even in such weakly powered portable traps as the CDC models (fig. 23). The standard portable, battery-powered, suction light trap used for many years as the "CDC trap" was described by Sudia and Chamberlain (1962). Driggers et al. (1980) described a greatly improved version of the CDC trap called the "Army miniature solid-state" or AMAA trap. Service (1970) described a very efficient, battery-powered, portable, suction-fan light trap called the "Monks Wood trap." A great advantage in using light traps or vehicle traps is the collection of males, which often are extremely helpful in identification, but unfortunately some species are not especially attracted to light or do not travel far from their breeding places.

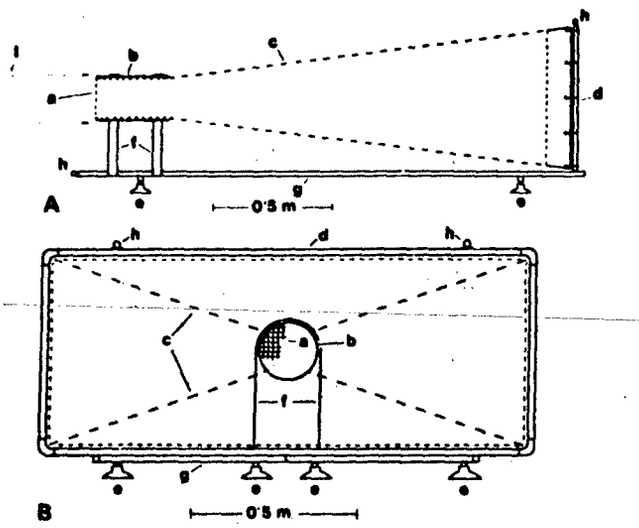


Fig. 21. Truck or car-top trap: A. lateral plan; B. front plan: a. metal mesh to exclude large insects (variable according to size of target group); b. sheet metal sleeve; c. terylene net (13 x 22 cm) funnel laced to the metal frame in front and fixed to the sheet metal sleeve behind; d. front opening 1.5 x 0.6 m with tube metal frame; e. suction cups which seat on top of motor vehicle; f. metal support struts attached to b and g; g. tube metal "A" frame undercarriage; h. guy rope attachment rings for securing trap to vehicle; i. removable terylene voile bag in which insects aggregate (from Dyce et al. 1972).

Walker and Boreham (1976a) found that use of a 7.5 g/liter solution of unbuffered saline with addition at 1:200 of a cetrimide antiseptic cleansing and wetting agent was quite effective for collecting and short-term storing of *Culicoides* taken in light traps. Collecting bottles containing the saline were attached directly to the [illegible] tests for blood meal determination were accurate on material

Fig. 22. New Jersey mosquito light trap and principal parts: fan, interior screen, clock timer, cyanide jar, and carton for storing collected insects (from Mulhern 1953).

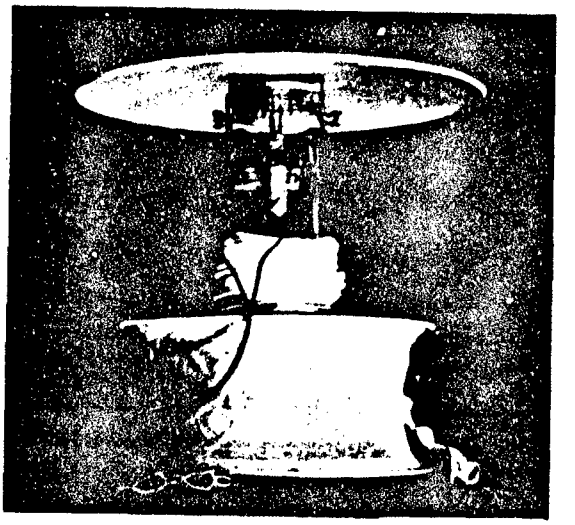


Fig. 23. CDC miniature light trap equipped for live catches; wire gauze funnel and mason

Carpenter (1951) described a method of using papers coated with castor oil fastened on boards and placed in horse-baited traps or fastened on stakes at various heights above ground level in the Panama jungle to sample *Culicoides* populations. He considered the use of adhesive papers superior to light traps or hand catches for measuring densities of adult *Culicoides*. Sticky cylinder traps consisting of sheets of adhesive-coated paper or plastic film clipped to cylinders fastened at various heights to posts were used successfully by Kettle (1951) in Scotland to capture adult midges as they flew from surrounding larval habitats. Such traps have recently been used by Kline and Axtell (1977) to determine the relative abundance of different *Culicoides* species in coastal salt marshes in North Carolina and to record their seasonal emergence.

Dyce et al. (1972) described equipment and methods for the collection, handling, and sorting of Ceratopogonidae for virus isolation. They emphasized the desirability of processing living females of suitable physiological age and discussed the need for flexibility in the use of collection methods. Live adults were collected in modified CDC light traps, truck traps, burrow egress traps, and over animal bait. The collections were held and transported in separate plastic containers stored on ice in a styrofoam cooler. They were immobilized for sorting by a light anaesthesia with chloroform and sorted under a microscope on a grid tray on a chilled table. Males and nulliparous unfed females were excluded from virus tests, but samples were held in 70% alcohol for species confirmation. The utmost care was taken to exclude blood engorged females from virus test material; these were instead tubed separately for serological tests to determine the host origin of the blood meals in their guts. Tubes containing samples for virus tests and blood meal tests were stored in tubes over liquid nitrogen.

PRESERVATION AND STUDY

Adult *Culicoides* are preserved most satisfactorily for study by killing and preserving them directly in 70% alcohol. Some specimens are quite useful for study of the thoracic color pattern if collected dry with trap or net, killed in cyanide or ethyl acetate fumes, and pinned on small minuten pins.

It is usually necessary to mount and dissect adult *Culicoides* on microscope slides for accurate identification under the magnification of a compound microscope. While various water-soluble, chloral-gum media such as Hoyer's or Swan's media are convenient and make excellent temporary mounts, we advise against their use if any permanent collection is to be maintained. Even careful ringing of such mounts with sealant compounds will not make them permanent, and sooner or later the seal will break and the preparation will dry out and darken. We have had excellent results in quick preparation of permanent slide mounts by clearing our specimens in phenol and mounting them in a mixture of phenol-balsam. The procedure for making phenol-balsam preparations was described in detail by Wirth and Marston (1968).

IMMATURE STAGES

Techniques for searching, collecting, isolating, and rearing the immature stages of *Culicoides* have been described in detail by Hill (1947), Wirth (1952a), Kettle and Lawson (1952), Molev (1958), Jamnback (1965a), Glukhova (1967a), Nevill (1969), Jones (1978), and Blanton and Wirth (1979). In order to locate specific breeding places, samples of all possible larval habitats must be collected. Small samples (1 cup to 1 pint) of mud, moss, wet soil, debris, or other media can be placed in jars, ice cream cartons, or other containers, suitably covered with an emergence cage, and adults captured as they emerge. The authors prefer to float off the pupae in a small pan or dipper from samples in the field and isolate them on moist cotton in small (1 x 5 cm) vials stoppered with cotton plugs. We find this is the easiest way to make a quick survey of potential breeding places. If numerous pupae are found, larger quantities of the substrate can be collected and taken to the laboratory for mass rearing or recovery of the larvae.

The larvae are easily concentrated by sieving and flotation with magnesium sulphate, or ordinary sugar or salt in nearly saturated solution, which quickly floats the larvae, along with various other organisms and organic debris, to the surface where they may be sorted and counted, pipetted off, and if desired preserved or rinsed in clean water and introduced into culture pans or study chambers (Davies and Linley 1966). Berlese funnels are useful for extracting larvae and pupae from semi-aquatic media, especially for species of *Avaritia* whose pupae do not readily float in water. If larvae are to be preserved for study, they may be killed by quick submersion in hot water and preserved in 70% alcohol.

The following account is taken from Howarth's (1974) dissertation, explaining the techniques he used in his very successful rearings of Laotian *Culicoides*:

"Most emphasis was placed on rearing and obtaining associated pupae. The rearing technique was modified from Wirth (1952). Samples, consisting of 75-125 cc of suspected breeding substrate were broken up in water in a 300-cc white porcelain dish in the field. Sample size varied with ease of washing and sorting. Samples high in organic detritus were smaller, due to the difficulty of sorting much floating debris. Usually, such samples were equated to a standard sample volume for comparison. Pupae which floated or were seen were removed from the dish individually. A microspatula mounted at the end of a hypodermic needle and syringe was used to transfer each pupa to a vial. The pupa was washed off the spatula onto moist cotton in a 2.9-cc shell vial by water spray from the syringe. Usually each pupa was placed in a separate vial. The vials were stoppered with cotton and later were laid on their sides in shallow trays. After each adult had emerged and hardened, alcohol was added, and the exuviae and adult preserved together."

"Since the substrate was broken up using fingers, the percentages of vegetation, silt, organic detritus, gravel, sand, and clay could easily be determined and noted on a field data sheet. . . . Determinations of pollution and moisture content were more subjective. The level of pollution was estimated from the presence of decomposing organic matter, especially manure, or the presence of a fetid odor.

"Samples of rotting plant material which were suspected of breeding *Culicoides* were placed in tin cans of various sizes and the tops covered with black cloth. A hole was cut in each can near the top rim and a vial attached with tape to capture the emerging *Culicoides*. Water was added to the cans periodically."

Kettle et al. (1975) described a satisfactory technique for rearing individual larvae of *Culicoides*, adapted from a combination of methods used by Linley (1968, 1969, 1970a) and Sun (1974). Ordinary commercial agar is added to sterile petri dishes to a depth of 5 mm and small nematodes are added from time to time as they are consumed by the *Culicoides* larvae. The nematodes are cultured on a cereal porridge. Larval and pupal exuviae may easily be found by visual examination of the agar media after adult emergence. Linley (1979) adapted this technique by the use of corn meal agar and a proprietary artificial sea water mix to culture a variety of microorganisms innoculated from salt marsh substrates. Potential prey organisms can be isolated and cultured by microbiological techniques and eventually tested as *Culicoides* food and grown in pure culture if desired.

MORPHOLOGY

ADULTS

Good descriptions of the structure of adult *Culicoides* (fig. 24) have been given by Carter et al. (1920), Jobling (1928), Tokunaga (1937), Gad (1951), Wirth (1952a), Forattini (1957), Wirth and Blanton (1959), Jamnback (1965a), Kremer (1966), Atchley (1967, 1970), Ortiz (1969), Downes and Wirth (1981), and Blanton and Wirth (1979), to whom the reader is referred for a fuller account. The following brief explanations are given to define the most important characters used in *Culicoides* classification.

Head (fig. 25): The head is subspherical, with the anterior surface more or less flattened and in line with the anterior surface of the proboscis. The compound eyes are large and reniform and more or less contiguous above the bases of the antennae; they may be bare or with short pubescence between the ommatidial facets. The degree of separation or contact is often useful in distinguishing species; in the angle between them on the frons is an interocular seta, and above this is often a transverse suture which marks the separation of the frons and vertex.

The antenna has 15 divisions which in this paper for convenience are termed segments, although it is recognized that the 13 divisions of the flagellum are not true segments in the morphological sense. The basal scape is ringlike, submerged in the head capsule, and hidden by the greatly enlarged pedicel; the first flagellar segment is slightly enlarged and always bears a number of small sensory pits (sensilla coeloconica), each surrounded by minute setae; some or all of the distal segments also bear these distal sensilla (fig. 26), the number, shape, and distribution of which are of great importance in classification. In the female the first 8 flagellar segments are shorter and bear long verticils (sensilla chaetica) basally, and the 5 distal segments are more elongated and without verticils; the

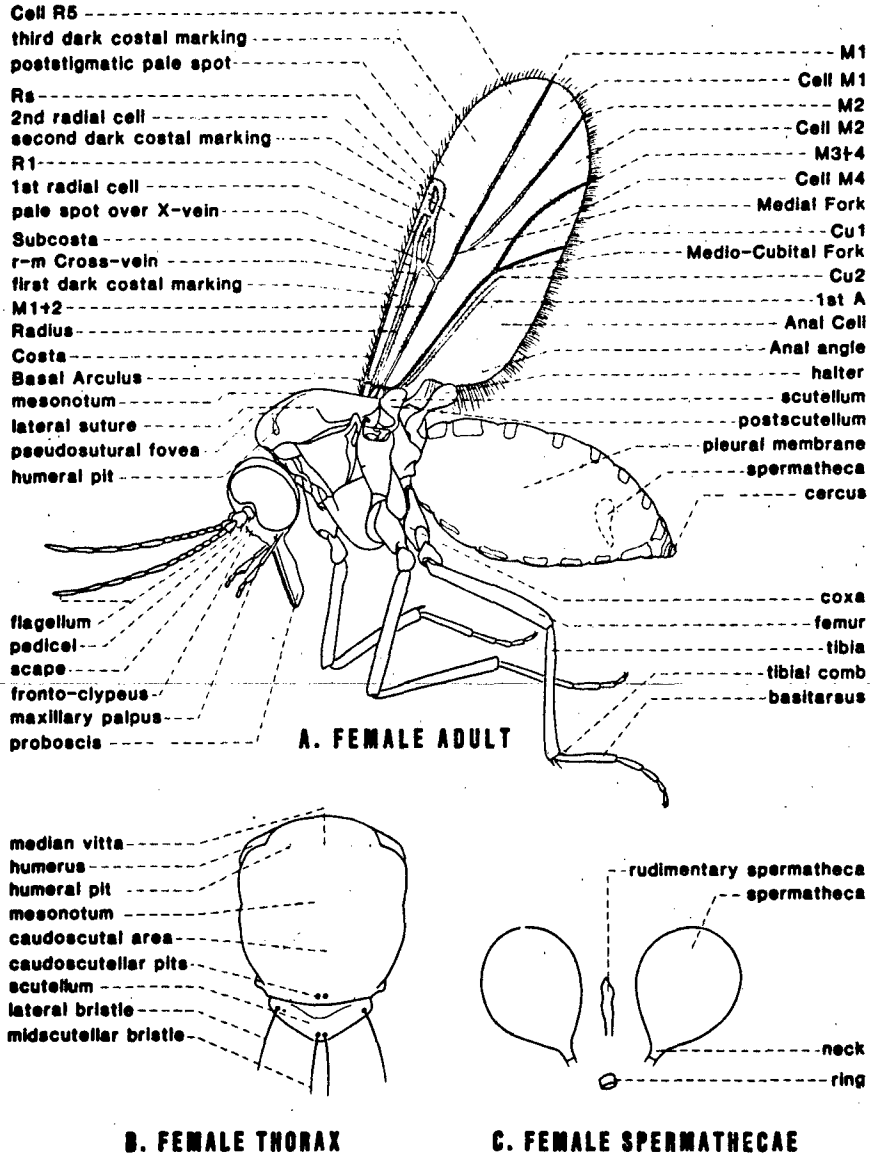


Fig. 24. *Culicoides* adult morphology: A. adult female with parts labelled; B. dorsal view of thorax; C. spermathecae (from Arnaud 1956).

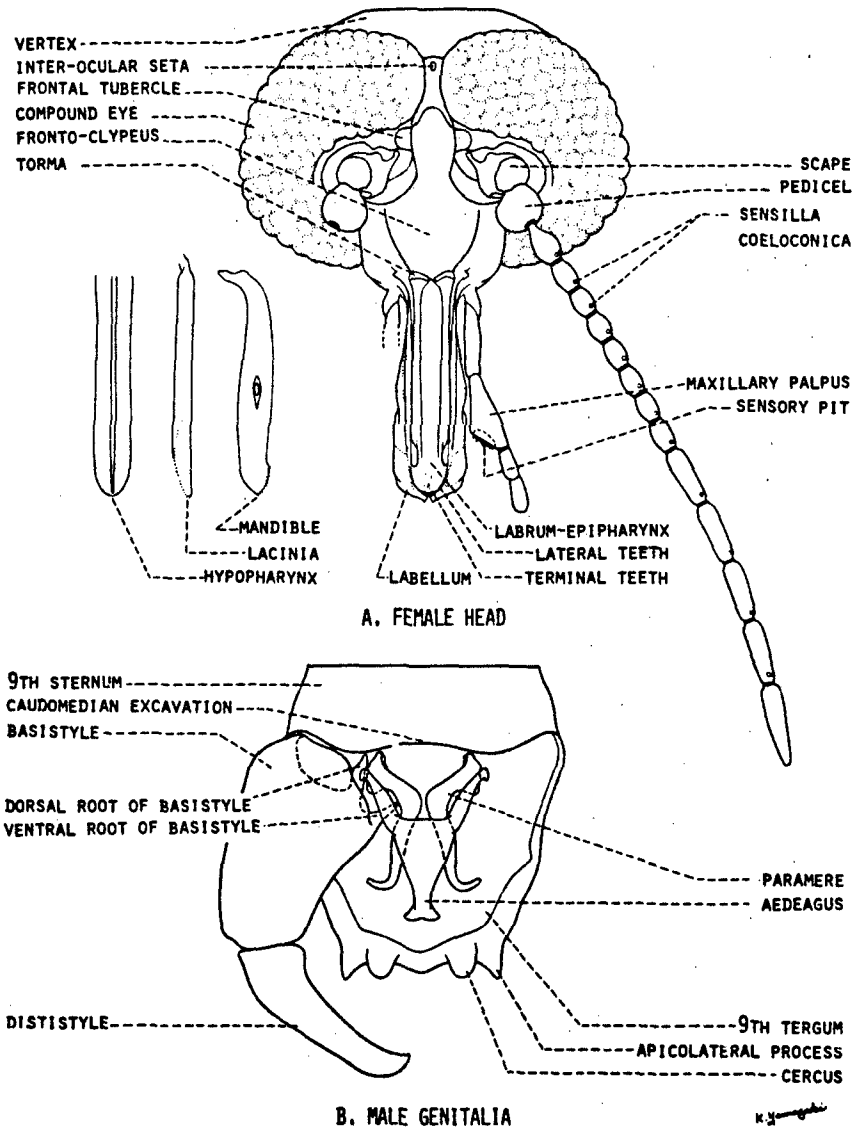


Fig. 25. *Culicoides* adult morphology: A. head and mouthparts of female, schematic, parts labelled; B. male genitalia, schematic, parts labelled (from Arnaud 1956).

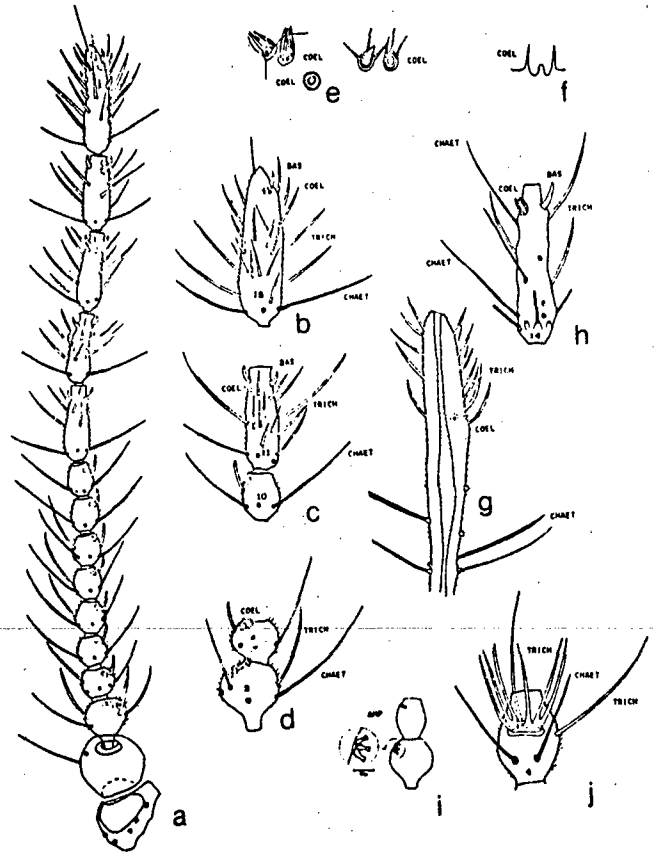


Fig. 26. A. antenna of female *Culicoides* showing general pattern of major bristles, setae, and sensory organs; B. antennal segment 15 of female *Culicoides* showing typical arrangement of sensory organs; C. antennal segments 10 and 11 of female *Culicoides* showing typical arrangement of sensory organs; D. antennal segments 3 and 4 of female *Culicoides* showing typical arrangement of sensory organs; E. enlarged view of two types of sensilla coeloconica of female *Culicoides* (after Campbell and Pelham-Clinton 1960); F. diagram of vertical section of typical sensilla coeloconica of female *Culicoides* (after Cornet 1974); G. tip of male antenna of *Corynoneura* (Chironomidae) showing sensillum coeloconicum; H. segment 14 of female antenna of *Corethrella* (Chaoboridae) showing sensory organs; I. sensilla ampullacea (after Campbell and Pelham-Clinton, 1960); J. segment 4 of female antenna of *Culicoides xanifer* showing modified branched sensillum trichodeum (*amp*, sensilla ampullacea; *bas*, sens. basiconica; *chaet*, sens. chaetica; *coel*, [illegible] *trich*, sens. trichodea) (from Wirth and Naval 1978).

In the male the pedicel is more enlarged and contains the important Johnston's organ. The transition in lengths of the flagellar segments occurs between segments 12 and 13 in the male; segments 3-12 each have a whorl of greatly elongated, erectile verticils forming a more or less dense plume.

Shevchenko and Dzhafarov (1968), Atchley (1970), and Cornet (1974) described the antennal sensilla of *Culicoides* but their terminology lacked uniformity. Chu-Wang et al. (1975) published excellent scanning electron micrographs (SEM) and transmission electron micrographs (TEM) of *Culicoides* antennal sensilla and gave detailed accounts of their histology and function. Chaika (1978) gave a similar account for several USSR species. Wirth and Navai (1978) summarized the conflicting usage and made a plea for uniform terminology in taxonomic and morphological descriptions. The following is a summary of their terminology:

"The antennae of *Culicoides* biting midges bear 5 types of sensory organs or sensilla, visible externally with good light microscopy, that offer useful taxonomic characters in their shapes and segmental distribution. These organs include 1 type of thick-walled, sharp-tipped bristles or setae innervated at the base which are tactile or mechanoreceptive in function (sensilla chaetica) and 4 types of thin-walled, transparent sensilla that are innervated distally and are chemoreceptive or olfactory in function: sensilla trichodea--simple setae, long or short, with sharp tips, or long or short tubes or filaments with blunt tips; sensilla basiconica--pegs and cones of various lengths and shapes; sensilla coeloconica--peg organs sunken into shallow pits, nearly always surrounded by a ring or picket fence of dark microtrichia of various numbers and lengths; and sensilla ampullacea--peg organs sunken into a deep pit with a narrow opening."

Jamnback (1965a,b) first suggested that the number of antennal sensilla coeloconica might be used as an indication of host preference; those species with a low to moderate number preferring mammalian hosts, while those with sensilla on nearly all segments were usually ornithophilic. Braverman and Hulley (1979) supported this conclusion from a study of 12 South African species. The number of sensilla in the palpal pit showed a similar correlation.

The mouthparts (fig. 27) are well developed, often as long as the head capsule itself, stronger in the female than in the male, and in females of most species are fitted for piercing and blood-sucking. They consist of six slender, distally toothed blades of subequal lengths, including a strong upper labrum-epipharynx, a pair of maxillae, a pair of strongly toothed mandibles, and a median tubular hypopharynx. These parts are enclosed in the proboscis formed by the fleshy part of the labium; the length of the proboscis is of value in classification and is expressed as the proboscis/head ratio (P/H ratio), which is obtained by dividing the distance from the end of the labrum-epipharynx to the tormae by the distance from the latter to the interocular seta base. The maxillary palpus is 5-segmented and the third segment is more or less swollen and bears on the distal part of the medioventral surface a specialized sensory pit or group of sensilla which forms an important taxonomic character (Fig. 25). The palpal ratio (PR) is a useful index obtained by dividing the length of the third palpal segment by its greatest breadth. Mitra (1952) described and figured the sensilla in the palpal pit of *Culicoides peregrinus* Kieffer and compared them with analogous sensilla of related families.

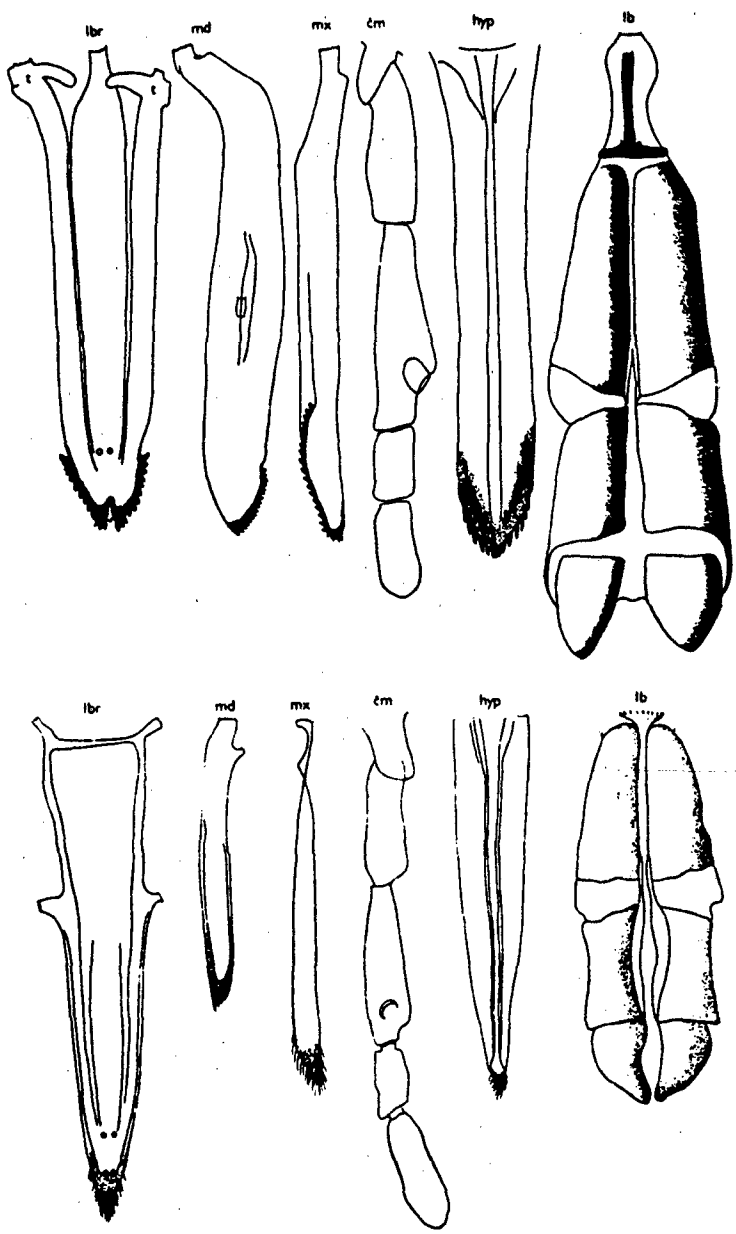


Fig. 27. Mouthparts of *Culicoides nubeculosus*, female above, male below; *lbr*, labrum; *md*, mandible; *mx*, maxilla; *cm*, palpus; *hyp*, hypopharynx; *lb*, labium (from Orszagh 1976).

Rowley and Cornford (1972) presented SEM micrographs of the palpal sensory pits of several *Culicoides* species (fig. 28).

Fig. 28. Scanning electronmicrographs of *Culicoides*: A,B,C. female maxillary palpus showing detail of sensilla in pit; D. sensillum coeloconicum on antenna (photo W.A. Rowley; A-C from Rowley and Cornford 1972).

Mukerji (1931a) called attention to the presence of a patch of backwardly directed teeth in the pharynx of *Culicoides pulicaris* (L.), and the absence of such a cibarial armature in *C. peregrinus* Kieffer and *C. oxystoma* Kieffer. De Meillon (1937) compared the oesophageal pump and pharynx of 12 ceratopogonid

genera and showed the cibarial armature of one South African *Culicoides* species. Callot et al. (1972) illustrated the cibarial armature of 22 Palaearctic and Ethiopian species of *Culicoides* (fig. 29).

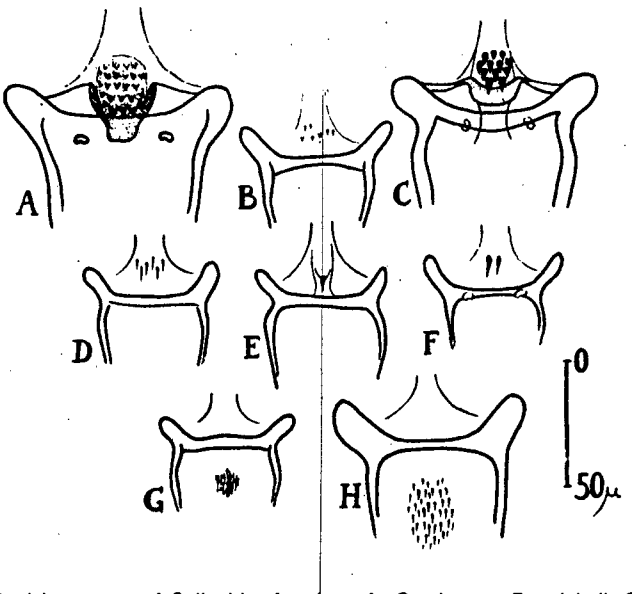


Fig. 29. Cibarial armature of *Culicoides* females: A. *C. nivosus*; B. *micheli*; C. *distinctipennis*; D. *gambiae*; E. *similis*; F. *exspectator*; G. *kobae*; H. *bassetorum* (from Callot et al. 1972).

Glukhova (1982) studied the structure of the mouthparts of 115 species of *Culicoides* and found a remarkable uniformity in structure except for small differences in the number of denticles on the mandibles and maxillae and occasionally their complete absence, and in the number of lateral denticles on the labrum. An exception was found in the subgenus *Trithecoides*, which showed a remarkable diversity which Glukhova grouped into four general types. Discussion of this diversity will be found in the taxonomic treatment of the subgenus *Trithecoides*.

Buerger (1967) described and figured the sense organs on the labrum of *Culicoides variipennis* and compared them with similar organs on the labra of seven other blood-sucking species in the families Simuliidae, Tabanidae, and Muscidae. There were four sensilla in the food channel a short distance from the tip of the labrum; their diameter at the base was only 2.5 mu.

Thorax: The thorax (fig. 24a,b) is moderately broad and convex above, arched anteriorly, and projecting slightly over the head; it bears dorsally a pair of small depressions behind the humeri, known as the humeral pits, which have been assumed to be sensory but whose exact function is unknown. In various species

the disc of the mesonotum is ornamented with a distinctive pattern, best seen in fresh or dried specimens, but usually visible to some degree in slide-mounted material.

The legs are slender without special armature, but the foretibia bears apically a small spur and tuft of modified hairs, and the tip of the hindtibia bears an anterior spur and 2 transverse rows of modified spines. The hindtibial "comb" includes only the longer spines in the distal row and is of some value in classification. The fourth tarsomere is usually cylindrical but in a few groups is cordiform; the claws are small and equal on all legs, simple in the female but divided at the apices in the male. The empodium is vestigial.

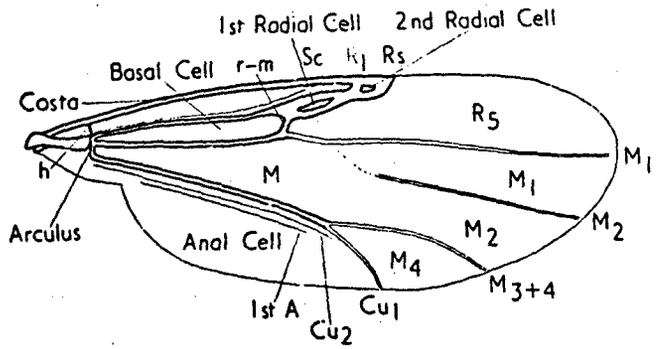


Fig. 30. Wing venation of *Culicoides* female to show nomenclature (from Campbell and Pelham-Clinton 1960).

The wings (fig. 30) bear dense microtrichia, the size and pigmentation of which give rise to the characteristic pattern of dark or light spots, and more or less abundant macrotrichia or longer hairs. The color pattern of spots or bands is characteristic for each species and is of primary importance in classification; however, in some groups of species it is poorly developed or even absent. In the males the wing is longer and narrower, and the color pattern is less contrasting. The wing length is measured from the basal arculus to the wing tip; the costa extends usually to more than half the wing length; the costal ratio (CR) is the value obtained by dividing the length of the costa by the wing length. There are with rare exceptions 2 complete radial cells formed by the more heavily sclerotized radial branches; usually the second or distal one is broader and longer than the first, which is often slitlike. We use the Tillyard modification of the Comstock-Needham system of wing venation, in which the branches of the anterior fork are called M1 and M2 and those of the posterior fork are M3+4 and Cu1, from front to back. The color of the halter is also useful in species separation.

Abdomen: The female abdomen (fig. 24a) is relatively stout, the apex somewhat tapered, with a pair of small rounded cerci visible below the ninth tergum. Internally the female possesses from 1 to 3 sclerotized spermathecae, which are usually oval to pyriform, with the slender bases of the ducts sclerotized a short distance. The spermathecae (fig. 24c) are joined by hyaline ducts to a common duct, and at the juncture there is usually a small sclerotized ring. The primitive number of spermathecae in Diptera is 3 (Downes 1968). In most species with 2 sclerotized spermathecae there is also a small vestigial third one. The number and shapes of the functional spermathecae and the presence or absence of a ring are important in classification. The length of the spermatheca is measured in the axis of the base of the duct and includes the sclerotized portion of the duct, or neck.

The male abdomen is slender and bears terminally the prominent genitalia (fig. 25b) which are or primary importance in group classification and species identification. The ninth segment is in the form of an irregular sclerotized ring consisting of the fused tergum and sternum. The ninth tergum forms an expanded plate, convex externally and hollowed out mesally, and bearing the anus flanked by a pair of membranous cerci on the ventromesal face. The hind corners of the ninth tergum are frequently expanded as a pair of apicolateral processes. The ninth sternum is much shorter than the tergum, usually with a caudomedian excavation on its hind margin, at the lateral corners of which the base of the aedeagus articulates. The forceps-like genital appendages or gonopods arise laterally at the base of the tergum and are two-segmented. The enlarged basal segment or basistyle (gonocoxite of Downes and Wirth 1981) bears 2 internal processes at the base, a mesally directed ventral root and an anterior directed dorsal root, the latter articulating directly with the base of the paramere. The distal segment or dististyle (gonostylus of Downes and Wirth) is setose and slightly swollen at the base, slender and nearly bare distally with an incurved point, and when not extended is folded mesad across the mesal face of the ninth tergum. The aedeagus is usually a Y-shaped structure with a median process directed ventrocaudad, forming a sclerotized support on the ventral surface of the male genital duct. The parameres are usually a pair of sclerotized internal rodlike sclerites with knobbed bases and ventrally directed distal points, but they are subject to great modification in the shape and direction of the basal knob, the middle stem, and the distal point. In some groups of species the parameres may fuse mesally in part or completely in the plate-like structure. Although some morphologists suggest that it is more appropriate to use the term paramere for the primary gonopod here called the basistyle and dististyle, and the term claspette for the internal sclerite here called the paramere, we prefer to follow the traditional usage.

IMMATURE STAGES

Kettle (1977) made the following appropriate remarks: "Detailed knowledge of the larval biology is essential for a full understanding of the bionomics. Without this information it is impossible to construct life tables or to identify key factors limiting pest populations. Such studies are dependent on sound taxonomy, and although the characters separating the immature stages at subfamily level have been known for nearly 50 years, the taxonomy of larvae and pupae, with the ex-

ception of the Forcipomyiinae, is very poorly understood. In *Culicoides*, the most widespread and abundant of the blood-sucking ceratopogonids, 88 larval descriptions are available (in 1977) for a known world fauna of 924 species, i.e., less than 10%."

Good larval and pupal descriptions with good illustrations have been presented by Lawson (1951) and Kettle and Lawson (1952) for 28 British species; by Wirth (1952b), Jones (1961b), Linley and Kettle (1964), Jamnback (1965a), Linley (1965a, 1970a,b), and Blanton and Wirth (1979) for 30 North American species; Glukhova (1968a,b, 1979) for 37 species in the USSR; Nevill (1969) for eight South African species; Kettle and Elson (1975a,b, 1976, 1978, 1980), and Kettle et al. (1976) for 22 Australian species; and Howarth (1974, 1985) for 17 Laotian species.

CLASSIFICATION

The Ceratopogonidae can be distinguished from other Diptera, or two-winged flies, by their long, usually 15-segmented antennae; mouthparts usually well developed and fitted for piercing and blood-sucking; usually rather stout body, the scutellum lacking a median furrow or keel; and their characteristic wing venation. In the Ceratopogonidae the radial veins are usually thickened and shortened and the branches form 1 or 2 radial cells on the anterior wing margin; the posterior veins are less conspicuous, forming 2 forks, the anterior comprised of M1 and M2, and the posterior fork made up of M3+4 and Cu1. In the genus *Culicoides* the wing is more or less hairy, usually with a conspicuous pattern of pale spots on a dark ground; 2 radial cells are usually present and more or less of the same length; the costa ends usually at slightly past midlength of the wing; the tarsal claws are small and equal in both sexes; the empodium is small and inconspicuous; and large thoracic humeral pits are present.

Attempts to subdivide the large genus *Culicoides* into subgenera have been only partially successful. Root and Hoffman (1937) and Edwards in Edwards et al. (1939) first proposed division of the genus into 2 series based on the male genitalia and certain external features. Fox (1948) erected the subgenus *Hoffmania* for 12 Neotropical species and later (1955) proposed *Macfiella* and *Avaritia*. Khalaf (1954) made the first major attempt to group *Culicoides* species according to their phylogenies and recognized 4 subgenera: *Culicoides* s. str., *Monoculicoides* Khalaf, *Selfia* Khalaf, and *Oecacta* Poey. Vargas (1953) erected a new subgenus *Beltranmyia*; in 1960 he proposed 5 new subgenera, *Anilomyia*, *Diphaomyia*, *Drymodesmyia*, *Glaphiromyia*, and *Mataemyia*, and resurrected *Haematomyidium* Goeldi for some species formerly placed in *Oecacta*; he published a table to subgenera (1973a); and in 1973b he proposed *Wirthomyia* to include 1 North American species.

In the Old World fauna, the subgenera *Haemophoructus* Macfie, *Trithecoides* Wirth and Hubert, *Meijerehelea* Wirth and Hubert, *Pontoculicoides* Remm, and *Callotia* Vargas and Kremer are recognized. Most of the subgenera are well [illegible] in the regions where their type species occur. Dif-

Haematomyidium, etc. At present *Oecacta* is still a dumping ground for many species that cannot be assigned to other subgenera, and species groups may, when they are better known, be assigned to additional subgenera.

Gutsevich (1970), Remm (1974), and Glukhova (1977) discussed the subgeneric and group classification of the *Culicoides* of the USSR. The first 2 authors restricted their classification to adult characters, but Glukhova also made use of characters of the larvae. She recognized the following subgenera and groups: *Avaritia*, *Culicoides* s. str., *Beltranmyia*, *Monoculicoides*, *Remmia* Glukhova new subgenus with *C. schultzei* (Enderlein) as type species, and *Silvaticulicoides* Glukhova new subgenus with *C. fascipennis* (Staeger) as type species.

Wada and Kitaoka (1977) published a preliminary arrangement of the Japanese *Culicoides* into subgenera and groups based on adult characters. Subgenera: (1) *Trithecoides*; (2) *Avaritia*; (3) *Culicoides*; (4) *Oecacta* with species groups (a) Schultzei, (b) Similis, (c) Kibunensis, (d) Dendrophilus, (e) Claggi, (f) Midorensis, (g) Nagahanai, (h) Saninensis, (i) Sasai, (j) Fascipennis, (k) Segnis, (l) Comosioculatus, and (m) Charadraeus; (5) *Beltranmyia* (synonym *Meijerehelea*); and (6) *Monoculicoides*.

The subgeneric and group classification of the Southeast Asian *Culicoides* is outlined in Table 1. These subgenera and species groups are briefly characterized in the appropriate sequence in the taxonomic description of species which follows this section. Table 1 also summarizes the mean values of certain useful numerical characters of the females. The necessarily linear sequence in this listing is in general from what is in our opinion the more primitive to the more derived groups. Our knowledge of the phylogeny of the family Ceratopogonidae, and in it the genus *Culicoides*, is still very incomplete and concepts of polarity of taxonomic characters are in a state of flux. It is probably still premature to make any attempts at a cladistic analysis of the subgenera and species groups of *Culicoides*.

Table 1. Systematic Arrangement of the Southeast Asian Species of *Culicoides* and Mean Values of Certain Numerical Characters

	Wing Length (mm)	Costal Ratio	Antennal Ratio	Palpal Ratio	Mandible Teeth	Antennal Sensillar Pattern	Spermatheca Mandible Type	P/H Ratio
Subgenus *Trithecoides*								
Anophelis Group								
anophelis	1.01	0.69	1.00	2.1	15	3,11-15	A-1	0.38
baisasi	0.95	0.69	0.98	2.3	18	3,11-15	D-1	0.52
pendleburyi	1.29	0.68	0.99	2.3	7	3,11-15	D-1	0.60
Flavescens Group								
flavescens	1.03	0.71	1.10	3.8	21	3,11-15	A-2	0.60
paraflavescens	1.13	0.70	1.12	3.0	20	3,11-15	A-2	0.55
Acanthostomus Group								
acanthostomus	1.00	0.78	0.96	3.9	9	3,11-15	A-3	0.71
Tenuipalpis Group								
tenuipalpis	1.53	0.69	1.09	4.4	8	3,11-15	A-4	0.72
nyungnoi	0.98	0.71	1.12	2.2	8	3,11-15	A-4	0.54
paksongi	1.38	0.73	1.07	3.4	9	3,11-15	A-4	0.65
Macfiei Group								
cylindripalpis	1.01	9.72	0.86	3.8	7	3,11-15	C-4	0.77
luteolus	1.08	0.77	1.15	2.4	7	3,11-15	C-4	0.45
macfiei	0.99	0.69	1.15	2.0	7	3,11-15	C-4	0.67
manikumari	0.81	0.70	1.19	1.1	0	3,11-15	D-0	0.38
nampui	0.96	0.67	1.00	2.2	7	3,11-15	D-4	0.58
palpifer	0.92	0.69	1.01	2.1	7	3,11-15	C-4	0.58
parahumeralis	1.17	0.67	1.04	2.2	7	3,11-15	C-4	0.77
rugulithecus	1.04	0.68	0.94	2.2	7	3,11-15	C-4	0.64
subpalpifer	0.93	0.71	0.95	2.5	7	3,11-15	D-4	0.64
tonmai	1.01	0.71	0.96	2.5	7	3,11-15	C-4	0.57
Raripalpis Group								
albibasis	0.89	0.70	1.03	2.2	11	3,11-15	C-5	0.63
allantothecus	0.86	0.70	0.95	1.9	13	3,11-15	D-5	0.57
barnetti	0.92	0.70	0.88	2.4	12	3,11-15	D-5	0.59
dungunensis	1.00	0.70	0.88	3.1	15	3,11-15	D-5	0.62
elbeli	0.84	0.70	0.89	2.4	12	3,11-15	D-5	0.65
flaviscu-latus	0.85	0.69	0.93	2.5	12	3,11-15	D-5	0.64
flaviscutellaris	0.85	0.74	0.82	1.7	11	3,11-15	C-5	0.62
fordae	0.74	0.70	1.00	2.4	11	3,13-15	D-5	0.59

	Wing Length (mm)	Costal Ratio	Antennal Ratio	Palpal Ratio	Mandible Teeth	Antennal Sensillar Pattern	Spermatheca Mandible Type	P/H Ratio
Raripalpis Group (cont.)								
gouldi	0.78	0.70	0.97	2.1	13	3,11,13-15	D-5	0.60
hinnoi	0.86	0.69	0.91	2.4	11	3,11-15	D-5	0.56
huberti	0.97	0.70	0.93	2.6	11	3,11-15	D-5	0.60
laoensis	1.00	0.68	1.03	3.0	11	3,11-15	D-5	0.68
parabarnetti	0.83	0.75	0.91	2.7	12	3,13-15	D-5	0.63
raripalpis	0.77	0.66	1.15	2.1	11	3,12-15	D-5	0.61
sarawakensis	0.81	0.70	1.05	2.7	13	3,11-15	D-5	0.73
tamada	0.86	0.67	0.88	2.6	11	3,13-15	D-5	0.66
triallantionis	0.96	0.70	0.87	2.2	11	3,11-15	B-5	0.58
Subgenus Haemophoructus								
Maculipennis Group								
calcaratus	1.34	0.70	1.25	3.3	15	3,7,9,11-15		0.75
maculipennis	1.58	0.71	1.36	3.8	19	3-5,7,9-15		1.00
tawauensis	1.36	0.74	1.42	3.9	18	3,11-15		1.00
Gymnopterus Group								
boormani	1.26	0.73	1.10	4.7	19	3,11-15		0.99
gemellus	1.20	0.72	1.21	3.7	15	3,11-15		0.90
gentilis	1.69	0.73	1.15	5.4	18	3,11-15		1.00
gymnopterus	1.23	0.70	1.08	4.5	18	3,11-15		0.88
hoffmanioides	1.06	0.70	1.21	3.7	19	3,11-15		0.83
kinari	1.18	0.68	1.16	4.6	16	3,(7,9),11-15		0.86
kisangkini	1.38	0.76	1.17	4.4	20	3,11-15		0.70
mellipes	1.18	0.78	1.04	4.6	19	3,11-15		1.00
nitens	1.80	0.78	1.09	5.0	19	3,11-15		1.10
nyakini	1.27	0.70	1.11	4.5	17	3,11-15		0.89
unicus	1.23	0.69	1.01	3.6	15	3,11-15		0.70
Subgenus Hoffmania								
andrewsi (male)	0.90	0.64	--	--	--	--		--
brinchangensis	1.63	0.68	1.15	3.2	19	3,11-15		0.87
bubalus	1.24	0.69	1.13	2.7	18	3,11-15		0.69
cameronensis	1.24	0.69	--	4.2	20	3,11-15		1.00
carpophilus	1.09	0.69	0.90	1.7	0	3,11-15		0.54
cheahi	1.11	0.67	1.20	5.7	20	3,11-15		0.90
divisus	1.19	0.69	1.25	3.5	15	3,11-15		0.75
effusus	1.15	0.68	1.07	2.6	13	3,11-15		0.62
hirtipennis	0.87	0.63	1.08	2.8	13	3,11-15		0.70
indianus	1.05	0.68	1.03	4.5	18	3,11-15		0.85
innoxius	1.09	0.68	1.19	2.9	19	3,11-15		0.82
insignipennis	1.09	0.67	1.05	3.6	17	3,11-15		0.90
kinabaluensis	1.43	0.67	1.20	2.9	0	3,11-15		0.67
klossi	1.21	0.69	0.99	4.6	18	3,11-15		0.95

	Wing Length (mm)	Costal Ratio	Antennal Ratio	Palpal Ratio	Mandible Teeth	Antennal Sensillar Pattern	P/H Ratio
lansangensis	1.08	0.67	1.13	3.0	18	3,11-15	0.68
liui	1.45	0.68	1.09	3.1	18	3,11-15	0.82
malayae	1.02	0.68	1.03	3.3	21	3,11-15	0.81
orestes	1.26	0.69	0.92	3.0	13	3,11-15	0.65
parabubalus	1.21	0.69	1.10	2.9	21	3,11-15	0.81
paramalayae	1.19	0.66	1.07	2.9	19	3,11-15	0.65
peregrinus	1.14	0.63	1.18	2.9	14	3,11-15	0.92
pikongkoi	1.21	0.64	0.95	4.3	17	3,(11,12)13-15	0.95
recurvus	1.00	0.63	1.19	2.2	13	3,11-15	0.74
spiculae	1.13	0.69	1.08	3.9	18	3,11-15	0.78
sumatrae	1.06	0.68	1.11	3.1	20	3,11-15	0.85
tenuifasciatus	1.21	0.68	0.95	4.0	18	3,11-15	0.87
trimaculi-pennis	1.13	0.62	0.99	3.4	16	3,11-15	0.89
Subgenus Avaritia							
Actoni Group							
actoni	0.74	0.57	1.22	2.6	13	3,12-15	0.80
minimus	0.57	0.51	1.27	1.8	11	3,11-15	0.73
Orientalis Group							
boophagus	0.92	0.59	1.09	11	--	3,11-15	0.68
brevipalpis	0.91	0.60	1.17	2.3	12	3,11-15	0.81
brevitarsis	0.75	0.55	1.22	2.2	12	3,12-15	0.70
dumdumi	0.82	0.65	1.35	1.9	14	3,11-15	0.73
flavipunctatus	0.76	0.61	1.30	2.1	15	3,11-15	0.80
fulvus	0.78	0.60	1.23	2.2	13	3,11-15	0.70
hui	0.84	0.62	1.12	2.5	12	3,11-15	0.77
imicola	0.82	0.58	1.18	2.3	12	3,12-15	0.88
jacobsoni	0.78	0.64	1.21	1.6	14	3,11-15	0.76
maculatus	1.10	0.61	1.10	2.9	17	3,11-15	0.89
nudipalpis	0.80	0.58	1.20	2.4	14	3,12-15	0.68
orientalis	0.89	0.65	1.13	3.1	15	3,11-15	0.85
pastus	1.34	0.63	1.08	3.1	14	3,11-15	0.80
pungens	0.81	0.65	1.37	2.2	16	3,11-15	0.87
wadai	0.87	0.63	1.17	2.9	15	3,11-15	0.87
Subgenus Unplaced							
Ornatus Group							
circumbasalis	0.99	0.63	1.12	2.1	14	3-14	0.84
cordiger	1.05	0.63	1.71	1.9	11	3-15	0.59
corti	0.81	0.59	0.97	1.5	6	3,13-15	0.52
damnosus	0.86	0.63	1.34	1.9	13	3-14	0.63
flumineus	0.96	0.62	1.25	2.5	14	3-14	0.80
garciai	0.97	0.64	1.40	1.6	13	3-7,9,11-14	0.60
griffithi	0.89	0.61	1.06	2.3	12	3,11,13-14	0.92
hewitti	0.93	0.63	1.11	2.2	14	3-14	0.72
infulatus	0.88	0.63	1.14	2.3	15	3-10,13-14	0.72
maai	1.00	0.64	0.78	2.0	13	3-15	0.53

	Wing Length (mm)	Costal Ratio	Antennal Ratio	Palpal Ratio	Mandible Teeth	Antennal Sensillar Pattern	P/H Ratio
Ornatus Group (cont.)							
mcdowelli	0.95	0.64	1.23	2.0	13	3-14	0.67
niphanae	1.15	0.62	1.23	2.0	16	3-14	0.73
okinawensis	1.06	0.62	1.40	2.3	19	3-14	0.82
ornatus	0.95	0.62	1.20	2.2	18	3,11-14	0.90
palawanensis	1.00	0.66	1.50	2.2	11	3-14	0.81
pampangensis	0.99	0.62	1.45	--	12	3-14	0.87
pangkorensis	1.18	0.57	1.25	2.0	13	3-15	0.75
papuensis	0.96	0.64	1.36	2.1	12	3-15	0.60
peliliouensis	1.01	0.63	1.11	2.4	13	3-14	0.67
pongsoniensis	1.16	0.64	1.16	2.6	14	3-14	0.70
quatei	0.80	0.63	1.19	1.9	13	3-14	0.76
Shermani Group							
bigeminus	0.90	0.58	0.98	2.3	16	3-9,11-14	0.74
dryadeus	0.97	0.58	0.98	2.5	15	3,11-15	0.80
geminus	0.93	0.60	1.15	2.0	12	3,11-14	0.70
jefferyi	1.00	0.54	1.20	1.8	10	3-15	0.52
kelantanensis	1.06	0.59	1.15	2.3	16	3-5,11-15	0.92
kepongensis	0.89	0.68	1.09	2.3	13	3,13-15	0.63
macclurei	1.08	0.66	1.01	2.3	13	3,11-15	0.68
marginatus	0.96	0.60	1.33	2.4	12	3,11-14	0.72
minipalpis	0.72	0.58	1.50	1.3	9	3,8-10,12	0.58
nigripes	1.28	0.56	--	2.0	16	3,11-15	0.70
selangorensis	1.05	0.60	1.43	1.8	14	3-15	0.83
shermani	0.92	0.59	1.07	2.0	11	3-9,11-14	0.66
siamensis	1.28	0.58	1.05	1.7	12	3,11-15	0.64
thurmanae	1.24	0.61	1.53	2.1	17	3-11,13-14	0.91
wenzeli	0.86	0.63	1.12	2.1	11	3-15	0.58
Clavipalpis Group							
arenicola	0.94	0.56	1.46	1.8	12	3,7-10	0.58
clavipalpis	0.67	0.55	1.28	1.8	11	3,8-10	0.65
distinctus	0.74	0.56	1.04	--	10	3,7-10	0.66
huffi	0.83	0.54	1.46	1.8	10	3,5,7-10	0.57
notatus	0.95	0.65	1.55	1.9	12	3,7-10	0.65
parviscriptus	0.88	0.58	1.24	1.8	12	3,(5,6),7-10	0.55
perornatus	0.95	0.64	1.24	2.0	10	3,7-10	0.49
similis	0.87	0.55	1.41	1.9	10	3,5,7-10	0.53
Williwilli Group							
cambodiensis	0.85	0.60	1.68	1.9	11	3,10,12,14	0.60
delfinadoae	0.77	0.60	1.34	1.8	11	3,10,12,14	0.65
murrayi	0.78	0.60	1.49	1.8	9	3,10,12,14	0.62
palpisimilis	0.79	0.59	1.15	2.1	11	3,10,12,14	0.72
pictilis	0.95	0.65	0.00	2.0	10-11	3,10,12-14	0.62
pseudopalpalis	0.74	0.53	1.40	1.6	8-12	3-14	0.57
yasumatsui	0.86	0.62	1.55	1.8	10	3,(5,7,9)10, 12,14	0.64

	Wing Length (mm)	Costal Ratio	Antennal Ratio	Palpal Ratio	Mandible Teeth	Antennal Sensillar Pattern	P/H Ratio
Schultzei Group							
oxystoma	0.96	0.53	1.03	2.1	12	3,8-10	0.67
Shortti Group							
fadzilii	0.82	0.56	1.00	2.4	13	3,8-10	0.71
shortti	0.82	0.57	0.99	2.5	13	3,8-10	0.65
Costalis Group							
novairelandi	1.02	0.66	1.25	2.9	15	3,11-15	0.64
Chaetophthalmus Group							
majorinus	1.75	0.64	1.05	3.5	20	3,11-15	0.98
Subgenus Meijerehelea							
arakawae	1.11	0.60	1.52	2.5	12	3-14	0.95
guttifer	1.02	0.64	1.35	2.1	13	3-14	0.83
hegneri	0.99	0.60	1.34	2.3	14	3,11-14	0.82
histrio	0.90	0.60	1.26	2.2	12	3-14	0.82
prolixipalpis	1.00	0.67	1.33	5.0	16	3,11-14	1.32
Subgenus Beltranmyia							
circumscriptus	0.96	0.56	1.10	2.0	15	3-14	0.91
halonostictus	1.16	0.56	1.07	2.1	14	3-14	1.00
Subgenus Monoculicoides							
homotomus	1.55	0.56	0.79	3.3	14	3,8-10	0.77
Subgenus Pontoculicoides							
kamrupi	1.09	0.59	1.22	2.2	12	3,8-10	0.70
Miscellaneous Species							
agas	1.22	0.68	1.31	3.3	17	3,7-12	0.86
coronalis	0.95	0.64	1.12	2.0	14	3,7-10	0.75
kusaiensis	0.84	0.66	1.48	2.3	11	3,5,7,9,11-14	0.90
longipalpis	0.96	0.67	1.39	3.2	13	3,11-15	0.81
perakensis	0.90	0.67	1.12	5.0	13	3,11,13-15	1.10
pseudocordiger	0.87	0.60	1.14	1.6	12	3-14	0.60
uncistylus (male)	1.15	0.60	--	--	--	--	--
yoshimurai	0.69	0.68	1.15	1.6	13	3,8-10	0.80

KEY TO THE SPECIES OF CULICOIDES OF SOUTHEAST ASIA
(primarily for females)

1. Wing without distinct pale or dark areas. 2
-- Wing with more or less distinct pale or dark areas. 9

2. Male only; dististyle elongate, 1.5 times as long as basistyle, abruptly bent at base, slender and straight to slightly sinuate distally; apicolateral processes of ninth tergum fingerlike. . . . . .uncistylus n. sp. (p. 449)
-- Females; if males, dististyle gradually tapering and curving from base to tip 3

3. Spermathecae 2. 4
-- Spermathecae 3. . . . . .kamrupi Sen and Das Gupta (p. 436)

4. Mandibular teeth vestigial; (antennal sensory pattern 3,13-14). . . . . .corti Causey (part) (p. 298)
-- Mandibular teeth strong and numerous. 5

5. Antennal sensory pattern 3,5,7-12 . . . . . .agas n. sp. (p. 438)
-- Antennal sensory pattern otherwise. 6

6. Antennal sensory pattern 3,7-10; wing with indistinct pattern . . . . . coronalis Lee and Reye (p. 440)
-- Antennal sensory pattern otherwise. 7

7. Antennal sensory pattern 3,10,12-14 . . . murrayi n. sp. (p. 388)
-- Antennal sensory pattern 5,7,9,11-14 or 3-7,9,11-14 8

8. Antennal sensory pattern 3,5,7,9,11-14; male antenna with short verticils, as in female . . . . . .kusaiensis Tokunaga (p. 442)
-- Antennal sensory pattern 3-7,9,11-14; male antenna with plume . . . . . garciai n. sp. (p. 304)

9(1). Second radial cell at least partially included in a pale spot. 10
-- Second radial cell wholly included in a dark spot 117

10. Three functional spermathecae present; second radial cell very long and broad; wing without distinct subapical pale spot in cell R5 (except in tenuipalpis), although a pale mark involving all of wing tip may extend across extreme apex of cell R5; thorax usually bright yellow in large part (Subgenus Trithecoides) 11
-- Two functional spermathecae present; second radial cell, if very long, is narrow; cell R5 nearly always with a separate subapical or apical pale spot in addition to poststigmatic pale area at tip of second radial cell; thorax usually brown with paler markings. 50

SUBGENUS TRITHECOIDES

11. Mesonotum entirely dark brown, or yellow with dark brown areas on anterior margin 12

-- Mesonotum uniformly yellow or pale brown, or brownish only in front of scutellum. 27

12. Mesonotum predominantly dark brown, sometimes with paler markings. 13
-- Mesonotum predominantly yellow or light brown with darker areas on anterior and humeral margins 20

13. Mandible with 6-8 curved teeth, distal ones largest; ducts of all three spermathecae joined at one point. 14
-- Mandible with 10-15 small subequal triangular teeth; ducts of the two small spermathecae joined before duct of large one. . . .16

14. Spermathecae unequal, with large, unsclerotized entrances to the ducts; palpal ratio less than 3.0; hindtibial comb with 4 spines; small species, wing 1.0 mm long 15
-- Spermathecae subequal, pyriform, with slender sclerotized necks; third palpal segment slender, palpal ratio 4.4; large species, wing 1.5 mm long; hindtibial comb with 5 spines . . . . . .tenuipalpis Wirth and Hubert (p. 96)

15. Wing tip broadly pale, with extensive pale areas between veins; mesonotum dark brown with small contrasting yellow areas near lateral margin and on disc. . . . . nanpui Howarth (p. 105)
-- Wing darker, with indistinct narrow pale apex; mesonotum brown . . . . . macfiei Causey (p. 101)

16(13). Halter pale; forefemur with subapical pale band 17
-- Halter dark; forefemur dark distally or with rather indistinct pale band 19

17. Dark brown of mesonotum and light brown of upper pleuron abruptly meeting in a straight line laterally; antennal sensory pattern 3,11-15; (male parameres slender) . . . . . .elbeli Wirth and Hubert (p. 127)
-- Brown markings on mesonotum fading into light brown pleuron laterally; usually with darker brown margins on humeral angles 18

18. Female antennal sensory pattern 3,13-15; male parameres slender . . . . . .tamada Howarth (part) (p. 152)
-- Female antennal sensory pattern 3,11-15; male parameres massive, tips recurved . . . . . .hinnoi Howarth (part) (p. 141)

19(16). Forefemur dark distally; antennal ratio 1.02-1.09; sensory pattern 3,11-15; 12-15 mandibular teeth; palpal ratio 2.5-3.0; pale spot over second radial cell poorly contrasting. . . . . .sarawakensis Wirth and Hubert (p. 150)
-- Forefemur with indistinct subapical pale band; antennal ratio 1.11-1.19; sensory pattern 3,(12),13-15; 11-12 mandibular teeth; palpal ratio 2.1-2.2; pale spot over second radial cell contrasting . . . . . raripalpis Smith (p. 148)

20(12). Three subequal pyriform spermathecae with narrow sclerotized entrances to ducts. 21
-- One large and 2 small spermathecae with wide entrances to ducts 23

21. Mandible with 8-9 large recurved teeth; palpal ratio greater than 4; epi- and hypopharynx normal. . . . .*Dasongi* Howarth (p. 95)
-- Mandible with 12-23 teeth palpal ratio 3.0 or less; epi- and hypopharynx greatly expanded. 22

22. Mandible with 12-15 large teeth, proximal ones largest; palpus very short, palpal ratio about 2; female tarsal claws bifid; parasitic on mosquitoes . . . . . *anophelis* Edwards (p. 80)
-- Mandible with 19-23 teeth, apical tooth large and separated from series of small triangular teeth, 4-5 proximal teeth very short, spinelike and directed distad; palpal ratio about 3; female tarsal claws simple. . . . . *paraflavescens* Wirth and Hubert (p. 90)

23(20). Mandible with 7 strong teeth, distal ones largest; hindfemur entirely dark . . . . . *parahumeralis* n. sp. (p. 110)
-- Mandible with 10-17 small, subequal, triangular teeth 24

24. Hindfemur with apical third pale; tip of wing broadly pale; spermathecae sausage-shaped, almost twice as long as wide; (halter pale; antennal sensory pattern 3,11-15) . . . . . *allantothecus* n. sp. (p. 121)
-- Hindfemur dark or with indistinct subapical pale band; tip of wing narrowly pale; spermathecae not sausage-shaped 25

25. Halter infuscated; (hindfemur entirely dark; antennal sensory pattern 3,11-15). . . . . .*gewertzi* Causey (p. 136)
-- Halter pale 26

26. Antennal sensory pattern 3,13-15; male parameres slender. . . . . .*tamada* Howarth (part) (p. 152)
-- Antennal sensory pattern 3,11-15; male parameres massive, tips recurved. . . . . .*hinnoi* Howarth (part) (p. 141)

27(11). Mandible with 8 large curving teeth, proximal ones slightly larger; (parasitic on mosquitoes; femora banded; wing with pale spot covering second radial cell nearly to base) . . . . . .*baisasi* Wirth and Hubert (p. 83)
-- Mandible with teeth small and uniform or distal ones larger . .28

28. Thorax and legs entirely yellow or pale brown 29
-- Thorax or legs marked with brown. 30

29. Thorax and legs entirely yellow; mandible with 9 very large, rakelike teeth, lacinia also strongly developed and rakelike; spermathecae ovoid with slender necks . . . . . .*acanthostomus* n. sp. (p. 92)
-- Thorax pale brown, legs with narrow apices of femora and tibiae pale brown; mandible with 7 short, broad, recurved teeth, lacinia normal; spermathecae elongate with globular apices, without slender necks . . . . . .*pendleburyi* n. sp. (p. 85)

30(28). Mandible with vestigial teeth; proboscis and palpus very short . . . . . .*manikumari* n. sp. (p. 103)
-- Mandible with well-developed teeth; proboscis and palpus normal 31

31. Mandible with 21-24 teeth; spermathecae subequal and pyriform with short sclerotized necks and small openings to the ducts; hindfemur with broad pale band, apex narrowly infuscated; wing pale-streaked, the apex not pale; scutellum pale brown. . . . . flavescens Macfie (p. 87)
-- Mandible with 7-16 teeth; spermathecae unequal, the openings to the ducts large (except in nyungnoi Howarth). 32

32. Mandible with 7-8 large curved teeth, distal ones usually largest 33
-- Mandible with 10-16 small, subequal, triangular teeth 39

33. Three subequal pyriform spermathecae with short, narrow, sclerotized necks . . . . . .nyungnoi Howarth (p. 93)
-- Spermathecae with wide openings to d[illegible]s. 34

34. Postscutellum dark brown; halter p[illegible] or dark 35
-- Postscutellum yellowish, rarely ti[illegible]ed with pale brown; halter dark; hindfemur with broad apical or subapical pale band. . .37

35. All knees broadly pale. . . . . tonmai Howarth (p. 116)
-- Hindfemur with distinct dark apex 36

36. Hindfemur dark to apex or rarely with narrow pale subapical band; halter usually dark; wing mostly dark, second radial cell only partly in a pale spot, which barely reaches media narrowly. . . . . palpifer Das Gupta and Ghosh (p. 107)
-- Hindfemur with broad subapical pale band; halter pale; wing mostly pale, second radial cell almost completely in a pale spot, which crosses media broadly .rugulithecus n. sp. (p. 113)

37(34). Third palpal segment long, cylindrical, palpal ratio 3.4-4.2 . . . . . cylindripalpis n. sp. (p. 98)
-- Third palpal segment shorter, and at least slightly broadened toward distal third 38

38. Foreknee pale; hindfemur pale to knee; larger species, wing 1.08 mm long; antennal ratio 1.16; large spermatheca shorter, rugulose. . . . . .luteolus n. sp. (p. 100)
-- Fore- and hindfemora usually with knees darkened; smaller species, wing 0.94 mm long; antennal ratio 0.99; large spermatheca longer, not rugulose. . subpalpifer n. sp. (p. 115)

39(32). Hindfemur with apical or subapical pale band. 40
-- Hindfemur dark to apex. 46

40. Halter dark 41
-- Halter pale or slightly infuscated. 42

41. Wing largely pale on proximal half, apex dark; mesonotum brownish on posterior portion next to scutellum. . . . . albibasis Wirth and Hubert (p. 118)
-- Wing not paler on proximal half, apex narrowly pale; mesonotum uniformly yellowish . . . . . .gouldi n. sp. (p. 139)

42. Scutellum yellow. 43
-- Scutellum dark brown. 44

43. Spermathecae subequal, elongate, usually sausage-shaped; wing extensively pale. . . . . triallantionis Howarth (p. 154)
-- Spermathecae unequal, large one broader than long, conoidal, smaller ones subspherical; wing not extensively pale. . . . . .flaviscutellaris n. sp. (p. 132)

44. Hindfemur with subapical pale band covering almost half of femur; wing tip indistinctly pale; antennal sensory pattern 3,13-15. . . . . .parabarnetti n. sp. (p. 146)
-- Hindfemur with narrow subapical pale band; pale area at wing tip broad and distinct; antennal sensory pattern 3,11-5 45

45. Poststigmatic pale spot in cell R5 covering distal 2/3 of second radial cell; subapical pale band on hindfemur prominent . . . . . .barnetti Wirth and Hubert (p. 122)
-- Poststigmatic pale spot in cell R5 covering less than distal half of second radial cell; pale band on hindfemur less distinct . . . . . .huberti Howarth (p. 142)

46(39). Antennal sensory pattern 3,13-15. 47
-- Antennal sensory pattern 3,11-15. 48

47. Wing tip broadly pale . . . . . .fordae n. sp. (p. 133)
-- Wing tip slightly pale only in apices of cells R5 and M1. . . . . .tamada Howarth (part) (p. 152)

48. Spermathecae saclike, broadest at apical third; wing tip dark; (midknee pale). . . . . dungunensis n. sp. (p. 125)
-- Spermathecae not saclike; largest one broadest at basal third; wing tip usually narrowly to broadly pale 49

49. Disc of wing without pale spots behind medial fork; antenna and proboscis shorter, antennal ratio 0.93; palpal ratio 2.5; P/H ratio 0.64; male parameres and apicolateral processes on ninth tergum shorter. . . . . flaviscutatus Wirth and Hubert (p. 129)
-- Disc of wing with large pale spot in cell M2 behind medial fork; antenna and proboscis longer, antennal ratio 1.03; palpal ratio 3.0; P/H ratio 0.68; male parameres and apicolateral processes on ninth tergum longer. . . . . laoensis Howarth (p. 144)

50(10). Distal pale spot (or second, if 3 are present) in cell R5 usually transverse, sometimes round, but never extending to near apex of cell R5; pale markings distinct. 51
-- Distal pale spot in cell R5 extending to apex of cell and usually longitudinally elongated, or pale spots very indistinct . . .93

51. Three distinct pale spots in each of cells R5 and M1; second radial cell short . . . . . hui Wirth and Hubert (p. 270)
-- Not more than 2 pale spots in each of cells R5 and M1 (not counting any division of the poststigmatic pale spot in cell R5 into 2 separate pale spots) 52

52. Wing with a separate pale spot overlapping midportion of vein M1, no pale spot straddling midportion of vein M1; 1 radial cell present, pale only at extreme apex (Group uncertain). 53
-- Wing without separate pale spot overlapping or lying just in front of midportion of vein M1; with or without a large pale spot straddling midportion of vein M2; 1 or 2 radial cells. .54

53. Pale spot straddles midportion of vein M1; third palpal segment with sensilla scattered on entire length; palpal ratio 3.2. . . . . .longipalpis Delfinado (p. 444)
-- Pale spot lies on anterior side of midportion of vein M1; third palpal segment with sensilla scattered on distal half, palpal ratio 5.0 . . . . . perakensis Kitaoka (p. 447)

54. Wing with a large pale spot straddling midportion of vein M2. .55
-- Wing without pale spot straddling midportion of vein M2; (second radial cell short and broad; anal cell with longitudinal pale streak and pale spots or Orientalis Group pattern; antennal segments cylindrical as in Orientalis Group (Subgenus Avaritia) . . . . . jacobsoni Macfie (p. 275)

55. Wing with 2 radial cells in female. 56
-- Wing with 1 radial cell in female (Subgenus Haemophoructus) . .80

56. Wing with proximal part of vein Cu1 pale-marginated on both sides; second radial cell very short (Subgenus Avaritia). . . . . boophagus Macfie (p. 254)
-- Wing with vein Cu1 never pale-margined on anal cell side (Subgenus Hoffmania). 57

SUBGENUS HOFFMANIA

57. Wing with proximal pale spot in cell M4 at or near mediocubital fork and with marginal pale spot in cell M4 not touching vein M3+4. 58
-- Wing not with above combination of characters 61

58. Wing with r-m crossvein infuscated; proximal pale spot in cell M4 bordering vein M3+4 only, not reaching mediocubital fork. . . . . insignipennis Macfie (p. 209)
-- Wing with r-m crossvein not infuscated. 59

59. Wing with a dark line in cell R5 extending from vein R4+5 across poststigmatic pale spot to distal dark area . . . . . divisus n. sp. (p. 198)
-- Wing without a dark line extending beyond vein R4+5 across poststigmatic pale spot 60

60. Wing with infuscation on vein R4+5 extending into poststigmatic pale spot to point where vein bends toward costa; pale spot over r-m crossvein narrow, sometimes divided transversely at radius into 2 spots; halter pale. . peregrinus Ki ffer (p. 228)
-- Wing with infuscation on vein R4+5 not extending into poststigmatic pale spot; pale spot over r-m crossvein broad; halter dark . . . . . .effusus Delfinado (p. 200)

61(57). Eyes separated. 62
-- Eyes contiguous 63

62. Anal cell with pale spot at base; dark area along vein R4+5 penetrating into poststigmatic pale spot; apex of vein M1 pale . . . . . recurvus Delfinado (p. 234)
-- Anal cell without pale spot at base; dark area along vein R4+5 not penetrating into poststigmatic pale spot; apex of vein M1 dark. . . . . .hirtipennis Delfinado (p. 202)

63. Third palpal segment without trace of pit 64
-- Third palpal segment with definite round or irregular, sometimes subdivided pit. 68

64. Hindfemur dark to tip 65
-- Hindfemur broadly pale on distal portion. 67

65. Halter dark; forefemur dark to tip; small species, wing 1.05 mm long. . . . . .indianus Macfie (p. 201)
-- Halter pale; forefemur broadly pale apically; wing 1.11-1.21 mm long. 66

66. Postigmatic pale spot in cell R5 divided into 2 separate pale spots; veins M1, M2 and M3+4 with small pale spots at wing margin; sensilla scattered entire length of third palpal segment . . . . . cheahi Kitaoka (p. 197)
-- Poststigmatic pale spot in cell R5 not divided into 2 separate pale spots; veins M1, M2 and M3+4 without pale spots at wing margin; sensilla scattered on distal half of third palpal segment . . . . . .pikongkoi Howarth (p. 233)

67(64). Forefemur broadly pale apically; wing with dark spot in anal angle; cibarium without patch of spicules . . . . . klossi Edwards (p. 214)
-- Forefemur dark to tip; wing without dark spot in anal angle; cibarium with patch of about 50 spiculate teeth . . . . . spiculae Howarth (p. 237)

68(63). Anal angle of wing broadly pale; pale spot present about midway along anterior margin of vein M1, sometimes fused with poststigmatic pale spot in cell R5; (halter pale; mesonotum pale brown) . . . . . parabubalus n. sp. (p. 224)
-- Anal angle of wing with at least a dark spot (ordinarily without additional pale spot along anterior margin of vein M1). . . .69

69. Cell M4 with a small central dark spot enclosed by a C-shaped pale ring open to posterior wing margin . . . . . orestes n. sp. (p. 222)
-- Cell M4 without central dark spot enclosed by C-shaped pale mark 70

70. Very large species, wing length 1.63 mm; wing dark with small, faint, pale markings, without pale spot at tip of vein M1; cell M4 and anal cell often entirely dark; anal cell dark at base. . . . . .brinchangensis n. sp. (p. 190)

-- Small to large species, wing length less than 1.45 mm; base of anal cell with pale markings. 71

71. Tibial comb with 6 spines (rarely 5); halter pale or dark . . .72
-- Tibial comb with 4-5 spines; halter pale. 75

72. Pale spot in cell M4 at most narrowly touching veins M3+4 anteriorly; poststigmatic pale spot in cell R5 not reaching vein M1 73
-- Pale spot in cell M4 large and often connected anteriorly along vein M3+4 with a small proximal pale spot in mediocubital fork; poststigmatic pale spot in cell R5 broadly reaching and sometimes crossing vein M1. . . . . .bubalus Delfinado (p. 192)

73. Hindtibia with tip broadly and distinctly pale; wing with more extensive pale spots. 74
-- Hindtibia with apex dark or narrowly and indistinctly pale; wing dark with small distinct pale spots . . . . . .lansangensis Howarth (p. 216)

74. Third palpal segment with round sensory pit, palpal ratio 2.9; halter dark . . . . . innoxius Sen and Das Gupta (p. 207)
-- Third palpal segment with irregular subdivided pit; palpal ratio 4.2; halter pale. . . . . cameronensis Kitaoka (p. 195)

75(71). Tibial comb with 4 spines; male aedeagus with prominent subapical sclerotized spurs . . . . . .andrewsi Causey (p. 189)
-- Tibial comb with 5 spines; aedeagus not as above. 76

76. Third palpal segment not constricted beyond the pit; mandible with vestigial teeth. . . . . carpophilus n. sp. (p. 196)
-- Third palpal segment slender beyond the pit; mandible with or without well-developed teeth. 77

77. Poststigmatic pale spot in cell R5 not reaching vein M1; pale spot over r-m crossvein not produced angularly into base of cell R5 78
-- Poststigmatic pale spot in cell R5 reaching and sometimes crossing vein M1; pale spot over r-m crossvein projecting angularly distad in cell R5 and usually extending into cell M1. . . . . malayae Macfie (p. 220)

78. Pale spot over r-m crossvein narrow, usually interrupted by a dark line bordering radius; (small species, wing 1.06 mm long; mandibular teeth normal; pale wing spots small) . . . . . .sumatrae Macfie (p. 239)
-- Pale spot over r-m crossvein broad, not interrupted along radius 79

79. Large species, wing length 1.43 mm; mandibular teeth vestigial; pale wing spots small . . . . . kinabaluensis n. sp. (p. 211)
-- Smaller species, wing length 1.19 mm; mandibular teeth normal; pale wing spots extensive . . . . . barumalayae n. sp. (p. 226)

SUBGENUS HAEMOPHORUCTUS

80(55). Base of wing including anal angle dark; halter dark; legs dark brown with narrow pale bands 81
-- Base of wing including anal angle pale; halter pale; legs usually broadly pale at fore- and midknees or entirely pale 83

81. Wing with pale spots well defined; anal cell with 2 distal pale spots; hindtibial spur elongate . . .calcaratus n. sp. (p. 157)
-- Wing with pale spots indistinct; anal cell with 1 distal pale spot; hindtibial spur elongate or normal. 82

82. Radial cell with broad tip, costa displaced at this point; hindtibial spur elongate. . . . .maculipennis (Macfie) (p. 159)
-- Radial cell with narrow tip, costa straight; hindtibial spur normal. . . . . .tawauensis n. sp. (p. 161)

83(80). Hindfemur entirely yellow; mesonotum with disc yellowish; pale wing markings extensive; third palpal segment slender, palpal ratio 4.6. . . . . .mellipes n. sp. (p. 179)
-- Hindfemur dark on at least proximal half; wing markings and palpus various. 84

84. Cell M4 with distinct pale spot at base of mediocubital fork. .85
-- Cell M4 without pale spot at base of mediocubital fork. 86

85. Femora with broad distal pale bands; wing length 1.26 mm. . . . . boormani Giles and Wirth (p. 163)
-- Femora dark to apices; wing length 1.06 mm. . . . . hoffmanioides n. sp. (p. 173)

86. Large species, wing length 1.68-1.80 mm; third palpal segment slender, palpal ratio 5.0-5.4 87
-- Smaller species, wing length 1.00-1.43 mm; third palpal segment stouter, palpal ratio 3.6-4.5 88

87. Mesonotum shining brownish black; distal pale spot in cell M1 small and located more than its own length from wing margin . . . . . nitens Edwards (p. 181)
-- Mesonotum with yellowish brown pattern; distal pale spot in cell M1 larger and usually almost meeting wing margin. . . . . .gentilis Macfie (p. 168)

88. Hindfemur with distal third distinctly pale including knee; (mesonotum with disc yellowish) . . . unicus Delfinado (p. 185)
-- Hindfemur dark to tip or with faint subapical pale band, knee dark. 89

89. Hindtibial comb with 4 spines; cell M2 without pale spot lying in front of mediocubital fork; legs pale, with faint brown markings. . . . . kisangkini Howarth (p. 177)
-- Hindtibial comb with 5-6 spines; cell M2 with pale spot lying in front of mediocubital fork fused with pale streak at base of

90. Distal pale spot in cell M2 not attaining wing margin; mesonotum uniformly dark brown, without yellowish markings. 91
-- Distal pale spot in cell M2 meets wing margin, at least narrowly; mesonotum with yellowish brown markings 92

91. Midknees narrowly, narrow bases of fore- and hindtibiae, and narrow apex of hindtibia distinctly banded with yellow; antennal sensory pattern 3,(7,9),11-15, sensilla usually present on 7 and 9; male ninth tergum with a single median lobe on caudal margin; thorax and legs with weak setae. . . . . kinari Howarth (p. 175)
-- Pale leg markings indistinct, but more extensive than above; antennal sensory pattern 3,11-15; male ninth tergum with a pair of distinct submedian lobes on caudal margin; thorax and legs with strong bristly setae . . . . . .gemellus Macfie (p. 165)

92. Distal pale spot in cell M1 at most narrowly meeting wing margin; second dark band at costal margin usually as broad or broader than pale band on each side; pale mesonotal markings limited; male ninth tergum with single median lobe on caudal margin. . . . . .nyakini Howarth (p. 183)
-- Distal pale spot in cell M1 broadly meeting wing margin; second dark band at costal margin distinctly narrower than adjacent pale bands; pale areas on disc of mesonotum extensive; male ninth tergum with broad median notch and prominent low sublateral lobes. . . . . .gymnopterus Edwards (p. 171)

93(50). Third palpal segment large and greatly swollen apically or spindle-shaped, tapering beyond the pit, which if round is never small and deep; wing macrotrichia usually numerous. . .94
-- Third palpal segment small and not narrowed beyond the small round pit; wing macrotrichia sparse (Subgenus Avaritia) . . 105

94. Second radial cell at least twice as long as first, pale nearly to base, not narrowed distad; (large yellowish species) . . .95
-- Second radial cell not more than twice as long as first 96

95. Small round palpal pit present; pale wing markings more extensive, confluent, apex of wing including tip of vein M1 pale; pale spot in cell M4 extending proximad along vein M3+4 to base of mediocubital fork. . .liui Wirth and Hubert (p. 218)
-- Palpal pit absent, sensilla scattered on surface of third segment; pale wing markings not confluent, tip of vein M1 dark at wing margin; pale spot in cell M4 not produced proximad along vein M3+4 . . . . . .tenuifasciatus n. sp. (p. 243)

96. Cell R5 distally without pale spot or with only a small round pale spot at tip of cell. 97
-- Cell R5 with a large pale area more or less filling distal half of cell, pale wing markings usually extensive 98

97. Cell R5 without pale spot in distal portion; pale spot present in cell M2 just in front of mediocubital fork; antennal sensory

-- Cell R5 with a definite small round pale spot at tip of cell; pale spot absent in cell M2 just in front of mediocubital fork; antennal sensory pattern 3,13-15 (neavei group, part) . . . . . kepongensis n. sp. (p. 346)

98(96). Antennal sensory pattern 3,7-10; r-m crossvein dark; wing pattern inconspicuous; macrotrichia sparse, short and spinelike . . . . . .coronalis Lee and Reye (part) (p. 440)
-- Antennal sensory pattern 3-14, 3-9,11-14, 3,10,12-14, 3-15, or 3,11-15; r-m crossvein in a pale spot 99

99. Antennal sensory pattern 3,11-15. 100
-- Antennal sensory pattern 3-14, 3-9,11-14, 3,10,12-14, or 3-15 101

100. Wing pale yellowish with 3 conspicuous dark brown spots on anterior margin, faintly continued transversely to hind wing margin; halter pale . . . . . trimaculipennis n. sp. (p. 245)
-- Wing grayish with faint streaklike markings, mainly along veins; halter dark . . . . . .novairelandi Tokunaga (p. 409)

101. Antennal sensory pattern 3,10,12-14 or 3-14, sensilla absent on 15; halter dark 102
-- Antennal sensory pattern 3-15; halter pale. 103

102. Two large pale areas in cell R5, distal one filling apex of cell; base of mediocubital fork dark; antennal sensory pattern usually 3-14, sensilla sometimes absent on some of proximal series; third palpal segment with sensilla borne on surface of segment or in subdivided open pits or irregular concave area. . . . . .(peliliouensis Tokunaga (p. 330)
(pongsomiensis Chu (p. 333)
-- At least three irregular pale areas in cell R5, distal one arcuate and not filling apex of cell; base of mediocubital fork with pale margin; antennal sensory pattern 3,10,12-14; third palpal segment with shallow round pit . . . . . pictilis n. sp. (part) (p. 392)

103. Spermathecae small; legs brownish; eyes nearly contiguous; third palpal segment with small round pit; wing markings extensive . . . . . .papuensis Tokunaga (part) (p. 328)
-- Spermathecae large; legs yellow 104

104. Third palpal segment with small round pit; eyes moderately separated; wing markings distinct; male parameres slender distally. . . . . .pangkorensis n. sp. (p. 326)
-- Third palpal segment with larger pit; eyes nearly contiguous; wing markings indistinct; male parameres massive distally . . . . . .maai n. sp. (p. 312)

SUBGENUS AVARITIA

105(93). Eyes hairy; second radial cell pale only on extreme tip, on distal side of vein R4+5; legs pale yellowish . . . . . .

106. Wing with pale spots very indistinct, only pale spots over r-m crossvein and second radial cell prominent, remainder grayish, darker along veins, sometimes faint spots present; halter dark brown; legs dark, pale only at base of hindtibia. . . . . .pungens Meijere (p. 289)
-- Wing with large, distinct pale spots at least in apex of cell R5; legs pale or dark with prominent bands. 107

107. Anal cell with basal portion entirely pale; cell M2 with area in front of mediocubital fork pale 108
-- Anal cell with basal portion dark or at least with dark streak; cell M2 with area in front of mediocubital fork dark. . . . 113

108. Antennal sensory pattern 3,12-15; halter pale 109
-- Antennal sensory pattern 3,11-15; halter infuscated 110

109. Wing with dark mark on vein M2 narrowed subapically by a posterior broadening of pale spot in cell M1 distinctly before wing margin; third palpal segment with sensory pit shallow. 111
-- Wing with dark mark on vein M2 uniformly broad subapically, narrowed distally at wing margin; third palpal segment with sensory pit distinct. . . . . .brevitarsis Kieffer (p. 258)

110. Third palpal segment with indistinct pit, the margins not definite. . . . . nudipalpis Delfinado (p. 281)
-- Third palpal segment with distinct pit with well-defined sunken margins . . . . . .imicola Kieffer (p. 272)

111. Legs pale yellowish with indistinct markings, knees yellow; thorax yellowish brown; wing with indistinct markings, pale areas large and diffuse between the veins . . . . . .brevipalpis Delfinado (p. 256)
-- Legs dark with distinct pale bands, knee spots blackish, at least on one pair of legs; thorax dark brown; wing markings distinct 112

112. Wing vein M2 with isolated dark spot at base cut off from dark area over base of vein M1 and from distal dark area on vein M2 by pale areas encroaching from cells M1 and M2; dark mark on vein M2 ends distally in a point at wing margin; male ninth tergum with prominent submedian lobes . . . . . flavipunctatus Kitaoka (p. 265)
-- Wing vein M2 with dark area continuous from base to tip, pale spots in cells M1 and M2 not quite meeting on vein; male ninth tergum with broadly rounded sublateral lobes. . . . . fulvus Sen and Das Gupta (p. 267)

113(107). Larger species, wing length 0.85-1.20 mm; third palpal segment long and slender with small round pit, palpal ratio 2.9-3.1; sensilla chaetica (verticils) on segments 11-15 usually reduced . . . . . '114
-- Smaller species, wing length 0.82 mm; third palpal segment shorter and stouter, palpal ratio 1.9; sensilla chaetica well

114. Cell M2 with pale area absent or indistinct immediately distad of level of mediocubital fork; pale markings in anal cell faint, veins forming radial cells especially strong. 115
-- Cell M2 with distinct pale spot or streak present just distad of level of mediocubital fork; pale markings in anal cell distinct; veins forming radial cells not unusually strong . 116

115. Large blackish species, wing length 1.43 mm; wing markings more contrasting; spermathecae large, darker, without necks (0.071 by 0.054 mm). . . . . pastus Kitaoka (p. 287)
-- Smaller brownish species, wing length 1.00-1.20 mm; wing markings more diffuse; spermathecae small (0.047 by 0.038 mm); paler, with slender necks. . . . . .maculatus (Shiraki) (p. 278)

116. A quadrate dark spot present at tip of vein M2 entirely cut off from proximal dark portion of vein by pale area crossing from cell M1 to cell M2; third palpal segment short and stout; male aedeagus short with convex sides and bifid tip, basal arch low; (first dark costal marking as in orientalis; male ninth tergum bilobate) . . . . . .wadai Kitaoka (p. 291)
-- Distal portion of vein M2 not separated from dark midportion of vein by a pale area crossing vein from cell M1 to cell M2; third palpal segment longer and more slender; male aedeagus longer with straight sides and simple tip . . . . . .orientalis Macfie (p. 283)

SECOND RADIAL CELL DARK AT APEX

117(9). Wing with only 1 distinct pale spot, at end of costa on anterior margin; crossvein r-m dark; large species with dark stigma. . . . . .majorinus Chu (p. 411)
-- Wing with 2 or more pale spots. 118

118. Wing with only 2 pale spots, one over r-m crossvein and other at end of costa, both on anterior margin of wing 119
-- Wing with more than 2 pale spots, sometimes posterior ones very faint 121

119. Third palpal segment with sensory pit opening by broad pore; antennal ratio 1.25; legs without pale rings. . . . . .flumineus Macfie (part) (p. 302)
-- Third palpal segment with sensory pit opening by much smaller pore. 120

120. Antennal sensory pattern 3-15, sensilla usually small and one to a segment; antennal ratio 1.12; fore- and midfemora with subapical, and all tibiae with subbasal, narrow pale rings. . . . . .wenzeli Delfinado (p. 362)
-- Antennal sensory pattern 3-14, sensilla prominent and usually at least two to a segment; antennal ratio 1.40; legs without pale rings . . . . . okinawensis Arnaud (p. 318)

121(118). Wing without pale spot in cell M1. 122
-- Wing with 1 to 3 pale spots in cell M1. 125

122. Wing without macrotrichia; small species, wing length 0.57 mm; costa short, costal ratio 0.53; second radial cell vestigial (actoni Group). . . . . minimus n. sp. (p. 251)
-- Wing with dense long macrotrichia to base; large species, wing 1.0-1.4 mm long; costa long, costal ratio 0.58; second radial cell large, open. 123

123. Base of mediocubitus without pale spots; cells M2 and M4 with indistinct pale spots; third palpal segment broad and swollen to base with deep pit opening by smaller pore 124
-- Base of mediocubitus with a small distinct pale spot; cells M2 and M4 without pale spots; third palpal segment elongate with shallow round pit . . . . . .dryadeus Wirth and Hubert (p. 338)

124. Palpal pore round; spermathecae oval, slightly unequal; mandible with 12 teeth . . . . . siamensis n. sp. (p. 359)
-- Palpal pore elongate; spermathecae subequal, with tapering necks; mandible with 16 teeth. . . . . .nigripes n. sp. (p. 353)

125(121). Wing with definite pale spots straddling veins M1 and M2 at about midlength 126
-- Wing with distal pale spots located mainly between veins, none straddling vein M1 (basal pale spot in cell M1 extending over vein M2 in similis and selangorensis) 128

126. Distal pale spot in cell R5 small, round, and well separated from wing margin; third palpal segment with deep pit 127
-- Distal pale spot in cell R5 elongate and broadly meeting wing margin; third palpal segment with scattered sensilla. . . . . pseudocordiger n. sp. (part) (p. 447)

127. Blackish species; halter and legs dark; wing dark gray with discrete small pale spots, those in cells M1, M2 and M4 lying far from wing margin. . . . . bigeminus n. sp. (p. 336)
-- Brownish species with pale halter and legs; wing paler with larger, less definite pale spots, those in cells M1, M2 and M4 lying near or touching wing margin. . . . . kelantanensis n. sp. (p. 344)

128(125). Cell M1 with 3 pale spots; cell R5 with 2 pale spots in distal half 129
-- Cell M1 with 1 or 2 pale spots, the proximal one sometimes extending over vein M2. 130

129. Third palpal segment with a small deep pit; antennal sensory pattern 3-14. . . . . .circumbasalis Tokunaga (part) (p. 294)
-- Third palpal segment with irregular open sensory area; antennal sensory pattern 3,8-10. . .shortti Smith and Swaminath (p. 404)

130. Cell M1 with only 1 pale spot 131
-- Cell M1 with 2 pale spots 136

131. Pale spot present immediately anterior to mediocubital fork . 132
-- Pale spot absent anterior to mediocubital fork; (third palpal

132. Fourth tarsomere cordiform; vein M1 pale bordered; pale spot present straddling base of vein M2; (third palpal segment very short and swollen, with sensilla borne on surface; antenna stout, proximal segments transverse to moniliform, sensilla coeloconica present on segments 3-14) . . . . . pseudocordiger n. sp. (part) (p. 447)
-- Fourth tarsomere cylindrical; vein M1 not pale bordered; no pale spot straddling base of vein M2 133

133. Pale spot in cell M1 located near wing margin; radial cells narrow; pale spot over r-m crossvein located just distad of vein. 134
-- Pale spot in cell M1 located at midlength of cell; radial cells unusually broad; pale spot over r-m crossvein centered on vein; third palpal segment with shallow irregular pit . . . . . yoshimurai Tokunaga (p. 451)

134. Third palpal segment with deep round pit opening by a small pore; halter pale; male aedeagus with caudolateral spurs. . . . . distinctus Sen and Das Gupta (p. 370)
-- Third palpal segment with a large round shallow sensory pit; halter dark; male aedeagus without caudolateral spurs . . . . arenicola Howarth (p. 365)

135(131). Small species, wing length 0.74 mm; macrotrichia very sparse; costa short, costal ratio 0.56; antennal sensory pattern 3,12-15 . . . . . actoni Smith (part) (p. 248)
-- Large species, wing length 1.08 mm; macrotrichia long and numerous; costal ratio 0.66; antennal sensory pattern 3,11-15 . . . . . macclurei n. sp. (p. 348)

136(130). Pale spot present in distal portion of cell R5 137
-- No pale spot present in cell R5 distal to level of poststigmatic pale spots (ornatus Group, part). . . . . pampangensis Delfinado (part) (p. 324)

137. Cell R5 with small, usually more or less round, pale spot at extreme apex and with no pale spots lying between this spot and poststigmatic pale spot(s). 138
-- Cell R5 with distal pale spot located subapically and usually longitudinally elongate or irregular, if small and apical there is also a pale spot between it and poststigmatic pale spot(s); distal pale spot sometimes large, apical, and irregular . . 154

138. One saclike spermatheca present (Subgenus Meijerehelea) . . . 139
-- Two spermathecae present. 144

SUBGENUS MEIJEREHELEA

139. Wing without pale spot in cell R5 posterior to radial cells and midway between r-m crossvein and poststigmatic pale spot. . 140
-- Wing with pale spot present in this location. 141

140. Two separate poststigmatic pale spots in cell R5, the posterior one located slightly proximad of the one lying at end of costa; [illegible] spermatheca elongate pear-shaped

-- Only 1 large transverse poststigmatic pale spot in cell R5; wing markings faint; spermatheca broad and oval. . . . . hegneri Causey (p. 421)

141. Poststigmatic pale spot with distoposterior extension toward vein M1, or with separate spot at this angle to poststigmatic pale spot; spermatheca sagittate, widest near proximal third . . . . . histrio Johannsen (p. 423)
-- Poststigmatic pale spot without distoposterior extension, but with a separate posterior spot located slightly proximad. . 142

142. Spermatheca sagittate, widest near proximal third; palpus elongate, third segment 5 times as long as broad; proximal pale spot in cell R5 touching vein M1 but not reaching radius. . . . . proxilipalpis n. sp. (p. 426)
-- Spermatheca widest toward apex; third palpal segment 1.1-2.5 times as long as broad. 143

143. Proximal pale spot in cell R5 touching vein M1 but not reaching radius; spermatheca widest near distal third, tapering to base of duct . . . . . guttifer (Meijere) (p. 417)
-- Proximal pale spot in cell R5 lying near to or touching radius but not reaching vein M1; spermatheca saclike, widest near blunt apex. . . . . arakawae (Arakawa) (part) (p. 414)

144(138). Cell M2 with a pale spot lying immediately in front of mediocubital fork (Clavipalpis Group, part) 145
-- Cell M2 without pale spot lying immediately in front of mediocubital fork (Shermani Group). 150

CLAVIPALPIS GROUP

145. Poststigmatic pale spot in cell R5 in form of a trilobed spot extending from costal margin to vein M1; antennal sensory pattern 3,8-10. . . . . clavipalpis Mukerji (p. 368)
-- Poststigmatic pale spot in cell R5 usually divided into 2 separate pale spots. 146

146. Posterior poststigmatic pale spot touching vein M1 posteriorly 147
-- Posterior poststigmatic pale spot located midway between anterior poststigmatic pale spot and vein M1, not touching latter. . 148

147. Proximal pale spot in cell M1 laps over vein M2 into cell M2; third palpal segment slender with small deep pit; antennal sensory pattern 3,10,12,14. . . . . palpisimilis n. sp. (p. 390)
-- Proximal pale spot in cell M1 not lapping over vein M2 into cell M2; third palpal segment swollen with broad shallow pit; antennal sensory pattern 3,5,7-10 . . . . huffi Causey (p. 372)

148. Third palpal segment swollen to base, with deep pit opening by small pore. . . . . parviscriptus Tokunaga (p. 378)
-- Third palpal segment swollen distally with a shallow pit. . . 149

149. Proximal pale spot in cell M1 laps over vein M21 into cell M2; separate subapical pale spot in cell M2 absent; cibarial armature absent; male aedeagus without caudolateral spurs but with distal process extremely slender and pointed . . . . . .similis Carter, Ingram and Macfie (p. 382)
-- Proximal pale spot in cell M1 not crossing vein M1 caudad; a separate round subapical pale spot present in cell M2 past level of mediocubital fork; male aedeagus with caudolateral spurs present, distal process parallel-sided and blunt-tipped . . . . . .notatus Delfinado (p. 375)

SHERMANI GROUP

150(144). Cell M2 with 1 pale spot present distal to level of mediocubital fork 151
-- Cell M2 with 2 pale spots present distal to level of mediocubital fork. 152

151. Third palpal segment large with deep pit opening by small pore; antennal sensory pattern 3-9, 11-14; wing macrotrichia numerous; halter dark; spermathecae without necks . . . . . .shermani Causey (p. 357)
-- Third palpal segment small with shallow open sensory area; antennal sensory pattern 3,8-10,12; wing macrotrichia scanty; halter pale . . . . . .minipalpis n. sp. (p. 351)

152. Two pale spots (may be fused in a double spot) distally in anal cell; palpal pit broad and shallow; antennal sensory pattern 3,11-14; wing markings distinct on distal and posterior wing margin. 153
-- One pale spot distally in anal cell; palpal pit deep and round, opening by smaller pore; antennal sensory pattern 3-11,13-14; wing markings faint on distal and posterior parts of wing . . . . . thurmanae n. sp. (p. 360)

153. Wing only sparsely hairy and only on distal half; pale wing markings more extensive; sensilla borne singly on antennal segments. . . . . geminus Macfie (p. 340)
-- Wing with long hairs numerous distally and along posterior margin to base of anal cell; pale wing markings more restricted; sensilla borne several to a segment on antenna. . . . . marginatus Delfinado (p. 349)

154(137). One sclerotized functional spermatheca present 155
-- Two sclerotized functional spermathecae present 157

155. Pale spot over r-m crossvein containing a dark central spot; eyes narrowly separated; antennal sensory pattern 3-14 (Subgenus Beltranmyia). 156
-- Pale spot over r-m crossvein without dark central spot; cell M4 with dark central spot; eyes broadly separated; antennal sensory pattern 3,8-10 (Subgenus Monoculicoides). . . . . .homotomus Kieffer (p. 433)

156. Proximal pale spot in cell M1 and subapical pale spot in cell M2 each with a dark spot in center surrounded by a pale halo; halter dark; male parameres joined by a sclerotized basal bridge; aedeagus with a slender, ventrally bent, sclerotized peg at tip. . . . . halonostictus n. sp. (p. 431)
-- Proximal pale spot in cell M1 and subapical pale spot in cell M2 not containing dark spots in center; halter pale; male parameres not joined by a basal sclerotized bridge; aedeagus with simple, blunt tip. . . . . circumscriptus Kieffer (p. 429)

157(154). Pale spot present lying immediately adjacent to anterior side of mediocubital fork 158
-- No pale spot lying immediately adjacent to anterior side of mediocubital fork 166

158. Distal pale spot in cell R5 rounded, hourglass-shaped, or double, situated in or across cell at distal 0.6; antennal sensory pattern 3,8-10 or 3-15. 159
-- Distal pale spot in cell R5 very large, extending to wing tip, or divided longitudinally into 2 spots in apical half of cell; antennal sensory pattern usually 3,10,12,14 161

159. Cell R5 with separate small round pale spot between distal spot and poststigmatic pale spot(s); third palpal segment moderately swollen with shallow sensory pit; antennal sensory pattern 3,8-10. . . . . oxystoma Kieffer (p. 399)
-- Cell R5 without pale spot lying between poststigmatic and distal pale spots; third palpal segment swollen to base with deep sensory pit; antennal sensory pattern 3-15. 160

160. Vein M2 with pale spot straddling midportion; antennal ratio 1.43, distal segments more elongate; palpal pit extends nearly to base of third segment; proboscis elongate, P/H Ratio 0.83. . . . . selangorensis n. sp. (p. 355)
-- Proximal pale spot in cell M1 does not straddle vein M2; antennal ratio 1.20, distal segments not so elongate; palpal pit extends proximad to midlength of third segment; proboscis shorter, P/H Ratio 0.52. . . . . jefferyi Kitaoka (p. 342)

161(158). Distal pale spot in cell R5 irregularly oval, not emarginated on anterior side. 162
-- Distal pale spot in cell R5 containing a small anteriodistal dark spot, thus appearing crescent-shaped, open anteriorly, or completely divided into two separate spots. 163

162. Anal cell with 1 pale spot in distal portion. . . . . .yasumatsui Tokunaga (p. 396)
-- Anal cell with 2 pale spots in distal portion . . . . . cambodiensis Chu (p. 386)

163. Cell R5 with an elongate crescent-shaped pale spot distally; antennal sensory pattern 3,10,12,14 or 3,10,12-14; veins M1, M2, M3+4 and Cu1 dark at apices 164
-- Cell R5 with 2 separate pale spots on distal half; veins M1, M2, M3+4 and Cu1 pale-bordered distally; antennal sensory pattern 3,8-10. . . . . .perornatus Delfinado (part) (p. 380)

164. Pale wing spot in cell M4 not bordering vein Cu1; pale wing spots extensive and less distinct; palpal pit irregular . . . . delfinadoae n. sp. (p. 386)
-- Pale spot in cell M4 with an extension bordering vein Cu1; pale wing spots less extensive but distinct; palpal pit round. . 165

165. Poststigmatic pale spot extends proximad to involve vein R4+5 and narrow tip of second radial cell; distal arcuate pale spot in cell R5 narrowly arcuate without proximal V-shaped expansion or isolated distal round spot. . . pictilis n. sp. (part) (p. 392)
-- Poststigmatic pale spot not including vein R4+5 at tip of second radial cell; distal arcuate pale spot in cell R5 divided into a V-shaped proximal portion and an isolated round distal portion . . . . . .perornatus Delfinado (part) (p. 380)

166(157). Fourth tarsomere at most slightly broadened, not cordiform; sensilla coeloconica present on some or all of antennal segments 3-14 (except in papuensis with 3-15); spermathecae usually with sclerotized necks. 167
-- Fourth tarsomere distinctly cordiform; spermathecae without sclerotized necks; antennal sensory pattern 3-15; (wing sparsely hairy at apex) . . . . . .cordiger Macfie (p. 296)

ORNATUS GROUP (PART) ETC.

167. Distal pale spot in cell R5 usually attaining apex of cell. . 168
-- Distal pale spot in cell R5 round or oval, not extending to apex of cell 171

168. Halter pale or very slightly darkened; femora pale basally. . 169
-- Halter dark; femora unbanded, entirely dark; (one oblique poststigmatic pale spot in cell R5; tibiae with sub-basal, narrow pale rings). . . . . .mcdowelli Delfinado (p. 314)

169. Anal cell with 1 distal pale spot; 2 separate poststigmatic pale spots in cell R5; antennal sensory pattern 3,(4,5,6,8),11-14. . . . . ornatus Taylor (p. 320)
-- Anal cell with 2 distal pale spots; 1 large poststigmatic pale spot in cell R5; antennal sensory pattern 3-15. 170

170. Spermathecae very large, ovoid, tapering to long stout necks; second radial cell dark to tip. . . . .niphanae n. sp. (p. 316)
-- Spermathecae much smaller, necks shorter; second radial cell may be pale distally. . . . . .papuensis Tokunaga (part) (p. 328)

171(167). Anal cell with only 1 distal pale spot 172
-- Anal cell with 2 distal pale spots, the posterior one sometimes indistinct in some specimens. 179

172. Antennal sensory pattern 3,(11),13-14; spermathecae large and subspherical with long slender sclerotized necks; eyes hairy. 173
-- Antennal sensory pattern 3-9, sensilla also present on some of distal segments; eyes hairy or bare 174

173. Mandible with 5-6 rudimentary teeth; proboscis short, P/H Ratio 0.52; antennal sensory pattern 3-14; antennal ratio 0.97; palpal ratio 1.5. . . . . .corti Causey (part) (p. 298)
-- Mandible with 10-14 teeth; proboscis of normal length; antennal sensory pattern 3,11,13-14; antennal ratio 1.06; palpal ratio 2.3 . . . . . griffithi n. sp. (p. 307)

174. Antennal sensory pattern 3-10, 11,14; (palpal pit small and deep; spermathecae large and subspherical with long slender necks; distal pale spot in cell M1 often extending to wing margin) . . . . . infulatus Delfinado (part) (p. 311)
-- Antennal sensory pattern 3-14 (sometimes absent on 10 in damnosus) 175

175. Eyes hairy; (hindtibia dark to base; wing markings indistinct; halter dark). . . . . palawanensis Delfinado (p. 322)
-- Eyes bare 176

176. Hindtibia dark to base; wing markings indistinct, sometimes only two anterior pale spots present; halter very dark; (eyes moderately separated; spermathecae short) . . . . . .flumineus Macfie (part) (p. 302)
-- Hindtibia with sub-basal pale ring; wing markings distinct; halter pale or dark 177

177. Halter dark; (wing markings restricted but distinct; eyes narrowly to broadly separated; spermathecae much longer than broad). . . . . damnosus Delfinado (p. 300)
-- Halter pale 178

178. Two pale spots in cell M2 past mediocubital fork; poststigmatic pale spot in cell R5 distinctly oblique; wing macrotrichia dense; third palpal segment slender at base . . . . . quatei n. sp. (part) (p. 333)
-- One pale spot in cell M2 past mediocubital fork; poststigmatic pale spot in cell R5 nearly transverse; wing macrotrichia scenty; third palpal segment swollen to base. . . . . .pseudopalpalis n. sp. (p. 394)

179(171). Spermathecae oval, tapering abruptly to slender necks. . 180
-- Spermathecae slightly elongate, distinctly pyriform, tapering gradually to necks; halter dark . . . . hewitti Causey (p. 309)

180. Antennal sensory pattern 3,8-10 . . . . fadzilii Kitaoka (p. 408)
-- Antennal sensory pattern includes sensilla on segments 13-14. 181

181. Antennal sensory pattern 3-10,13-14 (sensilla sometimes missing on 4,6,8, and/or 10). . . . infulatus Delfinado (part) (p. 311)
-- Antennal sensory pattern 3-14 182

182. Halter dark; indistinct pale spot anterior to midportion of mediocubital stem . . . .circumbasalis Tokunaga (part) (p. 294)
-- Halter pale; distinct pale spot straddling midportion of mediocubital stem . . . . . quatei n. sp. (part) (p. 333)

DESCRIPTIONS OF SPECIES

Subgenus **Trithecoides** Wirth and Hubert

Culicoides, subgenus *Trithecoides* Wirth and Hubert, 1959: 2. Type-species, *Culicoides flaviscutatus* Wirth and Hubert (orig. desig.).

Diagnosis.--Moderately small species, usually with mesonotum and upper pleuron pale yellow contrasting with dark brown scutellum, postscutellum, and lower pleuron; some species with anterior portion of mesonotum marked with dark brown or with entire mesonotum brown. Wing with costa extending to 0.66-0.71 of wing length; radial cells well developed, especially second radial cell which is included in a pale spot. Wing markings consisting of two distinct anterior pale areas, one over r-m crossvein, second over apex of second radial cell; large distinct pale areas occasionally present on basal portion of wing and across extreme wing tip, other pale areas usually very indistinct, with veins more or less infuscated. Macrotrichia, if present, sparse and limited to tip of wing and along vein M1.

Eyes broadly contiguous, bare. Antennal ratio varying from 0.82 to 1.15; antennal segment 12 frequently shorter than 11; sensilla coeloconica present on segments 3,11-15, but in a few species (see Table 1) lacking on 11 or 12, or on 11 and 12. Palpus usually slender with sensilla scattered on surface of distal portion, a shallow pit rarely present. Mandibular teeth of several quite distinctive types, permitting further subdivision into groups of related species: (1) *anophelis* type, 8-14 recurved teeth with proximal ones larger; (2) *flavescens* type, 20-21 teeth in three series of differently shaped teeth; (3) *acanthostomus* type, 9-10 very long, rake-like teeth opposing similarly developed teeth on the lacinia; (4) *macfiei* type, 7-9 curved teeth with distal ones usually larger; and (5) *raripalpis* type, 11-16 small triangular teeth of subequal lengths. Glukhova (1982) with more limited material available for study, recognized 4 groups of *Trithecoides* species, based on the structure of all the mouthparts.

Hindtibial comb with 4 spines (5 in *tenuipalpis*), the second from the spur longest; tarsal claw of female with simple pointed tip (bifid in *anophelis*). Three well developed, sclerotized spermathecae always present, with a small sclerotized ring at the junction of the ducts. Shape of spermathecae of several types, consistent within groups of apparently related species: (A) *anophelis* type, equal or subequal and slightly pyriform with slender necks; (B) *fulvithorax* type, unequal, sausage-shaped, much longer than broad with broad, unsclerotized entrances to ducts; (C or D) *raripalpis* type, very unequal, one large and two subequal small ones, with broad, unsclerotized entrances to ducts, all spermathecae (C) more or less as broad as long, or (D) slightly longer than broad.

Male genitalia characterized by definite apicolateral processes on ninth tergum, the caudal margin between them often deeply cleft or bilobed; ventral membrane between ninth sternum and aedeagus never spiculate; basistyle with ventral root greatly reduced, dorsal root slender; aedeagus usually with short basal arch,

tapering sides, and simple blunt tip; parameres small, separate or fused a short distance near base; with short stem swollen at base, tapering to simple, slender tip, without ventral lobe or distal spines.

The species of the subgenus *Trithecoides* can be grouped according to certain important characters into the following 7 groups:

1. Anophelis Group. Teeth of lacinia strong; mandibular teeth large and recurved, in one species with numerous small extra distal teeth. Mesonotum more or less infuscated. Spermathecae various. Parameres fused at base. Mosquito parasites. Four Oriental species: *anophelis* Edwards, *baisasi* Wirth and Hubert, *culiciphagus* Wirth and Hubert, and *pendleburyi* n. sp.

2. Flavescens Group. Mandible with 20-21 teeth, distal tooth more or less enlarged, teeth in middle of series small, subequal and triangular, 3-6 proximal teeth very sharp, smaller and directed distad. Spermathecae subequal and slightly pyriform with slender sclerotized necks. Mesonotum various. Three Oriental species: *flavescens* Macfie, *paraflavescens* Wirth and Hubert, and *subflavescens* Wirth and Hubert.

3. Acanthostomus Group. Mandible with 9 very long, backwardly bent, sharp teeth in a rake-like series opposing a similar series of teeth on the lacinia; spermathecae subequal, ovoid with slender sclerotized necks; third palpal segment long and cylindrical; entire body pale yellow. One Malayan species: *acanthostomus* n. sp.

4. Tenuipalpis Group. Mandible with 8 teeth, the distal ones largest; spermathecae subequal, ovoid with slender sclerotized necks; third palpal segment extremely slender, 4.4 times as long as broad; 5 spines in hindtibial comb; mesonotum brown. Three species: *tenuipalpis* Wirth and Hubert, *nyungnoi* Howarth and *paksongi* Howarth.

5. Fulvithorax Group. Spermathecae sausage-shaped, much longer than broad, with broad unsclerotized entrances to the ducts; mandible with 9-11 subequal teeth; mesonotum yellowish. Two Ethiopian species: *fulvithorax* (Austen) and *ochrothorax* Carter.

6. Macfiei Group. Mandible with 7 curved teeth, the distal ones largest. Spermathecae unequal, one large and 2 subequal small ones, all about as broad as long or a little broader, with broad unsclerotized entrances to ducts, ducts of all spermathecae joined at one point near the sclerotized ring; thoracic adornment various. Ten Oriental species: *cylindripalpis* n. sp., *humeralis* Okada, *luteolus* n. sp., *macfiei* Causey, *manikumari* n. sp., *palpifer* Das Gupta and Ghosh, *rugulithecus* n. sp., *subpalpifer* n. sp., *nampui* Howarth, and *tonmai* Howarth.

7. Raripalpis Group. Mandible with 11-16 small, subequal, triangular teeth. Spermathecae unequal, with broad unsclerotized openings to ducts; one large and two subequal small spermathecae, usually all slightly longer than broad. Several species with variations from the normal pattern of antennal sensilla coeloconica. Great variations in thoracic adornment from pale yellow to part or all infuscated, and in some species blackish. Eighteen Oriental species: *albibasis*

gewertzi Causey, *gouldi* n. sp., *matsuzawai* Tokunaga, *parabarnetti* n. sp., *raripalpis* Smith, *sarawakensis* Wirth and Hubert, *laoensis* Howarth, *huberti* Howarth, *tamada* Howarth, *hinnoi* Howarth, and *triallantionis* Howarth.

Biology.--The species of *Trithecoides* with most remarkable habits are *anophelis*, *baisasi* and *culiciphagus*, which take second-hand blood meals from the abdomens of engorged mosquitoes (fig. 31) and *Phlebotomus* sand flies. Edwards (1922) and Laird (1946) give good summaries of locality records and the hosts involved. Most records of *anophelis* attacking vertebrate hosts directly are apparently based on misidentifications; in a previous paper (Wirth and Hubert, 1959) we reported re-identifications of some of these specimens. We have authentic records of *anophelis* biting cow and human from Malaya. Biting records have been made for the following additional species: On man--*barnetti*, *elbeli*, *flavescens*, *flaviscutatus*, *gewertzi*, *gouldi*, *humeralis*, *macfiei*, *matsuzawai*, *parabarnetti*, *raripalpis*, and *sarawakensis*. On cattle--*flavescens* and *macfiei*. On deer--*barnetti* and *flaviscutatus*.

Fig 31. Female of *Culicoides culiciphagus* feeding on *Anopheles koliensis* (from Slooff 1964).

Species of *Trithecoides* have been reared from water in the leaf axils of *Colocasia indica* in Java (Johannsen 1931; and Mayer 1934b) and from the stems and bases of rotting banana and plantain plants in Africa (Hopkins 1952) and India (Das Gupta and Ghosh 1956a). Manikumar has reared the following species in Malaya: *C. barnetti* from rotting banana stem, *palpifer* from decaying wild fruit, *sarawakensis* from decaying mushroom and decaying wood and leaves, *subpalpifer* from decaying fruit in jungle, and *manikumari* from decaying fruit in jungle. Howarth (1985) in Laos reared *subflavescens* from shaded stream and backwater margins, *tenuipalpis* from partly shaded and polluted pool and stream margins, *fordae* Wirth and Hubert from rotting *Alocasia* axil and humus in a tree buttress, and *tonmai* Howarth from a tree wound.

Anophelis Group

Culicoides anophelis Edwards
(Figs. 32, 199, 360)

Ceratopogon (?) sp.; Fearnside, 1900: 129 (midges parasitic on *Culex* mosquitoes).

Culicoides sp.; Gravely, 1911: 45 (ex *Anopheles*; India); Lalor, 1912: 42 (ex *Anopheles*; Burma); Stanton, 1912: 64 (ex *Anopheles*; Malaya); Annandale, 1913: 247 (ex *Anopheles*; India).

Culicoides anophelis Edwards, 1922: 161 (female; Malaya, Sumatra, India; ex *Anopheles* mosquitoes; fig. wing, abdomen, parasitized mosquito); Sinton and Little, 1925: 45 (habits, ex *Anopheles*; India); Macfie 1932: 493 (in part; Tonkin; ex *Anopheles*); Smith and Swaminath, 1932: 183 (in part; Assam; notes, ex *Anopheles* and *Phlebotomus*, also in error on cattle); Macfie, 1934b: 214 (Sumatra); Macfie, 1937a: 114 (descriptive notes on syntypes); Galliard and Gaschen, 1937: 320 (*Anopheles*; Tonkin); Iyengar, 1938: 237 (ex mosquitoes; India); Causey, 1938: 409 (female; Thailand, descriptive notes, fig. spermathecae; in part, some were *flavescens* Macfie); Okada, 1942: 140 (Formosa; female; fig. habitus, palpus, spermathecae, antenna; ex *Anopheles* host); Laird, 1946: 158 (records mosquito hosts; fig. female on host; New Britain; bibliography); Arnaud, 1956: 91 (Formosa; female; figs.); Amosova, 1957: 273 (compare *raripalpis*); Das Gupta and Ghosh, 1956b: 122 (India; records from *Anopheles* mosquitoes); Das Gupta and Ghosh, 1957: 26 (India; records from *Mansonia* mosquitoes); Sen and Das Gupta, 1958: 415 (India; male; figs.); Sen and Das Gupta, 1959a: 108 (India; feeding habits, sucks mosquito haemolymph); Wirth and Hubert, 1959: 8 (male, female redescribed; hosts, distribution; figs.); Das Gupta, 1964: 1 (feeding habits; India); Chastel et al., 1966: 151 (feeding habits; Cambodia); Debenham, 1978: 191 (bibliography); Howarth, 1985: 18 (Laos record).

Female.--Wing length 1.01 (0.93-1.09, n = 13) mm.

Head: Antenna (fig. 32a) with lengths of flagellar segments in proportion of 21-15-15-16-17-17-18-19-24-22-26-30-43, antennal ratio 1.00 (0.91-1.10, n = 8); sen-

short and very stout, third segment with sensilla scattered on surface of distal half of segment; palpal ratio 2.1 (1.6-2.3, n = 13). Proboscis short, P/H Ratio 0.38; clypeus greatly enlarged; mandible (fig. 32e) with 15 (12-19, n = 26) curved teeth, proximal ones largest.

Thorax: Mesonotum (fig. 32c) yellowish brown, dark brown on anterior fourth; scutellum, postscutellum, and lower pleuron dark brown. Legs (fig. 32j) pale brown; fore- and midlegs with knees pale, broad apical pale bands on femora and basal pale bands on tibiae; hindleg with knee dark, broad subapical pale band, sometimes indistinct, on femur, tibia with base and apex broadly pale; hindtibial comb (fig. 32f) with 4 spines, second from spur longest; tarsal claws (fig. 32i) divided at tip on all legs.

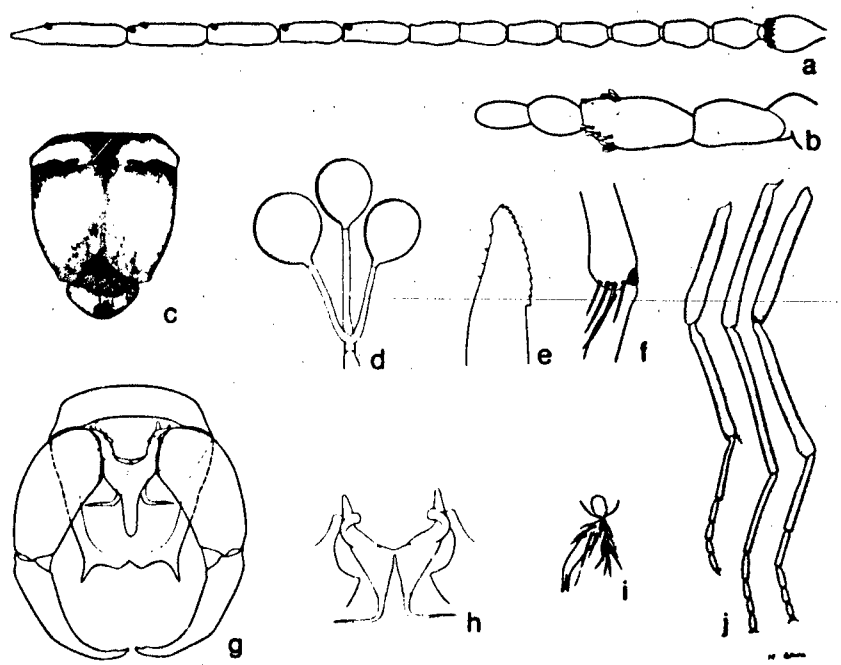


Fig. 32. *Culicoides anophelis*: a. antenna; b. palpus; c. thoracic pattern; d. spermathecae; e. mandible; f. tibial comb; g. male genitalia; h. male parameres; i. tarsal claw and empodium; j. legs.

Wing (fig. 199, 360): Pattern as figured; generally with dark streaks along veins and moderately pale areas in cells; 2 large, very pale yellow spots, one centering on r-m crossvein and other on apex of second radial cell, apex of wing narrowly pale. Costal ratio 0.69 (0.67-0.71, n = 13). Halter infuscated.

Abdomen: Dark brown, terga poorly sclerotized. Spermathecae (fig. 32d) 3, all very slightly unequal, measuring 0.039 x 0.033 mm, 0.040 x 0.033 mm, and 0.038 x 0.031 mm; subspherical to slightly ovoid, the necks slender and sclerotized a short distance.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 32g): Ninth sternum with very slightly perceptible caudomedian excavation; ninth tergum tapering to broad apex, apicolateral processes large, broad at bases, tapering to slender tips, the caudal margin of tergum between them with small submedian lobes and distinct median notch. Basistyle with ventral root very small, dorsal root slender; dististyle curved, swollen on basal half, tapering distally to slender point. Aedeagus with basal arms stout, basal arch extending to 0.4 of total length, distal portion slender with rounded tip. Parameres (fig. 32h) narrowly fused in midportions; each with large basal knob, basal portion bent laterally, stem very stout on short basal portion, tapering abruptly to slender, laterally curved, simple point.

Distribution.--Bangladesh, Burma, Cambodia, China, Hongkong, Indonesia, India, Laos, Malaysia, Sri Lanka, Taiwan, Thailand, Vietnam.

Types.--Nineteen female syntypes in BMNH from Malaysia (Kuala Lumpur), Sumatra (Deli), and Northwest India (Meenglas, Jalpaiguri). A female mounted on a slide from Kuala Lumpur, Malaysia, 14.v.1920, W.A. Lamborn #24b, "parasite on *A. fuliginosus* ♀," (BMNH #1921.408) is hereby selected as lectotype.

Southeast Asia Records.--

BURMA: Leben, Nyuang Bin Tha, Okset near Mandalay, Pyiban, Sule Gone, Yewon, and Ywathit (all collected by Büttiker and Beales).

CAMBODIA: Phnom Penh (Delfinado).

INDONESIA: Bali, Badung, Kuta, Jimbaran Carik (Lee); Peguyangan, Tag Tag (Lee). Java (Central), Cilacap, Adipala, Silangsur Lor and Karang Sari (Lee); (West) Bekasi, Teluk Buyung (Nasir); (West) West Jakarta, Kapuk (Lee). Lombok (East), Selong, Kerekong (Lee); (West) Mataram, Gerung, Dasan Geras (Lee). Sumatra, Bengkulu, Seluma, Bukit Peningauan (Mathis).

LAOS: Sayaboury Prov., Muong Pakse and Muong Xieng Hon (Howarth).

MALAYSIA: Johore, Kg. Parit Ahmad, ex swine shed (Garcia); Johore Kg. Sungei Pasir Puteh, Mersing, pig sty (Garcia); Kedah, Simpang Kuala Alor Star, ex *Culex gelidus* (Garcia); Kelantan, Kota Bharu, cattle shed (Garcia); Malacca, Kg. Piatu (Garcia); Negri Sembilan, Pekan Lama, ex *Mansonia uniformis* (Garcia); Pahang, Kg. Berchang, Kuala Lipis, near buffalo (Garcia); Pahang, Ulu Gali, cattle shed (Garcia); Selangor, Kuala Lumpur (Traub); Selangor, Puchong, from buffalo shed with mosquitoes (Garcia); Selangor, Segambut (Barnett).

THAILAND: No locality (1933, O.B. Causey). Chiang Mai Prov., Amphoe

VIETNAM: Chu Lai (Tisdale); Dilinh (Djiring), 1,200 m (Quate).

Discussion.--This species can be distinguished by the large curved mandibular teeth, the proximal ones larger, of a type similar to those of the other mosquito parasites, *baisasi* and *culiciphagus*. The spermatheca type is similar to that of the Flavescens Group. The bifid tarsal claws of *anophelis* are unique and are present on all legs and in both sexes. Some *anophelis* specimens from Sri Lanka differ in the reduction of the pale costal spots of the wings, but otherwise are quite typical.

The correct identification of the earlier records of *C. anophelis* biting vertebrate hosts were given in Wirth and Hubert (1959). Johannsen (1931) recorded *anophelis* reared from water in leaf axils of *Colocasia* in Java, and Mayer's description of the larva of this species, are probably misidentifications. Collections of *C. anophelis* from animal shelters and around animals usually indicate that the *Culicoides* were following the blood-filled mosquitoes to their resting places. Sen and Das Gupta (1959) were of the opinion that the prolonged period of attachment (36-48 hours) and feeding indicated that the midges fed on the mosquito haemolymph and not on their stomach contents. Moreover, Das Gupta (1964) reported that the guts of *C. anophelis* which had fed on engorged mosquitoes contained a pale yellow fluid that responded negatively to human and cattle antisera, but at the same time the blood in the guts of the mosquitoes was positive for cattle but negative to human antesera. This suggested that the *Culicoides* fed on the mosquitoes' haemolymph. The figure given by Chastel et al. (1966) of a female *C. anophelis* feeding on the abdomen of an *Aedes* mosquito host also indicates that feeding did not take place from the mosquitoes' gut.

Culicoides baisasi Wirth and Hubert
(Figs. 33, 200, 361)

Culicoides baisasi Wirth and Hubert, 1959: 12 (female; Philippines, Malaya; figs.); Delfinado, 1961: 666 (diagnosis; figs.; Philippines).

Female.--Wing length 0.95 (0.90-1.02, n = 7) mm.

Head: Antenna (fig. 33a) with lengths of flagellar segments in proportion of 20-19-20-20-22-20-20-20-26-24-30-33-46, antennal ratio 0.98 (0.94-1.00, n = 5); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 33b) with lengths of segments in proportion of 9-16-20-9-11; third segment short and stout, with sensilla grouped together on apical third of segment; palpal ratio 2.1 (1.9-2.3, n = 6). Proboscis short, P/H Ratio 0.52; clypeus swollen; mandible (fig. 33e) slender with apex bent abruptly, bearing 8 (n = 11) large recurved teeth, the basal ones somewhat larger, the apex of mandible somewhat hatchet-shaped.

Thorax: Mesonotum, scutellum and upper half of pleuron yellow; postscutellum and lower part of pleuron slightly darkened. Legs (fig. 33c) dark with distinct pale bands; foreleg with knee spot dark, narrow subapical band on femur and subbasal band on tibia pale; midleg with knee, distal third of femur and basal fourth of tibia pale; hindleg with knee spot dark, subapical band on femur and all of tibia

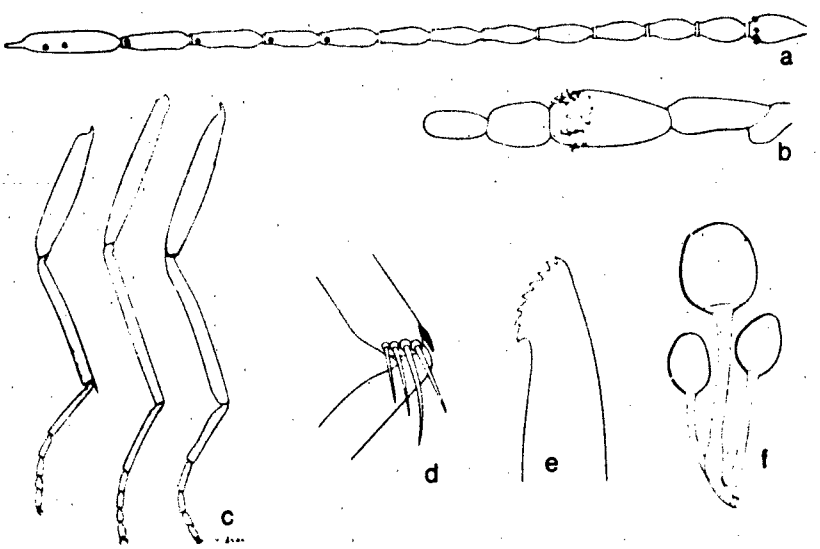


Fig. 33. *Culicoides balsasi*: a. antenna; b. palpus; c. legs; d. tibial comb; e. mandible; f. spermathecae.

Wing (fig. 200, 361): Pattern as figured; pale markings extensive; three small dark areas on costal margin; large pale area present over r-m crossvein; pale area covering second radial cell extending nearly to its base; wing narrowly pale at apex. Costal ratio 0.69 (0.69-0.71, n = 7). Halter pale.

Abdomen: Pale brown, terga poorly sclerotized, twice as broad as long on third segment. Spermathecae (fig. 33d) 3, unequal, a large one 0.041 x 0.037 mm, and 2 small subequal ones each 0.028 x 0.022 mm; without sclerotized necks, the openings to the ducts large; large spermatheca transversely rugulose.

Male.--Unknown.

Distribution.--Malaysia, Philippines, Solomons.

Types.--Holotype female, Philippines, Samar, Taft, 26.xi.1935, I. Balatbat, from carabao-baited trap (Type in USNM). Paratypes, 27 females.

Southeast Asia Records.--

MALAYSIA: Johore, Kahan Kluang (Hubert); Kelantan, Kota Bharu, from cattle shed (Garcia); Negri Sembilan, Pekan Lama (Garcia); Pahang, Kg. Berchang, Kuala Lipis, near buffalo (Garcia); Pahang, Kuala Singgora (Traub); Selangor, Kuala Selangor, Berjuntai, 6 km NW Batang, CO_2 baited trap in fresh-water swamp forest (Garcia).

PHILIPPINES: Lubon, Pampanga, Angeles, Clark Air Base (Balatbat); Luzon, San Pablo, Laguna (Balcita); Luzon, Tala, Rizal (Santos); Mindanao, Kidapawan, Cotabato (Kalaw); Mindanao, Tagum, Davao (Fontanilla); Mindanao, E. Zamboanga (Casimiro); Samar, Taft (Balatbat, types).

SINGAPORE: Nee Soon (Colless).

Discussion.--Culicoides baisasi is closely related to *culiciphagus* Wirth and Hubert from the Solomon Islands, which it closely resembles in structure of mandible, spermathecae, and palpus, but from which it can be distinguished by the more extensive pale wing markings, presence of distinct leg bands, and pale halteres. It is interesting that the widespread *C. anophelis* Edwards does not occur in the Philippines, although its range does extend farther north to Taiwan, it being replaced as a mosquito parasite in the Philippines by *baisasi*. Two females of *baisasi* have been examined from Lunga, Solomon Islands, 11.i.1966, R. Sloof, ex *Anopheles farauti* Laveran, thus overlapping the range of *culiciphagus*.

Culicoides pendleburyi Wirth and Hubert, new species
(fig. 34, 201, 362)

Female.--Wing length 1.29 mm.

Head: Antenna (fig. 34a) with lengths of flagellar segments in proportion of 40-32-32-32-30-30-32-34-45-47-50-50-68, antennal ratio 0.99; sensilla coeloconica present on segments 3,11-15. Palpal segments (fig. 34b) with lengths in proportion of 10-30-30-16-20; third segment short and scarcely swollen, with sensilla borne in a small irregular distal sensory pit; palpal ratio 2.3. Proboscis short, P/H Ratio 0.60; mandible (fig. 34d) with 7 broad, subequal, recurved teeth.

Thorax: Mesonotum, scutellum and postscutellum moderately dark brown, pleuron slightly paler. Legs (fig. 34f) yellowish; knee spots, especially on hindfemur, and apices of fore- and hindtibiae brownish; tibial comb as in fig. 34e.

Wing (fig. 201, 362): Pattern as figured; nearly unicolorous grayish brown, veins slightly darker; two indistinct pale spots, one over r-m crossvein, the other covering distal third of second radial cell. Macrotrichia very sparse at extreme tip of wing; costal ratio 0.68, first radial cell narrow, second with broad lumen. Halter slightly grayish.

Abdomen: Terga well sclerotized, dark brown, about three times as broad as long on third segment. Spermathecae (fig. 34c) 3; with characteristic shapes, elongate with distal portion slightly swollen, proximal portion subcylindrical, strongly sclerotized, with broad entrances to the ducts; unequal, the large one 0.046 x 0.025 mm, the two smaller ones subequal, each 0.019 x 0.009 mm; ducts of all 3 joined at one point at the sclerotized ring.

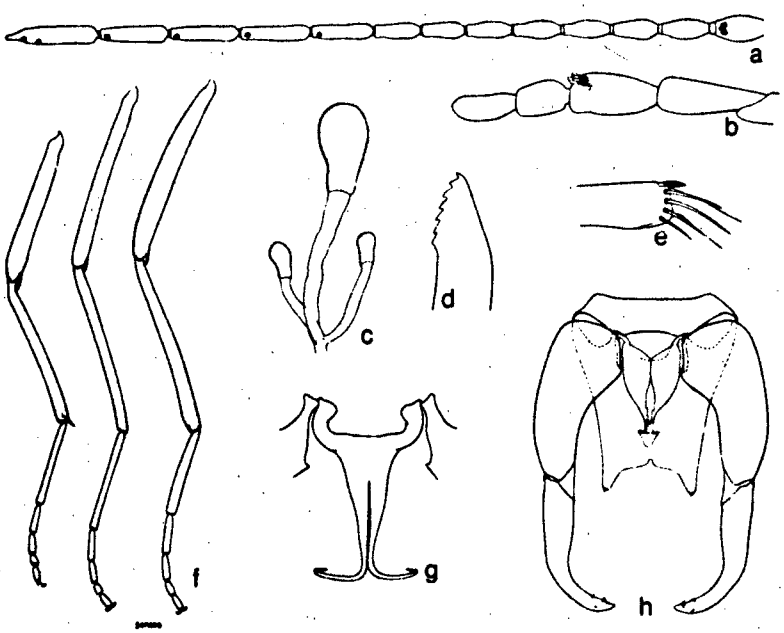


Fig. 34. *Culicoides pendleburyi*: a. antenna; b. palpus; c. spermathecae; d. mandible; e. tibial comb; f. legs; g. parameres; h. male genitalia, parameres omitted.

Male.--Similar to female, with usual sexual differences. Genitalia (fig. 34h): Ninth sternum without caudomedian excavation; ninth tergum strongly sclerotized and tapering to prominent, large, triangular, apicolateral processes, the caudal margin between them concave with small median cleft. Basistyle moderately stout at base, slender laterally, bowed distally, ventral root absent, dorsal root short and blunt; dististyle slender, distinctly sinuate, with pointed tip. Aedeagus with basal arch extending to a third of total length, basal arms stout; main portion with margins parallel basally, tapering distally to slender process bearing a caplike tip. Parameres (fig. 34g) fused for some distance at bases; each with short basal knob forming with the anterior margin of the fused portion, a strongly sclerotized, low basal arch; distal free portions slender, straight and contiguous and slightly tapering a considerable distance, then abruptly bent laterad and ventrad and ending in a slender, simple pointed tip.

Distribution.--Malaysia.

Types.--Holotype female, allotype male, Malaya, Pahang, Mt. Brinchang, 1,600 m, iii.1963, H.E. McClure, light trap (in USNM). Paratypes, 6 males.

MALAYSIA: Pahang, same data as types, 5 males. Perak, Maxwell Hill, Gunong Hijan Trail, 25.vi.1958, R. Traub, light trap, 1 male.

Discussion.--The stout recurved mandibular teeth of equal lengths, unicolorous thoracic dorsum, pale legs and fused parameres of the male genitalia place this species in the Anophelis Group. The shapes of the female spermathecae and the apicolateral processes and the aedeagus of the male genitalia are highly diagnostic. This species is dedicated to the memory of Mr. H.M. Pendlebury who in the early entomological history of Malaysia contributed so much to our knowledge of the insect fauna of the higher mountain peaks.

Flavescens Group

Culicoides flavescens Macfie
(Figs. 35, 202, 363)

Culicoides anophelis Edwards, var. *flavescens* Macfie, 1937a: 114 (female; Malaya, on cattle).

Culicoides anophelis Edwards, misident.; Causey, 1938: 409 (in part, misident.; female; Thailand).

Culicoides flavescens Macfie; Wirth and Hubert, 1959: 13 (status; records; figs.); Tokunaga, 1959: 247 (redescribed; figs.; New Guinea); Delfinado, 1961: 667 (diagnosis; figs.; Philippines); Tokunaga, 1962b: 501 (male; fig.; genitalia; New Guinea); Tokunaga, 1963a: 136a: 136 (New Guinea record); Howarth, 1985: 21 (Laos records; pupa described).

Culicoides subflavescens Wirth and Hubert, 1959: 14 (male, female; N. Borneo; figs.). NEW SYNONYMY.

Female.--Wing length 1.03 (0.97-1.07, n = 8) mm.

Head: Antenna (fig. 35a) with lengths of flagellar segments in proportion of 22-19-20-21-21-21-19-19-26-27-32-35-55, antennal ratio 1.10 (1.08-1.13, n = 8); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 35b) with lengths of segments in proportion of 10-18-25-11-13; third segment slender, sensilla scattered on surface; palpal ratio 2.8 (2.5-3.1, n = 7). Proboscis short, P/H Ratio 0.60; mandible (fig. 35d) with 21 (13-24, n = 13) teeth, distal teeth of series larger, teeth in middle of series small and even, triangular, 5-6 proximal teeth in series very sharp and directed distad.

Thorax: Mesonotum and upper pleuron pale yellow, scutellum pale brown, postscutellum and lower pleuron dark brown. Legs (fig. 35e) pale brown; fore- and midlegs with knees, distal halves of femora, and basal halves of tibiae pale yellow; hindleg with femur brown and with broad subapical pale band, knee dark, tibia entirely pale; tibial comb as in fig. 35d.

Wing (fig. 202, 363): Pattern as figured; pale areas extensive, brown infuscation prominent along veins; three small dark brown areas on anterior margin; pale areas over r-m crossvein and second radial cell very large, latter spot covering

second radial cell nearly to base and scarcely extending past apex of cell into cell R5; apex of wing usually dark, indistinctly pale in the palest specimens. Costal ratio 0.71 (0.69-0.72, n = 8). Halter pale.

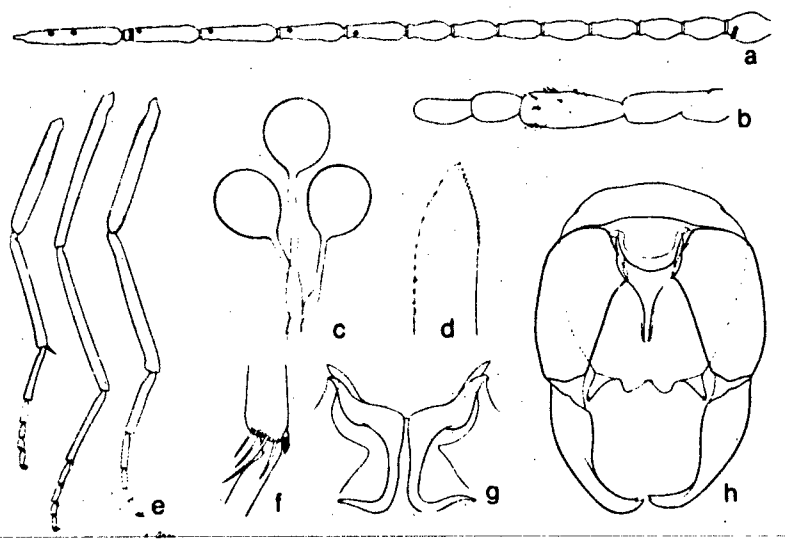


Fig. 35. *Culicoides flavescens*: a. antenna; b. palpus; c. spermathecae; d. mandible; e. legs; f. tibial comb; g. parameres; h. male genitalia, parameres omitted.

Abdomen: Yellow, terga unsclerotized except on eighth segment which is brown. Spermathecae (fig. 35c) 3, subequal, each 0.033 x 0.026 mm; slightly ovoid, necks very slender and sclerotized a short distance.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 35h): Ninth sternum with shallow caudomedian excavation; ninth tergum short, sides convex, apicolateral processes moderately long, very slender and pointed, the caudal margin between them with a pair of well developed, laterally pointed, submedian lobes. Basistyle with ventral root reduced, dorsal root slender; dististyle curving with slender pointed tip. Aedeagus with basal arch rounded, extending to a third of total length, basal arms stout; distal portion tapering to very slender rounded tip. Parameres (fig. 35g) each with short, moderately stout basal arm directed anterolaterad; stem very slightly swollen on basal portion, abruptly narrowed to

moderately slender, straight middle portion; distal portion abruptly bent ventrolaterad and tapering to bluntly pointed tip (described from a male from Kuala Lumpur, Malaya).

Distribution.--Indonesia, Laos, Malaysia, New Guinea, Philippines, Sabah, Sarawak, Solomon Islands, Thailand.

Types.--Of *flavescens*: Malaya, Kuala Lumpur, 1936, on cattle, J.J. Buckley, 3 female syntypes in BMNH, London. Of *subflavescens*: Holotype female, Malaysia (Borneo), Labuan Island, i.1959, D.H. Colless, at light (Type in USNM); paratypes, 3 males, 28 females.

Southeast Asia Records.--

INDONESIA: Bali, Badung, Denpasar, Tuban, Kampung Bugis (Lee); Badung, Mengwi (Lee). Java (West), Bogor (Adiwinata); Yogyakarta, Tungkak, Kampung Giwangan (Lee); (Central), Cilacap, Adipala, Bunton (Lee); (West), Garut, Pameungpeu, (Zubaedah). Kalimantan (South), Banjar, Astambul, Tanah Intan, Simpang Empat, Kampung Jawa (Lee). Lombok (West), Mataram, Gerung, Dasan Geras (Lee). Sumatra, Bengkulu, Bukit Peninjauan and Pekik Nyaring (Mathis); North Lampung, Kotabumi, Way Abung III, Mulyorago (Lee). Sumba, Kabaru, 96 km E Waingapu (Boeadi).

LAOS: Sayaboury Prov., Sayaboury and Wing Hon; Nam Houng River margin. Vientiane Prov., Ban Na Pheng, Ban Keun (all collected by Howarth).

MALAYSIA: Negri Sembilan, Telok Pelandok, Port Dickson (Traub). Pahang, Telok Sisek (Wharton). Selangor, Kuala Lumpur (Barnett); Segambut (Barnett); Serdang (Barnett). Trengganu, Bukit Besi (Traub).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Samar, Taft (Balatbat).

SABAH: Labuan Island (Colless).

SARAWAK: Limbang (Colless).

THAILAND: Bangkok (Causey, 1938). Chiang Rai (Causey, 1938). Nong Kai Prov. and Dist. Manop R.). Udonthani Prov. and Dist. (Manop R.).

Discussion.--*Culicoides flavescens* was first confused with *anophelis* Edwards and was the basis for some erroneous records of *anophelis* biting vertebrates. Macfie recognized it as different in 1937 but called it only a variety of *anophelis*. *Culicoides flavescens* is distinguished by its distinctive mandibular teeth, simple tarsal claws and entirely yellow mesonotum. It can be distinguished from the other two species of the Flavescens Group by the larger mandibular teeth and the color of the mesonotum.

Wirth and Hubert described *C. subflavescens* as a distinct species from *flavescens* on the basis of the darker basal part of the hindfemur and by the apical mandibular tooth not enlarged and not set off from the others. We have noted frequent intergradation within series in these rather weak characters and are convinced that a single species is involved.

Biology.--Howarth (1985) reared *C. flavescens* in Laos from a shaded stream margin in a bamboo thicket, and from a shaded stagnant backwater margin. Both were shaded muddy water margin sites, more or less polluted.

Culicoides paraflavescens Wirth and Hubert
(Figs. 36, 203, 364)

Culicoides paraflavescens Wirth and Hubert, 1959: 15 (male, female; Sri Lanka; figs.); Kitaoka, 1977: 195 (records, Nansai Is.); Howarth, 1985: 24 (Laos record).

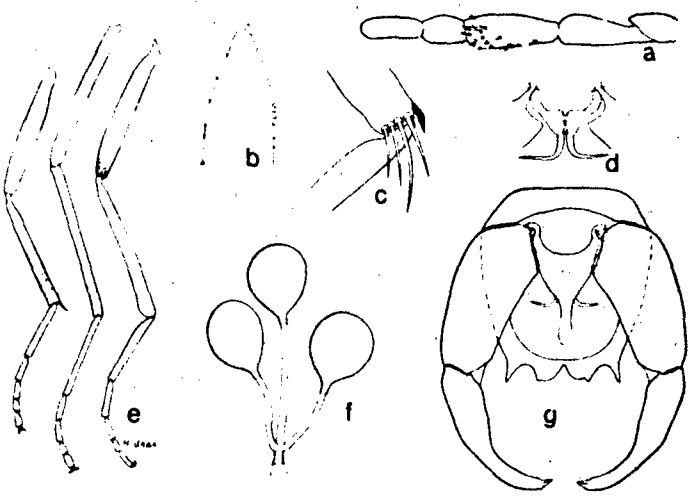


Fig. 36. *Culicoides paraflavescens*: a. palpus; b. mandible; c. tibial comb; d. parameres; e. legs; f. spermathecae; g. male genitalia.

Female.--Wing length 1.13 (1.07-1.16, n = 10) mm.

Head: Antenna with lengths of flagellar segments in proportion of 21-19-20-21-22-22-21-22-30-29-38-39-56, antennal ratio 1.12 (1.09-1.20, n = 9); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 36a) with lengths of segments in proportion of 11-18-26-12-16; third segment slender, sensilla scattered on surface of apical half; palpal ratio 3.0 (2.9-3.5, n = 10). Proboscis short, P/H Ratio 0.55; clypeus broad and convex; mandible (fig. 36b) with 20 (19-23, n = 12 teeth, apical tooth distinctly larger and separated from second, distal teeth of series large, decreasing in size to smaller, even, triangular teeth, 4-5 proximal teeth in series very sharp and directed distad.

Thorax: Mesonotum pale yellow, dark brown on anterior fourth; scutellum and postscutellum dark brown; pleuron yellow above, dark brown on lower half. Legs (fig. 36e) pale brown; fore- and midlegs with knees, distal halves of femora and basal halves of tibiae pale yellow; hindfemur brown with broad subapical pale band, apex dark; hindtibia entirely pale, tibial comb as in fig. 36c.

Wing (fig. 203, 364): Pattern as figured; pale areas not as extensive as in *flavescens*; two dark brown areas on costal margin, first a small area over vein R1; second a larger area just past end of second radial cell, cell R5 posterior to the latter distinctly infuscated across to vein M1; veins M1 and M2 infuscated along entire length to wing tip; pale areas over r-m crossvein and second radial cell moderately large, the former spot covering about half of first radial cell and the latter covering second radial cell nearly to base; apex of wing pale at apices of cells R5 and M1. Costal ratio 0.70 (0.69-0.72, n = 10). Halter pale.

Abdomen: Pale brown, terga poorly sclerotized, twice as broad as long on third segment. Spermathecae (fig. 36f) 3, subequal, each 0.035 x 0.026 mm, slightly ovoid, the entrances to the ducts very slender and sclerotized a short distance.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 36g): Ninth sternum with shallow caudomedian excavation; ninth tergum with apicolateral processes short and slender, caudal margin between them convex with a pair of mesally rounded submedian lobes nearly as long as apicolateral processes. Basistyle with ventral root reduced, dorsal root slender; dististyle curving with slender, pointed tip. Aedeagus with basal arch extending to nearly a third of total length, basal arms stout, distal portion moderately slender and tapering to slender rounded apex. Parameres (fig. 36d) each with stout basal arm bent laterocephalad, stem stoutly swollen, tapering gradually to fine, simple, distal point curving laterocephalad.

Distribution.--Japan (Nansai Islands), Laos, Malaysia, Sri Lanka, Thailand.

Types.--Holotype female, Sri Lanka, Colombo, Kalutaluwewa, 19.ii.1958, Medical Research Institute, light trap (Type in USNM). Allotype, 5 male and 15 female paratypes.

Southeast Asia Records.--

LAOS: Sayaboury Prov., Muong Sayaboury (Howarth); Muong Xieng Hon (Howarth). Sedone Prov., Muong Pakse, sweeping over cow (Howarth).

MALAYSIA: Ulu Kelantan, Sungei Betis (Wharton).

THAILAND: Cholburi Prov., Bangphra (Scanlon). Khon Kaen Prov., Amphoe Ban Phai and A. Chum Phae (Manop R.). Nong Khai Prov. and Dist. (Manop R.).

Discussion.--Although *C. paraflavescens* resembles *gewertzi* Causey, *humeralis* Okada, and other species in mesonotal adornment, the mandibular structure and spermathecae relate it to *flavescens* Macfie which has the mesonotum entirely yellow and the scutellum and wing paler.

Acanthostomus Group

Culicoides acanthostomus Wirth and Hubert, new species
(Figs. 37, 204, 366)

Female.--Wing length 1.00 (0.84-1.21, n = 6) mm.

Head: Antenna (fig. 37a) with lengths of flagellar segments in proportion of 24-22-24-27-28-25-26-25-34-33-36-37-49, antennal ratio 0.96 (0.90-1.03, n = 5); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 37b) with lengths of segments in proportion of 14-25-35-18-16; third segment long and slender, cylindrical, not swollen, with sensilla scattered on surface of distal half of segment; palpal ratio 3.9 (3.4-4.7, n = 5). Proboscis moderately long, P/H Ratio 0.71; mouthparts heavily sclerotized; lacinia (fig. 37f) and mandible with very large, rake-like teeth in opposing series; mandible (fig. 37e) with 9 (9-10, n = 12) very long, backwardly bent, sharp teeth, the distal one more widely spaced, the third to the fifth slightly shorter, and the remaining 4 of increasing lengths toward base of the mandible.

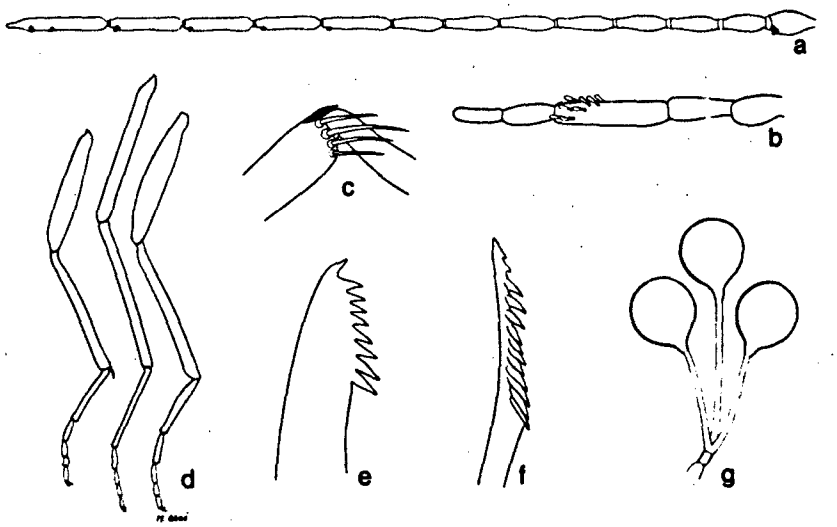


Fig. 37. *Culicoides acanthostomus*: a. antenna; b. palpus; c. tibial comb; d. legs; e. mandible; f. lacinia; g. spermathecae.

Thorax: Uniformly pale yellow including scutellum and postscutellum. Legs (fig. 37d) pale yellow; hind tibial comb as in fig. 37c.

Wing (fig. 204, 366): Pattern as figured; pale yellowish white with indistinct darker streaks along veins; 3 small dark spots on anterior margin; wing tip not paler than disc. Macrotrichia restricted to a few at extreme tip of wing; costal ratio 0.78 (0.76-0.79, n = 6); second radial cell broad, 2.5 times as long as first. Halter pale.

Abdomen: Pale yellow, terga unsclerotized. Spermathecae (fig. 37g) 3, subequal, each 0.039 x 0.030 mm, ovoid with short sclerotized necks, entrances to ducts slender, ducts of 2 lateral spermathecae joining before junction with that of middle spermatheca at ring.

Male.--Unknown.

Distribution.--Malaysia.

Types.--Holotype female, Malaysia, Selangor, Kuala Lumpur, viii.1958, R. Traub, light trap (Type in USNM). Paratypes, 5 females, same data except dates August and October 1958.

Discussion.--This species is readily distinguished by the uniform pale yellow color and by the very greatly developed armature of the mandibles and laciniae. The presence of 3 subequal spermathecae with slender necks, as well as the pale color pattern, ally *acanthostomus* with the Flavescens Group of *Trithecoides*, forming a link with *tenuipalpis* Wirth and Hubert.

Tenuipalpis Group

Culicoides nyungnoi Howarth
(Figs. 38, 205)

Culicoides nyungnoi Howarth, 1985: 24 (female; Laos; figs.).

Female.--Wing length 0.98 (0.95-1.03, n = 6) mm.

Head: Eyes contiguous, the diameter of 4 facets, bare. Antenna (fig. 38a) with lengths of flagellar segments in proportion of 20-17-16-16-17-16-17-17-25-24-31-33-50, antennal ratio 1.12 (1.06-1.20, n = 6); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 38b) with lengths of segments in proportion of 8-23-21-11-12; third segment short, swollen in middle, with scattered sensilla on distal half; palpal ratio 2.2 (2.1-2.4, n = 6). Proboscis very short, P/H Ratio 0.54; mandible (fig. 38c) with 8 (7-9, n = 6) large teeth, distal ones larger and more widely spaced; lacinia with 10 small teeth, distal ones slightly larger.

Thorax: Bright yellow; mesonotum sometimes dark just before scutellum; postscutellum and lower half of pleuron brown. Legs (fig. 38f) brown with wide pale bands; fore- and midknees broadly pale, hindfemur with wide diffuse pale subapical band, knee dark; hindtibia with wide basal pale band, apex dark; hindtibial comb with 4 spines, second from spur longest.

Wing (fig. 38d, 205): Pattern as figured, predominantly dark, paler between veins; two small pale spots on anterior margin, one over r-m crossvein and the other over tip of second radial cell; other pale spots located mainly between the

veins and diffuse; base of wing including part of anal angle pale; apex of wing narrowly pale; a large pale spot in middle of cell M1 which sometimes laps over vein M2 into cell M2; a large pale spot and streak in cell M2 at base of mediocubital fork and in medial fork; small indistinct pale spots located in apices of cells M2 and M4, a large indistinct pale spot apically in anal cell. Macrotrichia confined to near anterior margin of cell R5 distad of second radial cell and a few longitudinal lines in cells R5, M1, and M2; costal ratio 0.71 (0.70-0.72, n = 6). Halter distinctly infuscated to dark.

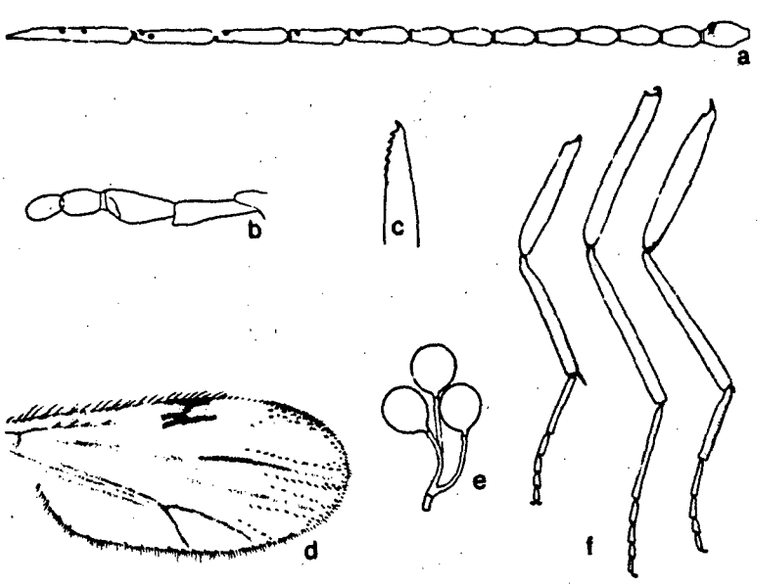


Fig. 38. *Culicoides myungnoi*: a. antenna; b. palpus; c. mandible; d. wing; e. spermathecae; f. legs.

Abdomen: Terga light brown. Spermathecae (fig. 38e) 3, subequal, pyriform, with short, narrow, sclerotized necks, each 0.033 x 0.026 mm.

Male.--Unknown.

Distribution.--Laos.

Types.--Holotype female, Laos, Sedone Prov., Muong Pakse, 100 m, 3.ix.1967, at light in forest, F.G. Howarth (Bishop Museum). Paratypes, 5 females, same data as type; 3 females from Vientiane Prov., Muong Ban Keun, Ban Na Pheng, 180 m, 21.v.1968, F.G. Howarth, light trap.

Discussion.--This species is intermediate between *C. tenuipalpis* and species of the Macfiei Group. The three subequal pyriform spermathecae and 8 mandibular teeth place it in the Tenuipalpis Group, but *nyungnoi* differs from the two other known species of that group by the thoracic and wing pattern and the short third palpal segment. In the latter respects it is more like *C. palpifer* of the Macfiei Group.

Culicoides paksongi Howarth
(Figs. 39, 206)

Culicoides paksongi Howarth, 1985: 25 (female; Laos; figs.).

Female.--Wing length 1.38 mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 39a) with lengths of flagellar segments in proportion of 21-24-24-24-27-25-25-26-34-35-41-44-56, antennal ratio 1.97; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 39b) with lengths of segments in proportion of 9-34-31-11-20; third segment long and slender, slightly broader than segments 2 and 4; sensilla scattered over distal half of segment; palpal ratio 3.4. Proboscis moderately long, P/H Ratio 0.65; mandible (fig. 39c) with 9 large teeth, distal ones slightly larger and more widely spaced; lacinia narrow with 11 small widely spaced teeth.

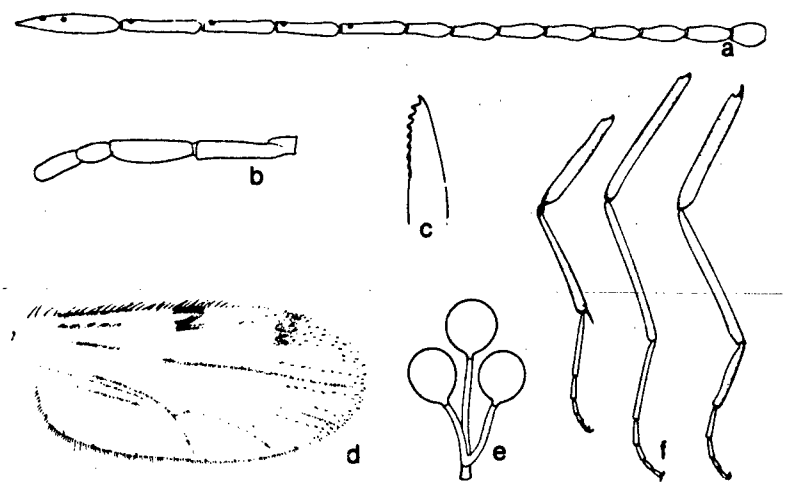


Fig. 39. *Culicoides paksongi*: a. antenna; b. palpus; c. mandible; d. wing; e. spermathecae; f. legs.

Thorax: Bright yellow; mesonotum darker in front of scutellum and very dark on anterior margin; scutellum and upper half of pleuron bright yellow; postscutellum and lower half of pleuron dark brown. Legs (fig. 39f) brown; forefemur with subapical pale band, foretibia with sub-basal pale band, midtibia with sub-basal pale band; hindknee dark, hindfemur with distinct subapical pale band, hindtibia pale on basal half, dark distally; hindtibial comb with 4 spines, second from spur longest.

Wing (fig. 39d, 206): Pattern as figured; dark stigmal spot very small on base of second radial cell; dark anterior spot distad of poststigmatic pale spot; two large pale spots on anterior wing margin, one over r-m crossvein, and one over second radial cell; second radial cell elongate and broad, almost entirely included in a pale spot; wing dark along veins, paler in cells; large indistinct pale spots located as follows: in apex of cell R5 broadly meeting anterior and distal wing margin; at base of wing including anal angle; in apices of anal cell and cell M5; pale streak along basal half of vein M2 including most of cell M2 and cell M1; pale streaks in cells M1 and M2 connecting basal pale streak with wing margin. Macrotrichia scattered in apices of cells M1 and M2; costal ratio 0.73. Halter slightly infuscated.

Abdomen: Terga brown. Spermathecae (fig. 39e) 3, subequal, pyriform, with short sclerotized necks, each 0.038 x 0.031 mm.

Male.--Unknown.

Distribution.--Laos.

Types.--Holotype female, Laos, Sedone Prov., Muong Paksong, 1,270 m, 6.ix.1967, F.G. Howarth, at light (in Bishop Museum).

Southeast Asia Records.--
LAOS: Known only from the holotype female.

Discussion.--This species differs from *C. tenuipalpis* Wirth and Hubert in the markings of the thorax and legs, and the presence of only 4 spines in the hindtibial comb.

Culicoides tenuipalpis Wirth and Hubert
(Figs. 40, 207)

Culicoides tenuipalpis Wirth and Hubert, 1959: 16 (Taiwan; female; figs.); Howarth, 1985: 27 (pupa described; Laos records).

Female.--Wing length 1.53 mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 40a) with lengths of flagellar segments in proportion of 36-32-32-32-33-32-32-31-46-47-56-58-76, antennal ratio 1.09; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 40b) with lengths of segments in proportion of 15-26-40-12-17; third segment very long and slender, not broader than segments 2 or 4, with sensilla scattered

over entire surface of segment; palpal ratio 4.4. Proboscis long, P/H Ratio 0.72; mandible (fig. 40e) with 8 teeth, distal ones slightly larger and more widely spaced.

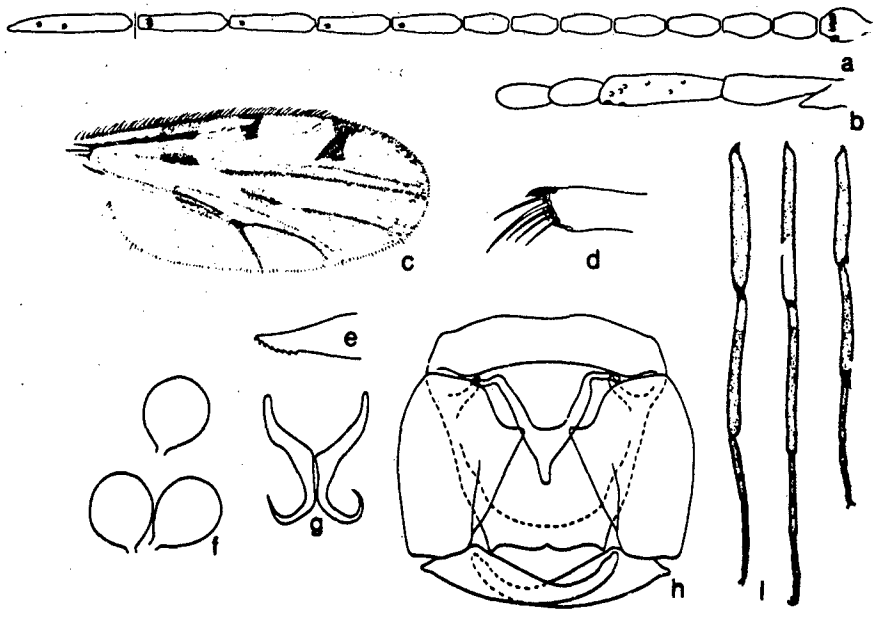


Fig. 40. *Culicoides tenuipalpis*: a. antenna; b. palpus; c. wing; d. tibial comb; e. mandible; f. spermathecae; g. parameres; h. male genitalia, parameres omitted; i. legs.

Thorax: Dark brown, mesonotum without pattern. Legs (fig. 40i) dark brown; knees dark; fore- and midfemora with narrow subapical pale ring and all tibiae with narrow sub-basal pale ring; tarsi paler brown; hindtibial comb (fig. 40d) with 5 spines, second from spur longest.

Wing (fig. 40c, 207): Pattern as figured; second and third dark marks on anterior margin and lines along veins very dark brown; with well-defined pale spots as follows: large rounded spot over r-m crossvein extending broadly to costal margin; large spot over second radial cell, extending nearly to its base and only slightly past its tip and into cell R5 two-thirds way to vein M1; large elongate spot at wing tip in cell R5 filling nearly all of apex of cell; a small spot broadly meeting wing margin in cell M1; a small spot straddling middle of vein M2; large spots broadly meeting wing margin in apices of cells M2 and M4, latter broadly bordering vein M3+4 on distal two-thirds; spots in cell M2 in front of mediocubital fork and lying behind stem of medial fork; 2 spots in distal portion of anal cell, larger one behind stem of mediocubital fork and smaller one at wing margin; base of

wing broadly pale from front to hind margins. Macrotrichia scanty in apices of cells R5 and M1; costal ratio 0.69; second radial cell broad, twice as long as first. Halter pale, slight trace of infuscation on knob.

Abdomen: Dark brown. Spermathecae (fig. 40f) 3, subequal, 0.042 x 0.032 mm, 0.040 x 0.029 mm, and 0.039 x 0.029 mm, ovoid with rt sclerotized necks.

Male.--Similar to the female with the usual sexual differences; hindtibial comb with 4 spines, the second from the spur longest. Genitalia (fig. 40h): Ninth sternum without perceptible caudomedian excavation; ninth tergum short and broad, apicolateral processes short, forming only a small angle on the margin of tergum, caudal margin between them with slight median cleft and sinuate margin. Basistyle with ventral root small, dorsal root slender; dististyle curving with slender, pointed tip. Aedeagus short and broad; basal arch extending to half of total length, basal arms slender with prominent recurved ends; distal portion broad at base, markedly tapering to slender tip. Parameres (fig. 40g) separate; each with rather long, curved, basal arm; midportion only moderately swollen at base of contiguous part; gradually tapering distally to slender, pointed, simple tip curving lateroventrad.

Distribution.--Laos, Taiwan, Thailand.

Types.--Holotype female, Taiwan, 1954, Su-yong Liu (on slide), deposited in the Taiwan Malaria Research Institute, Chaochow, Taiwan.

Southeast Asia Records.--

LAOS: Sayaboury Prov., Muong Phieng, 1 male, 1 female, reared from partly shaded rut margin (Howarth); Muong Sayaboury, 5 females, reared from partly shaded stream margin (Howarth).

THAILAND: Karnchanaburi (Niphan).

Discussion.--This species occupies an anomalous position in *Trithecoides*; resembling *macfiei* Causey in mandibular structure and color of mesonotum, but appearing more like *anophelis* Edwards and the Flavescens Group in wing pattern and spermathecal structure. The extremely slender third palpal segment and the 5 tibial spines of the female are unique in the subgenus.

Macfiei Group

Culicoides cylindripalpis Wirth and Hubert
(Figs. 41, 208, 365)

Female.--Wing length 1.01 (0.95-1.08, n = 2) mm.

Head: Antenna (fig. 41a) with lengths of flagellar segments in proportion of 22-23-25-26-27-27-25-25-30-31-33-32-49, antennal ratio 0.86 (0.85-0.87, n = 2); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 41b) with lengths of segments in proportion of 10-17-37-10-11; third segment elongate and slightly swollen its entire length, cylindrical, with sensilla scattered over surface of seg-

ment; palpal ratio 3.8 (3.4-4.2, n = 2). Proboscis moderately long, P/H Ratio 0.77; mandible (fig. 41e) with 7 (7-8, n = 4) recurved teeth, the distal one slightly larger and widely spaced.

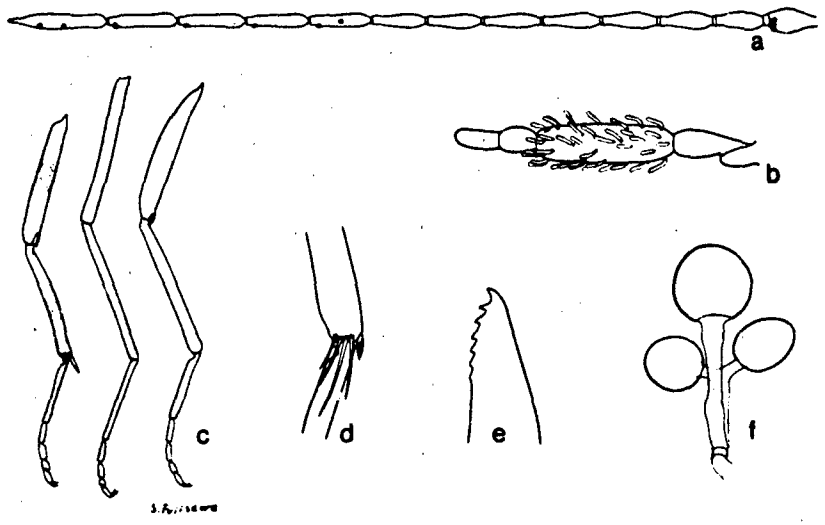


Fig. 41. *Culicoides cylindripalpis*: a. antenna; *b.* palpus; c. legs; d. tibial comb; e. mandible; f. spermathecae.

Thorax: Mesonotum, scutellum and postscutellum yellow; lower pleuron pale brown. Legs (fig. 41c) brown; all knees pale; femora with distal and tibiae with basal, broad pale bands; hindtibia entirely pale, tibial comb as in fig. 41d.

Wing (fig. 208, 365): Pattern as figured; 3 dark spots on anterior margin; moderately strong infuscation along veins leaving indistinct pale areas between in the cells; tip of wing broadly pale. A few macrotrichia at wing tip; costal ratio 0.72 (0.71-0.73, n = 2); second radial cell only 1.3 times as long as first. Halter infuscated.

Abdomen: Brownish, sclerotized terga moderately broad. Spermathecae (fig. 41f) 3, unequal, with large entrances to ducts; larger one 0.031 x 0.031 mm, the 2 small ones each 0.024 x 0.022 mm, more or less globular; in holotype ducts of the 2 small spermathecae joined together very near to spermathecae, their common duct about 3 times as long as their separate ones and joining the duct from the large spermatheca near the ring; in paratype, the ducts from the small spermathecae joint just before juncture with third duct near the ring; ducts without enlarged sacs.

Male.--Unknown.

Distribution.--Malaysia, Singapore.

Types.--Holotype female, Malaysia, Tregganu, Dungun, Bukit Besi, 6.viii.1958, R. Traub, light trap (Type in USNM). Paratypes, 7 females, as follows:
MALAYSIA: Kelantan, Ulu Kelantan, Sungei Betis, 9.xi.1961, R.H. Wharton, light trap, 3 females. Pahang, King George V Nat. Park, 4-6.xi.1959, H.E. McClure, light trap, 1 female. Perak, Pulau Pangkor, 1.iv.1959, R. Traub, light trap, 1 female. Selangor, Kuala Lumpur, 10.x.1958, R. Traub, light trap, 1 female.
SINGAPORE: Nee Soon, 20.i.1960, D.H. Colless, light trap, 1 female.

Discussion.--The cylindrical palpi will distinguish this species from the other species in the subgenus *Trithecoides* with uniformly pale mesonotum, scutellum and postscutellum and 7 mandibular teeth with the distal one enlarged.

Culicoides luteolus Wirth and Hubert, new species
(Figs. 42, 209, 367)

Female.--Wing length 1.08 mm.
Head: Antenna with lengths of flagellar segments in proportion of 23-25-27-27-28-27-27-27-41-40-44-47-70, antennal ratio 1.15; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 42a) with lengths of segments in proportion of 12-22-25-x-x; third segment slightly swollen toward apex, with sensilla borne in a definite shallow pit; palpal ratio 2.4. Proboscis short, P/H Ratio 0.45; mandible (fig. 42b) with 7 (n = 2) widely spaced, recurved teeth of subequal lengths.

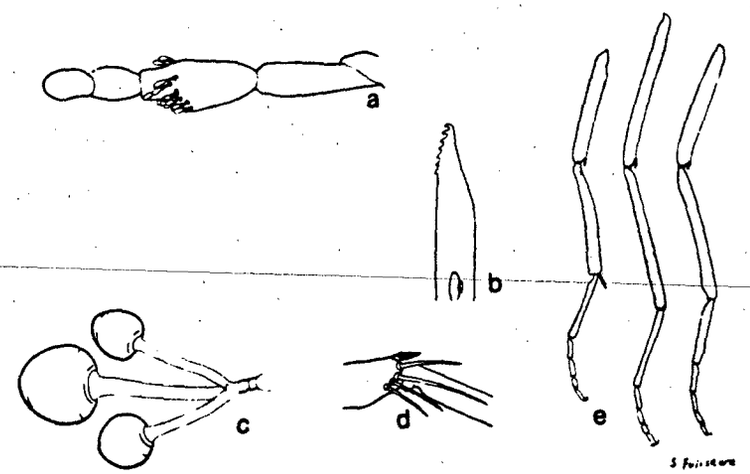


Fig. 42. *Culicoides luteolus*: a. palpus; b. mandible; c. spermathecae; d. tibial comb; e. legs.

Thorax: Mesonotum, scutellum and postscutellum yellow; lower pleuron brownish. Legs (fig. 42e) brown; all knees pale, femora with apical and tibiae with basal, broad pale bands; hindtibia entirely pale, tibial comb as in fig. 42d.

Wing (fig. 209, 367): Pattern as figured; extensively yellowish; anterior margin with 2 very dark brown spots, one over extreme apex of first radial cell and extreme base of second radial cell, second just past tip of second radial cell; veins extensively infuscated leaving paler areas in cells; wing tip slightly paler. Wing bare of macrotrichia except a few at margin at apex of cell R5: costal ratio 0.72; second radial cell broad and twice as long as first. Halter infuscated.

Abdomen: Pale brown; terga moderately sclerotized, twice as broad as long on third segment. Spermathecae (fig. 42c) 3, unequal, with large entrances to ducts; large one 0.031 x 0.033 mm, 2 smaller ones each 0.022 x 0.022 mm; the larger one broader than long, surface with transverse rugosity; ducts of all 3 joined in 1 point just before the ring, without enlarged sac at the juncture.

Male.--Unknown.

Distribution.--Indonesia, Malaysia.

Types.--Holotype female, Malaysia, Trengganu, Dungun, Bukit Besi, 6.viii.1958, R. Traub, light trap (Type in USNM). Paratypes, 52 females, as follows:

INDONESIA: Sulawesi (North), Dumoga Bone Nat. Park, 220 m, 31.x.1985, J.B. Heppner, 3 females.

MALAYSIA: Kelantan, Ulu Kelantan, Sungei Betis, 9.xi.1961, R.H. Wharton, light trap, 23 females. Pahang, Kuantan, Paya Bungor, ix-xi.1959, R.H. Wharton, light trap, 1 female; King George V Nat. Park, Tahan River, 4-6.xi.1959, H.E. McClure, light trap, 20 females. Selangor, Kuala Lumpur, x.1958, R. Traub, light trap, 1 female. Trengganu, same data as type, 4 females.

Discussion.--The pale mesonotum, scutellum, and postscutellum, dark halteres, pale yellowish wings, and pale knees with broad distal yellow band on hindfemur will separate *C. luetolus* from *palpifer* Das Gupta and Ghosh and other related species. *Culicoides subpalpifer* n. sp. is very close, with pale scutellum and postscutellum and dark halteres, but the tip of the hindfemur is dark, the large spermatheca is usually longer and without transverse rugulae, and it is a smaller species.

Culicoides macfiei Causey
(Figs. 43, 210, 368)

Culicoides macfiei Causey, 1936: 411 (male, female; Thailand; figs.); Sen and Das Gupta, 1959: 625 (redescribed; India; figs.); Wirth and Hubert, 1959: 22 (redescribed; figs.; distribution); Howarth, 1985: 28 (Laos records).

Female.--Wing length 0.99 (0.84-1.10, n = 6) mm.

Head: Antenna (fig. 43a) with lengths of flagellar segments in proportion of 21-17-18-20-22-21-22-22-31-31-40-41-55, antennal ratio 1.15 (1.05-1.21, n = 5); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 43b) with lengths of segments in proportion of 11-17-20-11-10; third segment moderately stout, with sensilla scattered on surface of segment distally; palpal ratio 2.0 (1.8-2.2, n = 9). Proboscis moderately short, P/H Ratio 0.67; mandible (fig. 43d) with 7 (6-8, n = 16) curved teeth, distal ones largest.

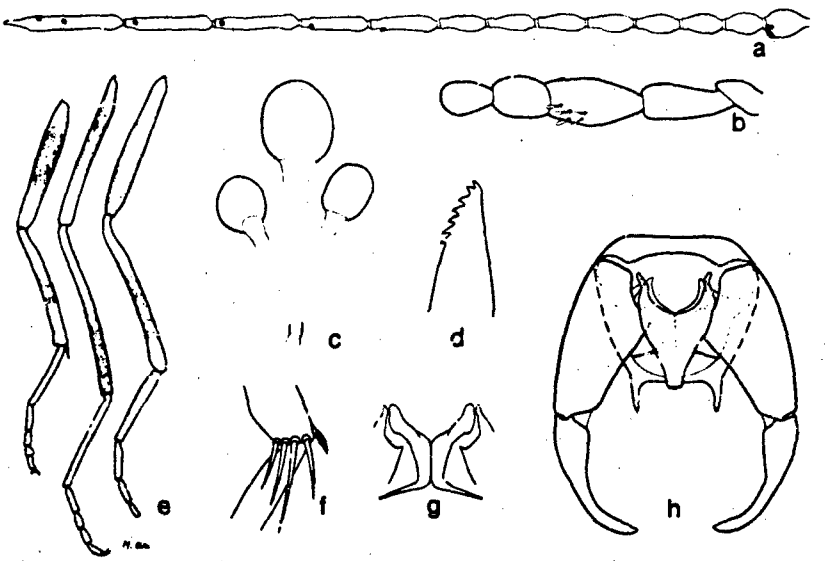


Fig. 43. *Culicoides macfiei*: a. antenna; b. palpus; c. spermathecae, d. mandible; e. legs; f. tibial comb; g. parameres; h. male genitalia, paramares omitted.

Thorax: Dark brown including mesonotum, scutellum, postscutellum, and pleuron. Legs (fig. 43e) dark brown; foreleg with knee slightly darkened, apex of femur and base of tibia broadly pale; midleg with knee, apex of femur and base of tibia broadly pale; hindfemur entirely dark, tibia with broad basal and apical pale bands; tibial comb as in fig. 43f.

Wing (fig. 210, 368): Pattern as figured; 3 darker areas on anterior margin, small but distinct pale spots over r-m crossvein and at apex of second radial cell, wing tip narrowly but distinctly pale, rest of wing dark along veins but paler in cells. Costal ratio 0.69 (0.67-0.70, n = 6). Halter infuscated.

Abdomen: Dark brown; terga well sclerotized, twice as broad as long on third segment. Spermathecae (fig. 43c) 3, unequal, a large one 0.031 x 0.032 mm, and two small subequal ones, each 0.025 x 0.024 mm; slightly broader than long, with broad, unsclerotized entrances to ducts, the ducts of all 3 spermathecae joined at one point.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 43h): Ninth sternum with shallow caudomedian excavation; ninth tergum short and rather broad distally, with long slender apicolateral processes and caudal margin between them nearly transverse, not lobate. Basistyle with ventral root small and pointed, dorsal root slender; dististyle curving with slender pointed tip. Aedeagus with basal arch extending to a third of total length, sides slightly convex, tapering to a blunt, slightly rounded tip. Parameres (fig. 43g) each with prominent basal knob; stem short, broad at base, gradually tapering to stout but sharp-pointed, laterally bent tip.

Distribution.--India, Indonesia, Laos, Malaysia, Thailand.

Type.--Holotype male, Chiang Mai Prov., Thailand, 1933, O.R. Causey (on slide, Type in USNM).

Southeast Asia Records.--
INDONESIA: Sulawesi (North), Dumoga Bone Nat. Park, 220 m (Heppner); Lake Mooat, 20 km NE Kotamobagu, 1050 m (Heppner).
LAOS: Sedone Prov., Muong Pakse (Howarth).
MALAYSIA: Selangor, Kuala Lumpur (Traub); Segambut (Barnett).
THAILAND: Bangkok (Causey). Chiang Rai (Causey). Khon Kaen Prov. and Dist. (Manop R.). Loei Prov., Dan Sai Dist. (Elbel).

Discussion.--Pinned specimens of *C. macfiei* may be distinguished from those of *C. raripalpis* Smith by the pale wing tip, which is entirely dark in *raripalpis*. The latter species, as well as *sarawakensis* Wirth and Hubert and *elbeli* Wirth and Hubert, share with *macfiei* the uniformly dark thorax, but all have 10-15 small, regular, mandibular teeth.

Culicoides manikumari Wirth and Hubert, new species
(Figs. 44, 211, 369)

Female.--Wing length 0.81 mm.
Head: Eyes contiguous (fig. 44d); bare. Antenna (fig. 44a) with lengths of flagellar segments in proportion of 25-28-20-21-23-25-24-24-35-34-40-42-63, antennal ratio 1.19; sensilla coeloconica present on segments 3,110-15. Palpus (fig. 44b) with lengths of segments in proportion of 8-10-15-10-10; third segment extremely short, with sensilla in a loose distal cluster; palpal ratio 1.1. Proboscis extremely short, P/H Ratio 0.28; mouthparts vestigial, mandible without teeth.

Thorax: Yellowish, scutellum and postscutellum brownish; lower pleuron dark brown. Legs (fig. 44f) brown; knee spots dark brown; fore- and hindfemora with moderately broad but rather indistinct pale subapical bands, fore- and midtibiae with basal pale bands; hindtibia entirely pale; tibial comb as in fig. 44e.

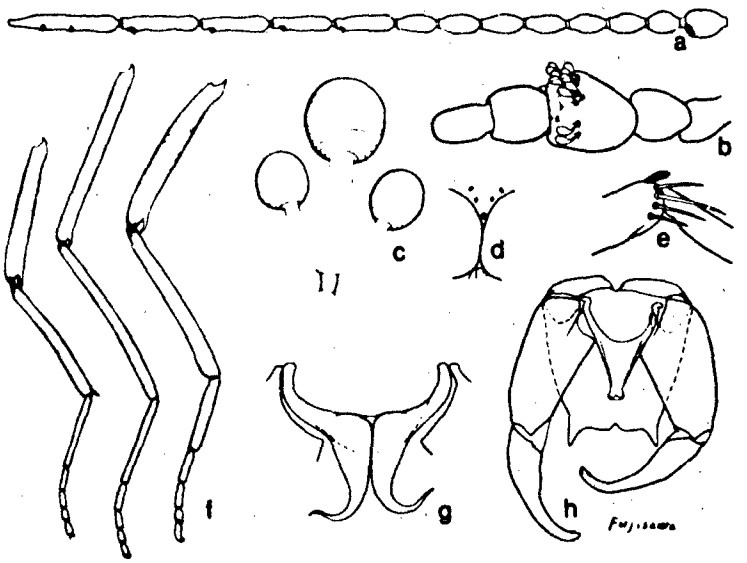


Fig. 44. *Culicoides manikumari*: a. antenna; b. palpus; c. spermathecae; d. eye separation; e. tiblal comb; f. legs; g. parameres; h. male genitalia, parameres omitted.

Wing (fig. 211, 369): Pattern as figured; indistinctly marked, only 2 moderately small pale areas, one over r-m crossvein, the other at end of costa and covering distal third of second radial cell, both rather faint; veins slightly darker than membrane which is grayish. A few macrotrichia at extreme wing tip; costal ratio 0.70. Halter with brownish knob.

Abdomen: Pale, terga poorly sclerotized. Spermathecae (fig. 44c) 3, unequal, with broad unsclerotized entrances to ducts; slightly longer than broad, large one 0.024 x 0.022 mm, the 2 smaller ones subequal, each 0.017 x 0.016 mm; ducts from all 3 joined at 1 point near the sclerotized ring.

Male.--Similar to female with usual sexual differences. Gentialia (fig. 44h): Ninth sternum with very broad and shallow caudomedian excavation; ninth tergum with short, slender, pointed, apicolateral processes, the caudal margin between them with small median cleft. Basistyle with ventral root absent, dorsal root short and slender; dististyle stout at base, slender distally, curving, with sharp distal point.

Aedeagus with faintly sclerotized basal arch extending to half of total length, basal arms short; sides of main portion straight, nearly V-shaped in ventral profile, tapering evenly to moderately slender distal portion with truncate, slightly caplike tip. Parameres (fig. 44g) separate, each with slender, rather long, anterolateral arm; main body very short, stout at base, tapering abruptly to slender simple tip curving ventrad.

Distribution.--Malaysia.

Types.--Holotype female, Malaysia, Selangor, Ulu Gombak Forest Reserve, 18.v.1961, C. Manikumar, reared from decaying wild fruit in jungle. Allotype male, same except 1.v.1960, H.E. McClure, light trap. Paratypes, 2 males, 4 females, as follows:

MALAYSIA: Same data as holotype except 11.vii.1961, 1 female; same data as allotype, 1 female; Sungei Buloh Forest Res., 4.iv.1962, C. Manikumar, reared from decaying wild fruit, 2 males, 1 female; Ulu Lui, 31.xii.1973, R. Parsons, light trap, 1 female.

Discussion.--This species is readily distinguished by its vestigial mouthparts and its pale mesonotum, brown scutellum and postscutellum, as well as the poorly marked wing and faintly banded hindfemur. The arrangement of the spermathecae ducts places it in the Macfiei Group. We are happy to name this species after C. Manikumar of the Institute of Medical Research in Kuala Lumpur, Malaysia, who under the direction of the junior author was successful in rearing a large number of Malaysian *Culicoides* from their immature stages.

Culicoides nanpui Howarth
(Figs. 45, 212)

Culicoides nanpui Howarth, 1985: 28 (female; Laos; figs.).

Female.--Wing length 0.96 mm.

Head: Eyes contiguous for a short distance, bare. Antenna (fig. 45a) with lengths of flagellar segments in proportion of 19-15-17-18-19-19-19-19-26-25-27-27-42, antennal ratio 1.00; sensilla coeloconica present on antennal segments 3,11-15. Palpus (fig. 45b) with lengths of segments in proportion of 7-21-25-12-12; third segment elongate, broad in midportion, with sensilla scattered over distal surface; palpal ratio 2.2. Proboscis short, P/H Ratio 0.58; mandible (fig. 45c) with 7 large triangular teeth, these larger distally; lacinia with 9-12 smaller teeth, slightly larger distally.

Thorax: Mesonotum dark brown with small bright yellow areas over lateral margin and on disc (as seen in slide mounts); scutellum, postscutellum, lower half of pleuron dark brown; upper half of pleuron light brown or yellow. Legs (fig. 45f) dark brown; all knees dark, fore- and midfemora each with subapical pale band; tibiae each with sub-basal pale band and dark apex; hindtibial comb with 4 spines, second from spur longest.

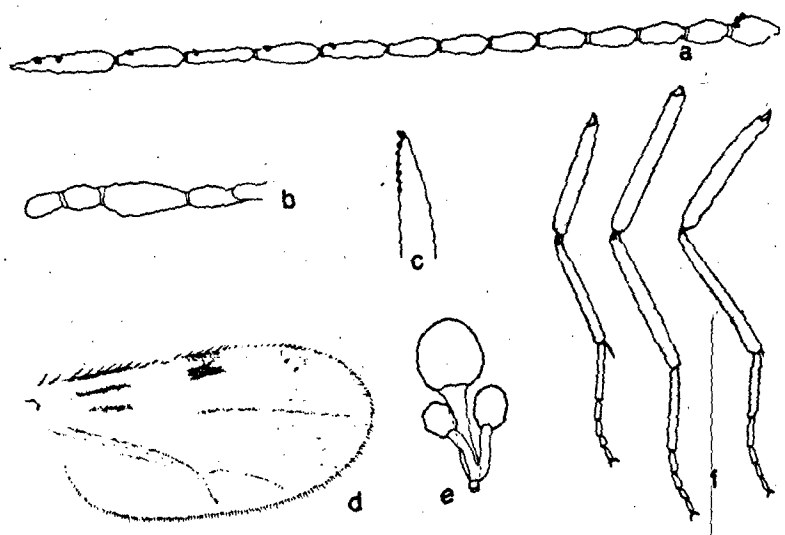


Fig. 45. *Culicoides nanpui*: a. antenna; b. palpus; c. mandible; d. wing; e. spermathecae; f. legs.

Wing (fig. 45d, 212): Pattern as figured, pale areas extensive; base of wing including anal angle broadly pale; pale spot over r-m crossvein broadly meeting anterior wing margin and confluent with spots in cell M2 and posterior wing margin in anal cell; poststigmatic pale spot covers most of large second radial cell and just meets vein M1; large double pale spot over midportion of vein M2 connected to distal wing margin by streaks in both cells M1 and M2; large distal pale spot in cell M4; very large distal pale spot in cell R5; wing tip broadly pale. Costal ratio 0.67. Halter dark.

Abdomen: Terga dark brown, terga on third segment 2.4 times as broad as long. Spermathecae (fig. 45e) 3, 1 very large and 2 subequal smaller ones with large unsclerotized entrances to ducts; large spermatheca finely rugulose, 0.038 x 0.035 mm; smaller spermathecae more elongate, each 0.026 x 0.019 mm; duct from large spermatheca enlarged saclike before joining sclerotized ring.

Male.--Unknown.

Distribution.--Laos.

Type.--Holotype female, Laos, Vientiane Prov., Muong Ban Keun, Ban Na Phen, 180 m, 21.v.1968, F.G. Howarth, light trap (Bishop Mus.).

Southeast Asia Records.--
LAOS: Sayaboury Prov., 22 km S Muong Phieng, Nam Poui River margin (Howarth). Vientiane Prov., holotype female, 2 paratype females, same data (Howarth).

Discussion.--This species is closely related to *C. macfiei* Causey, but may be separated from that species by the small bright yellow areas on the mesonotum, the dark legs, knees, and apices of the hindtibiae, and the extensively pale wing and dark halter. The pale markings on the wing closely resemble those of species in the Tenuipalpis Group.

Culicoides palpifer Das Gupta and Ghosh
(Figs. 46, 213, 370)

Culicoides palpifer Das Gupta and Ghosh, 1956a: 122 (female; India; larva reared from rotting banana plants); Wirth and Hubert, 1959: 25 (male, female; figs.); Tokunaga, 1959: 246 (female redescribed; figs.; New Guinea); Delfinado, 1961: 668 (diagnosis; figs.; Philippines); Tokunaga 1963c: 136 (Solomons, New Britain); Howarth, 1985: 29 (Laos records).

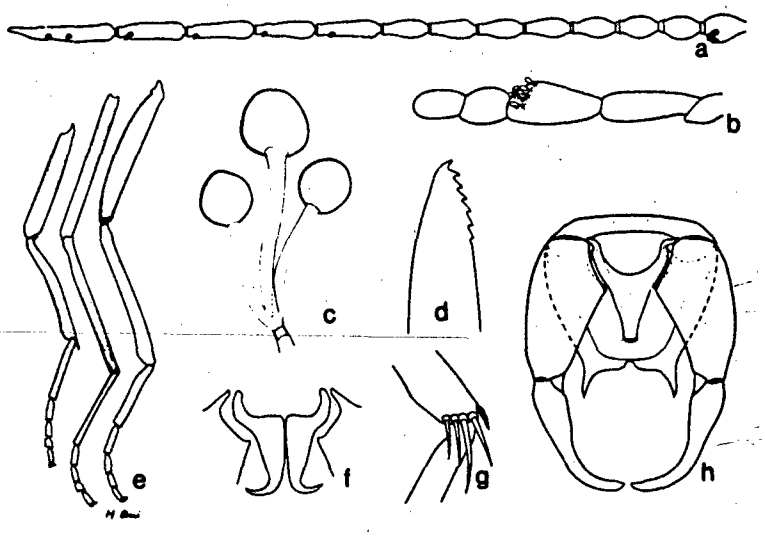


Fig. 46. *Culicoides palpifer*: a. antenna; b. palpus; c. spermathecae; d. mandible; e. legs; f. parameres; g. tibial comb; h. male genitalia, parameres omitted.

Female.--Wing length 0.92 (0.80-1.07, n = 21) mm.

Head: Antenna (fig. 46a) with lengths of flagellar segments in proportion of 18-16-17-18-21-20-21-20-26-26-28-31-44, antennal ratio 1.01 (0.91-1.05, n = 12); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 46b) with lengths of segments in proportion of 7-18-17-9-9; third segment short and moderately slender, sensilla borne distally in a shallow, open, pitlike area; palpal ratio 2.1 (1.7-2.6, n = 17). Proboscis short, P/H Ratio 0.58; mandible (fig. 46d) with 7 (6-8, n = 30) curved teeth, distal ones larger.

Thorax: Mesonotum and upper pleuron pale yellow, scutellum pale brown; postscutellum and lower pleuron dark brown. Legs (fig. 46e) dark brown; foreleg with knee spot dark, broad subapical pale band on femur and sub-basal pale band on tibia; midleg with pale knee, broad pale band at apex of femur and base of tibia; hindleg with femur usually dark to apex, tibia with broad dark band in middle, ends pale, but varying greatly sometimes with indistinct subapical pale band on femur and tibia entirely pale; tibial comb as in fig. 46g.

Wing (fig. 213, 370): Pattern as figured; 3 large, very dark areas on anterior margin; dark along veins and with indistinctly paler areas in cells; 2 pale spots on costal margin, one centering over r-m crossvein, the other on apex of second radial cell, the latter spot variable in size; apex of wing broadly pale. Costal ratio 0.69 (0.67-0.71, n = 21). Halter usually infuscated, sometimes pale.

Abdomen: Dark brown, sclerotized terga very broad, 3.2 times as broad as long on third segment. Spermathecae (fig. 46c) 3, unequal, with broad entrances to ducts; large spermatheca 0.030 x 0.030 mm, the 2 small ones each 0.023 x 0.022 mm, the shapes variable, ranging from slightly broader than long to slightly longer than broad; ducts of all 3 spermathecae joined at 1 point just before the ring, without enlarged sacs at the junction.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 46h): Ninth sternum with shallow caudomedian excavation; ninth tergum with apicolateral processes large, slender, with pointed tips, the caudal margin between them cleft mesad. Basistyle with ventral root reduced, dorsal root slender; dististyle curving with slender, pointed tip. Aedeagus with basal arch extending to a third of total length, basal arms stout; distal portion stout and tapering to blunt apex. Parameres (fig. 46f) each with large basal knob, basal arm directed laterad; stem short, very stout at base, tapering greatly to slender, simple point directed ventrolaterad.

Distribution.--Cambodia, India, Indonesia, Laos, Malaysia, New Britain, New Guinea, Philippines, Sabah, Sarawak, Singapore, Solomon Islands, Taiwan, Thailand.

Types.--Type data not stated; redescribed from females reared from rotten banana, Thakurpukur, near Calcutta, West Bengal, India, by Das Gupta and Ghosh.

Southeast Asia Records.--
CAMBODIA: Phnom Penh (Delfinado).

INDONESIA: Bali, Badung, Mengwi (Lee); Pedang Bay, 35 km NE Denpasar (Nicholls); Peguyangan, Tag Tag (Lee). Flores, Manggarai, Nangalili, Wai Jamal near Pandang (Lee); Manggarai, Reo, Golok (Lee). Java (Central), Cilacap, Adipala, Bunton (Lee); (West), Bogor (Adiwinata); Bogor, Pacet, Puncak (Lee); Yogyakarta (Adiwinata); Yogyakarta, Bantul, Imogiri, Girirejo, Karang Tengah (Lee); Yogyakarta, Tungkak, Kampung Giwangan (Lee). Kalimantan (South), Banjar, Astambut, Pengiuran (Lee); Astambul, Titian Matang, Tanah Intan (Lee); Banjar, Martapura, Bincau (Lee). Lombok, 35 km N Maratam (Nicholls); Tabane (Nicholls); (East), Kerekong (Lee). Maluku, P. Buru, Savanjaya (Bambang). Sulawesi (Central), Banggai, Batui, Kamiwangi (Bambang); (South), Unjung Pandang, Bontoala, Baraya, Unhas (Aep); (Southeast), Kendari, Ranometo, Randono, and Unaha (Bambang); (North), Dumoga Bone Nat. Park, 220 m (Heppner); Lake Mooat, 20 km NE Kotamobagu, 1050 m (Heppner). Sumatra, Fort de Kock (Jacobsen); Bengkulu, Gunung Agung and Enggeri (Mathis); North Lampung, Kotabumi, Way Abund III, Papaurejo (Lee). Sumba, Kabaru, 96 km E Waingapu (Boeadi). Sumbawa (Nicholls). Timor (East), Dilli, Comoro (Soeroto).

LAOS: Sayaboury Prov., Muong Phieng; Muong Sayaboury, reared from old banana stem; Muong Xieng Hon. Sedone Prov., Muong Pakse, sweeping over cow; Muong Paksong. Vientiane Prov., Muong Ban Keun, Ban Na Pheng; Muong Vang Vieng (all collected by Howarth).

MALAYSIA: Johore, Kahang Kluang (Hubert). Kelantan, Ulu Kelantan, Sungei Betis (Wharton); Ulu Kelantan, Sungei Nenggiri (Wharton). Pahang, Kg. Berchang, Kuala Lipis, near buffalo (Garcia); Kuala Tahan (Quate); Kuala Trengganu (Quate); King George V Nat. Park, Tahan River (McClure); Mount Brinchang, 1,600 m (McClure); Paya Bungor (Wharton). Perak, Pulau Pangkor (Traub). Perlis, Kangar Rest House (Traub). Selangor, Kepong Forest Reserve (McClure, Quate, Traub); Klang, Rantau Panjang (Traub); Kuala Lumpur (Barnett, Traub); Kuala Lumpur, reared from decaying wild fruit (Manikumar); Serdang (Barnett); Ulu Gombak Forest Res. (Soosai, McClure); Ulu Langat (Barnettt). Trengganu, Dungun, Bukit Besi (Traub).

MALAYSIA (BORNEO): Labuan Island (Colless). Paring, Ranau Dist. (Quate). Tambanun (Colless).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Pampanga Prov., Angeles, Clark Field (Balatbat); Rizal Prov., Tala (Delfinado). Mindanao, Cotabato Prov., Kidapawan (Kalaw); Davao Prov., Maco, Tagum (Fontanilla; Hoogstraal and Heneman); Mt. Apo School, 500 m (Davis). Negros Oriental, Cuemos de Negros, Camp Lookout (Delfinado).

SARAWAK: Kapit Dist., Nanga Pelagus (Traub).

SINGAPORE: Kg. Chantek Bahru (Colless); Nee Soon (Colless).

THAILAND: Chiang Mai (Causey); Chiang Rai (Causey). Cholburi, Bangphra (Scanlon). Khon Kaen Prov. and Dist. and Chum Phai Dist. (Manop R.). Loei Prov., Dan Sai Dist., Ban Na Muang and Koksato (Elbel). Minburi (Manop R.). Nakhon Ratchasima Prov. and Dist. and Pakchong Dist. (Manop R.). Nakronprathom (Manop R.). Nong Khai (Manop R.). Nonthaburi (Manop R.). Prabuddhabat, Saraburi (Manop R.). Pratomvan (Scanlon). Samuthprakan (Manop R.). Udonthani Prov., Nong Ham Dist. (Manop R.). Sakhon Nakhon (Manop R.).

Discussion.--Of the species of *Trithecoides* having 7 curved mandibular teeth with the distal ones largest, *palpifer* can be separated from *macfiei* Causey and *humeralis* Okada by the color of the mesonotum, from *rugulithecus* n. sp. by the color of the wing, halter, and hindfemur, by the shapes of the mandibular teeth and spermathecae, from *luteolus* n. sp. and *subpalpifer* n. sp. by the color of the postscutellum and hindfemur, and from *cylindripalpis* n. sp. by the shape of the third palpal segment.

Culicoides parahumeralis Wirth and Hubert, new species
(Figs. 47, 214, 371)

Culicoides humeralis Okada (misident.); Wirth and Hubert, 1959: 22 (in part, misident.; Malaya and Thailand records).
Culicoides sp. A, Howarth, 1985: 32 (Laos records).

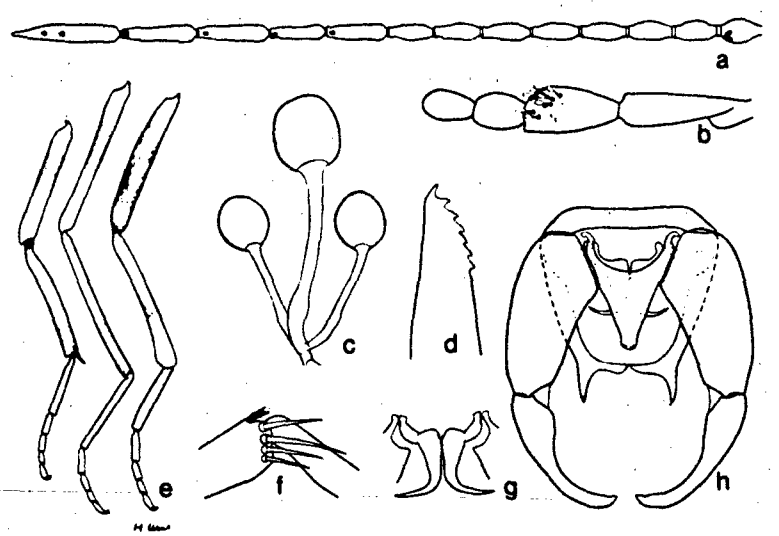


Fig. 47. *Culicoides parahumeralis*: a. antenna;, b. palpus; c. spermathecae; d. mandible; e. legs; f. tibial comb; g. parameres; h. male genitalia.

Female.--Wing length 1.17 (1.10-1.26, n = 10) mm.
Head: Antenna (fig. 47a) with lengths of flagellar segments in proportion of 19-17-19-19-20-19-20-20-28-26-29-33-47, antennal ratio 1.04 (0.98-1.09, n = 8); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 47b) with lengths of segments in proportion of 8-19-20-10-12; third segment moderately swollen, with

an open sensory area distally; palpal ratio 2.2 (1.9-2.4, n = 12). Proboscis short, P/H Ratio 0.52; mandible (fig. 47d) with 7 (7-8, n = 12) prominent curved teeth, the distal ones largest.

Thorax: Mesonotum yellow, anterior margin with dark brown spot on each humeral angle and a large median brown spot; scutellum and postscutellum dark brown; pleuron yellow on upper half, dark brown below. Legs (fig. 47e) dark brown; bases of femora narrowly pale; foreleg with dark knee spot and broad pale subapical femoral and sub-basal tibial bands; midleg with knee, distal third of femur, and basal third of tibia yellow; hindfemur dark to tip, hindtibia yellow with broad dark band just beyond middle, tibial comb as in fig. 47f.

Wing (fig. 214, 371): Pattern as figured; three very dark areas on anterior margin; second radial cell pale on distal half, wing tip broadly pale. Costal ratio 0.67 (0.66-0.71, n = 8). Halter knob pale.

Abdomen: Light brown; terga poorly sclerotized, twice as broad as long on third segment. Spermathecae (fig. 47c) 3, unequal, with large entrances to ducts; large one 0.032 x 0.034 mm, broader than long; the 2 small ones subequal, each 0.024 x 0.025 mm, also broader than long; the ducts of all 3 spermathecae joining at one point just before the sclerotized ring.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 47h): Ninth sternum with slight caudomedian excavation; ninth tergum with apicolateral processes large, slender, with pointed tips, the caudal margin between them transverse with distinct mesal notch. Basistyle with ventral root small, dorsal root slender; dististyle curving with slender, pointed tip. Aedeagus with basal arch extending to about half of total length, basal arms moderately slender; distal portion stout and tapering to blunt tip. Parameres (fig. 47g) each without basal knob, basal portion slender and curving laterad and then cephalad; stem stout, gradually tapered to moderately slender, bent, simple tip.

Distribution.--Cambodia, Indonesia, Laos, Malaysia, Thailand, Vietnam.

Types.--Holotype female, Kuala Lumpur, Selangor, Malaysia, vii.1958, R. Traub, light trap (Type in USNM). Allotype male, same data, but 12.vi.1958. Paratypes, 1 male, 66 females, as follows:

INDONESIA: Bali, Badung, Mengwi, 13-14.ii.1980, V.H. Lee, 1 female; Badung, Pedungan, 14-15.iii.1980, Lee, 2 females; Gianjay, 28.xi.1980, Lee, 1 female. Flores, Manggarai, Nunang, 15.xii.1977, Lee, 1 female; Manggarai, Reo, Robek, Gincu, 1-2.x.1978 (Nasir), 1 female; Manggarai, Nanglili, Wai Jamal near Pandang, 5-6.xii.1977, Lee, 1 female. Java (West), Bogor, 28.xi.1959, R.T. Adiwinata, light trap, 1 female; Bekasi, Teluk Buyung, 26-29.vi.1978, Nasir, 2 females; Central Java, Cilacap, Adipala, 20-21.xii.1978, Lee, 2 females. Kalimantan (South), Banjar, Astambut, Sungai Baru, 12-20.i-ii.1978, Lee, 2 females; Astambul, Tanah Intan, Pondok Delapan, 2-3.x.1978, Lee, 1 female. Lombok (East), Tabane, 20.x.1969, D.G. Nicholls, light trap, 1 female; (West), Mataram, Gerung, Dasan Geras, 14-15.v.1978, Lee, 1 female. Maluku, P. Buru, Savanjaya, 17.x.1980 (Bambang), 1 female. Sulawesi (North), Dumoga-Bone Nat. Park, 220 m, 16-20.x.1985, J.B. Heppner, 3 females; Lake Mooat, 20 km NE Kotamobagu, 1,050 m, 26-30.x.1985, J.B. Heppner, 14 females. Sumatra, Bengkulu, Pekik Nyaring,

1.v.1980 (Mathis), 1 female; Batam Island, Sungai Beduk, 17.i.1981 (Sustriayu), 3 females; North Lampung, Kotabumi, Way Abung, Papurejo, 22-24.vi.1978, 2 females.

MALAYSIA: Kelantan, Lambok, Sungei Betis, Ulu Kelantan, 9.xi.1961, R.H. Wharton, light trap, 4 females. Pahang, Kuantan-Pekan Road, swamp forest, 3.iv.1957, Wharton, 1 female; King George V Nat. Park,
Tahan River, 4-6.xi.1959, H.E. McClure, light trap, 8 females; Mt. Brinchang, 1,600 mi, 3.i.1959, L.W. Quate, light trap, 1 female. Perak, Pualu Pangkor, 1.iv.1-59, Traub, light trap, 1 female. Perlis, Kangar Rest House, 12.vii.1958, Traub, light trap, 1 female. Selangor, Kuala Lumpur, iii-x.1958, Traub, 1 male, 3 females; Ulu Lui, 31.xii.1973, R. Parsons, light trap, 4 females. Serdang, 15.ii.1955, H.C. Barnett, light trap, 1 female. Trengganu, Dungun, Bukit Besi, 26-28.ii.1961, A.A. Hubert, light trap, 1 female.

Other Specimens Examined.--
CAMBODIA: Phnom Penh (Delfinado).

LAOS: Sayabouri Prov., Muong Xieng Hon, Muong Sayabouri, Nam Houng River margin, 22 km S Muong Phieng. Sedone Prov., Muong Pakse; Muong Paksong. Vientiane Prov., Muong Ban Keun, Ban Na Pheng, sweeping over cows; Muong Vang Vieng, Ban Ky Sok. (All collected by F.G. Howarth).

THAILAND: Chiang Mai (Notonanda, Scanlon). Cholburi, Bangphra (Scanlon). Khon Kaen Prov., Ban Phai and Chum Phae (Manop R.). Loei Prov., Dan Sai, Ban Na Muang (Elbel). Minburi (Manop R.). Nakronpanom (Manop R.). Nakronprathom (Manop R.). Nonthaburi (Manop R.). Phangnga, Pulau Panjang (collector unknown). Pang-kam Paung (Gressitt). Prabuddhabat (Manop R.). Sakhonakron (Manop R.). Samuthprakan (Manop R.).

VIETNAM: Dralac Prov., Dalat (Spencer).

Discussion.--Four other species of *Trithecoides* have a yellow mesonotum marked with dark brown anteriorly: *Culicoides anophelis* Edwards differs in having the hindfemur with broad subapical pale band, halter dark, spermathecae ovoid, and the proximal mandibular teeth enlarged. *Culicoides gewertzi* Causey has the halter dark, wing only narrowly pale distally, mandibular teeth smaller, more numerous, and subequal, and the large spermatheca more elongate, and the spermathecal ducts with sacs before the ring, the ducts from the two small ones joining before meeting the duct from the large spermatheca. *Culicoides paraflavescens* Wirth and Hubert has the mandible with 19-23 teeth, the spermathecae subequal and ovoid, and the hindfemur banded. (We are indebted to S. Kitaoka for pointing out to us the characters that distinguish *C. parahumeralis* n. sp. from *humeralis* Okada from Japan, eastern USSR, China, and Taiwan.) *Culicoides humeralis* is a larger species (wing length 1.25 mm), with broader pale areas on the costal margin, and the male ninth sternum with deeper caudomedian excavation, ninth tergum with distinct median notch, and parameres fused at their bases.

Culicoides rugulithecus Wirth and Hubert, new species
(Figs. 48, 215, 372)

Culicoides species B, Howarth, 1985: 12 (Laos record).

Female.--Wing length 1.04 (0.96-1.15, n = 3) mm.

Head: Antenna (fig. 48a) with lengths of flagellar segments in proportion of 27-25-26-26-27-26-25-26-32-32-37-39-52, antennal ratio 0.94 (0.92-0.97, n = 2); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 48b) with lengths of segments in proportion of 9-24-23-11-13; third segment slightly swollen toward apex, with sensilla in an irregular distal pit; palpal ratio 2.2 (2.1-2.3, n = 3). Proboscis moderately short, P/H Ratio 0.64; mandible (fig. 48d) with 7 (6-7, n = 6) large subequal curved teeth.

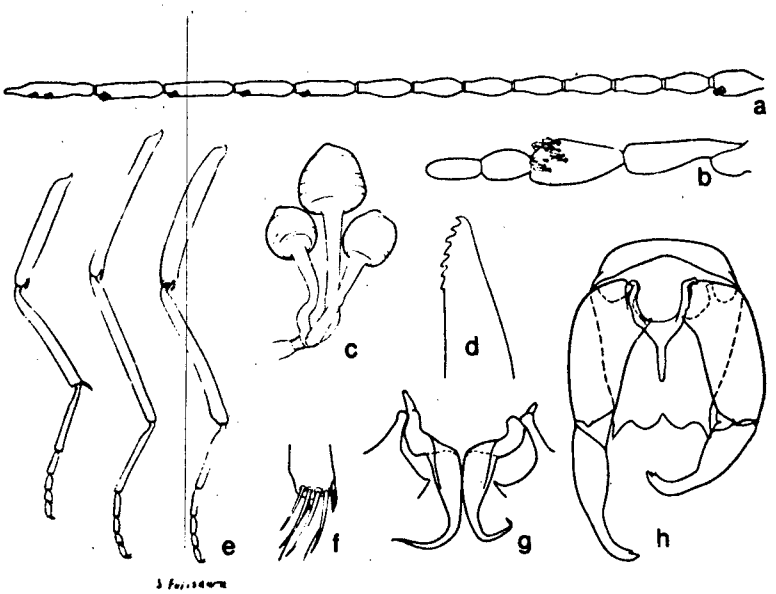


Fig. 48. *Culicoides rugulithecus*: a. antenna; b. palpus; c. spermathecae; d. mandible; e. legs; f. tibial comb; g. parameres; h. male genitalia, parameres omitted.

Thorax: Mesonotum and upper pleuron yellow; scutellum pale brown; postscutellum and lower pleuron dark brown. Legs (fig. 48e) brown; foreleg with black knee spot and moderately broad pale bands subapically on femur and subbasally on tibia; midleg with knee, broad apex of femur and broad base of tibia pale; hindleg with apex of femur blackish, broad subapical pale band on femur, tibia entirely yellow, tibial comb as in fig. 48f.

Wing (fig. 215, 372): Pattern as figured; pale, yellowish on anterior veins, posterior veins darkened with indistinct paler streaks between in the cells; second radial cell pale except at extreme base, first radial cell dark on distal third; tip of wing not distinctly paler. A few macrotrichia at wing margin in cells R5 and M1; costal ratio 0.68 (0.66-0.70, n = 3); second radial cell slightly narrowed distally, 1.5 times as long as first. Halter pale.

Abdomen: Pale brown, terga poorly sclerotized. Spermathecae (fig. 48c) 3, unequal, with large entrances to ducts; large spermatheca 0.030 x 0.031 mm, the 2 small subequal ones each 0.024 x 0.022 mm; shapes irregularly conoidal, surface irregularly rugulose; ducts of all 3 spermathecae joined at 1 point near the sclerotized ring, without saclike swellings.

Male.--Similar to female, with usual sexual differences. Genitalia (fig. 48h): Ninth sternum with shallow caudomedian excavation; ninth tergum with short, pointed apicolateral processes, the caudal margin between them with small median cleft and a pair of low, rounded, submedian lobes. Basistyle with ventral root absent, dorsal root slender; dististyle with stout basal portion longer than usual, distal portion curved, slender, with sharp distal point. Aedeagus with basal arch broad and rounded, extending to a third of total length, basal arms short and slender; main body short and broad, distal portion slender with narrow tip. Parameres (fig. 48g) each with small basal knob, basal arm directed laterad, then cephalad; main body moderately stout at base, tapering and curved ventrad to slender simple tip.

Distribution.--Laos, Malaysia.

Types.--Holotype female, Malaysia, Trengganu, Dungun, Bukit Besi, 6.viii.1958, R. Traub, light trap (Type in USNM). Allotype male, Pahang, King George V Nat. Park, 23.ii.1961, G. Hendrickson, light trap. Paratypes, 24 females:

MALAYSIA: Kelantan, Ulu Kelantan, Sungei Betis, 9.xi.1961, R.H. Wharton, light trap, 10 females. Pahang, same data as allotype, 10 females. Selangor, Kuala Lumpur, vi.1958, iii.1959, R. Traub, light trap, 2 females; Ulu Lui, 11.ix.1973, R. Parsons, light trap, 1 female. Trengganu, same data as holotype, 1 female.

Other Specimens Examined.--

LAOS: Vientiane Prov., Muong Ban Keun, Ban Na Pheng (Howarth).

Discussion.--*Culicoides rugulithecus* has a thoracic pattern near *palpifer* Das Gupta and Ghosh, from which it can be separated by its much paler, yellowish wing in which the distal pale spot in cell R5 crosses vein M1, its pale halter, extensively banded hindfemur, and rugulose spermathecae.

Culicoides subpalpifer Wirth and Hubert, new species
(Figs. 49, 216, 373)

Female.--Wing length 0.93 (0.85-1.00, n = 13) mm.

Head: Antenna (fig. 49a) with lengths of flagellar segments in proportion of 26-25-28-29-29-29-28-26-40-37-42-40-57, antennal ratio 0.95 (0.93-0.99, n = 12); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 49b) with lengths of segments in proportion of 10-22-22-10-10; palpal ratio 2.5, third segment short, not swollen, with sensilla scattered on surface of segment, sometimes grouped in an irregular distal sensory area. Proboscis moderately short, P/H Ratio 0.64; mandible (fig. 49e) with 7 (6-7, n = 18) recurved teeth, distal one larger and widely spaced.

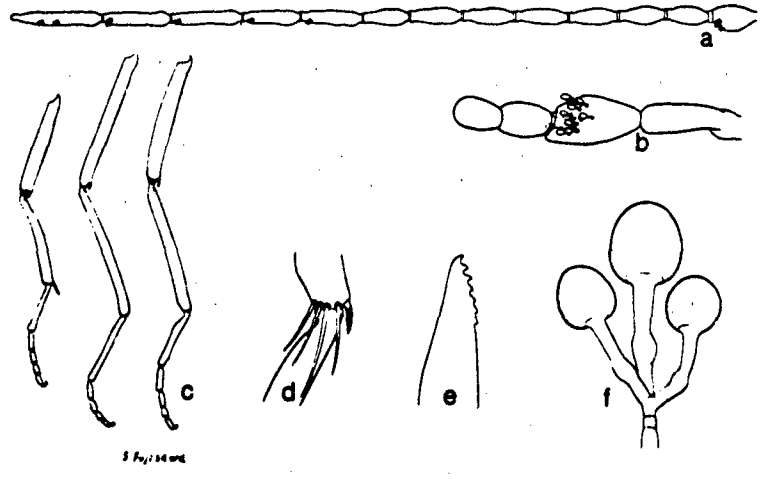


Fig. 49. *Culicoides subpalpifer*: a. antenna; b. palpus; c. legs; d. tibial comb; e. mandible; f. spermathecae.

Thorax: Mesonotum and scutellum yellow; postscutellum slightly darker; lower pleuron dark brown. Legs (fig. 49c) brown; fore- and hindknees somewhat infuscated, femora with broad distal, and tibiae with broad basal yellow bands; hindtibia entirely yellow; hindtibial comb (fig. 49d) with spines unusually long.

Wing (fig. 216, 373): Pattern as figured; three very extensive dark spots on anterior margin, large pale area over r-m crossvein extending caudad past vein M1; extensive infuscation along veins leaving indistinct pale areas between in the cells; tip of wing narrowly and indistinctly pale. Wing nearly bare of macrotrichia, only a few in apices of cells R5 and M1; costal ratio 0.71 (0.69-0.75), n = 13); second radial cell broad, twice as long as first. Halter infuscated.

Abdomen: Pale brown, sclerotized terga moderately broad, 2.5 times as broad as long on third segment. Spermathecae (fig. 49f) 3, unequal, with large entrances to ducts; larger one 0.026 x 0.029 mm; the 2 small ones subequal, each 0.022 x 0.022 mm; shapes variable, ranging from slightly broader than long to slightly longer than broad, usually mushroom-shaped; ducts of all 3 joined at 1 point just before the ring; without enlarged sacs at the junction.

Male.--Unknown.

Distribution.--Malaysia; Philippines, Sabah, Sarawak.

Types.--Holotype female, Malaysia, Trengganu, Dungun, Bukit Besi, 6.viii.1958, R. Traub, light trap (Type in USNM). Paratypes, 95 females:
MALAYSIA: Same data as type, 13 females. Kelantan, Ulu Kelantan, Lambok, Sungei Betis, 9.xi.1961, R.H. Wharton, 28 females. Pahang, Gudang Rasan, i-ii.1959, R. Traub, light trap, 2 females; Kuala Trengganu, 15.xii.1958, Gressitt and Maa, light trap, 2 females; Kuala Tahan, 16.xii.1958, L.W. Quate, light trap, 1 female; King George V Nat. Park, Tahan River, 4-6.xi.1959, H.E. McClure, light trap, 40 females; Kuantan, Paya Bungor, ix.1959, R.H. Wharton, light trap, 3 females. Selangor, Kuala Lumpur, i.1959, R. Traub, light trap, 1 female; 15 mi NNE Kuala Lumpur, 2.v.1961, C. Manikumar, reared from decaying fruit in jungle, 3 females; Ulu Langat, xi.1967, R. Garcia, chicken baited trap in secondary forest, 1 female; Ulu Lui, 31.xii.1973, R. Parsons, light trap, 1 female.
PHILIPPINES: Leyte, Mahaplag, 9.vii.1964, M.D. Delfinado, light trap, 1 female.
SABAH: Tawau Dist., Kalabakan, 19.xi.1958, T.C. Maa, light trap, 1 female.
SARAWAK: Kapit Dist., Nanga Pelagus, 28.xi.1958, R. Traub, at light, 1 female.

Discussion.--The 7 recurved mandibular teeth, concolorous mesonotum and scutellum, slightly darker postscutellum, dark halter, broad subapical pale band on hindfemur, and short third palpal segment will distinguish *C. subpalpifer* from its close relatives. Considerable variation exists in the shapes of the spermathecae, shape of the third palpal segment, color of the postscutellum and the antennal ratio, but this defies further analysis. Some individuals approach *C. palpifer* Das Gupta and Ghosh in appearance but can be separated on the basis of wing color and color of the postscutellum. This species has been reared by Manikumar near Kuala Lumpur, Malaysia, from rotting fruits in the jungle, where it was associated with larvae of *C. jacobsoni* Macfie.

Culicoides tonmai Howarth
(Figs. 50, 217)

Culicoides tonmai Howarth, 1985: 30 (male, female; Laos; figs.).

Female.--Wing length 1.01 mm.
Head: Eyes contiguous for a short distance, bare. Antenna (fig. 50a) with lengths of flagellar segments in proportion of 22-20-24-25-26-25-26-24-32-29-34-36-49, antennal ratio 0.96; antenna elongate, segments 6-9 each 3.2 times longer than wide; sensilla coeloconica present on segments 3,11-15. Palpus segments

(fig. 50b) with lengths in proportion of 9-24-26-11-11; third segment elongate, swollen nearly to base, widest in midportion; palpal ratio 1.6; a few sensilla scattered over segment. Proboscis moderately short, P/H Ratio 0.57; mandible (fig. 50d) with 7 large triangular teeth.

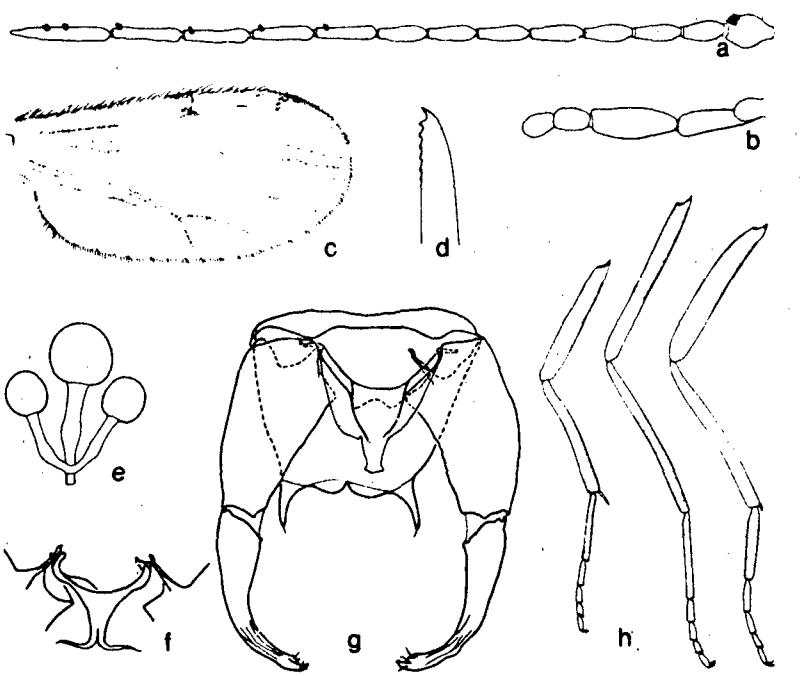


Fig. 50. *Culicoides tonmai*: a. antenna; b. palpus; c. wing; d. mandible; e. spermathecae; f. parameres; g. male genitalia, parameres omitted; h. legs.

Thorax: Mesonotum, scutellum, and upper half of pleuron pale yellow, postscutellum yellowish brown, lower half of pleuron brown. Legs (fig. 50h) with all femora brown basally, distal third pale yellowish, extreme apex sometimes indistinctly infuscated on fore- and hindfemora; fore- and midtibiae pale on basal fourth; hindtibia entirely pale; all knees broadly pale.

Wing (fig. 50c, 217): Pattern as figured; pale areas very extensive, poorly contrasting on wing posteriorly. Stigmal dark spot narrow; anterior pale spots over r-m crossvein and second radial cell large, broadly meeting anterior wing margin, the latter does not reach media posteriorly; base of wing narrowly pale; anal angle with poorly defined dark streak; cells M1 and M2 almost entirely pale; wing tip

broadly pale; large diffuse pale spot distally in cell M4 and in anal cell. Macrotrichia sparse, confined to anterior portion of cell R5 and apex of wing in cells R5 and M1; costal ratio 0.71. Halter slightly infuscated.

Abdomen: Yellowish brown, terga light brown. Spermathecae (fig. 50e) 3, with large unsclerotized entrances to ducts, surface not rugulose; spermathecae unequal, large one 0.028 x 0.038 mm, the 2 small ones subequal, each 0.027 x 0.026 mm; ducts each with slightly bulbous enlargement at midlength, without enlargement at common meeting point just before sclerotized ring.

Male.--Similar to female with usual sexual differences; smaller, wing length 0.67 mm. Genitalia (fig. 50g): Ninth sternum with shallow caudomedian excavation; ninth tergum with large elongate apicolateral processes, their length less than half the distance between their bases, caudomedian margin with narrow median cleft and short, wide, sublateral lobes. Basistyle with ventral root absent, dorsal root elongate, slender, apex bent; dististyle elongate, strongly curved to bent tip, rugulose in distal portion. Aedeagus with basal arch extending to a third of total length, basal arms thickened, straight; basal arch and distal portion of aedeagus weakly sclerotized, broad at base, tapering to short neck, apex expanded and recurved ventrad. Parameres (fig. 50f) broadly fused in midportion; basal arms slender and curving forming a low basal arch, distal processes each bent ventrad, then tapering to simple attenuated tip directed caudolaterad.

Distribution.--Laos.

Types.--Holotype female, Laos, Sayaboury Prov., Sayaboury, 300 m, 30.vii.1967, F.G. Howarth, reared from tree wound (Bishop Mus.). Allotype and paratypes, same data.

Southeast Asia Records.--
LAOS: Sayaboury Prov., Sayaboury (Howarth, types); 22 km S Muong Phieng (Howarth). Sedone Prov., Muong Pakse (Howarth).

Discussion.--Howarth reared this species from a slime flux and leaf detritus in the fork of a tree, 1.7 m above ground level; adults of *C. innoxius* Sen and Das Gupta, *C. clavipalpis* Mukerji, and *C. lunsangensis* Howarth also emerged from this sample. This species can be distinguished from *C. palpifer* Das Gupta and Ghosh and other related species with dark postscutellum in having the distal third of the femora pale.

Raripalpis Group

Culicoides albibasis Wirth and Hubert
(Figs. 51, 218, 374)

Culicoides albibasis Wirth and Hubert, 1959: 31 (male, female; Malaya, Philippines; figs.); Delfinado, 1961: 666 (diagnosis; figs.; Philippines).

Female.--Wing length 0.89 (0.86-0.93, n = 8) mm.

Head: Antenna (fig. 51a) with lengths of flagellar segments in proportion of 19-15-15-17-17-18-18-19-23-23-29-28-41, antennal ratio 1.03 (0.92-1.13, n = 4); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 51b) with lengths of segments in proportion of 10-25-28-14-16, third segment moderately slender, with sensilla borne on surface of distal portion; palpal ratio 2.2 (2.1-2.4, n = 6). Proboscis moderately short, P/H Ratio 0.63; mandible (fig. 51d) with 11 (10-12, n = 16) small triangular teeth subequal.

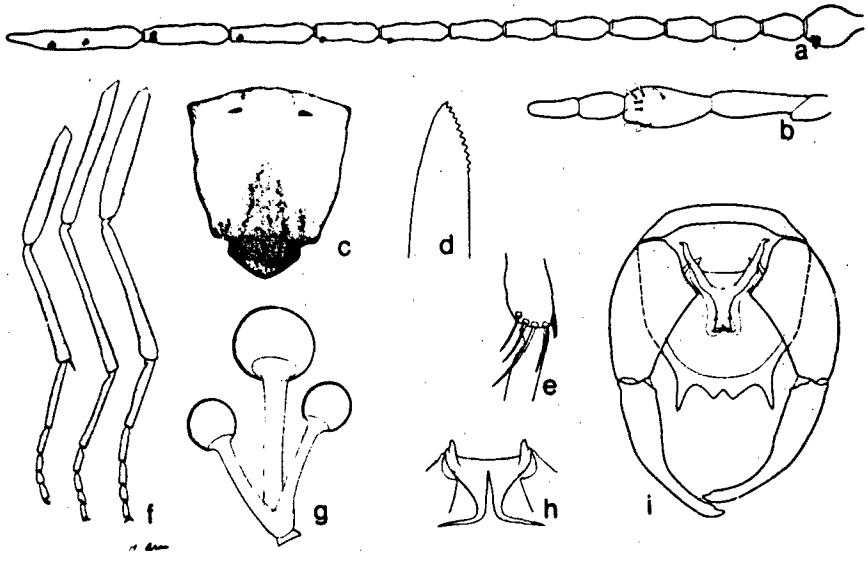


Fig. 51. *Culicoides albibasis*: a. antenna; b. palpus; c. thoracic pattern; d. mandible; e. tibial comb; f. legs; g. spermathecae; h. parameres; i. male genitalia.

Thorax: Anterior part of mesonotum and upper part of pleuron pale yellow; prescutellar area of mesonotum, scutellum, postscutellum, and lower half of pleuron dark brown (fig. 51c). Legs (fig. 51f) dark brown; all knees pale with broad pale bands on each side; hindtibia also pale at apex, tibial comb as in fig. 51e.

Wing (fig. 218, 374): Pattern as figured; in most specimens with entire wing proximad of r-m crossvein pale, sometimes with faint infuscation in a band just proximad of r-m crossvein, leaving crossvein in the center of a small pale spot which may not attain costal margin; pale spot at end of second radial cell very

small and centered on tip of vein; prominent broad darker areas on anterior wing margin proximad and distad of this spot; end of wing not pale. Costal ratio 0.70 (0.69-0.71, n = 8). Halter infuscated.

Abdomen: Pale brown, terga poorly sclerotized, twice as broad as long on third segment. Spermathecae (fig. 51g) 3, unequal, with broad unsclerotized entrances to ducts; the large one slightly broader than long, globular, 0.029 x 0.032 mm, the 2 smaller ones subequal, each 0.017 x 0.017 mm; ducts from the 2 small spermathecae joined before entrance to duct from large one proximal to the sclerotized ring.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 51i): Ninth sternum with shallow caudomedian excavation; ninth tergum with sides convex, apicolateral processes well developed but slender and pointed, caudal margin between them convex, with small median notch and a pair of small but distinct, angular, submedian lobes. Basistyle with ventral root absent, dorsal root slender; dististyle curving and tapering to slender pointed tip. Aedeagus with basal arch extending to a third of total length, basal arms stout; distal portion quite stout and truncated at tip. Parameres (fig. 51h) each without basal knob, basal portion slender and curved laterad; stem swollen at base, very short, the two parameres apparently fused a short distance at proximal corners of stems; stem tapering abruptly to slender simple tip curving ventrad.

Distribution.--Cambodia, Indonesia, Malaysia, Philippines.

Types.--Holotype female, allotype male, Malaysia, Selangor, Kuala Lumpur, 15.ii.1955, H.C. Barnett, light trap (Type in USNM).

Southeast Asia Records.--

CAMBODIA: Phnom Penh (Delfinado).

INDONESIA: Bali, Gianyar (Lee); Langan Juda (Lee). Java (West), Bogor (Adiwinata); Jakarta, West Jakarta, Kapuk (Aep); (Central), Cilacap, Adipala, Silangsur Lor of Wlahar (Lee). South Kalimantan, Banjar, Astambul, Sungai Baru (Lee); Banjar, Martapura, Bincau (Lee). Lombok (West), Cakra, Sayang (Lee). Sulawesi (Southeast), Kendari, Unaha (Bambang). Sumatra, Bengkulu, Padang, Panjang, Pekik Nyaring (Mathis); Bengkulu, Seluma, Bukit Peningauan (Mathis).

MALAYSIA: Pahang, Ulu Gali, cattle shed (Garcia). Perlis, Kangar Rest House (Traub). Selangor, Kuala Lumpur (Barnett, Traub).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Pampanga Prov., Clark Air Base, Angeles (Balatbat); Rizal Prov., Tala (Delfinado). Mindoro (Santos). Negros Oriental, Cuemos de Negros, Camp Lookout (Delfinado). Zamboanga (Casimiro).

SINGAPORE: Singapore (Course).

Discussion.--The pale basal wing area is a striking though not invariable character, and in connection with the distally pale femora, dark halteres, mesonotum yellow in front and brownish behind, and small, equal-sized mandibular teeth, will readily serve to distinguish this species.

Culicoides allantothecus Wirth and Hubert, new species
(Figs. 52, 219, 375)

Female.--Wing length 0.86 mm.

Head: Antenna (fig. 52a) with lengths of flagellar segments in proportion of 35-30-30-31-32-32-32-32-40-37-45-50-70, antennal ratio 0.95; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 52b) with lengths of segments in proportion of 10-15-23-15-13; third segment short and slightly swollen with sensilla in a loose distal cluster; palpal ratio 1.9. Proboscis short, P/H Ratio 0.57; mandible with 13 fine subequal teeth.

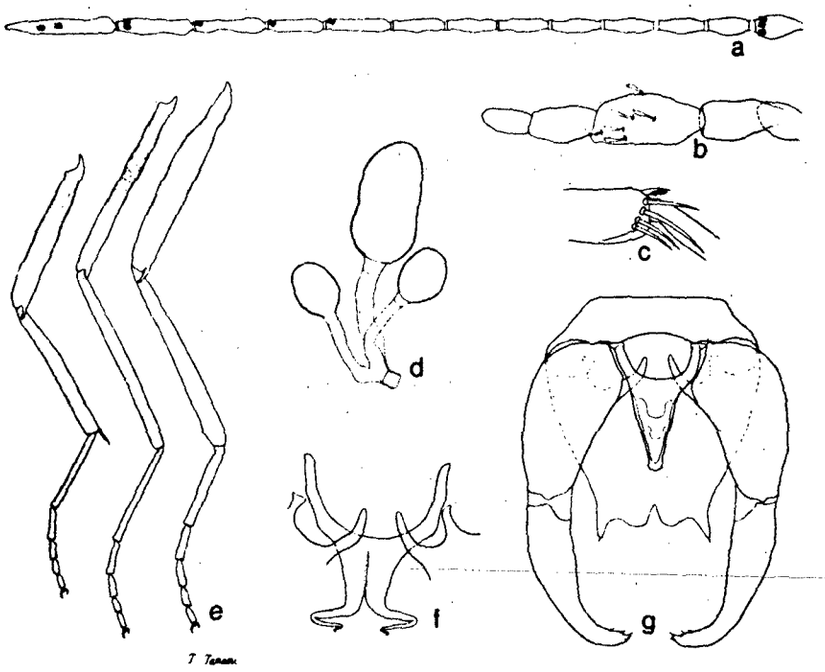


Fig. 52. *Culicoides allantothecus*: a. antenna; b. palpus; c. tibial comb; d. spermathecae; e. legs; f. parameres; g. male genitalia, parameres omitted.

Thorax: Mesonotum yellow, dark brown on anterior margin; scutellum, postscutellum, and lower half of pleuron dark brown. Legs (fig. 52e) dark brown; distal third of all femora and basal third of fore- and midtibiae pale yellow, hindtibia all yellow; apices of tarsi pale; hindtibial comb as in fig. 52c.

Wing (fig. 219, 375): Pattern as figured; base of wing to level of mediocubital fork and midlength of first radial cell pale except a small dark area anteriorly just past midlength of radial stem; a large pale poststigmatic spot covering distal 0.6 of second radial cell; apex of wing with a broad, sharply defined pale mark. Costal ratio 0.70. Halter pale.

Abdomen: Pale brown. Spermathecae (fig. 52d) 3, unequal, large one quite elongate, saclike, 0.046 x 0.025 mm, and 2 small subequal ones slightly longer than broad, 0.02 x 0.016 mm; with broad unsclerotized entrances to the ducts, ducts from the 2 small ones joined in a common duct just before entrance from the large one at the ring.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 51g): Ninth sternum without caudomedian excavation; ninth tergum short and tapering, apicolateral processes short and slender, pointed, caudal margin with deep mesal cleft, with a pair of large, rounded, sublateral lobes nearly as long as apicolateral processes. Basistyle with ventral root absent, dorsal root short; dististyle curved distally, with slender, pointed tip. Aedeagus with basal arch extending to a third of total length, basal arms moderately stout; sides nearly straight, tapering to slender, simple tip. Parameres (fig. 52f) each with long, slender, anterolateral arm nearly as long as distal portion; midportion stout, tapering to short, ventrally bent, pointed tip.

Distribution.--Malaysia.

Types.--Holotype female, allotype male, Malaysia, Pahang, Kuantan-Pekan Road, swamp forest, 3.iv.1957, R.H. Wharton, at light (Type in USNM). Paratypes, 5 females:

MALAYSIA: Same data as types, 1 female. Selangor, Kuala Selangor, Pacific Tin, i.1967, R. Garcia, swamp forest, 3 females; Ulu Langat, xi-xii.1967, R. Garcia, bait trap in secondary forest, 1 female.

Discussion.--*Culicoides allantothecus* resembles *albibasis* Wirth and Hubert in wing and leg markings, but can be distinguished by the brownish anterior marking of the mesonotum and distinct, broadly pale wing tip, as well as the elongate, saclike large spermatheca. On the mesonotal markings the species keys out with *gewertzi* Causey, but that species is much larger with much darker wing, dark halter, and hindfemur very dark brown to tip.

Culicoides barnetti Wirth and Hubert
(Figs. 53, 220, 376)

Culicoides barnetti Wirth and Hubert, 1959: 32 (male, female; Malaysia, Philippines; figs.); Delfinado, 1961: 667 (diagnosis; figs.; Philippines); Tokunaga, 1962b: 502 (redescribed; New Guinea, Solomon Is.); Debenham, 1978: 210 (New Guinea records).

Female.--Wing length 0.92 (0.79-0.99, n = 16) mm.

Head: Antenna (fig. 53a) with lengths of flagellar segments in proportion of 20-18-20-22-21-21-21-21-25-24-27-27-42, antennal ratio 0.88 (0.85-0.92, n = 7); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 53b) with lengths of segments in proportion of 9-17-22-10-8; third segment slender, with sensilla borne distally on surface, palpal ratio 2.4 (2.1-3.3, n = 10). Proboscis short, P/H Ratio 0.59; mandible (fig. 53d) with 12 (11-16, n = 25) minute, triangular, subequal teeth.

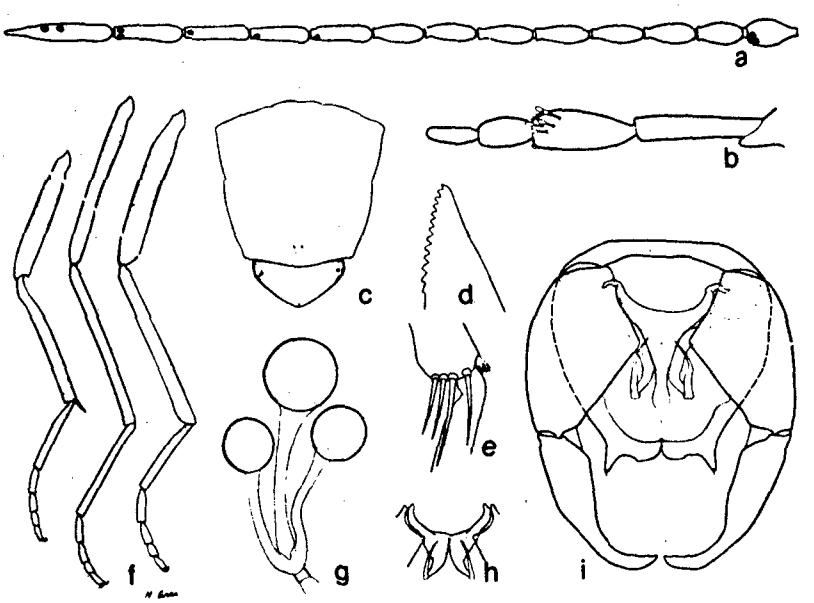


Fig. 53. *Culicoides barnetti*: a. antenna; b. palpus; c. thoracic pattern; d. mandible; e. tibial comb; f. legs; g. spermathecae; h. parameres; i. male genitalia.

Thorax: Mesonotum (fig. 53c) and upper pleuron pale yellow; scutellum, postscutellum, and lower half of pleuron dark brown. Legs (fig. 53f) dark brown; foreleg with knee spot blackish, pale bands subapically on femur and sub-basally on tibia; midleg with knee usually dark, femur with broad subapical pale band, tibia with broad sub-basal pale band; hindleg with blackish knee spot very prominent, femur with distinct subapical pale band, tibia entirely pale; tibial comb as in fig. 53e.

Wing (fig. 220, 376): Pattern as figured; three prominent dark spots on anterior margin; pale spots over r-m crossvein and second radial cell large and distinct, the pale area over second radial cell covering distal two-thirds of cell; pale area at wing tip very broad and distinct. Costal ratio 0.70 (0.68-0.72, n = 6). Halter pale.

Abdomen: Whitish, terga faintly sclerotized, twice as broad as long on third segment; eighth segment dark brown. Spermathecae (fig. 53g) 3, unequal, with broad unsclerotized entrances to ducts; large spermatheca 0.034 x 0.030 mm, usually slightly longer than broad; smaller ones each 0.021 x 0.021 mm; ducts from the 2 small spermathecae joined shortly before entering duct from large one, a definite saclike swelling on the latter at the ring.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 53i): Ninth sternum with scarcely perceptible caudomedian excavation; ninth tergum with short, slender, apicolateral processes, caudal margin between them convex, with a deep median cleft and large, angular, submedian lobes. Basistyle with ventral root reduced, dorsal root slender; dististyle curving with slender, pointed tip. Aedeagus with low, broad basal arch attaining a third of total length; distal portion with concave sides, narrowed to slender, rounded tip. Parameres (fig. 53h) each with moderately slender lateral arm; stem moderately swollen basally, gradually narrowed to very slender simple filament bent ventrad.

Distribution.--Indonesia, Malaysia, New Britain, New Ireland, New Guinea, Philippines, Sabah, Sarawak, Singapore, Solomon Islands, Thailand.

Types.--Holotype female, Malaysia, Selangor, Ulu Langat, 20.iv.1955, H.D. Barnett, light trap (Type in USNM). Paratypes, 6 males, 182 females.

Southeast Asia Records.--

INDONESIA: Bali, Gianyar, Tangan Juda (Sweatman). Java (Central), Cilacap, Adipala, Karang Sari, Bombel (Lee). Kalimantan (South), Banjar, Martapura, Bincau (Lee). Sumatra, Lampung, Kotabumi, Way Abung III, Paraurejo (Lee).

MALAYSIA: Johore, Kahang Kluang (Hubert). Pahang, Kuala Singgora (Traub); King George V Nat. Park (McClure, Quate); Kuala Tahan (Quate); Kuala Trengganu (Quate). Perak, Gunong Besont (Jeffery); Kuala Kengrong, Girik (Traub). Selangor, Ampang Res. (Traub); Gombak Forest Res., reared from rotting banana stem (Manikumar); Kepong (Barnett); Kuala Lumpur (Barnett, Traub); Kuala Selangor, 6 km N Batang Berjuntai (Garcia); Rantau Panjang, Klang (Traub); Segambut (Barnett); Subang Forest Res. (McClure); Sungei Dusun, swamp forest, biting man (Milton, Wharton); Ulu Langat (Barnett); Ulu Selangor, biting man (Wharton, McClure). Trengganu, Dungun, Bukit Besi (Traub).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Pampanga Prov., Angeles (Balatbat); Rizal Prov., Tala (Delfinado). Mindanao, Cotabato Prov., Kidapawan (Kalaw); Mt. McKinley E slope, 1,000 m, Davao Prov. (Werner); Cotabato Prov., Pikit (Werner). Negros Oriental, Cuemos de Negros, Camp Lookout (Delfinado). Samar Prov., Taft (Balatbat).

SABAH: Tawau Dist., Kalabakan (Maa).

SARAWAK: Kapit Dist., Nanga Pelagus (Traub). Limbang (Colless).

SINGAPORE: Kg. Chantek Bahru (Colless).

THAILAND: Loei Prov., Amphoe Thai Li (Manop R.). Nakronprathom (Manop R.).

Discussion.--*Culicoides barnetti* is distinguished by the yellow mesonotum, prominently banded hindfemur, pale halter and prominently marked wing with broadly pale apex. In three females from Ulu Langat, Malaysia, the knee of the midleg is pale instead of dark. In a long series from Chantek Bahru, Singapore and in some Philippine specimens the large spermatheca is considerably elongated, nearly twice as long as broad.

There is also some variation in the prominence of the median cleft and submedian lobes of the male ninth tergum. Our 1959 figure was from the male allotype from Kuala Lumpur, Malaysia. The male drawn in fig. 53h,i came from Klang, Rantau Panjang, and shows much less development of the submedian lobes.

The New Guinea record is based on two females from Metranken (New Hanover), 26.viii.1958, B. McMillan, aspirated at light 11:30 PM in nest house, and Nineia, Morobe Dist., 1,500 ft, 6.v.1960, B. McMillan, biting man 7:00 PM, kindly forwarded by D.J. Lee of the School of Public Health and Tropical Medicine in Sydney, Australia. We have also examined 3 females from the Solomon Islands, Guadalcanal, 17 km W Honiara, 28.vii.1962, rain forest, Noona Dan Expedition (courtesy Copenhagen Museum). In all these females the large spermatheca is elongated but otherwise they closely resemble typical *barnetti*. *Culicoides barnetti* was reared by Manikumar from the rotting stem of a banana tree at the Gombak Forest Reserve near Kuala Lumpur, Malaysia, where it was associated with larvae of *C. clavipalpis* Mukerji and *C. jacobsoni* Macfie.

Culicoides dungunensis Wirth and Hubert, new species
(Figs. 54, 221, 337)

Female.--Wing length 1.00 (0.97-1.04, n = 2) mm.

Head: Antenna (fig. 54a) with lengths of flagellar segments in proportion of 24-23-26-30-29-29-29-28-30-32-38-39-52, antennal ratio 0.88 (n = 2); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 54b) with lengths in proportion of 9-21-29-12-12-; third segment slightly swollen subapically, with sensilla grouped in an irregular area near apex of segment; palpal ratio 3.1 (n = 2). Proboscis moderately short, P/H Ratio 0.62; mandible (fig. 54e) with 15 (14-16, n = 4) very fine subequal teeth.

Thorax: Mesonotum and upper pleuron pale yellow; scutellum, postscutellum, and lower pleuron dark brown. Legs (fig. 54c) dark brown; foreleg with knee slightly darkened, femur with subapical and tibia with sub-basal, narrow pale rings; midleg with knee, distal third of femur and basal third of tibia pale; hindleg with femur dark brown to apex, tibia entirely pale, tibial comb as in fig. 54d.

Wing (fig. 331, 377): Pattern as figured; dark brown especially on anterior margin; costal margin with two very pale spots, first over r-m crossvein covering basal half of first radial cell and extending caudad only to media, second centering on tip of second radial cell and covering distal half of this cell; wing tip very narrowly

and indistinctly pale; area along veins more heavily infuscated than cells. A few macrotrichia at wing tip in cells R5 and M1; costal ratio 0.70 (0.69-0.72, n = 2); second radial cell slightly narrowed distally, 1.5 times as long as first. Halter pale.

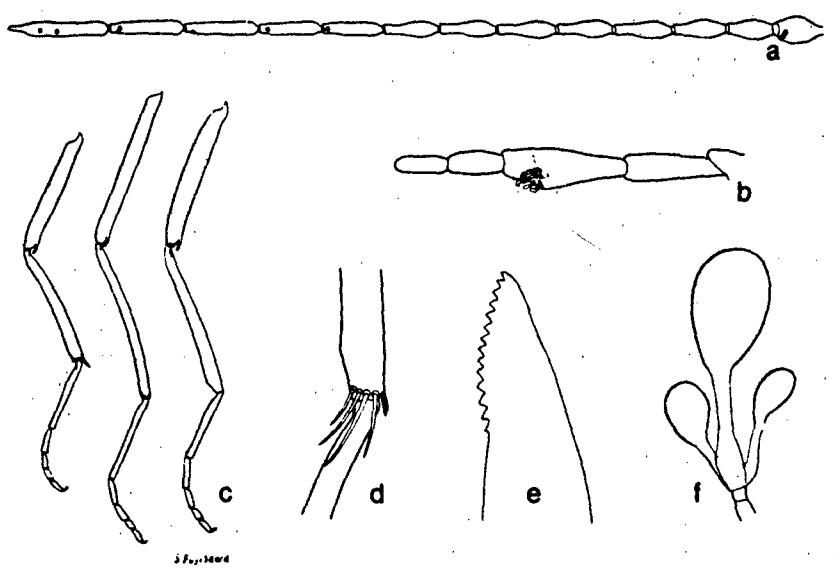


Fig. 54. *Culicoides dungunensis*: a. antenna; b. palpus; c. legs; d. tibial comb; e. mandible; f. spermathecae.

Abdomen: Pale brown, terga moderately sclerotized, twice as broad as long on third segment. Spermathecae (fig. 54f) 3, unequal, with broad entrances to ducts; 0.048 x 0.031 mm, 0.024 x 0.018 mm, and 0.023 x 0.013 mm, respectively; ovoid, very elongate, broadest distally; ducts from the 2 small spermathecae joined before entering duct of large one just before the ring; ducts slightly swollen near the junction.

Male.--Unknown.

Distribution.--Indonesia, Malaysia.

Types.--Holotype female, Malaysia, Trengganu, Dungun, Bukit Besi, 6.viii.1958, R. Traub, light trap (Type in USNM). Paratypes, 3 females.

INDONESIA: West Java, Garut, Pameungpeuk, 23.xii.1979 (Zubaedah), light trap in cattle shed, 1 female.

MALAYSIA: Trengganu, same data as type, 1 female. Selangor, Ulu Langat, xi.1967, R. Garcia, in chicken-baited trap in secondary forest, 1 female.

Discussion.--This species resembles *C. flaviscutatus* Wirth and Hubert closely in thoracic adornment, leg banding, halter color, shape of mandibles, and antennal sensilla, but can be distinguished by the peculiar elongated spermathecae which taper toward the ducts. The two small spermathecae in the paratype from Bukit Besi are more slender than those in the holotype and are sausage-shaped rather than ovoid.

Culicoides elbeli Wirth and Hubert
(Figs. 55, 222, 378)

Culicoides elbeli Wirth and Hubert, 1959: 27 (male, female; Malaysia, Sabah, Thailand; figs.); Howarth, 1985: 32 (Laos records).

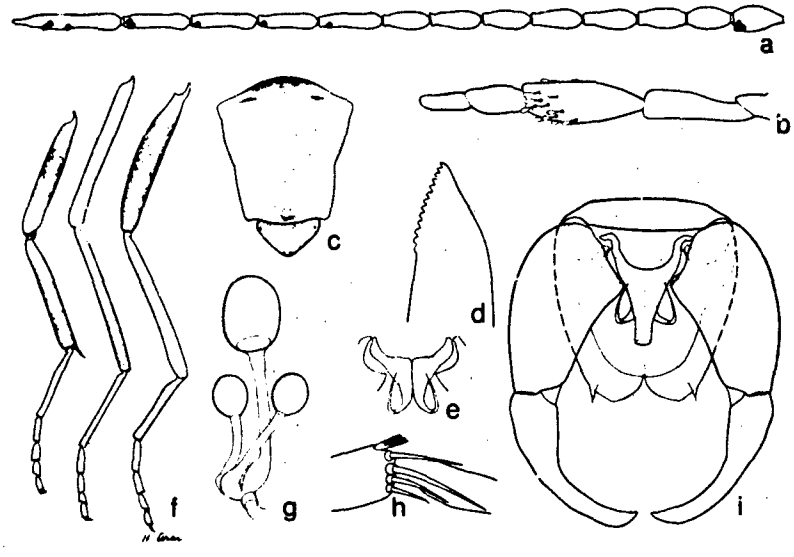


Fig. 55. *Culicoides elbeli*: a. antenna; b. palpus; c. thoracic pattern; d. mandible; e. parameres; f. legs; g. spermathecae; h. tibial comb; i. genitalia, parameres omitted.

Female.--Wing length 0.81 mm.

Head: Antenna (fig. 55a) with lengths of flagellar segments in proportion of 18-17-19-20-20-20-19-19-24-22-25-26-28, antennal ratio 0.89 (0.86-0.94, n = 10); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 55b) with lengths of segments in proportion of 6-18-18-10-8; third segment slender, with sensilla borne on surface of segment distally; palpal ratio 2.4 (2.2-2.6, n = 11). Proboscis moderately short, P/H Ratio 0.65; mandible (fig. 55d) with 12 (11-12, n = 23) subequal fine teeth.

Thorax: Dark brown including mesonotum, scutellum, postscutellum, and lower pleuron (fig. 55c). Legs (fig. 55f) dark brown; foreleg with black knee spot and narrow pale bands subapically on femur and sub-basally on tibia; midleg with knee, apex of femur, and base of tibia pale; hindleg with femur all dark, tibia with narrow basal and broad apical pale bands, tibial comb as in fig. 55h.

Wing (fig. 222, 378): Pattern as figured; moderately dark with large, distinct pale spots over r-m crossvein and centering over end of second radial cell; wing tip distinctly pale in some specimens in Malaysia; faint pale spots in apices of anal cell and cell M4. Costal ratio 0.68-0.72, n = 13. Halter pale.

Abdomen: Dark brown, terga faintly sclerotized, twice as broad as long on third segment. Spermathecae (fig. 55g) 3, unequal, large one 0.033 x 0.027 mm, and 2 small ones each 0.021 x 0.018 mm, slightly elongate, with broad, unsclerotized entrances to the ducts; duct from the 2 small ones joined immediately before entrance to the duct from the large one at the ring, ducts not saclike at the junction.

Male.--Similar to female, with usual sexual differences. Genitalia (fig. 55i): Ninth sternum with shallow caudomedian excavation; ninth tergum with small caudomedian cleft, with small, rounded submedian lobes, apicolateral processes small and slender, about twice as long as the lobes. Basistyle with ventral root reduced, dorsal root slender; dististyle curving with slender pointed tip. Aedeagus with basal arch attaining 0.4 of total length, basal arms stout; distal portion moderately stout and tapering to rounded tip. Parameres (fig. 55e) each with moderately large basal arm not abruptly bent laterad but directed obliquely anterolaterad; stem with short, moderately stout basal portion, abruptly narrowed to find filament which is sharply directed laterad, then ventrad, and then mesad to a fine threadlike tip.

Distribution.--Indonesia, Laos, Malaysia, Sabah, Sarawak, Thailand.

Types.--Holotype female, Malaysia, Selangor, Ulu Langat, 20.iv.1955, H.C. Barnett, light trap (Type in USNM). Paratypes, 2 males, 81 females

Southeast Asia Records.--

INDONESIA: Kalimantan (South), Banjar, Astambul, Tanah Intan, Simpang Empat, Kampung Baru (Lee); Tanah Intan, Pulo Tiga (Lee). Sulawesi (Southeast), Kendari, Ranometo, Randono (Bambang). Sumatra, Batam Island, Sungai Beduk (Sustriayu); Bengkulu, Cenggeri (Mathis); Jambi, Transmigrasi, Singkut (Lee); Lampung, Kotabumi, Way Abung, Margoreyo and Papanrejo (Lee).

LAOS: Sayaboury Prov., Muong Xieng Hon; Muong Sayaboury. Sedone Prov., Muong Pakse. Vientiane Prov., Muong Ban Keun, Ban Na Pheng, sweeping over cow (all collected by Howarth).

MALAYSIA: Johore, Kahang Kluang (Hubert). Kelantan, Lambok, Sungei Betis, Ulu Kelantan (Wharton). Pahang, Gunong Benom, primary forest, 540 m, biting man (Garcia); King George V Nat. Park, Tahan River (McClure); Kuala Singgora (Wharton); Kuala Trengganu (Quate, Gressitt, Maa); Kuantan-Pekan Road (Wharton). Selangor, Gombak Forest Res. (Traub); Kuala Lumpur (Barnett, Traub); Rantau Panjang, 6 km N Klang (Traub); Segambut (Barnett); Ulu Langat (Barnett).

SABAH: Kinabatangan Dist., SE end Dewhurst Bay (Inger and Davis). Tambunan (Colless). Tawau Dist., Kalabakan (Maa).

SARAWAK: Bau Dist., Pangkalan Tebang, 300 m (Maa). Kapit Dist., Nanga Pelagus (Traub).

THAILAND: Chiang Mai Prov. (Notananda). Loei Prov., Amphoe Dan Sai, Ban Na Muang (Elbel). Nakhon Ratchasima Prov. and Dist., and Pakchong Dist. (Manop R.).

Discussion.--The small, even mandibular teeth and dark mesonotum ally *C. elbeli* with *raripalpis* Smith and *sarawakensis* Wirth and Hubert, but *elbeli* can readily be distinguished by the pale halteres and banded forefemora, as well as the numerous structural characters given in the key.

The male allotype described and figured by Wirth and Hubert (1959) from the Gombak Forest Reserve was misidentified, having the wing tip conspicuously and broadly pale. We are indebted to F.G. Howarth for the opportunity to examine a long series of correlated males and females from Laos (Sedone Prov., Muong Pakse) from which the male is redescribed and figured.

Culicoides flaviscutatus Wirth and Hubert
(Figs. 56, 223, 379)

Culicoides flaviscutatus Wirth and Hubert, 1959: 34 (male, female; Ceylon, India, Malaya, Philippines, Sabah, Sarawak, Sumatra, Thailand; figs.); Delfinado, 1961: 66 (diagnosis; figs.; Philippines).

Female.--Wing length 0.85 (0.74-1.01, n = 14) mm.

Head: Antenna (fig. 56a) with lengths of flagellar segments in proportion of 20-17-19-20-20-19-19-19-24-23-27-27-43, antennal ratio 0.93 (0.88-0.99, n = 12), sensilla coeloconica present on segments 3,11-15. Palpus (fig. 56b) with lengths in proportion of 6-16-19-9-9; third segment slender, with sensilla borne on surface of segment distally; palpal ratio 2.5 (2.2-2.8, n = 12). Proboscis moderately short, P/H Ratio 0.64; mandible (fig. 56d) with 12 (10-13, n = 28) small, triangular, subequal teeth.

Thorax: Mesonotum and upper pleuron pale yellow; scutellum, postscutellum, and lower half of pleuron dark brown. Legs (fig. 56e) dark brown; foreleg with knee spot blackish, femur with subapical and tibia with sub-basal, broad, pale bands; midleg with knee pale, apex of femur and base of tibia broadly pale;

hindleg with femur all dark or with faint subapical pale band, tibia usually yellow, sometimes slightly darker with faint basal and apical pale bands, tibial comb as in fig. 56f.

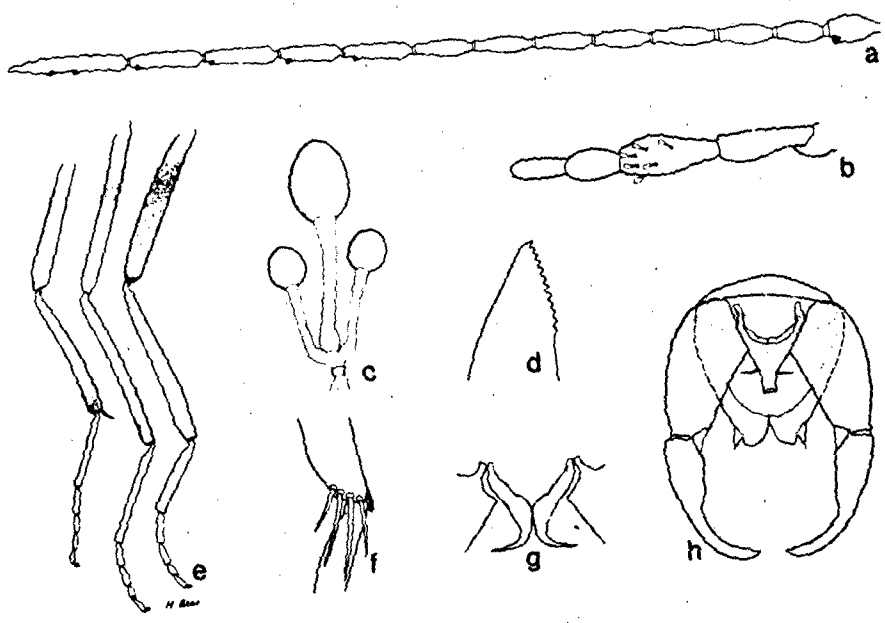


Fig. 56. *Culicoides flaviscutatus*: a. antenna; b. palpus; c. spermathecae; d. mandible; e. legs; f. tibial comb; g. parameres; h. male genitalia.

Wing (fig. 223, 379): Pattern as figured; anterior margin dark brown with two large pale spots, one centering over r-m crossvein and the other over end of second radial cell; less distinct pale spots also present on disc of wing and at tip of wing, including apices of cells R5 and M1. Macrotrichia moderately abundant at wing margin in cells R5, M1, and M2, and in rows along distal third of vein M1; costal ratio 0.69 (0.66-0.72, n = 14). Halter usually pale.

Abdomen: Light brown; terga poorly sclerotized, 2.3 times as broad as long on third segment. Spermathecae (fig. 56c) 3, unequal, with broad entrances to ducts; large spermatheca elongate, 0.035 x 0.028 mm, the 2 small ones each 0.019 x 0.017 mm; ducts from the 2 small spermathecae joined just before junction with duct from the large one at the ring; latter duct enlarged and saclike just before the junction; ducts each with hyaline ring near spermatheca.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 56h): Ninth sternum transverse, without caudomedian excavation; ninth tergum long and tapering, with deep caudomedian cleft and a pair of large sublateral lobes curving toward and nearly as long as the triangular, pointed, apicolateral processes. Basistyle with ventral root reduced, dorsal root slender; dististyle markedly curving to slender pointed tip. Aedeagus with basal arch extending to two-fifths of total length, basal arms stout; sides nearly straight, tapering to slender tip. Parameres (fig. 56g) each without basal knob, basal portion curving laterad and then cephalad from stem; stem quite short, swollen a short way at base, quickly tapering to simple filiform tip curving ventrolaterad.

Distribution.--Brunei, India, Indonesia, Malaysia, Philippines, Sabah, Sarawak, Singapore, Sri Lanka, Sumatra, Thailand.

Types.--Holotype female, allotype male, Malaysia (Borneo), Labuan Island, ix-xi.1948, D.H. Colless, at light (Type in USNM). Paratypes, 20 males, 70 females.

Southeast Asia Records.--

BRUNEI: Kg. Selimbigar (Colless).

INDONESIA: Bali, Badung, Mengwi (Lee); Peguyangan, Tag Tag (Lee). Flores (East), Henga (collector unknown). Java (West), Bekasi, Krangi (Lee). Kalimantan (South), Banjar Astambul, Pengiuran, Sawah Swamp (Lee); Astambul, Tanah Intan, Lombok Terang (Lee); Banjar, Martapura, Bincau (Lee). Lombok (East), Selong, Bagik Payung (Lee). Sulawesi (Central), Banggai, Tatui, Kamiwangi (Bambang). Sumatra, Bengkulu, Cenggeri (Mathis); Lampung, Way Abung, Mulyorejo (Lee).

MALAYSIA: Pahang, Gunong Benom, primary forest, 540 m, biting man (Garcia); King George V Nat. Park, Tahan R. (McClure); Kuala Singgora (Wharton); Kuala Trengganu (Gressitt, Maa); Kuantan Pekan Road (Wharton); Kuantan, Telok Sisek (Wharton); Ulu Gali, cattle shed (Garcia). Perak, Gunong Besont Forest Res. (Jeffery); Kuala Kengrong, Girik (Traub). Selangor, Anipang Forest Res. (Traub); Kepong (Barnett); Kuala Lumpur (Barnett, Traub); Segambut (Barnett); Serdang (Barnett); Subang, cocoa plantation, biting man (Traub); Subang Forest Res., Kuala Lumpur (Traub); Sungai Dusun, swamp forest, biting man (Milton); Ulu Langat (Barnett) and chicken baited trap (Garcia); Ulu Gombak Forest Res. (Traub). Trengganu, Dungun, Bukit Besi (Traub).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Pampanga Prov., Angeles (Balatbat); Samar Prov., Taft (Balatbat). Mindanao, Davao Prov., Camp Baclayan, E slope Mt. Apo (Werner). Negros Oriental, Cuemos de Negros, Camp Lookout (Delfinado). Palawan, Busanga, Pimaniang (Hoogstraal).

SABAH: Kinabatangan Dist., S end Dewhurst Bay (Inger and Davis). Labuan Island (Colless). Tambunan (Colless).

SARAWAK: Kapit Dist., Nanga Pelagus (Traub). Limbang and Lutong (Colless).

SINGAPORE: Kg. Chantek Bahru (Colless); Nee Soon (Colless).

SUMATRA: Deli (collector unknown).

THAILAND: Chiang Mai Prov. (Notonanda). Chiang Rai (Causey). Bangkok (Causey). Loei Prov., Dan Sai (Elbel, Manop R.); Ban Na Muang (Elbel). Minburi Prov. (Manop). Nakronprathom Prov. (Manop). Nong Khai Prov. (Manop). Nonthaburi Prov. (Manop). Phangnga Prov., Pulau Panjang (collector unknown). Paiao Prov. (Thurman). Sakron Nakhon Prov. (Manop).

Discussion.--The combination of subequal mandibular teeth, antennal sensilla present on segments 3,11-15, entirely pale mesonotum, well marked wing, pale halter, and entirely dark hindfemur will distinguish *C. flaviscutatus* from other species of *Trithecoides*.

Culicoides flaviscutellaris Wirth and Hubert, new species
(Figs. 57, 224, 380)

Female.--Wing length 0.85 mm.

Head: Antenna (fig. 57a) with lengths of flagellar segments in proportion of 20-19-21-23-24-24-22-21-25-24-27-25-41, antennal ratio 0.82; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 57b) with lengths of segments in proportion of 5-18-19-8-11; third segment slightly swollen toward tip, with sensilla borne in an irregular open sensory area near apex; palpal ratio 2.7. Proboscis moderately short, P/H Ratio 0.62; mandible (fig. 57e) with 11 (n = 2) small, subequal teeth.

Thorax: Mesonotum, scutellum and upper pleuron yellow; postscutellum and lower pleuron dark brown. Legs (fig. 57d) brown; fore- and midlegs with knee pale, apex of femur and base of tibia broadly pale; hindleg with blackish knee spot, nearly all of femur and all of tibia yellowish, tibial comb as in fig. 57c.

Wing (fig. 224, 380): Pattern as figured, darker over base of second radial cell, past end of costa and over base of mediocubital fork and vein Cu1; light infuscation along veins leaving indefinite pale areas in cell between; tip of wing not distinctly paler. Wing bare of macrotrichia; costal ratio 0.74; second radial cell broad, 2.5 times as long as first. Halter pale.

Abdomen: Pale yellow, terga unsclerotized. Spermathecae (fig. 57f) 3, unequal, with large entrances to ducts; poorly sclerotized, not measured because tilted in aspect on slide; the large one broader than long, conoidal, the 2 small ones subequal, subspherical; ducts obscured in slide mount.

Male.--Unknown.

Distribution.--Malaysia.

Types.--Holotype female, Malaysia, Trengganu, Dungun, Bukit Besi, 6.viii.1958, R. Traub, light trap (Type in USNM). Paratypes, 6 females.

MALAYSIA: Pahang, King George V Nat. Park, Tahan River, 4-6.xi.1959, H.E. McClure, light trap, 1 female. Trengganu, Kuala Brang, 14.viii.1973, R. Parsons, light trap, 2 females. Negri Sembilan, Paroi Estate, 26.xii.1973, R. Parsons, light trap, 2 females. Selangor, Ulu Lui, 17.xii.1973, R. Parsons, light trap, 1 female.

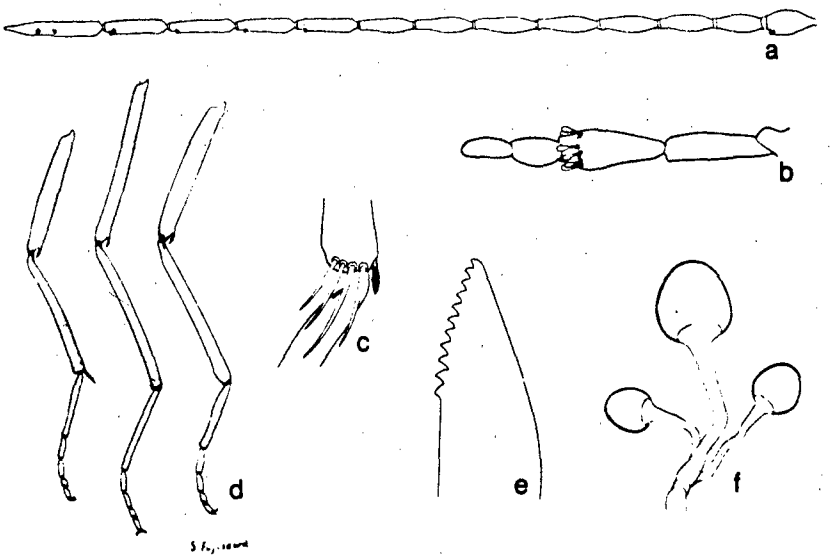


Fig. 57. *Culicoides flaviscutellaris*: a. antenna; b. palpus; c. tibial comb; d. legs; e. mandible; f. legs.

Discussion.--This species resembles *C. albibasis* Wirth and Hubert and *barnetti* Wirth and Hubert. It can be distinguished from the former by the pale mesonotum, scutellum, halter, and most of the hindfemur, as well as by the darker wing base; and from the second species by the more broadly banded hindfemur, poorly marked wing, and pale scutellum.

Culicoides fordae Wirth and Hubert, new species
(Figs. 58, 225, 381)

Culicoides species C; Howarth, 1985: 44 (Laos records).

Female.--Wing length 0.74 (0.72-0.79, n = 10) mm.

Head: Antenna (fig. 58a) with lengths of flagellar segments in proportion of 16-14-15-16-16-16-15-16-20-19-24-25-36, antennal ratio 0.98 (0.93-1.03, n = 10); sensilla coeloconica present on segments 3,13-15, absent on 11 and 12. Palpus (fig. 58b) with lengths of segments in proportion of 7-15-14-9-7; third segment short, slightly swollen, with sensilla borne in a loose cluster on surface of apical half of segment; palpal ratio 2.4 (2.3-2.7, n = 9). Proboscis moderately short, P/H Ratio 0.59; mandible (fig. 58d) with 11 (10-12, n = 18) very small, subequal teeth.

Thorax: Mesonotum and upper pleuron very pale yellow; scutellum, postscutellum and lower pleuron dark brown. Legs (fig. 58e) brown; foreleg with black knee spot and with moderately broad pale bands subapically on femur and sub-basally on tibia; midleg with pale knee, apex of femur and base of tibia broadly pale; hindleg with femur dark to apex, tibia entirely pale, tibial comb as in fig. 58f.

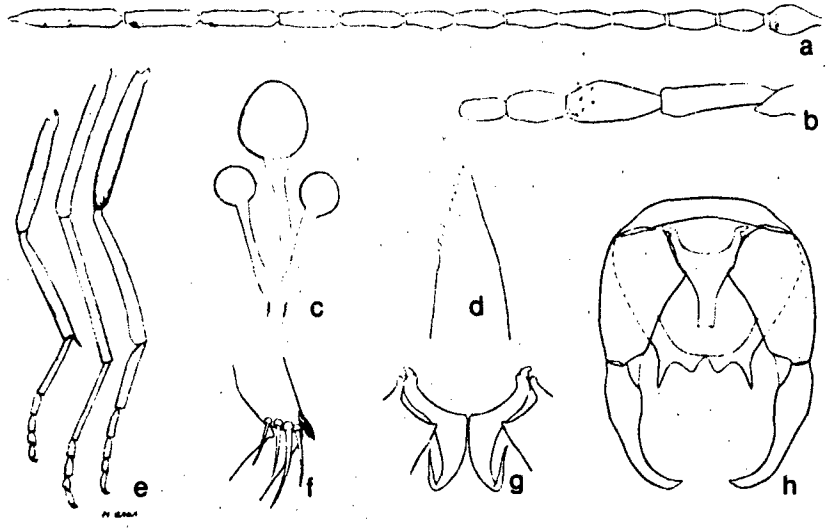


Fig. 58. *Culicoides fordae*: a. antenna; b. palpus; c. spermathecae; d. mandible; e. legs; f. tibial comb; g. parameres; h. male genitalia, parameres omitted.

Wing (fig. 225, 381): Pattern as figured; dark with two prominent pale spots on costal margin, apex of wing narrowly but distinctly pale, indistinct pale areas in middle of cells M1, M2, M4 and apex of anal cell; pale spot over r-m crossvein small and not extending caudad past media, second pale costal spot covering distal half of second radial cell and extending only slightly distad and caudad. Macrotrichia reduced to a very few in apices of cells R5 and M1; costal ratio 0.70 (0.68-0.72, n = 10); second radial cell broad, twice as long as first. Halter pale.

Abdomen: Pale brown; terga poorly sclerotized, not quite twice as broad as long on third segment. Spermathecae (fig. 58c) 3, unequal, with broad entrances to ducts; large spermatheca 0.029 x 0.025 mm, the 2 small ones subequal, each 0.016 x 0.017 mm; large spermatheca ovoid, the 2 small ones subspherical; ducts slightly swollen at bases, ducts of all spermathecae joined at one point near the ring, each with a slight saclike swelling near the junction.

Male.--Similar to female, with usual sexual differences. Genitalia (fig. 58h): Ninth sternum with very slight caudomedian excavation; ninth tergum short and tapering, apicolateral processes long and pointed, caudal margin between them with small median cleft and a pair of small but definite and pointed submedian lobes. Basistyle with ventral root reduced, dorsal root slender; dististyle curving with slender pointed apex. Aedeagus with basal arch low and broad, extending to a third of total length, basal arms stout and curving; distal portion moderately slender and curving ventrally to a rounded tip. Parameres (fig. 58g) each with a small basal knob directed anterolaterad; stem moderately swollen on basal portion, gradually narrowed to slender, filiform tip directed ventrad.

Distribution.--Indonesia, Laos, Malaysia, Sabah, Singapore, Thailand.

Types.--Holotype female, Malaysia, Trengganu, Dungun, Bukit Besi, 6.viii.1958, R. Traub, light trap (Type in USNM). Paratypes, 29 males, 125 females, as follows:

MALAYSIA: Same data as types, 25 females. Johore, Kahang Kluang, 7.i.1961, A.A. Hubert, light trap, 5 males, 80 females. Kelantan, Lambok, Sungai Betis, 9.xi.1961, R.H. Wharton, light trap, 13 females; Sungai Nenggiri, Ulu Kelantan, 12.xi.1961, R.H. Wharton, light trap, 2 females. Pahang, Kuala Singgora, 17.vi.1958, 26.i.1959, R.H. Wharton, light at edge of padi field, 6 males, 24 females; Kuala Singgora, Maran, 15.ii.1959, R. Traub, at light, 3 males, 3 females; Kuala Tahan, 16.xii.1958, L.W. Quate, light trap, 2 females, 10.iv.1961, R. Domrow, biting man, 1 female; Kuala Trengganu, 15.xii.1958, Gressitt and Maa, light trap, 2 females; Kuala Brang, 14.viii.1973, R. Parsons, light trap, 2 females; Kuantan, Gudang Rasan, i-ii.1959, R. Traub, light trap, 20 females; King George V Nat. Park, Tahan R., 4-6.xi.1959, H.E. McClure, 1 male, 12 females; Lamir, Pekan, 5.ix.1961, R.H. Wharton, light trap, 3 females; Pahang Tua, Pekan, 6.ix.1961, R.H. Wharton, light trap, 3 males, 3 females; Tasek Bera, 11.x.1961, W.H. Wharton, light trap, 1 male, 28 females. Perak, Pulau Pangkor, 1.iv.1959, R. Traub, light trap, 2 females. Selangor, Kuala Lumpur, iii-x.1958, R. Traub, light trap, 4 males, 19 females, 15.ii.1955, H.C. Barnett, light trap, 2 females; Serdang, 15.ii.1955, H.C. Barnett, light trap, 7 females; Subang Forest Res., 1959, H.E. McClure, light trap, 1 female.

SINGAPORE: Nee Soon, 20.i.1960, D.H. Colless, light trap, 1 female.

Other Specimens Examined.--

INDONESIA: Java (West), Kapuk (Lee); Pandeglang, Ujung Kulon (Watters). Kalimantan (South), Banjar, Astambul, Sungai Baru (Lee); Astambut, Tanah Intan, Danau Kuriang and Pondok Delapan (Lee). Sulawesi (Central), Banggai, Batui, Dongin (Bambang); (Southeast) Kendari, Ranometo, Randono (Bambang). Sumatra, Bengkulu Cenggeri (Mathis).

LAOS: Sayaboury Prov., Muong Sayaboury, Muong Xieng Hon. Sedone Prov., Muong Pakse, Muong Paksong. Vientiane Prov., Muong Ban Keun, Ban Na Pheng (all collected by Howarth).

SABAH: Labuan Island (Colless). Tambunan (Colless).

THAILAND: Chiang Mai Prov. (Notananda). Chiang Rai Prov. (Causey).

Discussion.--Culicoides fordae most closely resembles *flaviscutatus* Wirth and Hubert in having small, subequal, mandibular teeth, pale mesonotum but dark brown scutellum and postscutellum, unbanded hindfemur and pale halteres, but it can be distinguished from *flaviscutatus* by the absence of antennal sensilla on segments 11 and 12, by its much smaller and blunter mandibular teeth, and by the reduction of macrotrichia at the wing tip.

We are pleased to be able to name this species after Thelma Ford, who as former scientific illustrator of the Department of Entomology, Walter Reed Army Institute of Research, and the Southeast Asian Mosquito Project, Smithsonian Institution, helped us in many ways, particularly with art work on this project.

Culicoides gewertzi Causey
(Figs. 59, 226, 382)

Culicoides gewertzi Causey, 1938: 409 (male; Thailand; figs.); Wirth and Hubert, 1959: 30 (male, female; figs.; distribution).

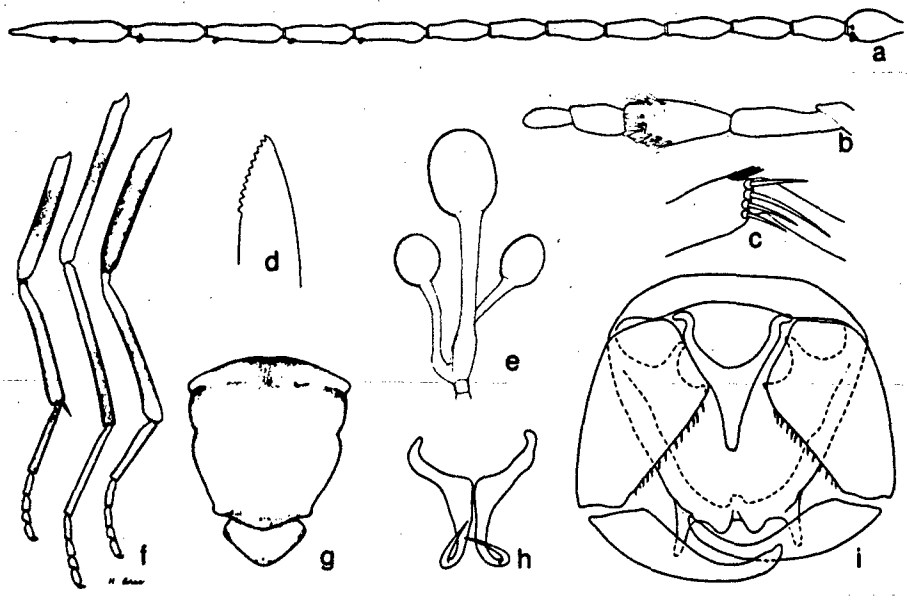


Fig. 59. *Culicoides gewertzi*: a. antenna; b. palpus; c. tibial comb; d. mandible; e. spermathecae; f. legs; g. thoracic pattern; h. parameres; i. male genitalia.

Female.--Wing length 0.88 (0.81-0.91, n = 10) mm.

Head: Antenna (fig. 59a) with lengths of flagellar segments in proportion of 19-16-18-19-19-18-17-18-24-23-27-28-44, antennal ratio 1.01 (0.95-1.05, n = 10); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 59b) with lengths in proportion of 7-17-22-10-10; third segment slender, with sensilla borne on surface of segment distally; palpal ratio 2.6 (2.3-3.0, n = 10). Proboscis moderately short, P/H Ratio 0.61; mandible (fig. 59d) with 16 (15-17, n = 17) fine teeth of subequal lengths.

Thorax: Mesonotum (fig. 59g) yellow, dark brown on anterior margin; scutellum, postscutellum, and lower half of pleuron dark brown. Legs (fig. 59f) dark brown; foreleg with black knee spot, femur with subapical pale band, tibia with basal pale band; midleg with knee, apex of femur and base of tibia pale; hindleg with femur dark to apex, tibia with basal and apical pale bands, tibial comb as in fig. 59c.

Wing (fig. 226, 382): Pattern as figured; costal margin with darker infuscation; small but distinct pale spots over r-m crossvein and centered on apex of second radial cell; apex of wing narrowly pale, rest of wing darkly infuscated except for indistinct paler areas between some of the veins. Costal ratio 0.69 (0.68-0.71, n = 10). Halter infuscated.

Abdomen: Dark brown, sclerotized terga broad, 3 times as broad as long on third segment. Spermathecae (fig. 59e) 3, unequal, large one 0.038 x 0.030 mm, and 2 small subequal ones, each 0.021 x 0.021 mm, the large spermatheca definitely longer than broad; with broad unsclerotized entrances to the ducts, ducts from the 2 small ones joined in a common sac just before entrance to the saclike duct from the large one at the ring.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 59i): Ninth sternum without caudomedian excavation; ninth tergum strongly cleft distally on midline, forming two rounded lobes greatly exceeding the small apicolateral processes. Basistyle with ventral root reduced, dorsal root short; dististyle curving to slender pointed apex. Aedeagus with basal arch extending to a third of total length, basal arms stout; sides nearly straight, tapering to bluntly pointed tip, but with slight evidence of shoulder-like subapical lateral swelling. Parameres (fig. 59h) each short and stout, basal knob not developed, abruptly bent in midportion, stem very short, stout, and gradually tapering to laterally curved, simple, pointed tip.

Distribution.--Indonesia, Malaysia, Philippines, Sabah, Sarawak, Singapore, Thailand.

Type.--Holotype male, Chiang Rai, Thailand, 1931-35, O.R. Causey, light trap (Type in USNM).

Southeast Asia Records.--

INDONESIA: Bali, Gianyar, Tangan Juda (Sweatman). Java (West), Garut, Pameungpeuk (Zubaedah). Kalimantan (South), Banjar, Astambul, Tanah Intan, Danau Kuriang and Pulo Tiga (Lee); Banjar, Martapura, Bincau (Lee). Sulawesi (Southeast), Kendari, Unaha (Bambang). Sumatra, Bengkulu, Cenggeri and Pekik Nyaring (Mathis). Timor (East), Dilli, Comoro, Kampung Marinir (Soeroto).

MALAYSIA: Johore, Kahang Kluang (Hubert). Kedah, Sungei Patani (Traub). Negri Sembilan, Telok Pelandok, Port Dickson (Traub). Pahang, King George V Nat. Park, Tahan R. (McClure); Kuala Singgora (Traub); Kuantan, Gudang Rasan (Traub); Kuantan Pekan Road (Wharton); Tasek Bera (Wharton). Perak, Pulau Pangkor (Traub). Selangor, Rantau Panjang, 6 km N Klang (Traub); Segambut (Barnett); Serdang (Barnett); Ulu Langat (Barnett). Trengganu, Dungun, Bukit Besi (Traub); Kg. Binjai, Kemaman (Wharton).

PHILIPPINES: Negros Oriental, Cuemos de Negros, Camp Lookout (Delfinado). Palawan, Brookes Point, Makagua (Noona Dan Exped.).

SABAH: Labuan Island (Colless). Tumbunan (Colless). Tawau Kalabakan (Maa).

SARAWAK: Limbang (Colless).

SINGAPORE: Nee Soon (Colless).

THAILAND: Bangkok (Causey, Niphan). Chiang Rai (Causey).

Discussion.--Culicoides gewertzi resembles *humeralis* Okada externally, but can be readily distinguished by the small, subequal mandibular teeth. *Culicoides allantothecus* n. sp. resembles *gewertzi* in its dark anterior portion of the mesonotum and subequal mandibular teeth, but it is a much smaller species and has the distal portion of the hindfemur broadly pale.

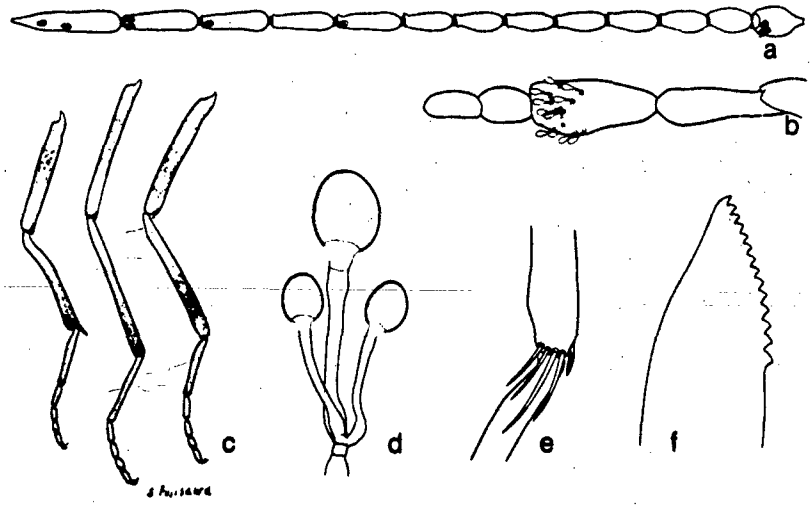


Fig. 60. *Culicoides gouldi*: a. antenna; b. palpus; c. legs; d. spermathecae; e. tibial comb; f. mandible.

Culicoides gouldi Wirth and Hubert, new species
(Figs. 60, 227, 383)

Female.--Wing length 0.78 (0.72-0.82, n = 10) mm.

Head: Antenna (fig. 60a) with lengths of flagellar segments in proportion of 17-15-17-19-19-18-19-19-24-23-26-28-40, antennal ratio 0.97 (0.92-1.03, n = 10); sensilla coeloconica present on segments 3,11,13-15, absent on 12. Palpus (fig. 60b) with lengths in proportion of 7-17-19-7-9; third segment very slightly swollen distally, with sensilla grouped loosely on surface of segment distally; palpal ratio 2.1 (2.0-2.4, n = 9). Proboscis moderately short, P/H Ratio 0.60; mandible (fig. 60f) with 13 (11-14, n = 15) very small, subequal teeth.

Thorax: Mesonotum and upper pleuron pale yellow; scutellum, postscutellum and lower pleuron dark brown. Legs (fig. 60c) dark brown, knees pale; fore- and hindlegs with apices of femora and bases of tibiae narrowly pale, distal pale band on hindfemur not prominent; midleg with apex of femur and base of tibia broadly pale; hindtibial comb as in fig. 60e.

Wing (fig. 227-383): Pattern as figured; dark brown with small pale areas, two quite distinct ones on costal margin, first over r-m crossvein extending caudad just to media, second centering on end of costa and covering distal third of second radial cell; very small pale area at wing tip; discal and posterior pale areas very poorly defined. Macrotrichia sparse, present on distal fourth of wing in cells R5, M1 and M2 only; costal ratio 0.70 (0.67-0.72, n = 10); second radial cell broad, 1.8 times as long as first. Halter infuscated.

Abdomen: Pale brown, terga moderately sclerotized, twice as broad as long on third segment. Spermathecae (fig. 60d) 3, unequal with broad entrances to ducts; large spermatheca 0.033 x 0.038 mm, the 2 small ones subequal, each 0.022 x 0.018 mm; all longer than broad, oval in shape; all ducts joined at 1 point near the ring, small swellings on the ducts near the spermathecae and also near the common junction.

Male.--Unknown.

Distribution.--Indonesia, Malaysia, Sabah, Sarawak, Sulawesi.

Types.--Holotype female, Malaysia, Negri Sembilan, Telok Pelandok, Port Dickson, 18.vii.1958, R. Traub, light trap (type in USNM). Paratypes, 35 females.

INDONESIA: Batam Island, Sungai Beduk, 17.i.1981 (Sustriayu), 1 female.

MALAYSIA: Same data as type, 7. Kedah, Langkaw Island, 18.vii.1958, R. Traub, light trap, 1. Pahang, Kuantan, Gudang Rasan, i-ii.1959, R. Traub, light trap, 1; Kuantan-Pekan Road, 3.iv.1957, R.H. Wharton, light trap in swamp forest, 1.

SABAH: Brunei, Kilwas, xi.1951, D.H. Colless, biting man, 1. Labuan Island, ix-xii.1948, D.H. Colless, at light, 4. Tawau, ii.1960, D.H. Colless, 1; Kalabakan, 14.xi.1958, T. Maa, 1.

SARAWAK: Limbang, xii.1950, D.H. Colless, at light, 3. Sutong, xii.1948, D.H. Colless, biting man, 2.

SULAWESI: (North), Dumoga-Bone Nat. Park, 220 m, 16-20.x.1985, J.B. Heppner, 7; Lake Mooat, 20 km NE Kotamobagu, 1,050 m, 26-30.x.1985, Heppner, 2.

Discussion.--Culicoides gouldi has the apices of the hindfemora pale and the halteres dark as in *albibasis* Wirth and Hubert, but differs from that species in having the mesonotum all yellow, the base of the wing not extensively pale, and quite unique in having sensilla only on antennal segments 3,11,13-15, lacking the usual sensillum on segment 12. In a few specimens of *gouldi* the apex of the hindfemur is dark. A few others have the foreknee slightly darkened. The wing tip varies from distinctly through narrowly pale to dark.

This species is dedicated to Dr. Douglas J. Gould, formerly of the Walter Reed Army Institute of Research, in recognition of his valuable contributions to the medical entomology of Southeast Asia while assigned to the Institute of Medical Research in Kuala Lumpur, Malaysia, and the U.S. Army Component, SEATO Medical Research Laboratory in Bangkok, Thailand.

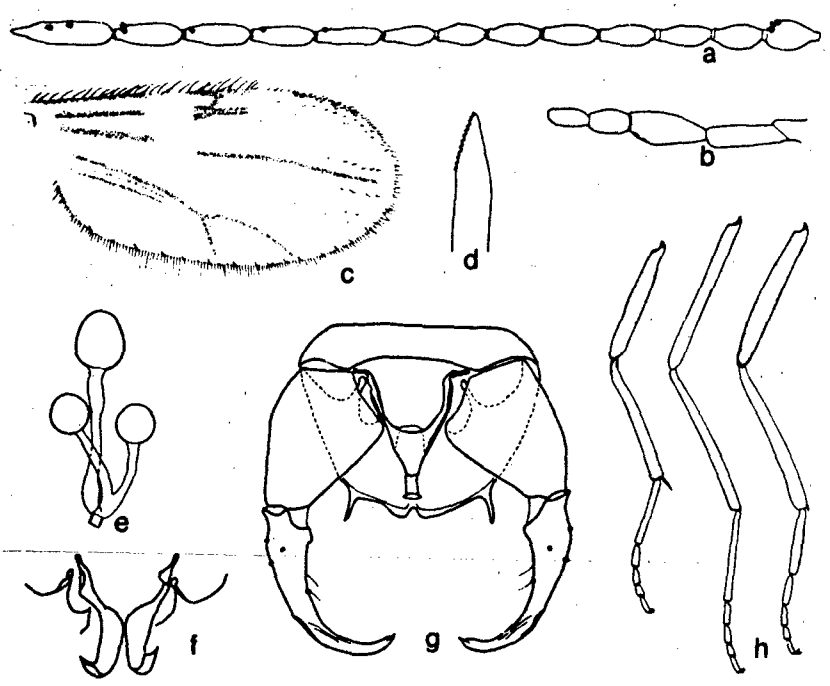


Fig. 61. *Culicoides hinnoi*: a. antenna; b. palpus; c. wing; d. mandible; e. spermathecae; f. parameres; g. male genitalia, parameres omitted; h. legs.

Culicoides hinnoi Howarth
(Figs. 61, 228)

Culicoides hinnoi Howarth, 1985: 33 (male, female; Laos; figs.).

Female.--Wing length 0.86 mm.

Head: Antenna (fig. 61a) with lengths of flagellar segments in proportion of 17-16-18-19-18-18-18-17-22-22-23-24-36, antennal ratio 0.91; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 61b) with lengths of segments in proportion of 7-18-17-9-10; third segment short, swollen in midportion, palpal ratio 2.4; sensilla clustered along distal half of mesal margin. Proboscis short, P/H Ratio 0.56; mandible (fig. 61d) with 11 small triangular teeth.

Thorax: Mesonotum variably yellowish to dark brown, dark brown on humeral angles, on anterior margin, and on disc in front of scutellum; scutellum, postscutellum and lower half of pleuron dark brown; upper half of pleuron yellowish, its boundary with dark brown lower half and along upper margin poorly defined. Legs (fig. 61h) predominantly dark brown; foreknee dark, forefemur with narrow subapical pale band, foretibia with sub-basal pale band; midknee broadly pale, midfemur with broad apical pale band; hindfemur dark to tip or with indistinct narrow subapical pale band, apex of femur dark brown, tibia light brown, paler at base and apex.

Wing (fig. 61c, 228): Pattern as figured; predominantly dark, darker anteriorly; three well defined small pale spots, one at base of wing, not including anal angle, a circular one over r-m crossvein reaching costal margin, and one centered over apex of second radial cell not reaching vein M1; diffuse indistinct pale spots located in apices of anal cell and cell M4; wing tip narrowly pale; wing paler on disc between veins. Macrotrichia sparse, a few near anterior wing margin distally in cell R5 and in rows parallel to vein M1 in apices of cells R5 and M1; costal ratio 0.69. Halter pale.

Abdomen: Dark brown, terga well sclerotized; third tergum twice as broad as long. Spermathecae (fig. 61e) 3, unequal with large unsclerotized entrances to ducts; large spermatheca 0.033 x 0.038 mm and 2 smaller subequal ones each 0.024 x 0.021 mm; ducts from smaller spermathecae joining each other in common sac before joining saclike duct from large spermatheca at the ring.

Male.--Similar to female with usual sexual differences; antenna with sensilla coeloconica on segments 3,13-15. Genitalia (fig. 61g): Ninth sternum with shallow caudomedian excavation; ninth tergum short and broad with small, slender, widely separated apicolateral processes, their length less than half the distance between their bases, caudal margin with distinct median cleft and small submedian lobes. Basistyle with small ventral root and slender dorsal root; dististyle strongly curving to slender pointed tip. Aedeagus with basal arch narrow, extending to half of total length; midportion well sclerotized, strongly tapering, distal process hyaline, narrowly spatulate, tip bent ventrad. Parameres (fig. 61f) separate; each stout, heavily sclerotized with strong basal arms; midportion stout, tapering to distal blade sharply bent ventrad.

Distribution.--Laos.

Types.--Holotype male, allotype female, Laos, Vientiane Prov., Muong Ban Keun, Ban Na Pheng, 180 m, 21.v.1968, F.G. Howarth, light trap (Bishop Mus.).

Southeast Asia Records.--
LAOS: Sayaboury Prov., Sayaboury, 300 m (Howarth). Sedone Prov., Muong Pakse, 100 m (Howarth). Vientiane Prov., Muong Ban Keun, Ban Na Pheng (Howarth, types).

Discussion.--The brown mesonotum and small equal mandibular teeth ally this species with *elbeli* Wirth and Hubert, from which it can be distinguished by the poorly defined margins of the yellow marking on the upper pleuron. The species is keyed out in two places because of the variable yellowish to dark brown infuscation of the mesonotum. The massive male parameres are diagnostic for this species.

Culicoides huberti Howarth
(Figs. 62, 229)

Culicoides huberti Howarth, 1985: 33 (male, female; Laos; figs.).

Female.--Wing length 0.97 mm.
Head: Antenna (fig. 62a) with lengths of flagellar segments in proportion of 19-18-19-21-21-20-19-20-25-24-27-30-41, antennal ratio 0.93; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 62b) with lengths of segments in proportion of 7-24-23-9-9; third segment slender, slightly swollen on distal half, sensilla scattered or grouped in smaller irregular depressions mesally on distal portion of segment; palpal ratio 2.6. Proboscis short, P/H Ratio 0.60; mandible (fig. 62d) with 11 small triangular teeth, proximal ones slightly larger.
Thorax: Mesonotum and upper half of pleuron bright yellow; prescutellar area, scutellum, postscutellum, and lower half of pleuron dark brown. Legs (fig. 62h) dark brown, bands prominent; foreknee narrowly dark, forefemur with broad subapical pale band, foretibia with narrow sub-basal pale band; midknee narrowly dark brown, midfemur with subapical or apical pale band, midtibia with sub-basal pale band; hindfemur with apex darkened and with narrow indistinct to distinct subapical pale band, knee dark, hindtibia with sub-basal pale band and indistinct apical pale band.
Wing (fig. 62c, 229): Pattern as figured; predominantly dark, darker along anterior margin; dark spot over vein R1 larger than pale spot over r-m crossvein; pale spots small; one at base of wing with marginal streak into anal angle; two anterior pale spots, one over r-m crossvein and other not quite covering distal half of second radial cell; small marginal spots in apex of anal cell and cell M4; wing tip broadly and distinctly pale as if dipped in white, including apices of cells R5, M1 and M2; indistinct pale streaks in cell M2 near medial fork and one sometimes present in base of cell M1. Macrotrichia sparse, confined to anterior and distal portion of cell R5, apices of cells M1 and M2, and in row parallel to apices of veins M1 and M2; costal ratio 0.48. Halter slightly infuscated.

Abdomen: Pale brown; terga slightly darker, twice as broad as long on third segment. Spermathecae (fig. 62e) 3, unequal, with broad unsclerotized entrances to ducts; large spermatheca elongate, 0.035 x 0.038 mm, the smaller ones subequal and slightly elongate, each 0.021 x 0.020 mm; ducts from smaller spermathecae joining just before junction with duct from large one at the ring; ducts not saclike before junction, and each with indistinctly hyaline ring near spermatheca.

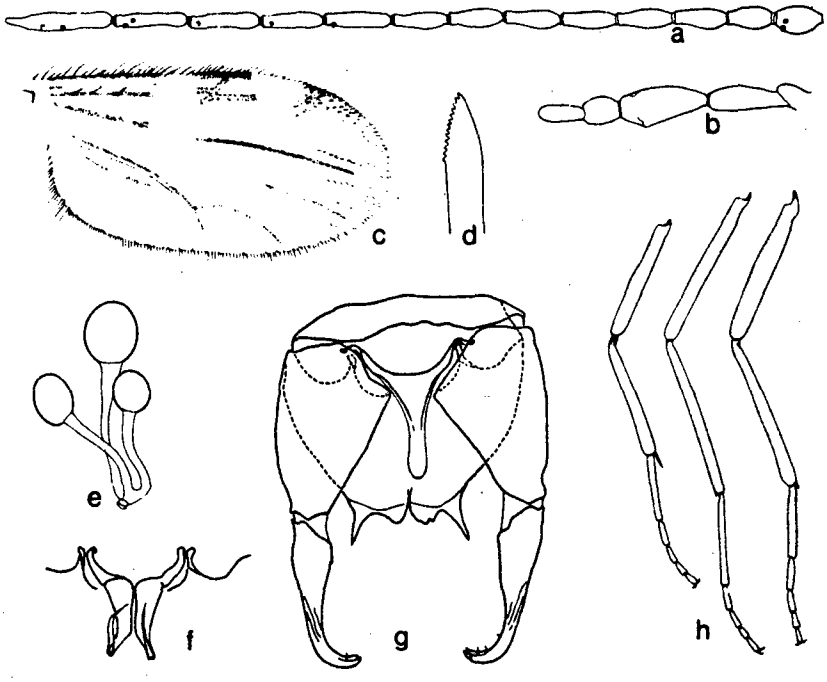


Fig. 62. *Culicoides huberti*: a. antenna; b. palpus; c. wing; d. mandible; e. spermathecae; f. parameres; g. male genitalia, parameres omitted; h. legs.

Male.--Similar to female with usual sexual differences; sensilla coeloconica present on antennal segments 3,13-15. Genitalia (fig. 62g): Ninth sternum with shallow caudomedian excavation; ninth tergum with long slender apicolateral processes slightly flaring, the caudal margin between them with distinct median notch and short, wide, submedian lobes. Basistyle with ventral root reduced, dor-

sal root slender; dististyle curving to slender pointed apex. Aedeagus with low basal arch extending less than a fourth of total length; distal portion abruptly tapered at base and with parallel margins distally, ending in slightly expanded, rounded tip. Parameres (fig. 62f) indistinctly joined near bases; each with slender basal arm directed anterolaterad; midportion rather stout, tapering distally, abruptly bent ventrad at distal third and ending in slender filiform tip directed cephalad.

Distribution.--Indonesia, Laos.

Types.--Holotype female, Laos, Sedone Prov., Muong Pakse, 100 m, 3.ix.1967, F.G. Howarth, at light in forest (Bishop Mus.). Allotype male, same data.

Southeast Asia Records.--
INDONESIA: Maluku, P. Buru, Savanjaya (Bambang).
LAOS: Sayaboury Prov., Sayaboury, 300 m (Howarth); Muong Xieng Hon, 500 m (Howarth). Sedone Prov., Muong Pakse, 100 m (Howarth, types).

Discussion.--This species is very similar to *C. barnetti* Wirth and Hubert, but the subapical pale band on the hindfemur is less distinct and the pale wing markings are less extensive, the poststigmatic pale spot covering less than the distal half of the second radial cell and the dark spot over vein R1 is as wide or wider than the pale spot over r-m crossvein. In the males of *barnetti* the apicolateral processes on the ninth tergum are not as long.

Culicoides laoensis Howarth
(Figs. 63, 230)

Culicoides laoensis Howarth, 1985: 37 (male, female; Laos; figs.).

Female.--Wing length 1.00 mm.
Head: Antenna (fig. 63a) with lengths of flagellar segments in proportion of 18-17-19-20-20-20-20-21-28-27-32-34-47, antennal ratio 1.03; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 63b) with lengths of segments in proportion of 8-27-25-12-12; third segment long, slender, slightly swollen in middle, sensilla scattered on distal half; palpal ratio 3.0. Proboscis moderately long, P/H Ratio 0.68. Mandible (fig. 63d) with 11 fine small triangular teeth, basal 5-6 slightly larger and more widely spaced.
Thorax: Mesonotum pale yellow except dark brown in front of scutellum; scutellum, postscutellum, and lower half of pleuron dark brown, upper half of pleuron yellow. Legs (fig. 63h) dark brown, pale bands prominent; foreknee dark, forefemur with broad subapical pale band, foretibia with broad sub-basal pale band; midknee broadly pale including distal third of femur and proximal third of tibia; hindfemur dark to tip, blackened distally, hindtibia with sub-basal pale band and pale apex.

Wing (fig. 63c, 230): Pattern as figured; predominantly dark. Two small pale spots on anterior margin, one over r-m crossvein and second at tip of second radial cell; dark spot over vein R1 large, much larger than costal pale spots; dif-

fuse pale spots located at base of wing but not including anal angle, at apex of anal cell, at apex of cell M4, at extreme apex of wing including apices of cells R5 and M1, and at base of medial fork in cell M2; no pale spot basally in cell M1. Macrotrichia moderately abundant anteriorly and distally in cell R5, distally in cells M1 and M2, and in longitudinal rows along veins M1 and M2; costal ratio 0.68. Halter pale or slightly darkened.

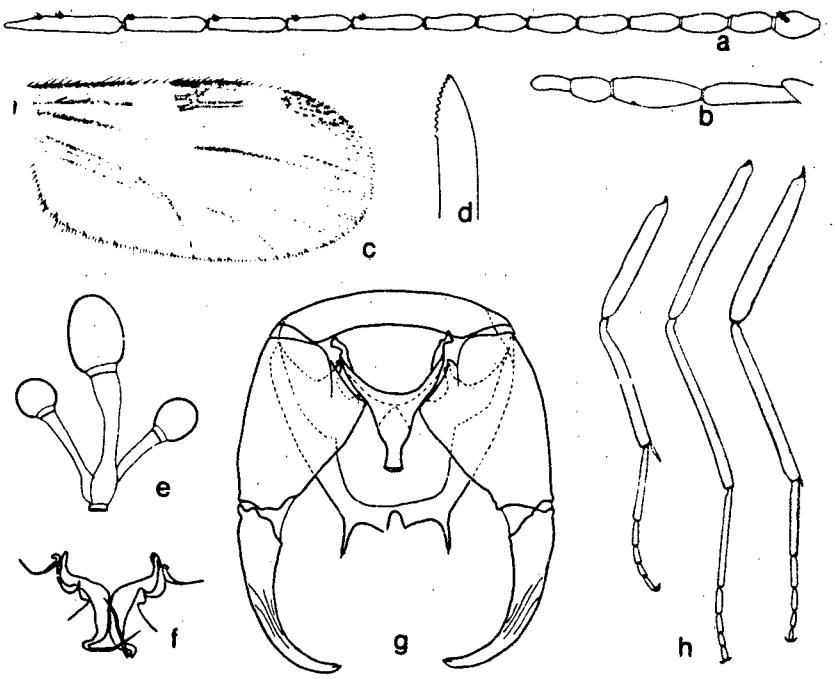


Fig. 63. *Culicoides laoensis*: a. antenna; b. palpus; c. wing; d. mandible; e. spermathecae; f. parameres; g. male genitalia, parameres omitted; h. legs.

Abdomen: Pale brown, terga darker, twice as broad as long on third segment. Spermathecae (fig. 63e) 3, unequal with large unsclerotized entrances to ducts; large spermatheca 0.035 x 0.028 mm, the 2 subequal small ones each 0.019 x 0.019 mm; each duct with hyaline ring near spermatheca and saclike before common junction with other ducts at the ring.

Male.--Similar to female, with usual sexual differences; sensilla coeloconica on antennal segments 3,13-15. Genitalia (fig. 63g): Ninth sternum with shallow caudomedian excavation; ninth tergum with long, slender, apicolateral processes, their length about half the distance between their bases, caudomedian margin with deep wide mesal cleft and short, triangular submedian lobes. Basistyle with ventral root short, dorsal root slender; dististyle curving to slender pointed apex. Aedeagus strongly sclerotized; basal arch rounded, extending to nearly half of total length; distal portion broad and tapering proximad, then narrowed to slightly flaring spatulate tip bent ventrad. Parameres (fig. 63f) appressed mesad but not fused; each with basal arm expanded caudally just before it bends cephalad to a small basal knob; main body rather stout, tapering distally, then abruptly narrowed and twisted laterad, ventrad, and mesocephalad in turn before ending in simple filiform process.

Distribution.--Indonesia, Laos.

Types.--Holotype female, Laos, Sedone Prov., Muong Paksong, 1,270 m, 6.ix.1967, F.G. Howarth, at light (Bishop Mus.). Allotype male, same data.

Southeast Asia Distribution.--
INDONESIA: West Java, Pandglang, Ujung Kulon (Watters).
LAOS: Sayaboury Prov., Muong Xieng Hon, 500 m (Howarth). Sedone Prov., Muong Paksong (Howarth, types).

Discussion.--This species is closely related to the common and widespread *C. flaviscutatus* Wirth and Hubert but can be distinguished from that species by the longer and more attenuated parameres and smaller submedian lobes on the ninth tergum, and by the presence of a large diffuse pale spot in cell M2 behind the medial fork and the lack of the basal pale spot in cell M1; the antennal, palpal and P/H ratios also differ.

Culicoides parabarnetti Wirth and Hubert, new species
(Figs. 64, 231, 384)

Female.--Wing length 0.83 (0.75-0.90, n = 10) mm.
Head: Antenna (fig. 64a) with lengths of flagellar segments in proportion of 21-19-21-23-23-22-22-21-26-26-28-27-42, antennal ratio 0.91 (0.97-0.99, n = 10); sensilla coeloconica present on segments 3,13-15, absent on 11 and 12. Palpus (fig. 64b) with lengths of segments in proportion of 7-17-17-8-9; third segment very slightly swollen distally, with sensilla grouped loosely on surface distally; palpal ratio 2.7 (2.4-3.0, n = 10). Proboscis moderately short, P/H Ratio 0.63; mandible (fig. 64d) with 12 (11-13, n = 19) very small subequal teeth.
Thorax: Mesonotum and upper pleuron pale yellow; scutellum, postscutellum, and lower pleuron dark brown. Legs (fig. 64e) brown; foreleg with knee spot black, moderately broad pale bands subapically on femur and sub-basally on tibia; midleg with knee pale, apex of femur and base of tibia broadly pale; hindleg with knee spot black, subapical band half the length of femur, and all of tibia pale, tibial comb as in fig. 64f.

Wing (fig. 231, 384): Pattern as figured; quite pale, yellowish, with indistinct darker areas along veins; distal third of first radial cell and proximal half of second included in a very dark costal spot; wing tip indistinctly pale. Macrotrichia apparently absent; second radial cell broad, twice as long as first; costal ratio 0.75. Halter pale.

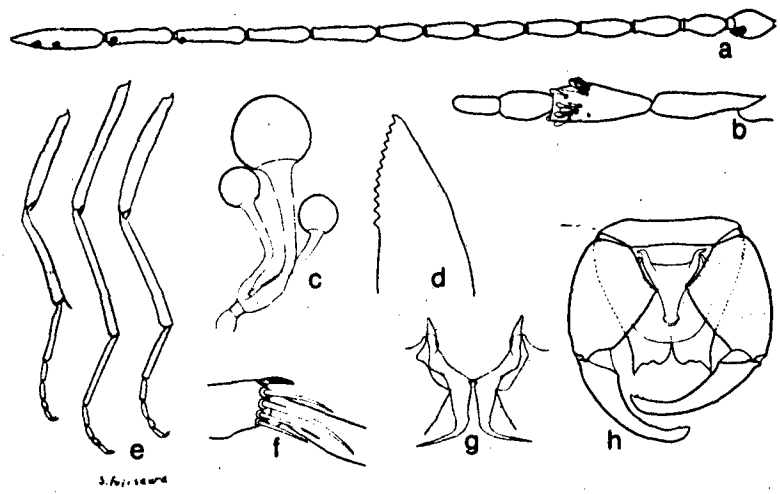


Fig. 64. *Culicoides parabarnetti*: a. antenna; b. palpus; c. spermathecae; d. mandible; e. legs; f. tibial comb; g. parameres; h. male genitalia, parameres omitted.

Abdomen: Very pale brown, terga not sclerotized. Spermathecae (fig. 64c) 3, unequal, with broad entrances to the ducts; large spermatheca 0.026 x 0.030 mm, the 2 small ones subequal, each 0.014 x 0.016 mm; spermathecae globular, slightly broader than long, ducts of the 2 small spermathecae joined immediately before junction with that of the large one at the ring, without saclike swelling.

Male.--Similar to female, with usual sexual differences. Genitalia (fig. 64h): Ninth sternum with slightly caudomedian excavation; ninth tergum short and tapered with small, slender apicolateral processes, caudal margin between them with deep mesal cleft and a pair of low rounded submedian lobes. Basistyle with ventral root reduced, dorsal root slender; dististyle curving with slender pointed tip. Aedeagus with basal arch reaching half of total length, basal arms stout and nearly straight; distal portion stout with truncated, ventrally bent tip. Parameres (fig. 64g) each with slender basal arm bent anterolaterad; stem stout, basal portion scarcely swollen, distal portion gradually narrowed to simple filiform tip curving ventrad.

Distribution.--Indonesia, Malaysia, Sarawak, Sabah.

Types.--Holotype female, allotype male, Malaysia, Negri Sembilan, Telok Pelandok, Port Dickson, 18.vii.1958, R. Traub, light trap (Type in USNM). Paratypes, 8 males, 55 females, as follows:

INDONESIA: South Kalimantan, Banjar, Astambul, Sungai Baru, 16-17.i.1978, V.H. Lee, 1 female; Tanah Intan, Lombok Terong, 10-11.xi.1978, V.H. Lee, 1 female.

MALAYSIA: Same data as types, 5 males, 3 females. Johore, Kahang Kluang, 7.i.1961, A.A. Hubert, light trap, 3 females. Pahang, Gudang Rasan, Kuantan, i-ii.1959, R. Traub, light trap, 12 females; Kuala Singgora, 17.vii.1958, 16.i.1959, R.H. Wharton, light trap at edge of padi field, 2 males, 19 females; Kuantan-Pekan Road, iv.1959, R.H. Wharton, at light, 7 females. Trengganu, Dungun, Bukit Besi, 6.viii.1958, R. Traub, light trap, 1 male; Kg. Binjai, Kemaman, 13.ii.1961, R.H. Wharton, light trap, 3 females.

SABAH: Tawau Dist., Kalabakan, 19.xi.1958, T. Maa, light trap, 2 females.

SARAWAK: Limbang, xii.1951, D.H. Colless, biting man, 4 females.

Discussion.--*Culicoides parabarnetti* is similar to *barnetti* Wirth and Hubert, which also has small even mandibular teeth, yellow mesonotum (but dark scutellum and postscutellum), pale halteres and banded hind femur, but *barnetti* differs in having sensilla coeloconica on antennal segments 11 and 12, the band on the hindfemur is narrower, and the wing markings are much more prominent with apex very broadly pale.

Culicoides raripalpis Smith
(Figs. 65, 232, 385)

Culicoides raripalpis Smith, 1929: 256 (female; Assam; figs.; biting man); Macfie, 1932: 493 (compare spermathecae with *anophelis*); Macfie, 1937a: 115 (female; Malaya; notes); Macfie, 1937b: 469 (Malaya; notes); Causey, 1938: 409 (male, female; Thailand; figs.); Wirth and Hubert, 1959: 29 (male, female redescribed; figs.).

Female.--Wing length 0.77 (0.76-0.79, n = 3) mm.

Head: Antenna (fig. 65a) with lengths of flagellar segments in proportion of 16-14-16-16-17-16-15-16-25-25-28-29-43, antennal ratio 1.15 (1.11-1.19, n = 11); sensilla coeloconica present on segments 3,12-15 (Thailand), or 3,11,13-15 (Malaysia). Palpus (fig. 65b) with lengths of segments in proportion of 7-16-16-7-7; third segment slender, with sensilla borne on surface of segment distally; palpal ratio 2.1 (2.1-2.2, n = 5). Proboscis moderately short, P/H Ratio 0.61; mandible (fig. 65d) with 11 (11-12, n = 8) fine subequal teeth.

Thorax: Dark brown including mesonotum, scutellum, postscutellum and pleuron; some Malaysian specimens with mesonotum paler, yellowish on anterior portion. Legs (fig. 65e) dark brown, forefemur with subapical pale ring, foretibia

with basal pale ring; midleg with knee, apex of femur and base of tibia pale; hindleg with femur all dark, tibia with narrow basal and apical pale rings, tibial comb as in fig. 65f.

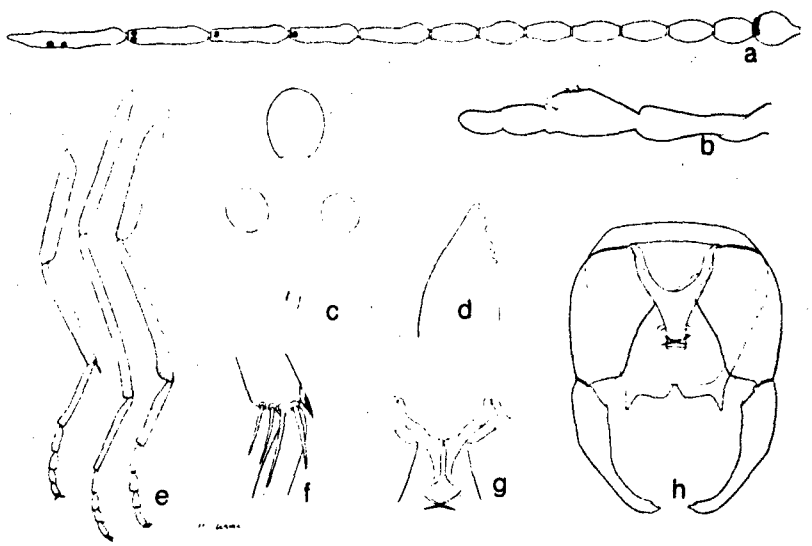


Fig. 65. *Culicoides raripalpis*: a. antenna; b. palpus; c. spermathecae; d. mandible; e. legs; f. tibial comb; g. parameres; h. male genitalia.

Wing (fig. 232, 385): Pattern as figured; relatively dark with veins more darkly infuscated; prominent pale spots over r-m crossvein and over distal third of second radial cell, the latter spot small but contrasting; apex of wing not pale. Costal ratio 0.66 (0.64-0.67, n = 3). Halter deeply infuscated.

Abdomen: Dark brown. Spermathecae (fig. 65c) 3, unequal, large one 0.030 x 0.026 mm, 2 small ones subequal, each 0.019 x 0.017 mm, all longer than broad; with broad unsclerotized entrances to the ducts; ducts from the 2 small spermathecae joined just before entrance to duct from the large one at the ring, ducts not saclike at junction.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 65h): Ninth sternum with shallow caudomedian excavation; ninth tergum with small caudomedian notch and long, pointed, apicolateral processes, the submedian lobes between the processes not well developed. Basistyle with ventral root small and pointed and dorsal root slender; dististyle curving to slender, pointed tip.

Aedeagus with basal arch extending to not quite half of total length, basal arms stout and nearly straight; distal process slightly tapering to moderately stout, truncated tip. Parameres (fig. 65g) each without prominent basal knob, basal half rather slender and bent laterally, stem slightly swollen at base, gradually tapered to slender, bent, simple tip.

Distribution.--China, India, Indonesia, Malaysia, Thailand.

Types.--According to Dr. P. Sen, in litt., types were not preserved; described from females from a village in the Burnihat area, Assam, attacking man.

Southeast Asia Records.--
INDONESIA: Sulawesi (North); Lake Mooat, 20 km NE Kotamogagu (Heppner).
MALAYSIA: Negri Sembilan, Telok Pelandok, Port Dickson (Traub).
THAILAND: Bangkok and Chiang Rai (Causey). Nakronprathom (Manop R.).

Discussion.--Of the species of *Trithecoides* with dark brown mesonotum, *C. macfiei* Causey may be distinguished from *raripalpis* by having 6-7 mandibular teeth with the distal ones largest. The two species, *sarawakensis* Wirth and Hubert and *elbeli* Wirth and Hubert, that have 10-15 fine even mandibular teeth and dark brown mesonotum like *raripalpis*, can be separated by the pale halter color in *elbeli*, and the banding of the forefemur and structural characters as outlined in the key. Like several other species in the Raripalpis Group, *raripalpis* is characterized by lack of sensilla coeloconica on antennal segment 11 or 12.

Culicoides sarawakensis Wirth and Hubert
(Figs. 66, 233, 386)

Culicoides sarawakensis Wirth and Hubert, 1959: 28 (female; Brunei, Sarawak, Malaysia, Philippines; figs.); Delfinado, 1961: 668 (diagnosis; figs.; Philippines).

Female.--Wing length 0.81 (0.76-0.86, n = 10) mm.

Head: Antenna (fig. 66a) with lengths of flagellar segments in proportion of 20-17-19-20-20-19-19-21-28-27-31-31-45, antennal ratio 1.05 (1.02-1.09, n = 10); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 66b) with lengths of segments in proportion of 8-20-21-20-11; third segment slender, with sensilla borne on surface of segment distally; palpal ratio 2.7 (2.5-3.0, n = 10). Proboscis moderately long, P/H Ratio 0.73; mandible (fig. 66f) with 13 (12-15, n = 12) fine teeth of subequal lengths.

Thorax: Dark brown including mesonotum (fig. 66g), scutellum, postscutellum, and pleuron. Legs (fig. 66d) dark brown; foreleg with femur dark to tip, tibia with narrow basal pale ring; midleg with knee, apex of femur and base of tibia pale; hindleg with femur all dark, tibia with broad basal and narrow apical pale bands, tibial comb as in fig. 66c.

Wing (fig. 233, 386): Pattern as figured; relatively dark and uniform except for only moderately contrasting pale spots centering over radial crossvein and distal half of second radial cell; apex of wing not pale. Costal ratio 0.70 (0.69-0.73, n = 10). Halter infuscated.

Abdomen: Dark brown, terga poorly sclerotized, twice as broad as long on third segment. Spermathecae (fig. 66e) 3, unequal, large one 0.041 x 0.031 mm and 2 small subequal ones each 0.020 x 0.019 mm, large spermatheca much longer than broad; with broad unsclerotized entrances to ducts, ducts from the 2 small spermathecae joined just before entrance to the duct from the large one at the ring, ducts not saclike at junctions.

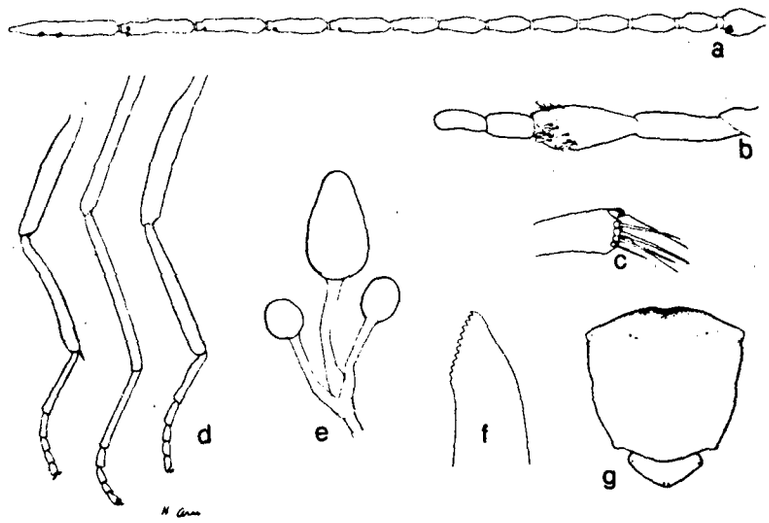


Fig 66. *Culicoides sarawakensis*: a. antenna; b. palpus; c. tibial comb; d. legs; e. spermathecae; f. mandible; g. thoracic pattern.

Male.--Unknown.

Distribution.--Brunei, Indonesia, Malaysia, Philippines, Sabah, Sarawak.

Types.--Holotype female, Sarawak, Umah Akeh, Baram River, vi.1953, D.H. Colless, biting man (Type in USNM). Paratypes, 12 females.

Southeast Asia Records.--
BRUNEI: Brunei (Colless).
INDONESIA: Kalimantan (South), Banjar, Astambul, Tanah Intan (Lee). Sulawesi (Central), Banggai, Batui, Kamiwangi (Bambang). Sumatra, Bengkulu, Pekik Nya:ing and Gunung Agung (Mathis); Lampung, Kotabumi, Way Abung, Margoreyo (Lee); Lampung, Utara, Papaneijo (Lee).

MALAYSIA: Johore, Kg. Parit Ahmad, swine shed (Garcia). Pahang, Gudang Rasan, Kuantan (Traub); King George V Nat. Park, Tahan River (Hendrickson, McClure); Kuantan Pekan Road, swamp forest (Wharton). Selangor, Ampang Forest Res., reared from decomposed wood and decaying leaves (Manikumar); Ulu Gombak Forest Res., reared from decaying mushrooms (Manikumar). Trengganu, Dungun, Bukit Besi (Traub).

PHILIPPINES: Mindanao, Cotabato Prov., Pikit (Werner).

SABAH: Tawau Dist., Kalabakan, primary forest (Maa).

SARAWAK: Akah River, Lg. Tap (Colless). Baram River, Lg. Kaseh, Lg. San and Umah Akeh (Colless). Bau Dist., Pangkalan Tebang, 300 m (Maa).

Discussion.--This species is very closely related to *C. raripalpis* Smith and *elbeli* Wirth and Hubert, but may be distinguished from them by its unbanded forefemur, and from the latter by its dark halteres, as well as by the structural characters mentioned in the key.

Culicoides tamada Howarth
(Figs. 67, 234)

Culicoides tamada Howarth, 1985: 39 (male, female; Laos, figs.).

Female.--Wing length 0.86 mm.

Head: Antenna (fig. 67a) with lengths of flagellar segments in proportion of 19-18-21-23-22-21-21-21-25-27-27-28-41, antennal ratio 0.88; sensilla coeloconica present on segments 3,13-15. Palpus (fig. 67b) with lengths of segments in proportion of 6-21-21-11-10; third segment moderately elongate, widest in mid-portion; sensilla scattered on distal half of segment, often in small, shallow, pitlike areas; palpal ratio 2.6. Proboscis moderately short, P/H Ratio 0.66; mandible (fig. 67d) with 11 fine triangular teeth, distal ones slightly larger.

Thorax: Mesonotum dark brown on anterior margin, over humeral angles and variably over disc; scutellum, postscutellum, and lower half of pleuron dark brown; upper half of pleuron and varying amounts on lateral margin of mesonotum light brown; boundary of light and dark marks not well defined. Legs (fig. 67h) dark brown; foreknees dark, forefemur with narrow subapical pale band, foretibia with narrow sub-basal pale band; midknee dark, midfemur with apical pale band, midtibia with basal pale band; hindfemur dark to tip, hindtibia with sub-basal pale band and indistinct apical pale band.

Wing (fig. 67c, 234): Pattern as figured; predominantly dark, darker on anterior margin, paler between veins on disc; four small round pale spots as follows: over r-m crossvein, centered over apex of second radial cell, in base of wing including only part of anal angle, and distally in cell M4; tip of wing pale only at apices of cells R5 and M1. Macrotrichia sparse anterodistally in cell R5, apically in cells M1 and M2, and in longitudinal rows distally in cells R5, M1, and M2; costal ratio 0.67. Halter pale.

Abdomen: Brown, terga lightly sclerotized; third tergum twice as broad as long. Spermatheca (fig. 67e) 3, with large unsclerotized entrances to ducts, unequal; large one elongate, 0.045 x 0.128 mm, the 2 smaller ones subspherical, 0.017 x

0.017 mm; ducts from smaller spermathecae meeting in short common duct before joining saclike duct from the large one; common duct from smaller spermathecae enlarged, sometimes saclike.

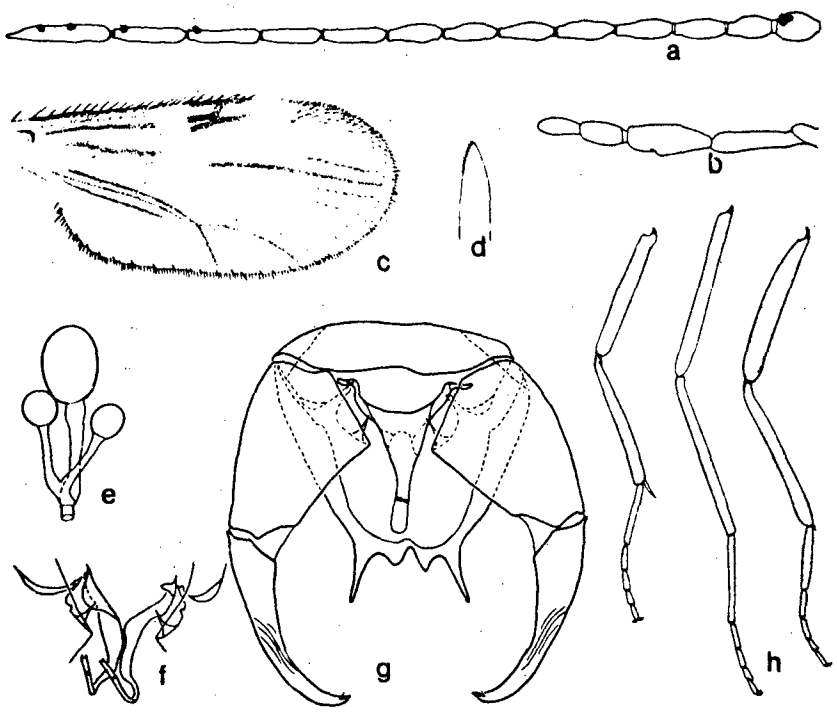


Fig. 67. *Culicoides tamada*: a. antenna; b. palpus; c. wing; d. mandible; e. spermathecae; f. parameres; g. male genitalia, parameres omitted; h. legs.

Male.--Similar to female with usual sexual differences; sensilla coeloconica present on antennal segments 3,14-15. Genitalia (fig. 67g): Ninth sternum narrow with imperceptible caudomedian excavation; ninth tergum with long, slender, slightly flaring apicolateral processes, their length slightly greater than half the distance between their bases; caudal margin with wide median cleft and short, slightly angulate, submedian lobes. Basistyle with ventral root small, dorsal root slender; dististyle slightly curved and tapered to slender distal point. Aedeagus with low basal arch extending less than a fourth of total length; midportion narrow, well sclerotized, lateral margins nearly straight; tapering distad, distal third

straight, hyaline, difficult to see. Parameres (fig. 67f) separate, each with long, slender basal arm, midportion moderately swollen, tapering, then narrowed and abruptly curving ventrally and ending in slender hyaline blade.

Distribution.--Laos.

Types.--Holotype female, allotype male, Laos, Sedone Prov., Muong Pakse, 100 m, 3.ix.1967, F.G. Howarth, at light in forest (Bishop Mus.).

Southeast Asia Records.--
LAOS: Sayaboury Prov., Sayaboury, 300 m (Howarth). Sedone Prov., Muong Pakse, 100 m (Howarth, types).

Discussion.--This species is keyed out twice since the amount of dark brown anteriorly on the mesonotum is variable and sometimes subject to misinterpretation. The antennal sensory pattern 3,13-15 is shared by only a few other species, which differ in thoracic ornamentation.

Culicoides triallantionis Howarth
(Figs. 68, 235)

Culicoides triallantionis Howarth, 1985: 42 (male, female; Laos; figs.).

Female.--Wing length 0.96 mm.
Head: Antenna (fig. 68a) with lengths of flagellar segments in proportion of 18-17-17-18-19-19-19-18-23-22-22-24-40, antennal ratio 0.87; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 68b) with lengths in proportion of 7-20-18-11-9; third segment small, swollen in midportion, sensilla scattered on distal half; palpal ratio 2.2. Proboscis short, P/H Ratio 0.58; mandible (fig. 68d) with 11-12 small triangular teeth.
Thorax: Mesonctum, scutellum and upper half of pleuron bright yellow; postscutellum and lower half of pleuron dark brown. Legs (fig. 68h) brown with bright yellow bands; foreknee narrowly dark, femur with broad subapical pale band, tibia with broad sub-basal band; midknee broadly pale, femur pale on distal half, tibia mostly pale; hindfemur with dark knee and broad subapical pale band, tibia mostly pale.
Wing (fig. 68c, 235): Pattern as figured; moderately dark, darker anteriorly, paler between veins; pale spots large, first spot at base of wing including part of anal angle; pale spot over r-m crossvein broadly crossing media; pale spot over distal half of second radial cell, narrowly reaching vein M1; 1 pale spot each in distal portion of anal cell and cell M4; wing tip broadly dipped in white, including apices of cells R5, M1 and M2; cell M1 and distal 0.75 of cell M2 each nearly filled by pale streak; basal portion of vein M2 pale. Macrotrichia scanty, a few near anterior wing margin distally in cell R5 and in rows parallel to veins M1 in apices of cells R5 and M1; costal ratio 0.70. Halter pale.

Abdomen: Terga light brown; third tergum twice as wide as long. Spermathecae (fig. 68e) 3, dark brown, subequal, elongate, somewhat sausage-shaped; each 0.038 x 0.19 mm; ducts wide at entrance to spermatheca, tapering to common junction point at the sclerotized ring.

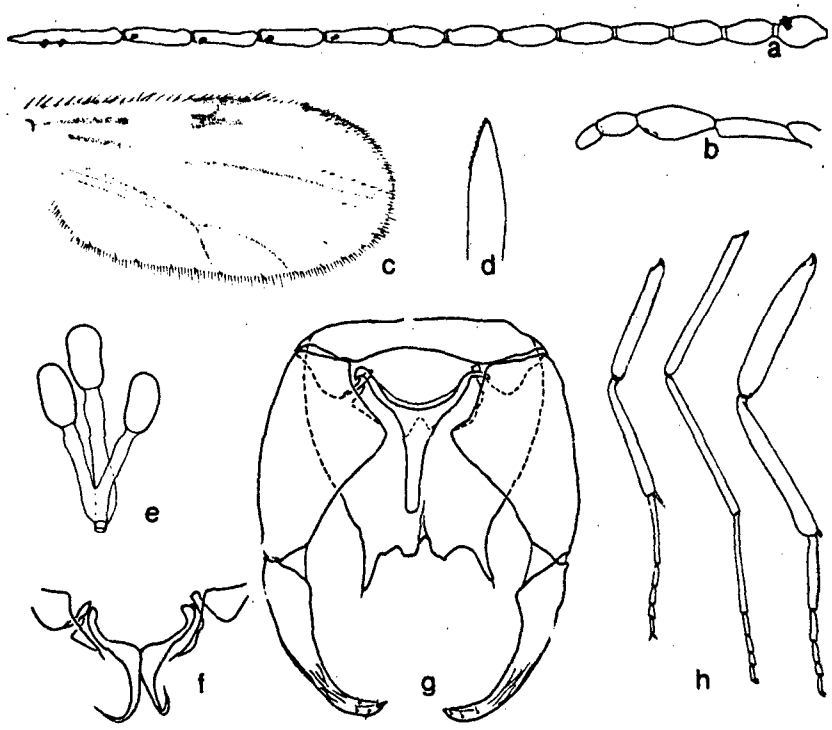


Fig. 68. *Culicoides triallantionis*: a. antenna; b. palpus; c. wing; d. mandible; e. spermathecae; f. parameres; g. male genitalia, parameres omitted; h. legs.

Male.--Similar to female with usual sexual differences; antenna with sensilla coeloconica present on segments 3,13-15. Genitalia (fig. 68g): Ninth sternum with shallow caudomedian excavation; ninth tergum with long, slender, slightly diverging, apicolateral processes, caudal margin between them with distinct median cleft and small submedian lobes. Basistyle with vestigial ventral root and slender dorsal root; dististyle curved and tapering to slender pointed tip. Aedeagus with basal arch extending to a fourth of total length, basal arms slender; main body tapering markedly at base with long, slender, distal stem with

hyaline spatulate tip. Parameres (fig. 68f) separate but with bases of stems contiguous; each with basal arm slender, directed caudolaterad with extreme end slightly swollen and bent slightly mesad; stem swollen at base, markedly tapering to slender blade curving ventrad and then cephalad and ending in a simple point.

Distribution.--Laos.

Types.--Holotype female, allotype male, Laos, Vientiane Prov., Muong Ban Keun, Ban Na Pheng, 21.v.1968, F.G. Howarth, light trap (Bishop Mus.).

Southeast Asia Records.--
LAOS: Known only from the type series.

Discussion.--This species is the only Oriental species of *Trithecoides* with 3 elongate, subequal, somewhat sausage-shaped spermathecae of the type found in the African species *C. fulvithorax* (Austen) and *C. ochrothorax* Carter. Of the Oriental species, it most closely resembles *C. flaviscutellaris* n. sp., especially in the thoracic and leg color pattern and the structure of the mandibular teeth, but *flaviscutellaris* differs in spermathecal shape and its darker wing.

Subgenus **Haemophoructus** Macfie

Haemophoructus Macfie, 1925: 349. Type-species, *Haemophoructus maculipennis* Macfie (monobasic).

Eyes contiguous for a considerable distance above antennal bases; bare. Antenna slender, with distal segments moderately elongate, antennal ratio 1.01-1.42; sensilla coeloconica present on segments 3,11-15, rarely on segments of proximal series. Third palpal segment slender, usually more or less spindle-shaped, with sensilla scattered along mesal side on distal half of segment, rarely in an irregular pit. Proboscis moderately long; mandible with 15-19 teeth. Thorax usually rather slender, mesonotum yellowish to shining blackish; legs slender, fore- and midknees usually pale, hindfemur sometimes pale distally, hindtibia pale at base and apex; legs entirely pale in one species; hindtibial comb with 5 or 6 spines (4 in *kisangkini* Howarth), the second from the spur longest; hindtibial spur greatly elongated in two species. Wing elongate, with one radial cell present in female, usually two present in male; costa long, costal ratio 0.69-0.78; radial cell usually narrow, greatly broadened distally in one species, with most of distal portion lying in a pale wing spot, sometimes extending past this spot into the next dark spot; cell M4 usually without pale spot at base of fork; distal pale spot in cell R5 never filling apex of cell, usually transverse and meeting anterior wing margin, sometimes a rounded large double pale spot straddling midportion of vein M2; distal pale spot in cell M1 may or may not meet wing margin, distal pale spot in cell M2 meets wing margin; base of wing usually pale including anal angle, anal cell usually with a double pale spot in distal portion; macrotrichia very sparse at apex of wing or practically absent. Abdomen often elongate and slender, slightly

petiolate; 2 large spermathecae present, usually ovoid with short slender necks; vestigial spermatheca and sclerotized ring present. Male genitalia with ninth sternum very narrow, caudomedian excavation not developed, ventral membrane not spiculate; ninth tergum without apicolateral processes, rounded caudad or bilobed with well-developed median cleft; usually with a submedian or sublateral pair of blunt-pointed or elongate, secondary, thinly sclerotized lobes on caudal margin, sometimes with low median secondary lobe. Basistyle with ventral root not developed, dorsal root short to long; dististyle usually slender and slightly curved to distal point. Aedeagus with low basal arch, basal arms very short, usually with anterior margin sclerotized in a basal bar, internal sclerotized peg present at base of distal stem; stem with or without terminal ball-like tip. Parameres usually separate, sometimes faintly joined across base of stems, basal arms usually slender and short, directed anterolaterad; stem usually stout, more or less abruptly narrowed distally, distal tapered portion bent ventrolaterad and ending in a long slender filament with or without minute distal hairs.

Apparently this is entirely an Oriental and Australasian group of species, of which 10 are known from Southeast Asia. These can be divided in 2 groups, those in the Maculipennis Group being set off by their large size and dark color, with the base and anal angle of the wing dark, the pale wing markings restricted, and the legs very dark with restricted pale rings, and the hindtibial spur very elongate in two of the 3 known species.

Biology.--Two species have been reared from polluted stream habitats in Laos (Howarth 1985), *calcaratus* and *kisangkini*. The latter appears to be closely associated with elephant droppings.

Maculipennis Group

Culicoides calcaratus Wirth and Hubert, new species
(Figs. 69, 236, 387)

Culicoides species D; Howarth, 1985: 55 (pupa descr.; larval habitat; Laos).

Female.--Wing length 1.34 (1.20-1.45, n = 4) mm.

Head: Eyes contiguous, bare. Antenna (fig. 69a) with lengths of flagellar segments in proportion of 27-22-23-24-25-24-25-25-39-41-46-46-70, antennal ratio 1.25 (1.23-1.29, n = 4); sensilla coeloconica present on segments 3,11-15 (3 each on segments 14 and 15). Palpus (fig. 69b) with lengths of segments in proportion of 12-31-37-16-24; third segment slightly swollen, with scattered sensilla on distal half; palpal ratio 3.3 (3.0-3.4, n = 4). Proboscis moderately long, P/H Ratio 0.75; mandible with 15 (14-17, n = 7) teeth.

Thorax: Dark brown, mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 69d) dark brown, fore- and midknees narrowly pale on each side with dark knee spots; hindtibia with narrow basal and apical pale rings; hindtibial comb with 6 spines, the second from the spur longest; hindtibial spur (fig. 69e) greatly enlarged, as long as apical breadth of tibia.

Wing (fig. 236, 387): Pattern as figured; deeply infuscated, with restricted pale spots; yellowish area located distad of basal arculus; small pale spot lying over r-m crossvein, continued slightly broader to costal margin; prominent pale spot lying over distal third of radial cell, continued slightly narrower caudad two-thirds way across cell R5; small transverse pale spot distally in cell R5, not meeting anterior wing margin; dark areas along anterior wing margin between these pale spots to level of vein M1, and an elongate dark area along proximal third of vein M2 darker than rest of dark areas of wing; a large pale spot lying in front of mediocubital fork; a double pale spot straddling midportion of vein M2; a small round pale spot lying far from wing margin distally in cell M1; a similar pale spot nearly attaining wing margin in cell M2; a small pale spot at wing margin in distal portion of cell M4; anal cell dark with an irregular pale area near base and two small separate pale spots in distal portion. Macrotrichia very sparse on distal fourth of wing; costal ratio 0.70 (0.60-0.72, n = 4); only 1 radial cell, very narrow basally, broader distad of tip of vein R1. Halter brown.

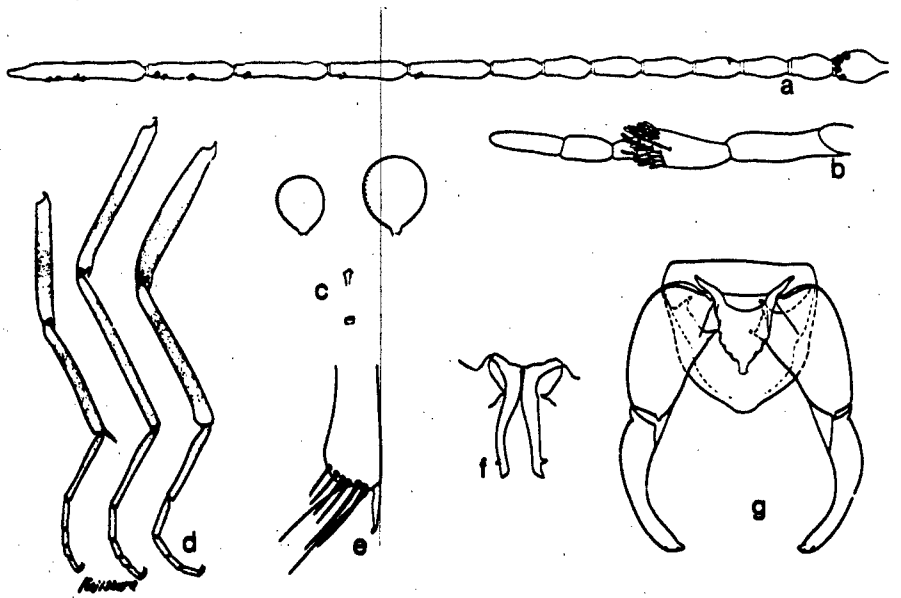


Fig. 69. *Culicoides calcaratus*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Abdomen: Dark brown. Spermathecae (fig. 69c) slightly ovoid, scarcely tapering to the very short, slender necks; unequal, 0.052 x 0.043 and 0.043 x 0.035 mm.

Male.--As in the female, with the usual sexual differences; two radial cells present. Genitalia (fig. 69g): Ninth sternum narrow, without caudomedian excavation, ventral membrane bare; ninth tergum rounded caudad, apicolateral processes absent, a low median lobe present on caudal margin. Basistyle short and stout, ventral and dorsal roots short; dististyle long and curved, moderately slender, with pointed tip. Aedeagus with moderately long basal arms, basal arch extending to about a third of total length, main portion broad and stout with convex, scalloped margins, distal process very short and stout. Parameres (fig. 69f) connected a short way at bases; each with very short anterolateral arm, stem nearly straight, moderately stout its entire length, with blunt tip and short, subapical, ventrolateral point.

Distribution.--Australia, Indonesia, Laos, Malaysia, Sri Lanka.

Types.--Holotype female, Kuala Lumpur, Selangor, Malaysia, viii.1958, R. Traub, light trap (Type in USNM). Allotype male, Chiang Mai, Amphoe Muang, Thailand, xi.1962, J.E. Scanlon, light trap. Paratypes, 9 females, as follows:

INDONESIA: Central Java, Cilacap, Adipala, Karang Sari, 6.viii.1979, V.H. Lee, 2 females.

MALAYSIA: Kelantan, Kota Bharu, 22.ii 1966, R. Garcia, near cattle shed, 1 female. Pahang, King George V Nat. [illegible]rk, Tahan River, 4-6.xi.1959, H.E. McClure, light trap, 2 females; Kuala Singgora, 17.vii.1958, R.H. Wharton, light trap, 1 female.

THAILAND: Chiang Mai, same data as allotype, 2 females. Cholburi, Bangphra, x.1962, J.E. Scanlon, light trap, 1 female.

Other Material Examined.--

LAOS: Sayaboury Prov., Muong Sayaboury (Howarth); Muong Xieng Hon (Howarth). Sedone Prov., Muong Pakse (Howarth).

Discussion.--*Culicoides calcaratus* is closely related to *C. maculipennis* Macfie, these two species alone having the very elongate spur on the hindtibia; but *maculipennis* can be readily distinguished by the greatly broadened radial cell which displaces the distal portion of the costa. *Culicoides tawauensis* n. sp. is also closely related, with similar wing and leg markings and dark halteres, but has the wing markings even more restricted than in *maculipennis* and *calcaratus*.

Howarth (1985) reared *C. calcaratus* (as species D) in Laos from shaded, highly polluted stream margins; where the species *C. guttifer*, *huffi*, *subflavescens*, *tenuipalpis*, and *arenicola* were also breeding.

Alan Dyce (in litt.) informs us that Australian specimens of *C. calcaratus* possess sensilla coeloconica on some or all of segments 7-9, in addition to those on 3,11-15 in our series. In live specimens from Australia the mesonotum is without pattern, pitch-black in color.

Culicoides maculipennis (Macfie)
(Figs. 70, 237, 388)

Haemophoructus maculipennis Macfie, 1925: 349 (female; Singapore; figs.).
Culicoides maculipennis (Macfie); Macfie, 1937a: 113 (combination; in key).

Female.--Wing length 1.58 mm.

Head: Eyes contiguous, bare. Antenna with lengths of flagellar segments in proportion of 18-16-16-16-16-16-16-16-30-31-32-34-40, antennal ratio 1.36; sensilla coeloconica present on segments 3-5,7,9-15. Palpus (fig. 70a) with lengths of segments in proportion of 7-20-30-13-7; third segment slender, with irregular open pit at distal third plus scattered sensilla, portion beyong pit narrower; palpal ratio 3.8. Proboscis moderately long, P/H Ratio 1.0; mandible with 19 teeth.

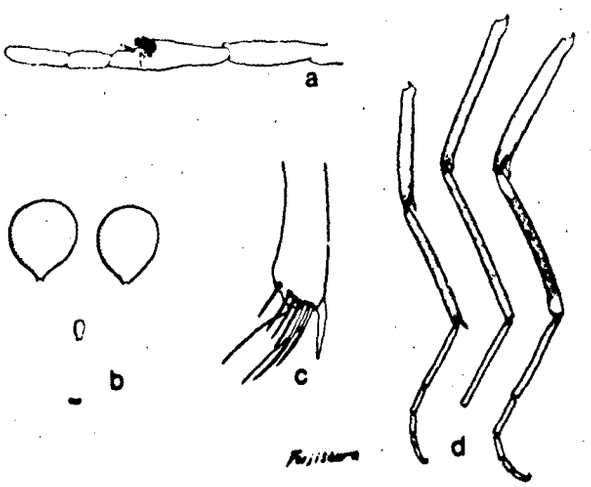


Fig. 70. *Culicoides maculipennis*: a. palpus; b. spermathecae; c. tibial comb; d. legs.

Thorax: Dark brown; mesonotum without apparent pattern. Legs (fig. 70d) brown; hindtibia with faint basal and apical pale rings; hindtibial comb (fig. 70c) with 6 spines, second from the spur longest; spur very strong, as long as apical breadth of tibia.

Wing (fig. 237, 388): Pattern as figured; pale spots diffuse, suppressed; pale area over r-m crossvein extending from costal margin to media; pale spot over apex of radial cell small, including only half of portion of cell beyond tip of vein R1, this pale spot extending caudad nearly to vein M1 and proximad as an indistinct streak in cell M1 nearly to r-m crossvein; distal pale spot in cell R5 small and transverse, not attaining anterior wing margin or vein M1; a double spot straddling vein M2 at proximal third; small oval pale spots distally in cells M1 and M2 not attaining wing margin; large pale area in cell M2 between medial and mediocubital forks; cell M4 with large indistinct pale area in distal portion; anal cell pale on proximal fourth, along posterior margin, and a paler rounded area anteriorly in

distal portion; wing darker in streaks along veins and on anterior margin on each side of poststigmatic pale spot. Macrotrichia confined to a few at extreme tip of wing; one radial cell of extraordinary form, the portion beyond tip of vein M1 extremely broadened and displacing the costa which is bowed anteriorly at this point; costal ratio 0.71. Halter dark brown.

Abdomen: Dark brown, slender and slightly petiolate. Spermathecae (fig. 70b) ovoid and tapering abruptly to short slender necks; unequal, 0.074 x 0.055 mm and 0.059 x 0.044 mm (Macfie 1925).

Male.--Unknown.

Distribution.--Indonesia, New Guinea, Singapore.

Types.--Described from 4 female syntypes from Singapore, 1924, Commander D.H.C. Given, deposited in BMNH. Syntype no. 3, which was studied by the senior author at the BMNH in 1957, is hereby designated lectotype. The present illustrations are made from syntype no. 2 kindly loaned through the offices of Paul Freeman. The wing photograph is from a female from New Guinea.

Southeast Asia Records.--

INDONESIA: Irian Jaya, Fak Fak, Mapurajaya, Gilligan's Island, Port Site ($4^{O}50'S$, $136^{O}51'E$) (Lee).

SINGAPORE: Singapore (type series).

Discussion.--This species, which is the type species of Macfie's genus *Haemophoructus*, has not been collected in Malaysia since the original capture, in spite of considerable emphasis given to *Culicoides* surveys in Singapore and adjoining Malaysia. It is obviously closely related to both *calcaratus* n. sp. and *tawauensis* n. sp., forming with them a distinct group of species in the subgenus *Haemophoructus*.

Culicoides tawauensis Wirth and Hubert, new species
(Figs. 71, 238, 389)

Female.--Wing length 1.36 mm.

Head: Eyes contiguous, bare. Antenna (fig. 71a) with lengths of flagellar segments in proportion of 17-17-17-17-17-17-17-18-26-30-31-34-50, antennal ratio 1.43; sensilla coeloconica present on segments 3,11-5 (4 each on segments 14 and 15). Palpus (fig. 71b) with lengths of segments in proportion of 10-34-47-17-24; third segment moderately swollen just distad of middle with scattered sensilla on distal third of segment; palpal ratio 3.9. Proboscis moderately long, P/H Ratio 1.0; mandible with 18 teeth.

Thorax: Brownish, mesonotal pattern not evident (fig. 71c). Legs (fig. 71e) brownish; narrow pale rings at bases of mid- and hindtibiae and at apex of hindtibia; hindtibial comb (fig. 71f) with 5 spines, second from the spur longest.

Wing (fig. 238, 389): Pattern as figured; pale spots very faint and ill-defined; moderately pale spot over r-m crossvein broadly meeting costal margin; a moderately large, faint pale spot at proximal third of cell R5 only faintly continued anteriorly across subapical portion of radial cell; only 1 radial cell, this with apical portion dark; very faint pale spot in distal portion of cell R5; a faint pale spot subapically in cell M1; a large irregular faint pale area across cell M2 from medial fork to mediocubital fork; faint pale spots distally in cell M2 and in cell M4; anal cell dark except for faint pale patch in proximal third and a double pale spot in distal portion. Macrotrichia confined to a few at wing tip and along distal fifth of vein M1; costal ratio 0.74; radial cell narrow but with distinct lumen on proximal half, but fairly broad distally. Halter infuscated.

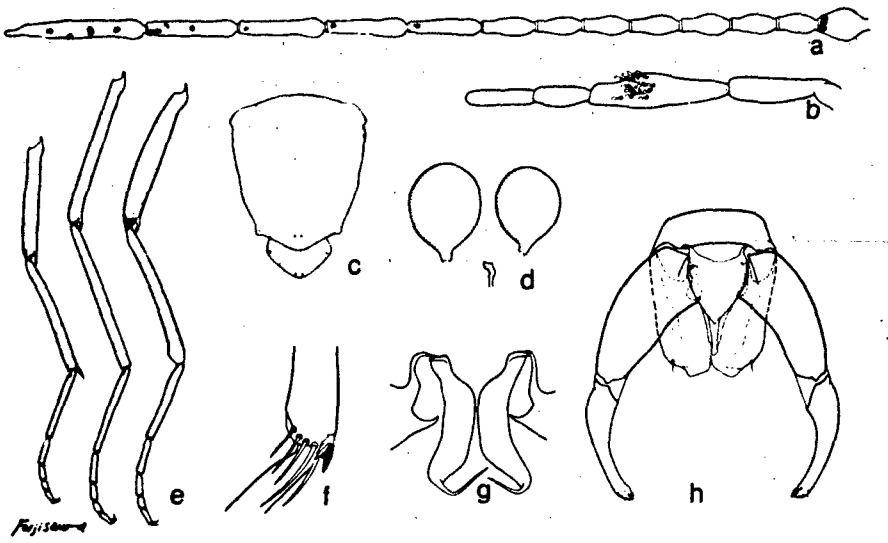


Fig. 71. *Culicoides tawauensis*: a. antenna; b. palpus; c. thoracic pattern; d. spermathecae; e. legs; f. tibial comb; g. parameres; h. male genitalia, parameres omitted.

Abdomen: Brownish; elongate and slightly petiolate. Spermathecae (fig. 71d) ovoid, tapering distinctly to short slender necks; subequal, each 0.057 x 0.041 mm.

Male.--Similar to female, but pale wing spots more prominent, two distinct radial cells present. Genitalia (fig. 71h): Ninth sternum without caudomedian excavation, ventral membrane bare; ninth tergum slightly bilobate, longest at

caudolateral corners, with a submedian pair of low, angular, thinly sclerotized lobes which are longest sublaterally. Basistyle slender and slightly curved, ventral root not developed, dorsal root slender; dististyle slightly curved, slender distally and ending in a sharp distal point with a minute apical tooth. Aedeagus with very low rounded basal arch; main portion broad with convex lateral margins, a distinct internal sclerotized peg present distally; distal process slender with round terminal papilla. Parameres (fig. 71g) separate; each with very short basal arm only slightly turned laterally; stout in midportion, distally tapering and turned caudolaterad, then ventrad, finally anteromesad, and ending in filamentous tip without apical fringing hairs.

Distribution.--Malaysia, Sabah, Sarawak.

Types.--Holotype female, Tawau, Sabah, 30 mi W, 14-15.ix.1958, T.C. Maa, at light (deposited in B.P. Bishop Museum, Honolulu). Allotype male, Kalabakan, Tawau Dist., Sabah, 19.xi.1958, T.C. Maa, light trap.
Paratypes, 4 males, 6 females, as follows:
MALAYSIA: Pahang, Gudang Rasan, Kuantan, i-ii.1959, R. Traub, light trap, 1 female. Pahang, King George V Nat. Park, Tahan River, 4-6.xi.1959, H.E. McClure, light trap, 2 males. Pahang, Mt. Brinchang, 1,600 m, iii.1963, H.E. McClure, light trap, 1 female.
SABAH: Same data as allotype, 2 males, 3 females.
SARAWAK: Limbang, xii.1950, D.H. Colless, at light, 1 female.

Discussion.--The dark, obscurely marked wing with dark anal angle will distinguish *Culicoides tawauensis* from all other species of the subgenus *Haemophoructus* except *maculipennis* n. sp. and *calcaratus* n. sp., but the latter two have an extremely long, stout spur on the hindtibia. *Culicoides maculipennis*, in addition, has the radial cell unusually broadened distally. The Malaysian specimens differ in having pale halteres, but otherwise agree.

Gymnopterus Group

Culicoides boormani Giles and Wirth
(Figs. 72, 239)

Culicoides boormani Giles and Wirth, 1985: 365 (female; Malaysia; figs.).

Female.--Wing length 1.26 (1.18-1.31, n = 9) mm.
Head: Brownish. Eyes (fig. 72e) bare, contiguous for a distance equal to diameter of three ommatidial facets. Antenna with segments 4-10 pale, their apices darker, 11-15 light brown; verticils well developed on all segments; lengths of flagellar segments (fig. 72a) in proportion of 24-19-20-21-22-21-21-23-31-32-34-36-55; antennal ratio 1.10; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 72b) brown; lengths of segments in proportion of 11-67-86-32-36; third segment narrowed beyond basal half, with scattered sensilla on distal 0.75;

palpal ratio 4.68 (4.00-4.89, n = 9). Proboscis brown; long, P/H Ratio 0.99 (0.93-1.00, n = 6); mandible (fig. 72d) with 19 (16-19, n = 8) well developed teeth, proximal teeth coarser.

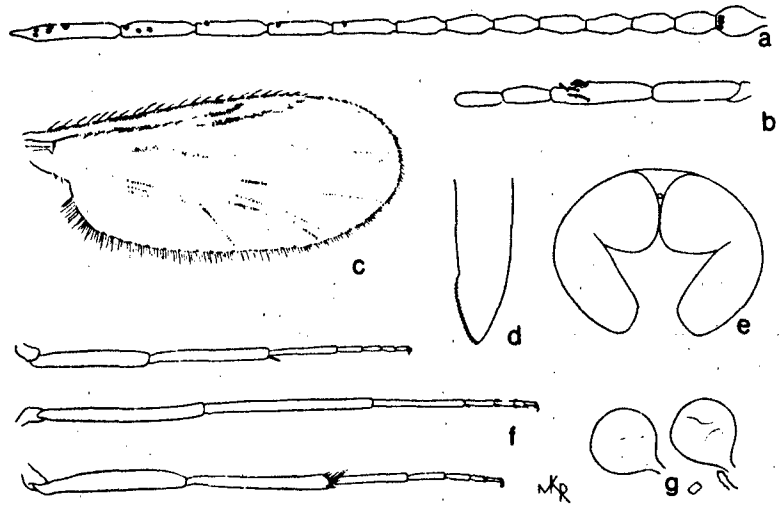


Fig. 72. *Culicoides boormani*: a. antenna; b. palpus; c. wing; d. mandible; e. eye separation; f. legs; g. spermathecae.

Thorax: Mesonotum and scutellum light brown; postscutellum and pleuron darker brown. Legs (fig. 72f) brown; femora each with narrow basal pale band and broad distal pale band; fore- and midtibiae with narrow pale bands basally; hindtibia with pale bands broad basally and narrow distally; hindtibial comb with 6 (5-6, n = 9) spines, second from spur longest.

Wing (fig. 72c, 239) yellowish brown with prominent pale spots. One radial cell somewhat broadened distally; base of wing pale to approximately half of distance to r-m crossvein; pale spot over r-m crossvein wider than dark area on each side; extending posteriorly broadly from costa, crossing vein M narrowly to broadly meet mediocubital stem; large pale spot covering distal five-eighths of radial cell; large round distal pale spot in cell R5 weakly meeting anterior wing margin; distal pale spots in cells M1 and M2 weakly meeting wing margin; cell M4 with large pale spot meeting wing margin and extending basally along vein M3+4 to junction of mediocubital fork, an intrusion of pigmentation across tip of vein Cu1 creating a pale C-shaped marking; distal portion of anal cell with a double pale spot extending from posterior wing margin to mediocubital vein. Costal ratio 0.73 (0.69-0.74, n = 9). Halter stramineous.

Abdomen: Brownish. Spermathecae (fig. 72g) spherical with moderately long sclerotized necks; subequal, each 0.044 x 0.035 mm including necks; vestigial spermatheca and sclerotized ring present.

Male.--Unknown.

Distribution.--Malaysia.

Types.--Holotype female, Malaysia, Kuala Trengganu, Kuala Brang, 14.viii.1973, light trap, R. Parsons (Type in USNM).

Discussion.--*Culicoides boormani* differs from *maculipennis* Macfie in its normal radial cell and pale basal wing angle and differs from *C. gemellus* Macfie, *gentilis* Macfie, *gymnopterus* Edwards, *nitens* Edwards, and *unicus* Delfinado in having a large pale spot at the base of the mediocubital fork.

Culicoides gemellus Macfie
(Figs. 73, 240, 390)

Culicoides gemellus Macfie, 1934a: 192 (female; Sabah, fig. wing); Delfinado, 1961: 661 (Philippines; fig. wing); Howarth, 1985: 44 (Laos record).
Culicoides gentilis Macfie (misident.); Tokunaga, 1959: 221 (female; New Guinea; figs.); Tokunaga, 1962b: 496 (male, female; New Guinea, New Ireland; fig. male genitalia); Tokunaga, 1963c: 132 (in key); Tokunaga, 1976: 39 (in key).

Female.--Wing length 1.20 (1.12-1.33, n = 22) mm.

Head: Eyes contiguous, bare. Antenna (fig. 73a) with lengths of flagellar segments in proportion of 23-18-20-21-20-21-23-30-32-40-40-61, antennal ratio 1.22 (1.12-1.28, n = 16); sensilla coeloconica present on segments 3,11-15 (3 on 14, 5 on 15). Palpus (fig. 73b) with lengths of segments in proportion of 11-26-40-18-20; third segment slightly swollen in midportion, very slender distally, with scattered sensilla on distal half; palpal ratio 3.9 (2.1-4.7, n = 22). Proboscis moderately long, P/H Ratio 0.90; mandible with 15 (13-17, n = 40) teeth.

Thorax: Subshining brownish black, without pattern on disc of mesonotum (fig. 73c), the latter with long bristly hairs. Legs (fig. 73e) brownish, with indistinct pale bands; fore- and midknees pale, narrowly on foreleg, broadly on midleg; hindfemur dark to tip, hindtibia with basal and apical pale band; hairs long and bristly; hindtibial comb (fig. 73d) with 6 (n = 22) spines, second from the spur longest; spur short.

Wing (fig. 240, 390): Pattern as figured; pale spots restricted, the second dark band on anterior margin broader than the pale areas on each side; base of wing pale a third way to r-m crossvein; pale spot over r-m crossvein small, reaching media posteriorly; pale spot over end of costa not reaching vein M1; distal pale spot in cell R5 round, not reaching anterior wing margin; moderately large pale spot straddling vein M1 at midlength; distal pale spot in cell M1 not attaining wing margin; pale area in cell M2 between medial fork and mediocubital fork; distal pale spot in cell M2 broadly meeting wing margin; anal cell with double pale spot in distal portion, the posterior one often small and separated from the other. Macro-

trichia confined to a few at extreme wing tip; costal ratio 0.72 (0.69-0.75, n = 22); one radial cell, broader at base than in most other *Haemophoructus*, slightly broader toward apex. Halter pale.

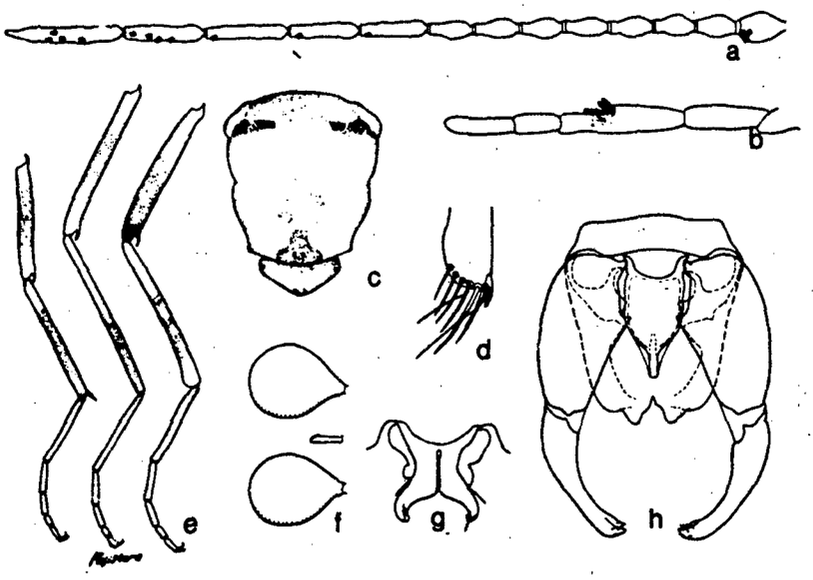


Fig. 73. *Culicoic'es gemellus*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Abdomen: Brownish, sparsely covered with rather long bristly hairs. Spermathecae (fig. 73f) ovoid, tapering to relatively broad, short necks; subequal, each 0.053 x 0.041 mm.

Male.--Similar to female, with usual sexual differences; two radial cells present. Genitalia (fig. 73h): Ninth sternum narrow, without caudomedian excavation, ventral membrane bare; ninth tergum bilobed, each lobe rounded but longer caudolaterally, a conspicuous caudomedian notch, caudal margin of tergum with a submedian pair of angular, thinly sclerotized, secondary lobes. Basistyle stout, ventral root absent, dorsal root slender; dististyle slender, slightly curved, with sharp pointed tip and distinct apical tooth. Aedeagus with low rounded basal arch, a sclerotized rim along arch; basal arms short; main portion stout, with subparallel sides and rounded shoulders extending much higher than usual, the distal process very short, only 0.25 as long as total length of aedeagus, without ball-like tip, internal sclerotized peg present. Parameres (fig. 73g) separate, each with

short, slender, anterolateral basal arm; stem short, quite stout, stout portion abruptly bent ventrolaterad, tapering and curved ventrocephalad and ending in filamentous tip with minute fringing distal hairs.

Distribution.--Cambodia, Indonesia, Laos, Malaysia, New Guinea, Sabah, Philippines, Sarawak, Thailand.

Type.--Holotype female, Sandakan, Sabah, 8.vii.1927, C.B. Kloss and H.M. Pendlebury (Type in BMNH).

Southeast Asia Records.--

CAMBODIA: Phnom Penh (Delfinado).

INDONESIA: Bali, Badung, Megwi (Lee); Badung, Pedungan (Lee). Java (West), Pandeglang, Ujung Kulon (Watters). Kalimantan (South), Banjar, Astambul, Tanah Intan, Simpang Empat, Pengiuran, and Pulo Tiba (Lee); Banjar, Martapura, Bincau and Sungai Batakan (Lee). Sulawesi (Central), Banggai, Batui, Kamiwangi (Bambang); (North), Dumoga-Bone Nat. Park, 220 m (Heppner); Lake Mooat, 20 km NE Kotamobagu, 1,050 m (Heppner); (Southeast), Kendari, Ranometo, Sabulohoa (Mambang); Kendari, Unaha (Bambang). Sumatra, Batam Island, Sungai Beduk (Sustriayu); Bengkulu, Bukit Peninjauan and Pekik Nyaring (Mathis); Jambi, Transmigrasi Singkut (Lee); Lampung, Way Abung, Mulyo-ejo (Lee); (South), Baturaja (Lee).

LAOS: Sayaboury Prov., Muong Sayaboury (Howarth).

MALAYSIA: Negri Sembilan, Telok Pelandok, Port Dickson (Traub). Pahang, Kg. Berchang-Kuala Lipis, near carabao (Garcia); Kuala Singgora (Wharton); Kuantan-Pekan Road, swamp forest (Wharton); Lamir, Pekan (Wharton); Tasek Bera (Wharton). Selangor, Carey Island, Klang (Rudnick); Kuala Lumpur (Traub); Serdang (Barnett). Trengganu, Bukit Besi, Dungun (Traub); Kg. Binjai, Kemaman (Wharton).

SABAH: Keningau Dist., Bingkok (Maa). Labuan Island (Colless, Maa). Ranau, 500 m (Quate). Tawau Dist., Kalabakan (Maa); Tawau, 48 km W (Maa).

PHILIPPINES: Balabac, Dalawan Bay (Noona Dan Exped.). Leyte, Mahaplag (Delfinado). Luzon, Solano, Nueva Viscaya, carabao baited trap (collector unknown). Mindanao, Agusan, Los Arcos (Quate); Cotabato, Burungkot, Upi (Werner); Cotabato, Kidapawan, carabao baited trap (Kalaw); Cotabato, Pikit (Werner); Davao, Tagum (Fontanilla). Mindoro, San Jose (Ross). Palawan, Brookes Point, Mekagwa (Noona Dan Exped.); Ransang River (Quate). Samar, Visayas. Taft (Balatbat). Tawi Tawi, Tarawakan (Noona Dan Exped.). Zamboanga, carabao baited trap (Casimiro). Zamboanga del Norte, Manucan, 500 m (Quate).

SARAWAK: Kuching, Santubong (Maa).

THAILAND: Phangnga Prov., Pulau Panjang (collector unknown).

Notes on Type.--The holotype female was examined by Wirth in 1980 (courtesy of Richard Lane). It is mounted on 1 slide under 5 cover slips and is in only fair condition, considerable shrinkage of the appendages having been suffered in dis-

section and mounting. However, the following measurements were made: wing length 1.22 mm; costal ratio 0.74; P/H Ratio 0.97, and spermathecae subequal, each 0.058 x 0.045 mm.

Discussion.--This species closely resembles *nitens* Edwards in wing pattern, dark legs, bristly body, and uniformly shining brownish black thorax, but it can be distinguished from that species by its smaller size, more slender body, larger pale marking over the radial cell and narrow transverse distal pale mark in cell R5 which attains the anterior wing margin, and in the male genitalia by the conspicuously short distal process without spherical tip on the aedeagus.

Tokunaga's figures and descriptions (1959, 1962b) fit the present material exceedingly well, although the variation which led him to believe *gentilis* and *gemellus* were the same species and adopt the name *gentilis* for his material leads us to believe that he was dealing with more than 1 species in New Guinea. We have seen 1 female from Maprik, New Guinea, iv.1958 (Malaria Control Section), sent to us by David J. Lee of Sydney, which fits *gemellus*.

A long series from Kalutaluwewa, Colombo, Sri Lanka, 19.ii.1958, Medical Research Institute, light trap, is provisionally referred here, but may represent a distinct species. The females agree structurally with *gemellus*, but the wings are a little darker than average for *gemellus*, while the male genitalia are very similar to those of *nitens* Edwards.

Culicoides gemellus, *gentilis*, and *gymnopterus* have very similar male genitalia, all having a broad caudomedian notch and low, obtuse, caudolateral lobes on the ninth tergum. The species differ mainly in the location and degree of development of an additional pair of hyaline submedian secondary lobes on the ninth tergum.

Culicoides gentilis Macfie
(Figs. 74, 241, 391)

Culicoides gentilis Macfie, 1934a: 191 (female; Malaya; fig. wing).

Female.--(Mt. Brinchang, Malaysia). Wing length 1.68 mm.

Head: Eyes contiguous, bare. Antenna (fig. 74a) with lengths of flagellar segments in proportion of 27-24-26-28-29-30-30-30-43-46-48-52-69, antennal ratio 1.15; sensilla coeloconica present on segments 3,11-15 (4-5 each on segments 14 and 15). Palpus (fig. 74b) with lengths of segments in proportion of 13-46-65-23-21; third segment long and slender, narrowed only a extreme tip, with scattered sensilla on distal half; palpal ratio 5.4. Proboscis moderately long, P/H Ratio 1.0; mandible with 18 (n = 4) teeth.

Thorax: Brownish, mesonotum yellowish-brown without pattern (fig. 74c). Legs (fig. 74e) brownish, fore- and midknees with yellow bands on each side, narrow on foreleg and broad on midleg; hindfemur often with pale band near tip; hindtibia with narrow basal and apical pale bands; hindtibial comb (fig. 74d) with 6 (n = 4) spines, the second from the spur longest, spur short.

Wing (fig. 241, 391): Pattern as figured; pale areas extensive, delimiting three narrow, irregularly transverse, dark bands and dark wing tip; large pale area at base extending across base of anal cell; broad pale area over r-m crossvein, narrowly connected proximad of crossvein to pale area in medial cell; second dark

band with very dark proximal extension along vein M1 to r-m crossvein; third pale costal band very broad, extending to tip of costa and caudad to vein M1; distal pale spot in cell R5 large, quadrate, extending from anterior wing margin to vein M1; a large, more or less quadrate, pale area extending across cell M1 before midlength and continued caudad across cell M2; two small distal pale spots in cells M1 and M2, the one in cell M1 not attaining wing margin; a large pale area in cell M2 from medial fork to mediocubital fork; cell M4 with large pale spot filling distal portion, often with fainter anterior extension proximad along vein M3+4 to base of cell M4; anal cell with a large double pale area in distal portion, connected to basal pale area. Macrotrichia moderately numerous on distal portion of wing; costal ratio 0.78 (n = 2); one radial cell, narrow at base, with comparatively broad distal portion. Halter pale.

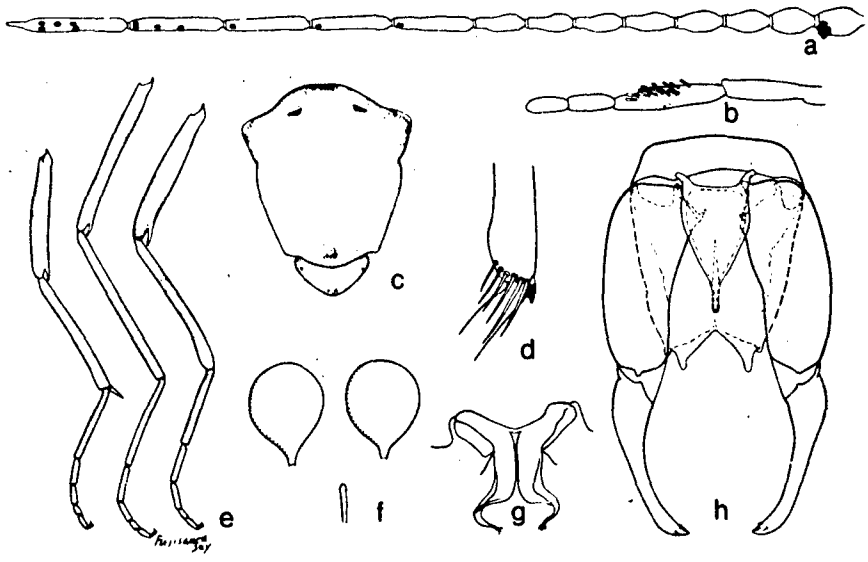


Fig. 74. *Culicoides gentilis*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Abdomen: Dark brown; long and slender and slightly petiolate. Spermathecae (fig. 74f) ovoid, tapering to slender necks; each 0.065 x 0.044 mm.

Male.--Similar to female, with usual sexual differences; one radial cell present; wing pattern of pale spots much reduced, diffuse. Genitalia (fig. 74h): Ninth sternum with very shallow caudomedian excavation, ventral membrane bare; ninth

tergum bilobed caudad, with distinct caudomedian cleft, a pair of long, fingerlike, thinly sclerotized, secondary lobes near caudolateral extremities. Basistyle slender, slightly curved to pointed double tip. Aedeagus with low convex basal arch, without sclerotized basal rim; main portion moderately broad, with convex sides tapering to distal process; the latter short, one-quarter length of aedeagus, with spherical tip; internal sclerotized peg present. Parameres (fig. 74g) separate; each with stout, crooked basal arm; stem somewhat swollen convexly and bent caudolaterad, then ventrad and abruptly tapering to long distal filament with fringing hairs at tip.

Distribution.--Brunei, Malaysia, Philippines, Sabah.

Types.--Described from three syntypes from Malaysia, two females from Larut Hills, Perak, 1,350 m, 21.ii.1932, and one female from Gunong Tahan, Pahang, 1,650 m, 6.i.1923, all taken at light by H.M. Pendlebury, deposited in the BMNH. We have selected as lectotype one of the females from the Larut Hills.

Southeast Asia Records.--
BRUNEI: Kg. Selimbigar, in fowl house (Colless).
MALAYSIA: Pahang, King George V Nat. Park (McClure); Mt. Brinchang, 1,650 m (Quate) (plesiotype). Perak, Gunong Besont Forest Res. (Jeffery).
PHILIPPINES: Mindanao, Surigao Prov., Lake Mainit (Yoshimoto). Negros Oriental, Lake Balinsasayao (Quate).
SABAH: Mt. Kinabalu, Tenompok, 1,460 m (Maa, Quate).

Discussion.--*Culicoides gentilis* is distinguished by its large size and long third palpal segment, yellow-marked mesonotum, and moderately prominent pale wing markings with the distal pale spot in cell M1 extending nearly to wing margin, and pale spot in cell M4 often with proximal extension along vein M3+4; the radial cell is relatively broad distally, and the macrotrichia are fairly numerous at the tip of the wing. Some specimens show a faint subapical pale band on the hindfemur; this is also characteristic of *gymnopterus* Edwards, another species with yellow-marked mesonotum and extensive pale wing markings, but *gymnopterus* has a prominent pale extension of the distal pale spot in cell M1 to the wing margin, and it is a smaller species with shorter third palpal segment. *Culicoides nitens* Edwards can be distinguished by its shining brownish black mesonotum and darker wing markings with the distal pale spot in cell M1 very small and not nearly attaining wing margin. The long, fingerlike, sublateral, secondary lobes on the male ninth tergum of *gentilis* are unique in *Haemophoructus*.

Notes on Type.--The lectotype female was examined by Wirth at the BMNH in 1957 (courtesy Paul Freeman) and again in 1980 (courtesy Richard Lane). It is mounted on a depression slide in creosote-balsam with only the wings dissected off and mounted separately. The wing length is 1.77 mm; costal ratio 0.72; antenna missing; remaining features not in proper position for measurement.
Alan Dyce informs us (in litt.) that he mounted the syntype from Gunong Tahan on a slide and the antennal sensory pattern on 1 antenna was 3,11-15 as usual, but on the other antenna was 3,7,9,11-5.

Culicoides gymnopterus Edwards
(Figs. 75, 242, 392)

Culicoides gymnopterus Edwards, 1926a: 247 (male, female; Sarawak; figs.).

Female.--Wing length 1.23 (1.19-1.30, n = 5) mm.

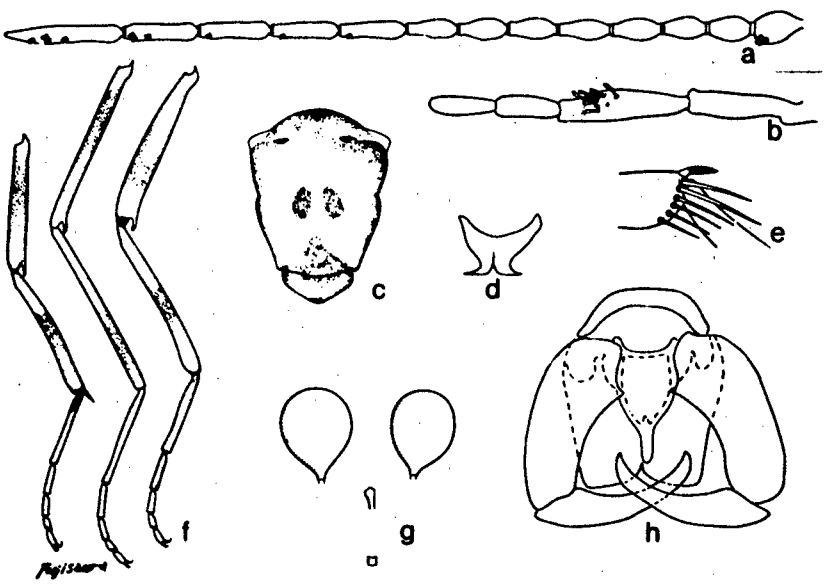


Fig. 75. *Culicoides gymnopterus*: a. antenna; b. palpus; c. thoracic pattern; d. parameres; e. tibial comb; f. legs; g. spermathecae; h. male genitalia, parameres omitted.

Head: Eyes contiguous, bare. Antenna (fig. 75a) with lengths of flagellar segments in proportion of 15-20-22-23-24-24-25-25-34-34-39-40-55, antennal ratio 1.08 (1.07-1.10, n = 2); sensilla coeloconica present on segments 3,11-15 (3 on segment 14, 4 on 15). Palpus (fig. 75b) with lengths of segments in proportion of 14-35-53-21-20; third segment slender, tapered distally, with sensilla scattered on distal half; palpal ratio 4.5 (4.1-4.0, n = 7) teeth.

Thorax: Brown with yellowish pattern (fig. 75c), disc of mesonotum extensively yellowish. Legs (fig. 75f) pale brown, femora pale at bases; fore- and midknees broadly pale on each side, hindfemur usually with faint subapical pale band, the

extreme tip darker brown, hindtibia with narrow basal and apical pale rings; hindtibial comb (fig. 75e) with 6 (n = 5) spines, the second from the spur longest; spur short.

Wing (fig. 242, 392): Pattern as figured; pale markings extensive and more or less interconnected; base of wing pale nearly half-way to r-m crossvein; broad pale area over r-m crossvein, notched distally by a very dark proximal extension of the distal dark band, continuous posteriorly with a large pale area extending behind medial fork to anterior side of mediocubital fork; anterior wing margin with three conspicuously darker transverse bands, these about half as broad as the pale areas on each side; distal pale area in cell R5 broadly meeting anterior wing margin, usually concave on distal side; a large pale area straddling vein M1 just proximad of midlength; distal pale spot in cell M1 continued with reduced breadth to wing margin; distal pale spot in cell M2 broadly meeting wing margin; large pale spot in cell M4 not continued proximad along vein M3+4; a large double pale area in distal portion of anal cell, not distinctly connected with pale basal portion of cell (a faint pale line may be present along vein M3+4). Macrotrichia confined to a few at wing tip; costal ratio 0.70 (0.68-0.72, n = 5); one radial cell, narrow at base, distal portion not very broad. Halter pale.

Abdomen: Dark brown, moderately slender, not petiolate. Spermathecae (fig. 75g) ovoid, tapering to short slender necks; subequal, each 0.051 x 0.038 mm.

Male.--Similar to female, with usual sexual differences; one radial cell present; hindfemur dark to tip. Genitalia (fig. 75h): Ninth sternum without caudomedian excavation, ventral membrane bare; ninth tergum deeply notched caudally, gradually curved and lengthened caudolaterally to gently angled caudolateral shoulders. Basistyle slender, with small pointed ventral root and short stout dorsal root; dististyle slender, curved to sharp apical point. Aedeagus with extremely low, transverse basal arch, basal arms short, anterior margin of arch with sclerotized band; main portion relatively short and broad, sides slightly convex, tapering gradually to short distal process with slender rounded tip, internal sclerotized peg present. Parameres (fig. 75d) apparently fused a very short distance at base; each with rather long stout basal arm directed ventrolaterad; midportion stout, abruptly narrowed and bent ventrally and ending in a short, pointed, terminal process.

Distribution.--Indonesia, Malaysia, Sabah, Sarawak.

Types.--Described from "Mt. Penrissen, 2,000 ft--type female; 3,000 ft--type male." The female is hereby selected as the lectotype; it was studied by Wirth at the BMNH in 1957. The present redescription and figures are from a male and female from Tahan River, Pahang, Malaysia.

Southeast Asia Records.--

INDONESIA: Kalimantan (South), Banjar, Astambul, Tanah Intan, Simpang Empat, Kampung Baru (Lee). Sulawesi (North), Dumoga-Bone Nat. Park 220 m (Heppner). Sumatra, Bengkulu, Seluma, Bukit Peningauan (Mathis); Jambi, Transmigrasi, Singkut (Lee).

MALAYSIA: Johore, Kahang Kluang (Hubert). Pahang, Gudang Rasan, Kuantan (Traub); Kuala Singgora (Wharton); Tahan River, King George V Nat. Park (McClure). Trenganu, Dungun, Bukit Besi (Traub).
SABAH: Tawau, 48 km W (Maa); Tawau Dist., Kalabakan (Maa).
SARAWAK: Kapit Dist., Nanga Pelagus (Traub).

Discussion.--This species can be distinguished by its yellow-marked mesonotum, hindfemur with faint subapical pale band and black knee spot, and extensively pale, distinctly marked wing pattern with the distal pale spot in cell M1 extending to the wing margin. It is very similar to *unicus* Delfinado, but that species has the third palpal segment much narrowed distally, the hindfemur with entirely distal third somewhat paler but lacking the black knee spot, the legs generally much paler, and the distal pale spot in cell M1 not reaching the wing margin.

Delfinado's (1961) Philippine record of *gymnopterus* is in error, as the female that Edwards (1929, p. 9) determined as this species, and Delfinado redescribed and figured (plate 10, fig. 4), does not fit Edwards' original description nor the present material. From Delfinado's description of the hyaline medial lobe of the ninth tergum, the species is probably *unicus* Delfinado.

Culicoides hoffmanioides Wirth and Hubert, new species
(Figs. 76, 243, 393)

Female.--Wing length 1.06 (0.96-1.11, n = 12) mm.

Head: Eyes contiguous, bare. Antenna (fig. 76a) with lengths of flagellar segments in proportion of 21-17-19-20-20-19-19-19-30-31-37-36-53, antennal ratio 1.21 (1.18-1.26, n = 11); sensilla coeloconica present on segments 3,11-15 (2-3 on segment 15, 3-4 on 15). Palpus (fig. 76b) with lengths of segments in proportion of 10-27-37-14-17; third segment very slightly swollen, spindle-shaped, with scattered sensilla on distal two-thirds; palpal ratio 3.7 (3.5-4.0, n = 12). Proboscis moderately long, P/H Ratio 0.83; mandible with 19 (16-21, n = 18) teeth.

Thorax: Brown, mesonotal pattern not evident. Legs (fig. 76c) brown; base of foretibia, tip of midfemur, base of midtibia, and base and apex of hindtibia narrowly pale; hindtibial comb (fig. 76d) with 6 spines, second from the spur longest, spur short.

Wing (fig. 243, 393): Pattern as figured; pale areas only moderately prominent and extensive; base of wing pale only about a third-way to r-m crossvein; pale spot over r-m crossvein not as wide as the dark area on each side, extending broadly to costa but only narrowly to media; pale area at tip of radial cell not broad, not extending to vein M1; distal pale spot in cell R5 moderately large, not round, only indistinctly extending to anterior wing margin; large pale area lying between medial and mediocutibal forks; double pale spot straddling midportion of vein M2; distal pale spot in cell M1 lying at considerable distance from wing margin; distal pale spot in cell M2 touching wing margin; cell M4 with large pale spot in distal portion, usually narrowly connected along vein M3+4 to a prominent pale spot bordering veins at base of cell; anal cell with a double pale spot in distal por-

tion, broadly separated from basal pale area of cell. Macrotrichia sparse over distal fourth of wing; costal ratio 0.70 (0.68-0.71, n = 12); one radial cell present, narrow proximally, slightly broadened distally. Halter pale.

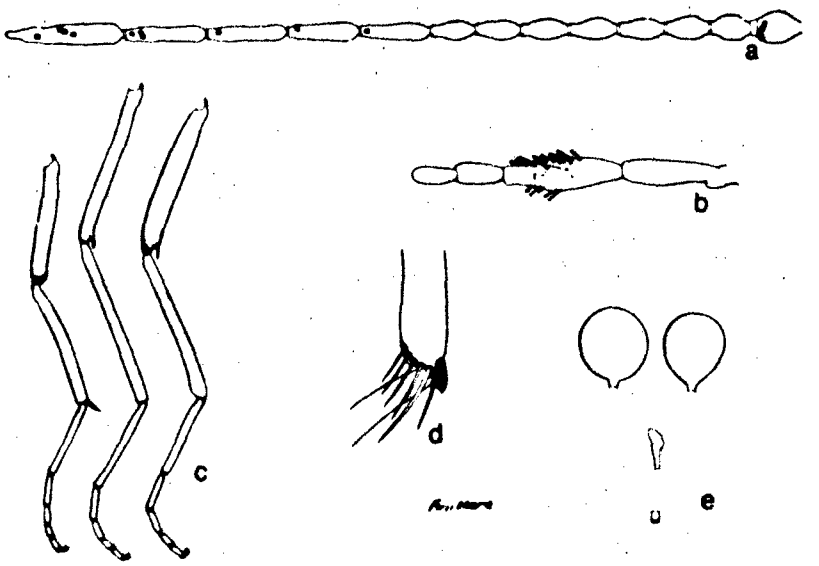


Fig. 76. *Culiciides hoffmanioides*: a. antenna; b. palpus; c. legs; d. tibial comb. e. spermathecae.

Abdomen: Brownish, with very sparse hairs. Spermathecae (fig. 76e) 1 subspherical, the other ovoid, with very short, slender necks; subequal, each 0.044 x 0.033 mm.

Male.--Unknown.

Distribution.--Malaysia, Sabah, Thailand.

Types.--Holotype female, Telok Pelandok, Port Dickson, Negri Sembilan, Malaysia, 18.vii.1958, R. Traub, light trap (Type in USNM). Paratypes, 84 females.

MALAYSIA: Same data as holotype, 1 female. Pahang, Gudang Rasah, i-ii.1959, R. Traub, light trap, 32 females.

SABAH: Labuan Island, various dates, 1949-52, C.H. Colless, at light, 50 females.

THAILAND: Phangnga Prov., Pulau Panjang, 11.xi.1954, collector unknown, 1 female.

Discussion.--*Culicoides hoffmanioides* can be separated from all other *Haemophoructus* species by the distinct pale spot at the base of cell M4, in this respect resembling species of the subgenus *Hoffmania*.

Culicoides kinari Howarth
(Figs. 77, 244)

Culicoides kinari Howarth, 1985: 44 (male, female; Laos; figs.).

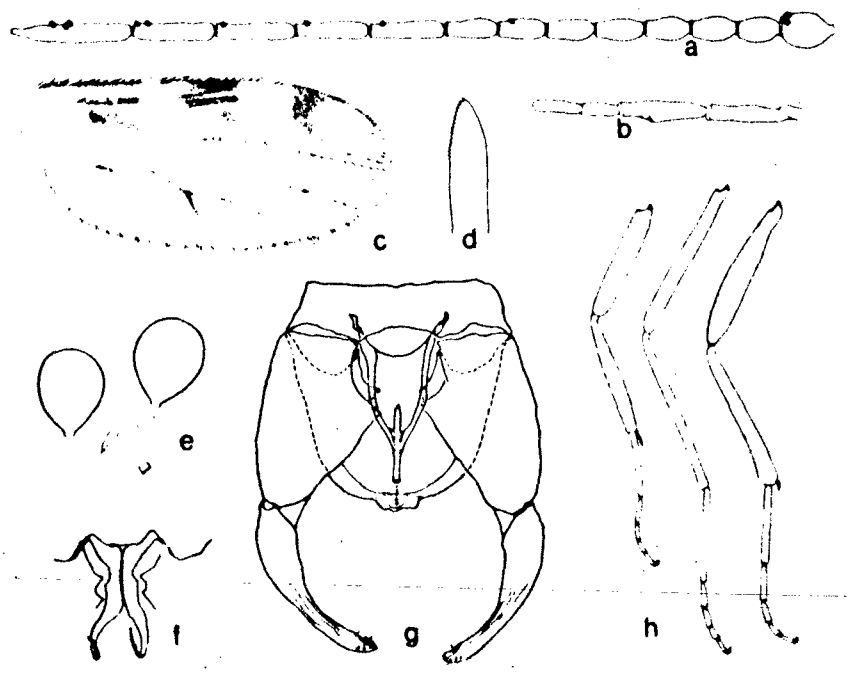


Fig 77 *Culicoides kinari* a antenna; b palpus; c. wing; d. mandible; e. spermathecae; f. parameres; g male genitalia, parameres omitted; h. legs.

Female.--Wing length 1.18 (1.12-1.25, n = 10) mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 77a) with lengths of flagellar segments in proportion of 21-18-18-19-20-19-20-21-31-31-34-35-52, antennal ratio 1.16 (1.11-1.23, n = 10); sensilla coeloconica present on segments

3,(7,9),11-15. Palpus (fig. 77b) with lengths of segments in proportion of 12-39-39-16-22; third segment long, slender, slightly swollen in midportion, sensilla scattered on distal half; palpal ratio 4.6 (4.1-5.3, n = 10). Proboscis long, P/H Ratio 0.86 (0.83-0.89, n = 9); mandible (fig. 77d) with 16 (15-18, n = 10) small teeth.

Thorax: Dark brown, without pattern in slide material. Legs (fig. 77h) dark brown with contrasting yellow bands; foreknee narrowly pale, femur with indistinct narrow apical pale band, tibia with narrow basal pale band; midknee narrowly pale, femur pale on distal fourth or less, tibia with narrow basal pale band; hindfemur dark to tip, tibia with distinct narrow pale basal and apical bands; hindtibial comb with 6 (6-8, n = 10) spines, second from spur longest.

Wing (fig. 77c, 244): Pattern as figured; pale and dark spots prominent; one long broad radial cell present. Base of wing pale including anal angle; pale spot over r-m crossvein broadly meeting wing margin, narrowly crossing media; poststigmatic pale spot in cell R5 not reaching vein M1, about two-thirds of its width overlapping tip of radial cells; distal pale spots in cells R5 and M1 not reaching distal margin; large double pale spot straddling midportion of vein M2; small marginal pale spots each in apices of cells M2 and M4; two separate distal pale spots in anal cell broadly separated from broad pale area at base of cell; pale spot present in cell M2 just anterior to mediocubital fork; connected with elongate spot at base of medial fork; dark band distad of poststigmatic pale spot narrow, less than half the width of each of the two proximal dark anterior bands. Macrotrichia sparse, confined to narrow band along anterior margin of cell R5 and apices of cells R5 and M1; costal ratio 0.68 (0.65-0.70, n = 9). Halter pale.

Abdomen: Dark brown. Spermathecae (fig. 77e) oval and tapering to short, narrow, sclerotized necks; subequal, each 0.049 x 0.038 mm.

Male.--Similar to female with usual sexual differences; one radial cell present as in female. Genitalia (fig. 77g): Ninth sternum with shallow caudomedian excavation; ninth tergum convex with narrow median sulcus and short, broad, hyaline, apicomedian lobe. Basistyle without strong mesal spines, ventral root absent, dorsal root short, triangular; dististyle slender, tapering and curving to pointed tip, rugulose subapically and narrowest at distal third. Aedeagus narrow, elongate; basal arch extending to a fourth of total length, basal arms short and slender; midportion with subparallel sides basally, then tapering to slender distal process, internal sclerotized peg present; distal process one-fifth length of aedeagus, slightly expanded with tip bent ventrad. Parameres (fig. 77f) weakly fused at base, mesal margins of main bodies contiguous; each with short stout basal arm, midportion moderately swollen, distal portion tapering to slender filament abruptly curved ventrad with hairy tip.

Distribution.--Laos.

Types.--Holotype female, allotype male, Laos, Sayaboury Prov., Sayaboury, 300 m, 22.vii.1967, F.G. Howarth, sweeping, secondary forest (Bishop Mus.).

Southeast Asia Records.--

LAOS: Sayaboury Prov., Sayaboury (Howarth, types). Vientiane Prov., Muong Ban Keun, Ban Na Pheng, 180 m (Howarth).

Discussion.--This species is closely related to *C. gemellus* but the legs have more contrasting pale bands, the costa does not extend as far as the dark band lying beyond the poststigmatic pale spot, and the antenna usually bears extra sensilla coeloconica on segments 7 and 9 in addition to those ordinarily present on 3,11-15. The male ninth tergum bears a single caudomedian lobe similar to that of *C. unicus*, rather than the paired submedian lobes found in *gemellus*.

Culicoides kisangkini Howarth
(Figs. 78, 245)

Culicoides kisangkini Howarth, 1985: 47 (male, female, pupa; Laos; figs.).

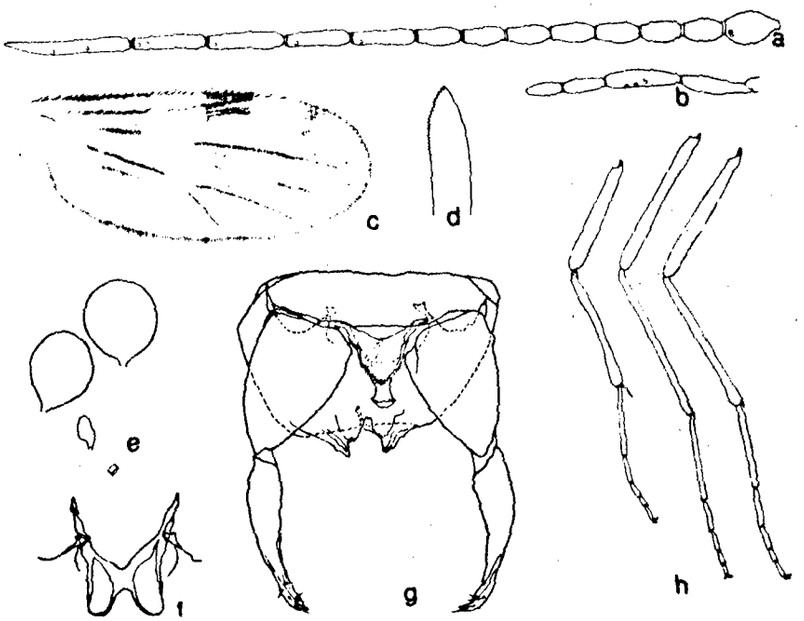


Fig. 78. *Culicoides kisangkini*: a. antenna; b. palpus; c. wing; d. mandible; e. spermathecae; f. parameres; g. male genitalia, parameres omitted; h. legs.

Female.--Wing length 1.38 (1.33-1.43, n = 4) mm

Head: Eyes contiguous a short distance, bare. Antenna (fig. 78a) with lengths of flagellar segments in proportion of 26-20-20-21-21-21-20-21-30-29-39-40-67, antennal ratio 1.17 (1.12-1.21, n = 4); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 78b) with lengths of segments in proportion of 12-40-43-21-20; third segment long and slender, slightly swollen in midportion, without trace of pit, sensilla scattered on distomesal surface; palpal ratio 4.4 (4.1-4.7, n = 4). Proboscis long, P/H Ratio 0.85 (0.82-0.86, n = 4); mandible (fig. 78d) with 30 (19-21, n = 4) small teeth.

Thorax: Brown, pleuron lighter brown. Legs (fig. 78h) pale brown, bands not distinct; fore- and hindknees very narrowly darkened, midknee infuscated; hindtibial comb with 4 spines, second from short spur longest.

Wing (fig. 78c, 245): Pattern as figured; one long radial cell present, reaching distal dark band. Wing darker anteriorly with large pale spots; three transverse dark bands on anterior margin, one distad of poststigmatic pale spot narrow, 1/2 and 1/3 the widths of mesal and distal bands, respectively; anal angle broadly pale; eight large pale spots, sometimes fused, located as follows: over r-m crossvein; over distal portion of radial cell; distal portion of cell R5 (sometimes attaining wing tip); subapically in cell M1; apically in cells M2, M4, and anal cell; and double pale spot over midportion of vein M2; no pale spot just anterior to mediocubital fork in cell M2. Macrotrichia sparse in apices of cells R5 and M1; costal ratio 0.76 (0.76-0.77, n = 4). Halter lightly infuscated.

Abdomen: Brown, terga well sclerotized. Spermathecae (fig. 78e) oval with short, narrow, sclerotized necks; subequal, each 0.059 x 0.045 mm.

Male.--Similar to female with usual sexual differences; two radial cells present; antenna with sensilla coeloconica on segments 3,13-15. Genitalia (fig. 78g): Ninth sternum without caudomedian excavation; ninth tergum short and rounded, with small shallow median cleft on caudal margin and a pair of large, hyaline, angulate, submedian lobes. Basistyle without strong setae on mesal margin, ventral root absent, dorsal root slender; dististyle slender, curving to slender distal point. Aedeagus relatively broad; basal arch short, extending to one-sixth length of aedeagus; basal arms short and stout; midportion short and tapering with vestiture of fine hairs, internal sclerotized peg absent; distal process short, stout, expanded into a caplike tip bent ventrad. Parameres (fig. 78f) broadly fused in midportion in a butterfly-shaped structure; basal arms relatively long and anterolaterally diverging; distal process of each slender, attenuated and curving ventrolaterad with tip connected to caudally directed lateral expansion of basal arm by a winglike hyaline membrane.

Distribution.--Laos.

Types.--Holotype male, allotype female, Laos, Sayaboury Prov., 20 km NE Sayaboury, 400 m, 26.xi.1967, F.G. Howarth, reared from elephant droppings in Houey La Stream (Deposited in Bishop Museum).

Discussion.--Howarth (1985) considered this as a coprophagous species, breeding in floating elephant feces. The pupae were collected in the aerial portion of the droppings floating in a stream. They were associated with horsefly larvae and muscoid fly pupae. The females must oviposit on relatively fresh droppings to assure the development of the larvae and pupae before the feces disintegrate in the water.

This species is distinguished from all other known species of *Haemophoructus* by the presence of only four spines in the hindtibial comb. The absence of a pale spot in cell M2 of the wing just anterior to the mediocubital fork, and the pale legs, are also characteristic. The males are unique in the butterfly-shaped parameres and the hairy ventral vestiture of the main body of the aedeagus.

Culicoides mellipes Wirth and Hubert, new species
(Figs. 79, 246, 394)

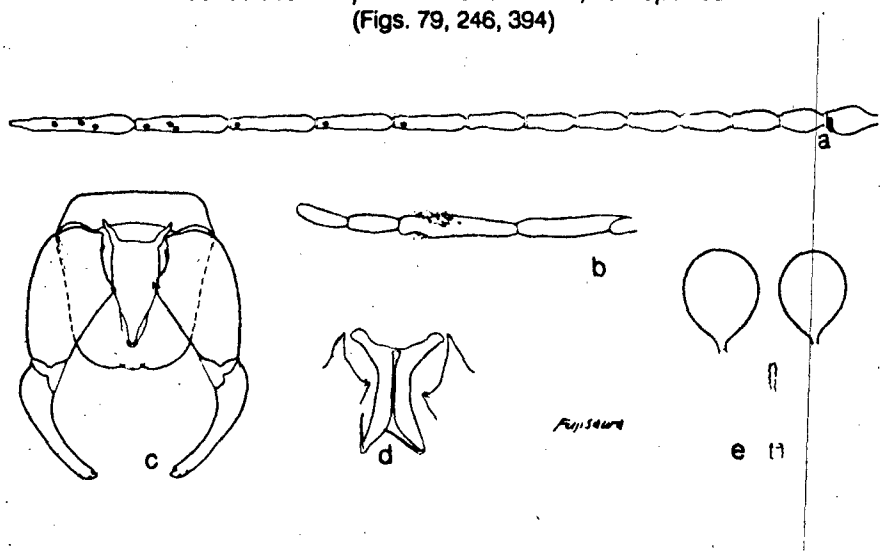


Fig. 79. *Culicoides mellipes*: a. antenna; b. palpus; c. male genitalia, parameres omitted; d. parameres; e. spermathecae.

Female.--Wing length 1.18 mm.

Head: Eyes contiguous, bare. Antenna (fig. 79a) with lengths of flagellar segments in proportion of 26-22-25-27-26-25-25-26-33-36-42-43-57, antennal ratio 1.04; sensilla coeloconica present on segments 3,11-15 (3 on segment 15, 4 on 15); sensilla trichodea long, straight and dark, appearing bristle-like, on segments 3-10. Palpus (fig. 79b) with lengths of segments in proportion of 10-39-46-19-18; third segment slender, slightly narrowed distally, with scattered sensilla on distal half; palpal ratio 4.6. Proboscis moderately long, P/H Ratio 1.00; mandible with 18 teeth.

Thorax: Brownish on sides, mesonotum yellowish. Legs entirely yellowish; hindtibial comb with 6 spines, the second from the spur longest.

Wing (fig. 246, 394): Pattern as figured; pale areas very extensive and interconnected, dark markings forming 3 fairly straight, transverse bands, each less than half as broad as the pale area distad; extreme apex of wing fairly dark, distal pale spot in cell R5 faint near anterior wing margin, distal pale spot in cell M1 faint and located well proximad of wing margin, distal pale spot in cell M2 distinct and meeting wing margin; pale spot in cell M4 a broad continuation of the third transverse pale band across wing, dark along vein Cu1 and apex of M3+4; anal cell with proximal third pale, broadly connected to broad pale area in distal portion of cell; only 1 radial cell present, very narrow throughout, the tip not quite attaining third dark band of wing. Macrotrichia confined to a few at extreme wing tip; costal ratio 0.78. Halter pale.

Abdomen: Pale yellowish, elongate and slightly petiolate. Spermathecae (fig. 79e) ovoid, tapering slightly to slender necks; subequal, each 0.052 x 0.035 mm.

Male.--Similar to female, but two radial cells present. Genitalia (fig. 79c): Ninth sternum very narrow, without caudomedian excavation, ventral membrane bare; ninth tergum rounded caudad, slightly bilobate, the slight median notch bearing a small sclerotized caudal point. Basistyle stout, ventral root absent, dorsal root short and triangular; dististyle slender, nearly straight, with tip slightly pointed. Aedeagus with low rounded basal arch, basal arms directed anterolaterad; main body relatively long and narrow, bearing distally a long, internal, sclerotized peg; tapering distally to slender tip without terminal papilla. Parameres (fig. 79d) each with short anterolateral basal arm; stem slender basally, slightly enlarged distally on contiguous portion; abruptly narrowed on distal portion to filamentous tip directed ventrocephalad and bearing a few minute hairs distally.

Distribution.--Indonesia, Malaysia, Sarawak.

Types.--Holotype female, allotype male, Tahan River, King George V Nat. Park, Pahang, Malaysia, 23.ii.1961, G. Hendrickson, light (Type in USNM). Paratypes, 17 male, 23 females.

INDONESIA: Sulawesi (North), Dumoga Bone Nat. Park, 220 m, 16-20.x.1985, J.B. Heppner, 4 males, 2 females; Lake Mooat, 20 km NE Kotamobagu, 1,050 m, 26-30.x.1985, Heppner, 3 males, 2 females; (Southeast), Kolaka, Tiracita, Lodongi Jaya, 26.ii.1979, Bambang coll., 1 female.

MALAYSIA: Pahang, same data as types, 8 males, 15 females. Perak, Gunong Besart Forest Res., 18 iii.1974, B. Knudsen, 15.v.1974, J. Jeffery, 3 females. Selangor, Kuala Lumpur, viii.1958, R. Traub, light trap, 1 male; Ulu Kelantan, Ft. Betis, 11.xi.1961, R. Traub, light trap, 1 female.

SARAWAK: Kapit Dist., Nanga Pelagus, 28.xi.1958, R. Traub, light, 1 male, 2 females.

Discussion.--The extreme reduction of the dark wing markings to narrow transverse bands is similar to those of *gentilis* and *unicus*, from which *mellipes* differs by its uniformly yellowish legs.

Culicoides nitens Edwards
(Figs. 80, 247, 395)

Culicoides nitens Edwards, 1933: 252 (female; North Borneo).

Female --Wing length 1.80 mm.

Head: Eyes contiguous, bare. Antenna (fig. 80a) with lengths of flagellar segments in proportion of 35-31-34-35-36-35-35-34-48-57-56-60-84, antennal ratio 1.09; sensilla coeloconica present on segments 3,11-15 (four tufts on segment 14, five on 15). Palpus (fig. 80b) with lengths of segments in proportion of 18-5--76-32-31; third segment long and slender, a short but distinct swelling at mid-length, with sensilla scattered on distal half; palpal ratio 5.0. Proboscis long, P/H Ratio 1.1; mandible with 18-21 teeth.

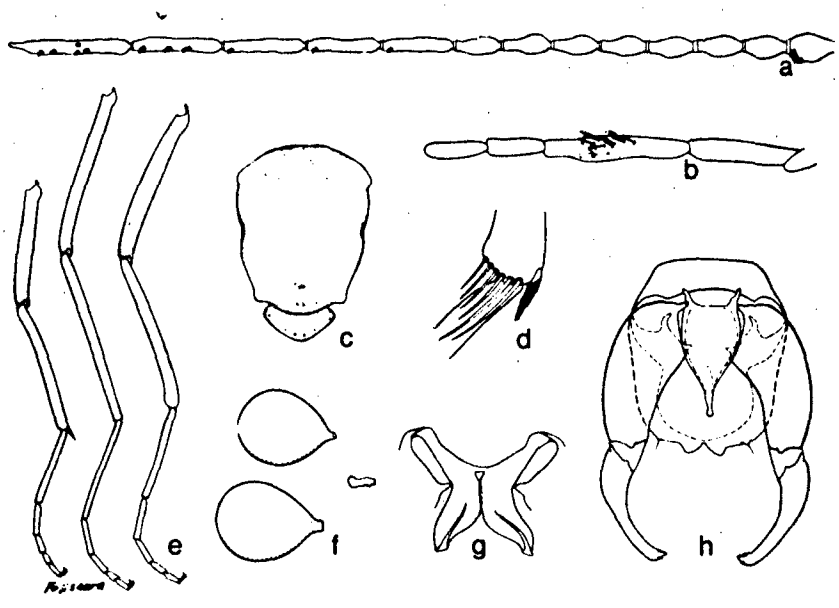


Fig. 80. *Culicoides nitens*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Thorax: Shining brownish black; mesonotum (fig. 80c) without pattern, with sparse bristly hairs. Legs (fig. 80e) brown; midknee faintly pale on each side, hindtibia pale at base and apex; hindtibial comb (fig. 80d) with 6 spines, second from the spur longest; spur short; legs with hairs long and bristly.

Wing (fig. 247, 395): Slender; pattern as figured; pale areas moderately large and distinct, smaller on distal part of wing; wing base pale one-third distance to r-m crossvein; pale spot over r-m crossvein small, broader at costal margin; pale spot over radial cell broad, extending posteriorly nearly to vein M1; extreme tip of radial cell ending in the dark spot distad; second and third anterior dark spots of wing about same width as pale spot next distad; distal pale spot in cell R5 narrow, transverse, extending to anterior wing margin; large pale spot straddling midportion of vein M2, distal pale spot in cell M1 very small and located distant from wing margin; pale area between medial and mediocubital forks continued proximad in cell M2 to basal pale area of wing; distal pale spot in cell M2 not attaining wing margin; pale spot in cell M4 broadly attaining wing margin, reaching vein M3+4 anteriorly; anal cell with faint double pale area in distal portion. Macrotrichia restricted to a few at extreme wing tip; costal ratio 0.78; radial cell narrow, only slightly broadening distally. Halter pale.

Abdomen: Brown, slender and slightly petiolate, with dense coarse hairs. Spermathecae (fig. 80f) ovoid, tapering to short slender necks; very slightly unequal, 0.055 x 0.043 mm and 0.051 x 0.042 mm.

Male.--Similar to female with usual sexual differences, two radial cells present. Genitalia (fig. 80h): Ninth sternum with very faint caudomedian excavation, ventral membrane bare; ninth tergum rounded caudad, with slight caudomedian cleft, a pair of low, angular, thinly sclerotized lobes near midline. Basistyle slender, ventral root short and angular, dorsal root slender; dististyle slender, slightly curved to pointed tip. Aedeagus with low basal arch, with a sclerotized basal bar; main portion moderately broad, with convex sides tapering to distal stem; stem moderately long, 0.3 length of aedeagus, with spherical tip; internal sclerotized peg present. Parameres (fig. 80g) with slender basal connection; each with long, moderately broad basal arm; stem swollen convexly and bent caudolaterad, then ventrad and tapering to distal filament without hairs at tip.

Distribution.--Brunei, Indonesia, Malaysia, Philippines, Sabah, Sarawak, Thailand, Vietnam.

Types.--Two females, Marei Parei, Sabah, Mt. Kinabalu, 1,500 m, 1.v.1929, holotype female pinned, the other on slide (in BMNH).

Southeast Asia Records.--

INDONESIA: Sumatra, Seluma, Bukit Peningauan (Mathis).

BRUNEI: Brunei, biting man (Colless).

MALAYSIA: Pahang, King George V Nat. Park, Tahan River (McClure); Kuantan-Pekan Road (Wharton).

PHILIPPINES: Luzon, Ifugao Prov., Liwo, 8 km E Mayoyao, 1,000-1,300 m (Torrevillas); Jacmal, Bunhian, 24 km E Mayoyao, 800-1,000 m (Torrevillas); Mtn. Prov., Abatan, Buguias, 60 km S Bontoc, 1,800-2,000 m (Torrevillas); Camarines

Sur, Mt. Isarog, Pili, 800 m (Torrevillas). Mindanao, Misamis Oriental, Mt. Pomalihi, Empagatao, 1,050 m (Torrevillas); Minabunan (Torrevillas); Minalwang, 1,050 m (Torrevillas); Mt. Pomalihi, 21 km W Gingoog City, 800-1,000 m (Torrevillas); Surigao, Lake Mainit (Yoshimoto). Palawan Id., Tarumpitao Pt. (Milliron).

SABAH: Forest Camp 19 km N Kalabakan (Hirashima). Mt. Kinabalu, Tenompok (Maa). Tawau Residency, Kalabakan R., 48 km W Tawau (Maa).

SARAWAK: Gunong Matang (Maa, Gressitt). Kuching, Santubong, 800-1,500 m (collector unknown).

THAILAND: Bangkok, Thonglo (Scanlon). Chanthaburi (Maa). Chiang Dao (Maa). Chiang Mai, Amphoe Muang (Scanlon); Ban Tin Doi (Gressitt). Cholburi, Bangphra (Scanlon). Nakronpanom (Manop). Nonthaburi (Manop R.). Udon Thani, Amphoe Muang (Scanlon).

VIETNAM: 13 km W Postal de m'Drak (Yoshimoto).

Discussion.--The shining blackish thorax, dark legs with hindfemur entirely dark, and dark wing with small subapical distal pale spot in cell M1 will distinguish *nitens* from all other *Haemophoructus* but *gemellus*, which is a smaller, stouter species with the distal pale spot in cell R5 more rounded; the male aedeagus of *gemellus* has a much shorter distal process which lacks the ball-like tip.

Culicoides nyakini Howarth
(Figs. 81, 248)

Culicoides nyakini Howarth, 1985: 49 (male, female; Laos; figs.).

Female.--Wing length 1.27 (1.15-1.33, n = 6) mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 81a) with lengths of flagellar segments in proportion of 24-21-22-23-23-23-23-25-33-33-37-42-59, antennal ratio 1.11 (1.05-1.14, n = 6); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 81b) with lengths of segments in proportion of 11-38-46-20-19; third segment slender, widest at distal third, sensilla scattered over distal half of segment; palpal ratio 4.5 (4.0-5.1, n = 6). Proboscis long, P/H Ratio 0.89; mandible (fig. 81d) with 17 (16-19, n = 6) small teeth.

Thorax: Dark brown, often with small contrasting paler areas on mesonotum. Legs (fig. 81h) dark, with contrasting pale bands; foreknee dark, femur with indistinct subapical pale band, tibia with sub-basal pale band; midknee broadly pale, femur pale on at least distal third; hindfemur darkened to apex with indistinct subapical pale band, knee spot blackish, tibia with distinct basal and apical pale bands; hindtibial comb with 6 spines, second from spur longest.

Wing (fig. 81c, 248): Pattern as figured; 1 long broad radial cell present. Three transverse dark bands on anterior wing margin, distal band narrow, half the width of basal band and usually half the width of middle band, the latter usually as broad as the pale areas on each side; pale spots large, confluent, contrasting; base of wing including anal angle pale; pale spot over r-m crossvein large, crossing media and joining double pale spot straddling midportion of vein M2; distal pale spots in cells M1 and M2 large; large pale spot in apex of cell M4; double pale spot distally

in anal cell; pale spot present just anterior to mediocubital fork fused with large pale spot lying just behind medial fork. Macrotrichia scantly, confined to narrow marginal band in cell R5; costal ratio 0.70 (0.69-0.71, n = 6). Halter pale.

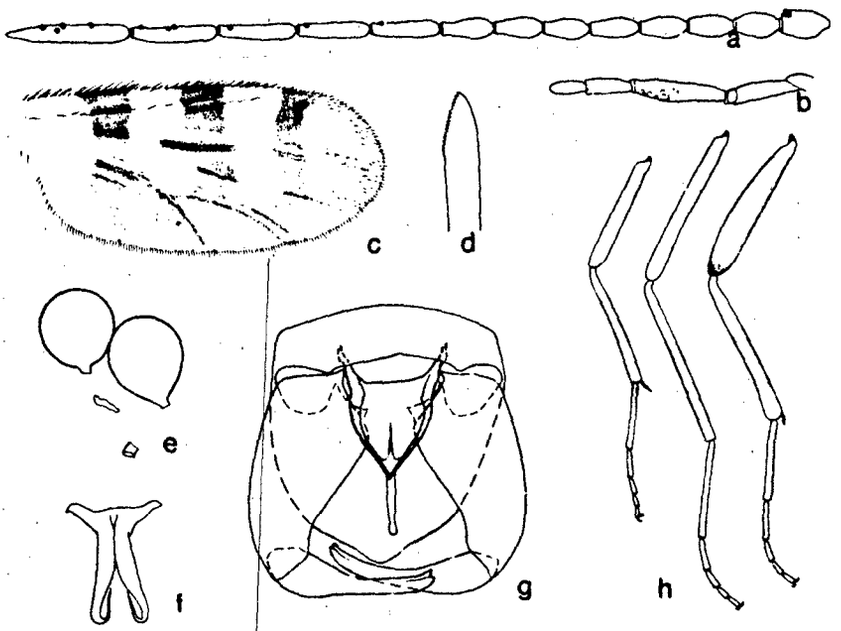


Fig. 81. *Culicoides nyakini*: a. antenna; b. palpus; c. wing; d. mandible; e. spermathecae; f. parameres; g. male genitalia, parameres omitted; h. legs.

Abdomen: Brown. Spermathecae (fig. 81e) oval, tapering to moderately long, narrow, annulate necks; subequal, each 0.060 x 0.042 mm.

Male.--Similar to female with usual sexual differences; wing with one or two radial cells. Genitalia (fig. 81g): Ninth sternum with shallow, wide, caudomedian excavation; ninth tergum rounded caudad with well developed, rounded, hyaline, median lobe. Basistyle without strong mesal spines, ventral root absent, dorsal root short, angular; dististyle slender and tapering, only slightly curving to pointed, slightly bifid tip. Aedeagus with wide, shallow basal arch extending to a fifth of total length; basal arms short and slender; midportion shield-shaped with convex side margins; distal process slender with parallel sides, about one-third length of aedeagus, with spherical tip. Parameres (fig. 81f) weakly fused near bases, con-

tiguous in midportions; each with basal arm short and stout, midportion slightly swollen, then gradually tapered to slender blade abruptly bent ventrad and ending in a simple attenuated point.

Distribution.--Laos, Malaysia.

Types.--Holotype female, allotype male, Laos, Vientiane Prov., Muong Ban Keun, Ban Na Pheng, 180 m, 21.v.1968, F.G. Howarth (Bishop Mus.).

Southeast Asia Records.--
LAOS: Sayaboury Prov., Muong Xieng Hon, 500 m (Howarth). Sedone Prov., Muong Pakse, 100 m (Howarth); Muong Pakson (Howarth). Vientiane Prov., same data as types.
MALAYSIA: Pahang, King George V Nat. Park, Tahan River (McClure).

Discussion.--The subapical pale band and black knee spot on the hindfemur and the extensively pale wing markings with the pale spot meeting the wing margin in cell M1 ally this species with *gymnopterus* Edwards, but in *gymnopterus* the pale spot in cell M1 usually meets the wing margin more broadly and the mesonotum lacks the pale areas on the disc; in the male of *gymnopterus* the ninth tergum has a broad mesal notch and somewhat angulate apicolateral shoulders, and the hyaline secondary caudomedian lobe is lacking, and the parameres are much shorter and stouter.

Culicoides unicus Delfinado
(Figs. 82, 249, 396)

Culicoides (*Culicoides*) *unicus* Delfinado, 1961: 665 (male, female; Philippines; figs.).
Culicoides gymnopterus Edwards (misident.); Edwards, 1929: 9 (male, Calapan, Mindoro, Philippines); Delfinado, 1961: 662 (Calapan, Philippines; male described; fig. wing, genitalia).

Female.--Wing length 1.23 (1.14-1.35, n = 5) mm.
Head: Eyes contiguous, bare. Antenna (fig. 82a) with lengths of flagellar segments in proportion of 24-20-22-23-23-21-22-24-30-30-33-34-45, antennal ratio 1.01 (0.97-1.06, n = 5); sensilla coeloconica present on segments 3,11-15 (three each on segments 14 and 15). Palpus (fig. 82b) with lengths of segments in proportion of 10-28-36-18-18; third segment swollen in midportion, slender distally, with sensilla scattered on distal half; palpal ratio 3.6 (3.2-4.0, n = 4). Proboscis short, P/H Ratio only 0.70; mandible with 15 (13-16, n = 9) teeth.
Thorax: Pale brown, yellowish on disc of mesonotum (fig. 82f). Legs (fig. 82e) yellowish, bases of femora and distal 0.6 of fore- and midtibiae pale brown; hindtibial comb (fig. 82g) with 6 (n = 5) spines, second from spur longest, spur short.
Wing (fig. 249, 396): Pattern as figured; pale markings extensive and more or less interconnected; base of wing pale halfway to r-m crossvein; broad pale area over r-m crossvein broadly continuous from costal margin and connecting in full

breadth with large pale area in medial cell between medial fork and mediocubital fork; anterior wing margin with three narrow transvese, much darker areas, each about half as broad as the pale area on each side; large pale area over radial cell extending distally slightly past tip of costa, broadly continuous posteriorly with large pale area straddling midportion of vein M2 and continued in full breadth through cell M4 to posterior wing margin; distal pale spots in cell R5 and M2 broadly meeting wing margin, that in cell M1 narrowly attaining wing margin; anal cell with broadly pale base and large double pale area in distal portion; cell M4 without proximal extension along vein M3+4. Macrotrichia confined to a few at extreme wing tip; costal ratio 0.69 (0.67-0.69, n = 5); 1 radial cell, slightly broadened distally past tip of vein R1. Halter pale.

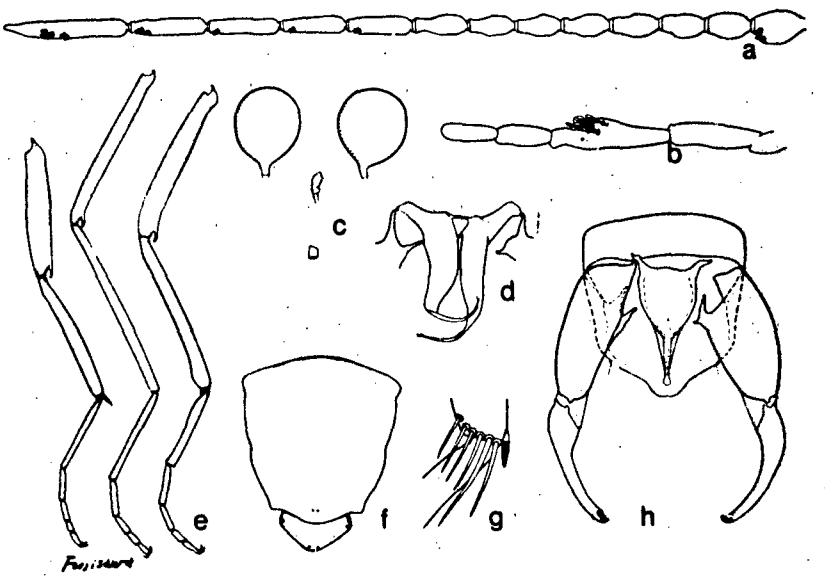


Fig. 82. *Culicoides unicus*: a. antenna; b. palpus; c. spermathecae; d. parameres; e. legs; f. thoracic pattern; g. tiblal comb; h. male genitalia, parameres omitted.

Abdomen: Pale brown; vestiture of long coarse setae. Spermathecae (fig. 82c) ovoid, tapering slightly to short slender necks; subequal, each 0.048 x 0.037 mm.

Male.--Similar to female; one radial cell present. Genitalia (fig. 82h): Ninth sternum broad, with shallow caudomedian excavation, ventral membrane bare; ninth tergum rounded apically with well-developed median lobe, apicolateral processes absent. Basistyle slender, ventral root absent, dorsal root short, pointed; distis-

tyle slender and gently curved, with pointed tip. Aedeagus with low basal arch, main portion fairly broad at base, without transverse sclerotized basal rim; dist portion long and slender with spherical tip; internal sclerotized peg present. Parameres (fig. 82d) separate; each with short basal arm; stem moderately slender, tapering to distal filament with a few minute fringing distal hairs.

Distribution.--Indonesia, Malaysia, Philippines, Sabah.

Types.--Holotype female, Mt. McKinley, Davao, Mindanao, Philippines, 1,000 m, 25.ix.1946, F.G. Werner, at light (in Field Museum of Natural History).

Southeast Asia Records.--
INDONESIA: Sumatra, Bengkulu, Seluma, Bukit Peningauan (Mathis).
MALAYSIA: Pahang, King George V Nat. Park, Tahan River (McClure).
PHILIPPINES: Luzon, Camarines Sur, Mt. Isarog, 750-850 m (Torrevillas); Mt. Isarog 20 km E Naga, 500-600 m (Torrevillas); Ifugao Prov., Liwo, 8 km E Mayoyao, 1,000-1,300 m (Torrevillas); Mtn. Prov., Abatan, Buguias, 60 km S Bontoc, 1,800-2,000 m (Torrevillas). Masawan, Mt. Malindang trail, 1,350 m (Milliron). Mindanao, Bukidnon, Mt. Katanglad (Quate); Clavin River, 1.6 km E Mt. Malindang, 1,250 m (Milliron); Augsan, Los Arcos (Quate); Davao, Mt. McKinley (Werner, types). Negros Oriental, L. Balinsasayo (Quate). Palawan, Mantalingajan, Tagembung, 1,150 m (Noona Dan Exped.). Zamboanga Norte, Labaun Mts., Manucan, 680 m (Quate).
SABAH: Forest Camp, 19 km N Kalabakan (Hirashima). Tawau, Quoin Hill (Holtmann); Cocoa Res. Sta. (Hirashima).

Discussion.--*Culicoides unicus* is very similar to *gymnopterus* Edwards, but can be distinguished by its paler color, with much paler legs, the hindfemur with distinctly pale tip; third palpal segment more swollen in middle in proportion to its length with distal portion slenderer, and the wing with distal pale spot in cell M1 not attaining the wing margin. The male genitalia of the two species are quite different, those of *gymnopterus* having the ninth tergum deeply notched on the caudomedian margin. The male from Calapan, Mindoro, P.I. described by Delfinado (1961) as *gymnopterus* has the hyaline medial lobe on the ninth tergum characteristic of *unicus*.

Subgenus **Hoffmania** Fox

Culicoides, subgenus *Hoffmania* Fox, 1948: 21. Type-species, *Culicoides inamollae* Fox and Hoffman (orig. desig.) (synonym of *insignis* Lutz).
Culicoides, subgenus *Culicoides*, in part; Delfinado, 1961: 660 (Philippine species); Wirth, 1973: 362 (in catalog of Oriental species); Howarth, 1985: 57 (Laotian species).

Diagnosis.--Wing with second radial cell ending in a pale spot; veins at base of mediocubital fork often pale-bordered in cell M4; small dark spot often present over r-m crossvein or at end of R4+5. Female antennal sensillar pattern usually 3,11-5. Eyes bare; usually contiguous. Spermathecae 2 plus vestigial third and

sclerotized ring; ovoid with short necks. Male genitalia rounded with apicolateral processes minute to small; dististyle usually with rounded tip; basistyle with ventral root absent, dorsal root short and slender; aedeagus usually with basal arch low and the anterior margin often with sclerotized rim, distal process slender, usually with internal sclerotized peg at base and with apical papilla; parameres with short basal arm, often joined in a mesal bridge, short and slender distally with minute fringing setae.

Immature Stages.--Pupa with respiratory horn unique in having no lateral spiracular openings and having tracheal rings extending two-thirds length of horn; operculum with short, stout spines, a unique elongate process near posterior end; *ad* setae long, subequal; caudal segment with a V-shaped patch of spines on disc.

Larva unique in having dark brown head capsule; thorax with contrasting purplish pigmented patches, most abundant on prothorax, often faint; no lateral pigmented spots. Head elongated, anterior end more or less narrower, ventral side with a suture; head setae long; parahypostomal setae located close to subgenal ring; hypostome without denticle; labium pointed, with three folds; epipharynx moderately sclerotized, with 4 combs, denticles on dorsal comb long, thin, and uniform in size, on second and third combs very small.

Biology.--The ubiquitous *C. peregrinus* Kieffer is the only Oriental *Hoffmania* species associated with terrestrial breeding sites, where it is common in rice paddies and puddles. Four other species have been reared from plant-associated habitats: *C. carpophilus* n. sp. from rotting jungle fruit, *C. innoxius* from a rotting banana stem and a tree wound, *C. lansangensis* from a tree wound, and *C. sumatrae* from a fungus, an arum leaf axil, and a rotting ginger flower.

Discussion.--Although the subgenus *Hoffmania* Fox has been distinguished with some success in the New World from various groups of the subgenus *Culicoides* s. str., the same characters will not provide a satisfactory separation in the Southeast Asian species. In the New World, *Hoffmania* has included those species with the base of cell M4 pale where it borders the veins at the base of the mediocubital fork, or with the apices of veins M1, M2, M3+4, and Cu1 pale, male genitalia with the apicolateral processes small or absent, aedeagus usually with a proximal sclerotization across the rim of the low transverse basal arch, a sclerotized internal point or peg distally, and a distinct spherical tip; parameres frequently fused more or less at the base. New World species of *Culicoides* s. str., on the other hand, have the base of cell M4 dark and the apices of veins M1, M2, M3+4 and Cu1 dark, the male aedeagus usually with higher basal arch without sclerotized anterior rim, internal sclerotized point, or spherical tip, and depending on the group; with various development of the apicolateral processes and fusion of the parameres. In the Southeast Asian fauna, the characters of the male genitalia are those of *Hoffmania*, not of the subgenus *Culicoides*. It appears that *Hoffmania* evolved as a Southern Hemisphere sister group of the Holarctic *Culicoides* s. str. We are greatly indebted to Alan L. Dyce for his advice leading us to this conclusion.

Culicoides andrewsi Causey
(Figs. 83, 250, 397)

Culicoides andrewsi Causey, 1938: 410 (male; Thailand; fig. wing, genitalia).

Female.--Unknown.

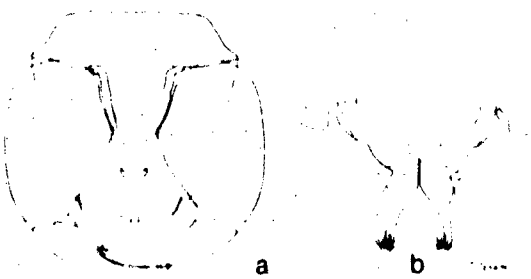


Fig. 83. *Culicoides andrewsi*: a. male genitalia, parameres omitted; b. parameres.

Male.--Wing length 0.90 mm.

Head: Not examined.

Thorax: Brownish; mesonotum with indistinct yellowish brown pattern as seen in slide-mounted specimens. Legs pale brown, without distinct markings; hindtibial comb with 4 spines, the one nearest the spur longest.

Wing (fig. 250, 397): Pattern as figured, not very distinct, with small round pale spots; base of wing with indistinct pale area; pale area over r-m crossvein broadly meeting costal margin, extending caudally to media; poststigmatic pale spot in cell R5 angular, proximal part covering most of second radial cell, extending distally a short way on anterior margin of cell R5, its rounded posterior corner not reaching vein M1; distal pale spot in cell R5 transverse, placed at right angles to axis of cell, posteriorly not reaching vein M1, reaching wing margin anteriorly with reduced intensity; midportion of vein M2 embraced by a pair of oval pale spots with a dark line along vein between them; distal pale spots in cells M1 and M2 small and round, located distant from wing margin; small round pale spot located at wing margin in cell M4; an indistinct pale area between medial and mediocubital

forks in cell M2; anal cell with two small round pale spots in distal portion; tips of veins dark. Macrotrichia not evident; costal ratio 0.64; first radial cell indistinct, possibly slitlike, second with narrow lumen, tapering to tip. Halter pale.

Abdomen: Pale brown. Genitalia (fig. 83g): Ninth sternum with shallow caudomedian excavation; ninth tergum rounded caudad, without apicolateral processes, a contiguous pair of small submedian lobes on caudal margin. Basistyle unusually stout, mesal side with dense dark spinules; dististyle curved, tip slender with distinct point. Aedeagus of quite unusual form; basal arch high and narrow, extending to nearly half of total length, basal arms slightly curved and quite strong, the strong sclerotization continued as a pair of ventrally curved, blunt hooks at base of distal process, the latter short with bluntly rounded tip. Parameres (fig. 83b) joined narrowly at bases by a strong sclerotization forming the archlike anterior margin of the basal arms; latter well developed, directed anterolaterally; main body of each paramere stout, short, distal portion tapering to moderately slender distal process curving ventrad and ending in a number of well developed, apical fringing hairs.

Distribution.--Thailand.

Type.--Lectotype male (here designated). Chiang Rai, Thailand, 1932, O.R. Causey (Type in USNM). The type slide is mounted in chloral-gum media which has deteriorated until only the wing and male genitalia are visible for study. Redescribed from a specimen from Khon Kaen Province.

Southeast Asia Records.--
THAILAND: Chiang Rai (Causey, 2 male syntypes). Khon Kaen Prov., Amphoe Choom Pae, 25.v.1959, Manop R., light trap, 1 male.

Discussion.--*Culicoides andrewsi* is easily distinguished from *sumatrae* and related species by the peculiar male genitalia, the pale color, and reduced wing markings. No females have been discovered which can definitely be matched with the male specimens. *Culicoides lungchiensis* Chen and Tsai (1962) from China and the Ryukyu Islands has a similar male aedeagus, but is a darker species without definite palpal pit, the basal arch of the male aedeagus is lower and the parameres have less hairy tips. A good description of *lungchiensis* was given under the name of *megaforticeps* by Kitaoka (1973), who later (1977) synonymized the two species.

Culicoides brinchangensis Wirth and Hubert, new species
(Figs. 84, 251, 398)

Female.--Wing length 1.63 mm.

Head: Eyes (fig. 84c) contiguous a short distance, bare. Antenna (fig. 84a) with lengths of flagellar segments in proportion of 36-30-33-35-35-35-35-37-50-54-60-63-90, antennal ratio 1.15; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 84b) with lengths of segments in proportion of 15-40-60-25-31; second segment moderately stout; third segment moderately swollen at base,

abruptly narrowed just past midlength with a moderately large, round, shallow, sensory pit at base of constriction; palpal ratio 3.2. Proboscis moderately long, P/H Ratio 0.87; mandible with 19 teeth.

Thorax: Dark brown; mesonotum without prominent pattern as seen in slide-mounted specimens. Legs (fig. 84f) dark brown; knee spots blackish on fore- and hindlegs; knees yellowish on each side on midleg; fore- and hindtibia with basal pale ring, hindtibia with apex pale; hindtibial comb (fig. 84d) with 6 spines, second from the spur longest.

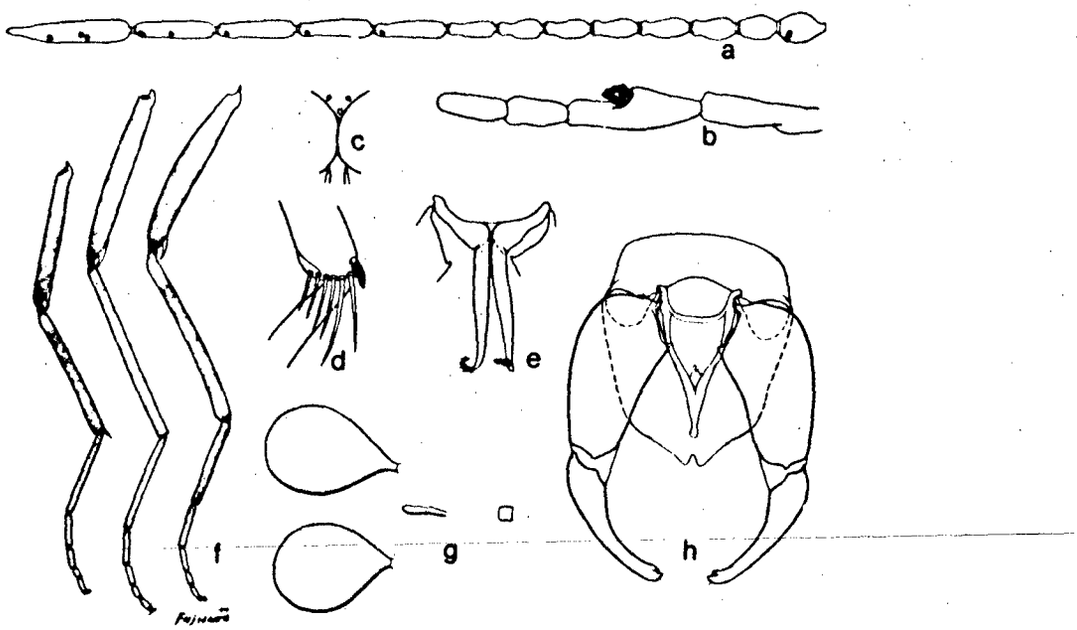


Fig. 84. *Culicoides brinchangensis*: a. antenna; b. palpus; c. eye separation; d. tibial comb; e. parameres; f. legs; g. spermathecae; h. male genitalia, parameres omitted.

Wing (fig. 251, 398): Pattern as figured; wing dark brownish with pale markings small and faint, veins more deeply infuscated; faint pale area over basal arculus; small pale spot over r-m crossvein, very faintly continued to costal margin in a broader pale area; small quadrate pale spot lying over distal 0.6 of second radial cell and extending a short way along anterior margin of cell R5, extending caudad in cell R5 about 0.6 way to vein M1; cell R5 with a small, transversely oval pale spot in distal portion, not meeting anterior wing margin or vein M1; subapical pale spots in cells M1 and M2 faint and small, not appearing to straddle vein M2; distal

pale spots in cells M1 and M2 small and faint, lying distant from wing margin; a very faint pale area in cell M2 between medial and mediocubital forks; cell M4 with small, round, faint pale spot in distal portion near wing margin; anal cell with faint pale area at base and a small distal pale spot; apices of veins dark. Macrotrichia very sparse on distal fourth of wing, lying mostly on the veins; costal ratio 0.68; first radial cell narrow, second with broad lumen. Halter pale.

Abdomen: Dark brown. Spermathecae (fig. 84g) ovoid, tapering to short slender necks; slightly unequal, 0.062 x 0.043 mm and 0.055 x 0.041 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 84h): Ninth sternum with shallow caudomedian excavation; ninth tergum rounded caudad, apicolateral processes absent, a pair of small, acute, submedian lobes present on caudal margin. Basistyle with very fine spinules on mesal surface; dististyle slightly curving, apex slender with distinct distal tooth. Aedeagus moderately broad at base, basal arch extending to about a fifth of total length, with heavily sclerotized anterior margin, sides slightly convex, tapering to slender distal process with distinct spherical tip; a well-sclerotized internal peg present. Parameres (fig. 84e) separate; each with short, moderately stout anterolateral arm; stem slender at base, tapering distally and gradually curving ventrad, ending in a distal filament with distinct fringing apical hairs.

Distribution.--Indonesia, Malaysia.

Types.--Holotype female, allotype male, Mt. Brinchang, 1,600 m, Pahang, Malaysia, iii.1963, H.E. McClure, light trap (Type in USNM). Paratypes, 12 males, 40 females, same data as types; 1 female, same data but collected 8.i.1959, L.W. Quate.

Other Material Examined.--
INDONESIA: West Java, Ciloto, at river side of Cikundul, 11.x.1980, Wiwiek coll., biting man, 2 females.

Discussion.--*Culicoides brinchangensis* is the largest, darkest, and most faintly marked of all the Oriental species of the subgenus *Hoffmania*. This modification is in line with the ecological rules which postulate in general that animals will appear larger and darker in the cooler and more humid parts of their general range.

Culicoides bubalus Delfinado
(Figs. 85, 252, 399)

Culicoides bubalus Delfinado, 1961: 658 (female; Philippines; figs.).

Female.--Wing length 1.13 (0.96-1.24, n = 8) mm.

Head: Eyes (fig. 85d) contiguous for a short distance, bare. Antenna (fig. 85a) with lengths of flagellar segments in proportion of 22-20-22-24-23-23-24-25-35-35-41-39-57, antennal ratio 1.19 (1.09-1.29, n = 8); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 85b) with lengths of segments in proportion of 13-25-35-18-20; second segment distinctly swollen; third segment swollen

basally, narrow distally, with large, round, shallow pit at base of narrow portion; palpal ratio 3.2 (2.8-3.5, n = 8). Proboscis moderately short, P/H Ratio 0.69; mandible with 18 (17-23, n = 14) teeth.

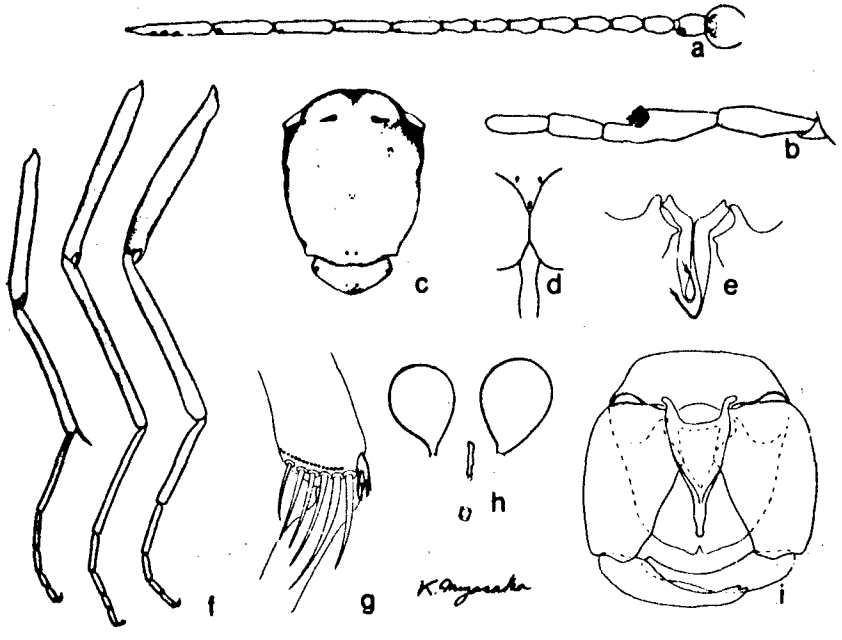


Fig. 85. *Culicoides bubalus*: a. antenna; b. palpus; c. thoracic pattern; d. eye separation; e. parameres; f. legs; g. tibial comb; h. spermathecae; i. male genitalia, paramer .s omitted.

Thorax: Dark brown, mesonotum with gray pollinosity and 2 dark brown sublateral vittae (fig. 85c). Legs (fig. 85f) dark brown; midknees narrowly yellow on each side of joint, foretibia with basal and hindtibia with basal and apical, narrow pale rings; hindtibial comb (fig. 85g) with 6 spines (rarely 5), second from spur longest.

Wing (fig. 252, 399): Pattern as figured; dark with extensive pattern of distinct large pale spots; anterior margin with 3 very dark areas, the third one very narrow, transverse; base of wing pale nearly halfway to r-m crossvein but extreme anal angle dark; pale spot over r-m crossvein large, but greatly narrowed at costal margin, narrowly connected over media to pale streak running through proximal half of cell M2 to the large double spot filling area between medial and mediocubital forks; poststigmatic pale spot in cell R5 covering distal third of second radial cell, slightly indented proximally by dark area on vein R4+5, broadened pos-

teriorly in cell R5 behind second radial cell, meeting vein M1 and usually extending posteriorly across the vein and joining the large double pale spot straddling vein M2 at midlength; large pale spot distally in cell R5 usually meeting wing margin; large pale spot distally in cell M1 quite distant from wing margin; cell M2 with pale spot at wing margin; large distal pale spot in cell M4 broadening anteriorly and usually following vein M3+4 as a pale line to base of mediocubital fork and sometimes slightly along vein Cu1; two separate round pale spots in distal portion of anal cell; pale area present at wing margin at tip of vein M1. Macrotrichia sparse on distal third of wing; costal ratio 0.69 (0.67-0.70, n = 8); two radial cells, the first narrow, second very long and moderately broad. Halter dark brown.

Abdomen: Dark brown. Spermathecae (fig. 85h) ovoid, distinctly tapering to long slender necks; slightly unequal, 0.058 x 0.042 mm and 0.056 x 0.040 mm.

Male.--Similar to female, with usual sexual differences. Genitalia (fig. 85g,i) identical with those of *C. sumatrae* Macfie.

Distribution.--Indonesia, Malaysia, Philippines, Sabah, Sarawak, Thailand, Vietnam.

Types.--Holotype female, Philippines, Mindanao, Cotabato Prov., Kidapawan, viii.1956, in carabao-baited trap, F. Kalaw (Type in USNM).

Southeast Asia Records.--

INDONESIA: Flores, Manggarai, Reo, Robek, Gincu and Golok (Lee). South Kalimantan, Banjar, Astambul, Tanah Intan, Batu Putih and Pulo Tiga (Lee). Sumatra, Lampung, Kotabumi, Way Abung III (Lee); Batam Island, Sungai Beduk (Sustriayu).

MALAYSIA: Kelantan, Ulu Kelantan, Lambok, Sungei Betis (Wharton). Pahang, King George V Nat. Park, Tahan River (McClure). Selangor, Kepong (Quate); Ulu Gombak Forest Res. (Soosai). Trengganu, Dungun, Bukit Besi (Traub).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Mindanao, Agusan, Esperanza (Yoshimoto); Los Arcos (Quate); Cotabato, Kidapawan (Kalaw, type); Milbuk (Milliron); 10 km SE San Francisco (Quate). Negros Oriental, Cuernos de Negros, Camp Lookout (Delfinado). Palawan, Tarumpitas Pt. (Quate). Tawi Tawi, Tarawakan (Noona Dan Exped.). Zamboanga del Norte, Manucan, Labaun Mts., 650 m (Quate).

SABAH: Tawau Dist., Kalabakan (Maa, Quate).

SARAWAK: Limbang (Colless).

THAILAND: Chiang Mai Prov., Ban Tin Doi (Gressitt). Loei Prov., Amphoe Dan Sai, Ban Na Muang (Elbel). Nakronrajasrima Prov., A. Meung, A. Pakchong (Manop R.).

VIETNAM: Dak Song, Ban Me Thuot (Quate).

Discussion.--This species is distinguished by the shape of the pale marking in cell M4, in which the round pale spot in the distal part of the cell reaches vein M3+4 and continues narrowly along the posterior margin of this vein to the base of the mediocubital fork where it expands in a pale area which sometimes follows

vein Cu1 partway to wing margin. The dark halter would confuse this species with *innoxius* Sen and Das Gupta and *lansangensis* Howarth, but those species lack the proximal extension of the pale spot in cell M4.

Culicoides cameronensis Kitaoka
(fig. 86)

Culicoides cameronensis Kitaoka, 1983: 20 (female; Malaysia; fig. wings, antenna, palpus, spermatheca).

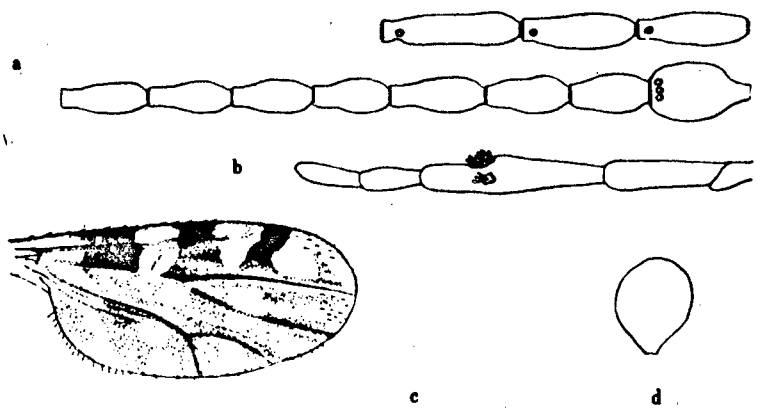


Fig. 86. *Culicoides cameronensis*: a. antenna; b. palpus; c. wing; d. spermathecae.

Diagnosis.--Female only (figures from Kitaoka 1983). Wing (fig. 86c) length 1.24 mm; costal ratio 0.69. A member of the subgenus *Hoffmania*, closely related to *C. innoxius* Sen and Das Gupta, *C. klossi* Edwards, and *C. cylindratus* Kitaoka, distinguished by the presence of a double sensory pit on the third palpal segment (fig. 86b) rather than scattered sensilla. Eyes contiguous for 2 facets. Antenna (fig. 86a) damaged. Palpal ratio 4.2. Proboscis long, P/H Ratio 1.0; mandible with 20 teeth. Thorax brownish, mesonotum with dark brown vittae. Legs brownish, fore- and midfemora at apex and fore- and midtibiae at base pale; base and apex of hindtibia pale; hindtibial comb with 6 spines, second from spur longest. Spermathecae (fig. 86d) 1, 0.097 x 0.082 mm, second possibly missing.

Type.--Holotype female, Cameron Highlands, Perak, 7.i.1978, S. Kitaoka (deposited in National Science Museum, Tokyo, Japan).

Culicoides carpophilus Wirth and Hubert, new species
(Figs. 87, 253, 400)

Female.--Wing length 1.09 mm.

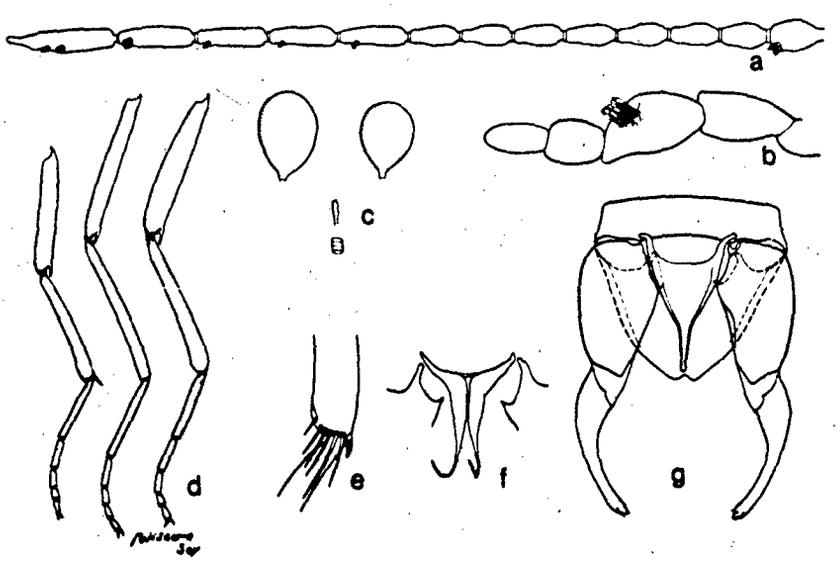


Fig. 87. *Culicoides carpophilus*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 87a) with lengths of flagellar segments in proportion of 14-12-14-14-14-14-14-14-17-18-18-18-27, antennal ratio 0.90; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 87b) with lengths of segments in proportion of 6-10-10-5-6; third segment short, with small, round, shallow sensory pit near apex; papal ratio 1.7. Proboscis very short, P/H Ratio 0.54; mandible with teeth vestigial.

Thorax: Brown, mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 87d) brown, knee spot blackish on foreleg, knee yellowish on midleg; tibiae with basal pale rings, hindtibia with apical pale band; hindtibial comb (fig. 87e) with 5-6 spines, second from the spur longest.

Wing (fig. 253, 400): Pattern as figured, generally dark with definite pale spots; pale spot over r-m crossvein small and round, separated from anterior pale area on costal margin by a dark line near radius and barely touching vein M1 posteriorly; poststigmatic pale spot quadrate, covering distal 0.6 of second radial cell but extending posteriorly only two-thirds way from costa to vein M1; small round pale spot in distal part of cell R5, well removed from anterior and distal wing margins and from vein M1; cell M1 with an oval pale spot well removed from wing

margin; vein M2 with a double pale spot straddling vein just proximad of mid-length; cell M2 with a large double pale spot between medial and mediocubital forks and with an oval pale spot very near wing margin; cell M4 with a round pale spot touching wing margin in distal half of cell; anal cell with an anterior round pale spot lying near apex of anal vein and two round pale spots at wing margin, one proximally and other distally in cell; apices of veins dark. Macrotrichia sparse on distal fourth of wing; costal ratio 0.69; radial cells well developed, second one unusually long, first slit-like, second with distinct lumen. Halter pale.

Abdomen: Brown. Spermathecae (fig. 87c) ovoid, tapering to short sclerotized necks; unequal, 0.056 x 0.040 mm and 0.048 x 0.032 mm.

Male.--Similar to female, with usual sexual differences. Genitalia (fig. 87g): Ninth sternum without caudomedian excavation, ventral membrane not spiculate; ninth tergum rounded caudad, without apicolateral processes and with very small median notch. Basistyle with ventral and dorsal roots small; dististyle slightly curved and tapering to sharp distal point. Aedeagus with low rounded basal arch extending to 0.20 of total length, basal arms short; main body moderately broad at base, sides moderately convex, distal process long and slender with rounded tip; a very faint, slender, internal sclerotized process present. Parameres (fig. 87f) each with short tapering basal arm, midportion moderately swollen, tapering distally to slender filament directed ventrocephalad, with minute fringing hairs near tip.

Distribution.--Malaysia.

Types.--Holotype female, allotype male, Subang Forest Reserve, Kuala Lumpur, Selangor, Malaysia, 29.iii.1962, C. Manikumar, reared from decaying wild fruit (Type in USNM). Paratypes, 5 males, 7 females, same data as type.

Discussion.--*Culicoides carpophilus* has a wing pattern similar to that of *C. jacobsoni* Macfie, which was reared from the same habitat. *Culicoides carpophilus* can be readily distinguished by its vestigial mouthparts, short palpi, longer antennae and longer second radial cell in the female, and by the rounded ninth tergum, non-excavated ninth sternum and bare tip of aedeagus in the male genitalia.

Culicoides cheahi Kitaoka
(Fig. 88)

Culicoides cheahi Kiaoka, 1983: 18 (female; Malaysia; figs.)

Diagnosis.--Female only (figures from Kitaoka 1983). Wing length 1.11 mm; costal ratio 0.67. A member of the subgenus *Hoffmania*, distinguished by the presence of separated poststigmatic pale wing spots (fig. 88c) and by the slender third palpal segment with scattered sensilla (fig. 88b). Eyes contiguous for 2.5 facets. Antennal ratio 1.20; sensillar pattern 3,11-15 (fig. 88a). Palpal ratio 5.7; sensilla scattered on entire surface of third segment. Proboscis long, P/H Ratio 0.90; mandible with 20 teeth. Thorax dark brown; mesonotum with median vitta

and pair of sublateral brown vittae. Legs brownish, distal third of fore- and mid-femora pale, all tibiae with basal pale bands; apex of hindtibia pale; hindtibial comb with 5 spines, second from spur longest. Spermathecae (fig. 88d) subequal, each 0.052 x 0.042 mm.

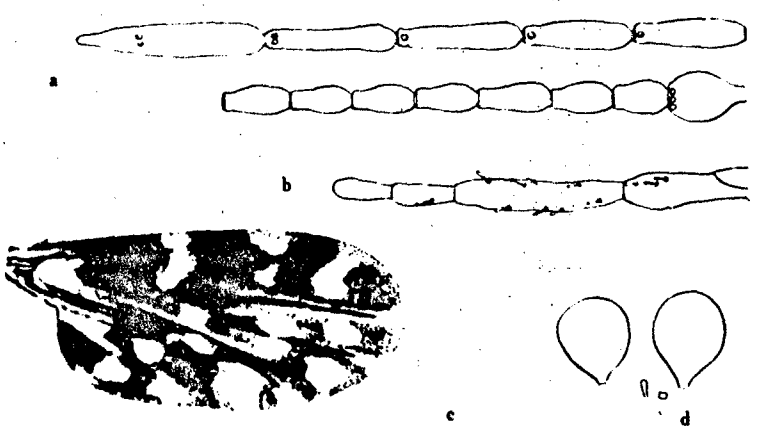


Fig. 88. *Culicoides cheahi*: a. antenna; b. palpus; c. wing; d. spermathecae.

Type.--Holotype female, Tanjong Rambutan, Perak, Malaysia, 27.ii.1980, S Kitaoka (deposited in National Science Museum, Tokyo, Japan).

Culicoides divisus Wirth and Hubert, new species
(Figs. 89, 254, 401)

Female.--Wing length 1.19 (1.14-1.26, n = 7) mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 89a) with lengths of flagellar segments in proportion of 23-17-20-21-22-21-20-22-33-33-36-39-54, antennal ratio 1.25 (1.17-1.29, n = 7); sensilla coeloconica present on segments 3,11-15. Palpal segments (fig. 89b) with lengths in proportion of 11-25-40-16-16; second segment slightly thickened; third segment moderately swollen, spindle-shaped, with sensilla scattered on distal half; palpal ratio 3.5 (3.2-3.9, n = 7). Proboscis moderately short, P/H Ratio 0.75; mandible with 15 (1 -17, n = 11) teeth.

Thorax: Dark brown; mesonotal pattern not evident. Legs (fig. 89c) brown; midknees narrowly yellowish, narrow yellow bands at base and apex of hindtibia; hindtibial comb (fig. 89d) with 5 (n = 7) spines, second from spur longest.

Wing (fig. 254, 401): Pattern as figured; 3 broad, very dark spots along anterior margin; base of wing pale for half the distance to r-m crossvein; pale spot over r-m crossvein moderately large, extending from costal margin into cell M2 and continuous there with pale streak from behind medial fork to basal pale area of wing; pale spot over second radial cell extending only halfway across cell R5 caudad, completely bisected by a narrow dark line along vein R4+5 which is con-

tinued into distal dark spot; distal pale spot in cell R5 emarginate distally, not extending anteriorly to wing margin; pale spot straddling midportion of vein M2 small, divided by dark line along vein; distal pale spots in cells M1 and M2 small and rounded, lying distant from wing margin; small pale spot lying immediately in front of mediocubital fork; cell M4 with a small round pale spot lying in middle of distal portion, not meeting wing margin, a separate pale spot at base of cell lying in mediocubital fork; anal cell with 2 small round pale spots in distal portion; apices of veins M1, M2, and M3+4 pale at wing margin. Macrotrichia sparse on distal fourth of wing; costal ratio 0.69 (0.67-0.70, n = 7); radial cells narrow, with distinct lumens, the second broader. Halter pale brownish.

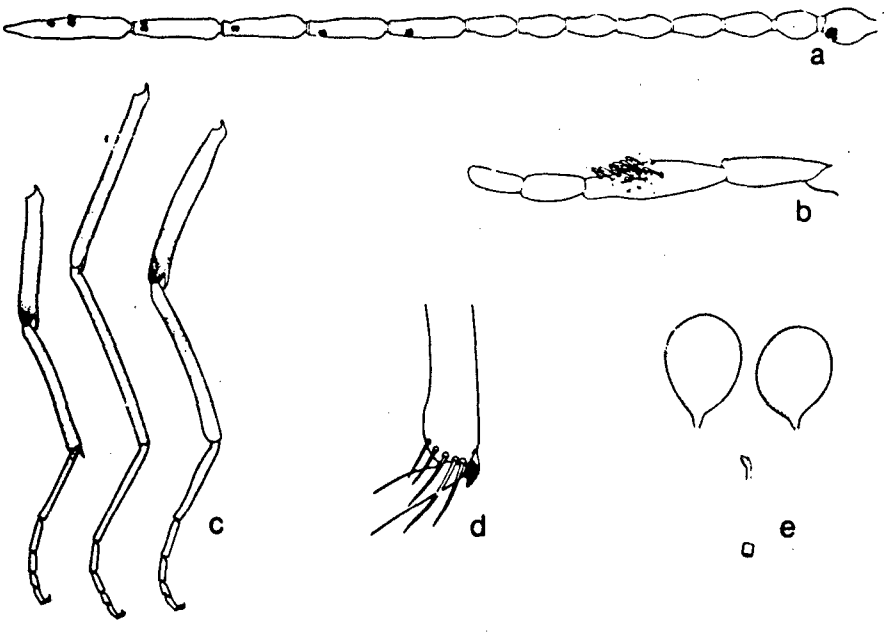


Fig. 89. *Culicoides divisus*: a. antenna; b. palpus; c. legs; d. tibial comb; e. spermathecae.

Abdomen: Dark brown. Spermathecae (fig. 89e) ovoid, tapering to short slender necks; subequal, each 0.053 x 0.039 mm.

Male.--Unknown.

Distribution.--Malaysia, Philippines, Sabah.

Types.--Holotype female, Rantau Panjang, 8 km N Klang, Selangor, Malaysia, 26.xii.1958, L.W. Quate (in B.P. Bishop Museum, Honolulu). Paratypes, 14 females, as follows:

MALAYSIA: Negri Sembilan, K. Pilah, Pekan Lama, v.1967, R. Garcia, 1 female. Perak, Pulau Pangkor, 1.iv.1959, R. Traub, light trap, 1 female.

PHILIPPINES: Basbas I., iv.1967, M. Delfinado, 2 females. Luzon, Tala, Rizal, 25.x.1955, J. Santos, 1 female; 3.xii.1955, F. Dantis, 1 female. Palawan, 12.i.1960, L.W. Quate, at light, 1 female. Samar, 26.xi.1955, I. Balatbat, 1 female. Tawi Tawi, Lapid Lapid at Manalik Channel, 19.xi.1961, at light, Noona Dan Exped., 3 females.

SABAH: Lauan Island, ix-x.1948, iv.1950, D.H. Colless, at light, 5 females.

Discussion.--*Culicoides divisus* resembles *C. insignipennis* Macfie in the division of the poststigmatic pale spot by a dark line extending along the axis of vein R4+5, but lacks the dark r-m crossvein and the pale spot at the base of the mediocubital fork extends also along vein Cu1. The third palpal segment with scattered sensilla resembles that of *C. effusus* Delfinado, but that species has much paler wing markings without the dark line in the poststigmatic pale spot.

Culicoides effusus Delfinado
(Figs. 90, 255, 402)

Culicoides effusus Delfinado, 1961: 658 (female; Philippines; figs.).

Female.--Wing length 1.15 (1.04-1.31, n = 9) mm.

Head: Eyes contiguous, bare. Antenna (fig. 90a) with lengths of flagellar segments in proportion of 21-17-18-19-19-20-20-21-26-27-30-35-46, antennal ratio 1.07 (1.04-1.11, n = 6); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 90b) with lengths of segments in proportion of 11-21-28-13-14; second segment slightly thickened; third segment moderately swollen, short, with sensilla scattered on distal half; palpal ratio 2.6 (2.4-2.8, n = 9). Proboscis short, P/H Ratio 0.62; mandible with 13 (13-14, n = 14) teeth.

Thorax: Dark brown; mesonotum grayish pruinose with a sublateral pair of broad blackish vittae (fig. 90c). Legs (fig. 90e) brown; midknees narrowly pale; narrow pale rings at base and apex of hindtibia; tarsi pale; hindtibial comb (fig. 90d) with 5 (n = 9) spines, second from spur longest.

Wing (fig. 255, 402): Pattern as figured; 3 very dark anterior areas; general pattern of extensive large rounded pale spots on dark field; base of wing pale halfway to r-m crossvein; pale spot over r-m crossvein large, extending broadly to costa, narrowed posteriorly and continuous in cell M2 with pale base of wing; pale spot over second radial cell large, rounded behind, not penetrated by a dark line at vein R4+5; distal pale spot in cell R5 crescent-shaped, concave distally, with broader extension to anterior wing margin; double pale spot straddling midportion of vein M2, penetrated by a dark line along vein; distal pale spots in cells M1 and M2 rounded, well removed from wing margin; cell M2 with pale streak behind medial fork continuous with pale spot lying immediately in front of mediocubital fork; cell M4 with a distal round pale spot lying at wing margin and a large pale spot filling entire base of cell in mediocubital fork; anal cell with 2 large separate

pale spots in distal portion; tips of veins M1 and M2 pale at wing margin. Macrotrichia sparse on distal fourth of wing; costal ratio 0.68 (0.65-0.71, n = 9); radial cells narrow, both with distinct lumen. Halter brownish.

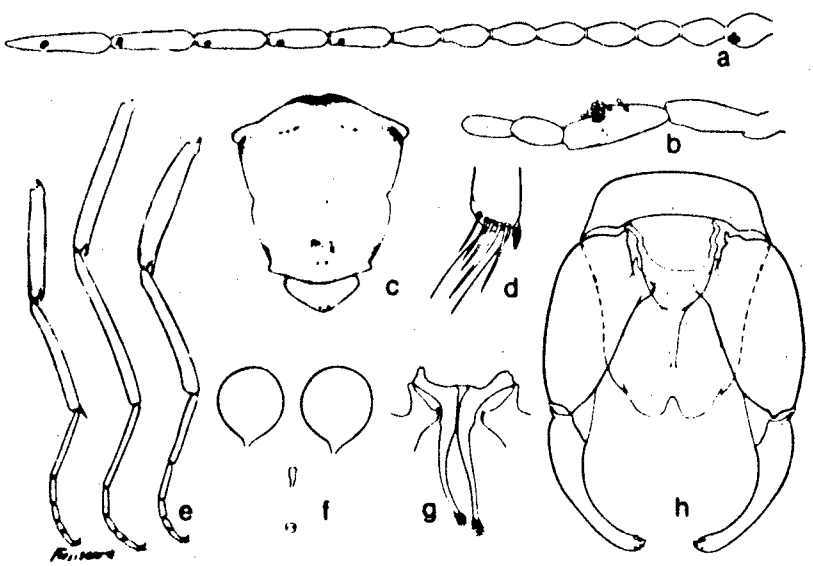


Fig. 90. *Culicoides effusus*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Abdomen: Dark brown. Spermathecae (fig. 90f) ovoid, slightly tapering to very short, slender necks; slightly unequal, 0.056 x 0.040 mm and 0.050 x 0.037 mm.

Male.--Similar to female, with usual sexual differences. Genitalia (fig. 90h): Ninth sternum narrow, without caudomedian excavation, ventral membrane bare; ninth tergum rounded caudad, with slight caudomedian cleft, two well developed submedian secondary lobes, apicolateral processes short. Basistyle moderately stout, with numerous fine mesal spinules, ventral and dorsal roots short; dististyle curved, slender in midportion, with round distal expansion bearing a minute apical tooth. Aedeagus with high rounded basal arch reaching a third of total length, basal arms very slender, no transverse basal sclerotization; main body with rounded shoulders, distal process tapering on proximal portion, very slender distally with small spherical tip. Parameres (fig. 90g) separate, each with short an-

terolateral basal arm, small anteromesal tooth; stem slender, gradually tapering to moderately slender, ventrally curved, distal blades with numerous fine apical fringing hairs.

Distribution.--Indonesia, Philippines.

Types.--Holotype female, Eastern slope of Mt. McKinley, Mindanao, Philippines, 1,000 m, 25.ix.1946, F.G. Werner, at light (deposited in Field Museum of Natural History).

Southeast Asia Records.--

INDONESIA: Bali, Badung, Denpasar, Tuban, Kampung Bugis (Lee); Badung, Kuta, Jimbaran Carik (Lee). Flores, Manggarai, Nangalili, Joneng Area (Lee); Manggarai, Nunang Mission on Lake Sano (Lee); Manggarai, Reo, Golok (Lee). Java (Central), Cilacap, Adipala, Karang Sari (Lee); Adipala, Silangsur Lor (Lee). Lombok (East), Selong, Bagik Payung (Lee). Sulawesi (Central), Banggai, Batui, Kamiwangi (Bambang); (North), Dumoga-Bone Nat. Park, 220 m (Heppner); Lake Mooat, 20 km NE Kotamogagu, 1,050 m (Heppner); (Southeast), Kendari, Unaha (Bambang). Timor (East), Dilli, Bidou (Soeroto); Dilli, Comoro, Kampung Marinir (Soeroto).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Pampanga Prov., Angeles, Clark Air Base, carabao-baited trap (Balatbat); Misamis Oriental, Mt. Empagatao (Torrevillas). Mindanao, Agusan, Esperanza (Yoshimoto); Agusan, Los Arcos (Quate); Davao, Mt. Apo School, 500 m (Davis); Lake Lanao, near Dansalan (Milliron); Mt. McKinley (Werner, types); Cotabato Prov., Kidapawan, carabao baited trap (Kalaw); Davao, Maco, Tagum (Hoogstraal, Heyneman, Puhawan); San Francisco (Quate); Suriago, Lake Mainit (Yoshimoto); Todaya, E slope Mt. Apo, 840 m (Hoostraal). Negros Oriental, Dumaguete (Quate); Lake Balinsasayo (Quate). Palawan, Brookes Point, Makagwa (Noona Dan Exped.); Kukukan, 19 km S Tarumpitao (Quate); Ransang River (Quate). Samar, Taft (Balatbat). Tawi Tawi, Tarawakan (Noona Dan Exped.).

Discussion.--This species can be distinguished by the extensive pale wing markings, with base of mediocubital fork pale, r-m crossvein not infuscated, and the pale spot at the end of the costa not penetrated by a dark line along vein R4+5; the scattered sensilla on the third palpal segment are also diagnostic.

Culicoides quadratus Tokunaga from Java and *novaguineanus* Tokunaga from New Guinea resemble *effusus* in wing markings, but both have a round sensory pit on the third palpal segment; moreover *novaguineanus* has only the tip of vein M1 pale at the wing margin.

Culicoides hirtipennis Delfinado
(Figs. 91, 256, 403)

Culicoides hirtipennis Delfinado, 1961: 662 (male, female; Philippines; figs.).

Female.--Wing length 0.87 (0.78-0.96, n = 10) mm.

Head: Eyes broadly separated (fig. 91d), bare. Antenna (fig. 91a) with lengths of flagellar segments in proportion of 16-12-15-16-17-16-16-17-22-23-25-27-40, antennal ratio 1.08 (1.02-1.14, n = 10); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 91b) with lengths of segments in proportion of 8-17-22-12-13; second segment stout, stouter than third; third segment without definite pit but an irregular area of sensilla distally, slightly narrowed distad from sensory area; palpal ratio 2.8 (2.5-3 2, n = 9). Proboscis short, P/H Ratio 0.70; mandible with 13 (11-15, n = 17) teeth.

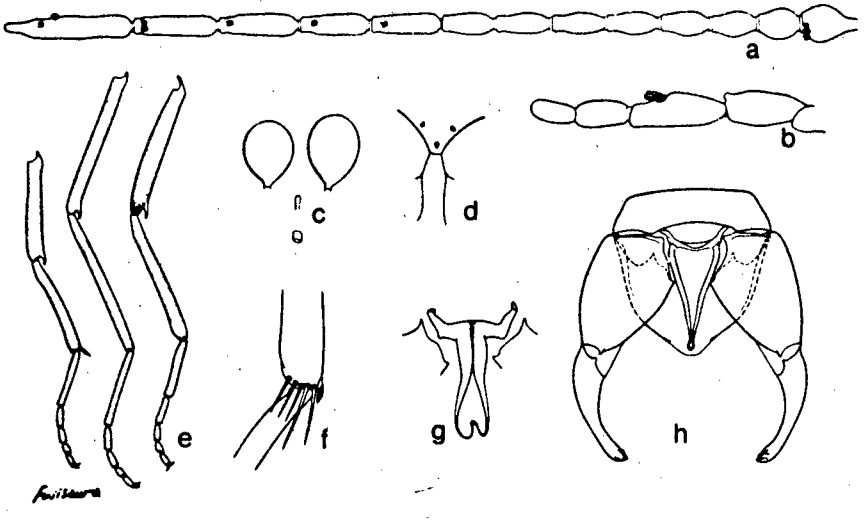


Fig. 91. *Culicoides hirtipennis*: a. antenna; b. palpus; c. spermathecae; d. eye separation; e. legs; f. tibial comb; g. parameres; h. male genitalia, parameres omitted.

Thorax: Dark brown, mesonotal pattern not evident. Legs (fig. 91e) brown; narrow apices of fore- and midfemora, bases of all tibiae, and narrow apex of hindtibia yellowish; four distal tarsomeres pale; hindtibial comb (fig. 91f) with 5 (n = 10) spines, second from spur longest.

Wing (fig. 256, 403): Pattern as figured; pale markings moderately distinct, well separated, and not very extensive; pale spot present over basal arculus; pale spot over r-m crossvein usually separated by dark line along radius from pale spot on costal margin; poststigmatic pale spot small, much narrower than the very dark spots on each side along anterior wing margin; distal pale spot in cell R5 small, usually not meeting anterior wing margin; a double pale spot in cell M2 lying just behind medial fork and just ahead of mediocubital fork; a double pale spot straddling vein M2 just proximad of midlength, but the vein forming a dark line running through the spot; cell M1 with an oval distal pale spot well removed from wing

margin; cell M2 with one distal pale spot lying at wing margin; cell M4 with a large pale spot nearly filling distal half of cell but not touching vein M3+4 or filling extreme apex of cell; anal cell with base sometimes faintly paler, 2 separate distinct pale spots in distal portion; a faint pale area at wing tip, apices of veins M2, M3+4 and Cu1 dark. Macrotrichia confined to a few along anterodistal margin of cell R5 and in lines bordering distal third of veins M1 and M2 and at extreme wing tip in cells M1 and M2; costal ratio 0.63 (0.60-0.66, n = 10); radial cells well developed, the second considerably broader. Halter faintly brownish.

Abdomen: Dark brown. Spermathecae (fig. 91c) slightly ovoid with short sclerotized necks; slightly unequal, 0.055 x 0.037 mm and 0.050 x 0.035 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 91h): Ninth sternum with broad shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum rounded caudally with well-developed, thinly sclerotized, median lobe, the apicolateral processes absent. Basistyle stout with moderately dense, moderately stout, mesal setae, ventral and dorsal roots poorly developed; dististyle slender, slightly curved to bluntly pointed apex. Aedeagus narrow, breadth at base 0.4 times total length; basal arch low, with a sclerotized anterior rim across base of arch, no internal sclerotized peg distally, apex slender with spherical tip. Parameres (fig. 91g) separate; each with short, curved, tapering basal arm; midportion only slightly swollen; tapering distally to a recurved filamentous tip bearing a few minute fringing hairs.

Distribution.--Malaysia, Philippines, Sabah.

Types.--Holotype female, Burungkot, Upi, Cotabato, Minanao, Philippines, 450 m, 1-6.i.1947, netted along forest floor, F.G. Werner (deposited in Field Museum of Natural History).

Southeast Asia Records.--
MALAYSIA: Selangor, Ulu Gombak Forest Res. (Traub).
PHILIPPINES: Mindanao, Cotabato Prov., Burungkot (Werner, type series).
SABAH: Kinabatangan Dist., S end Dewhurst Bay (Inger and Davis). Tambunan, biting man (Colless).

Discussion.--*Culicoides hirtipennis* can be distinguished from all other Oriental species of the subgenus *Culicoides* except *recurvus* Delfinado by the broadly separated eyes. *Culicoides recurvus* differs in having the anal cell with distinct basal pale spot, the dark area along vein R4+5 penetrating into the poststigmatic pale spot, and the apex of vein M1 pale. The stout second palpal segment is similar to that of *C. peregrinus* Kieffer and *C. nipponensis* Tokunaga.

Culicoides indianus Macfie
(Figs. 92, 257, 404)

Culicoides indianus Macfie, 1932: 488 (female; India; fig. wing).

Female.--Wing length 1.05 (0.97-1.14, n = 9) mm.

Head: Eyes (fig. 92e) contiguous a short distance, bare. Antenna (fig. 92a) with lengths of flagellar segments in proportion of 21-17-19-20-20-19-20-22-28-27-29-34-45, antennal ratio 1.03 (0.93-1.15, n = 8); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 92b) with lengths of segments in proportion of 10-27-36-17-15; second segment as stout as third; third segment long and slender, cylindrical, with stalked sensilla scattered on surface, a few stalked sensilla also on segment 4 and distally on segment 2; palpal ratio 4.5 (4.0-5.0, n = 9). Proboscis moderately long, P/H Ratio 0.85; mandible with 18 (16-20, n = 9) teeth.

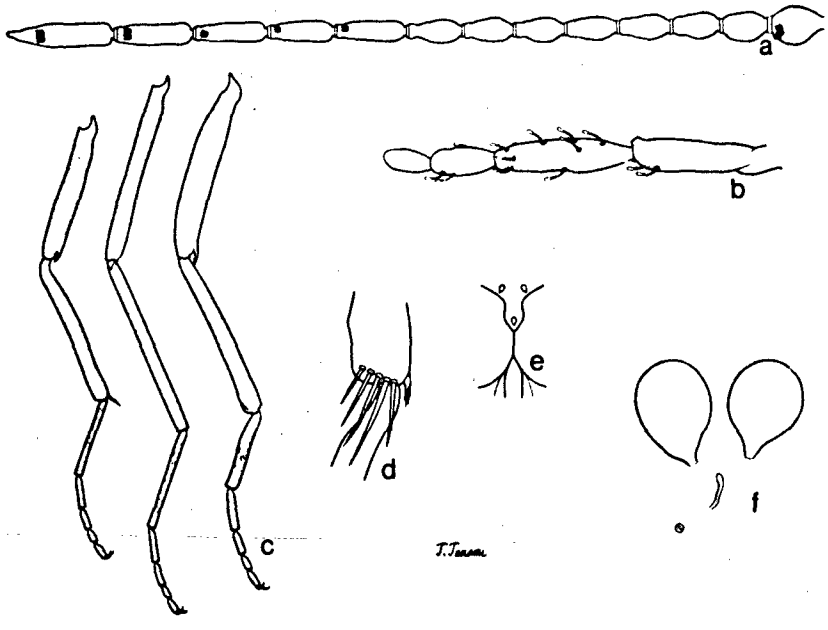


Fig. 92. *Culicoides indianus*: a. antenna; b. palpus; c. legs; d. tibial comb; e. eye separation; f. spermathecae.

Thorax: Dark brown, mesonotum without prominent pattern. Legs (fig. 92c) brown; midknees narrowly pale; hindtibia with basal and apical pale rings; hindtibial comb (fig. 92d) with 5 (n = 9) spines, second from spur longest.

Wing (fig. 257, 404): Pattern as figured; pale area over wing base extending a third way to r-m crossvein and into anterior portion of anal cell; 3 very dark brown areas on anterior margin, distal ones becoming narrower; pale spot lying over r-m crossvein slightly narrowed on costal margin, extending caudad into cell M2;

poststigmatic pale spot covering distal 0.5-0.7 of second radial cell and a narrow portion of cell R5 distal to it, produced angularly caudad but not reaching vein M1; distal pale spot in cell R5 round to irregular in shape, not meeting anterior wing margin or doing so only with reduced intensity; a moderately large pale spot straddling midportion of vein M2; distal pale spot in cell M1 oval, usually lying far from wing margin (nearly attaining wing margin in lectotype); distal pale spot in cell M2 broadly meeting wing margin; large pale spot lying between medial and mediocubital forks in cell M2; cell M4 with large round pale spot in distal portion; anal cell with 2 pale spots, in distal portion, sometimes narrowly connected, and a small pale area in anal angle narrowly connected to pale area at wing base; tips of veins M1, M2, and M3+4 each with a small pale spot at wing margin. Macrotrichia moderately numerous on distal half of wing; costal ratio 0.68 (0.66-0.70, n = 9); first radial cell narrow, second broad. Halter infuscated.

Abdomen: Dark brown, with rather long hairs; cerci pale. Spermathecae (fig. 92f) ovoid, tapering to short sclerotized necks; subequal, each 0.055 x 0.043 mm.

Male.--Unknown.

Distribution.--India, Malaysia, Sarawak, Thailand, Vietnam.

Types.--Syntypes, 5 females from India (no other data), and 3 females from Dharwar, Bombay Presidency, India (R. Newstead), in BMNH. Through the courtesy of Paul Freeman we have examined a slide on which are mounted 2 of the syntypes from Dharwar, and we hereby select the specimen with 1 wing appressed to the abdomen, allowing clear view of the other, as lectotype.

Southeast Asia Records.--

MALAYSIA: Johore, Kahang Kluang (Hubert). Kelantan, Ulu Kelantan, Lambok, Sungei Betis (Wharton). Pahang, Gunong Benom, biting man (Garcia); Kuantan, Paya Bungor (Wharton); Mt. Brinchang, 1,600 m (McClure); Telok Sisek, biting man (Wharton). Perak, Maxwell Hill, biting man (Traub); Gunong Besant Forest Res., biting man (Aru, Jeffery). Selangor, Ulu Gombak (Traub). Trengganu, Dungun, Bukit Besi (Traub).

SARAWAK: Limbang, biting man (Colless). Lg. Tebangan, Akah River, biting man (Colless).

THAILAND: Chiang Mai Prov., Doi Sutep (Thurman). Udonthani Prov., Amphoe Muang (Scanlon).

VIETNAM: Dak Song, 76 km SW Ban Me Thuot (Quate).

Discussion.--*Culicoides indianus* is closely related to *klossi* Edwards but can be distinguished by the dark apices of the fore- and hindfemora, dark halteres, smaller size, and less extensive pale wing markings. The numerous biting records indicate that it is by habit a bloodsucking pest of man.

Culicoides aterinervis Tokunaga from Japan and *C. cylindratus* Kitaoka from the Ryukyu Islands and Taiwan are also related, but can be distinguished by their pale halteres and swollen third palpal segment in *C. aterinervis*, and subapical pale band on the hindfemur in *C. cylindratus*.

Culicoides innoxius Sen and Das Gupta
(Figs. 93, 258, 405)

Culicoides innoxius Sen and Das Gupta 1959: 626 (male, female; India; figs.); Howarth, 1985: 57 (larval habitat; Laos records).

Female.--Wing length 1.09 (1.01-1.22, n = 10) mm.

Head: Eyes (fig. 93c) contiguous a short distance, bare. Antenna (fig. 93a) with lengths of flagellar segments in proportion of 17-15-17-18-19-19-20-22-27-28-33-35-50, antennal ratio 1.19 (1.09-1.27, n = 8); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 93b) with lengths of segments in proportion of 13-28-37-15-17; third segment short and spindle-shaped, with moderate size, round, shallow, sensory pit located distad of midlength; palpal ratio 2.9 (2.6-3.4, n = 10). Proboscis moderately long, P/H Ratio 0.82; mandible with 18 (16-20, n = 16) teeth.

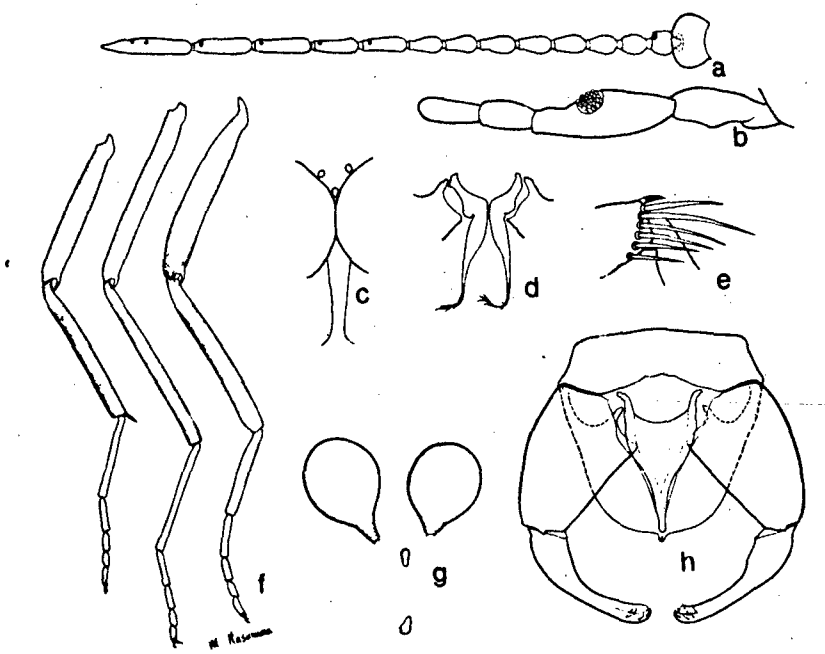


Fig. 93. *Culicoides innoxius*: a. antenna; b. palpus; c. eye separation; d. parameres; e. tibial comb; f. legs; g. spermathecae; h. male genitalia, parameres omitted.

Thorax: Dark brown; mesonotum dark reddish brown without conspicuous pattern. Legs (fig. 93f) dark brown; foretibia with narrow basal pale ring; midleg with knee, apex of femur and base of tibia narrowly pale; hindtibia with narrow base and apex pale; hindtibial comb (fig. 93e) with 6 (5-6, n = 11) spines, second from spur longest.

Wing (fig. 258, 405): Pattern as figured; nearly identical with that described for *C. sumatrae* Macfie but markings more diffuse; costal ratio 0.68 (0.66-0.71, n = 9). Halter infuscated.

Abdomen: Dark brown, cerci pale. Spermathecae (fig. 93g) ovoid with short sclerotized necks; slightly unequal, 0.056 x 0.041 mm and 0.052 x 0.038 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 93h): Ninth sternum with very shallow caudomedian excavation; ninth tergum rounded caudally without apparent apicolateral processes,the caudal margin with a small median lobe. Aedeagus with basal arch extending to a fifth of total length, base of arch without strongly sclerotized anterior rim, no internal sclerotized peg distally; distal portion slender with spherical tip. Parameres (fig. 93d) separate, each with moderately short and stout anterolateral arm; stem moderately stout, tapering gradually distally and curved ventrad, ending in a filamentous point with 5-6 minute fringing hairs.

Distribution.--Cambodia, India, Indonesia, Laos, Malaysia, Sabah, Sarawak, Sri Lanka, Thailand.

Types.--Holotype female, Calcutta, India, xi.1955, S.K. Das Gupta (Zoological Survey of India, Calcutta).

Southeast Asia Records.--

CAMBODIA: Phnom Penh (Delfinado).

INDONESIA: Bali, Badung, Mengwi (Lee); Badung, Pedungan (Lee). Flores, Manggarai, Nangalili, Pandeng, Wai Jamal (Lee); Manggarai, Wai Tuna (Lee). Java (Central), Cilicap, Adipala, Karang Sari (Lee); Yogyakarta, Kulon Progo (Lee); West Java, Pandeglang, Ujung Kulon (Watters). Lombok (East), Selong, Bagik Payung (Lee); (West), Mataram, Gerung, Dasan Geras (Lee); Cakra, Sayang (Lee). Sulawesi (North), Dumoga-Bone Nat. Park, 120 m (Heppner); (Southeast), Kendari, Unaha (Bambang). Sumatra (West), Sawahlunto, Tanjung Gadang, Sungai Tenang (Lee).

LAOS: Sayaboury Prov., Sayaboury, reared from tree wound (Howarth); 22 km S Muong Phieng (Howarth). Sedone Prov., Muong Pakse, sweeping over cow (Howarth). Vientiane Prov., Muong Ban Keun, Ban Na Pheng (Howarth); Muong Vang Vieng (Howarth); Vientiane, reared from rotting banana stem (Howarth).

MALAYSIA: Johore, Kahang Kluang (Hubert). Kelantan, Lambok, Sungei Betis, Ulu Kelantan (Wharton). Pahang, King George V Nat. Park, Tahan River (McClure); Kuala Tahan (Quate); Kuala Trengganu (Gressitt, Maa); Kuantan, Gudang Rasan (Traub); Kuantan Pekan Road, swamp forest (Wharton); Tasek Bera (Wharton). Selangor, Klang Gates (Quate); Kuala Lumpur, Ulu Gombak Forest Res. (Soosai); Ulu Langat (Garcia).

SABAH: Labuan Island (Colless). Ranau Dist., Paring (Quate). Tawau Dist., Kalabakan (Quate; Kuncheria); Quoin Hill, Cocoa Res. Sta. (Hirashima).

SARAWAK: Bau Dist., Pangkalan Tebang (collector unknown).

THAILAND: Chiang Mai Prov. (Notananda); Amphoe Muang (Scanlon). Chiang Rai Prov., A. Muang, Ban Kua Tae (Yasumatsu). Chelburi Prov., Bangphra (Scanlon). Loei Prov., A. Muang, A. Dan Sai (Elbel, Manop R.). Nakronpanom (Manop R.). Nakronrajasrima Prov., A. Pakchong (Manop R.). Pang Kam Paung (Gressitt). Samuthprakan (Manop R.).

Discussion.--*Culicoides innoxius* is the Indochinese counterpart of *C. sumatrae* Macfie, from which it can be distinguished by the stouter third palpal segment with pit located nearer midlength, the dark halter color, and presence of 6 spines in the hindtibial comb.

Biology.--Howarth (1985) reared *C. innoxius* in Laos from rotting banana stalks and from organic material found in a wound in a fork of a tree.

Culicoides insignipennis Macfie
(Figs. 94, 259, 406)

Culicoides insignipennis Macfie, 1937b: 469 (female; Malaya; fig. wing); Delfinado, 1961: 659 (Philippines; fig. wing); Howarth, 1985: 57 (Laos records).

Female.--Wing length 1.09 (0.94-1.28, n = 12) mm.

Head: Eyes contiguous, bare. Antenna (fig. 94a) with lengths of flagellar segments in proportion of 19-15-17-19-20-20-20-22-26-27-28-49, antennal ratio 1.05 (0.99-1.13, n = 9); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 94b) with lengths of segments in proportion of 10-23-37-17-16; second segment slender; third segment slightly swollen proximally, with small, round, shallow sensory pit at distal third; palpal ratio 3.6 (3.2-4.0, n = 12). Proboscis moderately long, P/H Ratio 0.90; mandible with 17 (16-18, n = 17) teeth.

Thorax: Brownish; mesonotum (fig. 94c) with a pair of prominent, broad, sublateral, dark brown vittae; narrow median line and sides of mesonotum also dark brown. Legs (fig. 94e) brownish; midknees, narrowly, and narrow rings at base and apex of hindtibia yellowish; tarsi pale; hindtibial comb (fig. 94d) with 6 (n = 15) spines, second from spur longest.

Wing (fig. 259, 406): Pattern as figured; color dark with definite pattern of rounded pale spots; base of wing pale nearly halfway to r-m crossvein; large pale spot over r-m crossvein extending from costal margin to slightly behind media, crossvein itself deeply infuscated except at junction with media; large rounded pale spot covering distal 0.6 of second radial cell, extending 0.7 way to vein M1, a dark line bisecting this spot along entire length of vein R4+5; distal pale spot in cell R5 crescent-shaped, concave distally, extending anteriorly to wing margin, not touching vein M1 caudad; small double pale spot straddling midportion of vein M2, but bisected by dark line along this vein; small round pale spots subapically in cells M1 and M2; a streaklike pale area in cell M2 extending proximad of medial fork, a small round pale spot lying just in front of mediocubital fork; cell M2 with a large round pale spot at wing margin; cell M4 with a small round pale spot at wing

margin midway between tips of veins M3+4 and Cu1, and an elongate pale spot bordering proximal half of veins M3+4 on posterior side; anal cell with two distinct pale spots in distal portion; small pale spots at wing margin at tips of veins M1 and M2. Macrotrichia sparse on distal fourth of wing; costal ratio 0.67 (0.64-0.72, n = 12); first radial cell narrow but with distinct lumen, second radial cell with broad lumen. Halter deeply infuscated.

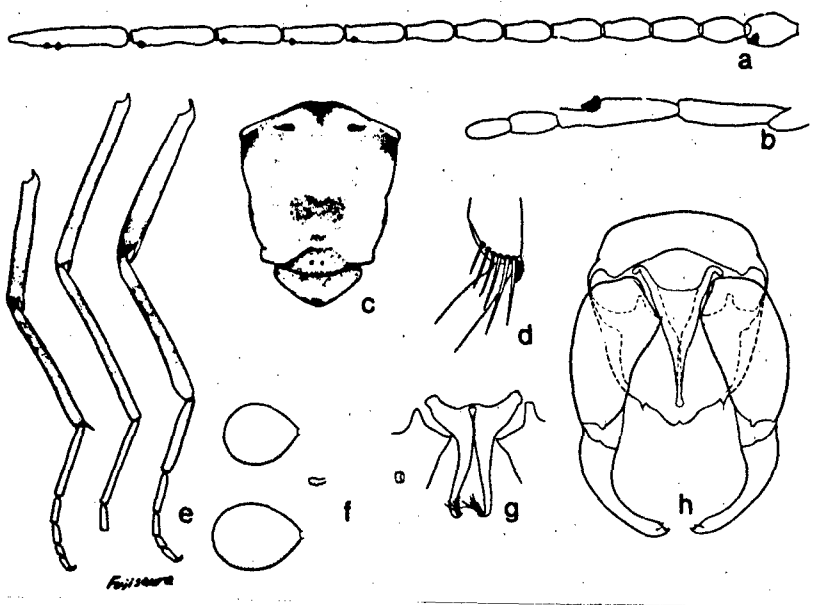


Fig. 94. *Culicoides insignipennis*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Abdomen: Dark brown. Spermathecae (fig. 94f) ovoid, slightly tapering to duct, without necks; unequal, 0.058 x 0.040 mm and 0.049 x 0.036 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 94h): Ninth sternum narrow, with distinct caudomedian excavation, ventral membrane bare; ninth tergum rounded caudad, apicolateral processes absent, with a distinct median, acutely rounded secondary lobe. Basistyle stout, with dense black setulae along mesal margin, ventral and dorsal roots short; dististyle slender, curving, with slightly enlarged, rounded tip. Aedeagus with low rounded basal arch, the margin sclerotized; main body triangular, tapering to long slender distal process with small spherical tip, internal sclerotized peg absent. Parameres (fig.

94g) separate, each with very short, stout, tapering basal arm, midportion slightly swollen, tapering almost from base gradually to slender, bladelike, ventrally curved tip bearing a few relatively long fringing hairs.

Distribution.--Brunei, Indonesia, Laos, Malaysia, Philippines, Sabah, Sarawak, Singapore, Thailand.

Types.--Syntypes, 4 females, Kuala Lumpur, Malaysia, 1937, J.J. Buckley (in BMNH).

Southeast Asia Records.--
BRUNEI: Brunei, biting man (Colless).
INDONESIA: Bali, Klung Kung, Timuhun (Lee). Java (West), Bogor, Pacet, Puncak (Lee); Garut, Pameungpeuk (Zubaedah). Lombok, Tabane (Nicholls); Sasant, 30 km N Maratom (Nicholls). Kalimantan (South), Banjar, Astambul, Tanah Intan, Pondok Delapan (Lee). Sulawesi (Central), Banggai, Batui, Kamiwangi (Bambang); (North) Dumoga-Bone Nat. Park, 220 m (Heppner); Lake Mooat, 20 km NE Kotamobagu, 1,050 m (Heppner); (Southeast), Kendari, Ranometo, Sabulohoa (Bambang). Sumatra, Jambi, Singkut, Transmigrasi (Lee).
LAOS: Sayaboury Prov., Sayaboury (Howarth); Xieng Hon (Howarth); 22 km S Mucng Pheng (Howarth). Vientiane Prov., Ban Ky Sok, Vang Vieng (Howarth); Ban Keun, Ban Na Peng (Howarth).
MALAYSIA: Kelantan, Lambok, Surigei Betis, Ulu Kelantan (Wharton). Pahang, Kuala Singgora (Wharton); Kuala Tahan, King George V Nat. Park (McClure, Quate). Perak, Pulau Pangkor (Braub). Selangor, Kepong (Quate); Kuala Lumpur (Barnett, Hubert, Quate, Traub); Serdang (Barnett); Ulu Langat (Barnett). Trengganu, Dungun, Bukit Besi (Traub).
PHILIPPINES: Mindanao, Cotabato Prov., Kidapawan, carabao baited trap (Kalaw). Palawan, Tarumpitas Pt. (Quate).
SABAH: Ranau (Maa). Tawau Dist., Kalabakan River (Maa, Quate).
SARAWAK: Bau Dist., Pangkalan Tebang, 300-450 m (Maa). Kapit Kist., Nanga Pelagus (Traub). Lg. Tegangan, Akah River, biting man (Colless). Matang (Maa, Gressitt).
SINGAPORE: Chantek Bahru (Colless); Nee Soon (Colless).
THAILAND: Chiang Mai Prov. (Maa, Scanlon). Loei Prov., Amphoe Dan, Sai, Koksato (Elbel). Nakronrajasrima (Manop R.).

Discussion.--This species is very readily separated from *peregrinus* Kieffer, *effusus* Delfinado, and other species with the second radial cell pale-tipped and a pale spot at the base of the mediocubital fork, by the deep blackish infuscation of the r-m crossvein.

Culicoides kinabaluensis Wirth and Hubert, new species
(Figs. 95, 260, 407)

Female.--Wing length 1.43 mm.

Head: Eyes (fig. 95c) contiguous a short distance, bare. Antenna (fig. 95a) with lengths of flagellar segments in proportion of 35-32-32-33-33-34-34-35-47-50-61-66-97, antennal ratio 1.20; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 95b) with lengths of segments in proportion of 12-38-46-20-24; third segment short, moderately swollen on basal portion, quite slender distally, a moderately large, shallow, round to irregular sensory pit at base of slender portion; palpal ratio 2.9. Proboscis short, P/H Ratio 0.67; mandible with vestigial teeth.

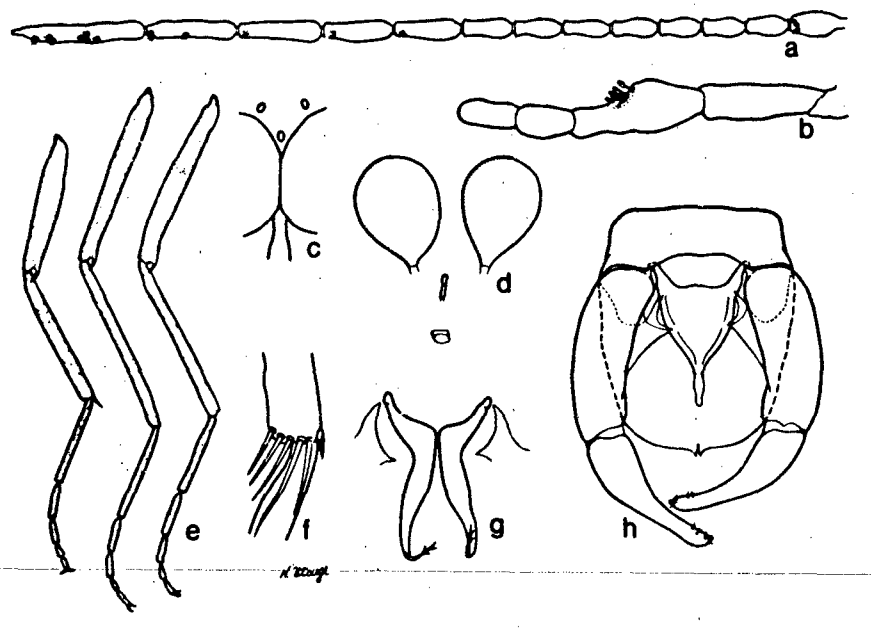


Fig. 95. *Culicoides kinabaluensis*: a. antenna; b. palpus; c. eye separation; d. spermathecae; e. legs; f. tibial comb; g. parameres; h. male genitalia, parameres omitted.

Thorax: Dark brown, mesonotum without pattern as seen in slide-mounted specimens. Legs (fig. 95e) dark brown; knee spots blackish on mid- and hindlegs, midknee yellowish on each side of joint; fore- and hindtibiae with narrow basal pale rings, hindtibia with narrow apex pale; hindtibial comb (fig. 95f) with 5 spines, second from spur longest.

Wing (fig. 260, 407): Pattern as figured; wing deeply infuscated with distinct pattern of moderately small pale spots, veins more deeply infuscated; base of wing yellowish for a third of distance to r-m crossvein, pale area extending caudad a short way into anal cell; pale spot over r-m crossvein small, broadly meeting costal margin, touching media caudad; poststigmatic pale spot covering distal two-

thirds of second radial cell and extending distad a short way into anterior margin of cell R5, broadest anteriorly not quite meeting vein M1 posteriorly; cell R5 with distal pale spot transverse, small, not attaining anterior wing margin or vein M1; subapical pale spots in cells M1 and M2 broadly joined across vein M2; distal pale spot in cell M1 small and round, lying distant from wing margin; distal pale spot in cell M2 round and larger and lying near wing margin; a large round pale area in cell M2 between medial and mediocubital forks; anal cell with 3 small round pale spots, 1 in anal angle, 1 lying near apex of anal vein, and 1 near wing margin in apex of cell; tips of veins dark, wing margin at tip of vein M1 sometimes narrowly pale. Macrotrichia present in anterior part of distal half of cell R5, and a few in apices of cells M1 and M2; costal ratio 0.67; first radial cell narrow, second with broad lumen. Halter pale.

Abdomen: Dark brown. Spermathecae (fig. 95d) ovoid with short slender necks; subequal, each 0.058 x 0.041 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 95h): Ninth sternum with shallow caudomedian excavation, ventral membrane bare; ninth tergum rounded caudad, apicolateral processes absent, a pair of very small papilliform submedian lobes present. Basistyle with inconspicuous setae on mesal surface; dististyle short, stout proximally, distal portion moderately slender and nearly straight, tip with small distomesal tooth. Aedeagus broad at base, basal arch extending to a sixth of total length, anterior margin of arch strongly sclerotized; lateral margins of main body convex; distal process slender with round tip; internal sclerotized peg inconspicuous. Parameres (fig. 95g) separate; each with anterolateral process moderately long and tapering; moderately stout in midportion, tapering distally and curving ventrad and ending in short filament with minute fringing hairs at tip.

Distribution.--Malaysia, Sabah.

Types.--Holotype female, allotype male, Kambaranga, Mt. Kinabalu, Sabah, 1.xi.1958, Quate and Maa, light trap (deposited in B.P. Bishop Muesum). Paratypes, 8 males, 15 females, as follows:

MALAYSIA: Pahang, Mt. Brinchang, 1,600 m, iii.1963, M.E. McClure, light trap, 1 female.

SABAH: Same data as types, 6 males, 8 females. Tenompok, Mt. Kinabalu, 3.xi.1958, T.C. Maa, at light, 1 male, 3 females; 2.x.1958, L.W. Quate, light, 1 female; Tenompok, 48 km E Jesselton, 17.x.1958, T.C. Maa and L.W. Quate, at light, 1 male, 2 females.

Discussion.--*Culicoides kinabaluensis* resembles *C. carpophilus* n. sp. in having vestigial mandibular teeth. In its large size, dark wings, and general features it appears to be the sister species of *brinchangensis* which replaces it in the high mountains of Malaysia. However, *C. brinchangensis* has much reduced pale wing markings and normal mouthparts. *Culicoides kinabaluensis* keys out with *C. sumatrae* Macfie which is a smaller species with normal mouthparts, and *C. malayae* Macfie, which has much more extensive pale wing markings.

Culicoides klossi Edwards
(Figs. 96, 261, 408)

Culicoides klossi Edwards, 1933: 252 (female; Sabah).

Female.--Wing length 1.21 mm.

Head: Eyes (fig. 96d) contiguous a short distance, bare. Antenna (fig. 96a) with lengths of flagellar segments in proportion of 30-26-30-30-30-30-28-29-40-38-40-48-64, antennal ratio 0.99; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 96b) with lengths of segments in proportion of 15-35-60-27-23; third segment long and slender, cylindrical, with sensilla scattered on distal half of segment; palpal ratio 4.6. Proboscis long, P/H Ratio 0.95; mandible with 18 teeth.

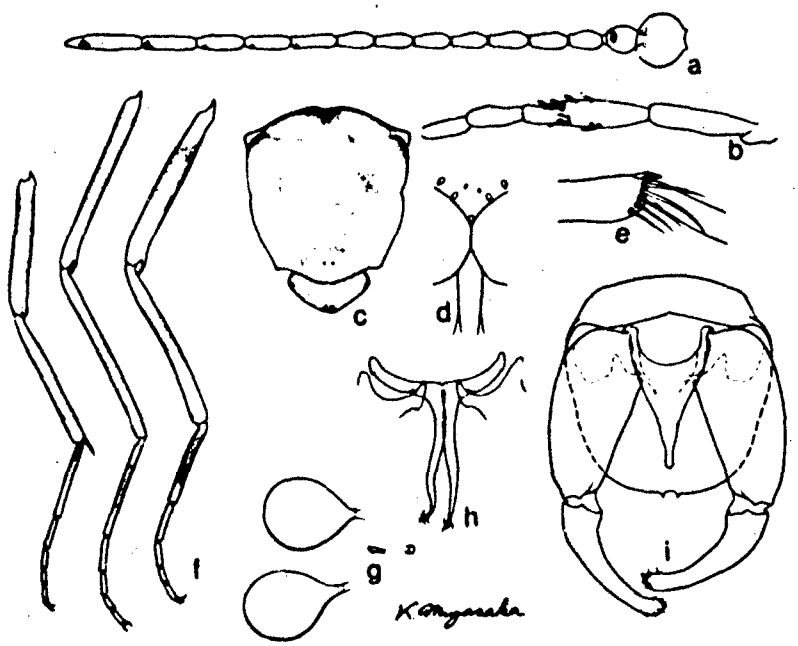


Fig. 96. *Culicoides klossi* a. antenna; b. palpus; c. thoracic pattern; d. eye separation; e. tibial comb; f. legs; g. spermathecae; h. parameres; i. male genitalia, parameres omitted.

Thorax: Dark brown; mesonotum (fig. 96c) uniformly pale reddish brown pollinose with 2 small sublateral brown vittae. Legs (fig. 96f) brown; femora with broad apical pale bands, less distinct on fore- and hindlegs; tibiae with broad basal pale bands; knees pale; hindtibia with apex broadly pale; hindtibial comb (fig. 96e) with 5 spines, second from spur longest.

Wing (fig. 261, 408): Pattern as figured; anterior wing margin with 3 narrow, transverse, very dark brown areas; pale area over wing base extending a third way to r-m crossvein and a short way into anterior portion of anal cell; pale spot over r-m crossvein broad anteriorly, narrowed caudad and extending a short way into cell M2; a broad pale spot covering entire length of second radial cell and extending a short way beyond, much narrowed caudad and extending nearly or all the way to vein M1; distal pale spot in cell R5 broader posteriorly, much fainter anteriorly and only rarely extending to anterior wing margin; a large pale spot straddling vein M2 just before midlength; cell M1 with a long oval pale spot distally, not quite meeting wing margin; cell M2 with round distal pale spot broadly meeting wing margin; a large pale spot in cell M2 filling space between medial and mediocubital forks; cell M4 with a large pale spot broadly meeting vein M3+4 and sometimes with a narrow proximal extension along this vein; anal cell with 2 distal pale spots, sometimes joined together, and with proximal pale spot in anal angle sometimes joined with basal pale area of wing; apices of veins M1 and M2 with small pale spots at wing margin. Macrotrichia moderately numerous on distal third of wing; costal ratio 0.69; radial cells distinct, the second long and broad. Halter pale.

Abdomen: Dark brown. Spermathecae (fig. 96g) ovoid and tapering to moderately long slender necks; subequal, each 0.058 x 0.042 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 96i): Ninth sternum without caudomedian excavation; ninth tergum rounded caudad, with slight caudomedian cleft, apicolateral processes absent. Basistyle with mesal spinules scarcely evident, ventral root absent, dorsal root short; dististyle very slightly curved, slender distally with slightly bent, toothed tip. Aedeagus with moderately broad basal arch extending to a third of total length, basal arms curved, without marginal sclerotized band mesally; distal portion tapering gradually to slender apex without spherical tip. Parameres (fig. 96h) joined at bases by a narrow band; each with long slender lateral arm; stem slender, gradually tapering distally to a slender filament bearing a few minute fringing distal hairs.

Distribution.--Malaysia, New Guinea, Sabah, Vietnam.

Types.--Syntypes of *klossi*, 7 pinned females in BMNH, Lumu Lumu, Mt. Kinabalu, Sabah, 1,600 m, 16.iv.1929, H.M. Pendlebury. We have mounted one female on a slide for study and hereby select it as lectotype.

Southeast Asia Records.--

MALAYSIA: Pahang, Mt. Brinchang, 1,600 m (McClure).

SABAH: Mt. Kinabalu, Kambaranga, 2,140 m (Maa, Quate); Mt. Kinabalu, Lumu Lumu (Pendlebury, type); Mt. Kinabalu. Tenompok (Maa, Quate).

VIETNAM: Dralac, Dalat (Spencer).

Discussion.--Culicoides klossi is distinguished from all other Oriental species of the subgenus *Culicoides* except *indianus* Macfie by the slender, cylindrical third palpal segment with scattered sensilla. *Culicoides indianus* differs in its smaller size, less extensive pale wing markings, dark halteres, and dark apices on fore- and hindfemora. Here again, *C. klossi* is characteristic of the Malaysian subregion while *indianus* in an Indochinese faunal element, although both species occur on Mt. Brinchang, Malaysia. *Culicoides jimmiensis* Tokunaga from New Guinea is closely related, but differs in its more extensive dark wing markings.

Culicoides lansangensis Howarth
(Figs. 97, 262)

Culicoides lansangensis Howarth, 1985: 58 (male, female; Laos; figs.).

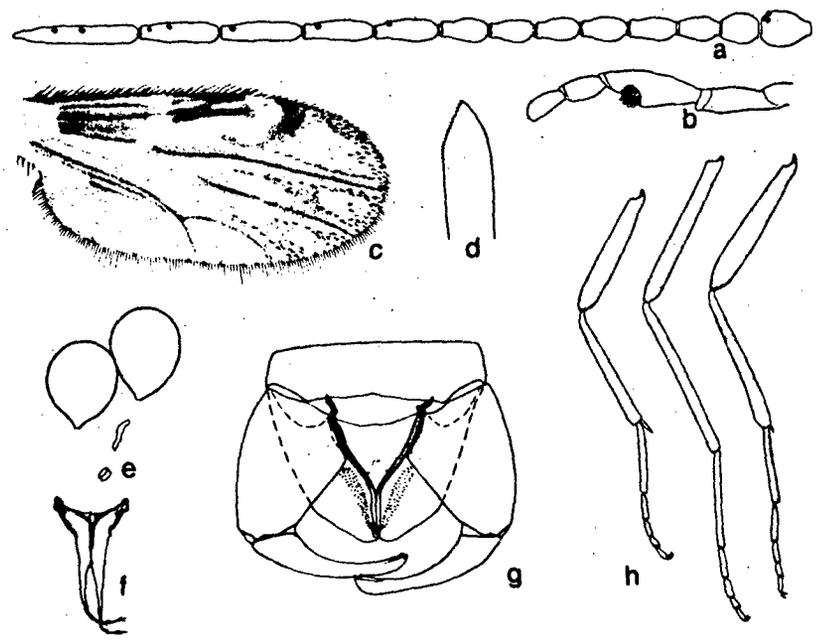


Fig. 97. *Culicoides lansangensis*: a. antenna; b. palpus; c. wing; d. mandible; e. spermathecae; f. parameres; g. male genitalia, parameres omitted; h. legs.

Female.--Wing length 1.08 (1.01-1.15, n = 3) mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 97a) with lengths of flagellar segments in proportion of 20-16-17-19-18-17-18-18-25-28-32-32-50, antennal ratio 1.13 (1.06-1.17, n = 3); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 97b) with lengths of segments in proportion of 8-29-31-14-15; third segment moderately long, swollen in midportion, with large, round, moderately deep sensory pit; palpal ratio 3.0 (2.9-3.0, n = 3). Proboscis moderately short, P/H Ratio 0.68 (0.65-0.69, n = 3); mandible (fig. 97d) with 19-21 (n = 2) small teeth.

Thorax: Thorax and legs dark brown, mesonotum in slide material without distinct pattern. Legs (fig. 97h) with all femora dark to tip; foretibia with narrow indistinct sub-basal pale band, midtibia with narrow indistinct basal pale band, hindtibia with distinct narrow basal pale band and narrow, indistinctly pale tip; hindtibial comb with 6 spines, second from spur longest.

Wing (fig. 97c, 262): Two radial cells present; pattern as figured, membrane quite dark brown due to coarse microtrichia, with pattern of contrasting small pale spots as follows: pale spot over r-m crossvein small, divided by dark line along radius, rounded on distal side, not much produced into base of cell R5; poststigmatic pale spot in cell R5 small, covering distal fourth of second radial cell, not crossing vein M1; distal pale spot in cell R5 transverse, not crossing vein M1; apex of wing dark at wing margin; base of wing with small pale spot not extending much distad of basal arculus; anal vein narrowly pale on proximal half; anal cell and anal angle dark except small round pale spot in anal angle and 2 small separate distal spots; double pale spot in cell M2 just in front of mediocubital fork and just behind medial fork; vein M2 with double pale spot straddling midportion; cells M1, M2 and M4 each with small round pale spot distally but well removed from wing margin. Macrotrichia moderately numerous on distal portion of wing; costa long, costal ratio 0.67 (0.65-0.68, n = 3). Halter dark brown.

Abdomen: Dark brown. Spermathecae (fig. 97e) ovoid, tapering to short, narrow necks, slightly unequal, 0.061 x 0.045 mm and 0.054 x 0.040 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 97g): Ninth sternum with shallow caudomedian excavation; ninth tergum rounded, caudal margin with pair of very inconspicuous, hyaline submedian lobes. Basistyle without strong spines on mesal margin, ventral root absent, dorsal root short; dististyle slender and curved, tapering until just before tip which is slightly expanded, subacutely pointed. Aedeagus with basal arch extending to less than a fourth of total length, its margin not sclerotized; main portion roughly in outline of equilateral triangle with sides slightly convex; distal stem extending a third of total length of aedeagus, the tip with rounded papilla; internal sclerotized peg at base of distal stem moderately prominent. Parameres (fig. 97f) narrowly joined at bases; each with short oblique lateral arm, midportion slightly swollen, tapering distally to elongate filiform tip with a few microscopic hairs.

Distribution.--Laos.

Types.--Holotype male, allotype female, Laos, Sayaboury Prov., Sayaboury, 300 m, 30.vii.1967, F.G. Howarth, reared from tree wound (B.P. Bishop Mus.).

Southeast Asia Records.--
LAOS: Sayaboury Prov., Sayaboury (Howarth, types); Nam Houng River margin (Howarth).

Discussion.--This species is closely related to *C. sumatrae* Macfie and *innoxius* Sen and Das Gupta. It is distinguished from *C. sumatrae* by the dark halteres, darker wings, dark wing tip and anal angle, the small pale spot over the r-m crossvein, and the darker legs. From *C. innoxius* it differs in its much more distinct wing markings and darker tip of the hindtibia.

Culicoides liui Wirth and Hubert
(Figs. 98, 263, 409)

Culicoides liui Wirth and Hubert, 1961: 20 (female; Taiwan; figs.); Howarth, 1985: 60 (Laos records).

Female.--Wing length 1.45 (1.34-1.59, n = 12) mm.
Head: Eyes (fig. 98d) contiguous a short distance, bare. Antenna (fig. 98a) with lengths of flagellar segments in proportion of 22-20-21-23-24-22-23-23-34-33-37-41-52, antennal ratio 1.09 (1.06-1.15, n = 10); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 98b) with lengths of segments in proportion of 12-29-40-19-19; third segment slightly swollen in midportion, with a definite, small, round, shallow sensory pit; palpal ratio 3.1 (2.8-3.4, n = 10). Proboscis moderately long, P/H Ratio 0.82; mandible with 18 (16-20, n = 22) teeth.
Thorax: Dark brown as seen in slide-mounted specimens, mesonotal pattern as in fig. 98c. Legs (fig. 98f) dark brown, knees pale; distal third of mid- and hindfemora and distal fourth of forefemur yellow; all tibiae with basal yellow bands, narrow on foreleg and broadest on hindleg, apex of hindtibia yellow; tarsi yellowish brown, hindbas tarsus dark brown; hindtibial comb (fig. 98e) with 6 (5-6, n = 7) spines, second from spur longest.
Wing (fig. 263, 409): Pattern as figured, prominent, the pale markings dominant, interconnected; large pale area over r-m crossvein extending broadly to costal margin; second radial cell pale except at extreme base, costa not extending through poststigmatic pale spot to the very narrowly transverse distal dark spot in cell R5; cell R5 with distal pale spot very large, nearly filling cell to wing tip but with a narrow dark line bordering anterior side of vein M1; vein M1 pale bordered except for dark spots at extreme base and just before apex, end of vein pale; vein M2 pale margined except for small dark spots near base and at extreme tip; cell M1 with distal pale spot elongate, extending to wing tip, vein M2 with large pale spot straddling midportion; cell M2 nearly all pale on proximal two-thirds, pale areas on distal portion of cell interconnected, large pale spot at apex open to wing margin; apices of veins M2, M3+4 and Cu1 dark; cell M4 with large pale spot filling distal portion, extending narrowly proximad along vein M3+4 and expanding slightly in a pale area at base of mediocubital fork; anal cell with 3 large pale spots interconnected in a zig-zag pattern. Macrotrichia confined to a few in apices of cells R5 and M1; costal ratio 0.68 (0.65-0.70, n = 12); 2 well-formed, long, narrow radial cells present. Halter pale.

Abdomen: Dark brown. Spermathecae (fig. 98g) pyriform, with conical necks to base of ducts; unequal, 0.060 x 0.044 mm and 0.048 x 0.046 mm.

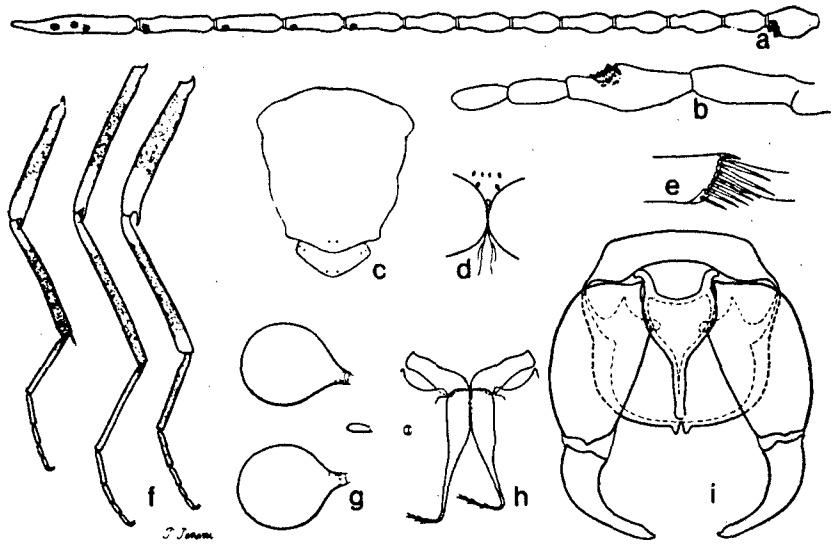


Fig. 98. *Culicoides liui*: a. antenna; b. palpus; c. thoracic pattern; d. eye separation; e. tibial comb; f. legs; g. spermathecae; h. parameres; i. male genitalia, parameres omitted.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 98i): Ninth sternum narrow with shallow caudomedian excavation; ninth tergum evenly rounded caudad with a pair of tiny submedian lobes. Basistyle with dense, slightly enlarged mesal spinules, ventral and dorsal roots short and inconspicuous; dististyle markedly curved, tapering to slender, bluntly pointed tip. Aedeagus with low basal arch extending to 0.13 of total length, basal arms slender and curved; main body with convex sides, anterior rim of arch sclerotized, internal sclerotized peg absent; distal process long and slender with parallel sides and spherical tip. Parameres (fig. 98h) separate; each with short, stout, anterolaterally directed basal arm, stem moderately swollen on proximal half, tapering distally to slender filament bearing numerous fine fringing hairs along a considerable distance of apical portion. (Male from King George V Nat. Park, Pahang, Malaysia).

Distribution.--Indonesia, Laos, Malaysia, Philippines, Taiwan, Thailand.

Type.--Holotype female, Tao Shan, Wufeng, Hsinchu Hsien, Taiwan, 12.xii.1953, Su-Yung Liu, from water buffalo shelter (deposited in Taiwan Malaria Research Institute, Chaochow, Pingtung, Taiwan).

Southeast Asia Records.--

INDONESIA: Bali, Klungkung, Timuhun (Sweatman). Flores, Manggarai, Reo, Gincu (Lee). Java (Central), Cilacap, Adipala, Silangsur Lor of Wlahar (Lee); (West), Garut, Pameungpeuk (Zubaedah). Lombok, Tabane (Nicholls). Sumatra, Bengkulu, Seluma, Bukit Peningauan (Mathis).

LAOS: Vientiane Prov., Ban Ky Sok, 30 km N Vang Vieng (Howarth).

MALAYSIA: Kelantan, Sungei Betis, Ulu Kelantan (Wharton). Pahang, King George V Nat. Park, Tahan River (McClure).

PHILIPPINES: Mindanao, Milbuk (Milliron).

THAILAND: Loei Prov., Amphoe Dan Sai, Koksato (Elbel).

Discussion.--*Culicoides klossi* Edwards is very similar to *C. liui*, but can be distinguished by its cylindrical third palpal segment with scattered sensilla, and by the much less extensive wing markings, which are scarcely interconnected. The Malaysian specimens differ from *C. liui* from other localities in their deeply infuscated halteres. No other characters could be found to distinguish them from typical *C. liui*.

Culicoides malayae Macfie
(Figs. 99, 264, 410)

Culicoides malayae Macfie, 1937b: 471 (female; Malaya; fig. wing); Delfinado, 1961: 663 (female redescribed; Philippines; fig. wing); Kitaoka, 1977: 194 (Nansai Islands records).

Female.--Wing length 1.02 (0.93-1.08, n = 10) mm.

Head: Eyes (fig. 99b) contiguous, bare. Antenna (fig. 99a) with lengths of flagellar segments in proportion of 20-17-19-20-20-20-20-21-25-26-34-32-45, antennal ratio 1.03 (0.99-1.09, n = 10); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 99c) with lengths of segments in proportion of 10-27-33-18-16; third segment slightly swollen distally, with a small, round, shallow, sensory pit at distal 0.7; palpal ratio 3.3 (3.1-3.9, n = 10). Proboscis moderately long, P/H Ratio 0.86; mandible with 21 (17-24, n = 18) teeth.

Thorax: Brown; mesonotum (fig. 99e) with submedian pair of prominent large yellowish brown patches, similar areas on lateral margins. Legs (fig. 99d) brown; foreleg with knee spot blackish, femur with subapical and tibia with sub-basal, narrow pale rings; midleg narrowly pale at knee; hindleg with femur dark to tip, tibia with narrow basal and apical pale rings; hindtibial comb with 5 (n = 11) spines, second from spur longest.

Wing (fig. 264, 410): Pattern as figured; similar to that of *C. sumatrae* Macfie, but pale spots yellowish and more extensive; large pale area over base of wing extending narrowly into anal cell to posterior wing margin leaving a narrow strip along anal angle dark; pale spot over r-m crossvein angularly produced caudodistally into base of cell R5 and a narrow posterior lobe across medial stem into cell

M2; poststigmatic pale spot in cell R5 about twice as broad as the dark spot lying distal to it, meeting vein M1 posteriorly and usually extending across the vein and joining the pale spot straddling midportion of vein M2; distal pale spot in cell R5 usually meeting anterior wing margin, though with reduced intensity; usually a distinct pale spot at apex of vein M1 continuing anteriorly to meet this spot; large pale spot in cell M2 usually filling space between medial and mediocubital forks, sometimes continuing slightly across vein M3+4 into base of cell M4; distal pale spot in cell M1 round and lying distant from wing margin; distal pale spots in cells M2 and M4 larger, round, and broadly meeting wing margin, that in cell M1 broadly touching vein M3+4 anteriorly; 2 pale spots in distal portion of anal cell; veins M1 and M2 pale apically, M3+4 and Cu1 dark. Macrotrichia sparse, confined to distal fourth of wing; costal ratio 0.68 (0.65-0.74, n = 10); 2 radial cells present, first slitlike, second with broad lumen. Halter pale.

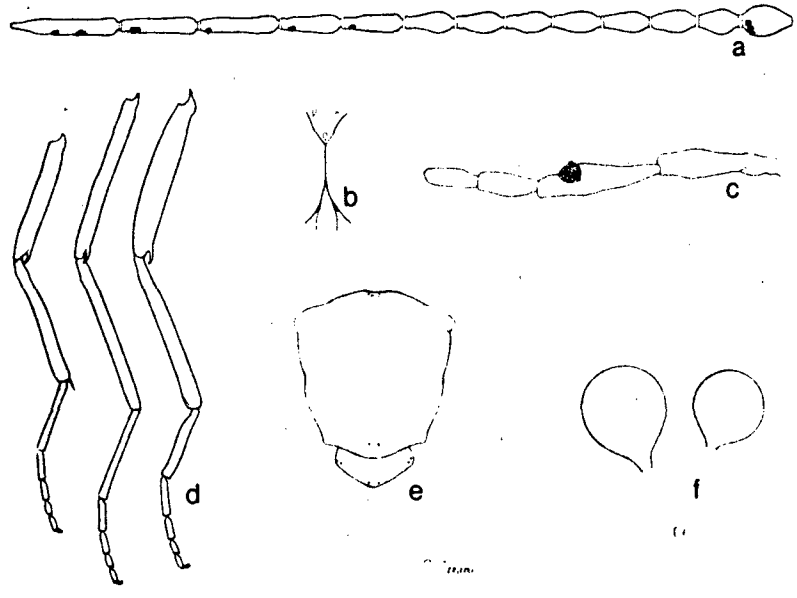


Fig. 99. *Culicoides malayae*: a. antenna; b. eye separation; c. palpus; d. legs; e. thoracic pattern; f. spermathecae.

Abdomen: Brown; cerci pale. Spermathecae (fig. 99f) ovoid, with short slender necks; unequal, 0.057 x 0.042 mm and 0.046 x 0.035 mm.

Male.--Not distinguished with certainty from male of *C. sumatrae* in our collections.

Distribution.--Indonesia, Japan (Nansai Islands), Malaysia, Philippines, Sabah, Thailand.

Type.--Holotype female, Kuala Lumpur, Malaysia, 1936, J.J. Buckley (in BMNH).

Southeast Asia Records.--
INDONESIA: Sumatra, Bengkulu, Bukit Peninjauan (Mathis); Jampi, Transmigrasi, Singkut (Lee); Lampung, Kotabumi, Way Abung, Papanrejo (Lee).
MALAYSIA: Johore, Kahang Kluang (Hubert). Kelantan, Lambok, Sungei Betis, Ulu Kelantan (Wharton). Pahang, King George V Nat. Park, Tahan River (McClure). Perak, Gunong Besant Forest Res. (Jeffery). Selangor, Kepong, biting man (Barnett); Kuala Lumpur (Barnett, Traub). Trengganu, Bukit Besi, Dungun (Traub).
PHILIPPINES: Luzon, Ifugao Prov., Liwo, 8 km E Mayoyao (Torrevillas). Mindanao, Cotabato Prov., Kidapawan (Kalaw); Bukidnon, Mt. Katanglad (Quate).
SABAH: Labuan Island (Colless). Ranau Dist., Paring (Quate). Tawau Residency, Kalabakan River, 48 km W Tawau (Maa).
THAILAND: Nakronpanom (Manop R.).

Discussion.--*Culicoides malayae* is nearly identical structurally with *C. sumatrae* Macfie, and it has not been possible to distinguish any males of *C. malayae* from our series of *C. sumatrae*. We are recognizing *malayae* on the basis of its pale brown mesonotum and its more extensive pale wing pattern, in which the pale spot covering the second radial cell is much broader than the dark spot following it in cell R5 and continues across vein M1 forming a zigzag pale band with the pale spots straddling the midportion of vein M2. The pale spot lying over the r-m crossvein is also much larger than in *C. sumatrae*, with prominent angular extension into the base of cell R5 and a narrower extension into cell M2. A few specimens have been seen with 6 tibial spines, but they otherwise seem to be typical *C. malayae*. We have examined the holotype of *C. malayae* through the courtesy of Richard Lane of the BMNH.

Culicoides orestes Wirth and Hubert, new species
(Figs. 100, 265)

Female.--Wing length 1.26 mm; breadth 0.58 mm.
Head: Eyes contiguous a short distance, bare. Antenna (fig. 100a) brown; lengths of flagellar segments in proportion of 30-26-27-28-28-30-30-29-32-34-36-41-62, antennal ratio 0.92; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 100b) blackish; segments with lengths in proportion of 10-30-36-15-16; second segment moderately stout; third segment short, stout at base, constricted distad, with moderately large, shallow, round, sensory pit at base of constriction; palpal ratio 3.0. Proboscis short, P/H Ratio 0.65; mandible with 13 teeth.
Thorax: Brown; mesonotum with faint paler markings. Legs (fig. 100e) brown; midknee broadly yellow on each side of joint; fore- and hindtibia with narrow basal and hindtibia with broad apical yellowish bands; hindtibial comb with 5 spines, second from spur longest.

Wing (fig. 100c, 265): Pattern as figured; wing dark brownish with pale markings rather indistinct, veins deeply infuscated; anterior portion with three darker brown markings; pale spot over basal arculus and extending along proximal third of mediocubital stem; pale spot over r-m crossvein extending broadly to costal margin and caudad slightly into cell M2; poststigmatic pale spot lying over distal 0.6 of second radial cell and extending to just past tip of costa, narrowing caudad and not attaining vein M1; third anterior dark marking slightly narrower than pale spot on each side; distal pale spot in cell R5 more or less rounded, not reaching anterior wing margin or apex of cell; a double pale spot straddling vein M2 just before midlength; distal pale spot in cell M1 oval, failing by its own length to reach wing margin; cell M2 with pale spot filling space between medial and mediocubital forks, and a round distal pale spot nearly meeting wing margin; cell M4 with dark line bordering veins M3+4 and Cu1, a prominent C-shaped pale marking nearly filling cell leaving a small dark spot in center of cell extending to wing margin and back to tip of vein Cu1; anal cell with a double pale spot in distal portion and a small round pale spot at base, leaving anal angle dark; tips of veins M1 and M2 with small, indistinct, pale spot. Macrotrichia sparse on distal third of wing; 2 radial cells, first narrow but distinct, second moderately broad and quite long; costal ratio 0.69. Halter pale.

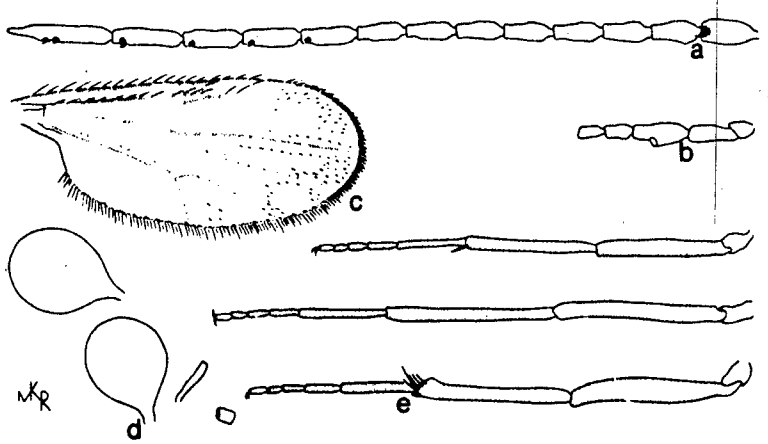


Fig. 100. *Culicoides orestes*: a. antenna; b. palpus; c. wing; d. spermathecae; e. legs.

Abdomen: Dark brown. Spermathecae (fig. 100d) ovoid with distinct, tapering necks; slightly unequal, 0.059 x 0.042 mm and 0.053 x 0.039 mm including necks.

Male.--Unknown.

Distribution.--Malaysia, Philippines, at higher elevations.

Types.--Holotype female, Malaysia, Pahang, Mt. Brinchang, 1,600 m, iii.1963, H.E. McClure, light trap (Type in USNM). Paratype, 1 female.
PHILIPPINES: Mindanao, Clavin R., 1,250 m, 1.6 km E Mt. Malindang, 12.vii.1958, H.E. Milliron, at light.

Discussion.--The specific epithet is from the Greek noun in apposition, *C. orestes*, dweller in the mountains. *Culicoides orestes* superficially resembles *C. pulicaris* Linnaeus in having a small dark spot in the middle of cell M4, but most of the species closely related to *C. pulicaris* have the sensilla scattered on the surface of the third palpal segment and the wings usually have more numerous macrotrichia. The nearest member of the Pulicaris Group geographically is *C. pulicaris monticolus* McDonald and Lu (1972) from the mountains of Taiwan, but *C. monticolus* differs in many ways, especially the scattered palpal sensilla, its larger size (wing 1.42 mm long), mandible with 17 teeth, 6 tibial spines, the second radial cell short with only the tip pale, only a single round pale spot distally in the anal cell, and no pale spot in the anal angle (female paratype from Tien Hsiang in USNM). The wing markings of *C. monticolus* differ so greatly from those of *C. pulicaris* that the taxon should be elevated from subspecies to species rank; and since *C. monticolus* is preoccupied in *Culicoides* by *C. monticola* Wirth and Lee (1967) from Colombia, we hereby propose the new name *C. mcdonaldi* Wirth and Hubert, NEW NAME, for *C. monticolus* McDonald and Lu (1972).

Culicoides parabubalus Wirth and Hubert, new species
(Figs. 101, 266)

Female.--Wing length 1.21 (1.06-1.16, n = 3) mm.
Head: Eyes contiguous a short distance, bare. Antenna (fig. 101a) with lengths of flagellar segments in proportion of 21-17-19-19-20-19-19-20-26-26-30-33-54, antennal ratio 1.10 (1.08-1.12, n = 3); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 101b) with lengths of segments in proportion of 11-24-32-15-14; third segment swollen proximally, slender past the round, shallow sensory pit located at midlength; palpal ratio 2.9 (2.7-3.2, n = 3). Proboscis moderately long, P/H Ratio 0.81; mandible with 21 (19-24, n = 6) teeth.
Thorax: Dark brown, mesonotum without evident pattern. Legs (fig. 101e) dark brown; midknees yellow, foretibia with basal, and hindtibia with basal and apical, narrow pale rings; hindtibial comb with 6 spines (5 on one side on holotype), second from spur longest.
Wing (fig. 101c, 266): Pattern as figured; dark with extensive pattern of large distinct pale spots; anterior margin with 3 very dark

areas, the third one narrow and chevron-shaped, notched distally; base of wing pale including proximal third of anal cell, anal angle pale; pale spot over r-m crossvein moderately large, expanded distally behind radius slightly into base of cell R5; poststigmatic pale spot in cell R5 covering distal half of second radial cell, slightly indented proximally by dark area on vein R4+5, more or less isolated from a narrow pale mark lying on anterior side of vein M1 as figured; distal pale spot in cell R5 obliquely meeting anterior wing margin but with reduced intensity; large irregularly rounded pale spot straddling midportion of vein M2; cell M1 with small oval distal pale spot not meeting wing margin; cell M2 with narrow pale streak from base meeting an oblique, double pale spot lying between medial and mediocubital forks, and a rounded pale spot lying at wing margin in tip of cell; cell M4 with moderately large rounded pale spot at wing margin, sometimes nearly meeting anterior margin at vein M3+4, base of cell also faintly pale along veins M3+4 and Cu1; anal cell with 2 separate rounded pale spots in distal portion; narrow pale border at wing margin in cells R5 and M1. Macrotrichia scanty on distal fourth of wing; 2 distinct radial cells, the first moderately narrow, the second broader; costal ratio 0.69 (0.67-0.70, n = 3). Halter pale.

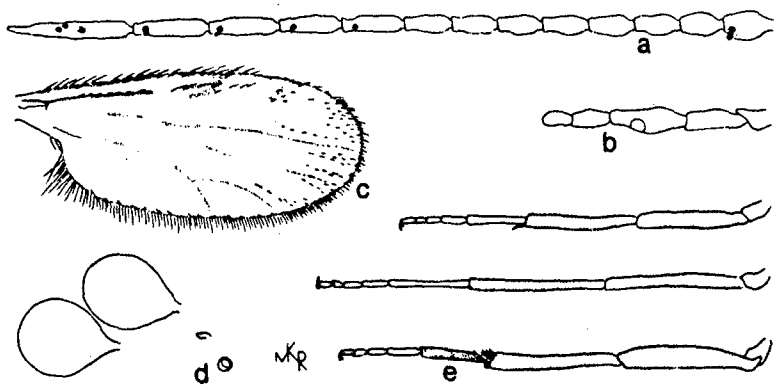


Fig. 101. *Culicoides parabubalus*: a. antenna; b. palpus; c. wing; d. spermathecae; e. legs.

Abdomen: Dark brown. Spermathecae (fig. 101d) ovoid, tapering to short inconspicuous necks; nearly equal, 0.053 x 0.040 mm and 0.051 x 0.038 mm.

Male.--Unknown.

Distribution.--Malaysia.

Types.--Holotype female, Malaysia, Trengganu, Dungun, Bukit Besi, 5.viii.1958, R. Traub, light trap (Type in USNM). Paratypes, 9 females, as follows:

MALAYSIA: Kelantan, Lambok, Sungei Betis, Ulu Kelantan, 9.xi.1961, R.H. Wharton, light trap, 5 females. Pahang, King George V Nat. Park, Tahan River, 4-6.xi.1959, H.E. McClure, light trap, 1 female. Selangor, Kepong Forest Res., iii-iv.1960, H.E. McClure, light trap, 1 female; Kuala Lumpur, 4.x.1958, R. Traub, light trap, 1 female. Trengganu, same data as holotype, 1 female.

Discussion.--This species is closely related to *C. bubalus* Delfinado and *C. malayae* Macfie, sharing with them the extensive pale yellowish wing markings in which the pale spot over the r-m crossvein is large and the poststigmatic pale spot more or less extends into the base of cell R5, and more or less broadly continues to vein M1, and the pale spot in cell M4 is large and nearly or quite reaches anteriorly to vein M3+4. *Culicoides parabubalus* can be distinguished from both species by the entirely pale base of the anal cell and the more or less separation of a distinct, elongate pale mark on the anterior side of the base of vein M1. Like *C. malayae*, *C. parabubalus* has pale halteres, which are dark in *C. bubalus*. Like *C. bubalus*, *C. parabubalus* has 6 tibial spines, while *C. malayae* has 5. Our present collections of this species are limited to low elevations in peninsular Malaysia.

Culicoides paramalayae Wirth and Hubert, new species
(Figs. 102, 269, 411)

Female.--Wing length 1.19 mm.

Head: Eyes (fig. 102c) contiguous a short distance, bare. Antenna (fig. 102a) with lengths of flagellar segments in proportion of 33-25-27-30-30-30-31-31-42-42-47-48-73, antennal ratio 1.07; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 102b) with lengths of segments in proportion of 15-45-60-30-20; third segment moderately swollen in midportion, with a large irregular pit at base of slender distal portion; palpal ratio 2.9. Proboscis moderately long, P/H Ratio 0.87; mandible with 19 teeth.

Thorax: Pale brownish, scutellum yellowish brown, mesonotum with indistinct yellowish pattern as seen in slide-mounted specimens. Legs (fig. 102d) pale brown; midknees broadly yellowish on each side; foretibia with narrow basal pale ring; hindtibia with broad basal and narrow apical pale rings; hindtibial comb (fig. 102e) with 5 spines, second from spur longest.

Wing (fig. 269, 411): Pattern as figured; pale wing spots definite and extensive, with yellowish tinge, especially over radial veins; pale spot over wing base extending along radius to a third of distance to r-m crossvein and for half the length of mediocubital stem, continuing broadly into base of anal cell; large pale spot over r-m crossvein, narrowing caudad and lapping over media a short way, broadly meeting costal margin; large pale spot, broad anteriorly covering all but extreme base of second radial cell, extending on wing margin a short way into cell R5 and extending caudad in reduced breadth nearly to vein M1; anterior wing margin with three very dark spots, the distal one transverse, slightly oblique with parallel sides; distal pale spot in cell R5 trapezoidal, broadest caudad but not reaching vein M1,

continuing with reduced intensity to anterior wing margin; distal pale spot in cell M1 elongate oval, narrowly meeting wing margin; a large quadrate pale spot straddling vein M2 just before midlength; distal pale spot in cell M2 round, broadly meeting wing margin; cell M4 with large pale spot filling most of distal portion, not continued proximad along vein M3+4; anal cell with a double pale spot in distal portion and a faint pale area in anal angle; tip of vein M1 slightly pale at wing margin, apices of other veins dark; a large, indistinct, pale area in cell M2 extending from pale spot over r-m crossvein to the space between medial and mediocubital forks. Macrotrichia sparse on distal fourth of wing; costal ratio 0.66; radial cells distinct, the second broad. Halter pale.

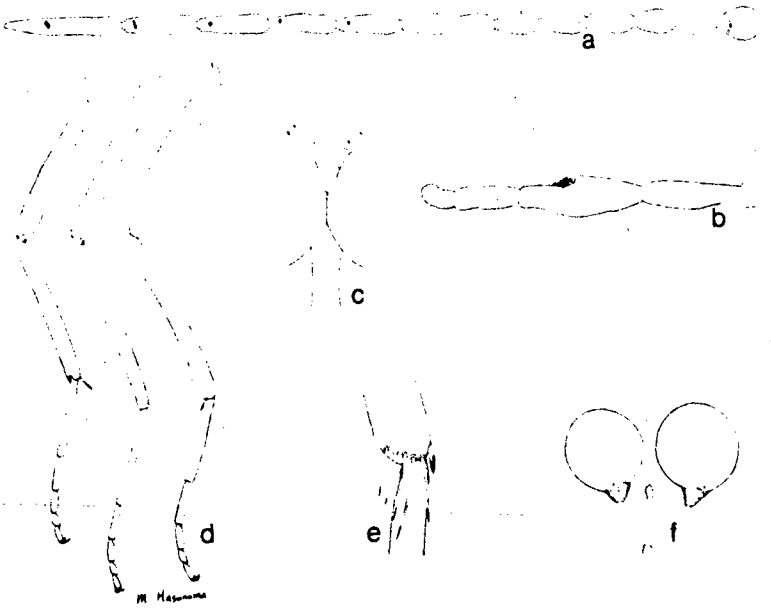


Fig. 102. *Culicoides paramalayae*: a. antenna; b. palpus; c. eye separation; d. legs; e. tibial comb; f. spermathecae.

Abdomen: Brownish, with scattered bristly hairs. Spermathecae (fig. 102f) subspherical with conical necks, necks arising slightly obliquely; slightly unequal, 0.060 x 0 048 mm and 0.057 x 0.043 mm.

Male.--Unknown.

Distribution.--Malaysia.

Types.--Holotype female, Ulu Langat, Selangor, Malaysia, 29.xi.1967, in chicken-baited trap, R. Garcia (Type in USNM). Paratype, 1 female, same data.

Discussion.--*Culicoides paramalayae* has a definite pale wing pattern which is more extensive than that of *C. sumatrae* Macfie and *C. kinabaluensis* n. sp., but not as extensive as that of *C. malayae* Macfie in which the pale spot over r-m crossvein is produced into the base of cell R5 and the poststigmatic pale spot in cell R5 extends to or across vein M1.

Culicoides peregrinus Kieffer
(Figs. 103, 292, 412)

Culicoides peregrinus Kieffer, 1910: 191 (female; India; fig. wing); Annandale, 1913: 246 (biting man; India); Edwards, 1922: 164 (Malaya; fig. wing); Mayer, 1934b: 187 (pupa; Sumatra); Macfie, 1937a: 113 (Malaya; in key; synonyms: *C. esmoneti*, *C. judicandus*, *C. philippinensis*); Causey, 1938: 408 (Thailand; figs.); Macfie, 1941: 69 (Malaya; notes on variation); Tokunaga and Murachi, 1959: 340 (redescribed; Micronesia; figs.); Sen and Das Gupta, 1959: 136 (India; figs.); Delfinado, 1961: 660 (Philippines; diagnosis; fig. wing); Wirth and Hubert, 1961: 19 (Taiwan); Murray and Dyce, 1970: 44 (Australia; feeding habits); Standfast and Dyce, 1972: 226 (mention; potential arbovirus vector in Australia); McDonald and Lu, 1972: 413 (female diagnosis; figs.; Taiwan records); McDonald, Bolinguit and Lu, 1973: 646 (female diagnosis; figs.; Okinawa records); Standfast et al., 1973: 618 (mention; possible ephemeral fever vector in Australia); Murray, 1975: 216 (summary of biology, distribution map, vector potential; Doherty, Carley, Filippich, Gravatt, Barrow, Brown and Smith, 1976: 8 (virus isolation in Australia); Kitaoka, 1977: 195 (Nansai Island records; synonymy; distribution); Muller et al., 1981: 579 (Australia; female blood meal sources; Howarth, 1985: 60 (Laos records).

Culicoides judicandus Bezzi, 1917: 108 (female; Philippines).

Culicoides esmoneti Salm, 1918: 136 (female; male; Java; figs.).

Culicoides philippinensis Kieffer, 1921b: 564 (female; Philippines).

Culicoides peregrinus var. *assamensis* Smith and Swaminath, 1932: 183 (Assam).

Culicoides quadratus Tokunaga, 1951: 109 (female; Java; fig. wing). Synonymy by Wada, in litt. based on examination of type of *quadratus*. NEW SYNONYMY.

Female.--Wing length 1.14 (0.99-1.27, n = 27) mm.

Head: Eyes touching in a point, bare. Antenna (fig. 103a) with lengths of flagellar segments in proportion of 19-13-15-16-17-16-16-18-23-25-27-34-45, antennal ratio 1.18 (1.11-1.24, n = 16); sensilla coeloconica present on segments 3,11-15 (two each on segments 14 and 15). Palpus (fig. 103b) with lengths of segments in proportion of 10-32-32-13-14; second segment very stout, as stout as third; third segment slender on distal half, stout basally, with an irregular sensory pit at base of slender portion; palpal ratio 2.9 (2.6-3.4, n = 25). Proboscis moderately long, P/H Ratio 0.92; mandible with 14 (12-16, n = 49) teeth; cibarium with patch of 10-30 small dark spicules.

Thorax: Dark brown, mesonotum with pattern as in fig. 103d. Legs (fig. 103e) brown; bases of tibiae, tip of midfemur, and tip of hindtibia narrowly pale; tarsi pale; hindtibial comb (fig. 103c) with 6 (5-7, n = 26) spines, second from spur longest.

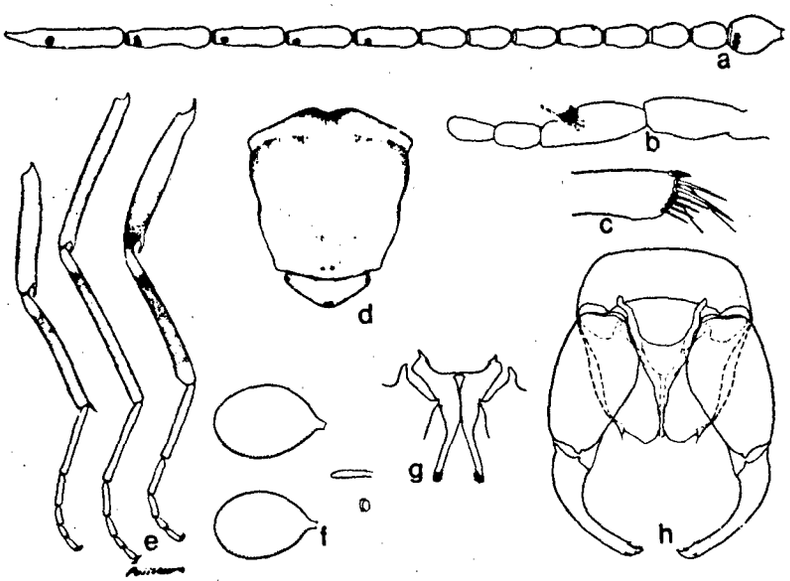


Fig. 103. *Culicoides peregrinus*: a. antenna; b. palpus; c. tibial comb; d. thoracic pattern; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Wing (fig. 292, 412): Pattern as figured; wing dark, pale spots small and definite; irregular pale area over wing base; pale spot over r-m crossvein small, nearly cut off from broader anterior portion of spot on costal margin; small pale spot over tip of second radial cell, with a deep proximal excision by dark area along vein R5 which extends distad to point where vein turns abruptly forward to meet costa; distal pale spot in cell R5 narrowly transverse and irregular, not meeting anterior wing margin; dark areas along anterior wing margin and narrowly along veins much darker than rest of wing; double pale spot straddling midportion of vein M2 separated into separate spots by dark line along vein; distal pale spots in cells M1 and M2 located far from wing margin; a streaklike pale spot lying behind medial fork and a round pale spot lying immediately in front of mediocubital fork; small round pale spot near wing margin in distal part of cell M4, lying far from

vein M3+4, a small separate pale spot lying at extreme base of cell in base of mediocubital fork; anal cell with irregular pale spot in basal portion and 2 separate round pale spots in distal portion; small pale spots lying at wing margin at tips of veins M1, M2, and M3+4. Macrotrichia sparse on distal fourth of wing; costal ratio 0.63 (0.61-0.65, n = 27); first radial cell narrow, second with broad lumen. Halter with knob white, stem at base of knob dark.

Abdomen: Brownish. Spermathecae (fig. 103f) ovoid, fairly elongate, with short slender necks; slightly unequal, 0.058 x 0.040 mm and 0.050 x 0.037 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 103h): Ninth sternum narrow, with slight caudomedian excavation, ventral membrane bare; ninth tergum rounded caudad with distinct median notch, two rounded, thinly sclerotized, submedian secondary lobes present, small, widely separated apicolateral processes present. Basistyle stout, with dense strong black spinules at base on mesal margin, dorsal and ventral roots short; dististyle slender, slightly curved, with rounded tip. Aedeagus with high, rounded basal arch extending nearly to 0.3 of total length, no basal sclerotized rim; main portion with nearly straight tapering sides, distal process slender, long and tapering to rounded tip without spherical point, internal sclerotized peg absent. Parameres (fig. 103g) separate; each with stout basal arm, distinct anteromesal tooth near base of stem or midportion; stem nearly straight, moderately swollen, tapering distally to moderately narrow, ventrally curved blade with hairy tip.

Distribution.--Oriental region from India and Sri Lanka to Indonesia, northern Australia, New Guinea, Taiwan, Micronesia, and Ryukyu Islands.

Types.--Type female of *C. peregrinus*, Puri, Orissa Coast, India, C. Paiva coll., in Indian Museum, Calcutta. Type of *C. judicandus*, female, Alabang, Rizal Luzon, Philippines, Mitzmain coll., in C.F. Baker collection, present location of type unknown. Type of *C. philippinensis*, female, Laguna, Los Banos, Luzon, Philippines, C.F. Baker collection, present location unknown. Syntype females of *C. quadratus*, Buitenzorg, Java, xi.1944, in botanical garden, M. Tokunaga, in entomological collection, Saikyo University, Kyoto, Japan.

Southeast Asia Records.--

BRUNEI: Kg. Selimbigar, in fowl house (Colless).

BURMA: Rangoon, in fowl house (Griffiths).

CAMBODIA: Phnom Penh (Delfinado).

INDONESIA: Bali, Badung Kuta, Jimbaran Carik (Lee); Badung, Mengwi (Lee); Gianyar, Tangan Juda (Sweatman); Pedang Bay, 35 km NE Denpasar (Nicholls). Flores, Manggarai, Nunang (Lee); Manggarai, Reo, Golok and Robek, Gincu (Nasir). Java, Bogor (Adiwinata); (Central), Klaten, Bonarum, Demangan (Soeroto); (West), Bekasi, Teluk Buyung (Nasir); Jakarta, West Jakarta, Kapuk (Aep); Pemeungpeuk (Delfinado). Kalimantan (South), Banjar, Astambul, Sungai Baru (Lee); Astambul, Tarah Intan, Pondok Delapan (Lee); Banjar, Martapura, Bincau, Sungai Batakan (Lee). Lombok (East), Selong, Bagik Payung (Lee). Maluku, P. Buru, Savanjaya (Bambang). Sulawesi, Bulu Kumba (Pietsch); (North), Lake Mooat, 20 km NE Kotamabagu, 1,050 m (Heppner); (Southeast),

Kendark, Lainea, Ombu Ombu (Bambang); Kendari, Ranometo, Randono (Bambang); Kendari, Unaha (Bambang); (Central), Banggai, Batui, Kamiwangi (Bambang); (South), Ujung Pandang, Bontoala, Baraya, Unhas (Aep). Sumbawa (Nicholls). Sumatra, Batam Island, Sungai Beduk (Sustriayu); Bengkulu, Bukit Peninjauan (Mathis); Bengkulu, Padang, Panjang, Pekik Nyaring (Mathis). Timor (East), Dilli, Comoro, Kampung Marinir (Soeroto).

LAOS: Saraboury Prov., Sayaboury (Howarth). Sedone Prov., Pakse and Paksong (Howarth, sweeping over cow). Vientiane Prov. (Quate); Ban Na Pheng, Ban Keun (Howarth).

MALAYSIA: Johore, Kg. Parit Ahmad, pig shed (Garcia); Kg. Sungei Pasir Pueh, Mersing, pig sty (Garcia); Klunag, pig sty (Garcia); Kedah, Simpang Kuala, Alor Star, ex pigs (Garcia). Kelantan, Kota Bharu, cattle shed (Garcia). Negri Sembilan, Pekan Lama (Garcia); Telok Pelandok, Pt. Dickson (Traub). Pahang, Kuala Singgora (Wharton); Kuantan, Gudang Rasan (Traub); Pekan, Pahang Tua (Wharton); Ulu Gali, cattle shed (Garcia). Perak, Pulau Pangkor (Traub). Perlis, Kangar Rest House (Traub). Selangor, Batu Caves, Onyx Tower, Cavern B (McClure); Kuala Lumpur (Barnett, Hubert, McClure, Traub); Puchong, ex swine shed (Garcia); Rantau Panjang, 8 km N Klang (McClure); Serdang (Barnett); Ulu Gombak Forest Res. (McClure). Trengganu, Dungun, Bukit Besi (Hubert, Traub); Kuala Trenganu (Garcia).

PHILIPPINES: Luzon, Pampanga Prov., Angeles, Clark Air Base (Balatbat); Rizal Prov., Tala (Delfinado). Mindanao, Agusan, Los Arcos (Quate); San Francisco (Quate); Zamboanga del Norte, Upper Dohinog River (Quate). Negros Oriental, Dumaquete (Quate). Palawan, Brookes Point, Uring Uring (Noona Dan Exped.).

SABAH: Keningau (Colless). Labuan Island (Colless, Maa, Quate). Ranau, West Coast Residency, 500 m (Quate). Tambuanan, biting man (Colless). Tawau (Quate).

SARAWAK: Bau Dist., Pangkalan Tebang, 300-450 m (Maa). Santubong (Maa).

SINGAPORE: Singapore (Course); Coast Road (Nicholls); Nee Soon (Colless); Kg. Chantek Bahru (Colless); Pasir Panjang (Colless).

THAILAND: Ayudhaya (Manop R.). Bangkok (Causey, Manop R., Scanlon). Chiang Mai (Notananda). Chiang Rai (Causey). Cholburi (Scanlon). Khon Kaen (Manop R.). Loei (Manop R.). Minburi (Manop R.). Nakronpanom (Manop R.). Nakronprathom (Manop R.). Nakronrajasrima (Manop R.). Nong Kai (Manop R.). Nonthaburi (Manop R.). Pechaburi (Manop R.). Phangnga, Pulau Panjang (collector ?). Sakhonakron (Manop R.). Samuthprakan (Manop R.). Thonburi (Manop R.). Udon Thani (Manop R., Scanlon).

The following collected in rice paddies by K. Yasumatsu: Chachoengsao Prov., Bangkanag, wild rice. Chiang Mai Prov., Amphoe Hang Dong, Ban Rong Ku; A. Muang, Ban Mae Khao Tom; A. San Pa Tong, Ban Thung Sieo; A. San Soi, Ban Mae Yoi. Chiang Rai Prov., Ban Pa Bong; A. Muang, Ban Teen Doi; A. Wiang Pa Pao, Ban Mae Kachiang. Khon Kaen Prov., Ban Kud Khae; Ban Nong Bua. Prachinburi Prov., A. Sa Kaeo, Ban Nong Ka Poa. SiSaKet Prov., A. Khun Han, Ban Ta Muan.

VIETNAM: Chu Lai (Tisdale). Da Nang (Hicks). Di Linh, Djiring (Quate). Phan Rang (Leech). Pleiku (Quate). Postal de M'drak (Yoshimoto).

Synonymy and Variation.--Some previous distribution records for *C. peregrinus* were based on misidentifications. Tokunaga (1937) erroneously recorded *C. peregrinus* from Taiwan and this record as well as Arnaud's (1956) redescription and records of *C. peregrinus* from Japan, Korea, and Taiwan refer to *C. nipponensis* Tokunaga. McDonald and Lu (1972) and McDonald et al. (1973) correctly redescribed and figured *C. peregrinus* from Taiwan and Okinawa, respectively, but included the previous erroneous records for *C nipponensis* in their synonymies. The correct distribution of *C. nipponensis* and *C. peregrinus* was given by Kitaoka (1977).

Culicoides nipponensis possesses the swollen, blackish second palpal segment like that of *C. peregrinus* and the wing pattern is similar, but in *C. nipponensis* the pale spot at the base of wing cell M2 and the pale spots at the wing margin at the apices of veins M1, M2, M3+4 and Cu1 are absent, the sensilla are scattered on the surface of the third palpal segment, the antennal sensory pattern is 3,5,7,9,11-15, and the ninth tergum of the male genitalia is not bilobed.

Tokunaga (1959, 1962b, 1976) did not record *C. peregrinus* from New Guinea and his separation of *C. novaguineanus* Tokunaga (1959) from *C peregrinus* was based on his erroneous earlier (1937) concept of *C peregrinus* sensu *nipponensis*.

Variation.--There is considerable variation in the extent of the pale wing markings of *C. peregrinus*. Some females from Cholburi, Thailand are larger with more extensive, yellowish, pale wing markings, and the pale spot at the base of the mediocubital fork continues along veins M3+4 and Cu1 to the wing margin.

According to Murray (1975) *C. peregrinus* in northern Australia is associated with flood plains, attacking cattle in the early morning while it is still dark, and ceasing at daylight, and attacking the back and upper sides of the host. The species also attacks buffalo (Standfast and Dyce 1972). According to Kitaoka (1977) both *C. peregrinus* and *C. nipponensis* are strongly zoophilic and feed readily on cattle and horses. Our records given above include numerous collections biting man, from cattle, pigs, and poultry. The species appears to be a general feeder. Standfast and Dyce (1972) and Murray (1975) considered *C. peregrinus* to be a potential disease vector of ephemeral fever of cattle and bluetongue of cattle and sheep in Australia, but subsequent experimental transmission attempts (Standfast et al. in prep.) demonstrated that this species was an ineffective vector of Australian bluetongue isolates in sheep.

Breeding Habits.--Edwards (1922) recorded *C. peregrinus* bred from a shaded muddy pool margin in Malaysia. Mayer (1934b) described the pupa from southern Sumatra. We have seen a specimen reared from a polluted drain, Singapore, ix.1961, K.L. Chan. The species was the most common *Culicoides* collected in rice paddies in Thailand by Yasumatsu et al. (1980).

Culicoides pikongkoi Howarth
(Figs. 104, 269)

Culicoides (*Haemophoructus* ?) *pikongkoi* Howarth, 1985: 51 (female; Laos; figs.).

Female.--Wing length 1.21 (1.17-1.26, n = 3) mm.

Head: Eyes contiguous for a short distance, bare. Antenna (fig. 104a) with lengths of flagellar segments in proportion of 19-18-19-20-20-21-20-22-27-26-28-29-41, antennal ratio 0.95 (0.93-0.96, n = 3); sensilla coeloconica present on segments 3,(11,12),13-15. Palpus (fig. 104b) with lengths of segments in proportion of 14-43-42-21-20; third segment elongate, slightly swollen in midportion, with sensilla scattered on distal half; palpal ratio 4.3 (4.0-4.7, n = 3). Proboscis long, P/H Ratio 0.89 (0.86-0.92, n = 3); mandible (fig. 104c) with 17 (17-18, n = 3) small teeth.

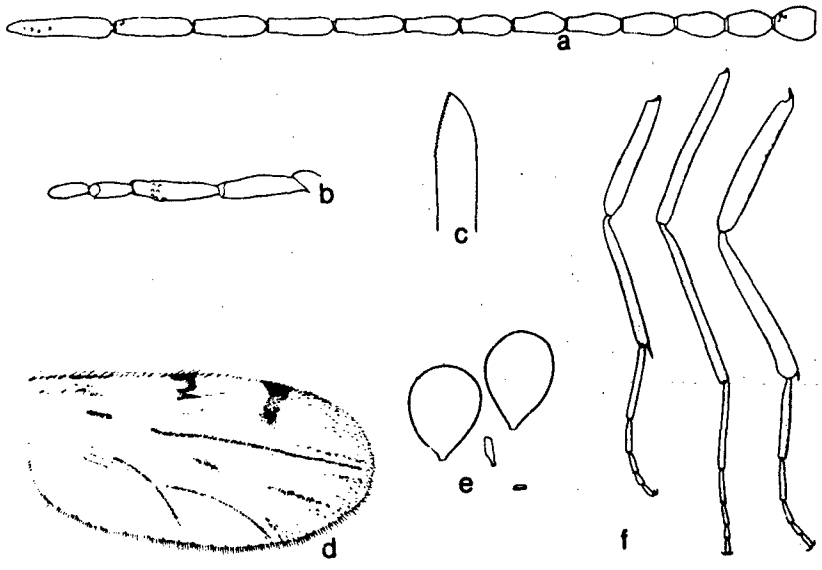


Fig. 104. *Culicoides pikongkoi*: a. antenna; b. palpus; c. mandible; d. wing; e. spermathecae; f. legs.

Thorax: Brown; mesonotum and pleuron yellowish brown with contrasting dark brown markings, scutellum light brown, postscutellum dark brown. Legs (fig. 104f) brown with stramineous bands; fore- and midknees broadly pale, fore- and midfemora with broad apical pale bands, tibiae with broad basal pale bands;

hindfemur with dark tip and narrow subapical pale band, tibia with broad basal and narrow apical pale bands; hindtibial comb with 6 spines, second from spur longest.

Wing (fig. 104d, 26♀): Pattern as figured; 2 radial cells present, the second moderately elongate and broad, weakly separated from first. Three transverse dark bands meeting anterior wing margin, narrow, subequal in width; base of wing including anal angle broadly pale; pale spot over r-m crossvein large, broadly meeting anterior wing margin and confluent with large pale spot in cell M2 just anterior to mediocubital fork; poststigmatic pale spot in cell R5 large, not crossing vein M1, covering most of second radial cell, costa not reaching distal dark band; distal pale spot in cell R5 large, round, not crossing vein M1; apex of wing narrowly pale; large double pale spot present over midportion of vein M1; small round pale spot indistinctly meeting pale wing margin in cell M1; small round pale spot in apex of cell M2 broadly meeting wing margin; large marginal pale spot in cell M4; large double pale spot distally in anal cell. Macrotrichia moderately dense in anterior half of cell R5 distad of poststigmatic pale spot, in apices of cells M1 and M2, and in longitudinal rows parallel to veins in apical third of cells M5, M1, and M2; costal ratio 0.64 (0.64-0.65, n = 3). Halter pale.

Abdomen: Light brown. Spermathecae (fig. 104e) ovoid, tapering to short slender necks; subequal, each 0.075 x 0.055 mm.

Male.--Unknown.

Distribution.--Laos.

Types.--Holotype female, 2 female paratypes, Laos, Sedone Prov., Muong Pakson, 1,270 m, 6.ix.1967, F.G. Howarth (in B.P. Bishop Mus.).

Southeast Asia Records.--
LAOS: Sedone Prov., known only from the type series.

Discussion.--This species is closely related to *C. indianus* Macfie but can be readily separated from that species by the pale halteres, the broadly pale apex of the forefemur, and its larger size. *Culicoides cylindratus* Kitaoka (1980) from the Ryukyu Islands and Taiwan is also similar but differs in having a subapical band on the hindfemur and dark halteres.

Culicoides recurvus Delfinado
(Figs. 105, 270, 413)

Culicoides recurvus Delfinado, 1961: 663 (male, female; Philippines; figs.); Howarth, 1985: 61 (Laos records).

Female.--Wing length 1.00 (0.95-1.04, n = 22) mm.

Head: Eyes (fig. 105c) moderately separated, bare. Antenna (fig. 105a) with lengths of flagellar segments in proportion of 19-13-115-16-16-15-16-17-24-24-29-31-44, antennal ratio 1.19 (1.13-1.26, n = 14); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 105b) with lengths in proportion of 10-18-28-12-

15; second segment nearly as stout as third; third segment moderately swollen, with an irregular double sensory area just beyond middle, tapering and slender beyond the sensory area; palpal ratio 2.2 (2.1-2.4, n = 5). Proboscis moderately short, P/H Ratio 0.74; mandible with 13 (12-16, n = 30) teeth.

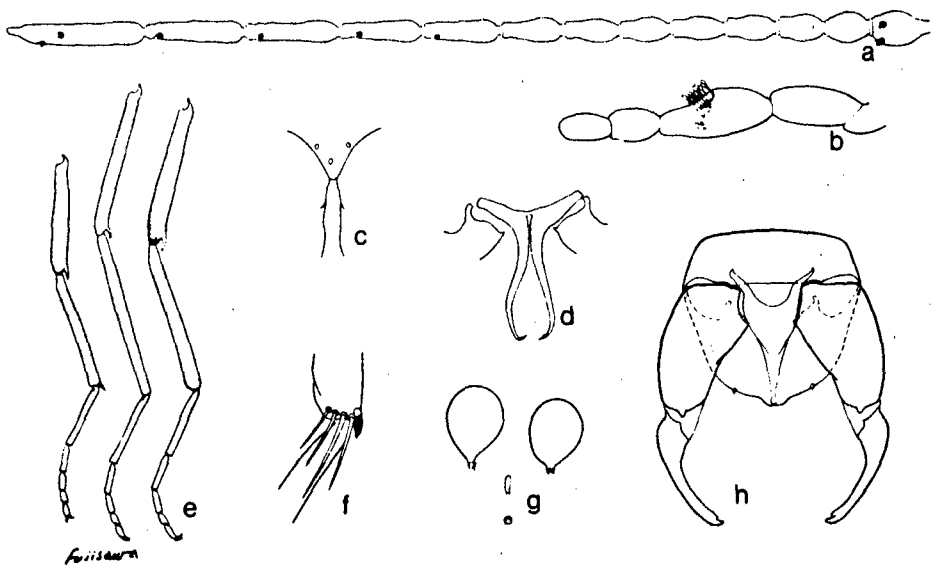


Fig. 105. *Culicoides recurvus*: a. antenna; b. palpus; c. eye separation; d. parameres; e. legs; f. tibial comb; g. spermathecae; h. male genitalia, parameres omitted.

Thorax: Brownish, mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 105e) brownish; femora dark to tip, bases of tibiae narrowly yellowish; tarsi pale; hindtibial comb (fig. 105f) with 5 (n = 18) spines, second from spur longest.

Wing (fig. 270, 413): Pattern as figured; pale spot over r-m crossvein small, distinctly separated by a dark line along radius from small pale spot anteriorly on costal margin; poststigmatic pale spot small, with prominent dark line penetrating proximal edge along vein R4+5 distad to point where vein turns abruptly cephalad toward costa; distal pale spot in cell R5 small, transverse, not meeting anterior wing margin; indistinct pale area at wing base along bases of radius and media; cell M2 with double pale spot lying between medial and mediocubital forks; vein M1 with pale spot at wing tip; vein M2 straddled at midlength or slightly distad by a small double pale spot formed of two pale spots distinctly separated by a dark line along the vein; cell M1 with one small pale spot in distal portion located distant from wing margin; cell M2 with a small pale spot distally near wing margin; cell M4 with small round pale spot at wing margin in distal part of cell; anal

cell with an oblique pale spot near base and two round pale spots in distal portion. Macrotrichia very scanty on distal fourth of wing; costal ratio 0.63 (0.60-0.65, n = 11); 2 radial cells, first narrow, second short and broad. Halter dark brown.

Abdomen: Brownish. Spermathecae (fig. 105g) ovoid, obliquely tapering to short slender necks; slightly unequal, 0.052 x 0.040 mm and 0.049 x 0.037 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 105h): Ninth sternum moderately broad, with shallow caudomedian excavation, ventral membrane bare; ninth tergum rounded caudad, with thinly sclerotized median lobe, apicolateral papillae minute. Basistyle moderately stout, mesal margin with very fine spinules, ventral root absent, dorsal root slender; dististyle stout and bent at base, slightly curved and slender distally, ending in a point. Aedeagus with rounded basal arch at proximal fourth, anterior sclerotized rim not well developed, main body relatively broad, tapering distally to slender apex with spherical tip, internal peg present but weakly sclerotized. Parameres (fig. 105d) narrowly joined at bases; each with basal arm tapering, rather slender laterally, stem slender, nearly straight, tapering distally to fine, curved, filamentous tip with very fine fringing distal hairs.

Distribution.--India, Indonesia, Laos, Malaysia, Philippines, Sri Lanka, Thailand, Vietnam.

Type.- Holotype female, Clark Air Base, Angeles, Pampanga, Philippines, 17.ix.1957, I. Balatbat (collection of Philippine Department of Health, Manila).

Southeast Asia Records

INDONESIA: Bali, Klungkung, Gianyar, Singapadu (Sweattman). Kalimantan (South), Astambul, Tanah Intan, Bumirata and Pulo Tiga (Lee). Sulawesi (Southeast), Kendari, Unaha and Ranometo, Randono, (Bambang). Sumatra, Bengkulu, Padang, Panjang, Pekik Nyaring (Mathis).

LAOS: Sayaboury Prov., Sayaboury (Howarth).

MALAYSIA: Pahang, Kuala Singgora (Wharton); Kuantan, Gudang Rasan (Wharton).

PHILIPPINES: Luzon, Pampanga Prov., Angeles, Clark Air Base (Balatbat, types). Mindanao, Kidapawan, Cotabato (Kalaw). Samar, Taft (Balatbat).

THAILAND: Bangkok (Causey). Chiang Mai Prov. (Notananda). Chiang Rai Prov. (Causey). Minburi (Manop R.). Nakronprathom (Manop R.).

VIETNAM: Ban Me Thuot, 500 m (Quate). Da Nang (Hicks). 13 km W Postal de M'drak (Yoshimoto).

Discussion.--In addition to the above records, there are in the USNM collection specimens from Sri Lanka, Colombo, Kalutaluwewa (Med. Res. Inst.) and from India, Assam, Rupsi, 16 mi NW Dhubri (Hardy). This species has the second palpal segment stout as in *C. peregrinus* Kieffer and *C. hirtipennis* Delfinado, and the dark line along vein R4+5 penetrating the base of the poststigmatic pale spot as in *C. peregrinus*. The broadly separated eyes and pale tip of vein M1 will separate *C. recurvus* from *C. peregrinus*, while the dark extension of vein R4+5 and the

pale tip of vein M1 will separate it from *C. hirtipennis*. This species is probably most closely related to *C. hirtipennis*, but has mainly a more northern and western distribution.

Culicoides spiculae Howarth
(Figs. 106, 271)

Culicoides (*Haemophoructus* ?) *spiculae* Howarth, 1985: 53 (male, female; Laos; figs.).

Female.--Wing length 1.13 (1.02-1.22, n = 20) mm.

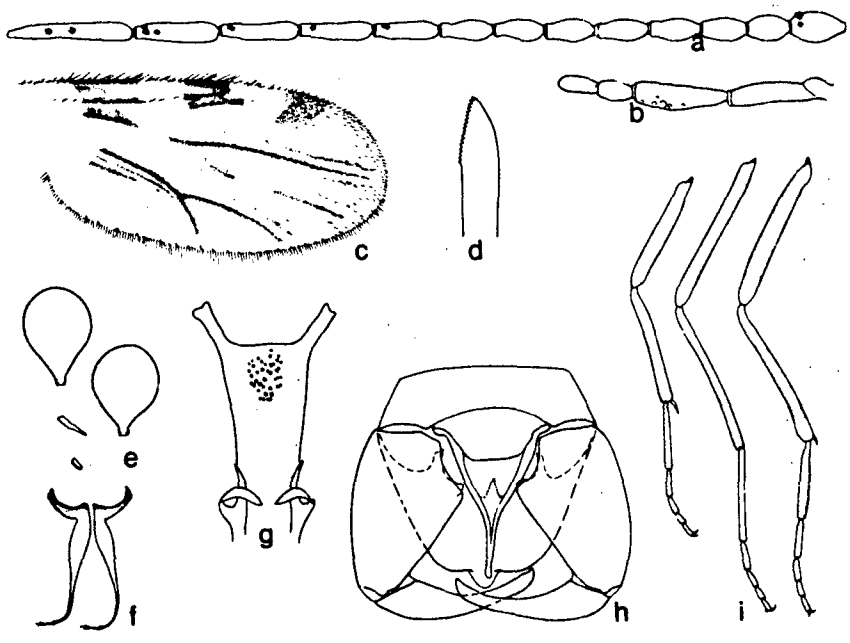


Fig. 106. *Culicoides spiculae*: a. antenna; b. palpus; c. wing; d. mandible; e. spermathecae; f. parameres; g. cibarial armature; h. male genitalia, parameres omitted; i. legs.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 106a) with lengths of flagellar segments in proportion of 21-17-19-19-20-19-20-20-25-28-31-34-48, antennal ratio 1.08 (1.01-1.14, n = 20); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 106b) with lengths in proportion of 10-31-32-12-14; third segment elongate, slightly swollen in midportion, sensilla scattered over distal half;

palpal ratio 3.9 (3.3-4.7, n = 20). Proboscis moderately long, P/H Ratio 0.78 (0.72-0.84, n = 20); mandible (fig. 106d) with 16-21 (n = 12) small teeth; cibarium (fig. 106g) with conspicuous patch of about 50 blunt triangular spinules.

Thorax: Dark brown; mesonotum with varying amounts of poorly contrasting paler markings. Legs (fig. 106i) dark brown, knees narrowly pale; forefemur with narrow indistinct apical pale band, tibia with narrow basal pale band; mid- and hindfemora each with narrow apical yellowish band, midtibia with narrow basal yellowish band, hindtibia with wide basal and narrow apical pale bands; hindtibial comb with 5-6 spines, second from short spur longest.

Wing (fig. 106c, 271): Pattern as figured; 1 or 2 radial cells, if divided the second broad and 1.5 times length of first. Three dark spots on anterior margin as wide as adjacent pale spots; base of wing including anal angle broadly pale; pale spot over r-m crossvein broadly meeting wing margin, narrowly crossing media and meeting pale streak in cell M2; poststigmatic pale spot in cell R5 transverse, not meeting vein M1; distal pale spot in cell R5 moderately large, round to slightly transverse, rarely crossing vein M1, often joining a narrow, indistinct pale streak along anterior wing margin; large double pale spot present over middle of vein M2; round or elongate pale spot distally in cell M1, sometimes meeting wing margin; one large apical pale spot each in cells M2 and M4; double pale spot distally in anal cell; large pale spot in cell M2 in front of mediocubital fork and behind medial fork connected to pale wing base by a narrow pale streak in cell M2. Macrotrichia moderately numerous in anterior half of cell R5, in apex of cell M1, and in rows parallel to veins M1, M2, and M3+4 in cells R5, M1, and M2; costal ratio 0.69 (0.65-0.72, n = 20). Halter pale.

Abdomen: Brown. Spermathecae (fig. 106e) ovoid, tapering conically to slender necks; subequal, each 0.058 x 0.040 mm.

Male.--Similar to female with usual sexual differences; wing with two radial cells; sensilla coeloconica present on antennal segments 3,13-15. Genitalia (fig. 106h): Ninth sternum with broad shallow caudomedian excavation; ninth tergum rounded caudad with well-developed hyaline median lobe. Basistyle with patch of moderately coarse setae on mesal margin, ventral root not developed, dorsal root short; dististyle slightly surved and tapering to pointed apex. Aedeagus with basal arch extending less than one-fourth length of aedeagus; main portion somewhat triangular in ventral outline, internal sclerotized peg present; distal portion slender, about a third of length of aedeagus, with rounded terminal papilla. Parameres (fig. 106f) with bases separate; each with short basal arm, main body moderately swollen, poorly sclerotized, tapering to attenuated tip abruptly bent ventrad, tip minutely hairy.

Distribution.--Laos.

Types.--Holotype female, allotype male, Laos, Vientiane Prov., Muong Ban Keun, Ban Na Pheng, 180 m, 21.v.1968, F.G. Howarth (Bishop Mus.).

Southeast Asia Records.--

LAOS: Sayaboury Prov., Muong Xiong Hon, 500 m (Howarth); Sayaboury, 300 m (Howarth). Sedone Prov., Muong Pakse, 100 m (Howarth). Vientiane Prov., types (Howarth).

Discussion.--The absence of a definite palpal pit, the contiguous eyes, and the presence of a subapical pale band on the hindfemur, ally this species with *C. klossi* Edwards. In *C. klossi*, however, the forefemur is pale apically, the wing has a dark spot in the anal angle, and the cibarium lacks the patch of spiculate teeth.

As pointed out by Howarth (1985), *Culicoides spiculae* belongs to a group of species intermediate between *Haemophoructus* and *Hoffmania* which possess one or two radial cells, sometimes in the same individual, and have widely scattered sensilla on the third palpal segment. We have retained these species for convenience in the subgenus *Hoffmania* since they cannot be assigned definitely to *Haemophoructus*. In addition to *C. spiculae*, this group of species includes *C. indianus* Macfie and *C. pikongkoi* Howarth.

Culicoides sumatrae Macfie
(Figs. 107, 272, 414)

Culicoides sumatrae Macfie, 1934a: 190 (female; Malaya); Macfie, 1934b: 215 (male; Sumatra; reared from *Polyporus*; fig. genitalia); Causey, 1938: 412 (male, female; Thailand; fig. spermathecae, wing (as *hewitti*, figs. 32 and 33 transposed); Howarth, 1985: 62 (Laos records); Kitaoka, 1985a: 79 (Japan; in key; syn.: *amamiensis*).

Culicoides amamiensis Tokunaga, 1937: 325 (female; Ryukyu Islands; figs.); Tokunaga, 1950: 66 (Japan; variation); Arnaud, 1956: 90 (redescribed; figs.; distribution); Tokunaga, 1959: 230 (New Guinea; redescribed); Wirth and Hubert, 1961: 17 (Taiwan; syn. *kagiensis* Tokunaga); Kitaoka et al., 1963: 47 (Japanese distribution); Bergner and Jachowski, 1968: 1 (vector of filaria of monkeys in Taiwan); Kitaoka and Suzuki, 1974: 17 (Amami-Oshima records); Kitaoka, 1977: 191 (Nansai Islands records).

Culicoides kagiensis Tokunaga, 1937: 327 (female; Taiwan; figs.).

Culicoides assimilis Delfinado, 1961: 660 (female; Philippines; figs.). NEW SYNONYMY.

Female.--Wing length 1.06 (0.90-1.21, n = 13) mm.

Head: Eyes contiguous, bare. Antenna (fig. 107a) with lengths of flagellar segments in proportion of 21-16-19-21-21-20-20-21-27-29-34-35-51, antennal ratio 1.11 (1.05-1.19, n = 8); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 107b) with lengths of segments in proportion of 7-20-30-15-12; third segment slightly swollen on basal half, slender distally, with a small, round, shallow sensory pit at base of narrowed portion; palpal ratio 3.1 (2.9-3.4, n = 11). Proboscis moderately long, P/H Ratio 0.85; mandible with 20 (18-23, n = 21) teeth.

Thorax: Dark brown, mesonotum (fig. 107c) dull dark grayish brown, with broad blackish median vitta anterior to level of humeral pits, and a pair of broad blackish sublateral vittae behind level of pits. Legs (fig. 107e) dark brown; foreleg with knee spot blackish, femur with subapical and tibia with basal, narrow pale rings; midleg with knee, apex of femur, and base of tibia pale; hindleg with narrow base and apex of tibia pale; apices of tarsi paler; hindtibial comb (fig. 107d) with 5 (n = 13) spines, second from spur longest.

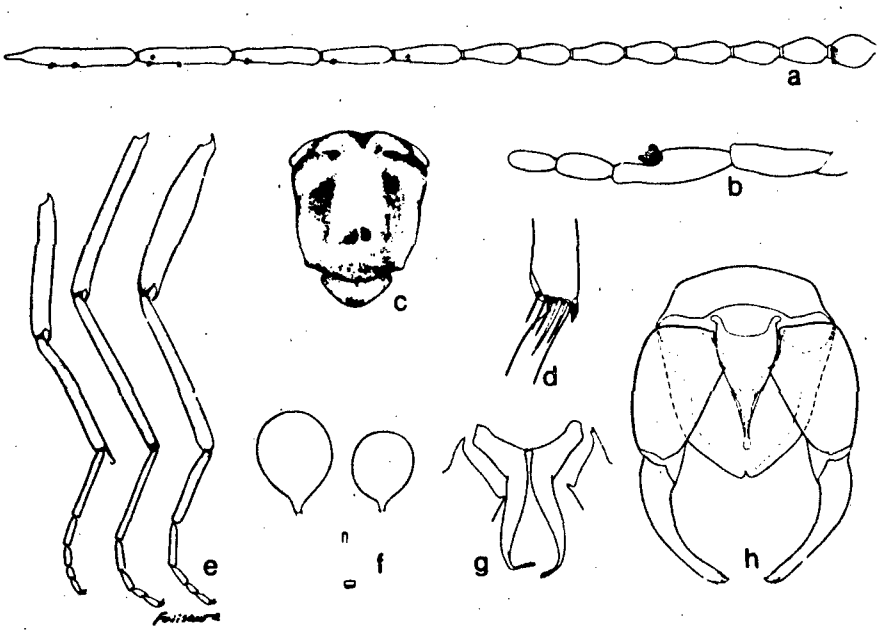


Fig. 107. *Culicoides sumatrae*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Wing (fig. 272, 414): Pattern as figured; dark brown with extensive pattern of distinct round pale spots; anterior margin with three very dark areas; base of wing with large pale area over basal arculus extending slightly into anal cell; pale spot over r-m crossvein narrow to moderately large, extending from costal margin to media, usually interrupted by a dark line bordering radius; poststigmatic pale spot in cell R5 about as broad as the very dark area distal to it, slightly broader at anterior wing margin, slightly indented proximad by a short dark distal extension of vein R4+5; pale spot in distal portion of cell R5 transverse, not reaching vein M1 and usually falling short of anterior wing margin; midportion of vein M2 embraced by a pair of oval pale spots in cells M1 and M2, usually not quite touching the vein; distal pale spot in cell M1 round to oval, not meeting wing margin; distal pale spot in cell M2 round and almost meeting wing margin; a similar pale spot at wing margin in cell M4; a large pale spot in cell M2 in space between medial and mediocubital forks, a pale streak connecting this spot narrowly with basal pale area of wing; anal cell with two round pale spots in distal portion and a small, less

regular one near anal angle; apex of vein M1 with pale spot at wing margin. Macrotrichia sparse, confined to distal fourth of wing; costal ratio 0.68 (0.67-0.70, n = 13); 2 radial cells present, the first slitlike, second with broad lumen. Halter pale.

Abdomen: Dark brown, cerci pale. Spermathecae (fig. 107f) ovoid, with slender sclerotized necks; unequal, 0.058 x 0.042 mm and 0.047 x 0.035 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 107h): Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum rounded caudally without apicolateral processes, caudal margin with very small median notch. Basistyle with ventral root absent, dorsal root short and slender; dististyle curving from base, straighter and slender distally, without distal expansion but with sharp inner point at tip. Aedeagus with basal arch short, extending to less than a fifth of total length, with a sclerotized anterior rim across base of arch, an internal sclerotized peg distally; distal portion quite slender with spherical tip. Parameres (fig. 107g) joined basally by a minute sclerotized filament; each with short, stout basal arm directed anterolaterally; stem moderately stout at base, gradually tapering to slender tip curving ventrad and ending in a filamentous point with 5-6 fringing hairs.

Distribution.--Eastern Asia from Manchuria to Ryukyu Islands, Taiwan, Philippines, Indonesia, Laos, New Guinea, Thailand and Malaysia.

Types.--Holotype female of *C. sumatrae*, Kuala Lumpur, Selangor, Malaysia, 29.i.1924, at light, H.M. Pendlebury (B.M. 1930-510; pres. by F.M.S. Museums) (in BMNH). Holotype of *C. amamiensis*, female, Yaku-kachi, Simiyo-mura, Amami-Oshima, Ryukyu Islands, 18.vii.1933, T. Esaki and K. Yasumatsu (deposited in Kyushu University, Hakata, Japan). Holotype of *C. kagiensis*, female, Kagi, Taiwan, 28.xii.1934, M. Tokunaga (in Kyushu University). Holotype of *C. assimilis*, female, Kidapawan, Cotabato, Philippines, 13.vii.1957, F. Kalaw, carabao-baited trap (in Philippine Department of Health, Manila).

Southeast Asia Records.--

BRUNEI: Kg. Selembigar, in fowl house (Colless).

INDONESIA: Bali, Klungkung, Timuhan (Sweatman). Flores, Manggarai, Reo, Golok (Nasir). Java, Bogor (Adiwinata); (Central), Ambarawa, Pogok Sari (Sudjadi); (Central), Cilacap, Adipala, Silangsur Lor of Wlahar (Lee); (West), Pandeglang, Ujung Kulon (Watters). Kalimantan (South), Banjar, Astambul, Tanah Intan, Pondok Delapan and Pulotiga (Lee); Banjar, Martapura, Bincau (Lee). Lombok, Tabane, 35 km N Maratam (Nicholls). Sulawesi (Central), Banggai, Batu, Kamiwangi (Bambang); (North), Dumoga-Bone Nat. Park, 220 m (Heppner). Sumatra, Batam Island, Sungai Beduk (Sustriayu); Bengkulu, Pekik Nyaring (Mathis); Bengkulu, Seluma, Bukit Penin Guan (Mathis). Timor (East), Dilli, Comoro (Soeroto).

LAOS: Sayaboury Prov., Sayaboury, reared from arum leaf axil from shaded damp woods (Howarth); Muong Phieng (Howarth); Muong Xieng Hon (Howarth). Sedone Prov., Muong Pakse (Howarth); Muong Pakxong (Howarth). Vientiane Prov., Muong Ban Keun, Ban Na Pheng (Howarth); Muong Vang Vieng, biting man (Howarth).

MALAYSIA: Johore, Kg. Parit Ahmad, Batu Pahat, pig shed (Garcia); Mersing Camp, biting man (Traub). Kelantan, Lambok, Sungei Betis, Ulu Kelantan (Wharton); Sungei Nenggiri, Ulu Kelantan (Wharton). Kedah, Lahgkaw Island (Traub). Pahang, King George V Nat. Park, Tahan River (McClure, Quate); Kuala Singgora (Wharton); Kuala Tahan (Quate). biting man (Domrow); Kuala Trengganu (Gressitt, Maa); Kuantan, Paya Bungor (Wharton); Mt. Brinchang, 1,600 m (McClure); Tasek Bera (Wharton); Ulu Gali, cattle shed (Garcia); Yatin to Trengganu (Quate, Maa and Gressitt). Perak, Gunong Besont Forest Res. (Jeffery); Kuala Kengrong, Girik (Traub) Pulau Pangkor (Traub). Selangor, Ulu Gombak Forest Res., reared from rotting ginger flower in jungle (Manikumar); Kepong Forest Res. (McClure); Kuala Lumpur (Barnett; Traub); Serdang (Barnett); Bugang Forest Res. (McClure); Ulu Lui, Ulu Langat, biting man (Wharton). Trengganu, Dungun, Bukit Besi (Traub).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Rizal Prov., Tala (Delfinado); Pampanga Prov., Angeles, Clark Air Base (Balatbat). Mindanao, Cotabato Prov., Kidapawan, carabao trap (Kalaw); Davao Prov., Maco, Tagum (Hoogstraal and Heyneman); Mindanao, Agusan Prov., Los Arcos (Quate). Negros Oriental, Cuernos de Negros, Camp Lookout (Delfinado). Palawan, Brookes Point, Makagwa (Noona Dan Exped.); Kukukan, Erah Point and Tarumpito (Quate). Tawi Tawi, Tarawakan (Noona Dan Exped.).

SABAH: Labuan Island (Colless, Quate). Sandokan Dist., Gomantong Caves (Quate and Maa). Tawau Dist., Kalabakan (Maa); Tawau, 48 km W (Maa).

SARAWAK: Kapit Kist., Nanga Pelagus (Traub). Gunong Matang (Maa and Gressitt). Kuching, Santabong (Maa). Limbang (Colless). Bau Dist., Pangkalan Tebang (Maa and Gressitt).

SINGAPORE: Kg. Chantek Bahru (Colless); Nee Soon (Colless).

THAILAND: Chanthaburi (Maa). Chaiyaphum, Chulabhorn Dam (Yasumatsu). Chiang Mai Prov., Ban Tin Doi (Gressitt). Chiang Rai Prov. (Causey). Lopburi (Manop R.). Nakronpanom (Manop R.). Nakronprathom (Manop R.). Nonthaburi (Manop R.).

VIETNAM: Chu Lai (Tisdale). Da Nang (Hicks). Dak Song, Ban Me Thuot (Quate). Dralac, Dalat (Spencer). Saigon (Spencer).

Discussion.--Macfie described *C. sumatrae* twice in the same year in separate journals. The paper in which the female from Kuala Lumpur, Malaysia, was described (Macfie, 1934a) appeared on 12.vii.1934, and the description of the male from Fort de Kock, Sumatra, appeared in November 1934 (Macfie, 1934b). Thus the description of the female clearly has priority; the holotype has been examined and is the same species that has gone under the name *C. amamiensis* Tokunaga in numerous recent papers (see above). The identity of the male Jacobson reared from *Polyporus* fungus and described by Macfie (1934b) is questionable. The pinned male type was borrowed from the BNMH in 1980; the genitalia and one wing had been dissected from the specimen and mounted on two celluloid slips attached to the pin. The slip which apparently had received the genitalia was bare and the genitalia are apparently lost; the slip containing the wing has been remounted permanently on a separate slide. This wing agrees in details with the wing of the holotype female from Kuala Lumpur. For exact deter-

mination of the species it would be necessary to examine the male genitalia and males of several species closely related to *C. sumatrae* are not presently distinguishable even by their genitalia.

Through the kindness of Dr. Paul Dessart we have examined the holotype female of *Culicoides nigroannulatus* Geotghebuer (1932) from Menado, Celebes (Van Brackel coll.) which is deposited in the Brussels Museum. The specimen, which is double-mounted on a minuten pin, is fragmentary, only the thorax and abdomen, 1 wing and a portion of 1 midleg remaining. The halter is pale, and from the wing the species is quite similar to *C. sumatrae*. Because of the poor condition of the type we decline to propose the synonymy with *C. sumatrae*, and prefer to regard *C. nigroannulatus* as an unrecognizable species.

Culicoides malayae Macfie is structurally very similar to *C. sumatrae*, with virtually the same measurements, and it has pale halteres also, but it can be distinguished by the more extensive pale wing pattern, with the pale spot lying over r-m crossvein extending angularly into the base of cell R5 and narrowly caudad into cell M2, and the pale spot covering the second radial cell extends broadly to vein M1 and usually connects with the pale spot straddling vein M2.

The commoner species which can be confused with *C. sumatrae* differ considerably in their distribution patterns, thus affording a clue to their existence as distinct species. *Culicoides sumatrae* occurs in abundance throughout the Malaysian Subregion, from Malaysia through the Philippines and north to Japan. It is not common in Thailand and does not occur to the west in India. *Culicoides innoxius* Sen and Das Gupta, on the other hand, is the only species in this complex which occurs in India according to our records; it is quite common in Thailand, but occurs only sparingly in peneinsular Malaysia and Sabah, and not at all as far as the Philippines. *Culicoides malayae* Macfie has a much more restricted distribution and is definitiely known only from Malaysia, Sabah, the Philippines, Thailand, and the Ryukyus.

Biology.--Macfie (1934b) reported a specimen reared from *Polyporus* fungus in Sumatra. Howarth (1985) reared *C. sumatrae* from arum leaf axils in Laos. Manikumar reared the species from rotting ginger flowers in the jungle in the Ulu Gombak Forest Reserve near Kuala Lumpur. This species appears to be highly attracted to man, as shown by the numerous biting records reported here.

Culicoides tenuifasciatus Wirth and Hubert, new species
(Figs. 108, 273, 415)

Female.--Wing length 1.21 mm.

Head: Eyes (fig. 108c) contiguous a short distance, bare. Antenna (fig. 108a) with lengths of flagellar segments in proportion of 30-26-29-31-32-32-32-32-39-39-40-45-68, antennal ratio 0.95; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 108b) with lengths of segments in proportion of 15-46-60-28-27; third segment slender, subcylindrical to slightly fusiform, with sensilla scattered on surface of distal portion of segment; palpal ratio 4.0. Proboscis moderately long, P/H Ratio 0.87; mandible with 18 teeth.

Thorax: Dark brown, mesonotum without prominent pattern as seen in slide-mounted specimen. Legs (fig. 108d) dark brown; knee spots absent; midknee pale on each side of joint; fore- and hindtibiae with narrow basal pale ring, hindtibia narrowly pale at tip; hindtibial comb (fig. 108e) with 6 spines, second from spur longest.

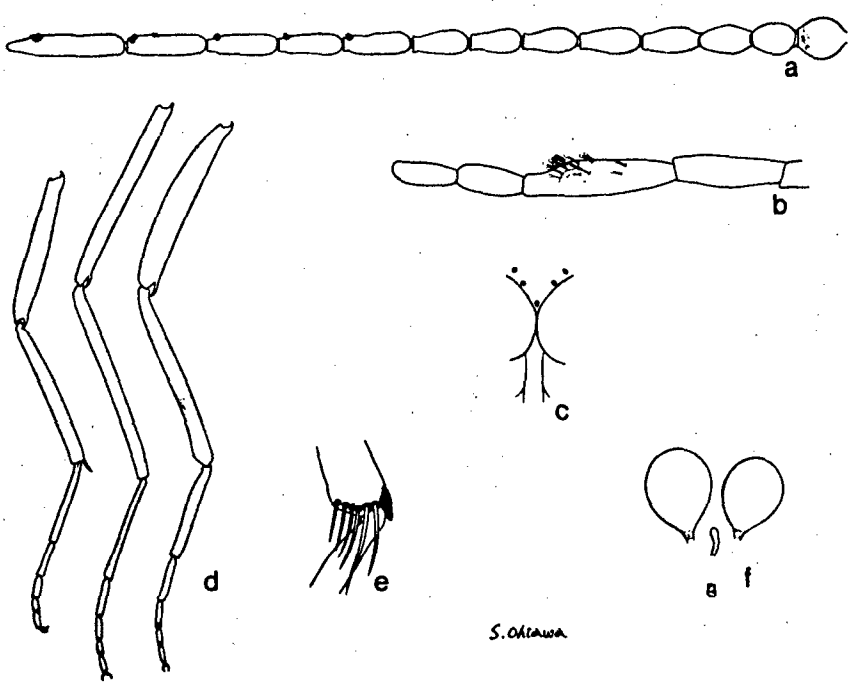


Fig. 108. *Culicoides tenuifasciatus*: a. antenna; b. palpus; c. eye separation; d. legs; e. tibial comb; f. spermathecae.

Wing (fig. 273, 415): Pattern as figured, anterior margin with 3 narrow dark brown transverse bands; base of wing pale more than half of distance to r-m crossvein, pale area extending entirely across base of anal cell to anal angle; pale areas over r-m crossvein and over distal part of second radial cell broad and quadrate, each about 4 times as broad as respective distal dark fascia; cell R5 with distal pale area large, extending to apex of cell; vein M2 with large quadrate pale area straddling midportion; distal pale area in cell M1 narrowly meeting wing margin, that in cell M2 round and broadly meeting wing margin; base of cell M2 pale, continuous with pale spot lying between medial and mediocubital forks; large pale spot in cell M4 filling most of distal portion of cell; anal cell with two

large, narrowly connected pale spots in distal portion; apices of veins M1, M2, M3+4, and Cu1 dark. Macrotrichia scanty on distal fourth of wing; costal ratio 0.68; first radial cell narrow, second with broad lumen. Halter pale.

Abdomen: Dark brown. Spermathecae (fig. 108f) ovoid with short slender necks; unequal, 0.055 x 0.038 mm and 0.049 x 0.034 mm.

Male.--Unknown.

Distribution.--Malaysia.

Type.--Holotype female, Kuala Lumpur, Selangor, Malaysia, i.1959, R. Traub, light trap (Type in USNM). Paratypes, Kepong, Selangor, Malaysia, 8.iii.1955, H.C. Barnett, biting deer, 1 female. Perak, Ipoh, 5.i.1978, S. Kitaoka, 1 female.

Discussion.--Although the broadly pale apex of cell R5 brings this species out in the key with *C. liui* Wirth and Hubert and species of *Avaritia*, its closest relation appears to be with *C. klossi* Edwards, which it resembles in having a slender third palpal segment with scattered sensilla, short distal antennal segments, and general features of the pale wing pattern.

Culicoides trimaculipennis Wirth and Hubert, new species
(Figs. 109, 274, 416)

Female.--Wing length 1.13 mm.

Head: Eyes (fig. 190c) separated by a distance equal to diameter of one ommatidial facet, bare. Antenna (fig. 137a) with lengths of flagellar segments in proportion of 30-24-25-26-27-27-27-27-40-36-37-38-55, antennal ratio 0.99; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 109b) with lengths of segments in proportion of 15-55-55-25-22; third segment long and slender, broadest toward tip near location of moderately large, round, shallow sensory pit; palpal ratio 3.4. Proboscis moderately long, P/H Ratio 0.89; mandible with 16 teeth.

Thorax: Yellowish brown, mesonotum without apparent pattern in slide-mounted specimen. Legs (fig. 109f) uniformly straw-yellowish; hindtibial comb (fig. 109d) with 5 spines, second from spur longest.

Wing (fig. 274, 416): Pattern as figured; pale yellowish with recessive pattern of small brownish areas; anterior wing margin with 3 narrow transverse dark brown spots; first spot not very dark, located halfway between basal arculus and r-m crossvein, extending from costa to media and with reduced intensity as a narrow band into anterior portion of anal cell; second spot quite dark, lying at apex of first radial cell and base of second, extending halfway across cell R5 to vein M1, continuing with reduced intensity as a narrow irregular band across medial fork and following course of vein Cu1 to posterior wing margin; third spot quite dark, appearing as a transverse anterior spot located a third way from end of costa to wing tip, extending three-fourths way across cell R5 to vein M1, appearing again in much reduced intensity as a dark area at tip of vein M3+4. Macrotrichia

scanty, a few in apices of cells; costal ratio 0.62; first radial cell slitlike, second only moderately broad with narrow lumen, slightly tapered distad, second radial cell only slightly longer than first. Halter slightly infuscated.

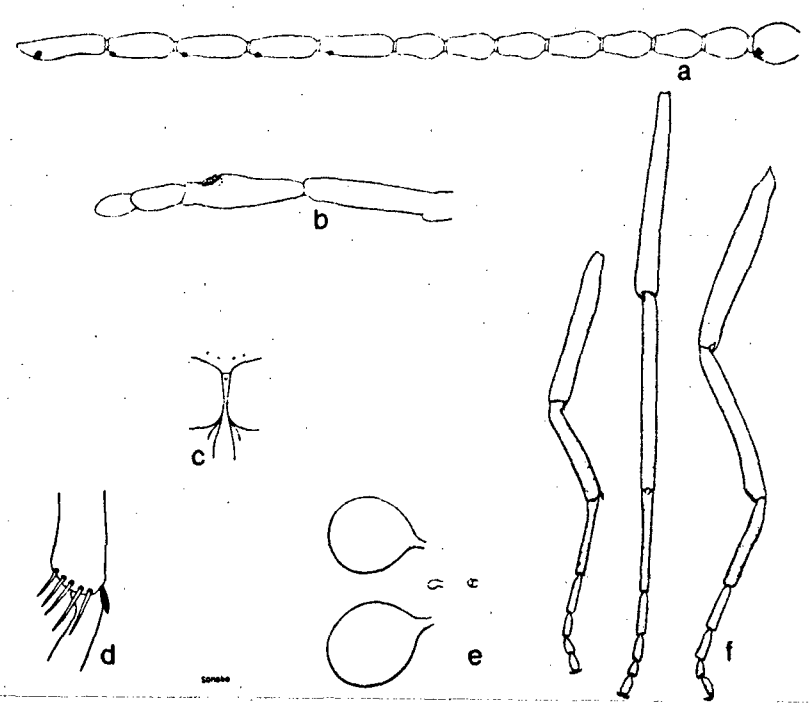


Fig. 109. *Culicoides trimaculipennis*: a. antenna; b. palpus; c. eye separation; d. tibial comb; e. spermathecae; f. legs.

Abdomen: Pale brownish. Spermathecae (fig. 109e) oval to subspherical, with long tapering necks stout at base, slender at duct; unequal, 0.080 x 0.045 mm and 0.058 x 0.042 mm.

Male.--Unknown.

Distribution.--Malaysia.

Type.--Holotype female, Ulu Langat, Selangor, Malaysia, xi-xii.1967, R. Garcia, bait trap in secondary forest (Type in USNM).

Discussion.--*Culicoides trimaculipennis* is provisionally referred to the subgenus *Hoffmania* on the basis of its wing pattern and palpal structure, although it might almost as well be placed in *Avaritia*. The relatively narrow radial cells, short costa, and slender third palpal segment with round shallow pit located near the apex of the segment are not typical of the subgenus *Hoffmania*. The wing pattern is similar to those of *C. tritenuifasciatus* Tokunaga, *C. trizonatus* Tokunaga, and *C. pallidizonatus* Tokunaga from New Guinea, but the New Guinea species have structural characters of a very different group related to the Australian *C. victoriae* Macfie (Alan Dyce, in litt.).

Subgenus **Avaritia** Fox

Culicoides, subgenus *Avaritia* Fox, 1955: 218. Type-species, *Ceratopogon obsoletus* Meigen, by original designation.

Diagnosis.--Eyes contiguous. Antenna with distal segments moderately elongated; sensilla coeloconica usually present on segments 3,11-15. Third palpal segment usually slender, sensory pit small and round, usually rather shallow, located near tip of segment with portion beyond pit not narrowed. Wing with two radial cells, the second short, costa short to moderately long; poststigmatic pale spot usually covering tip of second radial cell a short distance; distal pale spot in cell R5 usually filling apex of cell; apices of veins M1, M2, M3+4 and Cu1 dark at wing margin; macrotrichia scanty. Tibial comb of hindleg with 5 spines, the one nearest the spur usually longest. Two spermathecae, a vestigial one, and a sclerotized ring present; spermathecae ovoid, usually with a narrow sclerotized neck.

Male genitalia with ninth tergum rounded, apicolateral processes replaced by a pair of lightly sclerotized, dorsoventrally flattened flanges, usually emarginate. Basistyle with ventral and dorsal roots long, slender, and simple; dististyle usually slender with distomesal point. Aedeagus of normal form, with slender distal process, and with internal sclerotized peg extending anteriorly from process. Parameres short, usually separate, each with moderately long basal arm extending anterolaterad, midportion short and moderately swollen, tapering distad to simple filamentous point, sometimes with minute fringing hairs at tip.

Immature Stages.--Pupa with respiratory horn stout, without spines or transverse convolutions, lateral openings not borne on protuberances; operculum with long hairlike spines; *ad* setae long, subequal; *d* tubercles 1 to 3 in line and 1 and 2 quite close together; caudal segment with a transverse band of spines across disc.

Larva with unique small eyes made up of a single pigmented spot on each side; head very short and square, broad in front; collar weakly developed. Ventral side of head with short longitudinal suture, head setae moderately long; parahypostomal setae located at a distance from subgenal rim; labrum pointed, with two overlying folds; epipharynx with 2-3 combs, dorsal comb with 7-10 fine teeth. Thorax unpigmented dorsally, with lateral pigmented spots on each segment at midlength.

Habits.--In common with the other known species of *Avaritia*, the Oriental species breed in animal dung, manure piles, fungi, or rotting fruits or other plant materials. The close association of some species with domestic animal dung or manure brings them into play in the transmission of Bluetongue and other livestock diseases.

Actoni Group

Diagnosis.--Very close to the Orientalis Group, but differing in the following characters: Very small species, wing 0.57-0.74 mm long. Eyes contiguous for a shorter distance, with short interfacetal hairs. Distal antennal segments shorter, antennal ratio 1.22-1.27; sensillar pattern varying with the species, 3,12-15 or 3,13-15. Mesonotum blackish with slate-gray pollinosity. Costa shorter, costal ratio 0.51-0.56; second radial cell dark to tip or with very narrow pale area of poststigmatic pale spot covering only part of vein closing apex of cell. Legs paler, without rings but faint infuscation sometimes present on middle of femora and tibiae. This group is closely allied to the Pusillus Group of the Neotropical Region.

Included Species.--This group is found in the Oriental, Afrotropical, and Australian regions, with five species: *actoni* Smith (Oriental, Australasian), *dasyops* Clastrier (West Africa), *grahami* Austen (Africa), and *minimus* n. sp. (Southeast Asia). *Culicoides actoni* and *grahami* are of considerable importance as bloodsucking pests of man.

Culicoides actoni Smith
(Figs. 110, 275, 417)

Culicoides actoni Smith, 1929: 255 (female; Assam; figs.); Delfinado, 1961: 654 (Philippines; fig. wing); Hubert and Wirth, 1961: 236 (Okinawa; in key); McDonald and Lu, 1972: 411 (female diagnosis; Taiwan; figs.); McDonald et al., 1973: 644 (female; diagnosis; Okinawa; figs.); Kitaoka, 1977: 191 (Nansei Is.; syn. *okumensis*); Debenham, 1978: 187 (bibliography; Asutralia); Muller et al., 1981: 579 (Australia; female blood meal sources; Dyce, 1983: 272 (New Guinea records; notes); Howarth, 1985: 63 (diagnosis; Laos records).

Culicoides okumensis Arnaud, 1956: 119 (female; Okinawa; figs.); Lee, 1978: 82 (Rep. China; diagnosis; figs.).

Culicoides imperceptus Das Gupta, 1962c: 538 (male; figs.; India); Dyce and Wirth, 1983: 224 (synonym of *C. actoni*).

Culicoides pungens de Meijere (misident.); Macfie, 1937a: 115 (Malaya; syn.: *actoni*); Buckley, 1938: 142 (Malaya; feeding on cattle; filaria vector).

Culicoides orientalis Macfie (misident.); Tokunaga, 1959: 254 (in part, male only; fig.; New Guinea).

Culicoides robertsi Lee and Reye (misident.); Tokunaga, 1960: 74 (note on male); Tokunaga, 1962b: 485 (male, female; New Guinea, Solomons; fig. wing, male genitalia).

Female.--Wing length 0.74 (0.66-0.83, n = 14) mm.

Head: Eyes contiguous a short distance; with short interfacetal hairs. Antenna (fig. 110a) with lengths of flagellar segments in proportion of 14-10-10-12-13-13-14-16-20-20-24-25-36, antennal ratio 1.22 (1.14-1.29, n = 14); sensilla coeloconica present on segments 3,12-15. Palpus (fig. 110b) with lengths of segments in proportion of 7-18-19-10-11; third segment moderately long and slender, with a small round shallow sensory pit; palpal ratio 2.6 (2.3-3.0, n = 14). Proboscis moderately long, P/H Ratio 0.80; mandible with 13 (12-15, n = 26) teeth.

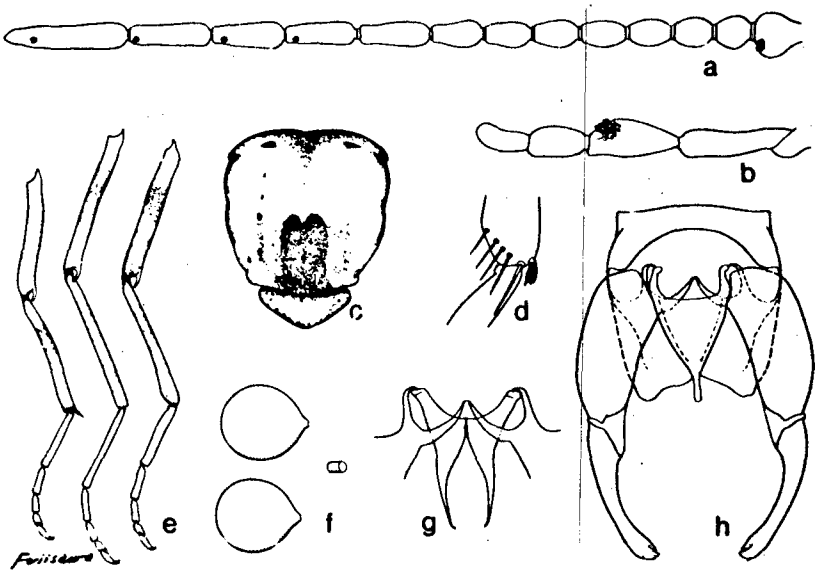


Fig. 110. *Culicoides actoni*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Thorax: Brownish black, mesonotum with greenish black pollenosity.
Legs (fig. 110c) yellowish brown, femora slightly darker in midportions, tibiae with faint paler rings at bases; hindtibial comb (fig. 110d) with 5 spines, the one nearest the spur longest.

Wing (fig. 275, 417): Pattern as figured; pale at base; pale spot over r-m crossvein extending broadly to costa; poststigmatic pale spot in cell R5 large, quadrate, extending proximad only over extreme tip of vein closing second radial cell distally; distal pale spot in cell R5 filling apex of cell, its proximal margin straight and perpendicular to vein M1; only one pale spot in cell M1, at wing mar-

gin; cell M2 with pale streak at base, dark distally except for pale spot at wing margin; cell M4 with pale spot in distal half of cell; anal cell pale at base, with large subapical pale area, the two separated by a wide dark transverse area; apices of veins dark. Macrotrichia very sparse and located near wing margin in apices of cells R5, M1 and M2; costal ratio 0.56 (0.53-0.60, n = 14); radial cells well developed, the second short but with broad lumen, first narrow. Halter pale.

Abdomen: Pale brown at base, darker brown distally. Spermathecae (fig. 110f) ovoid, without sclerotized necks; subequal, each 0.036 x 0.030 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 110h): Ninth sternum with broad, moderately deep, caudomedian excavation, ventral membrane with a narrow transverse band of sparse spicules; ninth tergum short and more or less quadrate, with well developed, somewhat angular, sublateral lobes. Basistyle with ventral and dorsal roots rather stout, ventral root slightly longer; dististyle slender, slightly curved, slightly expanded distally with a distinct distomesal point. Aedeagus moderately broad at base, basal arch extending to a fourth of total length, anterior sclerotized membrane slightly thickened anteriorly, the margin between the basal arms more transverse than rounded; distal process very long and slender, blunt-pointed at tip. Parameres (fig. 110g) separate; each with long basal arm, midportion not greatly swollen, tapering distally to a fine, filamentous tip.

Distribution.--Australia, Cambodia, India, Indonesia, Japan, Laos, Malaysia, New Guinea, Philippines, Ryukyu Is., Queensland, Sabah, Sri Lanka, Taiwan, Thailand, Vietnam.

Types.--The location of the type of *actoni* Smith is unknown. In the British Museum (NH) is a slide-mounted male marked paratype of *actoni*, but this cannot be accepted, since Smith on page 255 of his paper describing *actoni* stated "No males of the species to be described have been captured up to now. . . ." The holotype female of *okumensis* Arnaud from Okuma, Okinawa, Ryukyu Islands, is on a slide deposited in the USNM.

Southeast Asia Records.--

CAMBODIA: Phnom Penh (Delfinado).

INDONESIA: Flores, Manggarai, Tuteng, Bupat's House (Lee); Manggarai, Reo, Gincu and Golok (Lee). Java (West), Garut, Pameungpeuk (Zubaedah). Kalimantan (South), Banjar, Astambul, Sungai Baru (Lee); Astambul, Tanah Intan, Danau Kuriang and Pondok Delapan (Lee); Banjar, Martapura, Bincau (Lee). Maluku, P. Buru, Savanjaya (Bambang). Sulawesi (North), Dumonga-Bone Nat. Park, 220 m (Heppner); (Southeast), Kendari, Unaha and Ranometo, Randono (Bambang). Sumatra, Bengkulu, 72 km S Bengkulu, Gunung Agung (Mathis); Jambi, Transmigrasi, Singkut (Lee); Lampung, Kotabumi Way Abung, Papanrejo (Lee); (West) Sawalunto, Tanjung Godang, Sungai Tenang (Lee).

LAOS: Sayaboury Prov., Sayaboury (Howarth). Sedone Prov., Pakse (Howarth); Paksong (Howarth). Vientiane Prov., Ban Na Pheng, Ban Keun (Howarth).

MALAYSIA: Johore, Kahang Kluang (Hubert). Perak, Pulau Pangkor (Traub). Selangor, Kampong Kerdas, Gombak, from cow (Garcia); Kuala Lumpur, some biting man (Quate, Traub); Rantau Panjang, 6 km N Klang (McClure, Traub); Ulu Langat, chicken baited trap in secondary forest (Garcia).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Pampanga Prov., Angeles, Clark Air Base (Balatbat); Mountain Prov., Ifugao, Mayoyao, 1,000 m (Torrevillas). Mindanao, Agusan, Esperanza (Yosimoto); Davao Prov., E slope Mt. McKinley (Werner). Negros Oriental, L. Balinsasayao (Quate); Dumaguete (Yoshimoto).

SABAH: Keningau, swept from grass (Colless). Labuan Island (Colless). Tambunan (Colless).

SARAWAK: Bau Dist., Bau (BISH). Kuching, Santubong (BISH). Lundu Dist., Kampong Pueh (BISH). Tenompok, 48 km E Jesselton, 1,460 m (Maa).

THAILAND: Ayudhaya (Manop R.). Bangkok, Thonglo (Scanlon). Chachoengsao Prov. (Yasumatsu). Chiang Mai Prov., Doi Inthanon, Doi Pui Morn (Yasumatsu). Chiang Rai (Causey). Phangnga, Pulau Pangang (Colless). Si Sa Ket Prov., Amphoe Muang, Ban Kra Sang (Yasumatsu). Udonthani Prov., A. Pen (Manop R.).

VIETNAM: Chu Lai (Tisdale). Da Nang (Hicks).

Discussion.--*Culicoides actoni* was described by Smith (1929) as a man-biting species and some of our material was also taken feeding on man. The new Queensland record is from a slide-mounted female in the USNM from Cairns, 20.iv.1957, W.W. Wirth, at light.

Habits.--Buckley (1938) reported this species (as *C. pungens*) feeding on cattle along with other species of *Culicoides* at Kuala Lumpur, Malaysia. The species was common in daytime collections, exceeded in numbers only by *oxystoma*, but was never taken at night. It preferred to feed on the upper parts of the body of the host. It was never taken inside a roofed pen. The larval habitat was not found in spite of extensive searching. Microfilariae of *Onchocerca gibsoni* were often dissected from wild-caught females and filaria larvae developed to the infective stage, indicating that the species was an important filarial vector in Malaysia. Macfie (1937a) to whom Buckley sent his specimens for determination, reported that they agreed with a paratype of *C. actoni*, but he mistakenly considered *actoni* a synonym of *C. pungens* (de Meijere), which is actually a different coastal species. Some of the records and data reviewed by Debenham (1978) under the name *C. pungens* are based on similar misdeterminations and may refer to *C. actoni*.

Culicoides minimus Wirth and Hubert, new species
(Figs. 111, 276, 418)

Female.--Wing length 0.57 (0.51-0.59, n = 6) mm.

Head: Eyes contiguous a short distance, with short interfacetal hairs. Antenna (fig. 111a) with lengths of flagellar segments in proportion of 11-7-7-8-8-8-8-8-13-14-15-15-26, antennal ratio 1.27 (1.20-1.38, n = 4); sensilla coeloconica present on segments 3,13-15. Palpus (fig. 111b) with lengths of segments in proportion

of 6-12-13-6-7; third segment short and slightly swollen, with a small, round, shallow sensory pit; palpal ratio 1.8 (1.7-2.0, n = 6). Proboscis moderately short, P/H Ratio 0.73; mandible with 11 (11-12, n = 9) teeth.

Thorax: Dull blackish; mesonotum with greenish black pollinosity. Legs (fig. 111d) uniformly pale yellowish; hindtibial comb (fig. 111e) with 5 spines, the one nearest the spur longest.

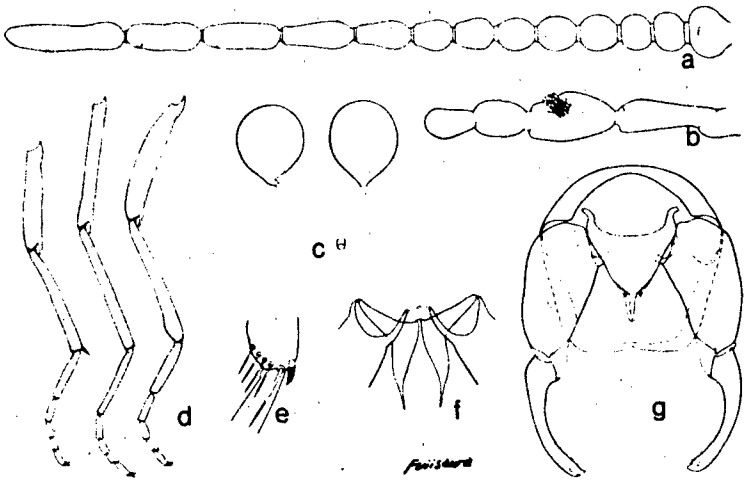


Fig. 111. *Culicoides minimus*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Wing (fig. 276, 418): Pattern as figured; very faint pattern; second radial cell dark to tip; wing pale on proximal fourth; large quadrate poststigmatic pale spot in cell R5 extending caudad broadly nearly to vein M1, no distinct pale spots near margin of wing except faintly at apex of cell R5, but veins indistinctly darker than the intervening spaces. No macrotrichia except at wing margin; costa short, costal ratio 0.51 (0.49-0.53, n = 6); second radial cell small and narrow with indistinct lumen, the first normal. Halter pale.

Abdomen: Pale brown, darker at apex. Spermathecae (fig. 111c) ovoid, with very short, slightly oblique, sclerotized necks; slightly unequal, 0.042 x 0.031 mm and 0.035 x 0.037 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 111g): Ninth sternum with broad, deep, caudomedian excavation, ventral membrane not spiculate; ninth tergum short and more or less quadrate, rounded caudad with a small caudomedian notch. Basistyle with ventral and dorsal roots short and moderately slender; dististyle slender and curved, the tip slightly expanded with distinct distomesal point. Aedeagus short and broad, the sides convex; basal arch extending to a fourth of total length, anterior margin of the sclerotized membrane more heavily sclerotized; distal process short and slender. Parameres (fig. 111f) separate; each with long, moderately stout, basal arm; midportion moderately swollen, tapering distally to slender, filamentous point directed ventrad.

Distribution.--Indonesia, Malaysia, Sabah, Thailand.

Types.--Holotype male, Kuala Lumpur, Malaysia, 6.vi.1958, R. Traub, light trap (Type in USNM). Allotype male, same data but iii.1958. Paratypes, 12 males, 13 females, as follows:

INDONESIA: Port. Timor, Cape Tafara, 5.viii.1969, D.G. Nicholls, light trap, 1 male, 2 females (CSIRO).

MALAYSIA: Same data as types, but dates iii-ix.1958, i.1960, 8 males, 8 females.

SABAH: Keningau, iii.1952, D.H. Colless, swept from grass, 1 male, 1 female. Tambunan, iii.1952, Colless, swept from grass, 1 male, 1 female.

THAILAND: Nakronrajasrima Prov., 5-7.vii.1959, Manop R., light trap, 1 male. Phangnga Prov., Pulau Panjang, 19.v.1954 (collector ?), 1 female.

Discussion.--This species is much smaller than the other known Oriental species of the Actoni Group, *C. actoni* Smith with wing length 0.74 mm. *Culicoides actoni* also differs in having the sensory pattern 3,12-15, the five distal antennal segments significantly longer in both sexes, the third palpal segment much longer, and in the male genitalia the apicolateral lobes of the ninth tergum usually are more prominent.

Orientalis Group

Diagnosis.--Eyes contiguous, without interfacetal hairs. Antennal ratio 1.09-1.35; sensilla coeloconica present on antennal segments 3,11-15 (rarely absent on 11). Proboscis moderately long, mandible with average number of 11-17 teeth. Mesonotum usually dark brown with pattern not well developed, or with pair of sublateral vittae only; femora rarely banded distally, sub-basal tibial pale rings usually present. Wing with characteristic pattern; distal pale spots in cells R5, M1, M2, and M4 usually meeting wing margin; anal cell typically with four pale spots more or less connected by a longitudinal pale streak through middle of cell, variations in extent of spots and streak forming specific characters. Costa moderately long, costal ratio 0.59-0.65; second radial cell short, distal portion in a pale spot.

Included Species.--The Orientalis Group is a large group in the Old World tropics with 15 species in Southeast Asia and the following species elsewhere: *dikhros* Tokunaga (New Guinea), *fragmentum* Tokunaga (New Guinea), *pseudopallidipennis* Clastrier (West Africa), and *suzukii* Kitaoka (Ryukyu Islands).

Culicoides boophagus Macfie
(Figs. 112, 277, 419)

Culicoides boophagus Macfie, 1937a: 116 (female; Malaya); Delfinado, 1961: 655 (Philippines; fig. wing); Howarth, 1985: 63 (Laos records).

Female.--Wing length 0.92 (0.86-0.99, n = 8) mm.

Head: Antenna (fig. 112a) with lengths of flagellar segments in proportion of 17-11-11-12-13-13-13-15-18-18-21-22-36, antennal ratio 1.09 (1.05-1.15, n = 6); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 112b) with lengths of segments in proportion of 6-13-15-9-10; third segment very short and slightly swollen, with a small round shallow sensory p.; palpal ratio 1.8 (1.7-2.0, n = 6). Proboscis short, P/H Ratio 0.68; mandible with 11 (10-13, n = 14) teeth.

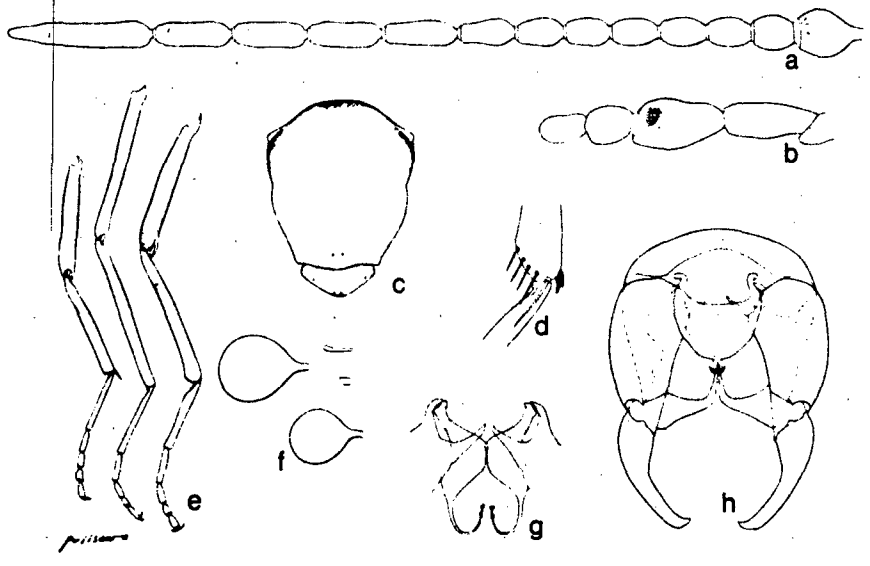


Fig. 112. *Culicoides boophagus*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Thorax: Brown; mesonotum (fig. 112c) with indistinct pattern when viewed in slide-mounted specimens. Legs (fig. 112e) yellowish brown, knee spots absent; bases of femora and tibiae and apices of fore- and midtibiae slightly paler; hindtibial comb (fig. 112d) with 5 spines, the one nearest the spur longest.

Wing (fig. 277, 419): Pattern as figured; pale markings extensive; pale spot over r-m crossvein large, broadly meeting anterior margin and continuous with pale area in cell M2; poststigmatic pale spot quadrate, twice as broad as dark spot distal to it, enclosing distal half of second radial cell; distal pale spot in cell R5 quadrate, broadly meeting wing margin subapically in cell, tip of cell dark toward vein M1; cell M1 with two pale areas, one near base and other near tip, latter narrowly extending to wing margin and fused anteriorly with the long pale streak bordering vein M1 from near base to its apex; apical pale spot in cell M1 also continuous posteriorly with the long irregular pale streak in cell M2, extending from base to apex, thus isolating a quadrate dark spot at the tip of vein M2; mediocubital fork with veins pale-bordered on basal portions, but dark at wing margin; cell M4 with pale area narrowly extending along wing margin; anal cell with typical Orientalis Group pattern of interconnected pale spots separating four separate dark areas. Macrotrichia confined to a very few at extreme wing tip; costal ratio 0.59 (0.58-0.61, n = 8); radial cells well developed. Halter infuscated.

Abdomen: Pale brown. Spermathecae (fig. 112f) ovoid, tapering to slender sclerotized necks, one more abruptly tapering than the other; unequal, 0.055 x 0.042 mm and 0.045 x 0.034 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 112h): Ninth sternum with broad shallow caudomedian excavation, ventral membrane spiculate only along margin of excavation; ninth tergum short and broad, with caudal margin deeply notched, forming two somewhat angular apicolateral lobes. Basistyle with ventral root moderately slender and curved, dorsal root shorter and stouter; dististyle curved, slender, with mesally pointed tip. Aedeagus short and broad, heavily sclerotized, with convex sides and bluntly rounded apex of main body, basal arch extending to 0.37 of length of main body, basal arms short and directed anteriorly; a slender, bifid, hyaline, posterior median process in place of the usual distal process, a short internal sclerotized point present. Parameres (fig. 112g) separate, but closely approximated on midportions; each very stout and short, with tapering, anterolaterally directed basal arm; distal portion abruptly tapering to very long, ventrally directed, filament bearing 2-3 short hairs at tip.

Distribution.--Laos, Malaysia, Philippines, Sri Lanka, Thailand.

Types.--Syntypes, 3 females, Kuala Lumpur, Malaysia, 1936, J.J. Buckley, on cattle, in BMNH.

Southeast Asia Records.--

LAOS. Luang Prabang (Quate). Sayaboury Prov., Sayaboury (Howarth).

MALAYSIA: Perlis, Kangar Rest House (Traub). Selangor, Kuala Lumpur (Barnett, Traub).

PHILIPPINES: Luzon, Pampanga Prov., Angeles. Clark Air Base (Balatbat).

THAILAND: Chiang Rai Prov. (Causey). Loei Prov., Amphoe Dan Sai (Manop R.).

Discussion.--*Culicoides boophagus* is distinguished from all other known members of the Orientalis Group by the very characteristic wing pattern, with veins M3+4 and Cu1 pale bordered from the base of the mediocubital fork nearly to the apices of these veins at the wing margin. We have examined specimens from Sri Lanka collected in a light trap at the Medical Research Institute at Kalutaluwewa, Colombo.

Culicoides brevipalpis Delfinado
(Figs. 113, 278, 420)

Culicoides brevipalpis Delfinado, 1961: 654 (female; Philippines; figs.); Kitaoka, 1973: 218 (male; Amami-oshima; figs.); Kitaoka, 1977: 192 (fig. wing; dist. add Ryukyu Is., Taiwan); Muller et al., 1981: 579 (Australia; female blood meal sources); Howarth, 1985: 63 (Laos records).

Female.--Wing length 0.91 (0.83-0.97, n = 14) mm.

Head: Eyes contiguous, bare. Antenna (fig. 113a) with lengths of flagellar segments in proportion of 17-11-11-13-13-12-13-14-19-21-22-24-36, antennal ratio 1.17 (1.13-1.23, n = 12); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 113b) with lengths of segments in proportion of 5-16-16-10-12; third segment slender from base to tip, with small, round, shallow, sensory pit near apex; palpal ratio 2.3 (2.0-2.6, n = 9). Proboscis moderately long, P/H Ratio 0.81; mandible with 12 (10-13, n = 23) teeth.

Thorax: Tawny yellowish brown; mesonotum (fig. 113c) darker along anterior margin; scutellum darker in middle; postscutellum dark brown. Legs (fig. 113e) yellowish brown, slightly darker in middle of femora and tibiae, tibiae pale at extreme bases; hindtibial comb (fig. 113d) with 5 spines, the one nearest the spur longest.

Wing (fig. 278, 420): Pattern as figured; pale markings extensive, isolating the rather indistinctly darker areas centering on the veins. Second radial cell with more than apical half pale; poststigmatic pale area more than twice as broad as the preceding dark area and nearly three times as broad as dark area next distally; distal pale area in cell R5 filling apex of cell; cells M1, M2, and M4 extensively pale; anal cell extensively pale with separate small dark spots at anterior and posterior margins at about midlength of cell. Macrotrichia absent or very few present at apices of cells R5 and M1; costal ratio 0.60 (0.58-0.63, n = 14); radial cells well developed, first narrow, second broad. Halter infuscated.

Abdomen: Pale brown. Spermathecae (fig. 113f) slightly ovoid to nearly subspherical, with short, slender, ringed, sclerotized necks; slightly unequal, 0.057 x 0.045 mm and 0.051 x 0.040 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 113h): Ninth sternum with moderately deep caudomedian excavation, ventral membrane not spiculate; ninth tergum short, broadly rounded caudally, slightly bilobate on caudal margin. Basistyle with ventral root long and slender, the two ventral roots

arching anteromesad and joined on midline, dorsal root shorter and stouter; dististyle markedly bent mesally near base, slender on distal portion, with mesally pointed tip. Aedeagus with basal arch short, only 0.2 of total length; sides nearly straight, tapering gradually to relatively short, fairly stout, blunt-tipped distal process; internal sclerotized point present. Parameres (fig. 113g) indistinctly fused a short distance at bases, anterior margin of basal arm including fused portion very poorly sclerotized; each paramere with midportion short and stout, tapering for a short distance to slender, simple, ventrally directed, distal filament without fringing hairs.

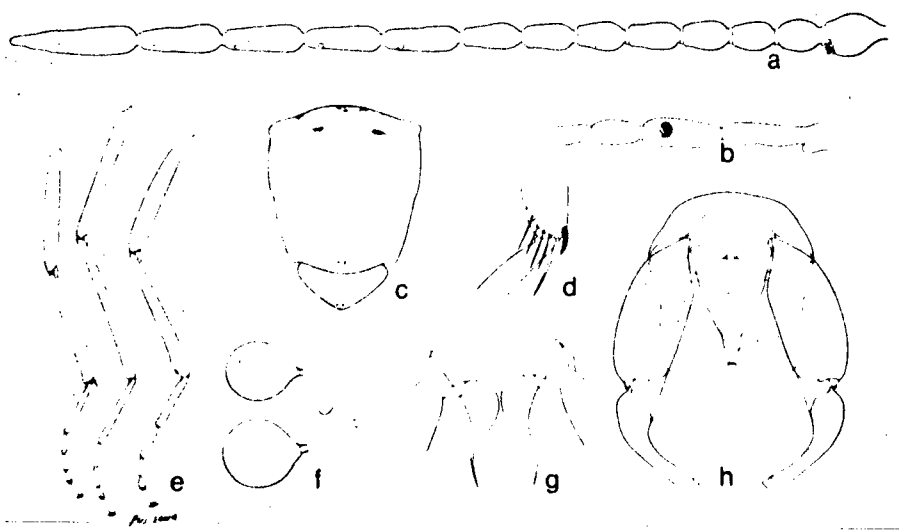


Fig 113. *Culicoides brevipalpis*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Distribution.--Australia, Indonesia, Laos, Malaysia, Philippines, Ryukyu Is., Sabah, Sri Lanka, Taiwan, Thailand.

Types.--Holotype female, Clark Air Base, Angeles, Pampanga Prov., Luzon, Philippines, 17.ix.1957, I. Balatbat, light trap (Type in USNM).

Southeast Asia Records.--

INDONESIA: Bali, Badung, Kuta, Jimbaran Carik (Lee); Badung, Mengwi (Lee); Bajung, Denpasar, Padungan (Lee). Java (Central), Cilacap, Adipala, Penggalang, Mandarasa (Lee); Adipala, Karang Sari (Lee); (West) Garut, Pameungpeuk (Zubaedah). Kalimantan (South), Banjar, Astambut, Sungai Baru

and Tanah Intan (Lee). Lombok (West), Mataram, Gerung, Dasan Geras (Lee). Sulawesi (North), Dumoga-Bone Nat. Park, 220 m (Heppner); (Southeast), Kendari, Ranometo, Sabulohoa (Bambang); Kolaka, Triacita, Lodongi Jaya (Bambang). Sumatra, North Lampung, Kotabumi, Way Abung, Papaurejo (Lee); (West) Wawalunto, Tanjung Godang, Sungai Tenang (Lee). Eimor (East), Dilli, Kampung Beto (Soeroto).

LAOS: Sayaboury Prov., Sayaboury (Howarth); Muong Xieng Hon (Howarth). Sedone Prov., Muong Pakse (Howarth).

MALAYSIA: Kedah, Sungei Patani (Traub). Pahang, Kuala Lipis, Kg. Berchang, near carabao (Garcia); Kuantan, Paya Bungor (Wharton); Lamir, Pekan (Wharton). Selangor, Kepong Forest Res. (McClure); Kuala Lumpur (Barnett, Hubert, Traub); Rantau Panjang, 8 km N Klang (McClure); Serdang (Barnett, McClure).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Clark Air Base, Angeles, Pampanga Prov. (Balatbat, types). Palawan, Brookes Point, Uring Uring (Noona Dan Exped.).

SABAH: Tambanun (Colless).

SARAWAK: Kuching, Mantubong (BISH).

SINGAPORE: Singapore (Course).

THAILAND: Nakronrajasrima Prov., Amphoe Pak Chong (Manop R.). Phangnga Prov., Pulau Panjang (collector ?).

VIETNAM: Da Nang (Hicks).

Discussion.--*Culicoides brevipalpis* can be distinguished from the other species of the Orientalis Group by its pale brown color, legs without dark knee spots, wing with extensive but much diffused pale pattern, and in the male genitalia by the basally bent dististyles and parameres indistinctly joined at the extreme bases. We have seen specimens collected in Sri Lanka (Colombo, Kalutaluwewa, Med. Res. Inst.).

Culicoides brevitarsis Kieffer
(Figs. 114, 279, 421)

Culicoides brevitarsis Kieffer, 1917: 187 (female; Australia); Lee and Reye, 1963: 362 (synonym: *robertsi*); Reye, 1964: 2 (biology and distribution summarized; vector potential); Cannon and Reye, 1966: 7 (immature stages in cow dung; Queensland); Standfast and Dyce, 1968: 585 (Queensland; attacking cattle); Doherty et al., 1972: 81 (isolation of Akabane, d'Aguillar, and Samford viruses; Queensland); Campbell, 1974: 1-255 (biology); Campbell and Kettle, 1975a: 203 (oogenesis, fecundity); Campbell and Kettle, 1975b: 333 (longevity); Murray, 1975: 216 (summary of biology, distribution, vector potential); Campbell, 1975: 97 (biology); Kettle et al., 1975: 264 (larval rearing technique); Kettle and Elson, 1976: 313 (larva, pupa descr.; figs.; Australia); Campbell and Kettle, 1976: 75 (biology); Kettle, 1977: 111 (summary of biology and behavior); Debenham, 1978: 215 (bibliography; extensive review; Australia); Campbell and Kettle, 1979a: 17 (swarming); Campbell and Kettle, 1979b: 251 (feeding habits on cattle); Dyce, 1979: 52 (notes on types; synonym *radicitus*); Edwards, 1980: 204 (survey methods; Queensland); Kettle and Elson, 1980: 11

(in key to pupae); Fain and Domrow, 1980: 41 (phoretic mites; Australia); Muller et al., 1981: 576 (female blood meal sources; Australia); Kay and Lennon, 1982: 207 (seasonal prevalence, bionomics; Australia); Howarth, 1985: 63 (Laos records).

Culicoides robertsi Lee and Reye, 1953: 386 (male, female; Australia; figs.); Riek, 1954: 116 (Queensland; biology; cause of "Queensland itch"); Tokunaga, 1960: 74 (*C. orientalis* male of Tokunaga 1959 misdet.); Tokunaga, 1962b: 485 (male, female redescribed; New Guinea and Solomons).

Culicoides superfulvus Das Gupta, 1962: 253 (female; India; figs.); Dyce and Wirth, 1983: 224 (synonym of *brevitarsis*).

Culicoides radicitus Delfinado, 1961: 657 (in part, male only; Philippines; figs.).

Culicoides orientalis Macfie (misident.); Tokunaga, 1959: 254 (male only; Irian Jaya record).

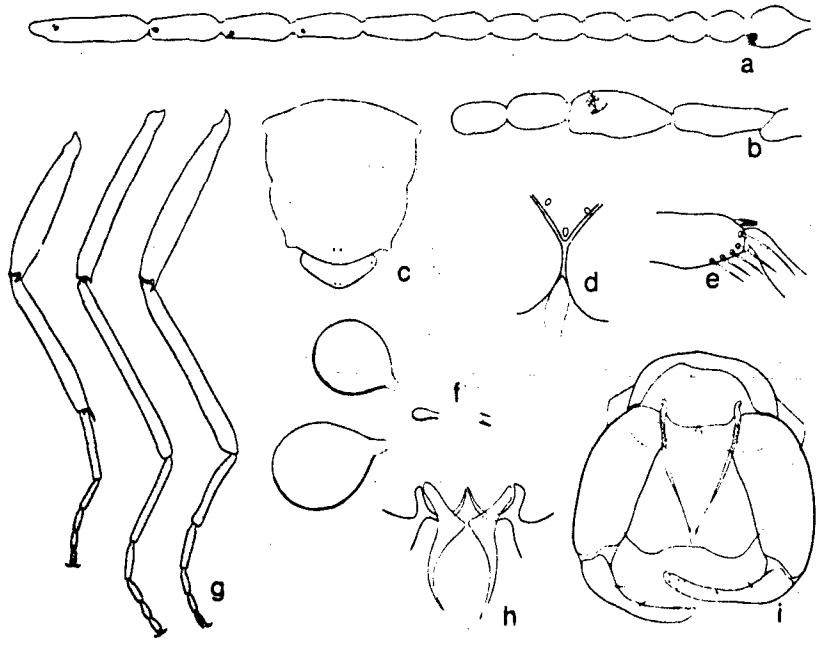


Fig. 114. *Culicoides brevitarsis*: a. antenna; b. palpus; c. thoracic pattern; d. eye separation; e. tibial comb; f. spermathecae; g. legs; h. parameres; i. male genitalia, parameres omitted.

Female.--Wing length 0.75 (0.66-0.82, n = 11) mm.

Head: Eyes (fig. 114d) contiguous a short distance, bare. Antenna (fig. 114a) with lengths of flagellar segments in proportion of 15-10-10-11-12-12-12-13-22-22-22-24-34, antennal ratio 1.22 (1.17-1.25, n = 5); sensilla coeloconica usually present on segments 3,12-15, rarely 3,11-15. Palpus (fig. 114b) with lengths of segments in proportion of 6-13-15-10-10; third segment short, not swollen, with a small, round, shallow, sensory pit located near tip; palpal ratio 2.2 (1.9-2.4, n = 10). Proboscis moderately long, P/H Ratio 0.70; mandible with 12 (9-15, n = 49) teeth.

Thorax: Dark brown; mesonotum (fig. 114c) pruinose gray, with more or less prominent pair of sublateral blackish patches behind humeral pits. Legs (fig. 114g) brown; knee spots blackish; femora paler at bases; tibiae with basal pale rings; hindtibial comb (fig. 114e) with 5 (n = 22) spines, the one nearest the spur longest.

Wing (fig. 279, 421): Pattern as figured; pale spots definite and moderately extensive; base of wing pale including proximal third of anal cell; large pale spot over r-m crossvein; poststigmatic pale spot in cell R5 large, covering distal fourth of second radial cell, not extending caudad to vein M1; distal pale spot in cell R5 covering large area at tip of cell; vein M1 with a long pale streak along midportion of vein; cell M1 with a small oval pale spot in basal portion and a long pale streak distally, the latter broadly meeting wing margin; cell M2 with long pale area from base to level of pale spot in cell M4, narrowly connected to broad pale spot broadly meeting wing margin (vein M2 thus is covered by an elongate dark streak with parallel sides ending abruptly in a point at wing margin); cell M4 with large pale area is distal portion; anal cell pale at base, a definite pale streak connecting basal area with irregular, variable, double spot in distal portion of cell. Macrotrichia sparse, on distal half of wing; radial cells short, second with small lumen; costal ratio 0.55 (0.54-0.60, n = 11). Halter pale.

Abdomen: Brown. Spermathecae (fig. 114f) slightly unequal, the larger 0.041 x 0.032 mm; short ovoid with short, slender necks.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 114i): Ninth sternum with broad shallow caudomedian excavation, ventral membrane bare; ninth tergum with two broadly rounded sublateral lobes. Basistyle with ventral root long and slender, dorsal root shorter and stouter; dististyle slender and curved, tapering to blunt distal point. Aedeagus 1.3 times as long as basal breadth, basal arch low, one-fifth of total length; sides slightly convex; distal process short and slender, poorly sclerotized, with long internal peg. Parameres (fig. 114h) each with long basal arm, about one-third of total length; mesal swelling angular, distal portion markedly tapering and slightly curved to slender distal point without fringing hairs.

Distribution.--Widely distributed in Australia, India to Indonesia, New Guinea, Philippines, Taiwan, Ryukyu Islands, Sri Lanka.

Types.--Type of *brevitarsis* from "Australie" in Budapest Museum, examined by Freeman in 1955 (see Lee and Reye, 1963) but presumably lost in the fire of October 1956. Holotype female of *robertsi* in SPHTM, Sydney, Australia, from

Yeerongpilly, Queensland, iv.1952, R.F. Riek, light trap, seen by Wirth in 1956. Holotype male of *radicitus*, Tala, Rizal, Philippines, 21.v.1958, M.D. Delfinado, deposited in Division of Malaria, Philippine Department of Health, Manila, but apparently lost. According to Dyce (1979) a male labelled "paratype" in the USNM bears data identical with those of the lost holotype; this specimen is hereby designated NEOTYPE. On the basis of this specimen Dyce (1979) made *C. radicitus* Delfinado a junior synonym of *D. brevitarsis* Kieffer.

Southeast Asia Records.--

INDONESIA: Bali, Pedang Bay, 35 km NE Denpasar (Nicholls); Klungkung, Timuhan (Sweatman). Flores, Manggarai, Nangalili, Joneng, Wai Tiong (Lee); Manggarai, Taituna, Timgung (Lee); Manggarai, Padang, Wai Aru (Lee). Java (West), Bogor (Adiwinata). Kalimantan (South), Banjar, Astambul, Tanah Intan, Pulo Tiga (Lee). Lombok, Tabane (Nicholls). Sumatra, North Lampung, Kotabumi, Way Abung, Mulyorejo (Lee). Sumbawa (Nicholls).

LAOS: Sayaboury Prov., Sayaboury (Howarth). Sedone Prov., Muong Pakse, ex cow (Howarth). Vientiane Prov., Muong Ban Keun, Ban Na Pheng (Howarth).

MALAYSIA: Johore, Kahang Kluang (Hubert). Kelantan, Ulu Kelantan, Lambok, Sungei Betis (Wharton). Pahang, Tasek Bera (Wharton). Perak, Pulau Pangkor (Traub). Selangor, Kepong Forest Res. (McClure); Kuala Lumpur (Barnett, Traub); Serdang (Barnett).

THAILAND: Nakronpanom Prov., Amphoe Muang (Manop R.). Loei Prov., Amphoe Dan Sai (Manop R.). Chiang Mai Prov. (Notananda). Phangnga Prov., Pulau Panjang (collector ?, cow shed).

Discussion.--Culicoides brevitarsis can be distinguished from the other species of the Orientalis Group by its small size, antennal sensory pattern 3,12-15, definite contrasting wing markings in which the base of the anal cell is pale, and typically a definite pale streak runs distally to the double pale spot in apex of cell, the poststigmatic pale spot overlaps less than half the second radial cell, the proximal pale spot in cell M1 is small and located well proximad, behind the second radial cell; the halter is pale to slightly darkened; the palpal pit is round and definite, and the legs are brownish with basal pale rings on the tibiae. In the male genitalia the aedeagus has a moderately low basal arch with non-spiculate membrane, and slender, non-spiculate tip, and the lobes of the ninth tergum are low and rounded and widely spaced. In the female the distal antennal segments are shorter than in most other species.

The specimens figured are from Moree, N.S. Wales, Australia, 23.ii.1963, A.L. Dyce and M.D. Murray, light trap (det. by A.L. Dyce).

Biology (mostly taken from Campbell (1974).--A good, concise summary of known information on the biology in Australia is given by Debenham (1978). The immature stages were described by Kettle and Elson (1976); they are found in cow pats. The dung pats are used for oviposition up to seven days after deposition; after that time the crust becomes too thick. Eggs are deposited on the supper surface of the pats, mostly in the afternoon to evening hours (Campbell and Kettle (1976). Oviposition was never observed directly, because of the small number of females on a dung pat, and those present would oviposit over the whole

24-hour period. Eggs of *C. brevitarsis* bear ansulae on the concave surface which function as a plastron to facilitate respiration under wet conditions (Campbell and Kettle, 1975a). Larvae and pupae remain in the pats, and when dung temperatures exceed 43°C, the larvae descend deeper in the dung even in drier but slightly moist portions. When larvae are placed in water they sink and do not swim; pupae usually attach to pieces of dung, and when flooded do not float.

Adults begin emerging from pats as early as 11 days after oviposition and emergence is completed by 24 days; very few emerge from dung-contaminated mud or soil. Swarming and presumably mating occurs in the hour before sunset; females are rare in swarms but possibly fly through to mate. Females collected after feeding on hosts were nearly always mated. Oocytes do not develop beyond stage I in females that have not mated or fed, indicating that autogeny is unlikely. The most frequent sources of blood meals are cattle, horses, and sheep, especially cattle; rarely on man. Attacks are heavy on buffalo where these animals occur. Upper parts of the host are preferred to the lower. Other mammals may be attacked, but there are no records from birds or poultry. Feeding activity is nocturnal, beginning just before sunset, peaking during the half hour after sunset, and decreasing to nil in the following six hours.

Kettle (1977) explained that *C. brevitarsis* is not autogenous because its life cycle is not adapted to a prolonged larval stage in order to build up larval food reserves. The species has based its survival strategy by selec ephemeral breeding sites (dung pats) in the vicinity of a constant supply of hosts (cattle, etc.) which could supply repeated blood meals.

Relation to Disease.--The potential for *C. brevitarsis* as a disease vector has been studied extensively in Australia. "Queensland itch" is often a severe problem in horses in northern Australia and is caused by the development of hypersensitivity to midge bites (Riek 1954).

Culicoides brevitarsis has been implicated in the actual or potential transmission of six animal virus diseases in Australia:

(1) Aino virus (Simbu group) has been isolated from *brevitarsis* and neutralizing antibodies have been found in cattle and horses (Doherty, Carley, Standfast, Dyce, and Snowdon 1972).

(2) Akabane virus (Simbu group) was isolated from *C. brevitarsis* in Queensland in 1968 and since then additional strains have been found. Neutralizing antibodies have been found in cattle, horses, sheep, and man. The spread of epizootics of Akabane disease (hydranecephaly and arthrogryposis in calves) from north to south in eastern Australia takes place under conditions and fitting a seasonal and geographic pattern suggesting *brevitarsis* transmission and wind-blown southerly transportation of infective midges (Murray et al. 1975).

(3) Bluetongue virus. Murray (1975) and others regard *C. brevitarsis* as a serious potential vector of bluetongue of sheep and cattle, if that virus should be imported into Australia. The disease is of great importance in South Africa, North America, and the Mediterranean, and is transmitted in South Africa mainly by *C. imicola* Kieffer, a close relative of *brevitarsis*.

(4) D'Aguilar virus (Palyam group) was isolated from *C. brevitarsis* at Bunya, Queensland in 1968, and several times subsequently, but it has not been possible to re-isolate the virus after each initial recovery (Doherty, 1972).

(5) Ephemeral fever. This virus has caused epizootics in cattle in Australia for many years but the vector is not known. Experimental attempts to transmit the virus using *Culicoides* have been negative, but those concerned (Standfast and Fanning 1968; Standfast and Dyce 1972) still regard *C. brevitarsis* as a potential vector. Virus was recovered from midges eight days after feeding on an infected mouse.

(6) Ngaingan virus (ungrouped) was isolated from one pool of *C. brevitarsis* from Mitchell River, Queensland, in 1970 and neutralizing antibodies from this strain were found in cattle, wallaby and kangaroo, but Doherty (1972) considered the data insufficient to seriously incriminate *C. brevitarsis* as a major vector.

Culicoides dumdumi Sen and Das Gupta
(Figs. 115, 280, 422)

Culicoides dumdumi Sen and Das Gupta, 1959: 628 (male; India; fig. wing, genitalia); Dyce and Wirth, 1983: 222 (notes on paratype).

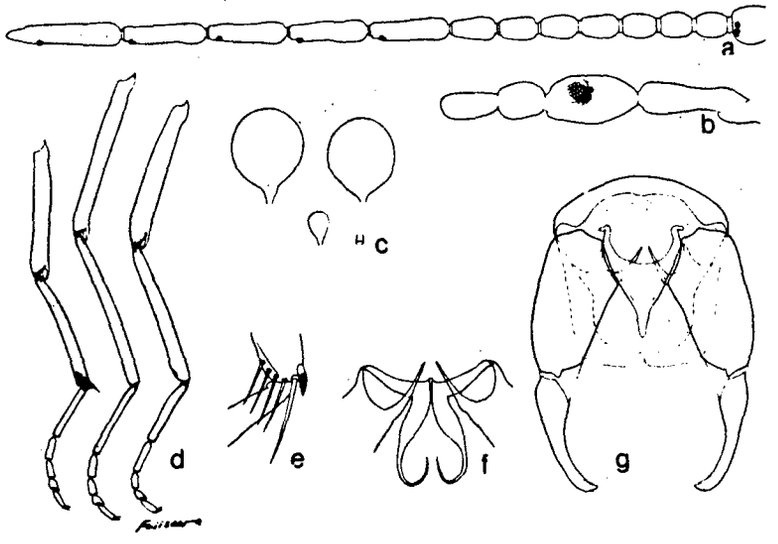


Fig. 115. *Culicoides dumdumi*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Female.--Wing length 0.82 (0.71-0.89, n = 10) mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 115a) with lengths of flagellar segments in proportion of 16-10-10-11-12-12-12-13-24-25-25-25-35, antennal ratio 1.35 (1.31-1.39, n = 10); sensilla coeloconica present on segments

3,11-15; sensilla chaetica on segments 11-15 nearly as strong as those on 3-10. Palpus (fig. 115b) with lengths in proportion of 9-17-19-9-12; third segment short and moderately swollen to tip, with a small round sensory pit near tip; palpal ratio 1.9 (1.7-2.0, n = 10). Proboscis moderately short, P/H Ratio 0.73; mandible with 14 (12-16, n = 17) teeth.

Thorax: Brown; mesonotal pattern in fresh specimens comprising two submedian oval yellow patches and weaker shoulder patches. Legs (fig. 115d) brown, knees darkened only on foreleg; tibiae with sub-basal pale rings; hindtibial comb (fig. 115e) with 5 spines, the one nearest the spur longest.

Wing (fig. 280, 422): Pattern as figured; pale spots usually very indistinct; pale spot over r-m crossvein broadly attaining costal margin, barely touching vein M posteriorly; poststigmatic pale spot in cell R5 covering distal half of second radial cell, broadest anteriorly at wing margin, not touching vein M1; distal pale spot in cell R5 usually not entirely filling apex of cell, but rounded on posterodistal corner leaving a dark area near apex of vein M; cell M1 with two faint elongate pale spots; cell M2 with indistinct pale streak on basal half, a more distinct pale spot just behind medial fork and a distinct pale spot distally at wing margin; cell M4 with pale area filling distal half of cell; anal cell with faint pale streak at base and two more distinct pale spots in distal portion; apices of veins dark. Macrotrichia sparse, confined to a few at apices of cells R5 and M1; costal ratio 0.65 (0.63-0.67, n = 10); radial cells distinct. Halter knob lightly infuscated.

Abdomen: Brown, darker on distal segments. Spermathecae (fig. 115c) ovoid, with moderately long sclerotized necks; subequal, each 0.047 x 0.035 mm.

Male.--Similar to the female, with the usual sexual differences. Genitalia (fig. 115g): Ninth sternum with very broad, shallow, caudomedian excavation, ventral membrane spiculate on anterior half of space from margin of sternum to base of aedeagus; ninth tergum rounded caudally, with well-developed median cleft. Basistyle with ventral root long and slender, dorsal root shorter and stouter; dististyle slender distally with well-developed distomesal point. Aedeagus with relatively broad base; basal arch extending to a third of total length, distal process moderately long and slender, with simple rounded tip. Parameres (fig. 115f) separate, each with moderately long, slender basal arm; midportion not greatly swollen, tapering distally to slender filament directed ventrocephalad.

Distribution.--India, Sabah.

Types.--Holotype male, 2 male paratypes, Dum Dum, India, viii.1957 (Zool. Surv. India, Calcutta; 1 paratype in USNM).

Southeast Asia Records.--

SABAH: Labuan Island (Colless, reared from rotting seaweed and resting in shallow caves on rocky shore). Tambunan (Colless).

Discussion.--This species is recognized by its small size, the reduced pale wing markings with the base of the anal cell usually extensively dark, the short, stout, third palpal segment, and the well-developed sensilla chaetica on the distal antennal segments. The coastal species *C. pungens* (Meijere) is closely related, but

has still more reduced pale wing markings, unbanded, uniformly dark legs and darker halteres, longer third palpal segment, and the male ninth sternum is densely spiculate up to the proximal ends of the basal arms of the aedeagus.

Culicoides flavipunctatus Kitaoka
(Figs. 116, 281, 423)

Culicoides flavipunctatus Kitaoka, 1975: 199 (male, female; Yonaguni, Nansei Is.; figs.); Kitaoka, 1977: 192 (rec. Ishigaki Is.).
Culicoides (*Avaritia*) species F; Howarth, 1985: 68 (diagnosis; Laos records).

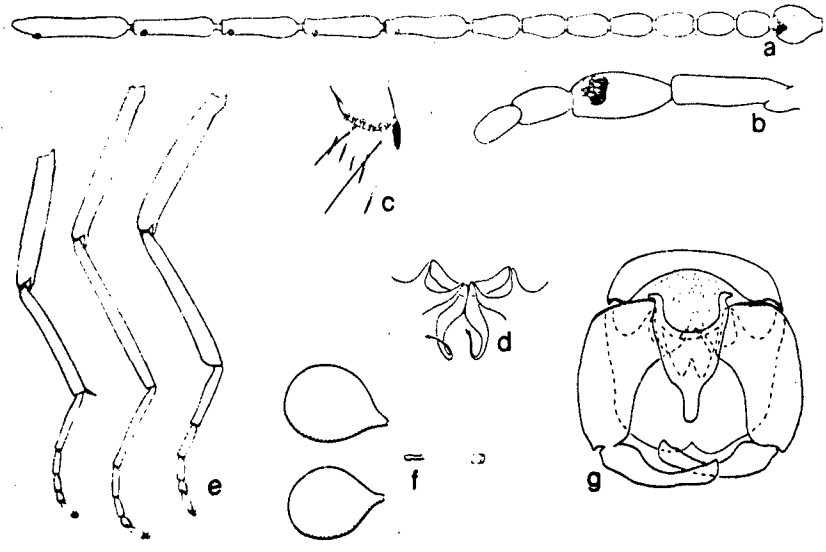


Fig. 116. *Culicoides flavipunctatus*: a. antenna; b. palpus; c. tibial comb; d. parameres; e. legs; f. spermathecae; g. male genitalia, parameres omitted.

Female.--Wing length 0.76 mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 116a) with lengths of flagellar segments in proportion of 20-15-15-17-18-18-18-19-33-34-34-35-48, antennal ratio 1.30; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 116b) with lengths of segments in proportion of 10-25-25-14-13; third segment moderately short and stout, with prominent, round, shallow, sensory pit near apex; palpal ratio 2.1. Proboscis moderately long, P/H Ratio 0.80; mandible with 15 teeth.

Thorax: Dark brown, mesonotum with pair of yellowish marks mesally; scutellum paler brown. Legs (fig. 116e) dark brown; knee spot on foreleg blackish, midknee yellowish; tibiae with basal pale rings; tibial comb (fig. 116c) with 5 spines, the one nearest the spur longest.

Wing (fig. 281, 423): Pattern as figured, typical of species of the Orientalis Group, pale spots moderately distinct; distal pale spot in cell R5 broadly reaching anterior and distal wing margins; pale spot over wing base large, covering proximal third of mediocubital stem, broadly extending into anal cell for about half of breadth of cell; longitudinal pale streak in anal cell indistinct or absent, only a small round pale spot in anterior portion of distal part of cell. A diagnostic feature is the presence of an isolated dark marking sub-basally on vein M2 that is rarely connected to the angular costal dark marking in front or the more distal dark marking on vein M2. Macrotrichia sparse, confined to a few at apices of cells R5 and M1; costal ratio 0.61; radial cells distinct. Halter infuscated.

Abdomen: Dark brown. Spermathecae (fig. 116f) ovoid with moderately long slender necks; slightly unequal, 0.040 x 0.032 mm and 0.036 x 0.029 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 116g): Ninth sternum with broad shallow caudomedian excavation, ventral membrane spiculate; ninth tergum broadly rounded distally with small median, cleft and a pair of distinct rounded submedian lobes. Basistyle with ventral root long and slender, dorsal root shorter and stouter; dististyle as dark brown as rest of genitalia, slender and curved, slightly stouter distally with distinct distomesal point. Aedeagus with base relatively narrow, basal arch extending to a fourth of total length; sides convex; distal process moderately long and slender, with simple rounded tip. Parameres (fig. 116d) each with moderately long, slender basal arm; contiguous midportions short and not greatly swollen; tapering distally to slender filament directed ventrocephalad.

Distribution.--Indonesia, Laos, Malaysia, Nansei Islands.

Types.--Holotype female, allotype male, Yonaguni Is., Sonai, 16.xi.1974, S. Kitaoka (in Nat. Sci. Mus., Tokyo). Paratypes, 11 males, 13 females.

Southeast Asia Records.--

INDONESIA: Bali, Klungkung, Timuhun (Sweatman). Flores, Manggarai, Reo, Robek (Lee). Java (Central), Cilacap, Adipala, Bunton (Lee); Klaten, Bonarum, Empangan (Soeroto); (West) Garut, Pameungpeuk (Zubaedah); Jakarta, West Jakarta, Kapuk (Aep); Pandeglang, Ujung Kulon (Watters); Yogyakarta, Bantul, Imogiri, Girirejo, Karang Tengah (Lee); (Central) Purworejo, Tegalmalang (Lee). Kalimantan (South), Banjar, Astambul, Sungai Baru and Tanah Intan (Lee); Banjar, Martapura, Bincau (Lee). Lombok (East), Selong, Bagik Payung and Kerekong (Lee). Sumatra, Batam Island, Sungai Beduk (Sustriayu); Bengkulu, Pekik Nyaring (Mathis); (West) Sawahlunto, Tanjung Godang, Sungai Tenang (Lee). Timor (East), Dilli, Bidou, Comoro, and Kampung Beto (Soeroto).

LAOS: Sayaboury Prov., Muong Xieng Hon; Sayaboury (Howarth). Sedone Prov., Muong Pakse, Muong Paksong (Howarth).

MALAYSIA: Selangor, Rantau Panjang, 8 km N Klang (Quate); same, biting man (Pungat). Perak, Pulau Pangkor (Traub).

Biology.--Howarth (1985, as species F) reared *C. flavipunctatus* in Sayaboury Prov., Laos, from rotting elephant dung in a shaded damp woodland. He collected adults at Muong Pakse, Sedone Prov., Laos, by sweeping around a cow in a cow shed.

Discussion.--This species can be distinguished in the female by its relatively small size and only moderately distinct wing pattern, anal angle of wing dark and pale streak faint to absent; mesonotum with a pair of yellowish markings; halter dark, and palpal pit relatively broad and distinct. The male genitalia are distinctive, with distinct submedian lobes on the ninth tergum, spiculate membrane on the ninth sternum, and aedeagus with convex sides.

Alan Dyce (in litt.) is of the opinion that the wing markings of *C. flavipunctatus* intergrade gradually into those of *C. fulvus* Sen and Das Gupta. Checking numerical values, it is possible that differences exist in proboscis length and antennal ratio, but more data need to be gathered and checked. The two forms occur together in Indonesia.

Culicoides fulvus Sen and Das Gupta
(Figs. 117, 282)

Culicoides fulvus Sen and Das Gupta, 1959: 628 (male only; India; fig. wing, genitalia); Das Gupta, 1962d: 254 (female described; figs.; India); Dyce and Wirth, 1983: 223 (notes on types); Howarth, 1985: 64 (Laos records).
Culicoides radicitus Delfinado (in part), 1961: 657 (fig. of wing; locality doubtful).

Female.--Wing length 0.78 (0.71-0.84, n = 12) mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 117a) with lengths of flagellar segments in proportion of 14-9-9-10-10-10-12-17-17-19-21-30, antennal ratio 1.23 (1.19-1.26, n = 7); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 117b) with lengths of segments in proportion of 6-19-16-9-10; third segment short, not swollen, with a small, round, shallow sensory pit located near tip; palpal ratio 2.2 (1.9-2.4, n = 9). Proboscis moderately long, P/H Ratio 0.70; mandible with 13 (11-15, n = 20) teeth.

Thorax: Dark brown; mesonotum pruinose gray, a prominent pair of elongate ovoid submedian yellow patches, and a more or less prominent pair of sublateral blackish patches behind humeral pits. Legs (fig. 117f) brown; knee spots blackish; femora paler at bases; tibiae with basal pale rings; hindtibial comb with 5 spines, the one nearest the spur longest.

Wing (fig. 117c, 282): Pattern as figured; pale spots definite and moderately extensive; base of wing pale including proximal third of anal cell; large pale spot over r-m crossvein; poststigmatic pale spot in cell R5 large, covering distal half of second radial cell, extending caudad to vein M1; distal pale spot in cell R5 covering large area at tip of cell; vein M1 with a long pale streak along midportion of vein; cell M1 with large oval pale spot in basal portion, nearly touching veins M1 and M2, and a long pale spot distally extending broadly to wing margin; cell M2

with long pale area from base to level of pale spot in cell M4 narrowly connected to a broad pale spot broadly meeting wing margin; cell M4 with a large pale area in distal portion; anal cell pale at base, a definite pale streak connecting basal area with irregular, double pale spot in distal portion of cell. Pale areas in cells M1 and M2 forming the outlines of a short, broad, somewhat diamond shaped dark marking straddling midportion of vein M2 (in *C. brevitarsis* this mark is longer with parallel sides and ends abruptly pointed at wing margin). Macrotrichia sparse, in distal half of wing; radial cells short, second with small lumen; costal ratio 0.60 (0.56-0.62, n = 14). Halter moderately infuscated.

Abdomen: Brown. Spermathecae (fig. 117d) subequal, each 0.040 x 0.031 mm; short, ovoid, with necks scarcely developed.

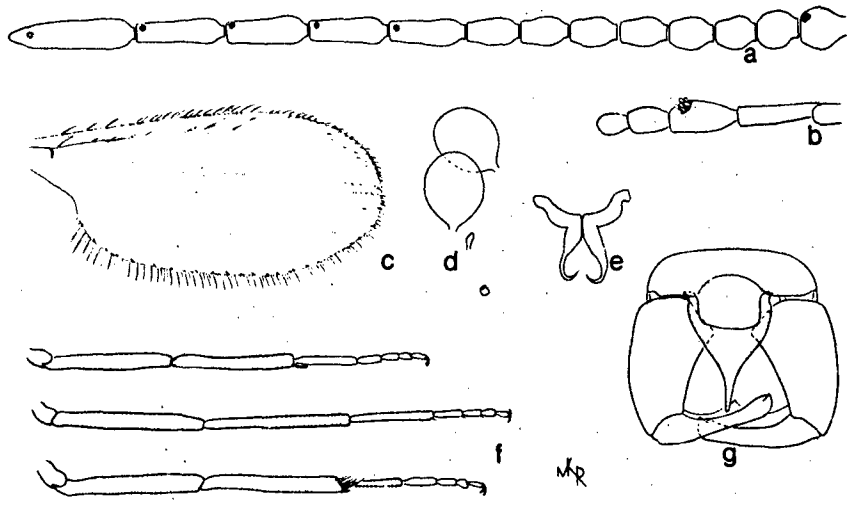


Fig. 117. *Culicoides fulvus*: a. antenna; b. palpus; c. wing; d. spermathecae; e. parameres; f. legs; g. male genitalia, parameres omitted.

Male.--Similar to female, with usual sexual differences. Genitalia (fig. 117g): Ninth sternum with broad, shallow caudomedian excavation, ventral membrane spiculate; ninth tergum distally with two broadly rounded sublateral lobes. Basistyle with ventral root long and slender, dorsal root shorter and stouter; dististyle slender and curved, tapering to sharp distal point. Aedeagus 1.8 as long as basal breadth, basal arch low, a fifth of total length; sides moderately convex; distal

process moderately long and slender, with simple rounded tip. Parameres (fig. 117e) separate, each with short, slender basal arm; a short bulbous contiguous portion at a fourth of total length; distal portion arcuate, tapering distally to a slender tip bearing minute fringing hairs.

Distribution.--Widely distributed in the Oriental Region and extending into Australasia.

Types.--According to Dyce and Wirth (1983) the holotype male of *C. fulvus* could not be found. Three male paratypes were specified; two of these were examined and are conspecific with the females described by Das Gupta (1962); one male had genitalia with conformation indicating it was the one originally illustrated (Sen and Das Gupta 1959).

Southeast Asia Records.--

CAMBODIA: Phnom Penh (Delfinado).

INDONESIA: Bali, Badung, Denpasar, Padungan (Lee); Badung, Mengwi (Lee); Peguyangan, Tag Tag (Lee). Flores, Manggarai, Nangalili, Wai Jamal near Pandang (Lee); Manggarai, Wai Tuna (Lee). Java (West), Bekasi, Bekasi (Lee); Yogyakarta, Bantul, Imogiri, Giriejo, Karang Tengah (Lee). Lombok (East), Selong, Bagik Payung and Kerekong (Lee); (West) Mataram, Gerung, Dasan Geras (Lee). Kalimantan (South), Banjar, Astambul, Tanah Intan, Pondok Delapan and Simpang Empat (Lee). Sulawesi (Central), Banggai, Batui, Dongin and Kamiwangi (Bambang); (North) Lake Mooat, 20 km NE Kotamobagu, 1,000 m (Heppner); (South), Ujung Pandang, Bontoala, Baraya, Unhas (Aep); (Southeast) Kendari, Unaha (Bambang). Sumatra, Batam Island, Sungai Beduk (Sustriayu); Bengkulu, Pekik Nyaring (Mathis); North Lampung, Kotabumi, Way Abung, Mulyorajo and Papaurejo (Lee); (West) Sawalunto, Tanjung Godang, Sungai Tenang (Lee). Timor (East), Dilli, Bidou (Soeroto); Dilli, Comoro, Kampung Marinir (Soeroto); Dilli, Kampung Beto (Soeroto).

LAOS: Sayaboury Prov., Muong Xieng Hon (500 m), Sayaboury (300 m); Sedone Prov., Muong Pakse (100 m) (all Howarth).

MALAYSIA: Negri Sembilan, Port Dickson, Telok Pelandok (Traub). Pahang, Kuala Singgora (Wharton); King George V Nat. Park (McClure); Kuantan, Gudang Rasan (Traub); Tasek Bera (Wharton). Selangor, Serdang (Barnett).

SINGAPORE: Kg. Chantek Bahru (Colless); Mee Soon (Colless).

THAILAND: Nakronprathom Prov. (Manop R.). Nakronrajasrima Prov., Amphoe Muang (Manop R.). Khon Kaen Prov., A. Ban Pai (Manop R.). Phangnga Prov., Pulau Panjang (collector ?), cow shed. Samuthprakan Prov. (Manop R.).

Discussion.--According to Dyce (1979), Delfinado's (1961) type series of *C. radicitus* was mixed, the paratype male and apparently the holotype whose genitalia were figured and described being *C. brevitarsis* Kieffer, and the allotype female agreeing with *C. nudipalpis* Delfinado. The wing photograph published by Delfinado (plate 9, fig. 12) was not of the allotype but was furnished by Wirth from non-Philippine material provisionally identified as *C. radicitus*; the specimen (which cannot now be located) was not *radicitus* but was apparently *C. fulvus* Sen and Das Gupta.

In the female, *C. fulvus* is most readily separated from *C. brevitarsis* by characters of the antenna; in *fulvus* segments 11-15 are much more elongate and the sensory pattern is 3,11-15; in *brevitarsis* segments 11-15 are shorter and the sensory pattern is 3,12-15. In *C. brevitarsis* the poststigmatic pale spot in cell R5 covers only the distal fourth of the second radial cell (half in *fulvus*); the proximal pale spot in cell M1 is small, lying behind the second radial cell and not touching veins M1 and M2 (larger, extending farther distad in *fulvus*, and filling the space between veins M1 and M2); and the dark streak lying over vein M2 is narrower in *C. brevitarsis* and extends nearly the whole length of the vein (in *fulvus* this mark is much broader and shorter). In *C. brevitarsis* the spermathecae are definitely unequal while in *fulvus* they are subequal. In *C. fulvus* the ninth tergum is divided into 2 low rounded lobes, the parameres have a short basal arm, the swollen portion is short and located at about the proximal fourth of the total length, and the long distal portion tapers to a fine tip.

Culicoides hui Wirth and Hubert
(Figs 118, 283, 424)

Culicoides hui Wirth and Hubert, 1961: 16 (female; Taiwan; figs.); McDonald and Lu, 1972: 405 (female redescribed; Taiwan dist.; figs.); Lee, 1978: 54 (Rep. China; diagnosis; figs.); Howarth, 1985: 65 (Laos records).

Female.--Wing length 0.84 (0.83-0.85, n = 3) mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 118a) with lengths of flagellar segments in proportion of 16-11-12-13-14-13-14-14-21-22-21-22-35, antennal ratio 1.12 (1.12-1.13, n = 2); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 118b) with lengths in proportion of 9-23-19-12-10; third segment slightly swollen, with small round sensory pit near tip; palpal ratio 2.5 (2.4-2.6, n = 3). Proboscis moderately short, P/H Ratio 0.77; mandible with 12 (n = 5) teeth.

Thorax: Dark brown; faint dark brown mesonotal pattern (fig. 118d) visible in slide-mounted specimens. Legs (fig. 118f) brown; tibiae with sub-basal and hindtibia with apical pale rings; hindtibial comb (fig. 118c) with 5 spines, the one nearest the spur longest.

Wing (fig. 283, 424): Pattern as figured; pale markings well defined; pale spot over r-m crossvein round, broadly meeting costal margin and narrowly touching vein M1; poststigmatic pale spot in cell R5 covering distal half of second radial cell, large, broadest at anterior wing margin, narrowly meeting pale streak along vein M1, this streak extending nearly to apex of vein; cell R5 with two distal pale spots, a small apical one at extreme tip of cell and a larger, V-shaped one subapically, the apex of the V located proximad, the arms of the V meeting wing margin anteriorly and pale streak along vein M1 posteriorly; cell M1 with three pale spots, the middle one touching pale streak along vein M1, the distal one meeting wing margin; cell M2 with a pale spot near base, another just behind medial fork, narrowly connected by a streak to third spot located cephalad of middle of cell M4 and a fourth spot at wing margin; cell M4 with a round spot at wing margin; anal cell with complete Orientalis Group pattern of 4 pale spots connected narrowly by

pale streaks; tips of all veins dark at wing margin. Macrotrichia sparse and restricted to apices of cells R5, M1, and M2; costal ratio 0.62 (0.61-0.64, n = 3); radial cells well developed. Halter infuscated.

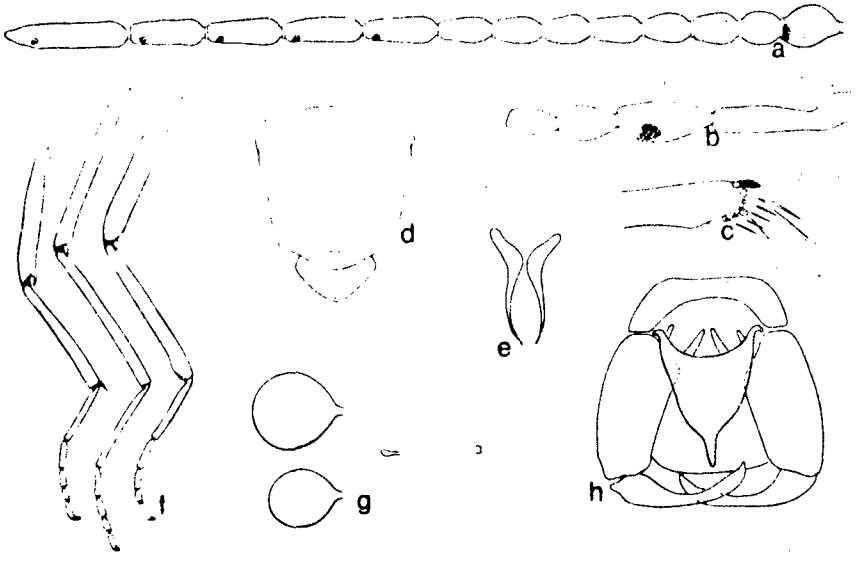


Fig. 118. *Culicoides hui*: a. antenna; b. palpus; c. tibial comb; d. thoracic pattern; e. parameres; f. legs; g. spermathecae; h. male genitalia, parameres omitted.

Abdomen: Brown. Spermathecae (fig. 118g) slightly ovoid, with short sclerotized necks; unequal, 0.051 x 0.041 mm and 0.041 x 0.033 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 118h): Ninth sternum with broad shallow caudomedian excavation, ventral membrane bare; ninth tergum short, broadly rounded caudad, with only slight trace of caudomedian indentation. Basistyle with dorsal and ventral roots long and slender; dististyle slender and curved, with mesally pointed tip. Aedeagus 1.25 as long as basal breadth, basal arch low, anterior margin of arch well sclerotized; sides slightly convex, tapering to slender, rounded tip, a sclerotized point directed internally towards base of aedeagus. Parameres (fig. 118e) separate, moderately swollen and closely approximated near midportions, each with moderately stout, tapering, anterolateral process, tapering and curving ventrally on distal portion to slender filament; due to poor preparation presence or absence of minute hairs at tip not determined.

Distribution.--Indonesia, Laos, Malaysia, Taiwan.

Type.--Holotype female, Taiwan, Utai, Pingtung, 24.ii.1954, J.K. Ni and S.Y. Liu, light trap (Type in USNM).

Southeast Asia Records.--

INDONESIA: Kalimantan (South), Banjar, Astambul, Tanah Intan, Simpang Empat and Titian Matang (Lee). Lombok, Sasaut, 30 km N Maratam (Nicholls); Tabane, East Lombok (Nicholls). Sulawesi (North), Dumoga Bone Nat. Park, 220 m, (Heppner); Lake Mooat, 20 km NE Kotamogagu, 1,050 m (Heppner).

LAOS: Sayaboury Prov., Sayaboury (Howarth). Vientiane Prov., Muong Van Vieng, Ban Ky Sok; Muong Ban Keun, Ban Na Pheng (Howarth).

MALAYSIA: Pahang, Kuala Singgora (Wharton).

Discussion.--This species is unique among the Oriental species of *Avaritia* in the presence of two pale areas in cell R5 distal to the post-stigmatic pale spot. Only the Afrotropical species *C. gulbenkiani* Caeiro is known with this wing pattern. There is a slight difference between examples from Taiwan and the Malaysian specimens described above. In *C. hui* from Taiwan the size is somewhat larger (wing length 0.98-1.18 mm), the distal antennal segments are longer and more slender (antennal ratio 1.17-1.21), and the apex of the hindtibia is entirely dark.

Culicoides imicola Kieffer
(Figs. 119, 284)

Culicoides imicola Kieffer, 1913: 11 (female; Mombasa, Brit. E. Africa); Kremer, 1972: 648 (female redescribed; figs. from type; syn.: *pallidipennis* Braverman et al., 1976: 181 (notes; Israel); Braverman et al., 1977: 102 (Israel; poultry feeding); Braverman et al., 1979: 123 (Sinai Pen.; feeding habits); Braverman et al., 1981: 13 (Israel records); Howarth, 1985: 65 (Laos records).

Culicoides pallidipennis Carter, Ingram and Macfie, 1920: 265 (male, female; Gold Coast; figs.); Clastrier, 1958: 194 (redescribed; figs.; Fr. West Africa); Nevill, 1968: 61 (larval breeding sites; cow pats; Transvaal); Nevill, 1969: 265 (immature stages described; figs.; S. Africa); Khamala and Kettle, 1971: 41 (redescribed; figs.; syn. *glabripennis*; distr. Kenya, Uganda, Tanzania); Nevill and Anderson, 1972: 147 (feeding preferences; Transvaal); Kremer, 1972: 645 (syn. of *imicola* from type); Braverman et al., 1974: 306 (larval breeding sites; Israel); Dyce and Wirth, 1983: 221 (Das Gupta types studied; syn.: *minutus, pseudoturgidus*).

Culicoides minutus Sen and Das Gupta, 1959: 622 (female; India; figs.); Dyce and Wirth, 1983: 221 (study of type series; holotype is syn. of *imicola*).

Culicoides pseudoturgidus Das Gupta, 1962c: 538 (male, female; figs.; India); Dyce and Wirth, 1983: 223 (study of type series; holotype female is syn. of *imicola*).

Culicoides sigaensis Tokunaga (misident.); Ratanaworabhan, 1975: 12 (misident.; fig. wing; Thailand records).

Female.--Wing length 0.82 (0.79-0.86, n = 5) mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 119a) with lengths of flagellar segments in proportion of 16-10-11-11-12-12-12-14-20-20-21-21-33, antennal ratio 1.18 (1.17-1.19, n = 2); sensilla coeloconica present on segments 3,12-15, sometimes also on 11. Palpus (fig. 119b) with lengths of segments in proportion of 8-17-18-11-11; third segment short and slightly swollen, without definite sensory pit but with sensilla grouped in a circular area on surface of segment; palpal ratio 2.3 (2.0-2.6, n = 5). Proboscis long, P/H Ratio 0.88; mandible with 12 (12-13, n = 11) teeth.

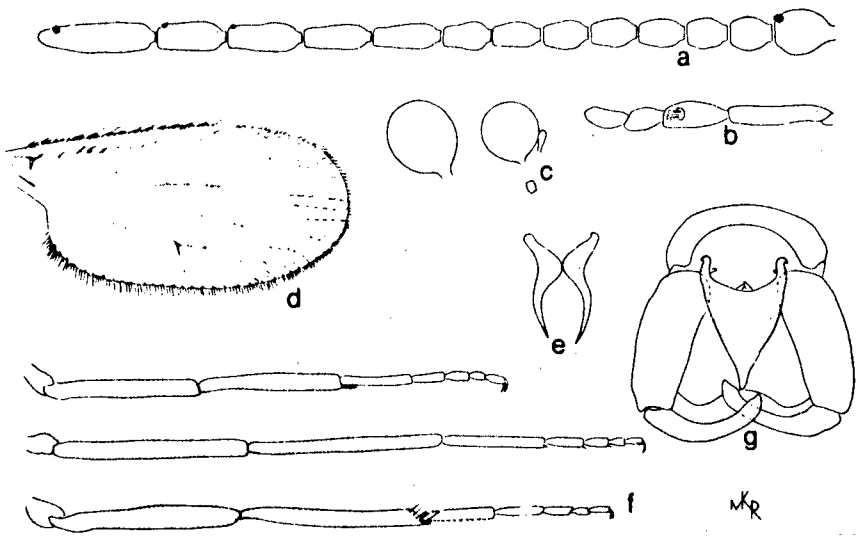


Fig. 119. *Culicoides imicola*: a. antenna; b. palpus; c. spermathecae; d. wing; e. parameres; f. legs; g. male genitalia, parameres omitted.

Thorax: Brownish, mesonotal pattern not visible in slide-mounted specimens. Legs (fig. 119f) brown, knee spots blackish; femora pale at bases, fore- and mid-femora with subapical and all tibiae with sub-basal, narrow pale rings, hindtibia pale at apex; hindtibial comb with 5 spines, the one nearest the spur longest.

Wing (fig. 119d, 284): Pattern as figured; typical of well-marked species of the Orientalis Group; wing pale at base; large pale spot over r-m crossvein, broadly meeting costal margin and fused posteriorly with pale streak in cell M2; poststigmatic pale spot in cell R5 large and quadrate, covering distal half of second radial cell and continuous posteriorly with basal end of long pale streak covering middle half of vein M1; distal pale spot in cell R5 quadrate, oblique in relation to vein M1

and continuous with distal end of pale streak along vein M1, broadly meeting anterodistal margin of wing; cell M1 with pale spot near base and a second long one narrowly continued to wing margin, expanded posteriorly nearly to vein M2 at distal third of the length of this vein; cell M2 with pale streak extending proximad from this level to base of cell, and also with a separate small pale spot at wing margin; cell M4 with large pale spot on posterior margin; anal cell with proximal third pale, the typical Orientalis Group pale mark complete in distal part of cell, the longitudinal mark cutting off separate dark spots on anterior and posterior margins at midlength of cell; tips of veins dark. Macrotrichia sparse and mostly in rows on distal fourth of wing; costal ratio 0.58 (0.57-0.60, n = 5); radial cells complete, first quite narrow. Halter pale.

Abdomen: Brown. Spermathecae (fig. 119c) slightly ovoid with short sclerotized necks; unequal, 0.043 x 0.033 mm and 0.033 x 0.029 mm including necks.

Male.--Indistinguishable from the male of *nudipalpis* Delfinado, except for the lack of a definite pit on third palpal segment. Genitalia as in fig. 119e,g.

Distribution.--Widespread and common in Africa, the Near and Middle East, India, Laos, Sri Lanka, Thailand, and Vietnam.

Types.--Holotype female of *imicola* in Mus. Natl. Hist. Nat. Paris, mounted on slide and redescribed and figured by Kremer (1972); data: "Afrique orientale anglaise: Tiwi, village situ près du littoral a 20 km sud de Mombase, st. no. 5, 3 novembre 1911."

Holotype female of *minutus*, Dum Dum, India, ii.1957, light trap, S.K. Das Gupta (in Zool. Surv. India, Calcutta). Holotype female of *pseudoturgidus*, Dum Dum, vii.1960, light trap (in Zool. Surv. India). Types of both species were studied and discussed by Dyce and Wirth (1983).

Southeast Asia Reocrds.--

LAOS: Sedone Prov., Muong Pakse (Howarth).

THAILAND: Cholburi Prov., Bangphra (Scanlon). Chiang Mai Prov. (Notananda). Loei Prov., Amphoe Muang, A. Ta Lee (Manop R.). Minburi Prov. (Manop R.). Khon Kaen Prov., A. Muang (Manop R.). Nakronprathom Prov. (Manop R.). Nakronrajasrima Prov., A. Muang (Manop R.). Nong Kai Prov., A. Juang, A. Ta Bo (Manop R.). Nonthaburi Prov. (Manop R.). Sakhonakron Prov., A. Muang (Manop R.). Samathprakan Prov. (Manop R.). Saraburi Prov., A. Prabuddhabat (Manop R.). Udonthani Prov., A. Muang, A. Nong Han, A. Pen (Manop R.).

VIETNAM: Phan Rang, 14 km W (Leech).

Discussion.--The status of this species is based on the excellent and detailed redescription and figures of the holotype female by Kremer (1972). Careful comparison of a large collection of African and Near and Middle East specimens with our Southeast Asia material failed to yield any detectable differences. In Southeast Asia the species appears to be separated geographically from the

nearly identical *C. nudipalpis* Delfinado, with abundant records from Thailand and Vietnam in the Indo-Chinese fauna, while *r udipalp.s* occurs in Indonesia, Malaysia, and the Philippines in the Malaysian fauna.

The African literature on *C. imicola* and *pallidipennis* is voluminous and some confusion remains which can be cleared up only by further detailed study of specimens from the localities and habitats reported in each reference. Because of this confusion no attempt will be made here to summarize what is known of the habits and vector relationships of this species in Africa.

Culicoides jacobsoni Macfie
(Figs. 120, 285)

Culicoides jacobsoni Macfie, 1934b: 215 (male; Sumatra; fig. genitalia); Delfinado, 1961: 655 (Philippines; fig. wing); Wirth and Hubert, 1961: 15 (Taiwan; syn. *kitaokai*); Tokunaga, 1962: 204 (Okinawa); McDonald and Lu, 1972: 406 (Taiwan, female diagnosis; figs.); McDonald et al., 1973: 639 (Okinawa; female diagnosis; figs.); Kitaoka and Suzuki, 1974: 173 (Amami-oshima; notes); Kitaoka, 1977: 193 (Japan distr.; synonymy; Nansei Islands); Lee, 1978: 57 (Rep. China; diagnosis; figs.); Kitaoka, 1980: 20 (male redescribed; figs.; distribution records); Dyce, 1983: 272 (New Guinea records; syn. *unisetiferus*, from types); Howarth, 1985: 65 (Laos records); Kitaoka, 1985a: 78 (Japan; in key; syns. *buckleyi*, *kitaokai*).

Culicoides buckleyi Macfie, 1937a: 117 (female; Malaya); Tokunaga, 1959: 238 (New Guinea; female redescribed; figs.); Tokunaga, 1962b: 505 (New Guinea; New Britain; male; figs. genitalia, probably misidentified); Tokunaga, 1963b: 137 (Solomon Islands); Lee, 1978: 34 (Rep. China; diagnosis; figs.).

Culicoides kitaokai Tokunaga, 1955: 6 (female, Japan; fig. wing); Arnaud, 1956: 109 (redescribed; figs.; Ryukyu Islands).

Culicoides unisetiferus Tokunaga, 1959: 213 (male, female; New Guinea, New Britain; figs.); Tokunaga, 1963c: 136 (male redescribed; fig. genitalia).

Culicoides orientalis Macfie (misident.); Tokunaga, 1962b: 514 (in part, male; genitalia figured (fig. 18).

Female.--Wing length 0.78 (0.64-1.04, n = 10) mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 120a) with lengths of flagellar segments in proportion of 15-10-11-12-13-13-13-15-23-23-22-22-36, antennal ratio 1.21 (1.13-1.28, n = 10); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 120b) with lengths of segments in proportion of 8-20-18-10-11; third segment slender, same thickness to tip, with a small, round, shallow sensory pit located near apex; palpal ratio 2.6 (2.4-1.9, n = 10). Proboscis moderetely short, P/H Ratio 0.76; mandible with 14 (13-16, n = 17) teeth.

Thorax: Dark brown; mesonotum (fig. 120f) pruinose gray, with a more or less prominent pattern consisting mainly of a sublateral pair of angular blackish patches behind humeral pits. Legs (fig. 120i) brown; knee spots blackish; femora slightly paler at bases, fore- and midfemora with subapical pale rings; tibiae with sub-basal pale rings and hindtibia with distal fourth pale; hindtibial comb (fig. 120d) with 5 (n = 10) spines, the one nearest the spur longest.

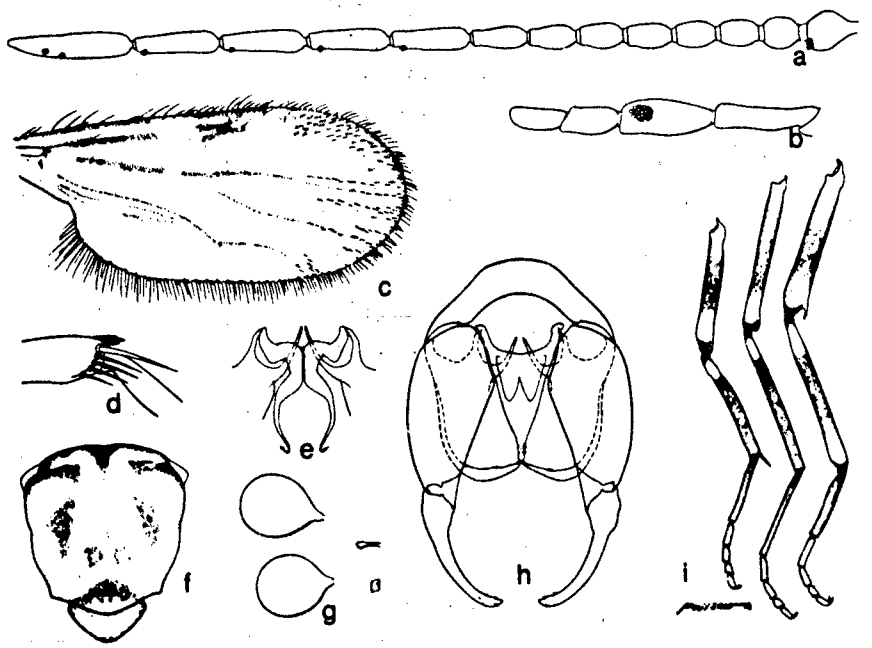


Fig. 120. *Culicoides jacobsoni*: a. antenna; b. palpus; c. wing; d. tibial comb; e. parameres; f. thoracic pattern; g. spermathecae; h. male genitalia, parameres omitted; i. legs.

Wing (fig. 120c, 285): Pattern as figured; pale spot over r-m crossvein large, extending broadly from costal margin to just over base of medial stem; poststigmatic pale spot quadrate, including distal half of second radial cell, its rounded posterior margin extending three-fourths way through cell R5 toward vein M1; distal pale spot in cell R5 more or less V-shaped, distal side usually concave, lying free from costal and distal margins of cell and from vein M1; 2 pale spots in cell M1, second lying far from wing tip; cell M2 with a pale streak in basal portion, expanding into a pale spot lying behind medial fork, no pale spot lying in front of mediocubital fork, 1 pale spot in distal part of cell, broadest at wing margin; cell M4 with a large pale spot occupying most of distal half and broadly meeting wing margin; anal cell with a pale streak at base and a double pale spot in distal portion; no pale spots at tips of veins at wing margin. Macrotrichia scanty, confined to 10-20 each in apices of cells R5, M1, and M2; costal ratio 0.64 (0.61-0.67, n = 10); radial cells well developed, short, each with distinct lumen. Halter pale.

Abdomen: Dark brown. Spermathecae (fig. 120g) ovoid, tapering to distinct short sclerotized necks; subequal, each 0.047 x 0.033 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 120h): Ninth sternum with moderately deep caudomedian excavation, ventral membrane minutely spiculate except near midline; ninth tergum short, broadly rounded caudally, slightly cleft in middle, with poorly developed, rounded lateral lobes. Basistyle with dorsal and ventral roots slender, ventral root quite long; dististyle slender and curved, with mesally pointed tip. Aedeagus with basal arch extending only to a fifth of total length, anterior margin of arch well sclerotized; sides straight, tapering to very slender tip which bears subapical, numerous, small, retrorse spinules; distal portion of aedeagus with a sclerotized point directed internally toward base of aedeagus. Parameres (fig. 120e) separate, closely approximated in midportions; each with stout, laterally bent basal process; midportion stout, tapering and curving ventrolaterally, ending in a slender tip with distal filament directed ventrally and bearing a few minute hairs near tip.

Distribution.--Japan (Tokyo) and south in Oriental Region through the Ryukyu Islands, Philippines, and Indonesia to New Guinea and the Solomon Islands, west to Malaysia and Thailand.

Types.--Types of *C. jacobsoni* Macfie and *C. buckleyi* Macfie in BMNH, London; type of *C. kitaokai* Tokunaga in Entomological collection of Saikyo University, Kyoto, Japan; type of *C. unisetiferus* Tokunaga in Bishop Museum, Honolulu.

Southeast Asia Records.--

INDONESIA: Flores, Manggarai, Reo Gincu and Golok (Lee). Kalimantan (South), Banjar, Astambul, Tanah Intan (Lee). Maluku, P. Buru, Savanjaya (Bambang). Sulawesi (North), Dumoga Bone Nat. Park, 220 m (Heppner); Lake Mooat, 20 km NE Kotamobagu, 1,050 m (Heppner). Sumatra, Bengkulu, Cenggeri (Mathis); (West), Sawahlunto, Tanjung Godang, Sungai Tenang (Lee).

LAOS: Luang Prabang (Quate). Sayaboury Prov., Nam Paui River margin, 22 km S Muong Phieng (Howarth); Xieng Hon (Howarth). Sedone Prov., Pakse (Howarth); Paksong (Howarth). Vientiane Prov., Ban Na Pheng (Howarth); Vang Vieng, Ban Ky Sok (Howarth); Ban Keun, Ban Na Peng (Howarth).

MALAYSIA: Johore, Kluang, Mersing Camp, biting man (Traub). Kelantan, Lambok, Sungei Betis, Ulu Kelantan (Wharton). Pahang, Kg. Berchang, Kuala Lipis, near carabao (Garcia); King George V Nat. Park, Tahan River (McClure); Kuala Tahan (Quate); Kuantan, Telok Sisek, biting man (Wharton); Kuantan, Paya Bungor (Wharton); Tasek Bera (Wharton). Perak, Gunong Besont Forest Res. (Jeffery); Kuala Kengrong, Girik (Traub). Selangor, Ulu Gombak Forest Res. reared from decaying fruits, ginger flowers, fungus, banana stems (Manikumar); Kepong (McClure, Quate); Klang Gates (Quate); Kuala Lumpur (Hubert, Traub); Kuala Lumpur, Ampang Forest Res., reared from decaying mushroom (Manikumar); Kuala Lumpur, Sungai Buloh Forest Res., reared from fungi (Manikumar); Serdang (Barnett); Subang Forest Res., reared from decaying jungle fruit (Manikumar). Trengganu, Dungun, Bukit Besi (Traub).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Mindanao, Surigao, Lake Mainit (Quate); Zamboanga del Norte, Upper Dohinog River (Quate).

SABAH: Tambunan (Colless). Tawau, Kalabakan River (Maa).

SARAWAK: Gunong Matang (Maa, Gressitt). Pangkalan Tebang, Bau Dist., 300-450 m (Maa).

THAILAND: Chiang Mai Prov., Ban Tin Doi (Gressitt). Loei Prov., Amphoe Dan Sai (Elbel). Lopburi (Manop R.). Nonthaburi (Manop R.).

VIETNAM: Dak Song, 76 km SW Ban Me Thuot (Quate). Di Linh (Djiring) (Quate).

Discussion.--Although the small distal pale spot in cell R5 which does not meet the margins of the cell is not typical of *Avaritia*, the structure of the third palpal segment, tibial comb, antenna, and shapes of the aedeagus, parameres, and ninth tergum of the male genitalia place *C. jacobsoni* in that subgenus. The peculiar spines at the tip of the male aedeagus are characteristic of this species. Another peculiar feature is the elongation of the antennal segments 9 and 10 of the female, each slightly longer than those proximad in the series.

This species has been reared several times near Kuala Lumpur, Malaysia, from decaying fruits and ginger flowers in the jungle, from rotting banana stems, and from decaying fungus on a rotting tree.

Culicoides maculatus (Shiraki)
(Figs. 121, 286, 425)

Ceratopogon maculatus Shiraki, 1913: 296 (male, female; Taiwan).

Culicoides maculatus (Shiraki); Tokunaga, 1937: 296 (combination; male, female redescribed; Taiwan; figs.; syn. *tainana*); Wirth and Hubert, 1961: 15 (Taiwan records; separation from *sigaensis*; taxonomic notes); McDonald and Lu, 1972: 408 (female redescribed; figs.; Taiwan); McDonald et al., 1973: 643 (female redescribed; figs.; Okinawa); Kitaoka, 1977: 194 (distribution; syn. *sigaensis*); Wada and Kitaoka, 1977: 343 (in list; syns. *kii*, *kyotoensis*, *sigaensis*); Lee, 1978: 67 (male, female redescribed; figs.; China); Lee, 1979: 106 (in key; Tibet); Dyce, 1980: 286 (Java; in paratype series of *orientalis* Macfie); Howarth, 1985: 66 (Laos records).

Culicoides tainana Kieffer, 1916: 114 (female; Taiwan).

Culicoides kii Tokunaga, 1937: 284 (male; Japan; figs.).

Culicoides sigaensis Tokunaga, 1937: 322 (female; Japan; figs. antenna); Kono and Takahasi, 1940: 77 (Hokkaido, Japan); Arnaud, 1956: 127 (male, female redescribed; figs.; Japan, Manchuria; syn. *kii*); Lee, 1978: 97 (diagnosis; figs.; China).

Culicoides kyotoensis Tokunaga, 1937: 329 (female; Kyoto, Japan; figs.).

Culicoides suborientalis Tokunaga, 1951: 106 (male, female; Java; figs.). NEW SYNONYMY.

Female.--Wing length 1.00-1.20 mm.

Head: Eyes (fig. 121d) contiguous a short distance, bare. Antenna (fig. 121a) with lengths of flagellar segments in proportion of 19-13-14-15-15-15-15-17-23-22-23-25-39, antennal ratio 1.10 (1.07-1.14, n = 2); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 121b) with lengths of segments in proportion

of 10-27-26-13-13; third segment long and slender, with small round sensory pit near tip; palpal ratio 2.9. Proboscis moderately long, P/H Ratio 0.89; mandible (fig. 121e) with 17 (15-18, n = 12) teeth.

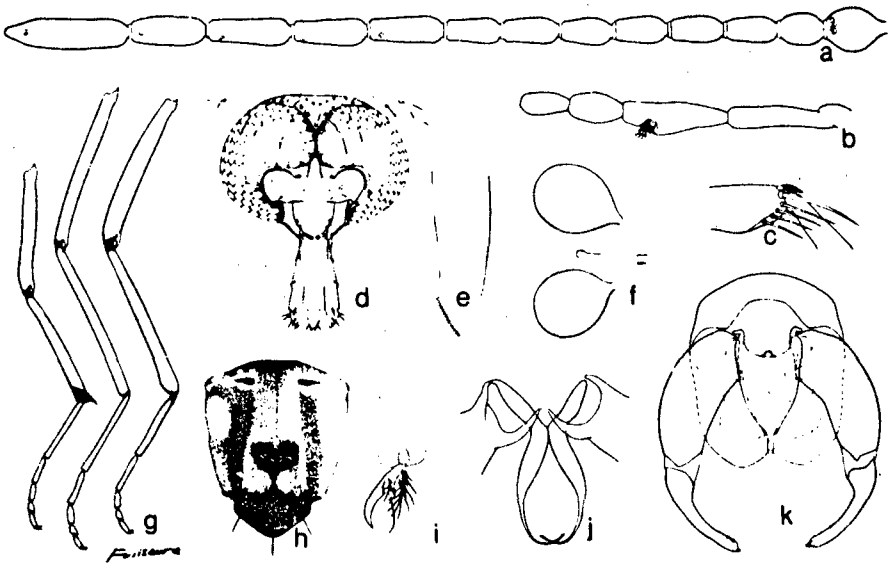


Fig. 121. *Culicoides maculatus*: a. antenna; b. palpus; c. tibial comb; d. head, anterior view; e. mandible; f. spermathecae; g. legs; h. thoracic pattern; i. tarsal claw and empodium, j. parameres; k. male genitalia, parameres omitted.

Thorax: Brown, mesonotum dull brownish, often with a sublateral pair of dark brown vittae (fig. 121h). Legs (fig. 121g) brown, knees not darkened; faint pale bands present at bases of tibiae and apex of hindtibia; hindtibial comb (fig. 121c) with 5 spines, the one nearest the spur longest; tarsal claw as in fig. 121i.

Wing (fig. 286, 425): Pattern as figured; pale markings rather faint; pale spot over r-m crossvein broadly meeting costal margin and barely touching vein M; poststigmatic pale spot in cell R5 more or less quadrate, broadly meeting anterior wing margin and not touching the faint pale streak along mid section of vein M1; an elongate pale spot filling apex of cell R5; cell M1 with a small pale spot at base and a larger, elongate pale spot at apex, the latter reaching wing margin; cell M2 with a pale streak in basal half, enlarged in a pale spot behind medial fork, distal half with pale streak faint, but with distinct pale spot at apex of cell reaching wing margin; cell M4 with round pale spot filling distal half or more; anal cell with very faint pale streak at base and two very faint pale spots in distal portion; apices of

veins dark. Macrotrichia sparse, confined to apices of cells R5, M1 and M2; costal ratio 0.61 (0.58-0.65, n = 6); radial cells distinct, the veins strong and contrasting in shading. Halter pale.

Abdomen: Dark brown. Spermathecae (fig. 121f) ovoid to subspherical, with short, slender, sclerotized necks; slightly unequal, 0.047 x 0.038 mm. (Description of female based on specimens from Thailand.)

Male.--Similar to female with usual sexual differences. Genitalia (fig. 121k): Ninth sternum with broad, shallow, caudomedian excavation, ventral membrane spiculate only along margin of excavation; ninth tergum rounded distally with slight caudomedian cleft. Basistyle with ventral root long and slender, dorsal root shorter and stouter; dististyle curved and slender distally, without mesal point at tip. Aedeagus long with narrow base, basal arch extending to a fourth of total length, distal process long, slender, and simple. Parameres (fig. 121j) separate, each with moderately long, slender basal arm, midportion not greatly swollen, distal portion tapered to ventrally directed filament with several minute hairs at tip (described from Japanese specimens figured by Arnaud 1956).

Distribution.--China, Indonesia, Japan, Laos, Malaysia, Manchuria, Philippines, Ryukyu Islands, Thailand, Vietnam.

Types.--According to Arnaud (1956) the type female of *C. sigaensis* is in the alcohol collection at Kyushu University, Japan, and the type male of *C. kii* is probably a male in alcohol labelled *Culicoides nudipennis* (manuscript name ?) in the same collection. The types of *C. suborientalis* are in alcohol and deposited in the entomological laboratory, Saikyo University, Kyoto, Japan.

Southeast Asia Records.--

INDONESIA: West Java, Bogor (Adiwinata).

LAOS: Sedone Prov., Muong Paksong, biting man (Howarth). Vientiane Prov., Vang Vieng, Ban Ky Sok; Muong Ban Keun, Ban Na Pheng (Howarth).

MALAYSIA: Pahang, Mt. Brinchang, 1,600 m (McClure).

PHILIPPINES: Luzon, Camarines Sur, Mt. Isarog, Pili (Torrevillas); Mountain Prov., Abatan, Baguias (Torrevillas).

THAILAND: Chiang Rai (Causey). Loei Prov., Dan Sai (Elbel).

VIETNAM: Dralac, Dalat (Spencer); Dalat, 1,500 m (Quate).

Discussion.--This species is larger than most other species of the Orientalis Group and can be distinguished by the wing pattern, with two large distinct anterior pale spots, and obscure posterior markings with the Orientalis-type pale markings in the anal cell poorly contrasting or partly or wholly absent. The radial veins are stronger and the radial cells are better developed than the other species of the group except in *C. pastus*.

Culicoides maculatus varies considerably in size and in the extent and shade of the wing markings, leading in part to its description under different names by various authors. Dyce (personal communication) made an intensive study of the available type specimens in this group, resulting in extensive synonymy. Tokunaga (1937) studied and figured male and female specimens from Shiraki's

Mt. Arisan collection of *maculatus* and stated that *maculatus* differed from *sigaensis* in the male genitalia having the lobes of the ninth tergum more angulate and widely spaced, and the less definite but more extensive wing markings. Kitaoka (1977) stated that the posterior outline of the ninth tergum of male *maculatus* from Taiwan had no significant differences from that of *sigaensis* from Japan, and he placed *sigaensis* in synonymy with *maculatus*. Dyce remounted the male specimen figured by Tokunaga (1937) and found that the apparent outline of the ninth tergum as shown by Tokunaga's figure was due to an artifact in Tokunaga's slide mount. Dyce studied male and female paratypes of *suborientalis* Tokunaga (1951) from Tjinjiroen, Java, and found them to be identical with *maculatus*.

Culicoides nudipalpis Delfinado
(Figs. 122, 287, 426)

Culicoides nudipalpis Delfinado, 1961: 655 (female; Philippines; figs.); Dyce, 1979: 52 (notes on types and synonymy).

Female.--Wing length 0.80 mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 122a) with lengths of flagellar segments in proportion of 34-23-23-27-27-27-30-30-44-47-51-51-74, antennal ratio 1.20; sensilla coeloconica present on segments 3,12-15, seomtimes also on 11. Palpus (fig. 122b) with lengths of segments in proportion of 17-40-44-27-30; third segment short and slightly swollen, palpal ratio 0.68, with a shallow, round, sensory pit. Mandible with 13-15 teeth; P/H Ratio 0.68.

Thorax: Brownish, mesonotal pattern not visible in slide-mounted specimens. Legs (fig. 122d) brown, knee spots blackish; femora pale at bases, fore- and mid-femora with subapical, and all tibiae with sub-basal, narrow pale rings, hindtibia pale at apex; hindtibial comb (fig. 122e) with 5 spines, the one nearest the spur longest.

Wing (fig. 287, 426): Pattern as figured; typical of well-marked species of the Orientalis Group; wing pale at base; large pale spot over r-m crossvein, broadly meeting costal margin and fused posteriorly with pale streak in cell M2; poststigmatic pale spot in cell R5 large and quadrate, covering distal half of second radial cell and continuous posteriorly with basal end of long pale streak covering middle half of vein M1; distal pale spot in cell R5 quadrate, oblique in relation to vein M1 and continuous with distal end of pale streak along vein M1, broadly meeting anterodistal margin of wing; cell M1 with pale spot near base and a second long one narrowly continued to wing margin, expanded posteriorly nearly to vein M2 at distal third of the length of this vein; cell M2 with pale streak extending proximad from this level to base of cell, and also with a separate small pale spot at wing margin; cell M4 with large pale spot on posterior margin; anal cell with proximal third pale, the typical Orientalis Group pale mark complete in distal part of cell, the longitudinal mark cutting off separate dark spots on anterior and posterior margins at midlength of cell; tips of veins dark. Macrotrichia sparse and mostly in rows on distal fourth of wing; costal ratio 0.58; radial cells complete, first quite narrow. Halter pale.

Abdomen: Brown. Spermathecae (fig. 122c) slightly ovoid, with short sclerotized necks; unequal, 0.051 x 0.034 mm and 0.040 x 0.030 mm.

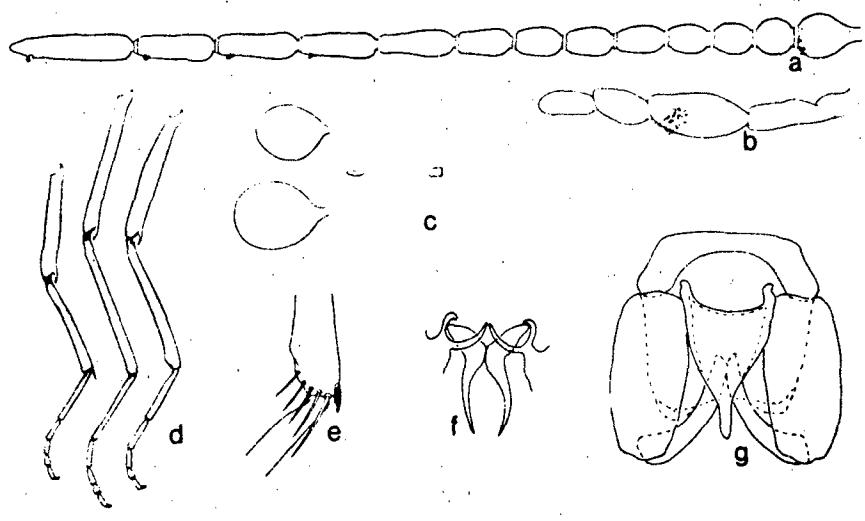


Fig. 122. *Culicoides nudipalpis*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Male.--(Described from Sumbawa, Indonesia.) Similar to female with usual sexual differences. Genitalia (fig. 122g): Ninth sternum with wide, relatively deep, caudomedian excavation, ventral membrane with a few microscopic spicules near excavation; ninth tergum short and broad, caudal margin slightly concave between well-developed, rounded, caudolateral lobes. Basistyle with ventral and dorsal roots long and slender; dististyle slender and curved, slightly stouter distally with distinct distomesal point. Aedeagus with relatively broad base, basal arch low, 0.22 of total length, main body broad with convex sides; distal process short, tapering to slender rounded tip. Parameres (fig. 122f) separate, each with moderately long, stout, tapering basal arm; midportion moderately swollen at base, tapering distally to slender filament without distal hairs.

Distribution.--Indonesia, Philippines.

Types and Notes on Synonymy.--Holotype female, Kidapawan, Cotabato, Philippines, 5.iii.1957, F. Kalaw, carabao-baited trap (deposited in Philippine Department of Health, apparently now lost). Paratypes, 3 females, same data as type except June and August, 1956 (deposited in CNHM, USNM and PDH; the specimen in the USNM is dated vi.1956 and is in poor condition). Two additional females from Kidapawan mounted and labelled by Delfinado, but not labelled paratypes, are in the USNM; the specimen with data 13.vii.1957 bearing the num-

ber "157" added by Wirth to designate specimen here figured, is hereby designated NEOTYPE and will remain in the USNM collection; the second specimen is dated v.1956. Two additional specimens from Delfinado's material are deposited in the USNM: 1 female paratype, Tala, Rizal, 21.v.1938, M. Delfinado; the second specimen was discussed by Dyce (1978) as follows:

"Furthermore, the designated allotype female *Culicoides radicitus* Delfinado is conspecific with *Culicoides nudipalpis* Delfinado, the holotype female of which is also apparently lost. The wing pattern of the designated allotype *C. radicitus* does not correspond with Plate 9, fig. 12 accompanying the original description, but matches precisely Plate 9, fig. 9 shown for *C. nudipalpis* Delfinado." This specimen bears the data "Clark Air Base, Angeles, Pamp., 17.ix.57, I. Balatbat."

Southeast Asia Records.--

INDONESIA: Flores, Manggarai, Nangalili near Wai Jarnl near Pandang (Lee); Manggarai, Padang, Wai Aru (Lee); Manggarai, Reo, Golok (Lee); Reo, Robek, Kampung Ojang Beach (Lee). Lombok (East), Selong, Kerekong (Lee). Maluku, P. Buru, Savanjaya (Bambang). Sumbawa (Nicholls); Timor (East), Dilli, Comoro (Soeroto). Timor, Cape Tafara, 11 km SE Suai (Nicholls)

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Pampanga Prov., Angeles, Clark Air Base (Balatbat); Rizal Prov., Tala (Delfinado). Mindanao, Cotabato, Kidapawan (Kalaw). Negros Oriental, Dumaguete (Quate and Yoshimoto).

Discussion.--Culicoides nudipalpis is nearly identical with *C. imicola* Kieffer and very similar to *C. brevitarsis* Kieffer. Females may be separated from those species by the virtual absence of the palpal pit; the third palpal segment of *C. nudipalpis* has a round pitlike area on the surface, but it lacks depth. In the wing of *nudipalpis* and *imicola* the dark streak on the distal part of vein M2 separates the pale areas in cells M1 and M2; the distal pale spot in cell M1 is broadened proximally on the posterior margin until it virtually touches vein M2. The male genitalia of *nudipalpis* and *imicola* are distinguishable from those of *brevitarsis* by the presence in *nudipalpis* of a band of spicules on the ventral membrane of the ninth sternum of the first two species.

Culicoides orientalis Macfie
(Figs. 123, 288, 427)

Culicoides orientalis Macfie, 1932: 490 (male, female, in part, female only; Malaya, India, Java; fig. wing, male genitalia); Macfie, 1937a: 115 (Malaya); Causey, 1938: 408 (Siam; descriptive notes; fig. male genitalia); Buckley, 1938: 147 (Malaya; larval habitat; feeding on cattle, filaria vector); Lever, 1943: 41 (Russell Islands); Sen and Das Gupta, 1959: 627 (India; in part, male only); Tokunaga, 1959: 254 (New Guinea; in part, female only); Delfinado, 1961: 656 (Philippines; male, female; figs.); Tokunaga, 1962b: 514 (New Guinea, Papua, New Britain, Solomon Is.; in part, female only; figs.); Lee, 1978: 83 (Rep. China; diagnosis; figs.); Dyce, 1980: 286 (redescribed from types; lectotype designated; figs.; synonymy); Debenham, 1978: 300 (bibliography; review); Dyce, 1983: 271 (New Guinea records; notes); Howarth, 1985: 66 (Laos records).

Culicoides nayabazari Das Gupta, 1963a: 35 (female; India; figs.); Dyce and Wirth, 1983: 224 (synonym of *C. orientalis*).

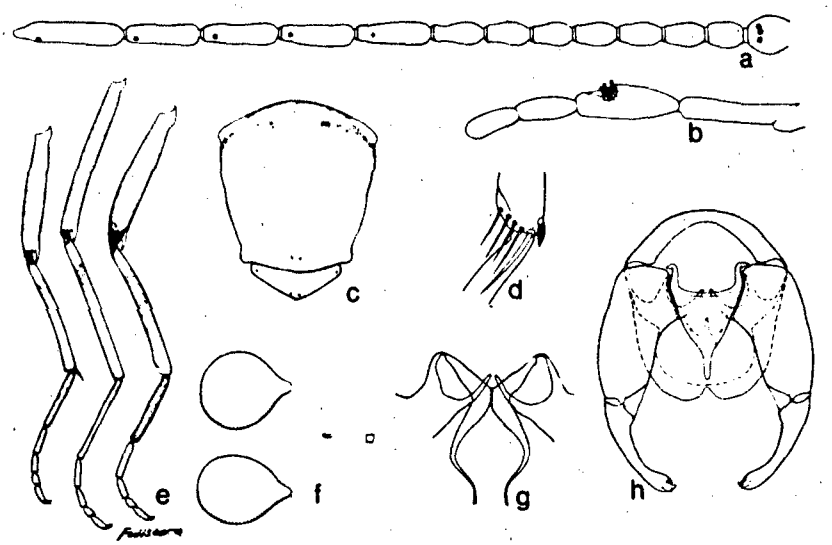


Fig. 123. *Culicoides orientalis*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Female.--Wing length 0.89 mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 123a) with lengths of flagellar segments in proportion of 17-12-13-13-14-14-14-17-22-23-23-24-47, antennal ratio 1.13; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 123b) with lengths of segments in proportion of 11-26-24-12-12; third segment long and slender, with a small round shallow sensory pit near apex; palpal ratio 3.1. Proboscis moderately long, P/H Ratio 0.85; mandible with 15 teeth.

Thorax: Dark brown, mesonotal pattern as in fig. 123c. Legs (fig. 123e) dark brown; knee spot blackish on foreleg; faint subapical pale ring on forefemur, faint apical band on midfemur, prominent sub-basal pale rings on all tibiae, and prominent apical pale band on hindtibia; hindtibial comb (fig. 123d) with 5 spines, the one nearest the spur longest.

Wing (fig. 288, 427): Pattern as figured; typical of well-marked species of the Orientalis Group; wing pale at base; pale spot over r-m crossvein broadly meeting costal margin and slightly overlapping vein M; poststigmatic pale spot in cell R5 quadrate, covering distal half of second radial cell, jointed caudad with base of pale streak bordering middle half of vein M1; distal pale spot in cell R5 extending to apex of cell in full breadth; two pale spots in cell M1, the distal one continuous

anteriorly at base with pale streak along vein M1, this vein dark at tip; cell M2 with pale streak nearly its entire length, expanded in a pale spot behind medial fork and a distal pale spot at wing margin; cell M4 with pale spot filling nearly distal half; anal cell with longitudinal pale streak from base extending to a double pale spot in distal portion of cell, anal angle narrowly pale but the longitudinal dark streak anterior to this is complete through proximal two-thirds of cell. Macrotrichia fairly numerous in distal third of cells R5 and M1 and in apex of cell M2; costal ratio 0.65; radial cells distinct. Halter pale to faintly infuscated.

Abdomen: Dark brown. Spermathecae (fig. 123f) ovoid, with short, tapering necks; subequal, each 0.048 x 0.035 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 123h): Ninth sternum with shallow caudomedian excavation, ventral membrane spiculate nearly to base of aedeagus except on ventral midline; ninth tergum with low submedian lobes on caudal margin, the margin slightly cleft between them. Basistyle with ventral and dorsal roots short and stout; dististyle curved and moderately slender, with distinct distomesal point. Aedeagus with basal arch extending to a fourth of total length, anterior margin of arch slightly more heavily sclerotized; distal process long and slender with rounded tip. Parameres (fig. 123g) separate, each with moderately long and slender basal arm; midportion only slightly swollen, tapering distally to a simple filamentous point directed ventrad.

Distribution.--India, Indonesia, Laos, Malaysia, New Guinea, Philippines, Sabah, Sarawak, Solomon Islands, Thailand, Vietnam.

Types.--Syntype series in BMNH from Malaysia, India, and Java. Lectotype female (designated by Dyce 1979: 289), "Malay States, S.T. Stanton (B.M. 1932.99)" on slide; also four females (lectoparatypes), same data, on slides. Lectoparatypes, "India, Chawar, R. Newstead (B.M. 1932.99.7 and 8)," 2 females, on slides; and "India," no other data (B.M. 1932.99.7), 1 female on slide. According to Dyce, the syntype male on a slide, and 23 females in alcohol from E. Java, Tosari, Dr. K. Fredericks (B.M. 1931.554), are identified as *C. maculatus* Shiraki. Dyce's description of the male of *orentalis* was made from specimens from Urimo, NE New Guinea. Our present descriptions and figures are made from specimens from Bogor, Java.

Southeast Asia Records.--

INDONESIA: Flores, Manggarai, Reo, Robek, Kampung Ojang Beach (Lee); Nanang (Lee). Java (Central), Cilacap, Adipala, Bunton (Lee); (West) Bogor (Adiwinata); Garut, Pameungpeuk (Zubaedah). Kalimantan (South), Banjar, Astambul, Tanah Intan, Karang Anyar, Lombok Terang, and Titian Mantang (Lee). Lombok, Kerekong (Lee); (West) Cakra, Sayang (Lee); Mataram, Gerung, Dasan Geras (Lee). Muluku, P. Buru, Savanjaya (Bambang). Sulawesi (Central), Banggai, Batui, Kamiwangi (Bambang); (North) Dumoga Bone Dat. Park, 220 m (Heppner); Lake Mocat, 20 km NE Kotamobagu, 1,050 m (Heppner); (Southeast) Kendari, Ranometo, Randono and Sabulohoa (Bambang); Kendari, Unaha (Bambang); Kolaka, Tiracita, Lodongi Jaya (Bambang). Sumatra, Bengkulu,

Bukit Penjauan (Mathis); (West) Sawalunto, Tanjung Godang, Sungai Tenang (Lee). Timor (East), Dilli, Comoro, Kampung Narinir (Soeroto); Dilli, Kampung Beto (Soeroto).

LAOS: Sayaboury Prov., Muong Xieng Hon, 500 m (Howarth); Sayaboury, 300 m, margin Nam Houng R. (Howarth); 22 km S Muong Phieng, margin Nam Poui R. (Howarth). Sedone Prov., Muong Pakse, 100 m, on cow and in cow shed (Howarth); Muong Paksong, 1,270 m, biting man (Howarth). Vientiane Prov., Muong Ban Keun, Ban Na Pheng, sweeping cows (Howarth).

MALAYSIA: Johore, Kahang Kluang (Hubert). Negri Sembilan, K. Pilah, Pekan Lama (Garcia). Pahang, Gudang Rasan, Kuantan (Traub); King George V Nat. Park, Tahan R. (McClure, Quate); Kuala Singgora (Wharton); Kuala Tahan (Domrow, biting man; Quate); Tasek Bera (Wharton); Ulu Gali, cattle shed (Garcia). Perak, Kuala Kengrong, Girik (Traub). Perlis, Kangar Rest House (Traub). Selangor, Anipang Forest Res. (Traub); Effingham Estate, Damasara (Garcia); Kepong (Quate); Kuala Lumpur (Barnett, Hubert, Traub); Serdang (Barnett); Ulu Langat (Barnett); Ulu Lui, Ulu Langat, biting man near cattle (Wharton). Trengganu, Dungun, Bukit Besi (Hubert, Traub).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Pampanga Prov., Angeles, Clark Air Base (Balatbat). Mindanao, Cotabato, Kidapawan (Kalaw); Agusan, Esperanza (Yoshimoto); Agusan, Los Arcos (Quate); Davao Prov., Tagum, Maco (Hoogstraal and Heyneman); Surigao, Lake Mainit (Yoshimoto). Palawan, Brookes Point, Uring Uring (Noona Dan Exped.). Tawi Tawi, Tarawakan, N of Batu Batu (Noona Dan Exped.).

SABAH: Labuan Id. (Colless). Ranau (Maa). Tambunan (Colless). Tawau (Maa); Tawau Dist., Kalabakan (Maa).

SARAWAK: Kapit Dist., Nanga Pelagus (Traub). Pangkalan Tebang, Bau Dist. (BISH).

THAILAND: Bangkok (Causey). Chiang Mai (Causey). Chiang Rai (Causey). Nakronprathom Prov. (Manop R.). Nong Kai Prov., Amphoe Muang (Manop R.). Nonthaburi Prov. (Manop R.). Phangnga Prov., Pulau Panjang, cow shed (collector ?). Samuthprakan Prov. (Manop R.).

VIETNAM: Dak Song, Ban Me Thuot (Quate). Dalat, Dralac (Spencer). Saigon (Spencer).

Discussion.--Macfie (1932) mentioned variation in his material of *C. orientalis* and in 1937 said there was probably a mixture of species. As indicated above under the discussion of "Types," Dyce (1980) selected as lectotype a female from Stanton's Malaysian series and assigned four Malaysian females and three females from India in Macfie's type series to *orientalis*.

This species is closest to *C. wadai* Kitaoka which differs principally in the outline of the dark area on the distal part of vein M2, and in the shape of the male aedeagus. According to Dyce (1980) the male from Hollandia, New Guinea, described by Tokunaga (1959) as *orientalis* is actually a male of *C. actoni*; and the male Tokunaga (1962b) later described under the name *orientalis* is probably the hitherto unknown male of *C. fragmentum* Tokunaga (1962b).

Habits.--Buckley (1938) reported *C. orientalis* feeding on cattle along with other species of *Culicoides* at Kuala Lumpur, Malaysia. This species was not nearly as common as *C. oxystoma, actoni*, or *shortti* in daytime collections but ranked high behind *shortti* and *peregrinus* at night. The species preferred to feed on the dorsal parts of cattle rather than ventral. *Culicoides orientalis* was reared from material obtained from old manure piles, i.e., 2-3 weeks old whose surface was well dried by the sun but which were still moist an inch or two under the surface, where the larvae were developing. It was concluded that *C. orientalis*, along with *C. actoni, oxystoma* and *shortti*, was an actual or potential vector of *Onchocerca gibsoni* in Malaysia.

Culicoides pastus Kitaoka
(Figs. 124, 289)

Culicoides "sp. ONODA" Wada and Kitaoka, 1977: 171 (in list).
Culicoides pastus Kitaoka, 1980: 11 (male, female; Japan; figs.).

Female.--Wing length 1.34 mm.

Head: Eyes contiguous for 2-3 facets, bare. Antenna (fig. 124a) with lengths of flagellar segments in proportion of 56-40-40-41-42-41-42-49-63-61-63-79-109, antennal ratio 1.08; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 124b) with lengths of segments in proportion of 18-81-64-51-43; third segment long and slender, with small round sensory pit near tip; palpal ratio 3.1. Proboscis moderately long, P/H Ratio 0.80; mandible with 13-16 teeth.

Thorax: Dark brown, unicolorous. Legs (fig. 124f) dark brown, knee spots blackish; fore- and midfemora with faint narrow subapical pale rings; all tibiae with basal pale rings, hindtibia with apical pale band; hindtibial comb with 5 spines, the one nearest the spur longest.

Wing (fig. 124c, 289): Pattern as figured; markings similar to those of *maculatus*; pale markings more definite but less extensive than in *maculatus*; the oval pale spot at base of cell M1 more isolated and more conspicuous than in *maculatus*; the dark spot lying across midportion of mediocubital stem more prominent and more quadrate in outline than in *maculatus*. Macrotrichia sparse, distributed along margin of distal half of wing; costal ratio 0.63; radial cells well formed, the second broad, veins prominent. Halter with base infuscated, knob pale on end.

Abdomen: Dark brown. Spermathecae (fig. 124d) ovoid without distinct neck; strongly pigmented; slightly unequal, 0.073 x 0.058 mm and 0.071 x 0.054 mm; rudimentary spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 124g): Ninth sternum with broad, deep, caudomedian excavation, ventral membrane bare; ninth tergum subrectangular, median cleft present, caudal margin with broad low rounded lobes. Basistyle slender, ventral root long and slender, dorsal root moderately long; dististyle slender, slightly curved. Aedeagus with basal arch low, extending to a fourth of total length; lateral margins slightly convex; distal process a fifth of total length, slender with rounded tip. Parameres (fig. 124e)

separate, contiguous in midportions; each with moderately long and slender basal arm, midportion swollen at base, tapering gradually and curving to fine filamentous tip directed ventrally and bearing distally a few microscopic hairs.

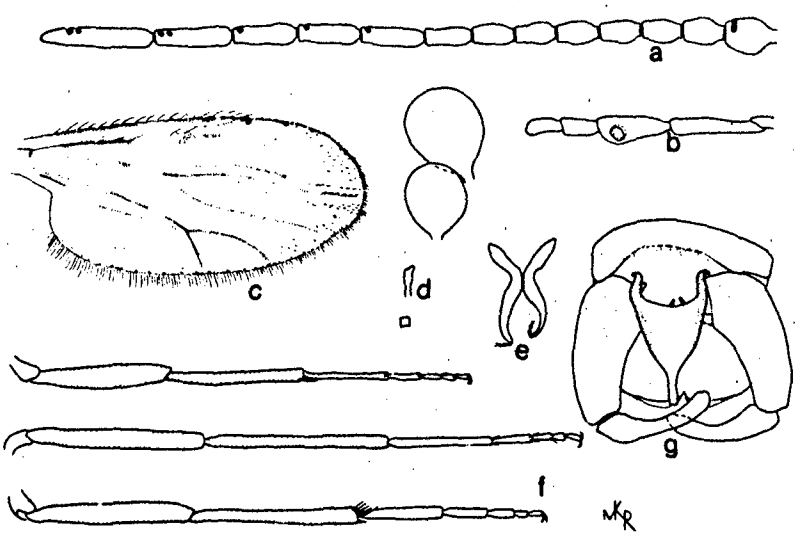


Fig. 124. *Culicoides pastus*: a. antenna; b. palpus; c. wing; d. spermathecae; e. parameres; f. legs; g. male genitalia, parameres omitted.

Distribution.--Japan, Malaysia, Philippines, Sabah.

Types.--Holotype female, allotype male, Onoda-machi, Miyagi Prefecture, Japan, 7.vii.1977, S. Kitaoka (Nat. Sci. Mus., Tokyo). Paratypes, 24 females.

Southeast Asia Records.--
MALAYSIA: Pahang, Mt. Brinchang, 1,600 m (McClure).
PHILIPPINES: Mindanao, Bukidnon, Mt. Katanglad, 1,480 m (Quate).
SABAH: Tenompok, 48 km E Jesselton (Maa and Quate).

Discussion.--This species is nearly identical with C. maculatus but is a larger, darker species with more restricted and more definite pale wing markings, in which the oval pale spot at the base of cell M1 is more isolated and conspicuous, and the dark area straddling the mediocubital stem is more prominent and quadrate in outline. The spermathecae of C. pastus lack the slender necks found in maculatus and are larger and darker.

Culicoides pungens de Meijere
(Figs. 125, 290, 428)

Culicoides pungens de Meijere, 1909: 200 (female; Sumatra; fig. antenna, wing); Salm, 1914: 407 (Java); Edwards, 1922: 164 (photo wing of holotype); Edwards, 1926b: 136 (Buru Island); Macfie, 1937a: 115 (Malaya); Macfie, 1941: 69 (Malaya); Delfinado, 1916: 656 (Philippines; fig. wing); Tokunaga, 1962b: 515 (New Ireland); Debenham, 1978: 352 (in part only; most records and data refer to *actoni*); Dyce, 1983: 271 (New Guinea records; syn.; *obscurus*).

Culicoides obscurus Tokunaga and Murachi, 1959: 347 (female; Caroline Islands; fig. wing).

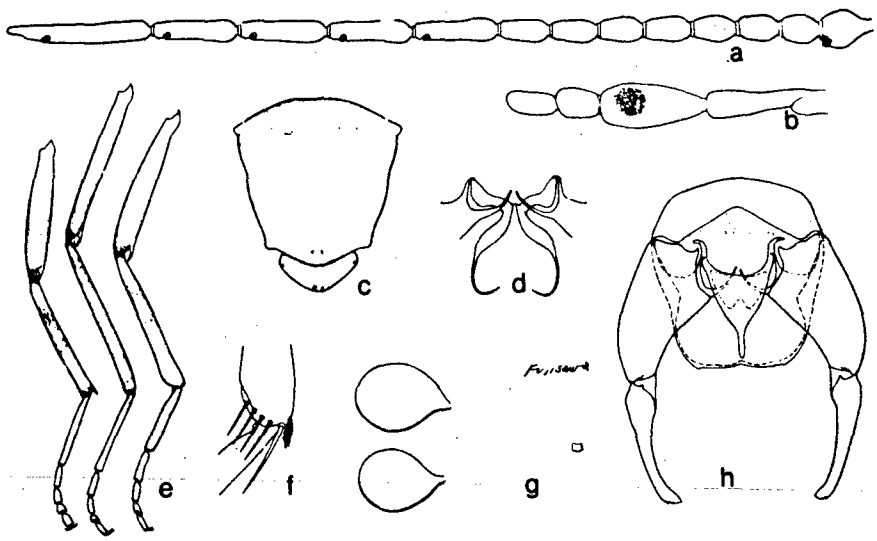


Fig. 125. *Culicoides pungens*: a. antenna; b. palpus; c. thoracic pattern; d. parameres; e. legs; f. tibial comb; g. spermathecae; h. male genitalia, parameres omitted.

Female.--Wing length 0.81 (0.70-0.91, n = 10) mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 125a) with lengths of flagellar segments in proportion of 14-11-12-12-14-12-13-14-24-25-25-25-42; antennal ratio 1.37 (1.27-1.47, n = 10); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 125b) with lengths of segments in proportion of 10-20-20-9-10-; third segment slightly swollen in midportion; with a small round, moderately deep sensory pit located close to apex; palpal ratio 2.2 (2.0-2.4, n = 8). Proboscis moderately long, P/H Ratio 0.87; mandible with 16 (13-18, n = 17) teeth.

Thorax: Uniformly dull brown, mesonotum (fig. 125c) without pattern. Legs (fig. 125e) brown, only extreme bases of femora and bases of fore- and hindtibiae paler; hindtibial comb (fig. 125f) with 5 spines, the one nearest the spur longest.

Wing (fig. 290, 428): Pattern as figured; pale areas very faint and diffuse; pale spot over r-m crossvein including only immediate area around crossvein; poststigmatic pale spot faint but fairly extensive, including distal half of second radial cell; no other distinct pale spots on wing, but apices between the veins more faintly infuscated than veins themselves over remainder of wing. Macrotrichia scanty, only a few near wing margin in extreme apices of cells R5 and M; costal ratio 0.65 (0.62-0.67, n = 10); radial cells well developed, moderately long. Halter deeply infuscated, dark brown.

Abdomen: Dark brown. Spermathecae (fig. 125g) ovoid, tapering gradually to short sclerotized necks; subequal, each 0.050 x 0.037 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 125h): Ninth sternum with broad shallow caudomedian excavation, ventral membrane with coarse spicules caudad to level of anterior ends of basal arms of aedeagus; ninth tergum short, broadly rounded distally with slight trace of caudomedian cleft, lateral corners without trace of lobes. Basistyle with ventral root long and slender, dorsal root shorter and stouter; dististyle slender, not very curved distally, with slender, mesally pointed tip. Aedeagus with basal arch extending to a third of total length, basal arms moderately stout and laterally bent; sides convex, distal process very long and slender with rounded tip; a well developed, blunt, internal sclerotized median point present. Parameres (fig. 125d) separate, closely approximated in midportions; each with moderately long, anterolaterally bent basal arm, midportion slightly constricted at the bend, slender, becoming more swollen caudad, then constricted on distal portion and tapering to fine filamentous tip directed ventrally.

Distribution.--Buru Island, Sumatra, Bismarck Islands, Malaysia, New Ireland, Nissan Island, Sabah, Sarawak, Thailand.

Type.--"Sumatra, Dr. Salm leg." According to Edwards (1922) the holotype is mounted on a slide in balsam in the Zoological Museum in Amsterdam.

Southeast Asia Records.--

INDONESIA: Sumatra.

MALAYSIA: Negri Sembilan, Telok Pelandok, Port Dickson (Traub). Pahang, Kuantan, Gudang Rasan (Traub); Kuantan, Paya Bungor (Wharton); Pahang, Kuantan, Telok Sisek, biting man (Wharton). Pengkalan Kempas, banks of shallow river (Ratnam, BMNH). Selangor, Gombak Forest Res. (Traub); Kuala Lumpur (Traub); Rantau Panjang, 8 km N Klang (biting man, Pundat; McClure; Quate; Traub); Subang Forest Res. (McClure).

SABAH: Labuan Island (Colless). Tawau, Kalabakan (Maa); Tawau, on beach at dusk (Quate).

SARAWAK: Santubong (Maa).

THAILAND: Phangnga Prov., Pulau Panjang (collector ?).

Discussion.--*Culicoides pungens* is readily distinguished from the other species of the Orientalis Group by its poorly marked wings, very dark halteres, and dark unbanded legs. Its distribution is apparently coastal in Malaysia and adjacent Thailand and Indonesia, where it is a biting pest of man. Some specimens of *C. dumdumi* Sen and Das Gupta have wings nearly as dark as *pungens*, but the dark brown halteres of *pungens* are diagnostic.

Macfie's (1937a, 1941) records of *pungens* must be referred to *actoni* Smith, with which he confused this species. Edwards (1922) correctly established the identity of *pungens* when he published a photograph of the wing of the holotype showing the very characteristic color pattern. For this reason Buckley's observations on the ability of *C. pungens* to serve as the vector of *Onchocerca gibsoni* of cattle in Malaysia must be referred to *C. actoni*. Some of Debenham's (1978) records and data under the name *pungens* must similarly be referred to *actoni*.

Culicoides wadai Kitaoka
(Figs. 126, 291)

Culicoides suzukii Kitaoka, in part, 1977: 196 (in part, misident.); Ishigaki, Iriomote and Yonaguni I. records); Dyce, 1980: 287 (compared with *orientalis*).
Culicoides wadai Kitaoka, 1980: 14 (male, female; Ryukyu Is.; figs.); Muller et al., 1981: 579 (Australia; female blood meal sources); Howarth, 1985: 67 (Laos records); Standfast et al., 1983: 383 (Qld. record).

Female.--Wing length 0.67 (0.82-0.93, n = 11) mm.

Head: Eyes contiguous a short distance, bare. Antenna (fig. 126a) with lengths of flagellar segments in proportion of 17-11-11-14-14-14-13-16-23-23-25-25-38; antennal ratio 1.17 (1.12-1.22, n = 10); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 126b) with lengths of segments in proportion of 8-18-20-10-13; third segment long and slender, with a small, round, shallow, sensory pit near apex; palpal ratio 2.9 (2.5-3.2, n = 7). Proboscis long, P/H Ratio 0.87; mandible with 15 (12-21, n = 21) teeth.

Thorax: Dark brown, mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 126h) dark brown; knee spots blackish; fore- and mid-femora with faint subapical pale rings, all tibiae with sub-basal and hindtibia with apical pale rings; hindtibial comb (fig. 126c) with 5 spines, the one nearest the spur longest.

Wing (fig. 126d, 291): Pattern as figured, typical of well-marked species of the Orientalis Group; nearly identical with that described for *orientalis* except that usually the pale markings in the anal cell are more extensive; dark area on vein M2 is completely isolated from the quadrate dark area at the tip of the vein by the broad coalescence of the distal pale spots in cells M1 and M2; first costal pale spot broader than the first dark costal marking. Macrotrichia numerous in distal third of cells R5 and M1 and in apex of cell M2; costal ratio 0.63 (0.61-0.65, n = 11); radial cells distinct. Halter infuscated.

Abdomen: Dark brown. Spermathecae (fig. 126e) ovoid with very short sclerotized necks; unequal, 0.051 x 0.048 mm and 0.041 x 0.038 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 126g): Ninth sternum with broad, shallow, caudomedian excavation, ventral membrane spiculate a short distance at base; ninth tergum unusually short and broad, caudal margin rounded with a very slight mesal cleft. Basistyle with ventral root moderately long and stout, dorsal root a little shorter; dististyle slender and slightly curved on distal portion, tip with distinct distomesal point. Aedeagus very short and broad, in general outline almost circular except for excavation of the basal arch and the distal process; basal arch extending to 0.30 of total length, the basal sclerotized membrane nearly transverse between basal arms, distal process short and slender with bifid tip. Parameres (fig. 126f) separate, each with short, stout basal arm, middle portion very stout, distal portion tapering abruptly to very fine filamentous tip with a few minute hairs.

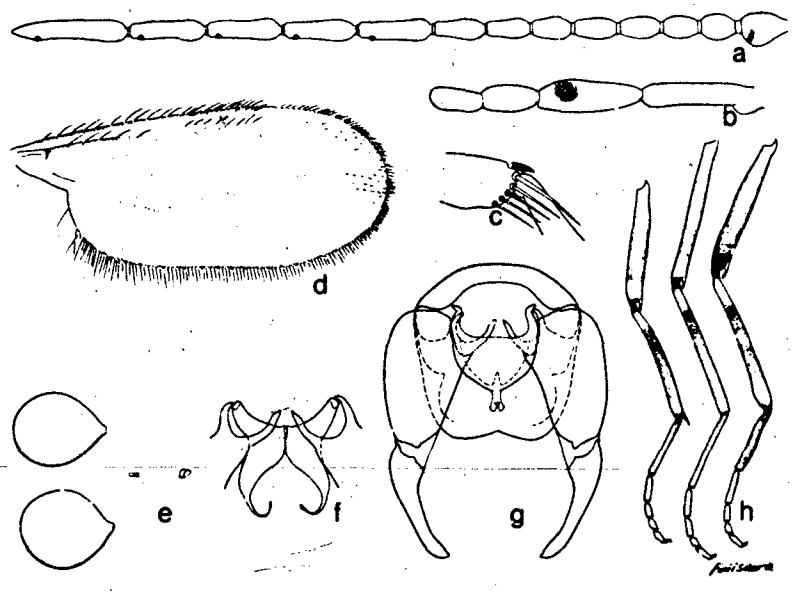


Fig. 126. *Culicoides wadai*: a. antenna; b. palpus; c. tibial comb; d. wing; e. spermathecae; f. parameres; g. male genitalia, parameres omitted; h. legs.

Distribution.--Australia, Indonesia, Laos, Malaysia, Philippines, Ryukyu Islands, Queensland, Sabah, Sarawak, Taiwan, Thailand, Vietnam.

Type.--Holotype female, Ishigaki Is., 15.xii.1972, H. Suzuki (in Nat. Sci. Mus., Tokyo). Allotype male, Yonaguni Islands, 16.xi.1974, S. Kitaoka. Paratypes also from Taiwan and Malaysia.

Southeast Asia Records.--

INDONESIA: Flores, Manggarai, Nunang, Lake Sano (Lee); Manggarai, Reo, Gincu, Robek (Narir). Java (West), Garut, Pameungpeuk (Zubaedah). Kalimantan (South), Banjar, Astambul, Tanah Intan, Pondok Delapan (Lee); Banjar, Martapura, Bincau (Lee).

LAOS: Sayaboury Prov., Muong Xieng Hon; Muong Sayaboury (Howarth).

MALAYSIA: Selangor, Kuala Lumpur (Traub); Segambut (Barnett).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Negros Oriental, Cuemos de Negros, Camp Lookout (Delvinado).

SABAH: Ranau (Maa). Tambunan (Colless).

Discussion.--This species is very similar to *orientalis* Macfie, but can readily be distinguished by the wing markings with the isolated quadrate dark spot at the tip of vein M2, the dark halteres, and the peculiar aedeagus with convex sides and short, bifid tip.

Culicoides suzukii Kitaoka (1973) from Hatsuno, Amami-oshima, northern Ryukyu Islands, is nearly identical with *C. wadai*, but differs in having the dark streak continuous along vein M2 but with a definite anterior recess caused by the posterior encroachment of the distal pale spot in cell M1 nearly to vein M2, but not entirely cutting off a separate quadrate dark spot on vein M2 at the wing margin. In *suzukii* the pale costal spot is much narrower than the preceding dark costal spot. In the male genitalia of *suzukii* the caudomedian notch on the ninth tergum is much less prominent than in *wadai*. Dr. Kitaoka deposited a female paratype of *suzukii* from Hatsuno I. in the USNM in which the wing pattern is that of *C. wadai*, so possibly the distribution of *wadai* goes north in the Ryukyus all the way to Amamai-oshima. The male wing figured by Kitaoka (1973) for *suzukii* is that of a different species than the female holotype. According to Dyce (in litt.) the Hatsuno series contains three species, *wadai*, *suzukii*, and *nudipalpis* Delfinado. We have included *suzukii* in our key but we do not have any Southeast Asian records that we can confidently refer to *suzukii*.

Ornatus Group

Diagnosis.--Eyes bare (rarely hairy); contiguous to moderately (1 facet) separated. Antenna with distal segments moderately elongated, antennal ratio 1.11-1.50; sensilla coeloconica usually present on segments 3-14, sometimes absent on some of the proximal series, 11 and/or 12, or present on 3-15; segment 14 with 4-5 sensilla forming a distal ring. Third palpal segment moderately stout, sensory pit various. Proboscis and mandibles reduced in *C. corti* Causey, otherwise well developed. Mesonotum usually brownish without prominent pattern, halteres frequently infuscated; legs unbanded or with sub-basal tibial rings, femor rarely banded distally; 4 (rarely 5) tibial spines, with one nearest the spur longest. Fourth tarsomeres cylindrical, except cordiform in *cordiger* Macfie. Second radial cell of wing moderately long, costal ratio 0.57-0.66; wing usually rather hairy,

second radial cell usually dark to tip but pale distally in some species; cell R5 usually with large distal pale area, this often filling apex of cell; no pale spots straddling veins M1 and M2, the pale spots on distal portion of wing falling between the veins, often extensive; no pale spot immediately in front of mediocubital fork. Female eighth sternum a distinct quadrate plate with sides reflexed internally and caudal margin deeply notched around gonopore. Two large sclerotized spermathecae and a vestigial one, sclerotized ring present or absent; spermathecae various in shape and highly diagnostic for species. Male genitalia with apicolateral processes usually well developed on ninth tergum, often with deep caudomedian cleft; aedeagus usually with low basal arch and long, tapering, rather blunt distal process, ventral membrane at base often spiculate; basistyle with ventral root not developed, dorsal root normal; parameres usually fused at bases, the basal portion of each directed laterad with well-developed anterior process, the distal portion usually straight, simple and slender, with simple pointed tip.

Included Species.--Species of the Ornatus Group are numerous in the Oriental and Australasian regions, breeding most commonly in coastal marshes near the sea, where the females are often vicious biters.

Biology.--With the exception of *C. peliliouensis* the larval habitats and biologies of the Oriental species of the Ornatus Group are unknown. By contrast there is an extensive literature on the biology and control of several pestiferous Australian species of this group (Reye and Lee, 1963; Lee, Reye, and Dyce, 1963; Kay, 1973; Kettle and Elson, 1975b). Dorsey (1948) published an extensive account of the biology of *peliliouensis* in the Palau Islands. The species is characteristic of the intertidal mangrove swamps.

Culicoides circumbasalis Tokunaga
(Figs. 127, 292, 429)

Culicoides circumbasalis Tokunaga, 1959: 232 (female; New Guinea; figs.); Tokunaga, 1962b: 476 (New Ireland; redescribed; fig. wing).
Culicoides praesignis Delfinado, 1961: 652 (female; Philippines; figs.). NEW SYNONYMY.

Female.--Wing length 0.99 mm.

Head: Eyes bare, nearly contiguous. Antenna (fig. 127a) with lengths of flagellar segments in proportion of 20-14-14-14-14-15-14-15-23-24-24-26-38, antennal ratio 1.12; sensilla coeloconica present on segments 3-14. Palpus (fig. 127b) with lengths of segments in proportion of 11-26-28-11-11; third segment moderately swollen, with a small deep sensory pit opening by a slightly smaller pore; palpal ratio 2.1. Proboscis moderately long, P/H Ratio 0.84; mandible with 14 teeth.

Thorax: Dark brown; mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 127c) brown, tibiae with narrow sub-basal pale rings; hindtibial comb (fig. 127d) with 4 spines, the one nearest the spur longest.

Wing (fig. 292, 429): Pattern as figured; pale spot over r-m crossvein moderately large, extending from vein M1 to costal margin; stigmal spot moderately dark, extending to tip of second radial cell; 1 poststigmatic pale spot in cell R5 but nearly subdivided into 2 spots, the posterior portion lying obliquely proximad behind second radial cell; usually 2 pale spots in distal portion of cell R5, the large subapical one slightly oval, not nearly reaching anterior wing margin, the distal one small and broadly meeting distal wing margin, sometimes absent; cell M1 usually with 3 pale spots, the distal one small and broadly meeting distal wing margin; cell M2 with narrow pale streak connecting a pale spot at base straddling medial stem, a pale spot lying just behind medial fork, and a subapical pale spot lying distad of level of mediocubital fork; the latter without pale spot lying immediately ahead; distal pale spot in cell M2 triangular and broadly meeting distal wing margin; cell M4 with round pale spot at margin in distal portion; anal cell with 2 pale spots in distal portion, the posterior one small, and a small pale streak at base; ends of veins not pale. Macrotrichia moderately dense and long on distal half of wing and over all of anal cell except base; costal ratio 0.63; second radial cell quite broad with well-developed lumen. Halter infuscated.

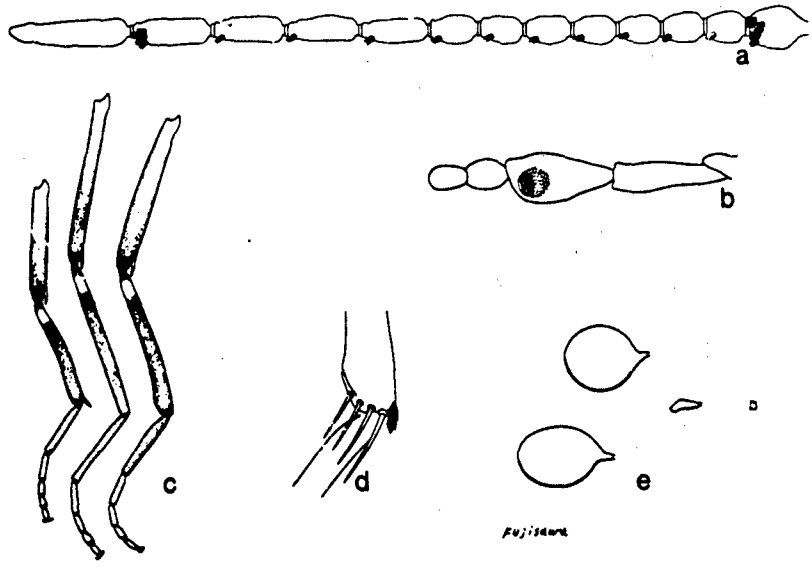


Fig. 127. *Culicoides circumbasalis*: a. antenna; b. palpus; c. legs; d. tibial comb; e. spermathecae.

Abdomen: Brown. Spermathecae (fig. 127e) subequal, each 0.061 x 0.038 mm; differing slightly in shape, one somewhat retort-shaped, both with slender, moderately long necks arising slightly obliquely; vestigial third spermatheca and small, faintly sclerotized ring present.

Male.--Unknown.

Distribution.--Indonesia, Malaysia, New Guinea, New Ireland, Philippines, Sarawak, Thailand.

Types.--Holotype female of *circumbasalis*, Hollandia, West Irian, 100 m, 23.viii.1955, J.L. Gressitt (Bishop no. 3872). Holotype female of *praesignis*, Philippines, Davao, Maco, Tagum, x.1946, H. Hoogstraal and D. Heyneman, near sea level (in Field Museum of Natural History).

Southeast Asia Records.--
INDONESIA: Bali, Badung, Denpasar, Padungan (Lee). Flores, Manggarai, Rio Robek, Kampung Ojang Beach (Lee). Sulawesi (Central), Banggai, Batui, Kamiwangi (Bambang). Sumatra, Sibolga (Ikemoto).
MALAYSIA: Negri Sembilan, Port Dickson, Telok Pelandok (Traub). Selangor, Klang, Rantau Panjang (McClure, Traub); Klang, Carey Island (Garcia); Tg. Karang, biting man (Wharton).
PHILIPPINES: Mindanao, Davao, Maco, Tagum (Hoogstraal and Heyneman, type). Sulu, Siasi Id., Siasi (Milliron).
SARAWAK: Lutong (Colless).
THAILAND: Phangnga, Pulau Panjang (? collector).

Discussion.--The series from Malaysia are provisionally referred to this species in spite of a number of differences of a minor nature: eyes narrowly separated; antennal ratio 1.06-1.11; more or less coalescence of the apical and subapical pale spot in cell M1, and spermathecae with longer, tapering, slender necks. More Philippine material will be necessary to ascertain the extent of variation in Philippine *circumbasalis*. The close resemblance of the wing pattern to that of *C. shortti* Smith and Swaminath of the Shortti Group is only superficial, for on group characters of antennal sensory pattern and spermathecae the two species are quite distinct.

Culicoides cordiger Macfie
(Figs. 128, 293, 430)

Culicoides cordiger Macfie, 1934a: 193 (female; Malaya; fig. wing); Delfinado, 1961: 642 (Philippines; fig. wing); Wirth, 1973: 367 (distribution including Australia, Bismarcks); Edwards, 1980: 201 (survey methods; Queensland).

Female.--Wing length 1.05 (1.00-1.12, n = 10) mm.
Head: Eyes bare; narrowly separated (fig. 128d). Antenna (fig. 128a) with lengths of flagellar segments in proportion of 22-14-14-14-13-13-12-12-34-34-34-34-48, antennal ratio 1.71 (1.55-1.93, n = 5); sensilla coeloconica present on seg-

ments 3-15. Palpus (fig. 128b) with lengths of segments in proportion of 10-20-30-11-14; third segment broadly swollen in midportion, with moderately large and deep, round, sensory pit opening by a smaller round pore just beyond midlength; palpal ratio 1.9 (1.7-2.0, n = 10). Proboscis short, P/H Ratio 0.59; mandible with 11 (9-12, n = 15) teeth.

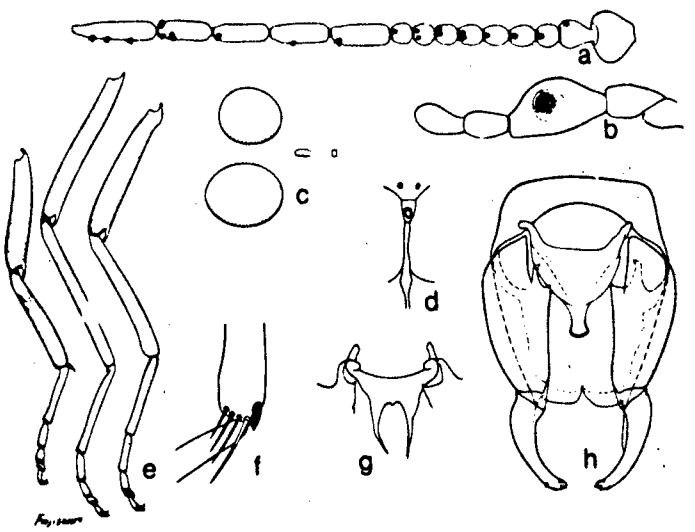


Fig. 128. *Culicoides cordiger*: a. antenna; b. palpus; c. spermathecae; d. eye separation; e. legs; f. tibial comb; g. parameres; h. male genitalia, parameres omitted.

Thorax: Dark brown, sometimes with gray pollinosity, mesonotum with numerous stout appressed setae. Legs (fig. 128e) dark brown, hindtibia with narrow basal pale ring, tarsi pale; hindtibial comb (fig. 128f) with 4 (n = 6) very long spines, the one nearest the spur longest, 1/3 length of basitarsus; fourth tarsomeres (fig. 128e) cordiform.

Wing (fig. 293, 430): Variably faint to distinct pattern; pale spots very extensive and more or less interconnected, centered in the cells; distal third of first radial cell and all of second very dark, forming a dark stigma, sometimes vein R4+5 pale at tip of second radial cell; a very prominent small round, very dark spot also present in midportion of cell R5; distal pale spots in cells R5, M1, M2, M4 and anal cell broadly meeting wing margin. Macrotrichia moderately numerous and long, extending to wing base in cell M2 and anal cell; costal ratio 0.63; radial cells complete, the second slightly narrowed distally. Halter dark brown.

Abdomen: Brown. Spermathecae (fig. 128c) subspherical to oval, without necks; unequal, 0.057 x 0.047 mm and 0.047 x 0.041 mm; vestigial third spermatheca and narrow sclerotized ring present.

Male.--Similar to female with usual sexual differences. Gentialia (fig. 128h): Ninth sternum with shallow caudomedian excavation, posterior membrane spiculate; ninth tergum bilobate, apicolateral processes very small, caudal margin of tergum with distinct mesal notch. Basistyle with ventral root absent, dorsal root short; dististyle markedly curved, slender distally with blunt-pointed tip. Aedeagus with short broad basal arch extending to 1/4 of total length, basal arms short, main body broadly triangular with thinner sclerotization forming a convex lateral margin; distal stem short and slender, with tip slightly expanded. Parameres (fig. 128g) fused mesally in a transverse basal plate bearing short anterolateral arms forming a convex anteromesal arch; free distal posterior portions each abruptly attenuated to long, slender filaments.

Distribution.--Australia, Bismarck Islands, Malaysia, Philippines.

Types.--Seven syntype males of *cordiger*, Negri Sembilan, Port Dickson, Malaysia, ii.1933, H.M. Pendlebury, in the BMNH; we have examined these and selected one as lectotype.

Southeast Asia Records.--
INDONESIA: Kalimantan (East), Samarinda, Kenangan (Soeroto). Sumba, Waigapu Bay (Boeadi).
MALAYSIA: Negri Sembilan, Port Dickson (Traub).
PHILIPPINES: Balabac, Dalawan Bay (Noona Dan Exped.). Palawan, Canacan, Aborlan (Hoogstraal and Werner); Brookes Point, Uring Uring (Noona Dan Exped.). Tawi Tawi, Lapid Lapid at Manalick Channel (Noona Dan Exped.); Tarawakan, N of Batu Batu (Noona Dan Exped.).

Discussion.--The hitherto unknown male is described from a series of 1 male and 3 females from Brookes Point, Palawan, Philippines. The male genitalia are typical of the Ornatus Group and this species is assigned to that group in spite of the cordiform fourth tarsomeres which are otherwise not found in that group.

Culicoides corti Causey
(Figs. 129, 294, 431)

Culicoides corti Causey, 1938: 411 (male, female; Thailand; fig. wing, male genitalia).

Female.--Wing length 0.81 mm.
Head: Eyes separated by width of one facet, with long interfacetal hairs. Antenna (fig. 129a) with lengths of flagellar segments in proportion of 16-12-12-11-12-12-13-13-17-17-18-21-25, antennal ratio 0.97; sensilla coeloconica present on segments 3,13-15. Palpus (fig. 129b) with lengths of segments in proportion of 8-12-14-9-10; third segment short and stout, with small round sensory pit on distal portion; palpal ratio 1.5. Proboscis short, P/H Ratio 0.52; mandible with 5-6 scarcely discernible, vestigial teeth.

Thorax: Dark brown; mesonotum slightly darker in three longitudinal vittae as seen in slide-mounted specimens. Legs (fig. 129e) pale brown; knee spots blackish; femora unbanded; tibiae with faint, sub-basal, narrow pale rings; hindtibial comb (fig. 129d) with 4 spines, the one nearest the spur longest.

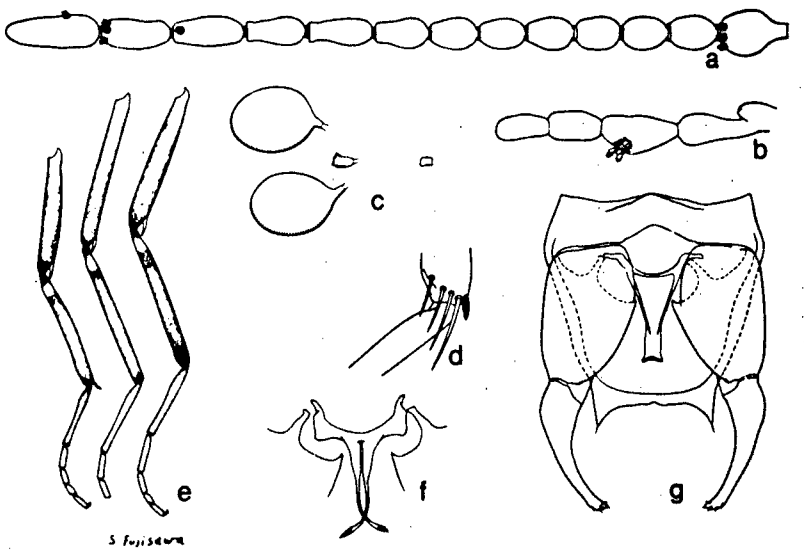


Fig. 129. *Culicoides corti*: a. antenna; b. palpus; c. spermathecae; d. tibial comb; e. legs; f. parameres; g. male genitalia, parameres omitted.

Wing (fig. 294, 431): Pattern as figured; pale markings not very definite or extensive; pale spot over r-m crossvein small, fading out toward costal margin; stigma over second radial cell only slightly darker, second radial cell paler on extreme tip; 1 oblique poststigmatic pale spot in cell R5; distal pale spot in cell R5 located subapically in cell, longitudinally elongated but not extending to anterior or distal wing margin; 2 pale spots in cell M1, the distal one scarcely attaining wing margin; cell M2 with pale streak from base to subapical pale spot past mediocubital fork, broadening in a pale spot behind medial fork, no pale spot lying immediately in front of mediocubital fork, the distal pale spot broadly meeting wing margin; cell M4 with a large round pale spot nearly filling distal portion of cell; anal cell with 1 pale spot in distal portion and 1 near base; tips of veins not pale. Macrotrichia very scanty on distal third of wing; costal ratio 0.59; second radial cell tapering distally with narrow lumen. Halter infuscated.

Abdomen: Brown. Spermathecae (fig. 129c) subspherical with long, slender, sclerotized necks; slightly unequal, 0.055 x 0.040 mm and 0.051 x 0.038 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 129g): Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum short with short, pointed, apicolateral processes, the caudal margin between them with distinct mesal notch. Basistyle with ventral root absent, dorsal root short and blunt; dististyle curved, slender distally with bent pointed tip. Aedeagus with very low basal arch, basal arms directed laterad; distal stem stout, tapering distally to blunt, truncated tip; ventral surface with very fine, soft, short hairs. Parameres (fig. 129f) fused a short distance at bases anteriorly; each basal arm directed anterolaterad with a well developed anterior process; distal processes rather stout at base and straight, tapering to simple distal filaments with microscopically brush-like tips.

Distribution.--Malaysia, Thailand, Vietnam.

Types.--Redescribed from the type series, on four poorly preserved slides, in USNM: holotype female, allotype male, and two female paratypes, Chiengrai, Thailand, Causey collector, light trap (Type in USNM).

Southeast Asia Records.--
MALAYSIA: Selangor, Klang, Rantau Panjang (Quate); Klang, Telok Gong, swamp forest, mangrove (Garcia).
THAILAND: Bangkok, Thonglo (Scanlon). Chiang Rai Prov. (Causey, type series). Songkhla (? collector).
VIETNAM: Saigon (Spencer).

Discussion.--This species closely resembles *C. infulatus* Delfinado in wing pattern, but can be distinguished by the distribution of sensilla coeloconica on the antennae, the irregular shallow palpal pit, and hairy eyes. The vestigial mandibular teeth and short proboscis will separate *corti* from *griffithi* n. sp., which otherwise is very similar.

Culicoides damnosus Delfinado
(Figs. 130, 295, 432)

Culicoides damnosus Delfinado, 1961: 642 (female; Philippines; figs.).

Female.--Wing length 0.86 (0.77-0.93, n = 12) mm.
Head: Eyes bare, narrowly (Palawan) to broadly (Malaysia) separated. Antenna (fig. 130a) with lengths of flagellar segments in proportion of 18-12-13-13-13-13-13-13-25-24-28-29-39, antennal ratio 1.34 (1.28-1.45, n = 11); sensilla coeloconica present on segments 3-14 (absent on 10 in type and some other Palawan specimens). Palpus (fig. 130b) with lengths of segments in proportion of 9-19-24-10-11; third segment moderately broad in midportion, with a round, shallow, sensory pit; palpal ratio 1.9 (1.8-2.1, n = 10). Proboscis short, P/H Ratio 0.63; mandible with 13 (11-17, n = 21) teeth.

Thorax: Dark brown; mesonotum (fig. 130c) without pattern, uniformly dark brown pollinose. Legs (fig. 130d) brown; hindtibia with narrow sub-basal pale ring; hindtibial comb (fig. 130e) with 4 spines, the one nearest the spur longest.

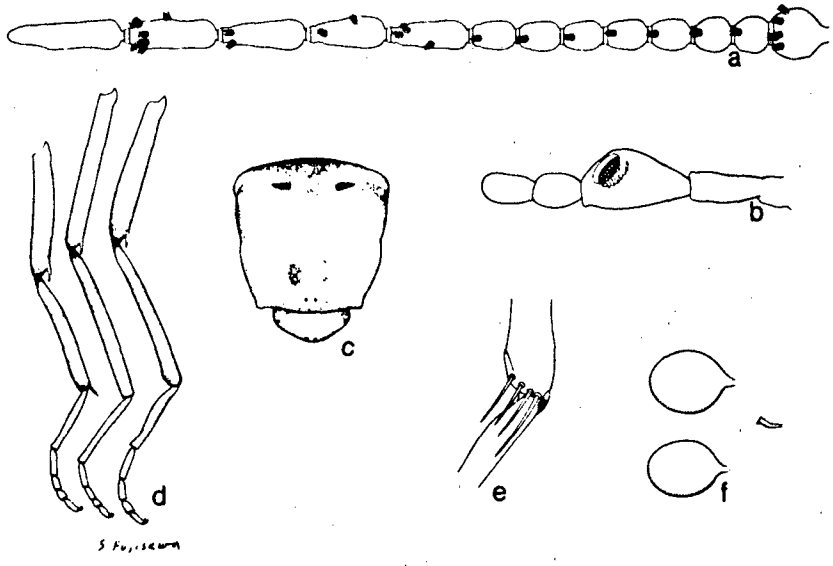


Fig. 130. *Culicoides damnosus*: a. antenna; b. palpus; c. thoracic pattern; d. legs; e. tibial comb; f. spermathecae.

Wing (fig. 295, 432): Pattern as figured; pale spot over r-m crossvein small, scarcely extending to costal margin; stigma moderately dark, extending to tip of second radial cell; poststigmatic pale spot in cell R5 usually divided into 2 oblique separate spots, the posterior one located slightly basad and about halfway between second radial cell and vein M1 (in type and some other Palawan specimens the posterior spot is obsolete); distal pale spot in cell R5 slightly elongated in axis of cell but never approaching close to distal wing margin; cell M1 with 2 pale spots, the distal one located far from wing margin; cell M2 dark at base, a small pale spot located behind medial fork and a distal one near tip of cell but not meeting wing margin; cell M4 with a round pale spot in distal portion; anal cell with 1 pale spot in distal portion, located just behind mediocubital fork, and 1 near base of cell; tips of veins not pale. Macrotrichia sparse to moderately numerous on distal half of wing and along posterior margin of anal cell; costal ratio 0.63 (0.61-0.64, n = 12); second radial cell broad to tip with well developed lumen. Halter infuscated.

Abdomen: Pale brown. Spermathecae (fig. 130f) subequal, each 0.055 x 0.042 mm; slightly oval with very short, paler, sclerotized necks arising obliquely (Malaysian specimens with spermathecae more elongate, 0.062 x 0.071 mm long, with necks longer and arising straight at end of spermathecae).

Male.--Unknown.

Distribution.--Indonesia, Malaysia, Philippines.

Type.--Holotype female, Bacungan, Puerto Princessa, Palawan Island, Philippines, 27.v.1947, F.G. Werner, biting man near sea level (in Field Museum of Natural History).

Southeast Asia Records.--
INDONESIA: Sulawesi (Central), Banggai, Batui, Kamiwangi (Bambang). Sumatra, Perupuk, Asaman (Ikemoto).
MALAYSIA: Pahang, Kuala Lipis, Kg. Penjom, near buffalo (Garcia); Ulu Gali, cattle shed (Garcia). Selangor, Klang, Carey Island, biting man (Rudnick); Puchong, ex buffalo shed (Garcia); Klang, Rantau Panjang, biting man (McClure, Pungat, Quate, Traub); Tanjang Klang (Garcia); Klang, Telok Gong, biting man, mangrove, swamp forest (Garcia).
PHILIPPINES: Palawan, Bacungan, Puerto Princessa, biting man (Werner, holotype); Puerto Princessa, 1924, biting man (McGregor).

Discussion.--Although there is a good deal of variation between the Philippine and Malaysian series as mentioned in the description, this variation also occurs to a more limited extent within each series and it is believed that only one species is represented. The species is a severe biter in the coastal swamps.

Culicoides flumineus Macfie
(Figs. 131, 296, 433)

Culicoides flumineus Macfie, 1937a: 116 (female; Malaya); Tokunaga, 1961: 185 (Saigon, fig. wing).

Female.--Wing length 0.94 mm.
Head: Eyes bare; separated by a space (fig. 131d) equal to diameter of one facet. Antenna (fig. 131a) dark brown; lengths of flagellar segments in proportion of 18-12-13-13-13-13-13-13-24-24-26-27-34, antennal ratio 1.25; sensilla coeloconica present on segments 3-14. Palpus (fig. 131b) with lengths of segments in proportion of 15-35-53-20-20; third segment swollen twoard tip, with large round shallow sensory pit located at extreme tip; palpal ratio 2.4. Proboscis moderately long, P/H Ratio 0.80; mandible with 14 teeth.
Thorax (fig. 131c): Dark brown with grayish pollenosity, leaving traces of 3 dark brown longitudinal vittae. Legs (fig. 131e) uniformly dark brown; tibial comb (fig. 131f) with 4-5 spines, the one nearest the spur longest.
Wing (fig. 296, 433): Pattern as figured; brownish with coarse microtrichia; radial cells infuscated forming a dark brown stigma, also a faint, somewhat evanescent dark spot a short way distad of costa in anterior portion of cell R5; veins slightly infuscated; small, very faint, pale spots over r-m crossvein and at end of costa, rarely with traces of indistinctly paler areas in cells on posterior part

of wing. Macrotrichia moderately numerous and very coarse, covering wing except radial field and base of anal cell; costal ratio 0.62; radial cells distinct, short. Halter deeply infuscated.

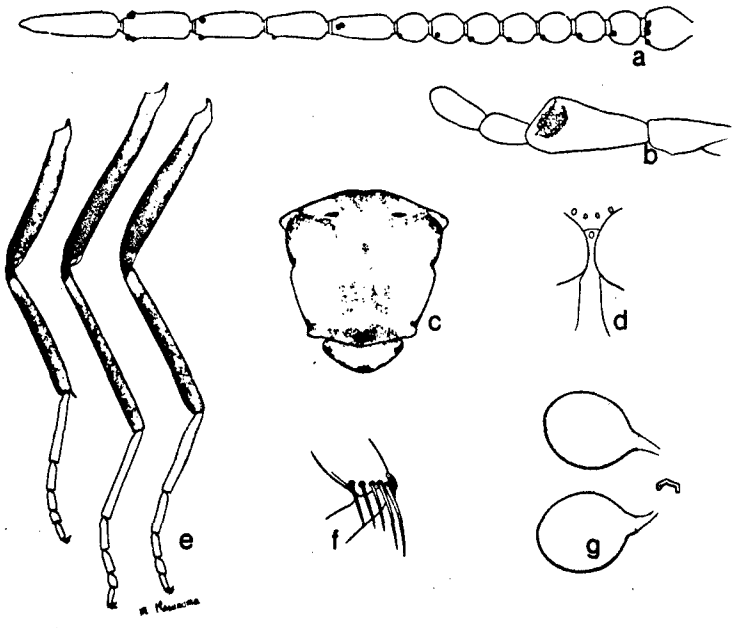


Fig. 131. *Culicoides flumineus*: a. antenna; b. palpus; c. thoracic pattern; d. eye separation; e. legs; f. tibial comb; g. spermathecae.

Abdomen: Dark brown. Spermathecae (fig. 131g) short oval, with rather long tapering necks; subequal, each 0.058 x 0.046 mm; vestigial third spermatheca present, sclerotized ring absent.

Male.--Unknown.

Distribution.--Indonesia, Malaysia, Philippines.

Types.--Syntypes, 43 females, Pengkalan Kempas, Malaya, 1936, banks of shallow river, C.H. Williams and A.K. Ratnam, in BMNH, London. Through the courtesy of Paul Freeman we have examined six of the syntypes, and hereby designate one of them, mounted on a slide, as lectotype.

Southeast Asia Records.--

INDONESIA: Irian-jaya, PADII, at river (V. Lee); Giligan Island, port site (V. Lee).
MALAYSIA: Pengkalan Kempas (Williams & Ratnam, types). Selangor, Klang, Telok Gong, mangrove swamp forest (Garcia); Rantau Panjang, 8 km N Klang (McClure).
PHILIPPINES: Balabac, Dalawan Bay (Noona Dan Exped.).

Discussion.--*Culicoides flumineus* is distinguished by its poorly marked wing and its dark brown thorax, legs, and halter. Specimens with a trace of paler areas in the posterior part of the wing may be confused with *damnosus* Delfinado, which has the bases of the tibiae pale. Specimens with only the two pale anterior spots key out with *wenzeli* Delfinado in the Shermani Group, which has pale leg markings, no dark area in cell R5, and the palpal pit opening by a smaller pore.

Culicoides garciai Wirth and Hubert, new species
(Figs. 132, 133, 297, 434)

Female.--Wing length 0.97 mm.
Head: Eyes bare, narrowly separated (fig. 132e), nearly contiguous. Antenna (fig. 132a) dark brown; lengths of flagellar segments in proportion of 30-20-20-20-20-20-20-20-44-44-46-50-56, antennal ratio 1.40; sensilla coeloconica present on segments 3-7,9,11-14, one or two sensilla each on proximal segments, four on 14. Palpus (fig. 132b) with lengths of segments in proportion of 15-20-35-16-18; third segment markedly short and broad, with a broad, shallow, round, sensory pit; palpal ratio 1.6. Proboscis short, P/H Ratio 0.60; mandible with 13 teeth.
Thorax: Uniformly dark brown. Legs (fig. 132c) uniformly brownish, without pale bands; tibial comb (fig. 132d) with 4 spines, the second from the spur longest.
Wing (fig. 297, 434): As figured, uniformly brownish, without pattern of pale spots. Macrotrichia moderately numerous, but long and coarse, covering wing except radial field and an area in cell R5 behind radial cells; costal ratio 0.64; radial cells moderately broad. Halter deeply infuscated.
Abdomen: Dark brown. Spermathecae (fig. 132f) short oval, with short slender necks; subequal, each 0.080 x 0.046 mm; vestigial third spermatheca present; sclerotized ring absent.

Male.--Unknown.

Distribution.--Malaysia.

Types.--Holotype female, Telok Gong, Klang, Selangor, Malaysia, 10.x.1964, R. Garcia, feeding on mud skipper in mangrove swamp forest (Type in USNM). Paratype, 1 female, same data.

Discussion.--This small, uniformly marked, dark brown species is readily distinguished by its lack of wing pattern and by its distinctive antennal sensillar pattern. We are happy to name it after the collector, Dr. Richard Garcia of the University of California at Berkeley, in recognition of his field studies on Malaysian biting midges.

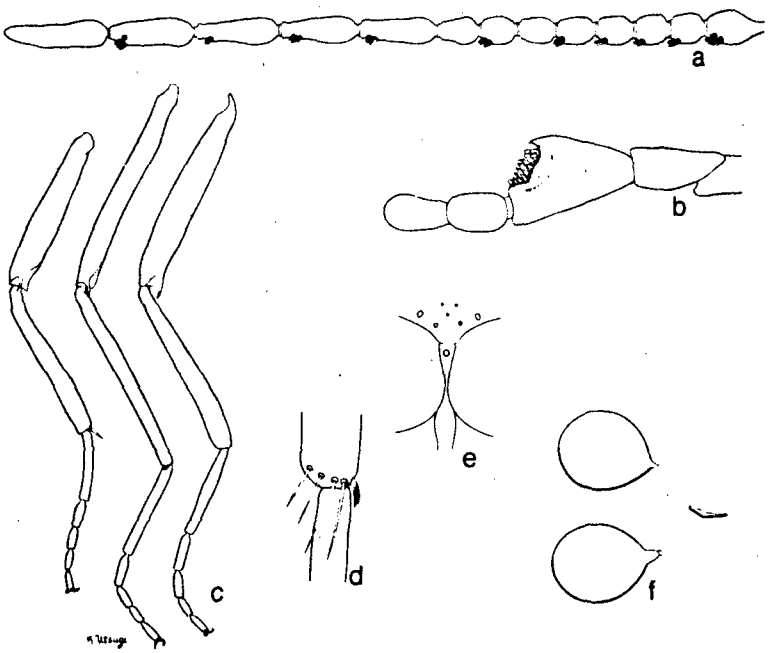


Fig. 132. *Culicoides garciai*: a. antenna; b. palpus; c. legs; d. tibial comb; e. eye separation; f. spermathecae.

Culicoides immaculatus Lee and Reye from northern Queensland is similar to *C. garciai*, but differs in having the antennal sensillar pattern 3-10, the eyes are moderately separated, and the spermathecae are much smaller, 0.035 x 0.030 mm. It is also a mangrove-associated species.

The midges were collected while feeding on the mud skipper, *Periophthalmodon schlosseri* (fig. 133). This mud skipper is a peculiar Oriental fish of shallow mud flats. We are not aware of any previous records of ceratopogonids biting fish, but the peculiar amphibious habits of this air-breathing fish make it uniquely susceptible to attacks from blood-sucking Diptera.

Sloof and Marks (1965) reported that on Gizo Island, British Solomons Protectorate, the mosquito *Aedea* (*Geoskusea*) *longiforceps* Edwards was observed feeding on the mud skipper *Periophthalmus musgravei* Whitley.

Fig. 133. Mud skipper (*Periophthalmus schlosseri*) on mud bank at Carey Island, Klang, Malaysia. Mosquito (*Aedes* (*Rhinoskusea*) sp.) feeding on right side of head (photo R. Garcia).

In February 1976 the senior author viewed a television film by National Geographic on a public television program entitled "Creatures of the Mangrove," filmed on the coastal island of Siarau, Borneo. Biting midges, identified by their small size and characteristic activity pattern, were seen landing and running around on the mud skipper host in preparation for feeding and were as numerous as the larger mosquitoes pointed out by the narrator.

Macnae (1968) gave a valuable discussion of the habits of the mud skippers. *Periophthalmus kalolo*, *P. chrysospilos*, *Periophthalmodon schlosseri*, *Boleophthalmus boddaerti* and *Scartelaos viridis* occur on the mangrove flats of Western Malaysia, of which *P. chrysospilos* is the most common and best known. Mud skippers feed on mud flats at low tide, but advancing tides force them landward, where they remain near the water line or seek refuge by climbing into the mangroves and clinging to the branches with the sucker formed by the fused pel-

vis fins, keeping the tail just under the water. Locomotion is normally by rather slow swimming, or by crutching or skipping on land, and skimming on the water surface when disturbed. In the breeding season the males build small burrows on the exposed mud flats just below the seaward mangrove fringe. The males are territorial and defend their burrows against other males, while waiting to attract a female for mating. Eggs are deposited in the walls of the burrows.

Culicoides griffithi Wirth and Hubert, new species
(Figs. 134, 298, 435)

Culicoides species G; Howarth, 1985: 68 (Laos record).

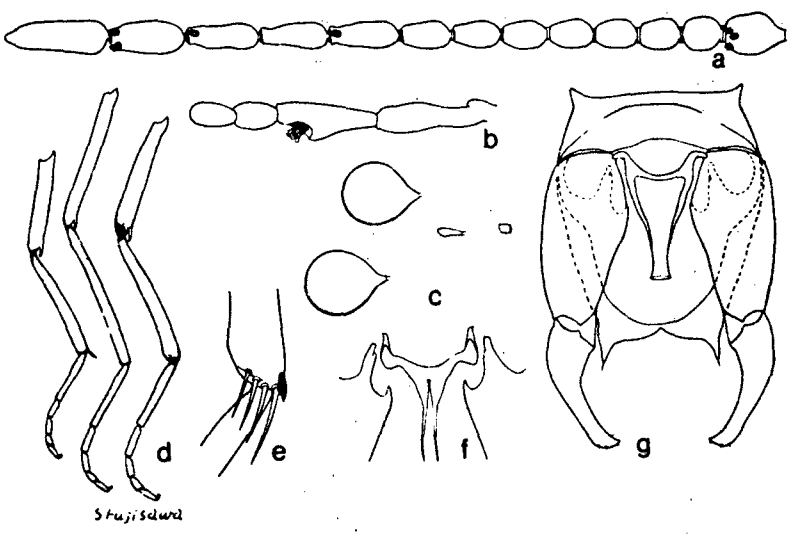


Fig. 134. *Culicoides griffithi*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Female.--Wing length 0.89 (0.80-1.01, n = 9) mm.

Head: Eyes separated by width of one facet, with short interfacetal hairs. Antenna (fig. 134a) with lengths of flagellar segments in proportion of 17-11-12-12-13-13-14-15-20-21-21-23-32, antennal ratio 1.06 (1.02-1.10, n = 9); sensilla coeloconica present on segments 3,11,13-14. Palpus (fig. 134b) with lengths of segments in proportion of 9-21-22-9-12; third segment moderately swollen, with a

shallow round sensory pit on distal portion; palpal ratio 2.3 (2.0-2.7, n = 9). Proboscis moderately long, P/H Ratio 0.82; mandible with 12 (10-14, n = 15) fine teeth.

Thorax: Moderately pale brown, mesonotal pattern not visible in slide-mounted specimens. Legs (fig. 134d) pale brown; knee spots blackish; femora pale at bases, unbanded distally; tibiae with faint, sub-basal, narrow pale rings; hindtibial comb (fig. 134e) with 4 spines, the one nearest the spur longest.

Wing (fig. 298, 435): Pattern as figured; pale markings fairly extensive; pale spot over r-m cross vein large, extending well into cell M2 and broadly meeting costal margin; stigma over second radial cell moderately dark, tip of second radial cell very narrowly pale, included in the large quadrate poststigmatic pale spot which broadly meets vein M1; cell R5 with 1 distal pale spot elongated in axis of cell, failing by about half its breadth to meet anterior or distal wing margin; cell M1 with 2 pale spots, distal one nearly attaining wing margin; cell M2 with pale streak from base to subapical pale spot lying distad of mediocubital fork, broadening in a pale spot behind medial fork, no pale spot lying immediately in front of mediocubital fork, the distal pale spot broadly meeting wing margin; cell M4 with a large round pale spot nearly filling distal portion of cell; anal cell with 1 large pale spot in distal portion and a large irregular pale area in basal part of cell; tips of veins not pale. Macrotrichia very sparse and confined to distal third of wing; costal ratio 0.61 (0.60-0.62, n = 9); second radial cell tapering distally with narrow but distinct lumen. Halter infuscated.

Abdomen: Pale brown. Spermathecae (fig. 134c) very heavily sclerotized, subspherical to slightly oval with short, slender, sclerotized necks; slightly unequal, 0.055 x 0.040 mm and 0.051 x 0.038 mm; vestigial spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 134g): Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum short with short, pointed, apicolateral processes, the caudal margin between them with distinct mesal notch. Basistyle with ventral root not developed, dorsal root short and blunt; dististyle curved, slender distally, with bent pointed tip. Aedeagus with very low basal arch, basal arms directed laterad; distal process very stout, tapering distally to blunt truncated tip; ventral surface with very fine, soft, short hairs. Parameres (fig. 134f) fused a short distance at base anteriorly; basal arm directed anterolaterad with a well developed anterior process; stem straight and tapering from near base to simple filamentous point distally.

Distribution.--Laos, Thailand.

Types.--Holotype female, Thailand, Khon Kaen Prov., Amphoe Muang, 20-24.v.1959, Manop R. collector, light trap (Type in USNM). Allotype male, Thailand, Nong Kai Prov., A. Muang, 10-14.vi.1959, Manop R., light trap. Paratypes, 57 males, 97 females, as follows:

LAOS: Vientiane Prov., Vientiane, 31.v-3.vi.1060, S. & L. Quate, light trap, 1 female (BISI

THAILAND (all collected in May and June 1959 by Manop Rattanarithikul in light traps except as noted): Bangkok Prov., A. Pratoomvan, 1 female. Khon Kaen Prov., A. Ban Pai, Choom Pae, and Muang, 3 males, 22 females; Rice Exp. Sta., 8.vii.1977, K. Yasumatsu, at light, 4 males, 2 females. Loei Prov., A. Dan Sai, Muang, and Thai Li, 21 males, 30 females. Nakhon Ratchasima Prov., A. Muang, 2 males, 4 females. Nong Kai Prov., A. Muang and Ta Bo, 7 males, 15 females. Sakon Nakhon Prov., A. Muang, 2 males, 3 females. Thonburi Prov., A. Bangkoknoi, 1 male. Udon Thani Prov., A. Muang, Nong Han, and Pen, 21 males, 21 females.

Discussion.--We are very happy to name this species in honor of Dr. Melvin E. Griffith, formerly Chief Malaria Advisor of the United States Operations Mission to Thailand, in recognition of his very generous and effective assistance in organizing a light trap survey for Thai *Culicoides*.

This species is closely related to *C. corti* Causey, but *corti* can be distinguished by the much shorter proboscis with vestigial mandibular teeth, the shorter third palpal segment, absence of sensilla coeloconica on the eleventh antennal segment, much less extensive pale wing markings and stouter stems on the male parameres.

Culicoides hewitti Causey
(Figs. 135, 299, 436)

Culicoides hewitti Causey, 1938: 413 (female; Siam; fig. wing, spermathecae).

Female.--Wing length 0.93 (0.86-0.98, n = 10) mm.

Head: Eyes bare, contiguous. Antenna (fig. 135a) with lengths of flagellar segments in proportion of 30-13-14-14-14-14-14-14-21-22-23-25-34, antennal ratio 1.11 (1.05-1.19, n = 9); sensilla coeloconica present on segments 3-14. Palpus (fig. 135b) with lengths of segments in proportion of 14-21-26-11-11; third segment moderately stout toward apex, with a round, moderately deep, sensory pit; palpal ratio 2.2 (2.1-2.4, n = 5). Proboscis moderately short, P/H Ratio 0.72; mandible with 14 (12-16, n = 19) teeth.

Thorax: Dark brown; mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 135c) brown; knee spots moderately blackish; femora pale at bases, dark apically; tibiae with narrow sub-basal pale rings; hindtibial comb (fig. 135d) with 4 spines, the one nearest the spur longest.

Wing (fig. 299, 436): Pattern as figured; pale spot over r-m crossvein moderately large and broadly meeting costal margin; stigmal spot only moderately dark, extending to tip of second radial cell; cell R5 with poststigmatic pale spot obliquely double, the posterior portion located proximad; the distal pale spot in cell R5 moderately large, oval in shape and obliquely oriented with margin paralleling anterodistal wing margin; cell M2 with pale streak at base, pale spot located behind medial fork, none in front of mediocubital fork; 2 pale spots in distal portion of cell M2 past mediocubital fork, the distal one broadly meeting wing margin; cell M4 with round pale spot broadly meeting wing margin; anal cell with 2 interconnected pale spots in distal portion and an irregular pale area at base; tips of

veins not pale. Macrotrichia numerous and well developed, extending to base of wing; costal ratio 0.63 (0.62-0.64, n = 10); second radial cell moderately broad and long, with well developed lumen. Halter infuscated.

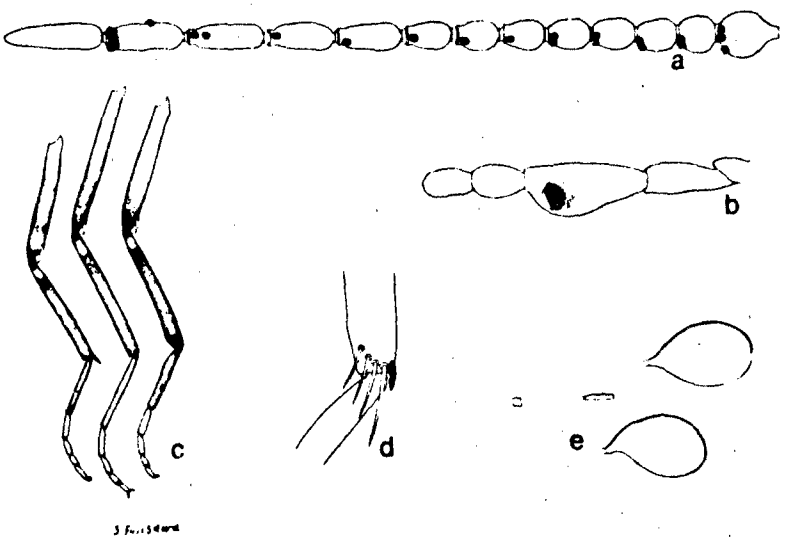


Fig. 135. *Culicoides hewitti*. a. antenna; b. palpus; c. legs; d. tibial comb; e. spermathecae.

Abdomen: Brown. Spermathecae (fig. 135f) subequal, each 0.059 x 0.035 mm, slightly differing in shape, one with duct arising more obliquely than the other, both ovoid, with tapering sclerotized necks; vestigial third spermatheca and sclerotized ring present.

Male.--Unknown.

Distribution.--Malaysia, Philippines, Sabah, Thailand, Vietnam.

Type.--Holotype female, Nakon Sri Tamarat, Thailand, Causey collector (Type in USNM).

Southeast Asia Records

MALAYSIA: Selangor, Rantau Panjang, Klang (McClure).
PHILIPPINES: Balabac, Dalawan Bay (Noona Dan Exped.).
SABAH: Labuan Island, biting man (Colless). Tawau, on beach at dusk (Quate).
THAILAND: Nakon Sri Tamarat (Causey, holotype).
VIETNAM: Da Nang (Hicks).

Discussion.--This species is recognized by the wing pattern with obliquely elongate pale spot in middle of distal portion of cell R5, the unbanded femora, dark halteres, hairy wing, presence of sensilla coeloconia on antennal segments 3-14, round pit toward apex of the third palpal segment, and tapering spermathecae, one with the duct arising obliquely. Causey's illustration of the wing (fig. 33) was erroneously numbered fig. 32, which we have been able to ascertain by examination of the holotype.

Culicoides infulatus Delfinado
(Figs. 136, 300, 437)

Culicoides infulatus Delfinado, 1916: 644 (female; Philippines; figs.).

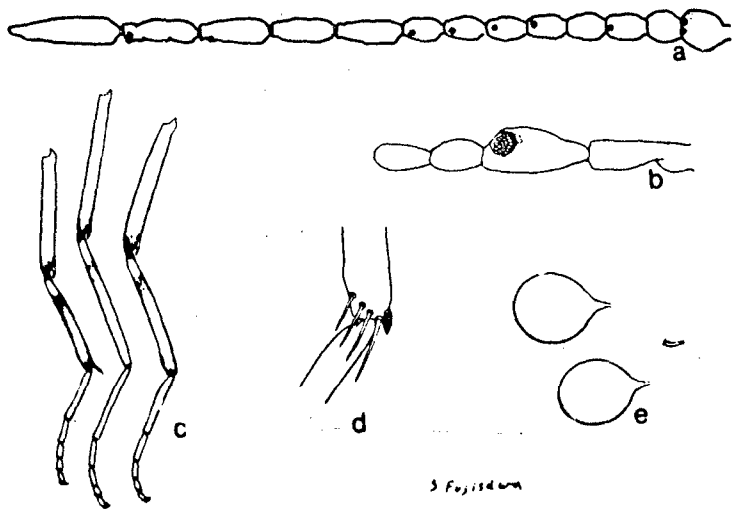


Fig. 136. *Culicoides infulatus*: a. antenna; b. palpus; c. legs; d. tibial comb; e. spermathecae.

Female.--Wing length 0.88 (0.83-0.92, n = 6) mm.

Head: Eyes bare, nearly contiguous mesad, with a narrow, wedge-shaped interocular space. Antenna (fig. 136a) with lengths of flagellar segments in proportion of 19-12-12-12-13-14-14-14-21-23-25-26-38, antennal ratio 1.16 (1.12-1.21, n = 4); sensilla coeloconica present on segments 3-10,13-14. Palpus (fig. 136b) with lengths of segments in proportion of 9-18-23-11-11; third segment slightly swollen, with small deep sensory pit; palpal ratio 2.3 (2.2-2.4, n = 6). Proboscis moderately short, P/H Ratio 0.72; mandible with 15 (13-17, n = 12) teeth.

Thorax: Brown; mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 136c) brown, femora paler at bases; tibiae with narrow sub-basal pale rings; hindtibial comb (fig. 136d) with 4 spines, the one nearest the spur longest.

Wing (fig. 300, 437): Pattern as figured; pale spot over r-m crossvein moderately large, extending broadly from vein M1 to costal margin; stigmal spot extending to tip of second radial cell; 1 poststigmatic pale spot in cell R5, with posterior extension proximad behind second radial cell; distal pale spot in cell R5 elongated in axis of cell, not extending close to distal wing margin; cell M1 with 2 pale spots, second elongated and usually meeting wing margin; cell M2 with narrow pale streak connecting a pale spot extending into cell from a position straddling midportion of medial stem, a pale spot lying behind medial fork, and a pale spot lying in front of midlength of vein M3+4; no pale spot lying immediately in front of mediocubital fork; distal pale spot in cell M2 usually broadly meeting wing margin; pale spot at wing margin in distal portion of cell M4; anal cell with 2 pale spots in distal portion, the posterior one sometimes faint or absent, and a pale spot at base of cell; tips of veins not pale. Macrotrichia sparse on distal half of wing and along posterior margin of anal cell; costal ratio 0.63 (0.61-0.64, n = 6); second radial cell moderately broad with distinct lumen. Halter infuscated.

Abdomen: Pale brown. Spermathecae (fig. 136e) large, subequal, each 0.079 x 0.059 mm; subspherical with moderately long slender sclerotized necks; vestigial third spermatheca present, sclerotized
ring absent.

Male.--Unknown.

Distribution.--Indonesia, Philippines.

Type.--Holotype female, Philippines, Mindanao, Davao, Tagum, Maco, x.1946, H. Hoogstraal and D. Heyneman, near sea level (in CNHM).

Southeast Asia Records.--

INDONESIA: Flores, E. Nusa, Tenggara, at beach (V. Lee). Sulawesi (Central), Banggai, Batui, Dongin (Bambang). Sumatra, Batam Island, Sungai Beduk (Sustriayu); Sibolga (Ikemoto). Timor, Flores, Henga (V. Lee).

PHILIPPINES: Mindanao, Davao, Maco, Tagum (Hoogstraal and Heyneman, type); Camp Meran, E slope Mt. Apo, Davao (Hoogstraal).

Discussion.--This species differs from all other members of the Ornatus Group in antennal sensory pattern, lacking the usual sensilla coeloconica on segments 11 and 12, occasionally sensilla are also absent on segments 4, 6, 8 and/or 10. The spermathecae are also unusually large and globular for members of the group. The wing pattern is very similar to that of *circumbasalis* Tokunaga, but that species has the usual sensory pattern 3-14.

Culicoides maai Wirth and Hubert, new species
(Figs. 137, 301, 438)

Female.--Wing length 1.00 mm.

Head: Eyes bare; very narrowly separated. Antenna (fig. 137a) with lengths of flagellar segments in proportion of 25-20-20-20-19-19-18-18-22-23-25-25-55, antennal ratio 0.78; sensilla coeloconica present on segments 3-15. Palpus (fig. 137b) with lengths of segments in proportion of 15-25-45-15-15; third segment broadly swollen in midportion, with a large, shallow, round sensory pit on distal half; palpal ratio 2.0. Proboscis short, P/H Ratio 0.53; mandible with 13 teeth.

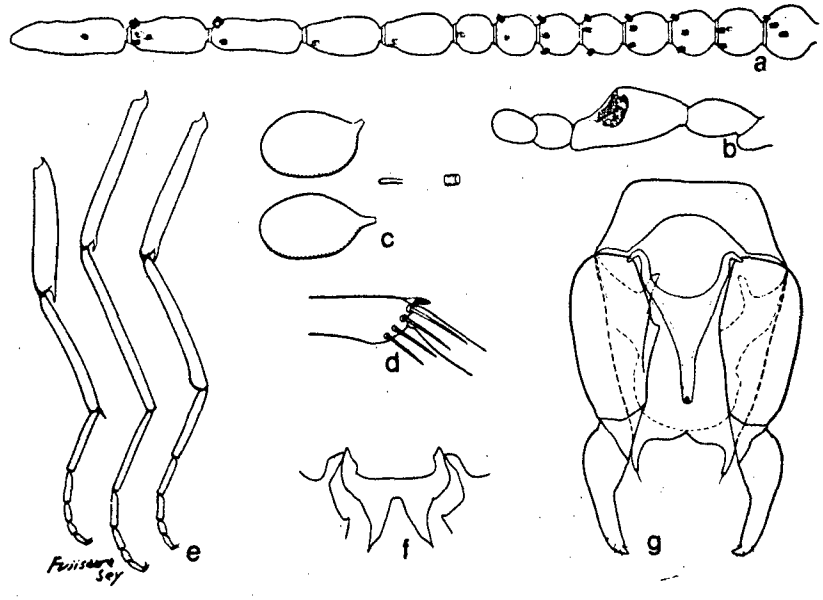


Fig. 137. *Culicoides maai*: a. antenna; b. palpus; c. spermathecae; d. tibial comb; e. legs; f. parameres; g. male genitalia, parameres omitted.

Thorax: Dark brown; mesonotal pattern not evident in slide-mounted specimen. Legs (fig. 137e) pale brown, unbanded, knees not darkened; hindtibial comb (fig. 137d) with 4 spines (5 in holotype), the one nearest the spur longest.

Wing (fig. 301, 438): Very faint pattern as figured; 3 broad areas on anterior margin very slightly darker; second radial cell indistinctly paler towards tip; large pale area over r-m crossvein extending to costal margin; poststigmatic pale spot in cell R5 covering distal half of second radial cell and extending to vein M1; cell R5 pale on distal half; cell M1 with 2 elongate pale spots, the distal one meeting wing margin; cell M2 with pale streak indistinct on proximal two-thirds and an indistinct pale spot at wing margin; cell M4 with indistinct pale spot in distal portion; anal cell with indistinct pale streak at base and double pale spot in distal portion.

Macrotrichia moderately strong and numerous on distal half of wing, sparse on proximal portion; costal ratio 0.64; second radial cell moderately narrow, with narrow lumen. Halter pale.

Abdomen: Brown. Spermathecae (fig. 137c) oval with slender sclerotized necks; large, subequal, each 0.099 x 0.064 mm; vestigial third spermatheca and elongate, annular sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 137g): Ninth sternum moderately long, with moderately deep and broad caudomedian excavation, ventral membrane not spiculate; ninth tergum relatively long, only slightly tapering, apicolateral processes long and slender, the caudal margin between them slightly bilobed. Basistyle moderately stout, ventral root absent, dorsal root moderately long and slender; dististyle very stout, swollen at base, distal portion broad with sharp, bent tip. Aedeagus narrow at base, basal arch extending to a third of total length, basal arms short and moderately stout; distal portion triangular, with nearly straight sides, tapering to slender tip. Parameres (fig. 137f) fused in a stout basal plate, anterior arms short and curved, median bridge of fused portion as thick as basal arm; each distal process stout at base, tapering to stout, bluntly pointed tip.

Distribution.--Sarawak.

Types.--Holotype female, allotype male, Santubong, Sarawak, 26.vi.1958, T.C. Maa, dancing over intertidal zone (in B.P. Bishop Museum). Paratypes, 28 males, 6 females, same data as types.

Discussion.--We are happy to dedicate this species to T.C. Maa, formerly of the B.P. Bishop Museum staff, who collected so many new and interesting ceratopogonids on his extensive field trips to Southeast Asia and the western Pacific area.

Culicoides maai is very similar to *papuensis* Tokunaga and *pangkorensis* n. sp., but has a less distinct wing pattern and stouter palpus, the distal antennal segments are much shorter, and the male parameres are very stout, much more so than in any other species of the group.

Culicoides mcdowelli Delfinado
(Figs. 138, 302, 439)

Culicoides mcdowelli Delfinado, 1961: 647 (female; Philippines; figs.).

Female.--Wing length 0.95 (0.91-1.00, n = 10) mm.

Head: Eyes bare, nearly contiguous mesad, with a wedge-shaped interocular space. Antenna (fig. 138a) with lengths of flagellar segments in proportion of 18-15-15-15-15-16-16-16-28-28-31-32-41, antennal ratio 1.23 (1.17-1.28, n = 7); sensilla coeloconica present on segments 3-14. Palpus (fig. 138b) with lengths of segments in proportion of 9-21-28-8-12; third segment very broad in midportion, with a round shallow sensory pit; palpal ratio 2.0 (1.9-2.3, n = 6). Proboscis moderately short, P/H Ratio 0.67; mandible with 13 (11-14, n = 22) teeth.

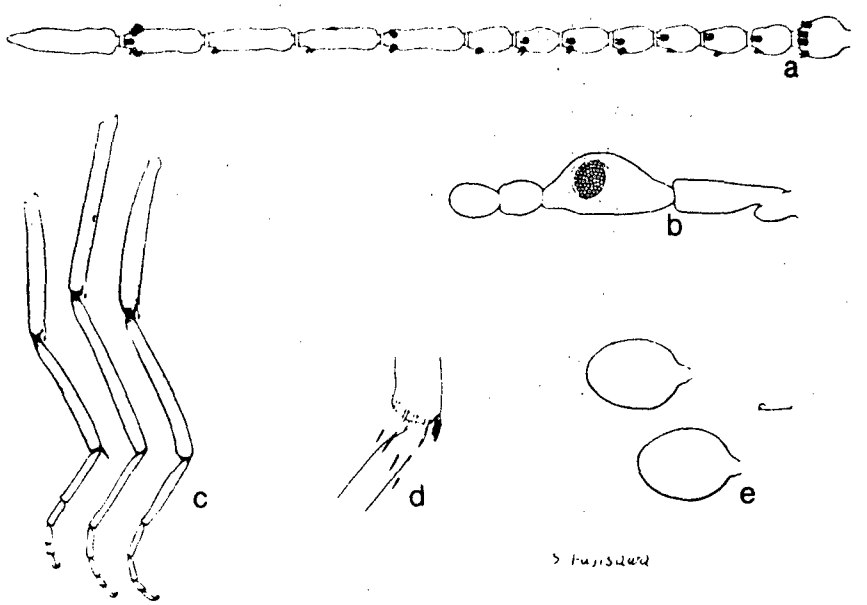


Fig. 138. *Culicoides mcdowelli*: a. antenna; b. palpus; c. legs; d. tibial comb; e. spermathecae.

Thorax: Dark brown; mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 138c) brown; tibiae with narrow sub-basal pale rings; hindtibial comb (fig. 138d) with 4 spines, the one nearest the spur longest.

Wing (fig. 302, 439): Pattern as figured; pale spot over r-m crossvein moderately large, extending broadly from vein M to costal margin; stigmal spot extending to tip of second radial cell and subapical dark area in cell R5 darker than rest of dark wing markings; poststigmatic pale spot in cell R5 single but with posterior lobe extending proximad around hind margin of second radial cell; distal pale spot in cell R5 variable in extent, but usually extending to wing margin on anterior and distal portion of cell; 2 pale spots in cell M1, distal one virtually meeting wing margin; cell M2 with pale spot near basal arculus, 1 overlapping midportion of mediocubital stem, 1 lying behind medial fork, 1 lying distad of level of mediocubital fork, no pale spot lying immediately in front of mediocubital fork, distal pale spot broadly meeting wing margin in cell M2; cell M4 with a large round pale spot in distal portion; anal cell with 2 pale spots in distal portion, posterior one at wing margin may be very faint; a pale area at base of anal cell and 1 nar-

rowly bordering anal angle; tips of veins not pale. Macrotrichia long and moderately numerous, extending nearly to base of anal cell; costal ratio 0.64 (0.63-0.67, n = 10); second radial cell broad to tip, with distinct lumen. Halter infuscated.

Abdomen: Brown. Spermathecae (fig. 138e) subequal, each 0.059 x 0.043 mm; slightly ovoid, slightly broader near base of duct, with only slight indication of sclerotized neck; vestigial third spermatheca present, sclerotized ring absent.

Male.--Unknown.

Distribution.--Indonesia, Philiopines, Sabah.

Type.--Holotype female, Philippines, Palawan, Culion Id., Siuk, Calamianes, 7.iv.1947, near sea level, "Z.D." (in Field Museum of Natural History).

Southeast Asia Records.--
INDONESIA: Sumatra, Riau, Bintan Utara, Tanjan Uban (Pletsch).
PHILIPPINES: Balabac, Dalawan Bay (Noona Dan Exped.; COP). Palawan, Busanga Id., Dimanianga (Hoogstraal); Culion Id., San Pedro (Hoogstraal); Bacungan, Puerto Princessa (Werner).
SABAH: Labuan Island (Colless).

Discussion.--*Culicoides palawanensis* Delfinado is very similar but has no leg bands, eyes distinctly separated, the third palpal segment longer, and the wings less distinctly marked.

Culicoides niphanae Wirth and Hubert, new species
(Figs. 139, 303, 440)

Female.--Wing length 1.15 mm.

Head: Eyes (fig. 139c) bare, nearly contiguous. Antenna (fig. 139a) with lengths of flagellar segments in proportion of 20-20-20-20-21-21-21-21-33-35-40-45-52, antennal ratio 1.23; sensilla coeloconica present on segments 3-14. Palpus (fig. 139b) with lengths of segments in proportion of 15-30-40-15-15; third segment much swollen subapically, with a moderately broad, shallow, round sensory pit; palpal ratio 2.0. Proboscis moderately short, P/H Ratio 0.73; mandible with 16 teeth.

Thorax: Brown, mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 139d) moderately dark brown; knee spots darker, tibiae with narrow, distinct, sub-basal pale rings; hindtibial comb (fig. 139f) with 4 spines, the one nearest the spur longest.

Wing (fig. 303, 440): Pattern as figured; pale spot over r-m crossvein large, extending broadly from costal margin to media; dark stigmal spot covering distal half of first radial cell and all of second; poststigmatic pale spot in cell R5 small at anterior wing margin, just overlapping vein R4+5 at tip of second radial cell, much broadened proximally behind second radial cell and extending nearly to vein M1; distal pale spot in cell R5 extensive, filling entire apex of cell except a narrow line along vein M1, dark area between distal pale spot and poststigmatic pale spot

forming a much darker oblique mark to anterior wing margin; cell M1 with 2 elongate pale spots, second broadly meeting wing margin; large pale spot covering proximal half of medial stem; cell M2 with distinct quadrate pale spot extending broadly on to mediocubital stem, an anterior pale spot just proximad of medial fork, an elongate streak-like pale spot lying anterior to cell M4, and a large pale spot distally broadly meeting wing margin; cell M4 pale except for narrow areas bordering veins M3+4 and Cu1; anal cell with 2 pale spots in distal portion and a proximal pale streak anteriorly; tips of veins not pale. Macrotrichia long and moderately dense over wing, extending proximad to bases of anal cell and cell M2; costal ratio 0.62; second radial cell moderately broad, with well developed lumen. Halter pale, base of knob slightly infuscated.

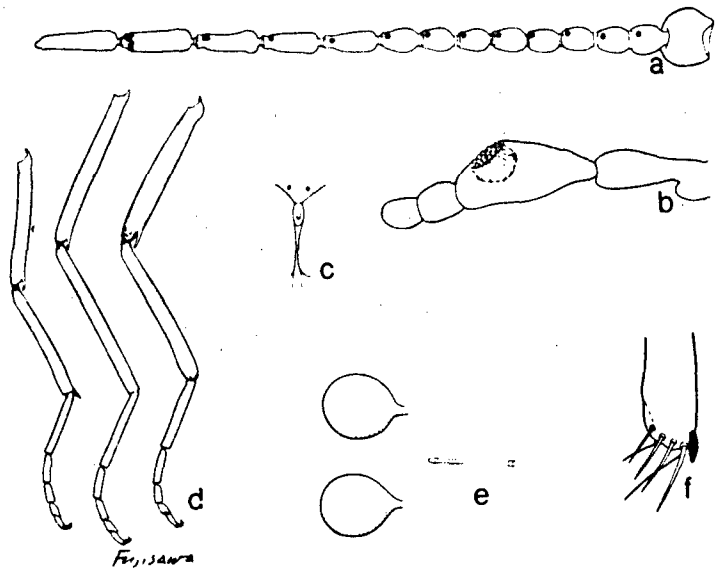


Fig. 139. *Culicoides niphanae*: a. antenna; b. palpus; c. eye separation; d. legs; e. spermathecae; f. tibial comb.

Abdomen: Pale brown. Spermathecae (fig. 139e) subequal, quite large, 0.076 x 0.058 mm; ovoid with distinct taper to moderately long, stout, sclerotized necks; vestigial third spermatheca and sclerotized ring present.

Male.--Unknown.

Distribution.--Thailand.

Types.--Holotype female, Thailand, Cholburi Prov., Amphoe Bangphra, i.1963, J.E. Scanlon, light trap (Type in USNM). Paratypes, 42 females, same data as type.

Discussion.--We are happy to name this species in honor of Dr. Niphan Chanthawanich Ratanaworabhan in recognition of her intense interest and fine work in Thai *Culicoides*. The extensively pale apex of cell R5, round palpal pit, and pale halter ally this species with *papuensis* Tokunaga, but the latter has the second radial cell extensively pale distally and the spermathecae much smaller with shorter necks.

Culicoides okinawensis Arnaud
(Figs. 140, 304)

Culicoides okinawensis Arnaud, 1956: 118 (male, female; Okinawa; figs.); Wirth and Hubert, 1961: 21 (Taiwan; notes); Hubert and Wirth, 1961: 236 (Okinawa; in key); Tokunaga, 1962a: 205 (male described; Okinawa; fig. genitalia); McDonald and Lu, 1972: 409 (Taiwan; female redescribed; figs.); McDonald et al., 1973: 644 (female redescribed; Okinawa; figs.); Kitaoka and Suzuki, 1974: 172 (record Amami-oshima); Kitacka, 1977: 195 (record Nansei Islands); Kitaoka, 1963: 48 (in table; Japanese records); Howarth, 1985: 77 (pupa descr.; figs.; Laos); Wada, 1986: 147 (redescribed; Japanese records; figs.).

Female.--Wing length 1.06 mm.

Head: Eyes (fig. 140c) very narrowly separated, bare. Antenna (fig. 140a) with lengths of flagellar segments in proportion of 32-20-20-20-22-22-22-23-45-46-50-50-64, antennal ratio 1.40; sensilla coeloconica present on segments 3-14, double on most segments, multiple on 3 and 14. Palpus (fig. 140b) with lengths of segments in proportion of 14-45-65-25-21; third segment broadly swollen, with a moderately large and deep sensory pit opening by a smaller pore; palpal ratio 2.3. Proboscis moderately long, P/H Ratio 0.82; mandible with 15 teeth.

Thorax: Dark brown; mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 140i) brownish, without pale rings; hindtibial comb (fig. 140g) with 4 spines, second from the spur longest.

Wing (fig. 140d, 304): Pattern as figured; pale pattern restricted to 2 small pale spots, 1 over r-m crossvein and second on anterior margin just past end of costa. Macrotrichia long and numerous, extending to base of wing; costal ratio 0.62; second radial cell with narrow lumen. Halter infuscated.

Abdomen: Brown. Eighth sternum with narrow dark brown sclerotization on lateral and posterior margin. Spermathecae (fig. 140e) short oval with moderately long slender necks; subequal, each 0.072 x 0.050 mm including necks; vestigial third spermatheca present, sclerotized ring absent.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 140h): Ninth sternum with shallow caudomedian excavation, ventral membrane spiculate; ninth tergum short and broad, tapering distally, with long slender apicolateral processes. Basistyle with ventral root inconspicuous, dorsal root short and slender; dististyle moderately long, rather stout distally with blunt tip. Aedeagus

with short, broad, basal arch extending to only 1/7 of total length; sides tapering to moderately slender, blunt tip. Parameres (fig. 140f) joined at bases, each with short, stout basal knob with short anterior process; distal portion moderately stout, short, sides parallel at base, distally becoming hyaline and curving ventrolaterad with blunt tip.

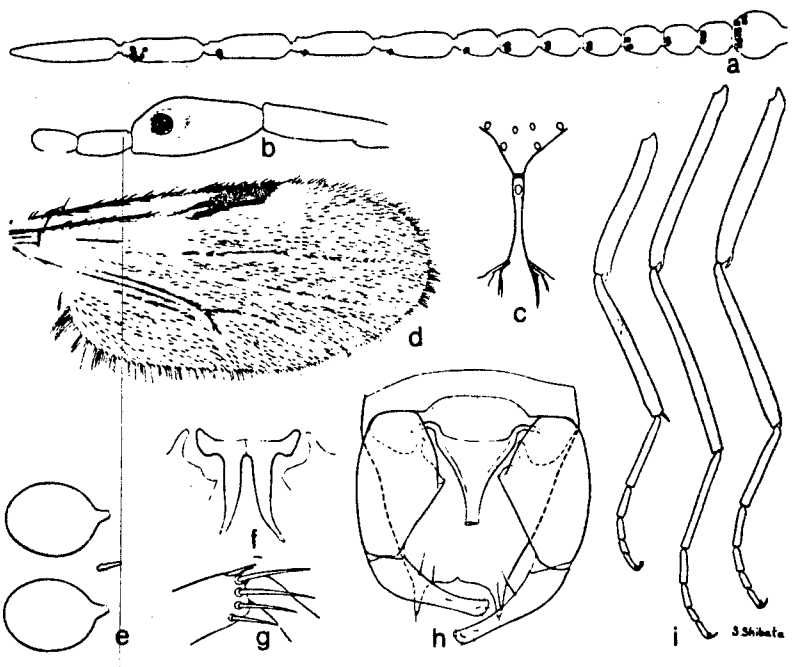


Fig. 140. *Culicoides okinawensis*: a. antenna; b. palpus; c. eye separation; d. wing; e. spermathecae; f. parameres; g. tibial comb; h. male genitalia, parameres omitted; i. legs.

Distribution.--Indonesia, Japan (Amami-oshima, Nansei Is., Ruykyu Is.), Laos, Taiwan, Thailand, Vietnam.

Types.--Holotype female, allotype male, Okinawa, Sukiran Area, iii.1955, light trap no. 1 (in USNM).

Southeast Asia Records.--
INDONESIA: Bali, Klungkung, Timuhun (Sweatman); Pedang Bay, 35 km N Denpassar (Nicholls). Sumbawa (Nicholls). West Java, Garut, Pameungpeuk (Zubaedah).

LAOS: Sayaboury Prov., Sayaboury (Howarth); Houay La Stream, 20 km N Sayaboury, 400 m (Howarth). Sedone Prov., Muong Pakse, 100 m (Howarth).
THAILAND: Chiang Mai Prov. (Notananda); Ban Tin Doi (Gressitt). Khon Kaen Prov., Amphoe Muang (Manop R.). Nong Kai Prov., A. Muang (Manop R.). Udon Thani Prov., A. Nong Han (Manop R.).
VIETNAM: Chu Lai (Tisdale). Da Nang (Dickens). Di Linh, Djiring, 1,200 m (light trap).

Discussion.--This species is very similar to *C. flumineus* Macfie which it resembles in wing pattern, but *flumineus* has a shallow palpal pit opening by a wide pore, the sensilla on antennal segments 4-9 are not doubled, and the antennal segments are much shorter and the necks of the spermathecae are longer and more tapering.

Biology.--Howarth (1985) reared this species in Laos from stream margins, sunny and shaded.

Culicoides ornatus Taylor
(Figs. 141, 305, 441)

Culicoides ornatus Taylor, 1913: 73 (female; Queensland); Lee and Reye, 1953: 381 (female redescribed; figs.; neotypes designated; Queensland); Lee and Reye, 1955: 242 (notes; distribution); Marks and Reye, 1973: 99 (summary of biology; distribution; fig. wing); Debenham, 1978: 332 (complete bibliography; summary biology, distribution); Kettle and Elson, 1980: 11 (pupa; figs.); Kay and Lennon, 1982: 207 (seasonal prevalence, bionomics; Australia).

Female.--Wing length 0.95 (0.91-1.00, n = 5) mm.
Head: Eyes separated by width of one facet, bare. Antenna (fig. 141a) with lengths of flagellar segments in proportion of 19-14-15-16-15-15-15-16-26-26-28-29-35, antennal ratio 1.20 (1.15-1.22, n = 4); sensilla coeloconica present on segments 3,11-14, sometimes also on 4, 5, 6, and 8. Palpus (fig. 141b) with lengths of segments in proportion of 13-24-31-13-13; third segment long and swollen toward apex, with a moderately large, round, shallow sensory pit; palpal ratio 2.3 (2.1-2.3, n = 5). Proboscis long, P/H Ratio 0.90; mandible with 17 (15-18, n = 10) fine teeth.
Thorax: Dark brown; mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 141c) brown; knee spots blackish; femora pale at bases and forefemur with subapical pale ring; tibiae with narrow sub-basal pale rings and hindtibia with apex broadly pale; hindtibial comb (fig. 141e) with 4 (n = 5) spines, the one nearest the spur longest.
Wing (fig. 305, 441): Pattern as figured; pale spot over r-m crossvein moderately large, extending from media to costal margin; stigma well defined, second radial cell dark to apex; two separate poststigmatic pale spots in cell R5, the posterior one located behind second radial cell midway between it and vein M1; distal pale spot in cell R5 extending to apex of cell; two pale spots in cell M1, the distal one broadly reaching wing margin; cell M2 with pale spot at base, one

lying immediately in front of midlength of mediocubital stem, one lying behind medial fork and two distad of mediocubital fork the apical one broadly reaching wing margin; cell M4 with pale spot lying near posterior margin of cell and broadly reaching wing margin; anal cell with one pale spot in distal portion and one near base; tips of veins not pale. Macrotrichia sparse, extending to base of wing in double row and in anal cell; costal ratio 0.62 (0.60-0.64, n = 5); second radial cell complete but only moderately broad, not tapering distally. Halter pale.

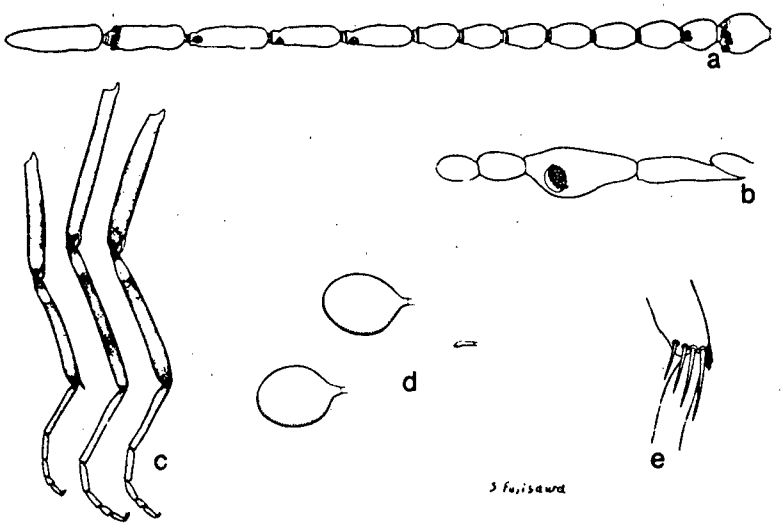


Fig. 141. *Culicoides ornatus*: a. antenna; b. palpus; c. legs; d. spermathecae; e. tibial comb.

Abdomen: Brown. Eighth sternum forming a dark brown trapezoidal sclerite with an angular notch caudally in front of gonopore. Spermathecae (fig. 141d) oval, slightly broader toward base of ducts, with moderately long, slender, sclerotized necks; subequal, each 0.055 x 0.036 mm; vestigial third spermatheca present, sclerotized ring absent.

Distribution.--Queensland, coastal northern Australia, Torres Strait Islands, southern Papua, Indonesia, Malaysia, Singapore.

Types.--Neotype female, Queensland, Magnetic Island, 9.vi.1952, E.J. Reye, designated by Lee and Reye (1953: 381) (ANIC).

Southeast Asia Records.--
INDONESIA: Sumatra, Riau, Bintan Utara, Tanjan Uban (Pletsch, biting man).
MALAYSIA: Negri Sembilan, Telok Pelandok, Port Dickson (Traub).

SINGAPORE: Pasir Panjang (Colless).

Discussion.--This species resembles *C. mcdowelli* Delfinado, *palawanensis* Delfinado, and *papuensis* Tokunaga in wing pattern but can be distinguished by having usually only one pale spot distally in the anal cell, two separate poststigmatic pale spots in cell R5, pale halter, banded forefemora, and sensilla coeloconica usually absent on some of antennal segments 4-10.

Culicoides palawanensis Delfinado
(Figs. 142, 306, 442)

Culicoides palawanensis Delfinado, 1961: 648 (male, female; Philippines; figs.).

Female.--Wing length 1.00 (0.96-1.08, n = 8) mm.

Head: Eyes separated by half the width of one facet; with long interfacetal hairs. Antenna (fig. 142a) with lengths of flagellar segments in proportion of 18-12-12-13-12-12-12-13-28-28-29-31-42, antennal ratio 1.50 (1.47-1.52, n = 4); sensilla coeloconica present on segments 3-14. Palpus (fig. 142b) with lengths of segments in proportion of 10-23-22-11-15; third segment moderately swollen toward tip, with round, moderately deep, sensory pit; palpal ratio 2.2 (2.2-2.3, n = 4). Proboscis moderately long, P/H Ratio 0.81; mandible with 12 (11-13, n = 6) teeth.

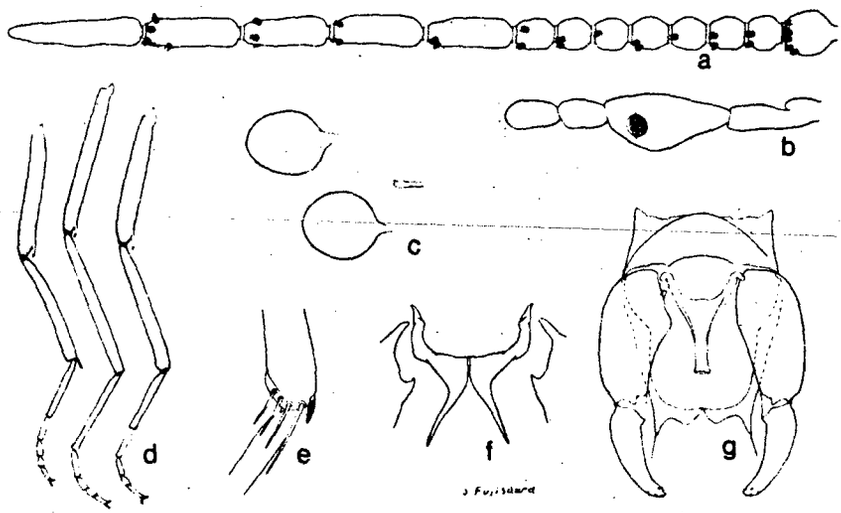


Fig. 142. *Culicoides palawanensis*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Thorax: Dark brown, mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 142d) dark brown, without pale bands; hindtibial comb (fig. 142e) with 4 spines, the one nearest the spur longest.

Wing (fig. 306, 442): Pattern as figured; pale spots very faint, especially at margin; pale spot over r-m crossvein small, not extending to costal margin; stigmal spot extending to tip of second radial cell moderately dark; 1 poststigmatic pale spot in cell R5, obliquely extending slightly proximad behind tip of second radial cell; distal pale spot in cell R5 indistinct, not extending to wing margin; 2 pale spots in cell M1, the distal one indistinct and not meeting wing margin; cell M2 with pale streak at base extending to pale spot behind medial fork, no pale spot immediately in front of mediocubital fork or in subapical position in front of vein M3+4, distal pale spot in cell M2 faint but apparently meeting wing margin; cell M4 with faint pale area distally; anal cell with 1 faint pale spot in distal portion and 1 in basal portion of cell; tips of veins not pale. Macrotrichia sparse on distal half of wing and posterior half of anal cell; costal ratio 0.66 (0.64-0.68, n = 6); second radial cell long and moderately broad with well developed lumen. Halter infuscated.

Abdomen: Brown. Spermathecae (fig. 142c) subequal, each 0.065 x 0.050 mm; subspherical with short, slender sclerotized necks; vestigial third spermatheca present, sclerotized ring absent.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 142g): Ninth sternum with very slight caudomedian excavation, ventral membrane with well-developed spicules on anterior half; ninth tergum with slender, pointed apicolateral processes, caudal margin between them with well-developed pair of rounded submedian lobes. Basistyle with ventral root undeveloped, dorsal root long and slender; dististyle stout, curved from base to mesally toothed tip. Aedeagus with basal arch extending to a third of total length, basal arms stout; distal process moderately slender in midportion but distally expanded to moderately broad, bluntly rounded tip. Parameres (fig. 142f) fused a short way anteriorly on midportions; each with long basal arm directed laterally, then bent anteriorly in a long slender process; distal stem moderately stout at extreme base, then bent laterocaudad in a distal straight portion with moderately blunt, simple tip.

Distribution.--Indonesia, Malaysia, Philippines, Sabah, Sarawak.

Types.--Holotype female and allotype male, Philippines, Palawan, Culion Id., San Pedro, 26.iii.1947, H. Hoogstraal, near sea level (Field Museum of Natural History).

Southeast Asia Records.--

INDONESIA: Bali, Badung, Denpasar, Padungan (V. Lee). Sumatra, Sibolga (Ikemoto).

MALAYSIA: Pahang, Kuantan, Telok Sisek (Wharton).

PHILIPPINES: Palawan, Busuanga Ids., Dimanianga (Hoogstraal), Culion Id., San Pedro (Hoogstraal).

SABAH: Tawau, on beach at dusk (Quate).

SARAWAK: Santubong (Maa).

Discussion.--This sea coast species is readily distinguished by the hairy eyes, dark second radial cell, faint wing markings with a single distal pale spot in anal cell, dark halteres, and unbanded brown legs.

Culicoides pampangensis Delfinado
(Figs. 143, 307, 443)

Culicoides pampangensis Delfinado, 1961: 650 (male, female; Philippines; figs.); Wada, 1977: 347 (fig. wing).

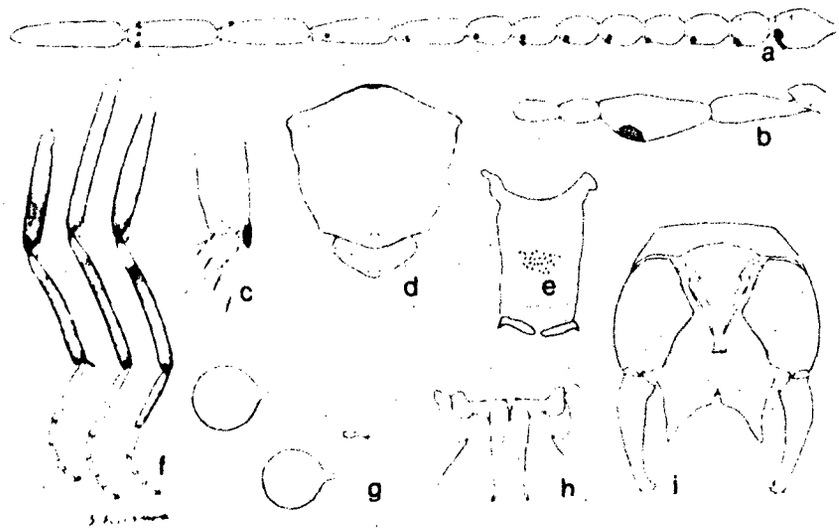


Fig. 143. *Culicoides pampangensis*: a. antenna; b. palpus; c. tibial comb; d. thoracic pattern; e. cibarial armature; f. legs; g. spermathecae; h. parameres; i. male genitalia, parameres omitted.

Female.--Wing length 0.99 (0.92-1.07, n = 8) mm.

Head: Eyes contiguous, bare. Antenna (fig. 143a) with lengths of flagellar segments in proportion of 20-12-13-13-13-13-13-13-27-31-35-35-47, antennal ratio 1.45 (1.39-1.59, n = 6); sensilla coeloconica present on segments 3-14. Palpus (fig. 143b) with lengths of segments in proportion of 12-25-36-15-13; third segment moderately swollen subapically, with broad, moderately deep, round sen-

sory pit; palpal ratio 2.5. Proboscis long, P/H Ratio 0.87; mandible with 15 (12-17, n = 15) small teeth; cibarium (fig. 143e) with patch of about 50 dark, blunt spicules in 5-6 uneven rows.

Thorax: Dark brown, mesonotum (fig. 143d) without apparent pattern in slide mounted specimens. Legs (fig. 143f) brown; knees not darkened; femora narrowly pale at bases but without distal pale rings; tibiae with narrow sub-basal pale rings only; hindtibial comb (fig. 143c) with 4 (n = 8) spines, the one nearest the spur longest.

Wing (fig. 307, 443): Pattern as figured; pale spot over r-m crossvein large, extending broadly to costal margin; a single large quadrate poststigmatic pale spot in cell R5 covering vein at extreme apex of second radial cell and extending caudad 2/3 way to vein M1; no pale spot in cell R5 distal to poststigmatic pale spot; large distal pale spots forming a prominent transverse band across wing behind poststigmatic pale spot, spots centering in cells M1, M2, and M4; only faint streaklike pale spots in apices of cells M1 and M2 at wing margin; base of wing pale from base of media across cell M2 and mediocubital stem into basal third of anal cell; cell M2 with area between medial fork and mediocubital fork pale; anal cell with 1 large round pale spot in distal portion; apices of veins not pale. Macrotrichia sparse but scattered over distal 2/3 of wing and extending nearly to base of anal cell; costal ratio 0.63 (0.62-0.64, n = 8); radial cells complete, the second broad with distinct lumen. Halter slightly infuscated.

Abdomen: Brown. Spermathecae (fig. 143g) oval with very short sclerotized necks; subequal, each 0.054 x 0.040 mm; vestigial third spermatheca present, sclerotized ring absent.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 143i): Ninth sternum with shallow caudomedian excavation, ventral membrane spiculate; ninth tergum tapering, apicolateral processes large and triangular, caudal margin between them deeply notched. Basistyle with ventral root absent, dorsal root short and blunt; dististyle slightly curved, rather stout distally with blunt, mesally toothed tip. Aedeagus with basal arch low, less than 1/4 of total length, basal arms short and stout; distal process broad basally, tapering to slender, distally flaring and slightly rounded tip. Parameres (fig. 143h) separate, each with laterally directed basal arm with expanded, rounded, lateral knob; stem short, slightly stouter basally, straight, gradually tapered to caudally directed point bearing a few microscopic hairs.

Distribution.--Indonesia, Malaysia, Philippines, Sabah, Sri Lanka, Thailand.

Types.--Holotype female, Philippines, Luzon, Pampanga Prov., Angeles, Clark Air Base, 17.ix.1957, I. Balatbat, light trap (Philippine Dept. of Health, Manila). Paratypes in USNM and Field Museum of Natural History.

Southeast Asia Records.--

INDONESIA: Bali, Badung, Tag Tag (Lee). Java (Central), Cilacap, Adipala, Karang Sari (Lee); (West), Bogor (Adiwinata); Serang, Anyer Beach Hotel (Lee). Kalimantan (South), Banjar, Astambul, Tanah Intan, Lombok Terong, and Pulo Empat. Sulawesi (Southeast), Kendari, Lainea, Ombu Ombu (Bambang). Sumatra, Bengkulu, Cenggeri (Mathis).

MALAYSIA: Pahang, Kuala Singgora (Wharton). Perak, Ipoh (Kitaoka). Trengganu, Bukit Besi, Dungun (Traub).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Pampanga Prov., Angeles, Clark Air Base (Balatbat, types); Rizal Prov., Tala (Delfinado). Mindanao, Surigao, Lake Mainit (Yoshimoto). Palawan, Busuanga Is., Dimanianga, near sea level (Hoogstraal). Tawi Tawi, Tarawakan, N of Batu Batu (Noona Dan Exped.).

SABAH: Sandakan (Wada).

THAILAND (all collected by Manop Rattanarithikul unless stated otherwise): Ayudhaya Prov., Bangkok, Amphoe Pratoomvan. Chiang Mai Prov. (Notananda). Cholburi Prov., Amphoe Bangphra (Scanlon). Loei Prov., A. Dan Sai, Meung. Nakronprathom Prov. Nonthaburi Prov. Pechaburi Prov. Rachaburi Prov., A. Banpong. Samuthprakan Prov. Thonburi Prov.

Discussion.--In spite of the pale area over the extreme tip of the second radial cell, the antennal sensory pattern and structure of the male genitalia will place this species in the Ornatus Group. The wing pattern with two prominent subapical transverse pale bands and no distal pale spot in cell R5, together with the distinctive male genitalia, readily separate *pampangensis* from the other species of the group. The Japanese *C. midorensis* Arnaud has a wing pattern closest to that of *pampangensis*, but the antennal sensory pattern, on segments 3,13-15, and broad, spinose apices of the male parameres are quite distinct.

Culicoides pangkorensis Wirth and Hubert, new species
(Figs. 144, 308, 444)

Female.--Wing length 1.18 mm.

Head: Eyes bare, separated by width of one ommatidial facet. Antenna (fig. 144a) with lengths of flagellar segments in proportion of 25-20-20-20-20-20-20-20-35-35-38-40-57, antennal ratio 1.25; sensilla coeloconica present on segments 3-15 (occasionally absent on 10 and/or 15). Palpus (fig. 144b) with lengths of segments in proportion of 15-35-40-17-23; third segment slightly swollen, with moderately large, round, shallow sensory pit, palpal ratio 2.0. Proboscis moderately long, P/H Ratio 0.75; mandible with 13 teeth.

Thorax: Dark brown; mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 144d) uniformly yellowish brown without trace of paler or darker bands; hindtibial comb (fig. 144e) with 4 spines, the one nearest the spur longest.

Wing (fig. 308, 444): Pattern as figured; pale markings dominant, tending to coalesce with the veins in darker areas; pale spot over r-m crossvein broader than the dark area on either side; stigmal spot moderately prominent, second radial cell with distal half included in the poststigmatic pale spot; the latter a broad, quadrate pale area twice as broad as the dark area distal to it; distal pale spot in cell R5 filling apex of cell; cell M1 with 2 elongate pale spots, distal one broadest at wing margin; cell M2 extensively pale at base with pale streak extending to the subapical pale spot distal to mediocubital fork, the latter without pale spot lying immediately in front; distal pale spot in cell M2 broadly meeting wing margin; cell M4 nearly filled with a large pale spot; anal cell with 2 extensive coalescing pale spots in distal portion and base extensively pale; tips of veins not pale. Macro-

trichia scanty on distal half of wing and in posterior half of anal cell; costal ratio 0.57; second radial cell slightly tapering distad, with moderately broad lumen. Halter pale.

Abdomen: Pale brown. Spermathecae (fig. 144c) collapsed and size and proportions not measured, but apparently subequal, oval and abruptly tapered to slender, moderately long, sclerotized necks; vestigial third spermatheca and sclerotized ring present.

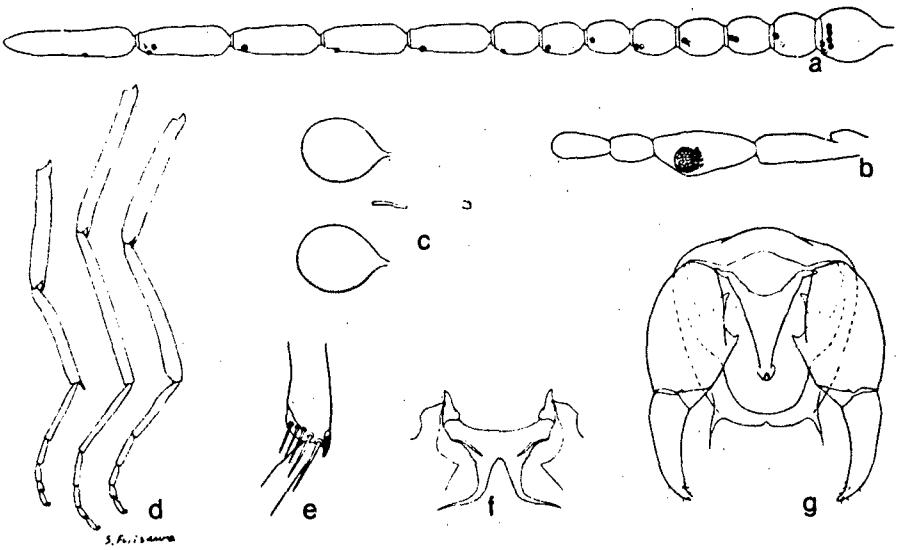


Fig. 144. *Culicoides pangkorensis*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 144g): Ninth sternum with distinct shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum with convex lateral and distal outline, apicolateral processes moderately long and quite slender, broadly separated on shoulders of tergum, the caudal margin between them rounded with only slight indicating of mesal notch. Aedeagus with low basal arch reaching only 1/4 of total length of aedeagus, basal arms stout and bent laterad, the distal process tapering gradually to moderately stout rounded tip. Basistyle with ventral root not developed, dorsal root stout; dististyle stout, gradually tapered to very slender, pointed tip. Parameres (fig. 144f) fused for about 1/3 of total length, forming a basal plate with a moderately slender process extending cephalad from each an-

terolateral corner; distal free portion of each paramere moderately stout and straight proximad, bent ventrolaterad just past midlength and tapered to simple pointed tip.

Distribution.--Indonesia, Malaysia.

Types.--Holotype female, allotype male, Malaysia, Perak, Pulau Pangkor, 1.iv.1959, R. Traub, light trap (Type in USNM). Paratypes, 10 females, as follows: INDONESIA: Flores, Manggarai, Nangalili, Wai Tiang, 10-11.xii.1977, V.H. Lee, light trap, 1 female; Manggarai, Reo, Galok, 2-3.x.1978, Nasir, light trap, 3 females. Central Java, Cilacap, Adipala, 10-11.i.1979, V.H. Lee, light trap, 3 females. West Java, Serang, Anyer Beach Hotel, at light, 2.ix.1979, V.H. Lee, 1 female. Sumbawa, 5 km W Sumbawa, 22.x.1969, D.G. Nicholls, light trap, 2 females.

Discussion.--This species is closely related to *C. papuensis* Tokunaga, but *papuensis* differs in its smaller size and darker legs, and the spermathecae are smaller and shaped differently.

Culicoides papuensis Tokunaga
(Figs. 145, 309, 445)

Culicoides papuensis Tokunaga, 1962b: 513 (female; Papua New Guinea); Tokunaga, 1963c: 122 (in key); Debenham, 1978: 242 (bibliography).
Culicoides sp. 19: Nordhin and Zachariah, 1976: 182 (Brunei; biting man).

Female.--Wing length 0.96 (0.91-1.01, n = 10) mm.

Head: Eyes bare, nearly contiguous. Antenna (fig. 145a) with lengths of flagellar segments in proportion of 19-12-12-12-12-12-12-12-24-26-26-27-37, antennal ratio 1.36 (1.25-1.43, n = 5); sensilla coeloconica present on segments 3-15. Palpus (fig. 145b) with lengths of segments in proportion of 11-20-29-12-15; third segment decidedly swollen in midportion, with a moderately large, shallow, round, sensory pit; palpal ratio 2.1 (1.9-2.2, n = 10). Proboscis short, P/H Ratio 0.60; mandible with 13 (11-13, n = 16) teeth.

Thorax: Brown, mesonotal pattern not discernible in slide-mounted specimens. Legs (fig. 145c) dark brown, knee spots darker; tibiae with narrow, faint, subbasal pale rings; hindtibial comb (fig. 145e) with 4-5 spines, the one nearest the spur longest.

Wing (fig. 309, 445): Pattern as figured; pale spots extensive, the dark areas forming 2 transverse, narrow, recessive, zigzag bands; pale spot over r-m crossvein very extensive, quadrate, extending broadly from costal margin halfway through cell M2; dark stigmal spot confined to small area at tip of first radial cell, distal 2/3 of second radial cell yellowish and included in poststigmatic pale spot; the latter large and extending broadly to vein M1; distal pale spot in cell R5 extensive and filling apex of cell except narrowly along vein M1; cell M1 with 2 extensive pale spots, distal one filling end of cell; cell M2 mostly pale on basal portion including portions of large pale spots at proximal end of medial stem, at proximal third of mediocubital stem, the one over r-m crossvein and extending behind

medial fork and the subapical one lying past level of mediocubital fork; no pale spot lying immediately in front of mediocubital fork; distal pale spot in cell M2 broadly meeting wing margin; pale spot in cell M4 filling all but very basal portion of cell; most of basal portion of anal cell pale; 2 more or less coalescing pale spots in distal portion of anal cell; tips of veins not pale. Macrotrichia moderately long and numerous on distal half of wing and in posterior half of anal cell; costal ratio 0.64 (0.63-0.66, n = 10); second radial cell tapering distally, moderately broad, with well-developed lumen. Halter pale.

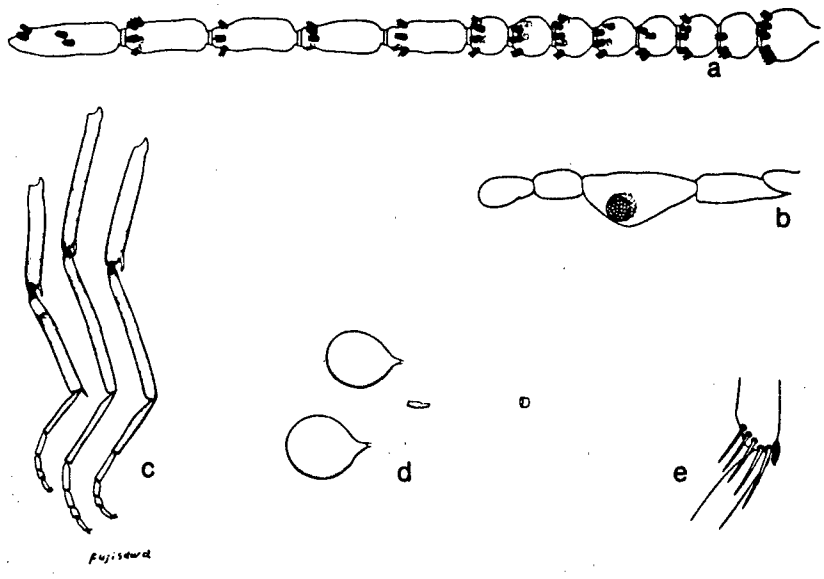


Fig. 145. *Culicoides papuensis*: a. antenna; b. palpus; c. legs; d. spermathecae; e. tibial comb.

Abdomen: Pale brown. Spermathecae (fig. 145d) slightly unequal, 0.054 x 0.038 mm and 0.051 x 0.036 mm, ovoid with slight taper to short, slender, sclerotized necks; vestigial third spermatheca and sclerotized ring present.

Male.--Unknown.

Distribution.--Brunei, Indonesia, Papua, Philippines, Sabah.

Type.--Holotype female, 1 female paratype, Papua, Port Moresby, i.1960 (Peters) (Bishop Mus.).

Southeast Asia Records.--

BRUNEI: Muara Beach (Chow, biting man).

INDONESIA: Java (West), Pandeglang, Ujung Kulon (Watters); Serang, Anyer Beach Hotel (Lee).

PHILIPPINES: Balabac, Dalawan Bay (Noona Dan Exped.).

SABAH: Labuan Island (Colless).

Discussion.--This species is keyed out twice, once with the species with the tip of the second radial cell pale where it comes out near *C. peliliouensis* Tokunaga, and again for specimens where the second radial cell is dark to the tip, where it keys out near *ornatus* Taylor and *mcdowelli* Delfinado. From all these species it differs in having sensilla coeloconica on the last antennal segment. *Culicoides peliliouensis* is superficially most similar to *papuensis*, but has the sensilla borne on the surface of the third palpal segment and the pale wing markings not so extensive.

Culicoides peliliouensis Tokunaga
(Figs. 146, 310, 446)

Culicoides peliliouensis Tokunaga, in Tokunaga and Esaki, 1936: 55 (female; Palau Id.; figs.); Tokunaga, 1937: 305 (notes); Dorsey, 1948: 805 (biology, control; Palau Islands); Tokunaga and Murachi, 1959: 342 (male, female redescr.; Caroline Islands; figs.).

Culicoides ejercitoi Delfinado, 1961: 643 (female; Philippines; figs.). NEW SYNONYMY.

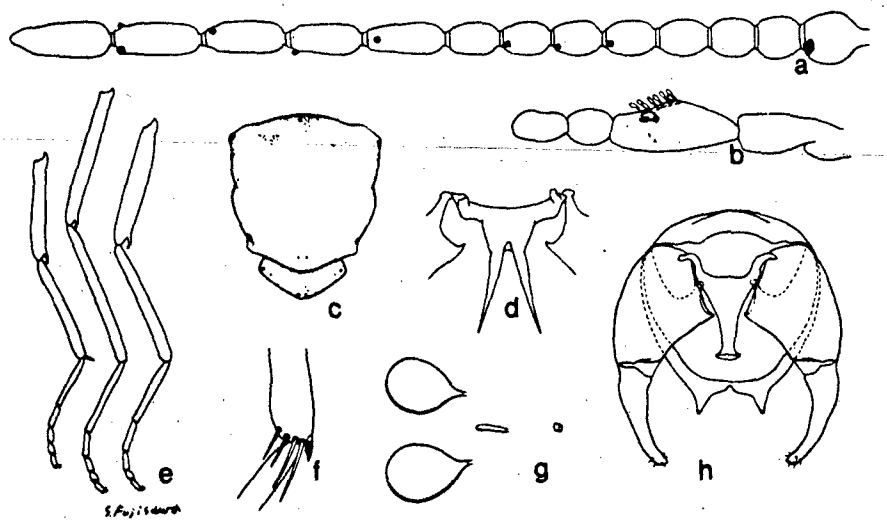


Fig. 146. *Culicoides peliliouensis*: a. antenna; b. palpus; c. thoracic pattern; d. parameres; e. legs; f. tibial comb; g. spermathecae; h. male genitalia, parameres omitted.

Female.--Wing length 1.01 (0.85-1.10, n = 35) mm.

Head: Eyes bare, nearly contiguous. Antenna (fig. 146a) with lengths of flagellar segments in proportion of 19-11-12-13-13-12-12-12-20-19-22-23-26, antennal ratio 1.11 (1.00-1.18, n = 17); sensilla coeloconica present on segments 3-14, regularly so in Philippine material, but in other localities sensilla may be absent on all or some of segments 4, 5, and 6, and usually also on 10. Palpus (fig. 146b) with lengths of segments in proportion of 10-19-26-9-12; third segment only slightly swollen, with sensilla borne on surface of segment in irregular sensory area sometimes subdivided into one or several, small, shallow, irregular pits; palpal ratio 2.4 (2.1-2.8, n = 24). Proboscis moderately short, P/H Ratio 0.67; mandible with 13 (10-17, n = 40) teeth.

Thorax: Yellowish brown; mesonotum (fig. 146c) dark brown with dense grayish pollinosity. Legs (fig. 146e) yellowish brown, without distinct pale markings; hindtibial comb (fig. 146f) with 4 spines, the one nearest the spur longest.

Wing (fig. 310, 446): Pattern as figured; pale spot over r-m crossvein moderately large, extending broadly from vein M1 to costal margin; stigmal spot not very dark, distal half to third of second radial cell included in poststigmatic pale spot; the latter rounded, broadest at anterior wing margin and extending almost to vein M1; distal pale spot in cell R5 more or less oval, nearly filling apex of cell; cell M1 with 2 oval pale spots, distal one meeting wing margin or falling only a little short; cell M2 with a pale spot at base extending up across medial stem broadly, an elongate spot lying behind medial fork, narrowly connected by a pale streak to a subapical pale spot lying distad of level of mediocubital fork, distal pale spot in cell M2 more or less meeting distal wing margin; cell M4 with large pale spot nearly filling cell; anal cell with 1 pale spot, sometimes a fainter second posterior one at wing margin, in distal portion of cell, and a large pale area at base; tips of veins not pale. Macrotrichia long and moderately numerous on distal half of wing and distal half of anal cell; costal ratio 0.63 (0.61-0.67, n = 25); second radial cell tapering distally, with narrow lumen. Halter infuscated.

Abdomen: Pale brown; eighth sternum a brownish sclerite slightly broader than long, with median cleft on caudal margin. Spermathecae (fig. 146g) slightly unequal, 0.059 x 0.039 mm and 0.056 x 0.039 mm; pyriform, tapering to the moderately long, slender, sclerotized necks; heavily sclerotized; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 146h): Ninth sternum with shallow caudomedian excavation, ventral membrane finely spiculate; ninth tergum with lateral margins convex, apicolateral processes triangular and rather closely approximated, caudal margin between them deeply cleft. Basistyle with ventral root not developed, dorsal root moderately stout; dististyle curved, with slender, pointed, bent tip. Aedeagus with low basal arch extending to a fourth of total length, basal arms stout and S-curved; distal stem gradually tapered to broad, truncate, somewhat capitate tip. Parameres (fig. 146d) fused at base for a distance of about a third of total length; each with stout basal portion abruptly bent laterad and then cephalad, free portion sword-like, straight, tapering to simple, sharp, distal point.

Distribution.--Caroline Islands (Palau, Ponape, Truk, Yap), Indonesia, Malaysia, Philippines, Sabah, Sarawak, Thailand, Vietnam.

Types.--Holotype of *peliliouensis*, female, Akarokuru, Peliliou, Palau Islands, 5.iii.1936, T. Esaki, mangrove (in Laboratory of Entomology, Kyoto University, Kyoto, Japan). Type of *ejercitoi*, female, Siuk, Calamianes, Culion Id., Palawan, Philippines, 7.iv.1947, near sea level, H. Hoogstraal (Field Museum of Natural History).

Southeast Asia Records.--

BORNEO: Tarakan (Humes).

INDONESIA: Bali, Badung, Pedungan (Lee). Flores, Manggarai, Reo, Gincu, Galok and Robek (Lee). Java (Central), Cilacap, Adipala, Bunton (Lee). Maluku, P. Buru, Savanajaya (Bambang). Sulawesi (Central), Banggai, Batui, Dongin and Kamiwangi (Bambang). Sumatra, Bintan, Tanjung Uban, Metinggi (Sumitro); Sibolga (Ikemoto). Timor (East), Dili, Comoro, Kampung Marinir (Soeroto).

MALAYSIA: Negri Sembilan, Port Dickson, biting man (Traub). Pahang, Kuantan, Telok Sisek, biting man (Wharton). Perlis, Kangar Rest House (Traub). Selangor, Klang, Rantau Panjang (Quate). Magnolia Bay, biting man (Lever).

PHILIPPINES: Mindanao, Davao, Maco, Tagum (Hoogstraal and Heyneman). Palawan, Busuanga Id., Dimanianga (Hoogstraal); Culion Id., Calamianes, Siuk (Hoogstraal). Tawi Tawi, Lapid Lapid at Manalik Channel (Noona Dan Expec.).

SABAH: Labuan Island (Colless). Tawau (Quate).

SARAWAK: Lutong (Colless).

THAILAND: Chanthaburi, Kung Wi Man (Mori). Phangnga Prov., Pulau Panjang (collector ?). Songkla (collector ?).

Discussion.--The above description is given mainly from material from Pulau Panjang, Thailand. We have been able to compare our material with a series of females from Peliliou, Palau Islands collected by C.K. Dorsey who published extensive observations on the biology and control of this species (1948) under the common name of the "Palau Gnat."

There is considerable variation both in color and structural characters in this species but not sufficient or of such a nature to lead us to believe that more than subspecific differences are involved. Nearly all of these varying characters have a wide range in each locality, so far as our material permits observation, and thus there is considerable overlap between localities. Some of the most conspicuous differences are as follows:

In two Palau female specimens examined, the antennal ratio (1.17) was high, and sensilla coeloconica were present on segments 3-9,11-14, and the palpus had a subdivided pit. Tokunaga and Murachi (1959) also figure the male parameres with a much shorter area of fusion for the Palaus. In Philippine material described by Delfinado (1961) as *ejercitoi*, the antennal ratio is high [1.15 (1.12-1.17, n = 5)] and the sensilla are always found on segments 3-14. Specimens from Labuan Island, Sabah, most closely resemble the Philippine material but with greater variation. Material from Pulau Panjang, Thailand, had a consistently low antennal ratio, 1.00-1.08, and sensilla consistently lacking on segments 4-6, 10, and 15, and usually only 11-12 mandibular teeth.

Culicoides pongsomiensis Chu

Culicoides pongsomiensis Chu, 1986: 259 (female; Cambodia; figs.).

Distribution.--Cambodia (coastal).

Type.--Holotype female, Kompong Som, coastal region, Cambodia, 2.iv.1976 (deposited in Department of Parasitology, Second Military Medical College, Shanghai, China).

Note.--This species is nearly identical, if not the same, with *Culicoides peliliouensis* Tokunaga, a common mangrove species throughout the Southwest Pacific. Only minor differences in measurements separate them, along with the pale halter and basal pale tibial bands in *C. pongsomiensis*. Numerical characters of *pongsomiensis* (from the original description) are: Wing length 1.16 mm; costal ratio 0.64. Antennal ratio 1.16, sensilla coeloconica present on segments 3-14. Palpal ratio 2.6, third segment with scattered sensilla. P/H Ratio 0.70; mandible with 14 teeth. Tibial comb with 4 setae. Spermathecae ovoid, with short neck,subequal, measuring 0.058 x 0.039 mm. The wing pattern of *pongsomiensis* is indistinguishable from that of *peliliouensis*.

Culicoides quatei Wirth and Hubert, new species
(Figs. 147, 311, 447)

Female.--Wing length 0.80 (0.75-0.84, n = 10) mm.

Head: Eyes bare, nearly contiguous, with a narrow wedge-shaped space. Antenna (fig. 147a) with lengths of flagellar segments in proportion of 16-11-12-13-13-13-13-14-21-22-23-25-34, antennal ratio 1.19 (1.17-1.22, n = 9); sensilla coeloconica present on segments 3-14, tufts long and prominent. Palpus (fig. 147b) with lengths in proportion of 9-16-23-8-10; third segment moderately swollen distally, with a small deep round sensory pit; palpal ratio 1.9 (1.7-2.0, n = 9). Proboscis moderately short, P/H Ratio 0.76; mandible with 13 (12-16, n = 17) teeth.

Thorax: Brown; mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 147c) pale brown; knee spots darker, bases of femora paler, tibiae with narrow sub-basal pale rings; hindtibial comb (fig. 147e) with 4 spines, the one nearest the spur longest.

Wing (fig. 311, 447): Pattern as figured; pale spots distinct and moderately small; pale spot over r-m crossvein half as broad as dark area distal to it, extending from vein M to costal margin; stigmal spot prominent, extending to tip of second radial cell; 2 separate poststigmatic pale spots in cell R5, the posterior one located obliquely proximad of the other behind second radial cell; distal pale spot in cell R5 more or less round, not meeting anterior margin of wing and lacking by its own diameter of extending to distal wing margin; 2 elongate pale spots in cell M1, distal one usually failing considerably to meet distal wing margin; a pale spot over base of medial stem near basal arculus and one straddling midlength of mediocubital stem; cell M2 otherwise dark at base, a small pale spot behind

medial fork, none in front of mediocubital fork, a small subapical pale spot past level of mediocubital fork, distal pale spot in cell M2 extending faintly to wing margin; cell M4 with a round pale spot in middle, extending very faintly to wing margin; anal cell with a distinct round pale spot anteriorly in distal portion with a more or less distinct pale area on wing margin posterior to it and a small pale spot in basal portion of cell; tips of veins not pale. Macrotrichia moderately numerous on distal 2/3 of wing and in anal cell; costal ratio 0.63 (0.60-0.64, n = 10); second radial cell broad to tip, with distinct lumen. Halter pale.

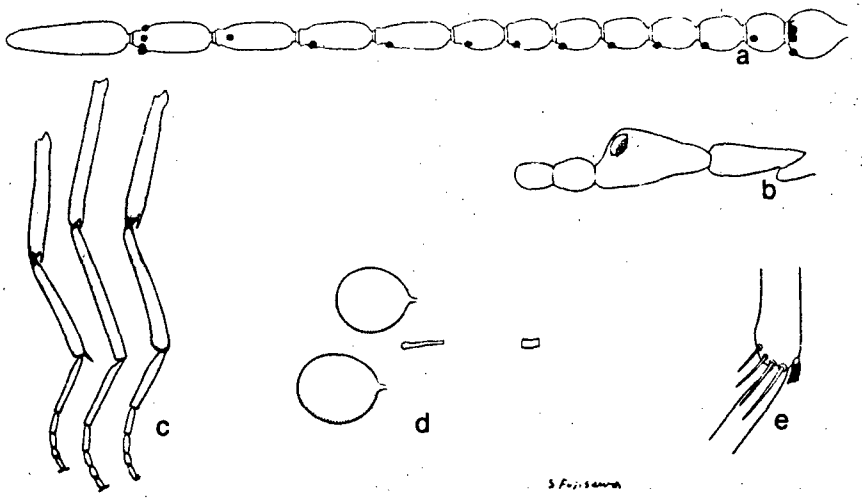


Fig. 147. *Culicoides quatei*: a. antenna; b. palpus; c. legs; d. spermathecae: e. tibial comb.

Abdomen: Pale brown. Spermathecae (fig. 147d) small, subequal, each 0.051 x 0.037 mm; oval with extremely slender, short, sclerotized necks; vestigial third spermatheca and sclerotized ring present.

Male.--Unknown.

Distribution.--Indonesia, Malaysia, Sabah, Sarawak.

Types.--Holotype female, Malaysia, Selangor, Rantau Panjang, 5 mi N Klang, 26-30.xiii.1958, L.W. Quate (Type in USNM). Paratypes, 87 females, as follows:
INDONESIA: Sumatra, Riau, Bintan Utara, Tanjan Uban, 28.xii.1977, D. Pletsch, 2 females.

MALAYSIA: Same data as type, 10 females; same data but collected 18.vii.1958, R. Traub, light trap, 6 females; same but ix-xii.1959, H.E. McClure, light trap, 20 females; same but 27.i.1961, Y.B. Pundat, biting man, 14 females. Selangor, Klang, Carey Island, 16.i.1968, in monkey bait-trap 16 m in tree canopy in rubber estate, R. Garcia, 27 females; Tg. Karang, 28.iii.1961, R.H. Wharton, biting man, 5 females. Kedah, Langkaw Island, 19.vii.1958, R. Traub, light trap, 2 females. Pahang, Kuantan, Telok Sisek, 7.x.1959, R.H. Wharton, biting man, 1 female.

SABAH: Labuan Island, ix-x.1948, D.H. Colless, at light, 1 female.

SARAWAK: Gayah, 14.iv.1967, M. Maffi, 4 females. Miri, xi.1949, D.H. Colless, biting man, 1 female.

Discussion.--This species is named in honor of Dr. Laurence W. Quate, formerly of the B.P. Bishop Museum in Honolulu, in recognition of his generous assistance in collecting ceratopogonids for our project during his travels in Southeast Asia.

This species is closely related to *C. damnosus* Delfinado, another anthropophilic seacoast species, but *damnosus* can be separated by its greater antennal ratio (1.34), dark halter and reduction of the distal wing spots with only one pale spot present distally in the anal cell. *Culicoides hewitti* Causey is also very similar, but has dark halteres, antennal ratio of only 1.11, and very differently shaped, pyriform spermathecae.

Shermani Group

Diagnosis.--Medium size to large species with hairy wings, usually with distinct pale spots. Eyes bare, contiguous to broadly separated. Antenna with distal segments elongated, antennal ratio 0.94-1.53, sensilla coeloconica usually present on segments 3,11-15 and sometimes also on proximal series; segment 15 frequently lacks sensilla. Third palpal segment usually broadly swollen, with a deep pit opening by a smaller pore. Mandible with 11-17 fine teeth. Legs usually dark, bases of tibiae with pale rings, sometimes femora with subapical pale rings, tibiae seldom pale distally; hindtibial comb with 4 spines, the one nearest the spur longest. Wing with costa moderately long, costal ratio 0.56-0.66, second radial cell usually moderately broad with distinct lumen; macrotrichia long and numerous; pale spots usually very distinct, spots in distal or midportion of wing often reduced, usually prominent toward apices of cells when present at all; rarely straddling vein M1 or M2; pale spot over r-m crossvein centers on the crossvein. Spermathecae 2, usually oval to slightly tapered to slender neck which is seldom sclerotized a great distance; vestigial third spermatheca and usually sclerotized ring present. Male genitalia with ventral root of basistyle not foot-shaped, simple and usually elongate; dististyle slender and pointed at tip; ninth tergum usually broad and transverse caudally, with long slender apicolateral processes; aedeagus usually with well-developed basal arch and simple distal process; parameres separate, usually with well-developed basal arm directed laterad or anterolaterad, basal knob usually not very large, stem usually slender and simple without ventral lobe, tip elongate, simple and sharp pointed.

Included Species.--Fourteen Oriental species: *bigeminus* n. sp., *dryadeus* Wirth and Hubert, *geminus* Macfie, *kelantanensis* n. sp., *kepongensis* n. sp., *macclurei* n. sp., *marginatus* Delfinado, *minipalpis* n. sp., *nigripes* n. sp., *selangorensis* n. sp., *shermani* Bausey, *siamensis* n. sp., *thurmanae* n. sp., and *wenzeli* Delfinado. Boorman and Dipeolu (1979) place the following Nigerian species in the Neavei Group, which replaces this group in Africa: *bwambanus* de Meillon, *citroneus* Carter, Intram and Macfie, *neavei* Austen, *ovalis* Khamala and Kettle, *vomensis* Boorman and Dipeolu, and *yankari* Boorman and Dipeolu. *Culicoides mackerrasi* Lee and Reye from Australia also falls here.

Biology.--Two species, *geminus* and *kepongensis*, have been reared from stream margins or buffalo wallows; three species, *dryadeus*, *macclurei*, and *selangorensis*, from tree holes. The biology of the Australian species *mackerrasi* from tree holes was reported by Dyce and Murray (1967).

Culicoides bigeminus Wirth and Hubert, new species
(Figs. 148, 312, 448)

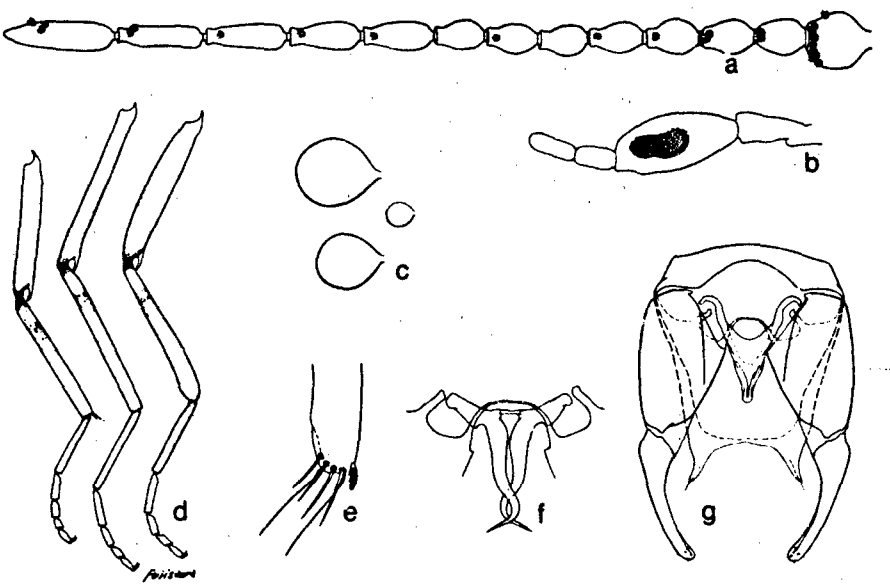


Fig. 148. *Culicoides bigeminus*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Female.--Wing length 0.90 (0.84-0.99, n = 8) mm.

Head: Eyes bare, nearly contiguous, slightly separated above by a narrow wedge-shaped space. Antenna (fig. 148a) with lengths of flagellar segments in proportion of 19-14-16-16-17-16-16-16-23-23-26-27-36, antennal ratio 1.01 (0.98-1.04, n = 7); sensilla coeloconica present on segments 3-9,11-14. Palpus (fig. 148b) with lengths of segments in proportion of 12-18-40-12-15; third segment swollen to base, spindle-shaped, with a very deep sensory pit opening by slightly smaller, oval pore; palpal ratio 2.3. Proboscis moderately short, P/H Ratio 0.74; mandible with 15 (15-18, n = 8) teeth.

Thorax: Dark brown; mesonotal pattern not evident in slide-mounted specimen. Legs (fig. 148d) dark brown; femora pale at extreme bases, hindfemur obscurely pale near apex; knee spots blackish; tibiae with distinct sub-basal pale rings; hindtibial comb (fig. 148e) with 4 spines, the one nearest the spur usually longest.

Wing (fig. 312, 448): Pattern as figured; deeply infuscated, especially along anterior margin and in a broad anterior area distad of poststigmatic pale spots; pale spot at basal arculus; pale spot over r-m crossvein extending from radius slightly overlapping media, a separate small pale spot on costa separated from that spot by a darkened area; a small round poststigmatic pale spot just past end of costa, straight behind this spot a double spot straddling vein M1; a small subapical pale spot in cell R5 midway between anterior margin and vein M1; cell M1 with narrow pale spot at extreme base and an oval pale spot near apex of cell; vein M2 with a double pale spot straddling midsection; cell M2 with an elongate pale spot lying immediately behind medial fork, a smaller pale spot lying just proximad and behind this spot; a small elongate pale spot lying immediately in front of and slightly distad of point of mediocubital fork, and a larger rounded pale spot near but well separated from wing margin; cell M4 with a round pale spot in subapical portion not meeting wing margin; anal cell with a large pale spot lying over midportion of anal vein and a larger, irregular one in distal portion of cell. Macrotrichia long and numerous, extending to base of cell M2 and anal cell; costal ratio 0.57 (0.55-0.58, n = 8); second radial cell long and moderately broad, with distinct lumen. Halter deeply infuscated.

Abdomen: Brown. Spermathecae (fig. 148c) subspherical with distinctly tapering necks, small and unequal, 0.047 x 0.039 mm and 0.038 x 0.032 mm; vestigial third spermatheca present, sclerotized ring absent.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 148g): Ninth sternum with broad shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum moderately broad distad, with large triangular apicolateral processes, caudal margin between them concave. Basistyle with ventral and dorsal roots simple, subequal, moderately long and slender; dististyle slender and slightly curved to bluntly pointed tip. Aedeagus with basal arch extending to only a fourth of total length, basal arms short; main portion triangular, tapering regularly to slender, rounded tip. Parameres (fig. 148f) joined at bases with a slender hyaline bridge; each with short anterolaterally directed basal arm; stem moderately stout at base, slightly sinuate, tapering to slender, simple point abruptly bent ventrad and mesad.

Distribution.--Malaysia, Thailand.

Types.--Holotype female, allotype male, Malaysia, Selangor, Kuala Lumpur, viii.1958, R. Traub, light trap (Type in USNM). Paratypes, 8 females, as follows:
MALAYSIA: Same data as types, 4 females.
THAILAND: Chiang Mai, iv-v.1958, V. Notananda, light trap, 4 females.

Discussion.--This species can readily be distinguished by the numerous distinct small pale wing spots, with two double pale spots straddling veins M1 and M2. The sensory pattern is identical with that of the closely related *shermani* Causey, while *selangorensis* n. sp. has a similar wing pattern but without the pale spot straddling vein M1.

Culicoides dryadeus Wirth and Hubert
(Figs. 149, 313, 449)

Culicoides dryadeus Wirth and Hubert, 1972: 41 (male, female; Malaysia; figs.).

Female.--Wing length 0.97 mm.
Head: Eyes very narrowly separated, bare. Antenna (fig. 149a) with lengths of flagellar segments in proportion of 20-15-15-16-15-16-16-19-23-24-24-25-28, antennal ratio 0.95; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 149b) with lengths of segments in proportion of 13-33-35-14-10; third segment moderately swollen subapically, with a small, round, shallow, subapical sensory pit; palpal ratio 2.5. Proboscis moderately long, P/H Ratio 0.80; mandible with 15 teeth.
Thorax: Dark brown, without apparent pattern in slide-mounted specimen. Legs (fig. 149d) dark brown, femora slightly paler at bases; femora with faint subapical pale rings, tibiae with distinct sub-basal pale rings; knee spots blackish; hindtibial comb (fig. 149e) with 4 spines, the one nearest the spur longest.
Wing (fig. 313, 449): Pattern as figured; intensely dark gray infuscated, even more so in region between radius and costa; with four prominent yellowish spots, a fairly large transverse one over r-m crossvein not quite reaching costa or vein M, a very small round one on anterior margin just distad of second radial cell, a small transverse one straddling base of media a third-way between basal arculus and r-m crossvein, and a large transverse one straddling mediocubital stem not quite halfway to its fork, the latter spot sometimes broken into two spots, over mediocubital stem and over anal vein, or absent (in one paratype); faint pale spots also usually present in cell M4 and distally in anal cell. Macrotrichia very long and abundant, reaching to base of cell M2 and anal cell abundantly; costal ratio 0.58; second radial cell moderately broad, with distinct lumen. Halter deeply infuscated.
Abdomen: Brown. Spermathecae (fig. 149c) ovoid with slight taper to very short, slender, sclerotized necks; subequal, each 0.058 x 0.044 mm; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 149g): Ninth sternum with broad, shallow, caudomedian excavation, ventral membrane not spiculate; ninth tergum moderately long and tapered, caudal margin transverse with a pair of very long, slender, slightly flaring, apicolateral processes.

Basistyle with ventral root very slender, moderately long, dorsal root longer and stouter; dististyle moderately slender, nearly straight, with bent, bluntly pointed tip. Aedeagus with basal arch extending to about 1/3 total length, basal arms stout, nearly straight with ends abruptly bent caudolaterad, main portion tapering to broad distal tip with three small teeth. Parameres (fig. 149f) each with short, laterally directed basal arm with enlarged basal knob; stem moderately swollen a short way at base, tapering distally and straight in midportion, with fine pointed apex abruptly bent laterad and then ventrad.

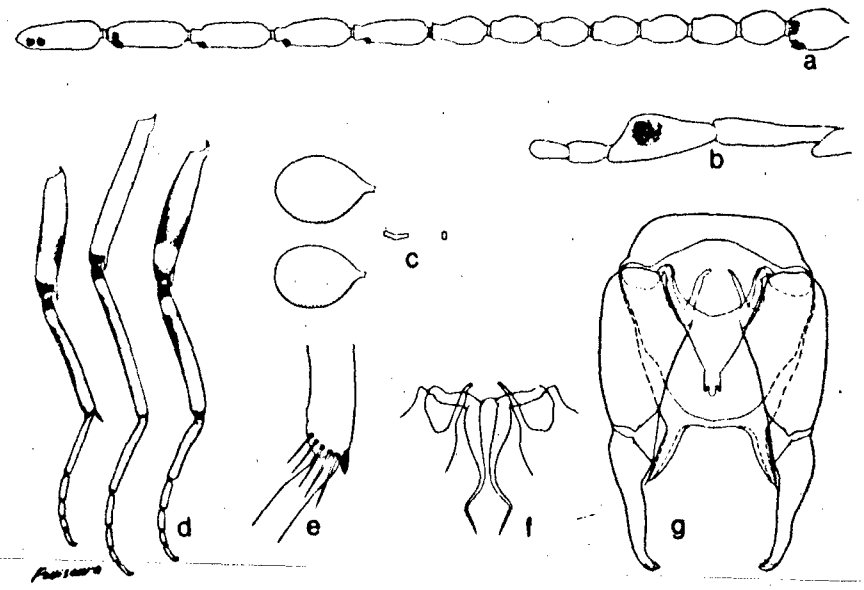


Fig. 149. *Culicoides dryadeus*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Distribution.--India, Malaysia, Sarawak, Sumatra, Thailand.

Type.--Holotype female, Malaysia, Selangor, Ampang Forest Reseve, 20.ix.1960, C. Manikumar, reared from soil in tree hole (Type in USNM).

Southeast Asia Records.--
MALAYSIA: Selangor, Ampang Forest Reserve (Manikumar, types); Gombak Forest Res., reared from tree hole 42 m in jungle canopy; Subang Forest Reserve, reared from tree hole (Manikumar).

SARAWAK: Matang (Maa and Gressitt).
SUMATRA: Kong Ke (Fairchild).
THAILAND: Chiang Mai Prov. (Notananda, Scanlon).

Discussion.--This species is easily recognized by the wing pattern, intensely infuscated with three or four very distinct pale spots on the anterior and proximal portions, and the shallow, round palpal pit.

Alan Dyce has recently called our attention to the close similarity between *dryadeus* and the widespread Subsaharan species *C. punctithorax* Carter, Ingram and Macfie. A close comparison with the detailed descriptions of *punctithorax* by Khamala and Kettle (1971) and Boorman and Dipeolu (1979) yields few characters to separate the species, but the broad shallow palpal pit of *C. dryadeus* is significantly distinct from the small deep pit of *punctithorax*. We cannot distinguish any prominent dark mesonotal punctations in our slide preparations of *dryadeus*, but our slides are not suitable for an accurate observation. The wing pattern, antennal sensillar pattern, and the male genitalia of the two species are indistinguishable, but additional material of both species should be examined critically for these characters. According to Dyce (in litt.) there are numerous examples of similar "paired species" or "sister species" in the Oriental and Subsaharan *Culicoides* faunas. Whether to call them distinct species or subspecies is rather an academic question; we view that the more parsimonious assumption is to view them as full species.

Culicoides geminus Macfie
(Figs. 150, 314, 450)

Culicoides geminus Macfie, 1937b: 472 (female; Malaysia); Howarth, 1985: 76 (pupa descr.; figs.; Laos).
Culicoides bifasciatus Tokunaga, 1951: 104 (male, female; Java; fig. wing, male genitalia). NEW SYNONYMY.

Female.--Wing length 0.93 (0.86-1.00, n = 12) mm.

Head: Eyes broadly separated, bare. Antenna (fig. 150a) with lengths of flagellar segments in proportion of 17-11-11-12-13-12-12-13-19-20-22-24-32, antennal ratio 1.15 (1.07-1.21, n = 10); sensilla coeloconica present on segments 3,11-14 (rarely absent on 12), single on distal segments. Palpus (fig. 150b) with lengths of segments in proportion of 10-17-23-10-14; third segment moderately swollen with sensilla borne in a shallow, irregular sensory area on constricted distal half of segment; palpal ratio 2.0 (1.8-2.2, n = 11). Proboscis relatively short, P/H Ratio 0.70; mandible with 12 (11-13, n = 25) teeth.

Thorax: Dark brown, mesonotal pattern as in fig. 150d. Legs (fig. 150e) pale brown; femora broadly pale at bases; forefemur with subapical and all tibiae with indistinct sub-basal, narrow pale rings; hindtibial comb (fig. 150c) with 4 (n = 12) spines, the one nearest the spur longest.

Wing (fig. 314, 450): Pattern as figured, markings faint and poorly defined; moderately dark spot over radial cells; moderately large pale spot over r-m crossvein extending to costal margin; one transverse poststigmatic pale spot in cell R5 not extending to vein M1; cell R5 with round pale spot at extreme tip of

cell; 2 pale spots in cell M1, distal one meeting wing margin; cell M2 with pale area at base, large pale spot behind medial fork, no pale spot in front of mediocubital fork, 2 pale spots distal to mediocubital fork, distal one meeting wing margin; cell M4 with round pale spot meeting posterior wing margin; anal cell with large pale area at base of cell and 2, more or less fused, pale spots in distal portion of cell; no pale spots at ends of veins. Macrotrichia sparse on distal half of wing with a few extending proximad in anal cell; costal ratio 0.60 (0.53-0.61, n = 12); second radial cell moderately large, with distinct lumen. Halter infuscated.

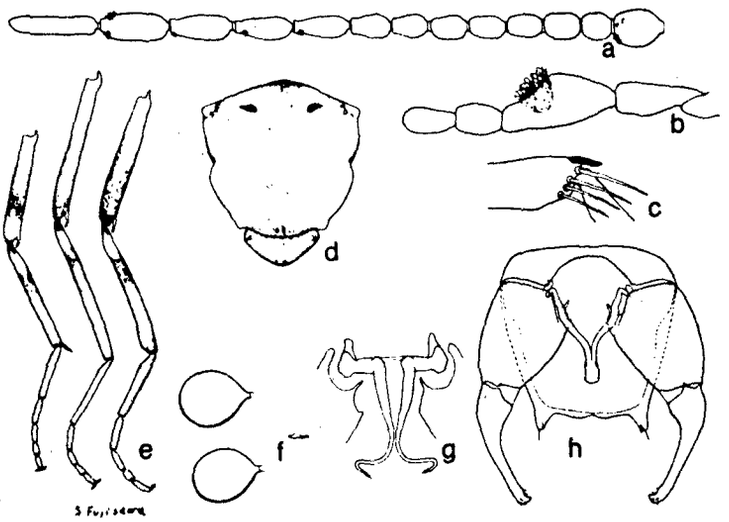


Fig. 150. *Culicoides geminus*: a. antenna; b. palpus; c. tibial comb; d. thoracic pattern; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Abdomen: Brown. Spermathecae (fig. 150f) oval to slightly pyriform with very short, slender, sclerotized necks; very slightly unequal, 0.046 x 0.037 mm and 0.043 x 0.034 mm; vestigial third spermatheca present, sclerotized ring absent.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 150h): Ninth sternum with distinct, rounded caudomedian excavation, ventral membrane not spiculate; ninth tergum short and only slightly tapering to widely spaced, short, pointed apicolateral processes, caudal margin between them transverse. Basistyle with ventral root poorly developed, short and pointed, dorsal root much longer and blunt distally; dististyle slender, nearly straight distally, with bent, bluntly pointed tip. Aedeagus Y-shaped, basal arch extending to 0.6 of total length, basal arms rather stout and only slightly curved, their juncture forming an acute angle; distal process short, slightly expanded distally in a spoon-shaped tip.

Parameres (fig. 150g) each with well sclerotized basal arm abruptly bent laterad from base of stem, with round, expanded, basal knob; stem only slightly swollen on basal half, straight, tapering distally to very fine, simple, filamentous tip abruptly bent laterad and then ventrad.

Distribution.--Indonesia, Laos, Malaysia, Thailand, Vietnam.

Types.--Two female syntypes, Kuala Lumpur, Malaysia, 1937, J.J. Buckley (BMNH). Syntypes of *bifasciatus*, numerous males, females in alcohol, Batavia, Java, xii.1944, M. Tokunaga (Entomological Laboratory, Saikyo Univ., Kyoto, Japan).

Southeast Asia Records.--

INDONESIA: Bali, Badung, Kuta, Jimbaran Carik (Lee); Pedang Bay, 35 km NE Denpasar (Nicholls). Flores, Manggarai, Lake Sano at Nunang Mission (Lee); Manggarai, Reo, Robek (Lee). Java, Batavia (Tokunaga); Bogor (Adiwinata); Jakarta Utara, Pulau Putri (Lee); West Java, Serang, Anyer Beach Hotel (Lee). Sulawesi, Bulu Kumba (Pletsch). Sumatra, Bengkulu, Pekik Nyaring (Mathis). Sumbawa (Nicholls).

LAOS: Sayaboury Prov., Muong Sayaboury (Howarth). Sedone Prov., Muong Pakse (Howarth).

MALAYSIA: Negri Sembilan, Pekan Lama (Garcia). Pahang, Ulu Gali, cattle shed (Garcia). Selangor, Kuala Lumpur (Barnett, Traub) (Traub, biting man).

THAILAND: Bangkok (Causey). Cholburi Prov., Amphoe Bang Phra (Scanlon). Loei Prov., A. Muang (Manop R.). Nakhon Phanom Prov., A. Muang (Manop R.). Nakhon Ratchasima Prov., A. Muang and Pak Chong (Manop R.). Samuthprakan Prov. (Manop R.). Chiang Mai Prov., A. Chom Thong, Wang Nam Yard (Yasumatsu). Mae Sariang Prov., A. Mae Hong Son (Yasumatsu).

VIETNAM: Da Nang (Hicks).

Discussion.--This species was quite common in the light trap collections from Kuala Lumpur, but is less common elsewhere. The description of the male is from Kuala Lumpur material. Tokunaga's description and wing figure of *bifasciatus* fits *geminus* very well, and the differences shown in the apices of the male parameres may be due to an improper slide mount.

Biology.--Howarth (1985) in Laos reared *C. geminus* twice from sunny buffalo wallow margins and once from a partly shaded stream margin; all sites were in or near rice paddies.

Culicoides jefferyi Kitaoka
(Fig. 151)

Culicoides jefferyi Kitaoka, 1983: 22 (male, female; Malaysia; fig. wing, antenna, palpus, spermathecae, male genitalia).

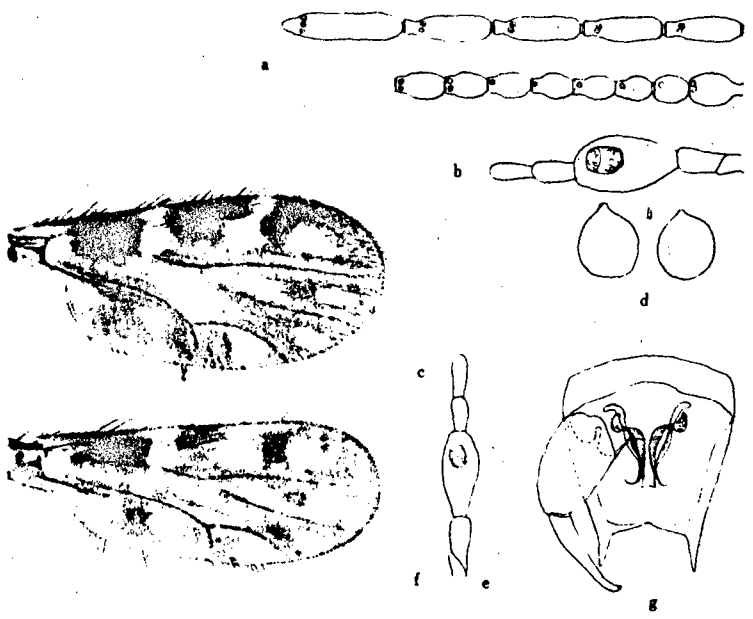


Fig. 151. *Culicoides jefferyi*: a-d. female; e-g. male; a. antenna; b,e. palpus; c,f. wing; d. spermathecae; g. genitalia (from Kitaoka 1983).

Diagnosis.--Female wing length 1.00 mm; costal ratio 0.54. Closely related to *Culicoides selangorensis* in the Shermani Group; like that species with the distal pale spot in cell R5 well removed from tip of cell, but differing in the lack of a pale spot straddling vein M2 (fig. 151c). Eyes narrowly separated, bare. Antennal ratio 1.20; sensilla coeloconica present on segments 3-15 (fig. 151a). Third palpal segment broadly swollen, palpal ratio 1.8, sensory pit wide and deep, 1/3 length of segment, opening by a smaller pore (fig. 151b). Proboscis short, P/H ratio 0.52; mandible with 10 teeth. Thorax brown; mesonotal pattern not evident. Legs brown, all tibiae with pale sub-basal bands; mid- and hindtibiae with slightly pale apical portion; hindtibial comb with 4 spines, second from spur longest. Spermathecae (fig. 151d) ovoid, slightly tapering to slender neck, 0.050 x 0.042 mm and 0.043 x 0.039 mm, vestigial third present, ring absent. Male genitalia (fig. 151g) short and tapering, apicolateral processes of ninth tergum long and slender, aedeagus with high basal arch, distal process narrow with parallel sides distally, tip truncate; parameres separate, anterolateral processes knoblike, distal portion short, tapering to slender pointed tip.

Type.--Holotype female, Gunong Besout, Perak, 23.v.1973, staff of ARU (deposited in National Science Museum, Tokyo, Japan).

Culicoides kelantanensis Wirth and Hubert, new species
(Figs. 152, 315, 451)

Female.--Wing length 1.06 mm.

Head: Eyes (fig. 152d) bare, narrowly separated. Antenna (fig. 152a) with lengths of flagellar segments in proportion of 25-17-18-18-18-18-20-21-33-37-40-40-48, antennal ratio 1.15; sensilla coeloconica present on segments 3-5,11-15. Palpus (fig. 152b) with lengths in proportion of 12-28-60-16-18; third segment greatly enlarged, swollen to base, with a deep pit opening by a slightly smaller, round pore; palpal ratio 2.3. Proboscis moderately long, P/H Ratio 0.92; mandible with 16 teeth.

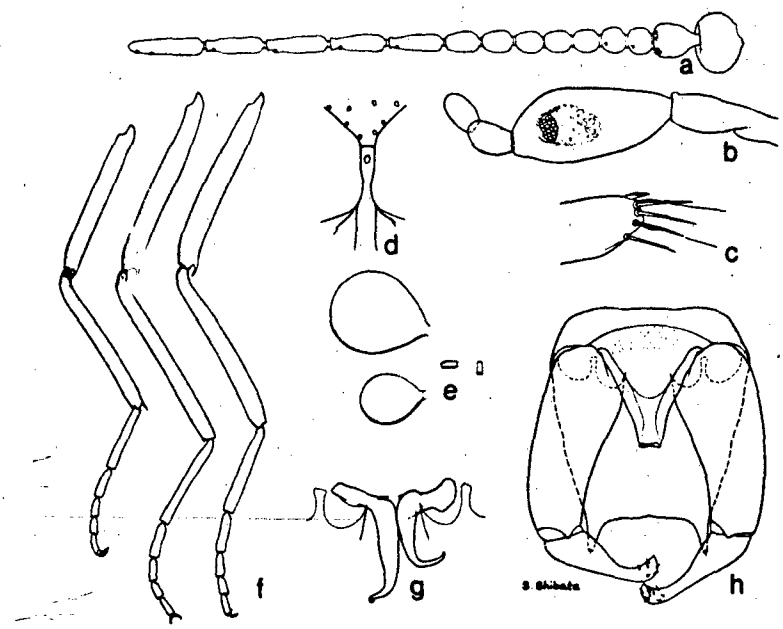


Fig. 152. *Culicoides kelantanensis*: a. antenna; b. palpus; c. tibial comb; d. eye separation; e. spermathecae; f. legs; g. parameres; h. male genitalia, parameres omitted.

Thorax: Brownish; mesonotum with faint pattern of large pale and dark patches as seen in slide-mounted specimen. Legs (fig. 152f) pale brown, knee spots blackish; tibiae with very faint, narrow, sub-basal pale rings; hindtibial comb (fig. 152c) with 4 spines, the second from the spur longest.

Wing (fig. 315, 451): Pattern as figured; moderately infuscated, with moderately distinct pattern of pale spots; stigma slightly darker, extending to tip of second radial cell; pale spot over r-m crossvein large, extending from costal margin slightly past level of medial stem; a double poststigmatic pale spot in cell R5, the posterior portion lying nearly entirely proximad of the other and behind second radial cell, distal pale spot in cell R5 small and longitudinally oval, failing by its own breadth to meet wing margin; veins M1 and M2 each with large pale spot straddling midportion, that on vein M2 slightly distad of level of the other; cell M1 with small oval pale spot nearly meeting wing margin; cell M2 with pale streak at base extending from pale spot covering base of media to level of mediocubital fork, a small round pale spot in cell M2 nearly meeting wing margin; cell M4 with large pale spot nearly filling distal portion of cell and meeting wing margin broadly; anal cell with pale area at base continuous with pale area over base of media, one moderately large round pale spot in anterior part of distal portion; tips of veins not pale. Macrotrichia numerous and moderately coarse, extending to base of wing in cell M2 and anal cell; costal ratio 0.59; second radial cell moderately broad with distinct lumen. Halter pale.

Abdomen: Pale brown. Spermathecae (fig. 152e) ovoid without sclerotized necks, very unequal, 0.050 x 0.044 mm and 0.032 x 0.036 mm; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 152h): Ninth sternum with broad, shallow caudomedian excavation, ventral membrane spiculate; ninth tergum long and slightly tapering, with long, slender, pointed apicolateral processes, caudal margin between them nearly straight. Basistyle with ventral root small and pointed, dorsal root longer and stouter; dististyle stout and nearly straight near base, slender distally with bent, pointed tip. Aedeagus with basal arch extending to 0.6 of total length, basal arms nearly straight; distal portion stout and tapering to broad truncated tip. Parameres (fig. 152g) each with basal process directed laterad with distinct basal knob, stem moderately swollen at base, straight in midportion, tapering gradually distally and twisted laterad and ventrad to slender, simple distal point.

Distribution.--Malaysia.

Types.--Holotype female, allotype male, Malaysia, Kelantan, Ulu Kelantan, Lambok, Sungei Betis, 9.xi.1961, R.H. Wharton, light trap (Type in USNM).

Discussion.--This species is one of the few Oriental species with large, distinct pale spots straddling the midportion veins M1 and M2 of the wing. It falls into the Shermani Group on the basis of palpal structure, antennal sensory pattern, and structure of the male genitalia, where it keys out along with *bigeminus* n. sp.

Culicoides bigeminus is a much darker species with dark halteres, blackish legs with distinct pale rings, and very small and discrete pale wing spots on a very dark background.

Culicoides kepongensis Wirth and Hubert, new species
(Figs. 153, 316, 452)

Culicoides sp. H; Howarth, 1985: 79 (Laos records).

Female.--Wing length 0.89 mm.

Head: Eyes bare; nearly contiguous, almost meeting on midline. Antenna (fig. 153a) with lengths of flagellar segments in proportion of 18-14-15-16-16-15-16-17-25-25-25-26-38, antennal ratio 1.09; sensilla coeloconica present on segments 3,13-15. Palpus (fig. 153b) with lengths of segments in proportion of 9-20-21-9-10; third segment short and only slightly swollen on proximal portion, with a small round shallow sensory pit; palpal ratio 2.3. Proboscis short, P/H Ratio 0.63; mandible with 13 teeth.

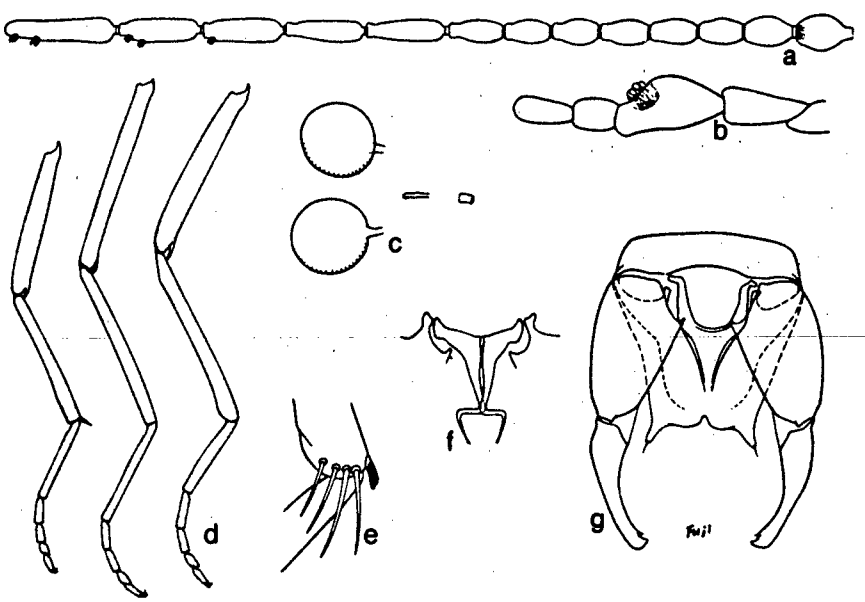


Fig. 153. *Culicoides kepongensis*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Thorax: Dark brown; mesonotum without prominent pattern. Legs (fig. 153d) brown, tibiae with narrow basal pale rings; hindtibial comb (fig. 153e) with 4 spines, the second from the spur longest.

Wing (fig. 316, 452): Pattern as figured; deeply infuscated, with small, indistinct pale spots; pale spot over r-m crossvein extending forward to meet costal margin broadly and behind to just past media; poststigmatic pale spot in cell R5 small, round, proximal half covering distal half of second radial cell, extending caudad only halfway to vein M1; a small, more or less round pale spot at extreme apex of cell R5, broadly meeting wing margin; cell M1 with indistinct oval pale spot in proximal portion and a small round definite pale spot at wing margin in tip of cell; cell M2 with an indistinct pale streak lying behind proximal half of vein M1, and a small pale spot at wing margin in tip of cell; cell M4 with a moderately large, rounded, pale spot in distal half of cell; anal cell with a small pale spot in anterobasal corner and a pale spot in distal part of cell. Macrotrichia sparse, confined to distal fourth of wing; costal ratio 0.68; radial cells with distinct lumen, the second especially large. Halter infuscated.

Abdomen: Brown. Spermathecae (fig. 153c) subspherical with long, slender, tubular sclerotized necks; subequal, each 0.058 x 0.054 mm; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 153g): Ninth sternum with shallow caudomedian excavation, ventral membrane bare; ninth tergum short and slightly tapering to short, pointed, apicolateral processes, caudal margin between them slightly cleft. Basistyle without ventral root, dorsal root short and slender; dististyle slightly curved, slender distally, with slight distomesal point. Aedeagus with basal arch broad and rounded, extending 1/2 of total length; distal process tapering to slender rounded tip. Parameres (fig. 153f) each with short basal arm extending laterad and bearing a short anterior process; contiguous midportions moderately stout basally, tapering distally, distal portion abruptly bent laterad, then ventrocaudad, and tapering to simple filamentous point.

Distribution.--Laos, Malaysia, Thailand.

Types.--Holotype female, allotype male, Malaysia, Selangor, Kepong, 27.xii.1958, L.W. Quate, light trap (in B.P. Bishop Museum). Paratypes, 7 females, as follows:

LAOS: Sayaboury Prov., Sayaboury, 30.xi.1967, F.G. Howarth, at light, 1 female; 22 km S Muong Phieng, Nam Poui River margin, F.G. Howarth, light trap, 1 female.

MALAYSIA: Same data as types, 1 female. Trangganu, Dungun, Bukit Besi, 6.viii.1958, R. Traub, light trap, 1 female.

THAILAND: Loei Prov., Amphoe, Dan Sai, Koksato, 27.xi.1957, R.E. Elbel, 1 female; Pangmakampon, near Fang, 450 m, 16.xi.1957, J.L. Gressitt, light trap, 1 female.

Discussion.--This species is readily distinguished from the other members of the Shermani Group by its reduced wing pattern in which the poststigmatic pale spot in cell R5 covers the distal half of the second radial cell, and by the reduced antennal sensilla coeloconica and small third palpal segment with small shallow pit.

Culicoides macclurei Wirth and Hubert, new species
(Figs. 154, 317, 453)

Female.--Wing length 1.08 mm.

Head: Eyes bare; nearly contiguous, separated along upper portion by a narrow wedge-shaped space bearing a seta-less tubercle. Antenna (fig. 154a) with lengths of flagellar segments in proportion of 35-30-30-30-30-30-30-30-43-43-50-50-60, antennal ratio 1.01; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 154b) with lengths of segments in proportion of 10-35-45-18-18; third segment moderately swollen on distal portion, with a round, moderately large, and deep sensory pit opening by a slightly smaller pore; palpal ratio 2.3. Proboscis moderately short, P/H Ratio 0.68; mandible with 13 teeth.

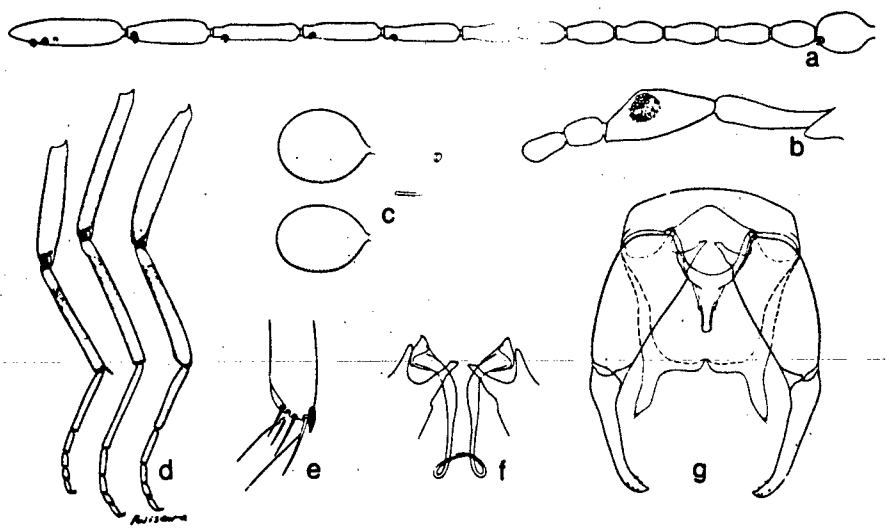


Fig. 154. *Culicoides macclurei*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Thorax: Brown; mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 154d) moderately brown, knee spots blackish, tibiae with prominent narrow sub-basal pale rings; hindtibial comb (fig. 154e) with 4 spines, the one nearest the spur longest.

Wing (fig. 317, 453): Pattern as figured; moderately infuscated, darker along anterior margin, second radial cell moderately darker; a pale spot at basal arculus; a small pale spot over r-m crossvein, not extending past radius nor media; a double, narrowly transverse, poststigmatic pale spot past end of costa extending caudad a little over halfway to vein M1; an indistinct small round pale spot at apex of cell R5 just short of wing margin; cell M1 with 1 faint round pale spot near apex; cell M2 with an elongate pale spot or streak just behind medial fork and a small round pale spot near apex; cell M4 with a small round pale spot in distal portion; anal cell with a pale streak near base and a small transverse pale spot in distal portion. Macrotrichia long and moderately numerous, extending to base of wing in cell M2 and anal cell; costal ratio 0.66; second radial cell long and moderately broad, with distinct lumen. Halter deeply infuscated.

Abdomen: Brown. Spermathecae (fig. 154c) oval, slightly tapering to duct, without sclerotized necks; subequal, each 0.064 x 0.048 mm; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 154g): Ninth sternum with moderately broad and deep caudomedian excavation, ventral membrane not spiculate; ninth tergum moderately long and broad, apicolateral processes very long, moderately slender and pointed, the caudal margin between them slightly convex with distinct median cleft. Basistyle with ventral and dorsal roots moderately long and slender, about equally developed; dististyle slender distally, slightly curved distad to pointed tip. Aedeagus with basal arch high and rounded, extending to 0.7 of total length, basal arms slender and curved; distal process short and tapered to slender, rounded tip. Parameres (fig. 154f) each with basal portion curving anterolaterad to moderately strong basal knob; midportion slender and simple, almost straight, abruptly bent subapically, first ventrad and then mesad, ending in simple filamentous tip.

Distribution.--Indonesia, Malaysia.

Types.--Holotype female, allotype male, Malaysia, Selangor, Nee Gombak Forest Reserve, 20 mi N Kuala Lumpur, 11.iii.1961, H.E. McClure, reared from tree hole 42 m high in jungle canopy (Type in USNM). Paratypes, 1 male, 6 females, same data as types.

INDONESIA: South Kalimantan, Banjar, Tanah Intan, Lombok Terong, 10-11.xi.1978, V.H. Lee, 1 female.

Discussion.--The costa of this species is unusually long, while the wing pattern is distinctive, with only one pale spot in cell M1 and the marginal pale spots rather small and distinct.

Culicoides marginatus Delfinado
(Figs. 155, 318, 454)

Culicoides marginatus Delfinado, 1961: 646 (male, female; figs.; Philippines).

Female.--Wing length 0.95 (0.83-1.06, n = 4) mm.

Head: Eyes narrowly separated, bare. Antenna (fig. 155a) with lengths of flagellar segments in proportion of 18-11-12-13-14-13-14-14-25-27-30-39-39, antennal ratio 1.33 (1.28-1.38, n = 2); sensilla coeloconica present on segments 3,11-14, multiple on distal segments. Palpus (fig. 155b) with lengths in proportion of 13-21-27-12-13; third segment moderately swollen, with a very broad, shallow sensory pit; palpal ratio 2.4 (2.2-2.8, n = 4). Proboscis moderately short, P/H Ratio 0.72; mandible with 12 (10-14, n = 7) well-developed teeth.

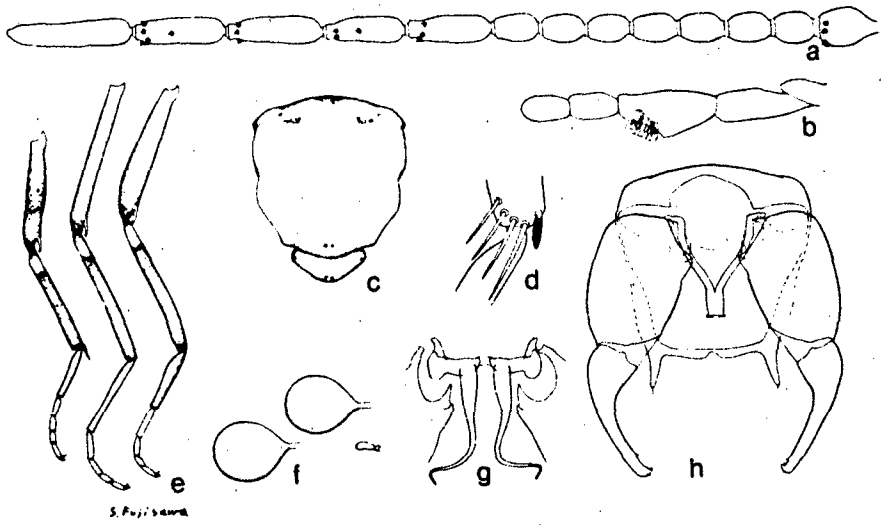


Fig. 155. *Culicoides marginatus*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Thorax: Dark brown; mesonotum (fig. 155c) with pattern of large pale patches as seen on slide-mounted specimens. Legs (fig. 155e) brown; knee spots blackish; femora narrowly pale at bases, without distal pale rings; tibiae with narrow sub-basal pale rings; hindtibial comb (fig. 155d) with 4 (n = 4) spines, the one nearest the spur longest.

Wing (fig. 318, 454): Pattern as figured; pale spot over r-m crossvein small, but broadly extended to costal margin; stigma moderately dark, extending to tip of second radial cell; a single, transverse, poststigmatic pale spot in cell R5 extending a little more than halfway across cell to vein M1; only 1 small round distal pale spot in cell R5, at apex of cell; cell M1 with 2 pale spots, the distal one located at wing margin; cell M2 pale at extreme base with a narrow pale streak extending to the pale spot behind medial fork; no pale spot in front of mediocubital fork, 2 pale spots in distal portion of cell M2, the proximal one sometimes faint, distal one lo-

cated at wing margin; cell M4 with round pale spot in distal portion of cell at wing margin; anal cell with transverse, more or less double, pale spot extending nearly to wing margin in distal portion and a large pale area in anteroproximal area; tips of veins not pale. Macrotrichia long and numerous, extending to base of wing posteriorly; costal ratio 0.60 (0.57-0.62, n = 4); radial cells complete, sector slightly tapering distally, the lumen distinct. Halter infuscated.

Abdomen: Brown. Spermathecae (fig. 155f) ovoid with only trace of slender sclerotized necks; slightly unequal, 0.050 x 0.037 mm and 0.045 x 0.036 mm; vestigial third spermatheca present, sclerotized ring absent.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 155h): Ninth sternum with deep caudomedian excavation, ventral membrane not spiculate; ninth tergum short with broad apex, apicolateral processes long and pointed, caudal margin between them transverse with slight median notch. Basistyle with ventral root not developed, dorsal root moderately long and blunt; dististyle curved at base, slender and nearly straight distally, with blunt tip. Aedeagus with basal arch low and rounded, extending to a third of total length, basal arms curved and slender; distal process tapering to moderately slender, ventrally bent, distally truncate tip. Parameres (fig. 155g) each with well-sclerotized basal arm abruptly bent laterad from base of stem, basal knob only slightly expanded; stem slender, straight in midportion, gradually tapered to fine, simple ventrolaterally curved, filamentous tip.

Distribution.--Indonesia, Philippines.

Types.--Holotype female, Philippines, Luzon, Rizal, Tala, 21.v.1958, M.D. Delfinado, light trap (deposited in collection of Philippine Department of Health, Manila). Paratypes, males and females, in USNM and Field Museum of Natural History.

Southeast Asia Records.--

INDONESIA: Sulawesi (Central), Banggai, Batui, Kamiwangi (Bambang).

PHILIPPINES: Luzon, Rizal, Tala (Delfinado, types). Mindanao, Davao, Maco, Tagum (Hoogstraal and Heyneman); Cotabato, Pikit (Werner).

Discussion.--This species is very closely related to *C. geminus* Macfie from which it can be distinguished by the presence of multiple sensilla coeloconica on each of the distal antennal segments, and the hairier wing with more restricted pale markings.

Culicoides minipalpis Wirth and Hubert, new species
(Figs. 156, 319, 455)

Female.--Wing length 0.72 mm.

Head: Eyes contiguous, bare. Antenna (fig. 156a) with lengths of flagellar segments in proportion of 20-15-15-16-16-17-18-18-25-26-26-40-56, antennal ratio 1.50; sensilla coeloconica present on segments 3,8-10,12. Palpus (fig. 156b) with

lengths in proportion of 10-20-20-12-13, third segment exceedingly short and very little swollen, bearing a shallow, open, sensory area; palpal ratio 1.3. Proboscis short, P/H Ratio 0.58, mandible with 9 minute teeth.

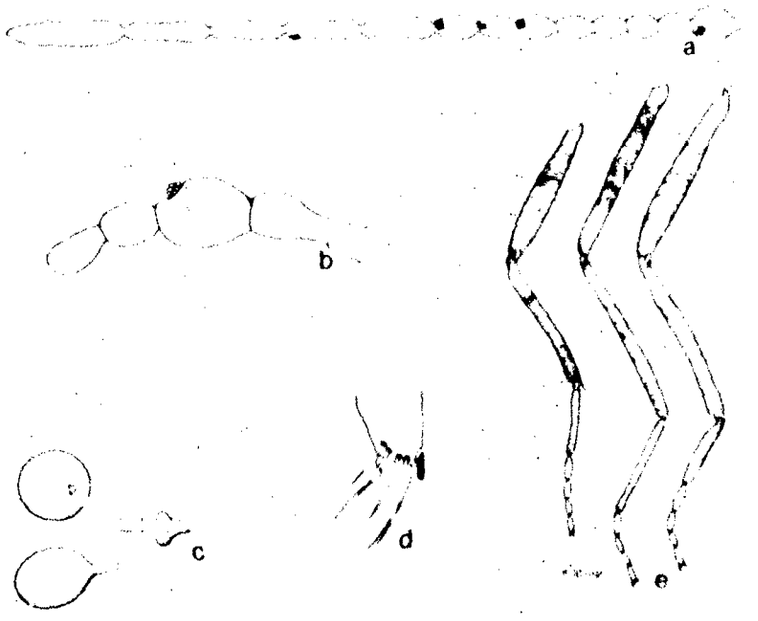


Fig. 156. *Culicoides minipalpis*. a. antenna; b. palpus; c. spermathecae; d. tibial comb; e. legs.

Thorax. Brownish, mesonotum with pattern of large pale areas obscured in slide mounted specimen. Legs (fig. 156e) brown, tibiae with narrow pale rings; tibial comb (fig. 156d) with 4 spines, the one nearest spur longest.

Wing (fig. 319, 455). Pattern as figured, pale spots moderately distinct; round pale spot over r-m crossvein, meeting costal margin broadly but with reduced intensity, a large transverse pale postero-gmatic pale spot, not meeting vein M1, a small round pale spot in extreme apex of cell R5, cell M1 with 2 pale spots, a small one near base of cell lying adjacent to vein M2, the second round, at extreme tip of cell, nearly meeting wing margin, cell M2 pale at extreme base, rather faint pale markings present behind medial fork and in front of mediocubital fork, a small round pale spot meeting wing margin at extreme tip of cell, cell M4 with a moderately large pale spot filling most of distal portion, anal cell with large inde-

tinct pale area in distal portion. Macrotrichia sparse, mostly confined to distal third of wing and mostly arranged in lines paralleling veins, a few in cell M4; costal ratio 0.58; radial cells short, second with distinct lumen. Halter pale.

Abdomen: Brown. Spermathecae (fig. 156c) oval with long slender necks; slightly unequal, smaller one 0.033 (+ 0.010 neck) x 0.026 mm, large one 0.030 mm broad, length not determined because of position on slide; sclerotized ring large and of characteristic shape as figured; vestigial third spermatheca present as a slender filament.

Male.--Unknown.

Distribution.--Malaysia.

Type.--Holotype female, Malaysia, Pahang, Kuala Trengganu, 15.xii.1958, J.L. Gressitt and T.C. Maa, light trap (deposited in B.P. Bishop Museum).

Discussion.--This species is placed in the Shermani Group because of the wing pattern, in which the pale spot over the r-m crossvein is centered on the vein. It is keyed out nearest *C. shermani* Causey, which has a somewhat similar wing pattern but more numerous macrotrichia, a deep palpal pit opening by a smaller pore, antennal sensory pattern 3,9,11-14, a well developed proboscis and mandibular teeth, dark halteres and spermathecae without necks. *Culicoides minipalpis* can be readily distinguished by its small size, reduced proboscis and mandibular teeth, small third palpal segment with open sensory pit, its distinct wing pattern and scanty macrotrichia.

Culicoides nigripes Wirth and Hubert, new species
(Figs. 157, 320, 456)

Female. Wing length 1.28 mm.

Head. Eyes contiguous, bare. Antenna (fig. 157a) with lengths of flagellar segments in proportion of 32-28-30-31-32-30-30-30-50-50-50-48-64, antennal ratio 1.00; sensilla coeloconica present on segments 3,11-15 or 3,12-15. Palpus (fig. 157b) with lengths of segments in proportion of 14-24-49-14-12; third segment greatly swollen, with a large deep sensory pit 2/3 length of segment, opening by an elongate pore; palpal ratio 2.0. Proboscis short, P/H Ratio 0.70; mandible with 16 teeth.

Thorax. Very dark brown, almost blackish, mesonotum without apparent pattern in slide mounted specimen. Legs (fig. 157e) very dark brown; knee spots blackish; fore- and midfemora with subapical and all tibiae with sub-basal, narrow, distinct pale rings; hindtibial comb (fig. 157d) with 4 spines, the one nearest spur longest.

Wing (fig. 320, 456). Pattern as figured, very deeply infuscated, with small pale spot at basal arculus and 2 distinct pale spots on anterior margin, a small round one on r-m crossvein, not extending forward beyond radius, the second one just past end of costa slightly larger, rounded, additional very faint pale grayish areas lying near apices of cells R5, M1, M2, M4, and anal cell. Macrotrichia long and

numerous, extending in full density to bases of cell M2 and anal cell; costal ratio 0.56; second radial cell moderately broad, with distinct lumen. Halter very deeply infuscated, blackish.

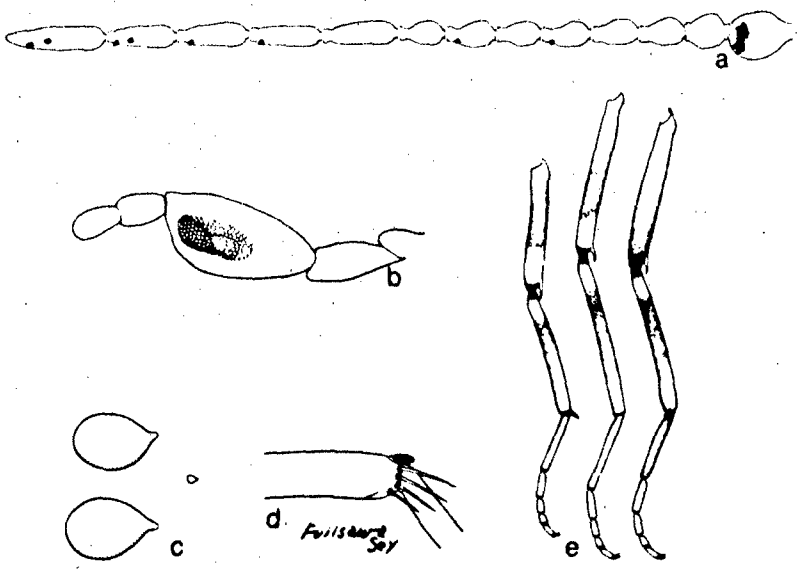


Fig 157. *Culicoides nigripes*: a. antenna; b. palpus; c. spermathecae; d. tibial comb; e. legs.

Abdomen: Dark brown. Spermathecae (fig. 157c) subequal, each 0.095 x 0.064 mm; ovoid, distinctly tapering to moderately long, slender, sclerotized necks; vestigial third spermatheca present, sclerotized ring absent.

Male.--Unknown.

Distribution.--Thailand.

Type.--Holotype female, Thailand, Chiang Mai, iv-v.1958, V. Notananda, light trap (Type in USNM).

Discussion.--This species is very close to *C. siamensis* n. sp., but is much darker, has more mandibular teeth, the palpal pore is elongate and the spermathecae are subequal and more tapering with sclerotized necks. It also greatly resembles *dryadeus* Wirth and Hubert, but that species has two additional distinct

wing spots, one near base of medial stem and the other nearly midway along mediocubital stem, and the palpi are much more elongate with a shallow subapical pit.

Culicoides selangorensis Wirth and Hubert, new species
(Figs. 158, 321, 457)

Female.--Wing length 1.05 mm.

Head: Eyes bare, nearly contiguous, separated above by a very narrow wedge-shaped space. Antenna (fig. 158a) with lengths of flagellar segments in proportion of 25-20-22-22-22-23-23-23-45-48-48-70, antennal ratio 1.43; sensilla coeloconica present on segments 3-15, multiple on segments 3-10. Palpus (fig. 158b) with lengths of segments in proportion of 15-30-62-18-18; third segment broadly swollen, spindle-shaped, with a deep pit half the length of segment opening by a smaller round pore; palpal ratio 1.8. Proboscis moderately long, P/H Ratio 0.83; mandible with 14 very fine teeth.

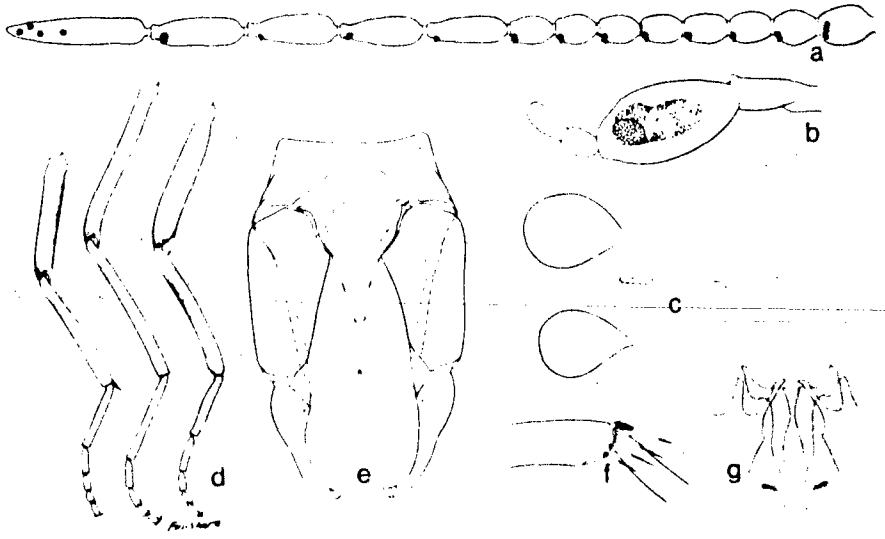


Fig. 158 *Culicoides selangorensis*: a. antenna; b. palpus; c. spermathecae; d. legs; e. male genitalia, parameres omitted; f. tibial comb; g. parameres.

Thorax: Dark brown, mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 158d) brown, tibiae with distinct sub-basal pale rings, knee spots not prominent; hindtibial comb (fig. 158f) with 4 spines, the one nearest the spur longest.

Wing (fig. 321, 457): Pattern as figured; deeply infuscated, especially along costal margin and in a broad anterior area distad of poststigmatic pale spots; small pale spot present at basal arculus; transverse pale spot over r-m crossvein from costal margin to media; a double, transverse, poststigmatic pale spot in cell R5 with faint proximal extension behind second radial cell; 1 rounded to distinctly transverse pale spot in middle of distal portion of cell R5; cell M1 with 1 rounded pale spot in distal portion, located far from wing margin; vein M2 with a double pale spot straddling midportion, the vein forming a dark line through the spot; cell M2 with an oval pale spot behind medial fork, a round one anterior to mediocubital fork, and a round one in apex of cell but separated from wing margin; cell M4 with a rounded pale spot in distal portion far from wing margin; anal cell with a rounded pale spot near anal angle and a round pale spot in distal portion. Macrotrichia long and numerous, extending to bases of cell M2 and anal cell; costal ratio 0.60; second radial cell moderately broad with distinct lumen. Halter infuscated.

Abdomen: Brownish. Spermathecae (fig. 158c) subequal, each 0.064 x 0.054 mm; subspherical to slightly ovoid, slightly tapering to slender neck, base of duct not sclerotized at neck; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 158e): Ninth sternum with broad, moderately deep caudomedian excavation, ventral membrane not spiculate; ninth tergum moderately long and broad, with long, slender, pointed apicolateral processes, caudal margin between them slightly biloped mesad. Basistyle with ventral root long and slender; dististyle slender and slightly curved distad, with bent, sharp pointed tip. Aedeagus with broadly rounded basal arch extending to 0.45 of total length, basal arms curved and moderately stout; distal process broad at base, tapering to moderately slender, rounded tip. Parameres (fig. 158g) each with slender basal arm extending anterolaterad, basal knob moderately developed with distinct anterior process; midportion slightly swollen towards base, somewhat crooked or sinuate in middle, becoming very slender and abruptly bending ventrad and mesad to end in simple pointed tip.

Distribution.--Malaysia.

Types.--Holotype female, allotype male, Malaysia, Selangor, Sungai Buloh Forest Researve, 31.v.1962, C. Manikumar, reared from soil and decaying leaves in tree hole in jungle tree (Type in USNM). Paratypes, 10 males, 19 females, as follows:

MALAYSIA: Selangor, same data as types, 1 male, 6 females; Ampang Forest Reserve, v-ix.1961, 5 males, 6 females; Subang Forest Reserve, v-viii.1961, viii.1962, 2 males, 4 females, 1 intersex; Weld Hill, 20.v.1961, 1 male, 2 females; all reared from tree holes by C. Manikumar.

Discussion.--This species is just another one of the several rare species reared from tree holes and similar habitats and seldom if ever taken in light traps. It is placed provisionally in the Shermani Group on the basis of palpal structure. general appearance of the hairy wings, and structure of the male genitalia, although it is the only one of these species known to have a pale spot straddling vein M2 and a distal pale spot in cell R5, and one of only a few species (c.f., *bigeminus*, *kelantanensis*, *macclurei*, *minipalpis*, and *siamensis*) with a pale spot lying immediately anterior to the mediocubital fork.

Culicoides shermani Causey
(Figs. 159, 322, 458)

Culicoides shermani Causey, 1938: 404 (female; Siam; reared from tree hole; fig. wing, spermathecae).

Female.--Wing length 0.92 (0.86-0.97, n = 3) mm.

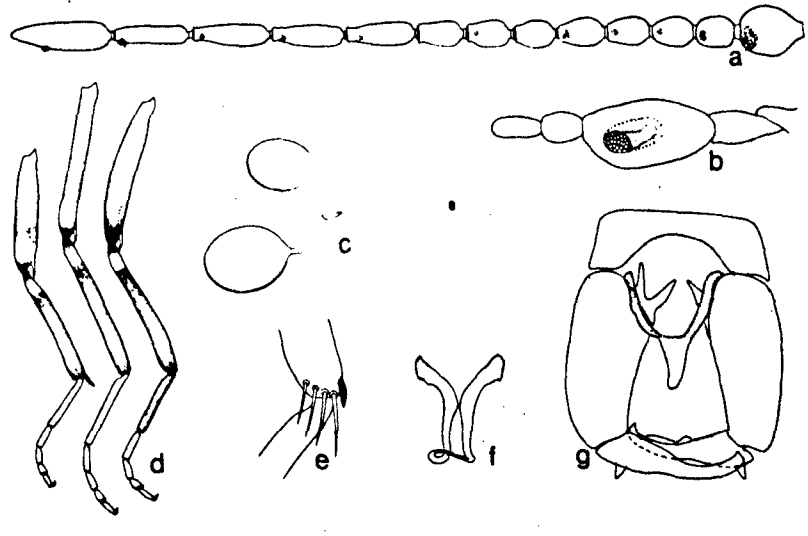


Fig. 159. *Culicoides shermani*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Head: Eyes bare, meeting at a point low down in interocular space leaving a narrow wedge-shaped space above. Antenna (fig. 159a) with lengths of flagellar segments in proportion of 20-13-15-15-15-14-15-15-23-25-25-28-34, antennal ratio 1.07 (1.01-1.11, n = 3); sensilla coeloconica present on segments 3-9,11-14, rarely absent on 9 or 13, rarely present on 15. Palpus (fig. 159b) with lengths in proportion of 10-12-34-9-12; third segment swollen to tip, with very deep pit, nearly as deep as half the length of segment, opening by a smaller, longitudinally oval pore; palpal ratio 2.0 (n = 2). Proboscis moderately short, P/H Ratio 0.66; mandible with 11 (10-11, n = 5) teeth.

Thorax: Dark brown; mesonotum without evident pattern in slide-mounted specimens. Legs (fig. 159d) brown; knee spots blackish; bases of mid- and hindfemora slightly paler; fore- and midfemora with subapical and all tibiae with sub-basal, narrow pale rings; hindtibial comb (fig. 159e) with 4 (n = 3) spines, the one nearest spur longest.

Wing (fig. 322, 458): Pattern as figured; pale spots small and sharply defined; very dark area over radial cells and 1 on anterior margin of cell R5 distal to the poststigmatic pale spot; very small pale spot centered on r-m crossvein, not extending to costal margin; small transverse poststigmatic pale spot in cell R5 past end of second radial cell extending back about 1/2 way to vein M1; a small round pale spot in extreme tip of cell R5; 2 pale spots in cell M1, proximal one very small, distal one not meeting wing margin; cell M2 with pale spot at extreme base, a small pale spot behind medial fork but none ahead of mediocubital fork, 1 pale spots in distal part of cell, the proximal one faint and linear in form, the distal one not meeting wing margin; a round pale spot near wing margin in cell M4; anal cell with a triangular pale spot at base near anal vein and one transverse angular spot in distal part of cell; no pale spots at tips of veins. Macrotrichia long and moderately numerous, extending to base of wing; costal ratio 0.59 (n = 3); second radial cell moderately long with well-developed lumen. Halter infuscated.

Abdomen: Brown. Spermathecae (fig. 159c) oval without sclerotized necks, not tapering toward ducts; unequal, 0.061 x 0.045 mm and 0.051 x 0.034 mm; vestigial third spermatheca and sclerotized ring present.

Male (from Neve Yaar, Israel).--Similar to female with usual sexual differences. Genitalia (fig. 159g): Ninth sternum with broad, moderately deep, caudomedian excavation, ventral membrane bare; ninth tergum long, slightly tapering, with long, tapering, slightly flaring apicolateral processes. Basistyle with ventral and dorsal roots similar, long and slender; dististyle slender, slightly curved to pointed tip. Aedeagus with basal arch rounded, extending to 0.66 of total length; distal process short and simple. Parameres (fig. 159f) each with obliquely directed basal portion ending in a strong basal knob; main body slightly swollen at base, tapering distally to slender process curved ventrally and mesally, and ending in a slender, pointed tip.

Distribution.--Indonesia, Israel, Thailand, Vietnam.

Type.--Holotype female, Chantaburi, Thailand (Causey), on slide in USNM.

Southeast Asia Records.--

INDONESIA: Java, Jakarta Utara, Pulau Putri (Lee).
THAILAND: Chantaburi (Causey). Chiang Mai (Notananda).
VIETNAM: Ban Me Thuot (Quate).

Discussion.--The very definite wing markings and the swollen third palpal segment with very deep pit are distinctive. Through the kindness of Alan L. Dyce we have been privileged to examine 1 male and 2 females from Neve Yaar, Israel, 3.v.1967, A.L. Dyce, light trap, that appear identical with Oriental *C. shermani*. The male of the species was previously undescribed.

Culicoides siamensis Wirth and Hubert, new species
(Figs. 160, 323, 459)

Female.--Wing length 1.28 mm.

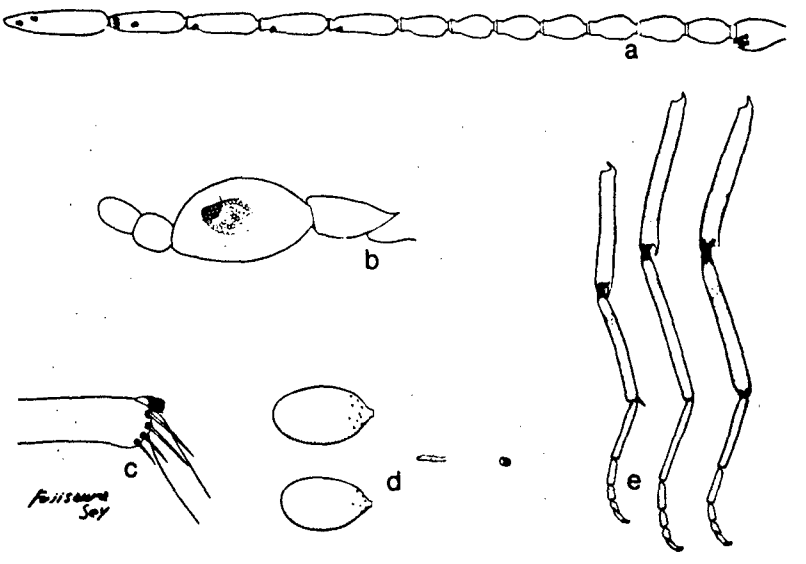


Fig. 160. *Culicoides siamensis*: a. antenna; b. palpus; c. tibial comb; d. spermathecae; e. legs.

Head: Eyes nearly contiguous, bare. Antenna (fig. 160a) with lengths of flagellar segments in proportion of 23-19-20-21-19-19-19-21-30-29-31-34-45, antennal ratio 1.05; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 160b) with lengths of segments in proportion of 12-16-35-7-8; third segment very

broadly swollen, with deep pit, nearly half the length of segment, opening by a much smaller round pore; palpal ratio 1.7. Proboscis short, P/H Ratio 0.64; mandible with 12 teeth.

Thorax: Brown; mesonotal pattern not distinct in slide-mounted specimen. Legs (fig. 160e) pale brown; knee spots blackish; fore- and midfemora with faint subapical pale rings; tibiae with distinct sub-basal pale rings; hindtibial comb (fig. 160c) with 4 spines, the one nearest spur longest.

Wing (fig. 323, 459): Pattern as figured; moderately infuscated, 2 distinct anterior pale spots, a small transverse one over r-m crossvein, not meeting costa but touching media, and a small transversely oval one just past end of costa; in addition with fairly large, very faint pale areas in cells immediately behind medial fork and in front of mediocubital fork and near apices of cells R5, M1, M2, M4, and anal cell. Macrotrichia long and numerous, extending to base of wing in medial and anal cells; costal ratio 0.58; second radial cell long and broad, with distinct lumen. Halter infuscated.

Abdomen: Brown. Spermathecae (fig. 160d) elongate oval, without sclerotized necks; slightly unequal, 0.069 x 0.044 mm and 0.062 x 0.035 mm; vestigial third spermatheca and sclerotized ring present.

Male.--Unknown.

Distribution.--Thailand.

Type.--Holotype female, Thailand, Chiang Mai Prov., Doi Sutep, xii.1957, E.B. Thurman, light trap (Type in USNM).

Discussion.--The wing pattern of *C. siamensis* is nearly identical with that of *nigripes* n. sp., but the latter is a much darker, blackish species, with an elongate pore on the palpal pit, 16 instead of 12 mandibular teeth, and larger, subequal spermathecae with distinctly tapering necks.

Culicoides thurmanae Wirth and Hubert, new species
(Figs. 161, 324, 460)

Female.--Wing length 1.24 (1.16-1.33, n = 7) mm.

Head: Eyes very narrowly separated, bare. Antenna (fig. 161a) with lengths of flagellar segments in proportion of 22-14-14-14-15-15-16-16-35-35-39-38-50, antennal ratio 1.53 (1.50-1.56, n = 3); sensilla coeloconica present on segments 3-11,13-14. Palpus (fig. 161b) with lengths of segments in proportion of 14-30-45-14-15; third segment markedly swollen, especially toward apex, with a large round, moderately deep sensory pit opening by a smaller pore; palpal ratio 2.1 (2.1-2.3, n = 2). Proboscis long, P/H Ratio 0.91; mandible with 17 (16-19, n = 14) teeth.

Thorax: Dark brown; mesonotal pattern as in fig. 161d. Legs (fig. 161e) brown; knee spots blackish; narrow sub-basal pale bands on all tibiae; hindtibial comb (fig. 161c) with 4 spines, the second from the spur longest.

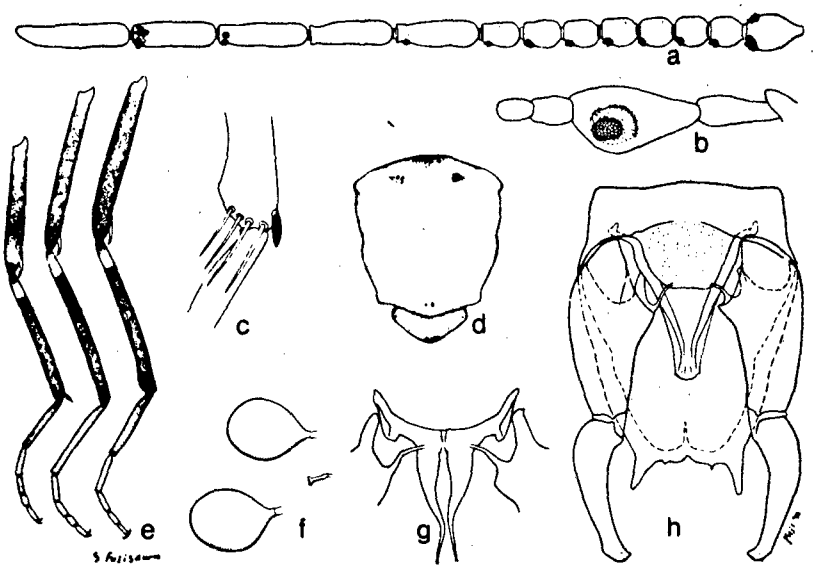


Fig. 161. *Culicoides thurmanae*: a. antenna; b. palpus; c. tibial comb; d. thoracic pattern; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Wing (fig. 324, 460): Pattern as figured; not very distinct, moderately dark area over radial cells and along anterior margin of cell R5 between the pale spots; transverse pale spot over r-m crossvein usually extending to costal margin; a transverse poststigmatic pale spot in cell R5 lying past end of second radial cell, extending only 2/3 way across cell to vein M1; very faint pale spot at extreme tip of cell R5; cell M1 with 2 pale spots, distal one meeting wing margin; cell M2 pale at base, with a sub-basal pale spot extending across stem of mediocubitus into anal cell, a pale spot lying behind medial fork, and 2 in distal part of cell, the distal one meeting wing margin; cell M4 with a round pale spot broadly meeting wing margin; anal cell with 1 rounded pale spot in distal portion; no pale spots at ends of veins. Macrotrichia moderately long and numerous, extending nearly to base of wing in cell M2 and anal cell; costal ratio 0.61 (0.60-0.63, n = 7); second radial cell well developed with well-developed lumen. Halter pale.

Abdomen: Brown. Spermathecae (fig. 161f) oval with short sclerotized necks; subequal, each 0.073 x 0.051 mm; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 161h): Ninth sternum with shallow caudomedian excavation, ventral membrane spiculate; ninth tergum long and tapering, with long, slender, pointed apicolateral

processes. Basistyle with slender ventral root, dorsal root rather short and stout; dististyle moderately stout, slightly curved to bent, bluntly pointed tip. Aedeagus with basal arch extending to a third of total length, distal portion tapering to moderately slender, bluntly rounded tip. Parameres (fig. 161g) each with well developed, laterally directed basal knob bearing distinct anterior process; distal portion moderately stout at base, rapidly narrowed to slender pointed tip directed caudad.

Distribution.--Thailand, Vietnam.

Types.--Holotype female, Thailand, Chiang Mai Prov., Doi Sutep, 3.xii.1957, E.B. Thurman, light trap (Type in USNM). Allotype male, Vietnam, Data, 20.v.1960, L.W. Quate, light trap (B.P. Bishop Museum). Paratypes, 13 females, as follows:
THAILAND: Chiang Mai Prov., same data as holotype, 8 females.
VIETNAM: Dalat, Dralac, 12-14.xi.1956, N.R. Spencer, light trap, 4 females. Di Linh, Djiring, iv,ix-x.1960, L.W. Quate, 2 females.

Discussion.--We are pleased to dedicate this species in memory of the late Dr. Ernestine Basham Thurman, who as a U.S. Public Health Service entomologist spent several very productive years in Thailand and added a great deal to our knowledge of Thai mosquitoes and other insects of medical importance.
The wing pattern, with pale spots forming two transverse bands across the mid-portion of the wing while the distal pale spots at the wing margin are recessive, is somewhat similar to that of *C. pampangensis* Delfinado and *dryadeus* Wirth and Hubert.

Culicoides wenzeli Delfinado
(Figs. 162, 325, 461)

Culicoides wenzeli Delfinado, 1961: 649 (male, female; Philippines; figs.).

Female.--Wing length 0.86 (0.81-0.92, n = 5) mm.
Head: Eyes contiguous, bare. Antenna (fig. 162a) with lengths of flagellar segments in proportion of 20-13-15-17-18-18-17-18-26-25-29-29-39, antennal ratio 1.12 (1.10-1.14, n = 4); sensilla coeloconica present on segments 3-15. Palpus (fig. 162b) with lengths in proportion of 9-20-31-12-14; third segment moderately swollen, with a moderately deep sensory pit opening by a smaller pore; palpal ratio 2.1 (n = 2). Proboscis short, P/H Ratio 0.58; mandible with 11 (11-12, n = 10) teeth.
Thorax: Dark brown; mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 162d) brown; knee spots blackish on foreleg; fore- and midfemora with subapical and all tibiae with sub-basal, faint, narrow pale rings; hindtibial comb (fig. 162c) with 4 (n = 3) spines, the one nearest the spur longest.
Wing (fig. 325, 461): Pattern as figured; very faintly marked, dark only over radial veins; only 3 small pale spots on wing, 1 at basal arculus, 1 over r-m crossvein not extending to costal margin, and 1 small poststigmatic pale spot in cell R5 lying past end of second radial cell. Macrotrichia long but sparse, extend-

ing nearly to base of wing in cell M2 and anal cell; costal ratio 0.63 (0.62-0.64, n = 5); second radial cell rather long, slightly narrowed distad with distinct lumen. Halter pale to very slightly infuscated.

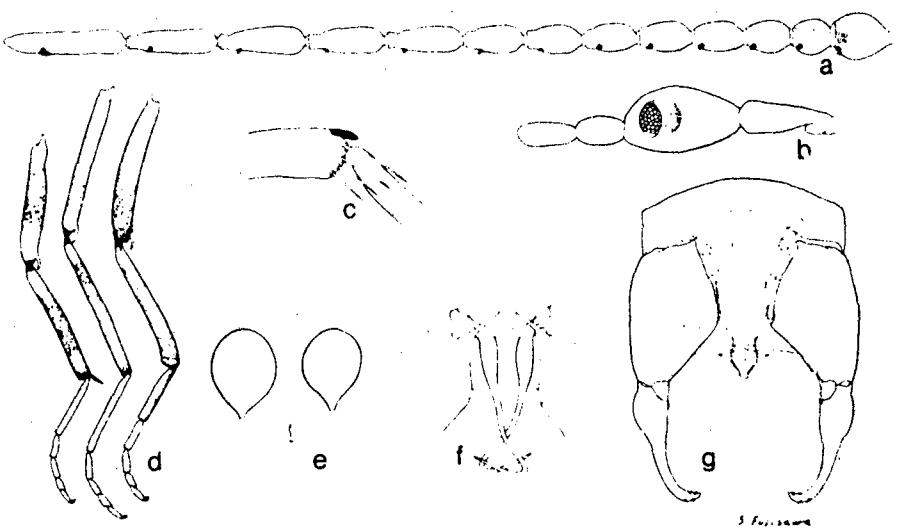


Fig. 162. *Culicoides wenzeli*: a. antenna; b. palpus; c. tibial comb; d. legs; e. spermathecae; f. parameres; g. male genitalia, parameres omitted.

Abdomen: Brown. Spermathecae (fig. 162e) pyriform, tapering very slightly to very short, slender, sclerotized necks; slightly unequal, 0.065 x 0.047 mm and 0.059 x 0.043 mm; vestigial third spermatheca present, sclerotized ring absent.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 162g): Ninth sternum with distinct caudomedian excavation, ventral membrane not spiculate; ninth tergum short, slightly tapering to widely separated, very long, slender and pointed, slightly divergent, apicolateral processes, the caudal margin between them transverse with a slight median notch. Basistyle with ventral root simple, long and very slender, dorsal root shorter and blunt tipped; dististyle slender, markedly curved distally to bent, pointed tip. Aedeagus with basal arch very short, extending to only 1/4 of total length, basal arms short and directed anterolaterad; distal portion stout, tapering gradually to bluntly rounded, cap-shaped tip which bears a subapical, spurlike, recurved expansion on each side. Parameres (fig. 162f) each with very short, laterally directed, basal arm bearing a transversely expanded basal knob; stem slender, straight and gradually tapered to very fine, simple, filamentous tip abruptly bent ventrad.

Distribution.--Philippines, Sabah.

Types.--Holotype female, allotype male, Philippines, Luzon, Rizal, Tala, 22.v.1958, M.D. Delfinado, light trap (Type in USNM).

Southeast Asia Records.--
PHILIPPINES: Luzon, Rizal Prov., Tala (Delfinado, types).
SABAH: Labuan Island (Colless).

Discussion.--This species is readily distinguished by the poorly marked hairy wing with the second radial cell dark and only 2 pale spots present, 1 over crossvein and the other at the end of the second radial cell, and in the male by the characteristic parameres and the long, tapered, apically capped aedeagus.

The male here described and illustrated was collected along with a series of 5 females from Labuan Island, Sabah. Its genitalia differ markedly from those figured by Delfinado (l.c.) for the Philippine allotype. Examination of the Philippine males indicates a species with abundant pale wing markings of the *C. geminus* pattern, not at all like the female holotype, and there is a distinct possibility that Delfinado's male was wrongly associated. On the other hand, our Borneo male has a wing marked like the females and in our opinion is the true male of *C. wenzeli*.

Culicoides flumineus Macfie from Malaysia has a similarly marked wing, but the macrotrichia are stouter, setiform; there is a distinct darker area in cell R5, the legs are unbanded, and the palpal pit opens by a broad pore.

Clavipalpis Group

Diagnosis.--Small species. Eyes contiguous to narrowly separated, bare or hairy. Antennal ratio 1.04-1.46; sensilla coeloconica present on proximal series of segments and absent on segments 11-15. Third palpal segment usually swollen. Mandible with about 10 teeth, usually very fine. Cibarial armature of short spinules present or absent. Wing with second radial cell dark, short; costal ratio 0.54-0.56; pale spot over r-m crossvein usually lying on distal side of crossvein; a small round pale spot usually present at extreme apex of cell R5 with no pale spots between it and poststigmatic pale spots, the latter various in shape, usually diagnostic for species. Cell M2 always with pale spot lying in front of mediocubital fork, usually only 1 pale spot distad of fork, at wing margin; a transverse, somewhat double pale spot distally in anal cell; no pale spots at tips of veins; macrotrichia not numerous. Four tibial spines, the one nearest the spur longest. Two spermathecae, unequal, ovoid to oval in shape with long slender sclerotized necks; rudimentary third spermatheca and sclerotized ring present. Male genitalia with ninth tergum tapering distally with usually slender, pointed, apicolateral processes; ventral root of basistyle foot-shaped; aedeagus with broad basal arch, often with sclerotized spurs on posterior side of arch near distal process, the latter parallel-sided and channel-like (tapered and sharp-pointed in *similis*); parameres separate, each with rounded basal knob, slender stem with more or less developed ventral lobe, distal portion slender with subapical fanlike expansion bearing lateral spines before the pointed tip.

Included Species.--Nine Oriental species. Cornet and Chateau (1970) placed 13 Subsaharan species in the "Similis Group," its African counterpart, and Khamala and Kettle (1971) added four more East African species for a total of 17. *Culicoides mihensis* Arnaud from Japan and *C. marginalis* Lee and Reye from Australia also belong here.

Taxonomic Notes.--The name Similis Group has been used in most previous publications on the Oriental species, but the Subsaharan *C. similis* Carter Ingram and Macfie is rather atypical for most of the included Oriental species and may eventually be placed in a separate group. Also, we believe it the best policy to name a species group after a well-known species characteristic of the region being treated. For these reasons we believe the time is appropriate to change the name of this group of species to the Clavipalpis Group, after the widespread, well-known species *Culicoides clavipalpis* Mukerji.

As pointed out by Khamala and Kettle (1971), this group is related by the characters of the male genitalia to the North American Haematopotus Group. The species of the latter group were placed by Vargas (1960) in the new subgenus *Diphaomyia* Vargas, whose type-species is *baueri* Hoffman. The following group from Southeast Asia, the Williwilli Group, resembles the Clavipalpis Group remarkably in the shape of the male aedeagus, but differs typically in its antennal sensory pattern and wing pattern. The most obvious characters used to distinguish these groups, such as the distal displacement of the pale spot over the r-m crossvein, the presence of caudal spurs on the lateral shoulders of the aedeagus, the antennal sensory pattern, etc., are not universal within each group and differ in combinations from group to group. For this reason it appears that the usefulness of *Diphaomyia* as a subgeneric taxon is limited and it is better to deal informally with species groups for the Southeast Asian species of the Clavipalpis and Williwilli Groups.

Biology.--Seven of the 8 known Southeast Asian species of this group have been reared. Aquatic sites such as stream and puddle margins were favored by 5 species, but 2 species, *clavipalpis* Mukerji and *parviscriptus* Tokunaga, were reared only from plant materials in non-terrestrial sites.

Culicoides arenicola Howarth
(Figs. 163, 326)

Culicoides arenicola Howarth, 1985: 79 (male, female, pupa; Laos; figs.).

Female.--Wing length 0.94 mm.

Head: Eyes narrowly separated, bare. Antenna (fig. 163a) with lengths of flagellar segments in proportion of 18-11-11-12-13-13-13-15-28-30-29-30-40, antennal ratio 1.46; sensilla coeloconica present on segments 3,7-10, multiple on 3,8-10, with long setae. Palpus (fig. 163b) with lengths in proportion of 7-18-25-

8-11, third segment greatly swollen in midportion, with large, shallow, round sensory pit on distal third; palpal ratio 1.8. Proboscis short, P/H Ratio 0.58; mandible (fig. 163d) with 12 small teeth; cibarial armature a patch of 14-17 blunt spicules.

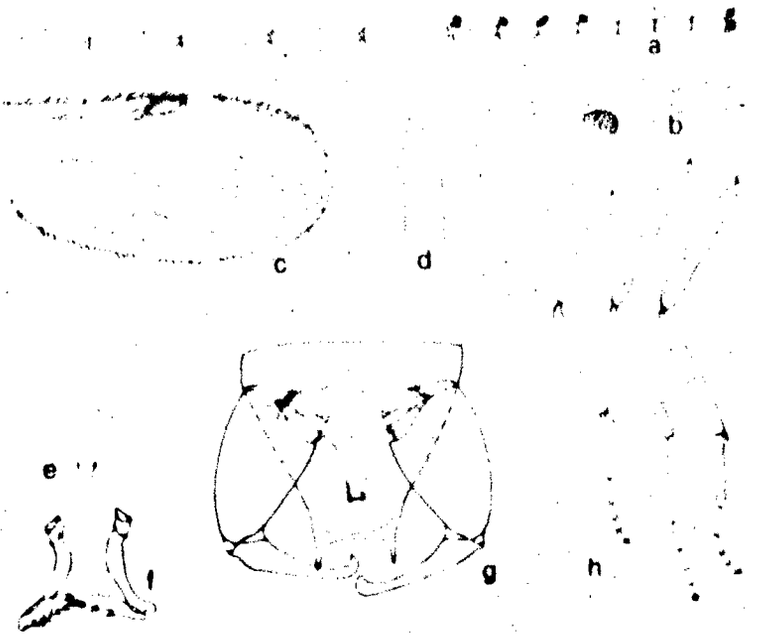


Fig. 163. *Culicoides arenicola*. a, antenna; b, palpus; c, wing; d, mandible; e, spermathecae; f, parameres; g, male genitalia, parameres omitted; h, legs.

Thorax: Dark brown; mesonotum with distinct small pale patches. Legs (fig. 163h) brown; knee spots blackish; fore- and midfemora with subapical, all tibiae with sub-basal, and hindtibia with apical pale bands; hindtibial comb with 4 spines, the one nearest spur longest.

Wing (fig. 163c, 326): Pattern as figured; dark gray with contrasting small round pale spots; pale spot centering just distad of r-m crossvein, extending from costal margin to media; cell R5 with single poststigmatic pale spot just past tip of costa, becoming narrower caudad and failing by about half its length of reaching vein M1, a small round pale spot at extreme tip of cell R5 not reaching wing margin; cell M1 with 1 small round pale spot, near apex of cell and well separated from wing margin; cell M2 with pale spot at basal arculus, a pale spot behind medial fork, one in front of mediocubital fork, and one at apex of cell not touching wing margin; cell M4 with small pale spot at wing margin in distal portion; anal cell with small pale area at anal angle and a double, transverse pale spot in distal portion.

nearly reaching wing margin caudally. Macrotrichia moderately numerous, extending in a double row nearly to base of cell M2 and a few on distal half of anal cell, costal ratio 0.56, radial cells distinct, second with moderately broad lumen. Halter dark.

Abdomen. Pale brown. Spermathecae (fig. 163e) oval with short slender necks, slightly unequal, 0.064 x 0.042 mm and 0.059 x 0.038 mm including necks, tubular vestigial spermatheca and short sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 163g). Ninth sternum with moderately deep caudomedian excavation, ventral membrane not spiculate, ninth tergum short and tapering, apicolateral processes long and slender, closely approximated, caudal margin between them transverse. Basistyle with ventral root foot shaped, both heel and toe poorly developed but toes connected by hyaline band on midline, dististyle slender and nearly straight, with bent tip. Aedeagus short and Y shaped, basal arms slender, nearly straight and divergent at about 120°, basal arch extending to about half of total length; caudolateral spurs absent, distal process moderately stout, sides slightly tapering to blunt, truncated tip. Parameres (fig. 163f) each with stout basal knob, only slightly diverging, stemlike midportion slightly swollen proximad, with only slight indication of ventral swelling, distal portion abruptly bent ventrad and flattened subapically, bladelike, with lateral fringe of 6-8 teeth and tapering to distal point.

Distribution.--Laos, Malaysia.

Types.--Holotype male, allotype female, 64 paratypes, Laos, Sayaboury Prov., 15 km N Sayaboury, Ban Nala, 400 m, 2 xii 1967, reared from partly shaded stream margin, F. G. Howarth (B. P. Bishop Museum).

Southeast Asia Records.--

LAOS. Sayaboury Prov., types, also rearings from Houay La stream margin (Howarth).

MALAYSIA. Perak, Gunong Besont Forest Res. (Kitaoka).

Discussion.--This species is very close to *C. distinctus* Sen and Das Gupta, but *distinctus* has the palpal pit deep and opening by a small pore, the halteres are yellowish, and the leg markings are paler; males of *distinctus* have a pair of large subapical spurs on the aedeagus.

Howarth (1985) described the pupa from Laos. He reared the species many times from shaded sandy stream and river margins near Sayaboury; it was specific for sandy habitats.

Culicoides clavipalpis Mukerji
(Figs. 164, 327, 462)

Culicoides clavipalpis Mukerji, 1931b: 1052 (female; Calcutta; figs.); Causey, 1938: 405 (male, female; Thailand; figs.); Delfinado, 1961: 641 (Philippines; fig. wing); Lee, 1978. 40 (Rep. China; diagnosis; figs.); Howarth, 1985: 81 (larval habitat; Laos records).

Culicoides candidus Sen and Das Gupta, 1959. 620 (male, female; India; figs.). NEW SYNONYMY.

Female --Wing length 0.67 (0.64-0.73, n = 10) mm.

Head: Eyes contiguous, with sparse interfacetal hairs. Antenna (fig. 164a) with lengths of flagellar segments in proportion of 14-8-9-10-10-11-11-13-21-21-22-21-29, antennal ratio 1.28 (1.11-1.46, n = 9); sensilla coeloconica present on segments 3,8-10. Palpus (fig. 164b) with lengths of segments in proportion of 6-12-19-7-7; third segment moderately swollen to tip, with large, moderately deep sensory pit; palpal ratio 1.8 (1.7-1.9, n = 5). Proboscis short, P/H Ratio 0.65; mandible with 11 (10-12, n = 9) fine, almost vestigial teeth; cibarium without patch of spines.

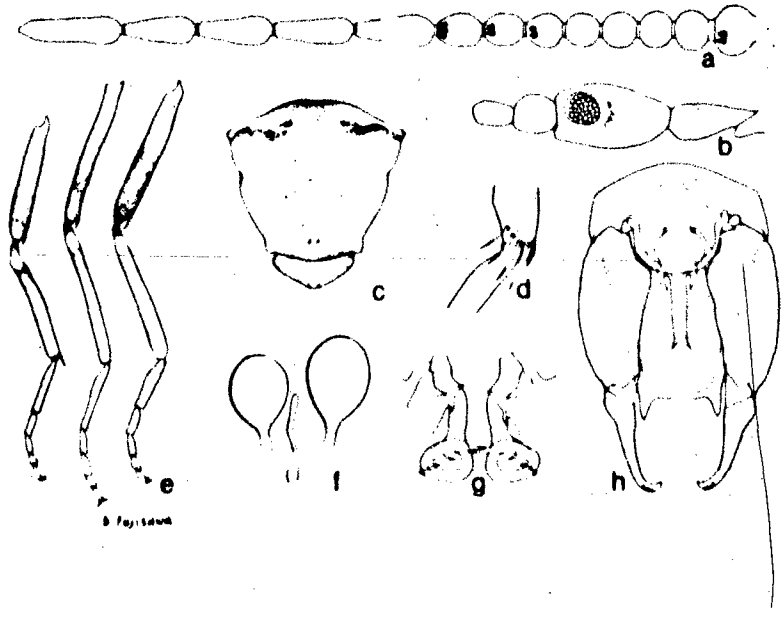


Fig. 164. *Culicoides clavipalpis*. a antenna; b palpus; c thoracic pattern; d tibial comb, e legs; f. spermathecae; g parameres; h male genitalia, parameres omitted

Thorax: Dark brown including scutellum and pleuron; mesonotal pattern as in fig. 164c. Legs (fig. 164e) dark brown; knee spots blackish; femora narrowly pale at bases; all tibiae with basal and hindtibia with apical, narrow pale rings; hindtibial comb (fig. 164d) with 4 (4-5, n = 12) spines, the one nearest spur longest.

Wing (fig. 327, 462): Pattern as figured; dark with very distinct pale spots, very dark spot over radial cells; small pale spot present lying entirely on distal side of r-m crossvein; poststigmatic pale spot in form of an irregularly trilobed or V-shaped spot extending from costal margin to vein M1, the point of the V located proximad; 1 small round pale spot at extreme tip of cell R5 but not touching wing margin; 2 small round pale spots in cell M1, distal one not quite meeting wing margin; cell M2 with pale area at base of cell, a small pale spot just behind medial fork, one just in front of mediocubital fork and a small round one at extreme tip of cell not quite meeting wing margin; cell M4 with a transverse pale mark, broader anteriorly, extending from vein M3+4 to wing margin; anal cell with pale area at base and transverse, more or less double pale spot in distal portion; no pale spots at tips of veins. Macrotrichia very sparse, mostly arranged in lines on distal third of wing; costal ratio 0.55 (0.53-0.58, n = 10); second radial cell short with small lumen. Halter infuscated.

Abdomen: Brown. Spermathecae (fig. 164f) oval with long, slender, sclerotized necks about half as long as spermathecae; unequal, 0.058 x 0.034 mm and 0.053 x 0.031 mm; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 164h): Ninth sternum with moderately deep, somewhat wedge-shaped caudomedian excavation, ventral membrane not spiculate; ninth tergum very long and tapering to the moderately long, pointed, rather narrowly separated, apicolateral processes, caudal margin between them not cleft or lobate. Basistyle with foot-shaped ventral root, posterior heel short, anterior toe long and slender; dististyle slender, only slightly curved to bent and pointed tip. Aedeagus with rounded basal arch extending to 0.4 of total length, basal arms curved and slender; a submedian pair of sharp spurs on posterior side of arch flanking base of distal process; the latter slender and nearly parallel-sided, with emarginate, channel-like tip. Parameres (fig. 164g) each with strong basal knob; stem bent basally, straight in midportion, long ventral lobe present, the portion beyond slender and curved ventromesad, somewhat flattened subapically with lateral fringe of 4-5 small spines before the pointed tip.

Distribution.--India, Indonesia, Laos, Malaysia, Philippines, Sabah, Sarawak, Thailand.

Types.--Location of type of *C. clavipalpis* not known; that of *candidus* in Zoological Survey of India in Calcutta.

Southeast Asia Records.--

INDONESIA: Flores, Manggarai, Nunang, Lake Sano (Lee). South Kalimantan, Banjar, Astambul, Tanah Intan, Lombok Tergon (Lee).

LAOS: Sayaboury Prov., Muong Sayaboury, reared from tree wound (Howarth). Sedone Prov., Pakse (Howarth).

MALAYSIA: Negri Sembilan, Telok Pelandok, Port Dickson (Traub). Pahang, King George V. Nat. Park, Tahan River (McClure); Pekan-Kuantan Road (Wharton). Perak, Gunong Besont Forest Res. (Jeffery). Selangor, Kepong (Quate); Ulu Lui, chicken baited trap at 16 m above ground (Garcia).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Pampanga Prov., Clark Air Base, Angeles (Balatbat).

SABAH: Labuan Island (Colless).

SARAWAK: Gunong Matang (Gressitt and Maa).

THAILAND: Bangkok (Causey). Chiang Mai (Maa, Notananda). Karnchanaburi (Niphan). Minburi (Manop R.). Nakhon Ratchasima, Pak Chong (Manop R.). Nakronprathom (Manop R.). Nong Kai, Ta Bo (Manop R.). Nonthaburi (Manop R.). Sakon Nakhon (Manop R.). Samuthprakan (Manop R.).

Discussion.--The synonymy of *C. candidus* is based on the study of paratype male and female specimens in the USNM. Sen and Das Gupta misidentified *C. huffi* Causey as *C. clavipalpis* and their *clavipalpis* specimens as the new species *candidus*. Mukerji's figures of the wing and palpus clearly show the peculiar shape of the poststigmatic pale spot and the shape of the palpal pit so characteristic of *clavipalpis*.

Biology.--Howarth (1985) reared this species in Laos from material collected from a tree wound.

Culicoides distinctus Sen and Das Gupta
(Figs. 165, 328, 463)

Culicoides distinctus Sen and Das Gupta, 1959: 618 (male, female; India; figs.).

Female.--Wing length 0.74 (n = 2) mm.

Head: Eyes bare, narrowly separated, the interocular space narrowly wedge-shaped above. Antenna (fig. 165a) with lengths of flagellar segments in proportion of 16-11-11-12-12-13-12-14-19-19-19-20-28, antennal ratio 1.04; sensilla coeloconica present on segments 3,7-10. Palpus (fig. 165b) with lengths of segments in proportion of 6-12-16-6-10, third segment distinctly swollen to tip, with moderately large, deep pit opening by a slightly smaller pore; palpal ratio 1.5. Proboscis moderately short, P/H Ratio 0.66; mandible with 10 teeth; cibarium without armature.

Thorax: Dark brown; mesonotal pattern not evident in slide-mounted specimens. Legs (fig. 165d) pale brown; knee spots blackish; femora pale at bases, fore- and midfemora with faint subapical pale ring; tibiae with narrow subbasal and apical pale rings; hindtibial comb (fig. 165e) with 4 spines, the one nearest spur longest.

Wing (fig. 328, 463): Pattern as figured; very dark spot over radial cells; small round pale spot lying mostly or entirely on distal side of r-m crossvein; 2 small round poststigmatic pale spots, the anterior one lying at end of second radial cell on wing margin, the second lying directly behind it in cell R5 but not touching vein M1; a small round pale spot near apex of cell R5; only one pale spot in cell M1, near but not meeting wing margin; cell M2 with small pale spot lying behind

medial fork, 1 lying immediately in front of mediocubital fork and 1 near wing margin in apex of cell; cell M4 with small round pale spot narrowly meeting vein M3+4 and almost touching wing margin; anal cell with 1 pale spot at base and a transverse, more or less double, pale spot in distal portion; no pale spots at tips of veins. Macrotrichia rather sparse but scattered over wing nearly to base of cell M2 and in anal cell; costal ratio 0.56 (0.55-0.57, n = 2); second radial cell small with indistinct lumen. Halter pale.

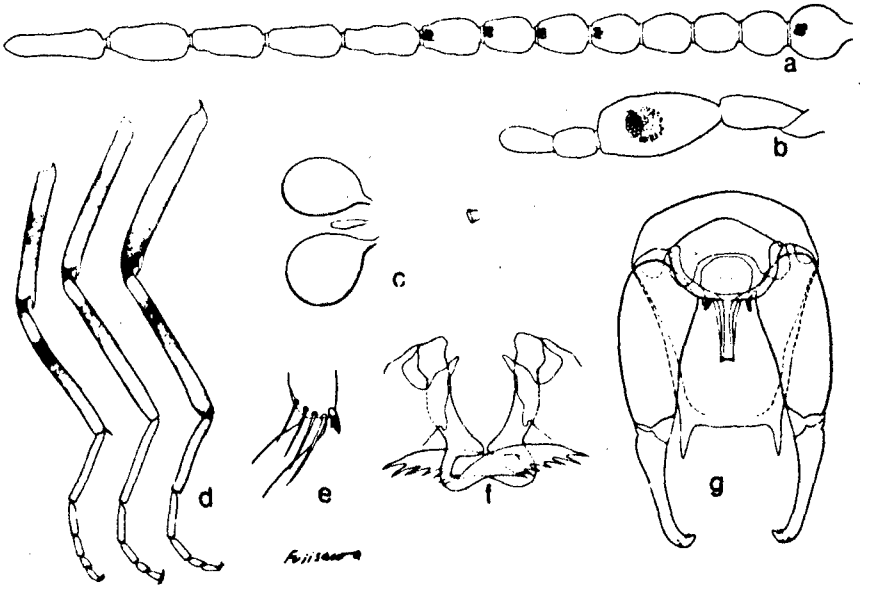


Fig. 165. *Culicoides distinctus*: a. antenna; b. palpus; c. spermathecae; d. legs; e. tibial comb; f. parameres; g. male genitalia, parameres omitted.

Abdomen: Brown. Spermathecae (fig. 165c) not measured but slightly unequal, pyriform to ovoid in shape with long, slender, sclerotized necks; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 165g): Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum with slender, pointed apicolateral processes. Basistyle with ventral root foot-shaped, the anterior toes sometimes joined mesad; dististyle relatively short with slender hooked tip. Aedeagus with basal arch extending to about half of total length, basal arms curved, with submedian pair of pointed sclerotized spurs on posterior side near base of distal process, the latter short

and parallel-sided with truncated tip. Parameres (fig. 165f) each with large basal knob; stem short and relatively stout, straight in midportion; a well-developed ventral lobe; portion beyond lobe slender, flattened subapically with a lateral fringe of 4-6 sharp spines before the pointed tip.

Distribution.--India, Thailand.

Types.--Holotype female, India, W. Bengal, Dum Dum, light trap, in collection of Zoological Survey of India, Calcutta; paratype male and female with same data in USNM.

Southeast Asia Records.--
THAILAND: Bangkok (Causey); Bangkok, Pratoomvan (Manop R.). Thonburi (Manop R.).

Discussion.--The reduction of the pale wing spots, the proximal one absent in cell M1, and the posterior poststigmatic pale spot in cell R5 not meeting vein M1, the antennal sensory pattern, the shape of the third palpal segment, and the presence of submedian spurs on the male aedeagus are distinctive features. *Culicoides parviscriptus* Tokunaga from New Guinea resembles *distinctus* and *clavipalpis* Mukerji in the male genitalia, but has sensilla coeloconica at least on antennal segments 5-10, the poststigmatic pale spot in cell R5 consists of two separate spots instead of being trilobed as in *clavipalpis*, and the palpal pit is extremely deep, reaching nearly to base of third segment.

Culicoides huffi Causey
(Figs. 166, 329, 464)

Culicoides huffi Causey, 1938: 406 (male, female; Thailand; figs.);
Delfinado, 1961: 644 (Philippines; fig. wing); Lee, 1978: 54 (Rep. China; diagnosis; figs.); Howarth, 1985: 82 (pupa descr.; larval habitats; Laos).
Culicoides clavipalpis Mukerji, misident.; Sen and Das Gupta, 1959: 620 (India; figs.).

Female.--Wing length 0.83 (0.78-0.96, n = 11) mm.
Head: Eyes bare, narrowly separated, interocular space slightly wedge-shaped, very narrow below. Antenna (fig. 166a) with lengths of flagellar segments in proportion of 16-10-10-10-11-11-11-12-22-22-22-26-34, antennal ratio 1.46 (1.35-1.64, n = 10); sensilla coeloconica present on segments 3,5,7-10. Palpus (fig. 166b) with lengths of segments in proportion of 6-11-21-7-11; third segment swollen, with very broad, shallow sensory pit; palpal ratio 1.8 (1.6-2.0, n = 12). Proboscis short, P/H Ratio 0.57; mandible with 10 (9-11, n = 12) very fine, almost vestigial teeth; cibarium without armature.

Thorax: Mesonotum (fig. 166d) pale brown with 2 moderately prominent dark brown sublateral vittae; scutellum pale brown, narrowly dark on center portion; postscutellum and pleuron moderately dark brown. Legs (fig. 166f) brown; knee

spots blackish; femora broadly pale at bases; fore- and midfemora with subapical and all tibiae with sub-basal, narrow pale rings; hindtibia with broad apical pale band; hindtibial comb (fig. 166c) with 4 (4-5, n = 13) spines, the one nearest spur longest.

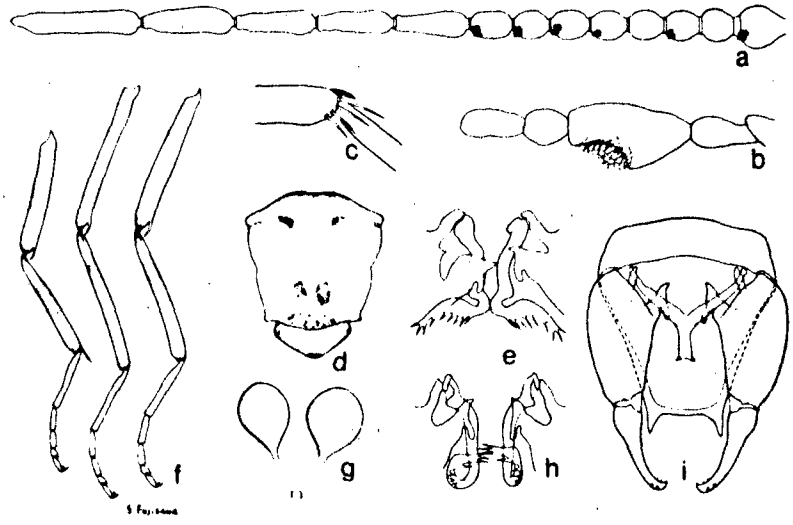


Fig. 166. *Culicoides huffi*: a. antenna; b. palpus; c. tiblal comb; d. thoracic pattern; e,h. parameres; f. legs; g. spermathecae; I. male genitalia, parameres omitted.

Wing (fig. 329,464): Pattern as figured; second radial cell in a very dark spot; small pale spot present lying entirely on distal side of r-m crossvein; a small round poststigmatic pale spot on costal margin in cell R5 just past end of second radial cell, a second small elliptical poststigmatic pale spot lying slightly distad of first and immediately anterior to vein M1; 1 small round pale spot at extreme apex of cell R5; cell M1 with 2 small pale spots, distal one lying near, but separate from wing margin; cell M2 with a pale spot lying immediately behind medial fork, 1 immediately in front of mediocubital fork, and 1 at wing margin in extreme apex of cell; cell M4 with large pale spot extending from posterior wing margin and broadening anteriorly to meet vein M3+4; anal cell with small pale area at base and a transverse, more or less double, pale spot in distal part of cell; ends of veins without pale spots. Macrotrichia scanty and arranged mostly in lines on distal half of wing; costal ratio 0.54 (0.53-0.56, n = 10); second radial cell short with small lumen. Halter pale.

Abdomen: Brown. Spermathecae (fig. 166g) pyriform, tapering abruptly to very slender, elongate necks almost half as long as spermathecae; slightly unequal, 0.058 x 0.034 mm and 0.052 x 0.030 mm; vestigial third spermatheca and sclerotized ring present.

Male --Similar to female with usual sexual differences. Genitalia (fig. 166i): Ninth sternum with scarcely perceptible caudomedian excavation, ventral membrane not spiculate; ninth tergum long and tapering to moderately long pointed apicolateral processes which are not widely separated, caudal margin between them not cleft or lobate. Basistyle with ventral root foot-shaped, posterior heel better developed than the anterior toe; dististyle slender, only slightly curved to bent, pointed tip. Aedeagus Y-shaped, basal arms widely separated and only slightly arcuate, without spurs or points sublaterally on caudal side; distal process moderately broad, nearly parallel-sided, with emarginate tip indicating the dorsally-channeled nature of the process. Parameres (fig. 166e,h) each with sclerotized basal knob; stem slender, curved at base, straighter on midportion, with a low ventral lobe past which the tip is flattened and expanded with a lateral fringe of 8-10 spines to the pointed apex.

Distribution.--Brunei, Cambodia, India, Indonesia, Laos, Malaysia, Philippines, Sabah, Sarawak, Singapore, Sri Lanka, Thailand.

Types.--Holotype male, Bangkok, Siam, O.R. Causey, 1932, on slide, in USNM.

Southeast Asia Records.--

BRUNEI: Kg. Selimbigar, in fowl house (Colless).

CAMBODIA: Phnom Penh (Delfinado).

INDONESIA: Bali, Badung, Kuta, Jimbaran Carik (Lee); Badung, Mengwi (Lee); Klungkung, Singapadu (Seatman); 20 km N Denpasar (Nicholls); Pedang Bay, 35 km NE Denpasar (Nicholls). Flores, Manggarai, Reo, Gincu and Golok (Lee). Java, Bogor (Adiwinata); Jakarta City, Cianjur Street (Lee); West Java, Serang, Anyer Beach Hotel (Lee). Lombok, 35 km N Maratam (Nicholls); (East), Bagik Payung (Lee). Kalimantan (South), Banjar, Martapura, Bincau, Sungai Ratakan (Lee). Sulawesi (Central), Banggai, Batui, Dongin (Bambang); (North), Dumoga-Bone Nat. Park, 220 m (Heppner); (Southeast), Kendari, Ranometo, Wolasi (Bambang), Sumatra, Bengkulu, Cenggari (Mathis); Riau, Bintan, Tanjung Uban, Metinggi (Sumitro, biting man); Lampung, Kotabumi, Way Abung III, Mulyorejo (Lee). Sumbawa, Alas (Nicholls).

LAOS: Sayaboury Prov., Sayaboury (Howarth); 22 km S Muon Phieng, Nam Poui River (Howarth). Sedone Prov., Pakse (Howarth). Vientiane (Quate).

MALAYSIA: Negri Sembilan, Port Dickson, Telok Pelandok (Traub). Pahang, Kuala Singgora (Wharton); Tasek Bera (Wharton). Perak, Gunong Besont Forest Res. (James); same, pigeon-baited trap (Jeffery); Pulau Pangkor (Traub). Selangor, Batu Caves (McClure); Kepong Forest Res. (McClure); Klang, Carey Island, Monkey-baited trap (Garcia); Klang Gates, reared from stream bed (Manikumar); Kuala Lumpur (Barnett, Hubert, Traub); Rantau Panjang (Traub); Subang Forest Res. (McClure). Selangor, Ulu Langat, chicken-baited trap in secondary forest (Garcia).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Pampanga Prov., Angeles, Clark Air Base (Balatbat); Rizal Prov., Tala (Delfinado). Mindanao, Cotaboto Prov., Pikit (Werner).

SABAH: Labuan Island, in fowl house (Colless). Tambunan (Colless). Tawau Dist., Kalabakan (Maa).

SARAWAK: Limbang (Colless). Santubong (Maa).

SINGAPORE: Singapore, in fowl house (Course); Nee Soon (Colless).

THAILAND: Bangkok (Causey). Chiang Mai, Amphoe Hang Dong, Ban Rong Ku (Yasumatsu); Doi Sutep (Thurman); Chiang Mai (Notananda). Cholburi, Bangphra (Scanlon). Khon Kaen Prov., A. Khon Kaen and Chum Phae (Manop R.). Loei Prov., A. Loei and Dan Sai (Manop R.). Minburi (Manop R.). Nakhon Ratchasima (Manop R.). Nakronprathom (Manop R.). Nong Khai Prov., A. Muang and Ta Bo (Manop R.). Nonthaburi (Manop R.). Samuthprakan (Manop R.). Udonthani Prov., A. Muang and Nong Han (Manop R.).

Discussion.--Culicoides huffi is easily recognizable by the wing pattern and details of palpi and antennae. *Culicoides palpisimilis* n. sp. has a nearly identical wing but the proximal pale spot in cell M1 extends posteriorly partly into cell M2, the palpal pit is very small and deep, and sensilla coeloconica are borne on antennal segments 3, 10, 12, and 14.

Biology.--Culicoides huffi has been reared twice near Kuala Lumpur, from a stream bed in partial shade, and from soil at the edge of a grassy swamp where trash was dumped. Howarth (1985) in Laos reared it from 21 different sites, mostly river and stagnant backwater margins and one from the edge of a buffalo wallow.

Culicoides notatus Delfinado
(Figs. 167, 330)

Culicoides notatus Delfinado, 1961: 648 (female; Philippines; figs.); Howarth, 1985: 83 (pupa; Laos records; figs.).

Culicoides papuae Tokunaga, 1962b: 481 (female; New Guinea, New Ireland; fig. wing). NEW SYNONYMY.

Female.--Wing length 0.95 (0.88-1.00, n = 8) mm.

Head: Eyes narrowly separated, a few interfacetal hairs in midportion. Antenna (fig. 167a) with lengths of flagellar segments in proportion of 19-13-14-14-15-14-14-16-31-32-35-39-50, antennal ratio 1.52 (1.43-1.57, n = 5); sensilla coeloconica present on segments 3,7-10. Palpus (fig. 167b) with lengths of segments in proportion of 9-16-24-8-11; third segment short and moderately swollen on basal portion, with an irregular open sensory pit; palpal ratio 1.9 (1.7-2.0, n = 8). Proboscis moderately short, P/H Ratio 0.61-0.65; mandible (fig. 167d) with 12 (9-14, n = 13) fine teeth; cibarial armature of 10-13 median and 9-12 small submedian spicules.

Thorax: Dark brown; mesonotum with prominent pattern of large yellowish patches as seen in slide-mounted specimens. Legs (fig. 167h) brown; knee spots blackish; femora narrowly pale at bases and with narrow subapical pale rings, the ring on hindfemur often quite faint; tibiae with narrow sub-basal pale rings and apex of hindtibia broadly pale; hindtibial comb with 4 (n = 7) spines, the one nearest the spur longest.

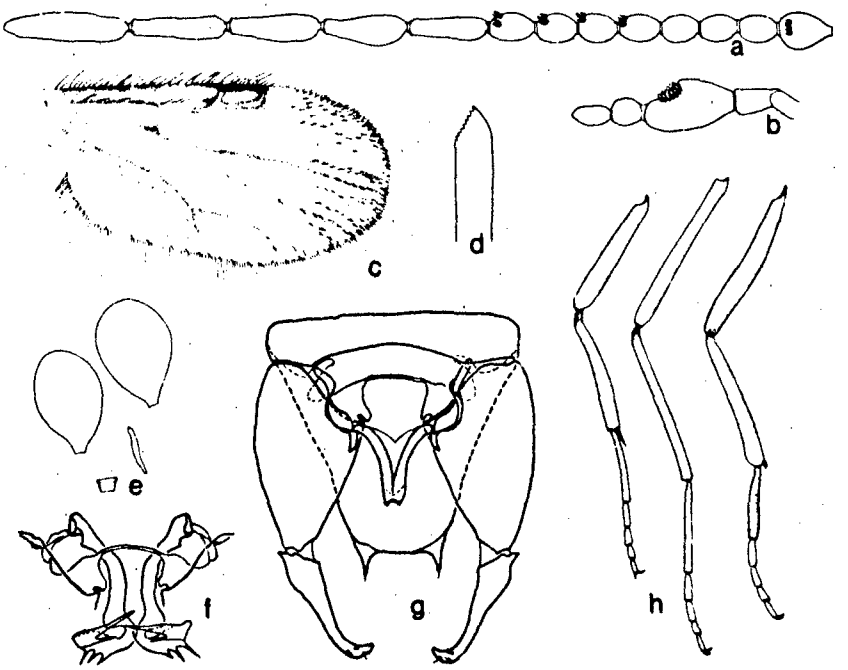


Fig. 167. *Culicoides notatus*: a. antenna; b. palpus; c. wing; d. mandible; e. spermathecae; f. parameres; g. male genitalia, parameres omitted; h. legs.

Wing (fig. 167c, 330): Pattern as figured; pale spot over r-m crossvein small, lying mostly on distal side of crossvein, broadly extending to costal margin; very dark stigmal spot extending to apex of second radial cell; cell R5 with 2 small round poststigmatic pale spots, lying at same level, one immediately posterior to the other and lying halfway between it and vein M1; distal pale spot in cell R5 wedge-shaped (sometimes round), lying obliquely across tip of cell with broad end meeting wing margin; cell M1 and 2 pale spots, the distal one narrowly meeting wing margin; cell M2 dark at base, a pale spot lying behind medial fork and one lying at nearly same level immediately anterior to mediocubital fork; 2 pale spots in distal portion of cell M2, distal one broadly meeting wing margin; cell M4 with a large pale spot in distal portion of cell and continued proximad a short way

along vein M3+4; anal cell with 2, more or less connected, pale spots in distal portion; tips of veins not pale. Macrotrichia scanty and confined to distal half or third of wing; costal ratio 0.64 (0.62-0.65, n = 8); radial cells well developed, broad and elongate, especially the second, which has a broad lumen. Halter slightly infuscated.

Abdomen: Spermathecae (fig. 167e) elongate oval with very long, slender, sclerotized necks; slightly unequal, 0.067 x 0.039 mm and 0.061 x 0.035 mm; tubelike vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 167g): Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum short and tapering, with well-developed, tapering apicolateral processes situated rather close together, caudal margin between them transverse. Basistyle with ventral root foot-shaped, toes connected by slender hyaline band, dorsal root slender; dististyle slender, tapering to bent, pointed tip. Aedeagus with broad basal arch extending to about half of total length, basal arms brace-shaped, each with sharp sclerotized spur on caudal shoulder; distal process tapering to slender, channel-like tip bent ventrad. Parameres (fig. 167f) each with small basal knob, basal portion slender, directed anterolaterad; stemlike midportion slender with distinct ventral lobe; distally slender, abruptly curved dorsad, caudad, and then ventrad, expanded subapically in a blade bearing five fringing spines and tapering distally to sharp point.

Distribution.--Indonesia, Laos, Malaysia, New Guinea, New Ireland, Philippines, Queensland.

Types.--Holotype female of *C. notatus*, Philippines, Davao, Maco, Tagum, x.1946, H. Hoogstraal and D. Heyneman, near sea level (in Field Museum of Natural History). Holotype female of *C. papuae*, Kavieng, New Ireland, 4.vi.1959 (Peters) (B.P. Bishop Museum).

Southeast Asia Records.--

INDONESIA: Sulawesi (North), Dumoga-Bone Nat. Park, 220 m (Heppner). Sumba, Kabaru, 96 km E Waingapu (Boeadi).

LAOS: Sayaboury Prov., 20 km N Sayaboury (Howarth).

MALAYSIA: Negri Sembilan, Telok Pelandok, Port Dickson (Traub).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Mindanao, Agusan, Esperanza (Yoshimoto); Davao Prov., Maco, Tagum (Hoogstraal and Heyneman, type). Negros Oriental, Dumaguete City (Quate and Yoshimoto).

Discussion.--Redescribed from a series of 11 females from Port Dickson, Malaysia, agreeing closely with the holotype from the Philippines, except that the type has the antennal ratio 1.39. A female paratype from the same locality as the type differs in other respects, mainly in having paler legs, the second palpal segment longer than the third, which is more slender than usual (Palpal ratio 2.6), and the spermathecae lack the long sclerotized necks. The illustrations and the male

description are from specimens from Laos, reared by F. Howarth from Houay La stream margin, 20 km N Sayaboury. The stream margins were partially shaded, formed when the relatively steep stream banks collapsed from erosion.

This species keys out with *similis* Carter, Ingram, and Macfie, but in *similis* the subapical pale spot is lacking in cell M2 past the mediocubital fork and the proximal pale spot in cell M1 crosses over vein M2 into cell M2, the cibarial armature is lacking, the male aedeagus is greatly attenuated distally, ending in a slender sharp point, and the caudolateral processes are lacking on the basal arch.

Culicoides parviscriptus Tokunaga
(Figs. 168, 331, 465)

Culicoides parviscriptus Tokunaga, 1959: 213 (male, female; New Britain, New Guinea; figs.); Howarth, 1985: 85 (Laos record).

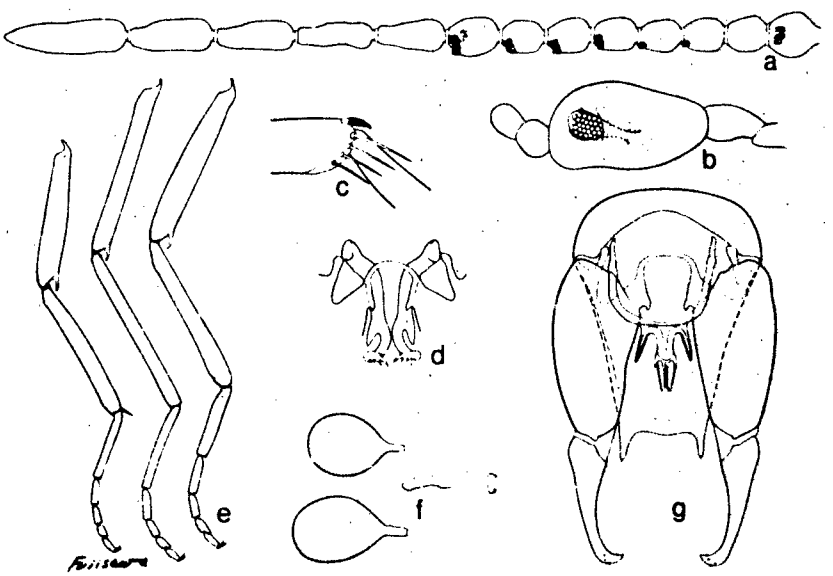


Fig. 168. *Culicoides parviscriptus*: a. antenna; b. palpus; c. tibial comb; d. parameres; e. legs; f. spermathecae; g. male genitalia, parameres omitted.

Female.--Wing length 0.88 mm.

Head: Eyes contiguous, with sparse, short, interfacetal hairs. Antenna (fig. 168a) with lengths of flagellar segments in proportion of 25-16-18-18-18-19-19-20-30-30-32-35-52, antennal ratio 1.24; sensilla coeloconica present on segments 3,5-10, sometimes absent on 5 and 6, number of pits varying from one on 5 to three on 9 and seven encircling segment 10. Palpus (fig. 168b) with lengths of segments in proportion of 10-15-48-10-10; third segment markedly swollen from base to tip, with very deep pit (half as long as segment) opening by a small distal pore; palpal ratio 1.8; fourth segment broader than long, broader than fifth. Proboscis short, P/H Ratio 0.55; mandible with 12 teeth; cibarium without armature.

Thorax: Dark brown; mesonotum with coarse, long hairs. Legs (fig. 168e) brown, knees not darkened; femora narrowly pale at bases, tibiae faintly pale at bases; hindtibial comb (fig. 168c) with 4 spines, the one nearest the spur longest.

Wing (fig. 331, 465): Pattern as figured; membrane dark gray, pale spots very distinct; round pale spot distad of r-m crossvein barely overlapping anterior portion of crossvein; poststigmatic pale spot in cell R5 forming a V with point proximad, or more or less divided into 2 separate spots, the hind one not quite touching vein M1; cell R5 with a small round spot at apex not quite reaching wing margin; cell M1 with 2 small pale spots, proximal one oval and lying in contact with vein M2, distal one not reaching wing margin; cell M2 with a pale spot lying behind midportion of medial stem, a pale spot immediately behind medial fork, a pale spot immediately in front of mediocubital fork, and a small round distal spot well separated from wing margin; cell M4 with a transverse subapical pale spot extending from vein M3+4 to wing margin; a double pale spot in distal part of anal cell, a pale spot lying near base of anal cell, and one lying immediately distad of basal arculus. Macrotrichia fairly numerous and long, extending in a line to base of cell M2, but very sparse in anal cell; costal ratio 0.58; second radial cell rather narrow, but with distinct lumen. Halter deeply infuscated.

Abdomen: Brown. Spermathecae (fig. 168f) elongate oval, with very long, slender, sclerotized necks, subequal, each 0.064 x 0.038 mm; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 168g): Ninth sternum with moderately deep caudomedian excavation, ventral membrane bare; ninth tergum long and tapering, with only moderately separated, pointed, apicolateral processes. Basistyle with ventral root foot-shaped, posterior heel poorly developed, the toes faintly joined mesad; dististyle slender, only slightly curved to bent, pointed tip. Aedeagus with high rounded basal arch reaching to half of total length (Tokunaga's figure shows a broader aspect in a severely flattened slide), the basal arms slender, with a long pair of submedian spurs on posterior side of arch near median process; the latter slender with slightly swollen midportion and truncated tip. Parameres (fig. 168d) each with small basal knob, bent near base, straight in midportion, with a very long, pointed ventral lobe; distal portion slender, flattened subapically and fringed with about 5 spines before the pointed tip.

Distribution.--Laos, Malaysia, New Britain, New Guinea, Philippines, Sabah.

Type.--Holotype male, Wum, 850 m, Jimmi Valley, New Guinea, in B.P. Bishop Museum.

Southeast Asia Records.--
LAOS: Sayaboury Prov., 22 km S Muong Phieng (Howarth).
MALAYSIA: Pahang, King George V Nat. Park, Tahan River (McClure). Perak, Gunong Besont Forest Res. (Aru). Selangor, Ulu Gombok Forest Res., reared from tree hole 42 m high in jungle canopy (McClure); reared from rotting banana tree (Manikumar); Kuala Lumpur (Hubert); Sugai Buloh Forest Res., reared from soil in tree hole (Manikumar).
PHILIPPINES: Negros Oriental, Cuernos Negros, Camp Lookout (Delfinado).
SABAH: Mt. Kinabalu, Kiau Gap (1,760 m) (Wada).

Discussion.--This species is very closely related to *C. clavipalpis* Mukerji, but differs in the longer antennal segments, with additional distal sensilla coeloconica present on segments 5-7, the poststigmatic pale wing spot does not reach caudad to vein M1, the third palpal segment has a much more extensive, deeper pit with smaller distal pore, and the male aedeagus has the submedian posterior spurs much longer.

Biology.--This is a tree hole and plant material species, having been reared twice in Malaysia from tree holes and once from a rotting banana tree.

Culicoides perornatus Delfinado
(Figs. 169, 332)

Culicoides perornatus Delfinado, 1961: (female; Philippines; figs.).
Culicoides multinotatae Tokunaga, 1962b: 475 (female; New Ireland; fig. wing). NEW SYNONYMY.

Female.--Wing length 0.95 mm.
Head: Eyes (fig. 169d) contiguous, bare. Antenna (fig. 169a) with lengths of flagellar segments in proportion of 18-8-9-9-10-10-10-10-17-17-19-21-30, antennal ratio 1.24; sensilla coeloconica present on 3,7-10, two per segment, with long picket setae. Palpus (fig. 169b) with lengths of segments in proportion of 9-16-27-11-16; third segment greatly swollen in midportion, with large, moderately deep, round sensory pit near midlength; palpal ratio 2.0. Proboscis short, P/H Ratio 0.49; mandible with 10 well-developed teeth.
Thorax: Brown; mesonotum with prominent pattern of large yellowish patches. Legs (fig. 169i) brown; knee spots blackish; fore- and midfemora with prominent subapical pale rings; tibiae with sub-basal pale rings and hindtibia with apex broadly pale; hindtibial comb (fig. 169g) with 4 spines, the one nearest spur longest.
Wing (fig. 169c, 332): Pattern as figured; large pale spot over r-m crossvein extending broadly to costal margin; very dark stigmal spot extending to apex of second radial cell; cell R5 with 2 small, sometimes fused, poststigmatic pale spots, the posterior one located slightly proximad of the other, a third small elon-

gate pale spot lying at same level just in front of vein M1, distal pale spot in cell R5 irregular in shape, occupying much of distal half of cell, shape more or less U-shaped, with a large anterior dark emargination, the arms of the "U" not quite meeting wing margin and the base of the "U" sometimes broken; cell M1 with 2 oval pale spots, distal one elongate and not quite meeting wing margin; cell M2 with a large pale spot at basal arculus involving proximal half of medial stem, a pale spot in front of midportion of mediocubital stem, one immediately behind medial fork and one immediately in front of mediocubital fork, a small pale spot lying against vein M2 just proximad of basal pale spot in cell M1, and a small pale spot just short of wing margin; cell M4 with pale spot broader next to vein M3+4, with extension proximally along vein Cu1; anal cell with 2 interconnected pale spots in distal portion and faint irregular pale area basally; tips of veins not pale. Macrotrichia sparse on distal half of wing and in distal portion of anal cell; costal ratio 0.64; radial cells well formed, both moderately broad. Halter with pale stem, knob conspicuously dark brown.

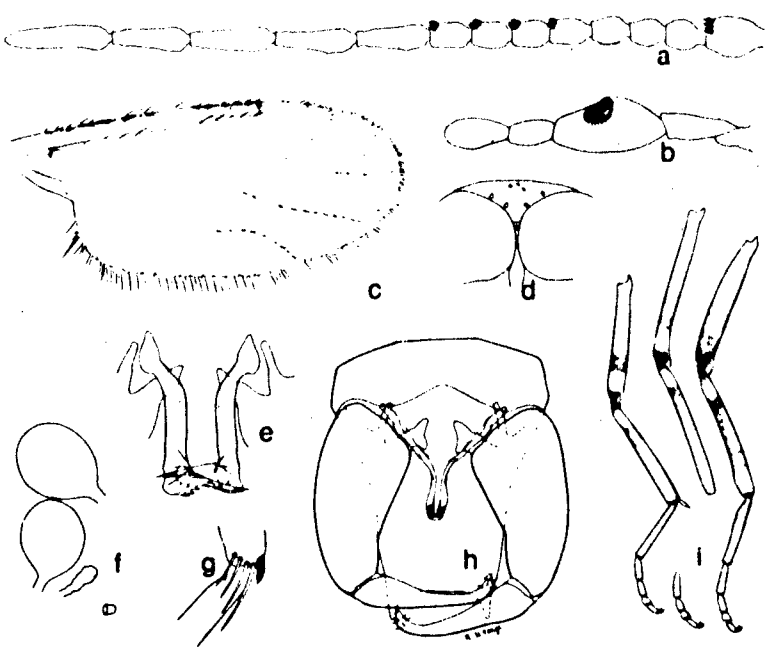


Fig. 169. *Culicoides peromatus*: a. antenna; b. palpus; c. wing; d. eye separation; e. parameres; f. spermathecae; g. tibial comb; h. male genitalia, parameres omitted; i. legs.

Abdomen: Brown. Spermathecae (fig. 169f) ovoid with long slender sclerotized necks, surface smooth; unequal, 0.062 x 0.033 mm and 0.052 x 0.033 mm; vestigial spermatheca saclike, sclerotized ring tapering.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 169h): Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum long and tapering with long pointed apicolateral processes, caudal margin between them not indented. Basistyle with ventral root bearing long posterior process and short anterior toe, dorsal root long and slender. Aedeagus with basal arch extending to half of total length, distal process with parallel sides, and simple, blunt, finely serrated tip. Parameres (fig. 169e) each with stout basal knob; slightly curved on basal portion, midportion straight and moderately stout; bearing a peculiarly shaped, flangelike ventral lobe near end of straight portion, distal portion slender and abruptly bent ventromesad and flattened and tapering to sharp distal point and bearing lateral fringing spines.

Distribution.--Indonesia, New Ireland, Philippines.

Types.--Holotype female of *perornatus*, Philippines, Mindanao, Davo, Maco, Tagum, x.1946, H. Hoogstraal and O. Heyneman, near sea level (in Field Museum of Natural History). Holotype female of *multinotatae*, New Ireland, Kavieng, 4.vi.1959, Peters (Bishop Type no. 3235).

Southeast Asia Records.--
INDONESIA: Bali, Badung, Denpasar, Pertamine Cottage at Tuban (V. Lee). Flores, Manggarai, Reo, Golok (V. Lee). West Java, Serang, Anyer Beach Hotel (V. Lee). Sulawesi (Central), Banggai, Batui, Dongin (Bambang). Sumatra, Sibolga (Ikemoto). Sumba, Waingapu Bay (Boeadi). Sumbawa, Alas (Nicholls).
PHILIPPINES: Known only from the type locality.

Discussion.--The wing pattern of this species is quite similar to that of *C. delfinadoae* in the Williwilli Group, but that species can be readily distinguished by its more extensive pale wing spots including a definite posterior connection between the poststigmatic pale spots and the apical spot in cell R5, the antennal sensillar pattern 3,10,12,14, and the shape of the spermathecae. The antennal sensillar pattern of *perornatus*, moreover, precludes its includion in the Williwilli Group.

Culicoides similis Carter, Ingram and Macfie
(Figs. 170, 333, 466)

Culicoides similis Carter, Ingram and Macfie, 1920: 255 (male, female; Gold Coast; figs.); Smith and Swaminath, 1932: 183 (Assam; on cattle); Causey, 1938: 404 (male, female; Siam; fig. male genitalia); Fiedler, 1951: 28 (S. Africa; diagnosis; figs.); Sen and Das Gupta, 1959: 618 (diagnosis; figs.; India); Clastrier, 1959: 171 (redescribed; figs.; Senegal); Clastrier, 1961: 261 (distribution; syn.: *baghdadensis*); Khamala and Kettle, 1971: 78 (diagnosis; figs.; East Africa); Howarth, 1985: 85 (pupa descr.; larval habitats; Laos).

Culicoides similis baghdadensis Khalaf, 1957: 341 (male, female; Iraq; figs. wing).

Female.--Wing length 0.87 (0.77-0.94, n = 9) mm.

Head: Eyes bare; narrowly separated, interocular space parallel-sided. Antenna (fig. 170a) with lengths of flagellar segments in proportion of 16-9-10-10-11-11-11-12-20-21-23-24-42, antennal ratio 1.41 (1.20-1.53, n = 9); sensilla coeloconica present on segments 3,5,7-10. Palpus (fig. 170b) with lengths of segments in proportion of 8-16-23-8-13; third segment moderately swollen, with broad shallow sensory pit; palpal ratio 1.9 (1.8-2.1, n = 8). Proboscis short, P/H Ratio 0.53; mandible with 10 (9-10, n = 9) small, almost vestigial teeth; cibarium with median patch of 3-6 inconspicuous spicules.

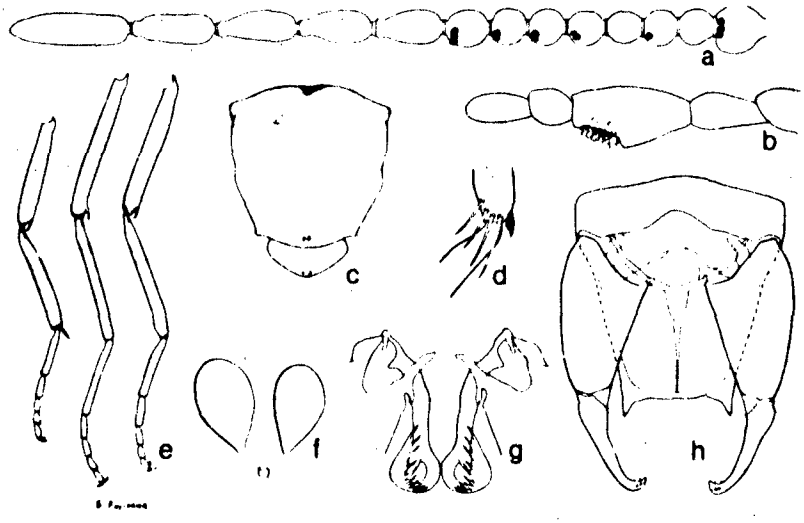


Fig. 170. *Culicoides similis*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Thorax: Dark brown; mesonotal pattern as in fig. 170c. Legs (fig. 170e) brown; knee spots blackish; femora pale basally, forefemur sometimes with faint distal pale ring; tibiae with narrow sub-basal pale rings, hindtibia pale apically; hindtibial comb (fig. 170d) with 4 (4-5, n = 10) spines, the one nearest spur longest.

Wing (fig. 333, 466): Pattern as figured; very dark spot over second radial cell; pale spot over r-m crossvein lying mostly on distal side of crossvein, extending broadly to costal margin; 2 poststigmatic pale spots in cell R5, one at anterior wing margin, second lying slightly less than halfway betwen first and vein M1, these spots may occasionally join; 1 small round pale spot in extreme tip of cell

R5; 2 oval pale spots in cell M1, proximal one broadly continued across vein M2 and a short way into cell M2, distal one at wing margin; cell M2 with pale area at base, a pale spot immediately behind medial fork, one immediately in front of mediocubital fork and a round one at wing margin at tip of cell; cell M4 with a broad pale spot extending from vein M3+4 to wing margin; anal cell with narrow pale area on anal angle and a transverse, more or less double, pale spot in distal portion of cell; tips of veins not pale. Macrotrichia fairly numerous, covering distal half of wing and extending nearly to base of anal cell; costal ratio 0.55 (0.53-0.58, n = 10); second radial cell moderately large with distinct lumen. Halter very lightly infuscated.

Abdomen: Brown. Spermathecae (fig. 170f) elongate oval, with long, slender, sclerotized necks; unequal, 0.070 x 0.039 mm and 0.063 x 0.034 mm; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 170h): Ninth sternum with moderately deep caudomedian excavation, ventral membrane not spiculate; ninth tergum long and tapering to only moderately separated, pointed apicolateral processes, caudal margin between them transverse. Basistyle with ventral root foot-shaped, posterior heel short, anterior toe long and slender; dististyle slender, only slightly curved to bent, pointed tip. Aedeagus with low and very broad basal arch, basal arms slender and curved; no spurs or points on posterior side of arch; distal process tapering gradually to long, very slender, pointed tip. Parameres (fig. 170g) each with strong basal knob; stem slender, bent at base, straight in midportion; with a moderately long ventral lobe; distal portion slender, flattened subapically and fringed with 6-8 sharp spines before the pointed tip.

Distribution.--Africa, Middle East, India, Laos, Malaysia, Thailand.

Types.--Syntypes in BMNH; from Accra and Oblogo, Gold Coast, I-iv.1920.

Southeast Asia Records.--

LAOS: Luang Prabang (Quate). Sayaboury Prov., Sayabcury (Howarth). Sedone Prov., Muong Pakse (Howarth).

MALAYSIA: Negri Sembilan, Telok Pelandok, Port Dickson (Traub).

THAILAND: Bangkok (Causey); Bangkok, Thonglo (Scanlon). Chiang Mai Prov., Chiang Mai (Notonanda). Cholburi, Bangphra (Scanlon). Khon Kaen (Manop R.). Loei Prov., Amphoe Dan Sai and Thai Li (Manop R.). Minburi (Manop R.). Nakronprathom (Manop R.). Nonthaburi (Manop R.). Samuthprakan (Manop R.).

Discussion.--*Culicoides similis* is easily recognized by the wing pattern, particularly the posterior poststigmatic pale spot in cell R5 which lies between the anterior one and vein M1, and the proximal pale spot in cell M1 which laps over vein M2 into cell M2, and by the peculiar form of the male aedeagus with its slender, sharp-pointed, distal process. We have compared our Asian material closely with a long series of specimens from Nigeria and they are identical in every respect.

Biology.--Howarth (1985) reared *C. similis* from seven sites in Laos, three from sunny margins of buffalo wallows, two from sunny margins of backwaters, one from a shaded backwater margin, and one from the sunny margin of a small stream on a gravel beach of the Nam Houng River. In West Africa, Carter et al. (1920) reared the species from debris in a leaky canoe in a river and from soft mud from the margins of pools and puddles and from a sandy river margin.

Williwilli Group

Diagnosis.--Small species. Eyes contiguous, bare (hairy in *C. murrayi*). Antennal ratio 1.08-1.55; sensory pattern distinctive, sensilla coeloconica always present on segments 3,10,12 and 14, and sometimes also on 5,7,9, or 13. Third palpal segment short and swollen, with definite or irregular pit or scattered sensilla. Mandible with very fine teeth, usually 10-12. Wing with second radial cell short, dark, costal ratio 0.59-0.64; macrotrichia sparse. Wing rarely without markings, pattern usually extensive and distinct, pale spot over r-m crossvein broad, usually extending to costal margin, cell R5 with large oval spot in distal portion, usually meeting wing margin, but sometimes anterior side of spot with dark emargination; cell M1 with 2 pale spots, distal one usually elongate and meeting wing margin; pale spot usually present in cell M2 in front of mediocubital fork, 1 or 2 pale spots between this and wing margin; cell M4 with pale spot broader anteriorly; usually a double pale spot in distal part of anal cell. Four tibial spines, the one nearest the spur longest. Two spermathecae, usually nearly equal, pyriform to oval with long, slender, sclerotized necks, surface of spermathecae usually irregularly indented; rudimentary spermatheca and sclerotized ring present. Male genitalia with ninth tergum narrowed distad with pointed apicolateral processes; ventral root of basistyle foot-shaped; aedeagus with broad basal arch with a pair of sclerotized spurs or low points on posterior side of arch near distal process, the latter usually parallel-sided; parameres separate, with rounded basal knob, fairly stout midportion with more or less developed ventral lobe distal portion slender with subapical fanlike expansion bearing lateral spines before the pointed tip.

Included Species.--Seven Oriental species. The group takes its name from the Australian species, *C. williwilli* Lee and Reye, and eight additional species have been described from Australia and New Guinea. The group is very closely related to the Clavipalpis Group (which see), but the antennal sensillar pattern and the shapes of the spermathecae are distinctive.

Biology.--Of the 7 known Southeast Asian species of this group, two have been reared: *C. palpisimilis* n. sp. was reared by Howarth (1985) from a shaded stream backwater margin in Laos, and *C. pictilis* n. sp. was reared by Manikumar from a stream bed near Kuala Lumpur, Malaysia. Freshwater stream and pond habitats seem to be characteristic of this group, since 4 species of the group have been reared from them in Australia: *austropalpalis* and *narrabeenensis* (reported by Kettle and Elson, 1976, 1978), and *narrabeenensis*, *nattaiensis*, and *williwilli* (reared by Wirth in 1956-57 in New South Wales, unpublished notes).

Culicoides cambodiensis Chu

Culicoides cambodiensis Chu, 1986: 258 (male, female; Cambodia; figs.).

Distribution.--Cambodia.

Type.--Holotype female, Kompong Som, coastal region, Cambodia, light trap, 1.iv.1976 (deposited in Department of Parasitology, Second Military Medical College, Shanghai, China).

Note.--The description of this species became available too late for the species to be included in our key or to be illustrated. The antennal sensillar pattern and structure of the male aedeagus definitely place the species as a member of the Williwilli Group, and it is distinct from the species of this group that we have studied. Numerical characters (from the original description) are: Wing length, 0.85 mm; costal ratio 0.60. Antennal ratio 1.68; antennal sensillar pattern 3,10,12,14. Palpal ratio 1.9, sensory pit shallow. P/H Ratio 0.60. Mandible with 11-12 teeth; galea with 13-14 teeth; cibarial armature bare. Hindtibial comb with 4 setae. Spermathecae ovoid with long neck, subequal, each 0.059 x 0.035 mm. Male aedeagus with well-developed sclerotized processes on posterior shoulders of basal arms, distal process elongate and parallel-sided; parameres with low ventral swelling on midportion. The species is nearly identical to *C. yasumatsui* Tokunaga but differs in the presence of 2 rather than 1 pale spots distally in the anal cell.

Culicoides delfinadoae Wirth and Hubert, new species
(Figs. 171, 334, 467)

Female.--Wing length 0.77 (0.70-0.82, n = 10) mm.

Head: Eyes bare, contiguous a short distance. Antenna (fig. 171a) with lengths of flagellar segments in proportion of 15-10-10-11-11-12-11-13-22-21-33-27-35, antennal ratio 1.34 (1.20-1.39, n = 10); sensilla coeloconica present on segments 3,10,12, and 14. Palpus (fig. 171b) with lengths in proportion of 8-19-21-9-11; third segment short and slightly swollen, with sensilla borne in an irregular concavity on distal half; palpal ratio 1.8 (1.6-2.1, n = 10). Proboscis short, P/H Ratio 0.65; mandible with 11 (9-13, n = 17) small teeth.

Thorax: Dark brown; mesonotum (fig. 171c) with prominent pattern of large pale patches. Legs (fig. 171e) brown; knee spots blackish; femora with narrow basal pale bands and on fore- and midlegs with narrow subapical pale rings; tibiae with narrow basal pale rings and on hindlegs with narrow apical pale band; hindtibial comb (fig. 171f) with 4 (n = 9) spines, the one nearest spur longest.

Wing (fig. 334, 467): Pattern as figured; large pale spot over r-m crossvein broadly attaining costal margin, with a prominent large dark spot on costal margin proximad to it and one distad, the latter extending to tip of second radial cell; distal pale spots of wing more or less interconnected, forming a zig-zag pattern of 3 transverse bands; veins M1 and M2 pale-margined for a considerable distance in midportions; cell R5 with poststigmatic pale spot extending caudad to vein M1 and also proximad behind radial cells to pale spot over r-m crossvein, distal pale

spot in cell R5 irregular and occupying most of distal half of cell, extending to wing margin in 2 places but emarginated by a small dark spot on wing margin anterodistally giving the pale spot a round U-shape; 2 pale spots in cell M1, proximal one continuous with pale margin of vein M2, distal one elongate and extending to wing margin; cell M2 with basal portion extensively pale including a pale spot behind medial fork and one immediately in front of mediocubital fork, only 1 pale spot past mediocubital fork, at wing margin; cell M4 with large pale spot extending across midportion of cell; anal cell with 2 pale spots more or less connected in distal portion, and an indistinct, irregular pale area in basal portion and along caudal margin; tips of veins not pale. Macrotrichia sparse and confined to distal third of wing; costal ratio 0.60 (0.59-0.62, $n = 10$); second radial cell moderately broad with distinct lumen. Halter infuscated.

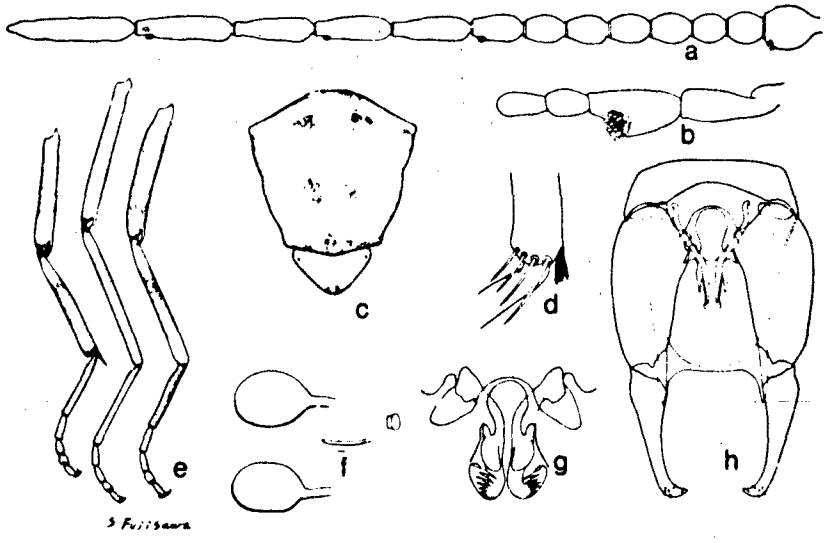


Fig. 171. *Culicoides dellinadoae*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Abdomen: Brown. Spermathecae (fig. 171g) irregularly elongate oval, with very long, slender, sclerotized necks, surface with marked, irregular indentations; subequal, each 0.049 x 0.027 mm; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 171h): Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum quite long and only slightly tapering distally, with large, pointed, widely separated, apicolateral processes. Basistyle with ventral root foot-shaped, with long, subequally developed, posterior heel and anterior toe, dorsal root long and blunt; dististyle slender with bent pointed tip. Aedeagus with basal arch high and rounded, extending to about half of total length, basal arms each with short sclerotized posterior point near junction with distal process; the latter parallel-sided with blunt tip. Parameres (fig. 171g) each with large basal knob; stem slightly bent at base, moderately stout and straight in midportion, with a low ventral lobe; slender and abruptly bent ventrad and then mesad, distally flattened, with a lateral fringe of about seven long, sharp spines toward the pointed tip.

Distribution.--Philippines, Sabah.

Types.--Holotype female, Labuan Island, Sabah, x.1951, D.H. Colless, at light (Type in USNM). Allotype male, same data except ix-xi.1948. Paratypes, 2 males, 58 females, as follows:

PHILIPPINES: Palawan, Brookes Point, Uring Uring, 21.viii.1961, Noona Dan Exped., 1 female (COP); Ransang River, 12.i.1960, L.W. Quate, at light, 4 females (BISH).

SABAH: Same data except dates i-xi.1948-1952, 2 males, 53 females.

Discussion.--We take great pleasure in naming this species in honor of Dr. Mercedes Delfinado Baker in recognition of her outstanding work in revising the species of *Culicoides* occurring in the Philippines (Delfinado, 1961).

Culicoides delfinadoae is a typical member of the Williwilli Group as shown by the wing pattern, antennal sensillar pattern and male genitalia. The shape of the distal pale spot in cell R5 is similar in *delfinadoae*, *pictilis*, *cemicircum* Tokunaga, and *williwilli* Lee and Reye, but in *williwilli* this spot entirely encloses a small dark spot. *Culicoides semicircum* differs in the semicircular shape of this pale area butin the other species it is more crescent shaped. Otherwise *semicircum* closely resembles *delfinadoae* but has but one functional spermatheca, and the male aedeagus lacks the sclerotized posterior points on the shoulder. The palpal pit is definitely round in *semicircum* and *williwilli*, but irregularly open in *delfinadoae*.

Culicoides murrayi Wirth and Hubert, new species
(Figs. 172, 335, 468)

Female.--Wing length 0.78 mm.

Head: Eyes contiguous a distance equal to diameter of three facets, with long interfacetal hairs. Antenna (fig. 179a) with lengths of flagellar segments in proportion of 22-15-15-15-15-16-16-18-35-33-35-40-53, antennal ratio 1.49; sensilla coeloconica present on segments 3,10,12,14. Palpus (fig. 172c) with lengths of segments in proportion of 8-22-33-14-16; third segment moderately swollen, with round shallow sensory pit; palpal ratio 1.8. Proboscis short, P/H Ratio 0.62; mandible with 9 teeth.

Thorax: Moderately dark brown, without pattern visible in slide-mounted specimens. Legs (fig. 172e) pale brown, knee spots indistinctly darker; hindtibial comb (fig. 172d) with 4 spines, the one nearest the spur longest.

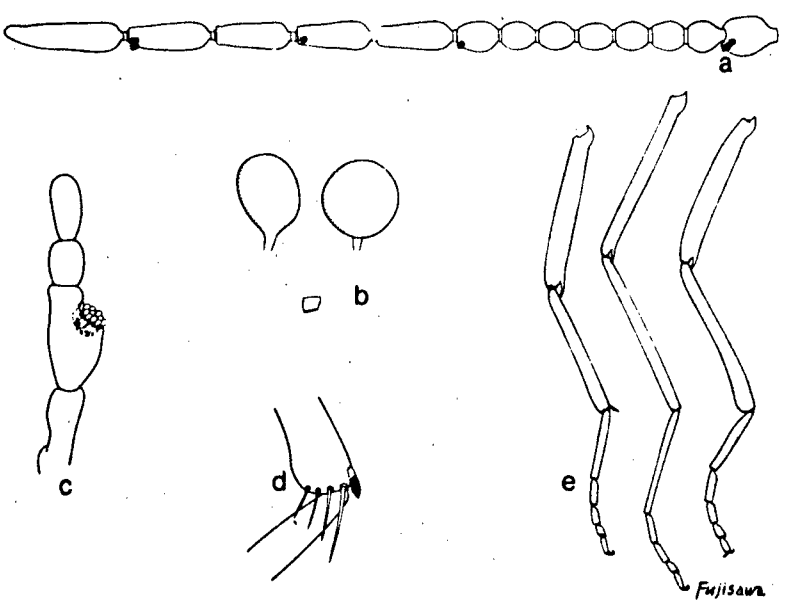


Fig. 172. *Culicoides murrayi*: a. antenna; b. spermathecae; c. palpus; d. tibial comb; e. legs.

Wing (fig. 335, 468): Uniformly grayish brown, without pale markings, area over radial cells indistinctly darker; macrotrichia sparse and confined to apices of cells M5, M1, and M2; radial cells moderately broad, with distinct lumens; costal ratio 0.60. Halter very slightly infuscated.

Abdomen: Pale brown. Spermathecae (fig. 172b) broad sclerotized ring present, vestigial third reduced to a threadlike filament; functional spermathecae with long slender necks; unequal, 0.048 x 0.036 mm and 0.043 x 0.029 mm.

Male.--Unknown.

Distribution.--Indonesia.

Types.--Holotype female, 1 female paratype, Waingapu Bay, Sumba, Indonesia 20.x.1969, Boeadi collector (deposited in Australian National Collection, Canberra). Paratypes, 2 females: Flores, Manggarai, Reo, Robek, Gincu, 26-27.vii.1979, light trap, V.H. Lee, 1 female. Sumatra, Sibolga, 24.xi.1980, T. Ikemoto, 1 female (Tokyo).

Discussion.--This species is dedicated to M. Durno Murray of the CSIRO McMaster Laboratory, Sydney, Australia, in appreciation of his interest in Australasian biting midges, and his valuable assistance in placing at our disposal for study a fine collection of Indonesian *Culicoides*.

Culicoides leei Tokunaga from New Guinea resembles *murrayi* in size, color, and its unmarked wing, but in *leei* the eyes are bare and moderately separated, the antennal sensory pattern is usually 3,5,7,9,11-14, there are 5 spines in the tibial comb, and the spermathecae are larger and more strongly sclerotized.

Culicoides palpisimilis Wirth and Hubert, new species
(Figs. 173, 336, 469)

Culicoides species J; Howarth, 1985: 86 (pupa descr.; Laos).

Female.--Wing length 0.79 (0.73-0.84, n = 5) mm.

Head: Eyes narrowly separated, bare. Antenna (fig. 173a) with lengths of flagellar segments in proportion of 18-11-11-13-13-12-13-14-21-22-23-26-32, antennal ratio 1.15 (1.08-1.18, n = 4); sensilla coeloconica present on segments 3,10,12,14. Palpus (fig. 173b) with lengths of segments in proportion of 6-17-19-9-9; third segment slightly swollen, with a small deep pit opening by a slightly smaller pore; palpal ratio 2.1 (2.0-2.3, n = 4). Proboscis moderately short, P/H Ratio 0.72; mandible with 11 (10-13, n = 10) well-developed teeth; cibarium without armature.

Thorax: Dark brown; mesonotal pattern not apparent in slide-mounted specimens. Legs (fig. 173e) dark brown; knee spots blackish; fore- and mid-femora with subapical and all tibiae with sub-basal, narrow pale rings; apex of hindtibia pale; hindtibial comb (fig. 173d) with 4 (4-5, n = 5) spines, the one nearest the spur longest.

Wing (fig. 336, 469): Pattern as figured; very dark spot over radial cells; small pale spot over r-m crossvein, lying mostly on distal side of crossvein and extending to costal margin; 2 small, well separated, poststigmatic pale spots in cell R5, the anterior one lying at end of costa on wing margin, the other located directly behind it and resting on anterior side of vein M1; small round pale spot at extreme tip of cell R5 but not quite touching wing margin; 2 pale spots in cell M1, proximal one usually lapping slightly over vein M2 into cell M2, the distal one not quite meeting wing margin; cell M2 with a pale spot at wing base, one behind medial fork, one in front of mediocubital fork, and one at extreme tip of cell not quite meeting wing margin; cell M4 with a pale spot extending from vein M3+4 to wing margin; anal cell with a pale spot at basal angle and 2 spots in distal portion of cell; no pale spots at tips of veins. Macrotrichia very sparse and confined to distal half of wing; costal ratio 0.59 (0.58-0.60, n = 5); second radial cell small with small lumen. Halter pale.

Abdomen: Dark brown. Spermathecae (fig. 173c) ovoid with very long, slender, sclerotized necks about half as long as spermatheca; unequal, 0.061 x 0.033 mm and 0.050 x 0.027 mm; vestigial third spermatheca and sclerotized ring present.

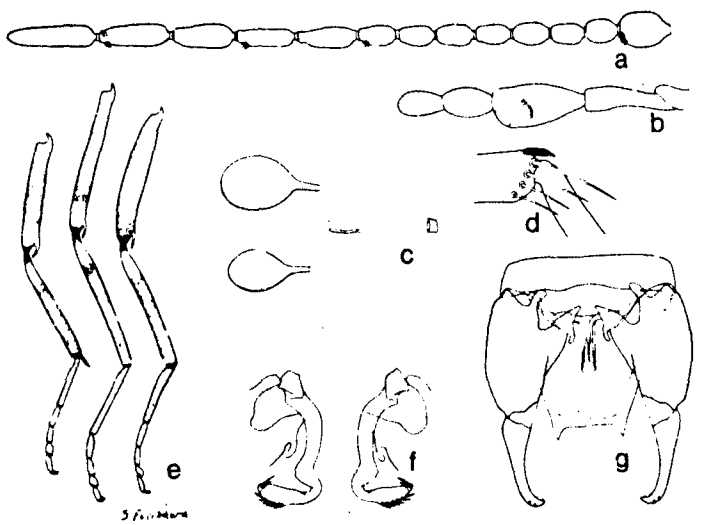


Fig. 173. *Culicoides palpisimilis*: a. antenna; b. palpus; c. spermathecae; d. tibial comb; e. legs; f. parameres; g. male genitalia, parameres omitted

Male.--Similar to female with usual sexual differences. Genitalia (fig. 173g): Ninth sternum without caudomedian excavation, ventral membrane not spiculate; ninth tergum tapering to small, narrowly separated, pointed, apicolateral processes. Basistyle with ventral root foot-shaped, posterior heel long, anterior toe short; dististyle slender, curved to bent, pointed tip. Aedeagus with low broad basal arch, basal arms each with a markedly thickened, sublateral, posterior sclerotization in place of the usual spur; distal process slender, parallel-sided to somewhat broader distally, with blunt tip. Parameres (fig. 173f) each with small basal knob; stem curved from basal portion, with low ventral lobe; distal portion slender, then broadly expanded and flattened distally with a lateral fringe of about seven very small spinose points.

Distribution.--Indonesia, Laos, Malaysia, Sabah.

Types.--Holotype female, allotype male, Malaysia, Selangor, Kuala Lumpur, iii.1958, R. Traub, light trap (Type in USNM). Paratypes, 2 males, 12 females as follows:

INDONESIA: West Java, Ujung Kulon 2.v.1980, V.H. Lee, light trap, 1 female.
LAOS: Sayaboury Prov., Muong Sayaboury, reared, backwater river margin, 7.i.1968, F.G. Howarth, 1 female.
MALAYSIA: Same data as types, 1 male, 7 females. Selangor, Ulu Gombak Forest Reserve, 6.x.1961, R.D. Soosai, light trap, 1 female. Trengganu, Dungun, Bukit Besi, 6.viii.1958, R. Traub, light trap, 1 male, 1 female.
SABAH: Sandakan, 28.vi.1982, Y. Wada, 1 female (Tokyo).

Discussion.--The wing pattern of *C. palpisimilis* is nearly identical with that of *C. huffi* Causey, but the pale spot over the crossvein extends very slightly proximad of the crossvein and the proximal pale spot in cell M1 usually laps over into cell M2 as in *C. similis* Carter, Ingram and Macfie. The slender third palpal segment with small deep sensory pit and the antennal sensory pattern of *palpisimilis* are quite distinctive, as are the posterior sclerotized swellings on the basal arch of the male aedeagus, which replace the sharp spurs found in some species of the Clavipalpis Group.

Biology.--Howarth (1985) reared this species in Laos from the shaded margin of a backwater of the Nam Huong River.

Culicoides pictilis Wirth and Hubert, new species
(Figs. 174, 337)

Female.--Wing length 0.95 mm, breadth 0.45 mm.
Head: Dark brown. Eyes contiguous for a distance equal to diameter of five facets; bare. Antenna (fig. 174a) dark brown throughout; with lengths of flagellar segments in proportion of 30-23-24-24-25-25-27-27-36-37-40-40-50, antennal ratio 0.99; sensilla coeloconica present on segments 3,10,12-14, with prominent long setae, segment 14 nearly ringed by six sensilla. Palpus (fig. 174b) with lengths of segments in proportion of 6-26-33-10-20, second segment especially long and slender; third segment moderately swollen distally, with an apical round shallow sensory pit; palpal ratio 2.0. Proboscis short, P/H Ratio 0.62; mandible with 10-11 minute teeth.
Thorax: Dark brown, mesonotum without paler markings, scutellum yellowish brown. Legs (fig. 174d) brown; foretibia with narrow basal pale ring; midknee slightly paler on femur and tibia; hindknee dark brown, tibia with basal pale ring; hindtibial comb (fig. 174f) with 4 spines, the one nearest spur longest.
Wing (fig. 174c, 337): Pattern as figured; pattern unusually conspicuous because of the coarse blackish microtrichia over all dark portions of wing; stigma not especially darkened, second radial cell pale over veins at extreme tip; pale spot over r-m crossvein transverse, extending broadly from costal margin to media; poststigmatic pale spot irregularly transverse, forming a double spot, proximally involving the vein closing second radial cell distally, with a narrow pale line extending proximad behind vein R4+5 to base of second radial cell, not reaching vein M1 caudad; a separate elongate pale spot resting on vein M1 almost reaching pale spot over r-m crossvein; cell R5 with a subapical transverse pale mark joining a pale arcuate mark lying in front of apex of vein M1 and extending nearly to wing margin; cell M1 with 2 elongated pale spots, distal one not

meeting wing margin; cell M2 with small pale spot at basal arculus, a small pale spot resting on midportion of mediocubital stem, a small oval pale spot behind medial fork and a similar one in front of mediocubital fork, a pale streaklike spot resting against vein M2 just behind proximal pale spot in cell M1, and a rounded pale spot in apex of cell not quite meeting wing margin; cell M4 with a prominent C-shaped pale mark with its side and one arm lying along vein M3+4 and Cu1 filling mediocubital fork, the second arm turning caudad short of tip of vein M3+4 and extending across cell subapically to meet posterior wing margin; anal cell with irregular pale area at base and a pair of small round pale spots in distal portion, the posterior spot of the pair lying on posterior wing margin; tips of veins not pale. Macrotrichia sparse, confined to distal third of wing; costal ratio 0.65; second radial cell broad with broad lumen. Halter slightly infuscated, grayish.

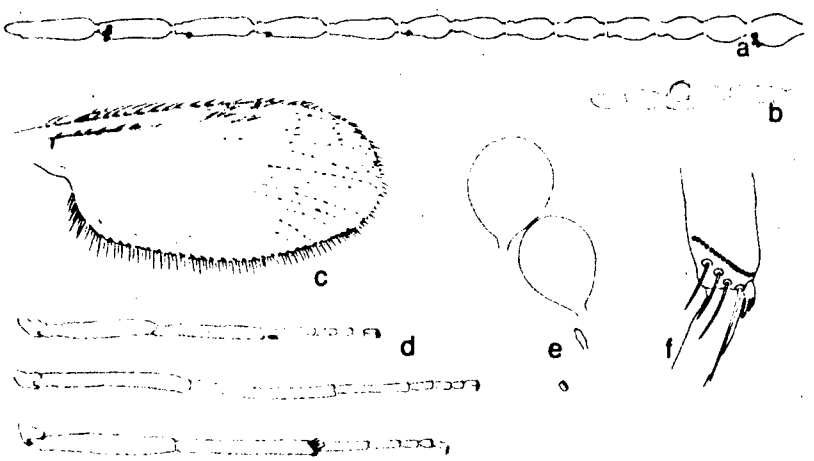


Fig. 174. *Culicoides pictilis*: a. antenna; b. palpus; c. wing; d. legs; e. spermathecae; f. tibial comb.

Abdomen: Brown. Spermathecae (fig. 274e) ovoid with short slender necks, deep brown in shade; slightly unequal, 0.058 x 0.043 mm and 0.054 x 0.039 mm including necks; vestigial third spermatheca and sclerotized ring present.

Male.--Unknown.

Distribution.--Malaysia.

Type.--Holotype female, Malaysia, Selangor, Kuala Lumpur, Ulu Langat, 5.vii.1961, C. Manikumar, reared from stream bed (Type in USNM).

Discussion.--This species is superficially similar to *C. perornatus* Delfinado, with very similar wing pattern, but in *perornatus* the second radial cell is dark to the tip, the microtrichia are not coarse and highly contrasting, the proximal pale spot in cell R5 resting on vein M1 is not located so far proximad, and the distal arcuate pale mark is arranged differently, while the mesonotum has a definite pale pattern, the halter knobs are dark brown, the pale leg bands are more prominent with the hindtibia pale at tip, and the antennal sensillar pattern 3,7-10 is typical of the Clavipalpis Group. The species *pictilis* takes its name from the prominent picture-like wing markings.

Culicoides pseudopalpalis Wirth and Hubert, new species
(Figs. 175, 338, 470)

Female.--Wing length 0.74 mm.

Head: Eyes bare, contiguous. Antenna (fig. 175a) with lengths of flagellar segments in proportion of 20-12-12-12-13-13-13-15-25-28-28-28-45, antennal ratio 1.40; sensilla coeloconica present on segments 3-14. Palpus (fig. 175d) with lengths in proportion of 8-15-35-10-13; third segment greatly swollen bulbously, with moderately deep pit opening by a large round pore; palpal ratio 1.6. Proboscis short, P/H Ratio 0.57; mandible with 8-10 vestigial, scarcely visible teeth.

Thorax: Dark brown, mesonotal pattern not apparent in slide-mounted specimens. Legs (fig. 175g) pale brown, knee spots blackish; fore- and midfemora with subapical, and tibiae with basal, narrow pale rings; midtibia paler at tip and hindtibia with subapical pale ring; tibial comb (fig. 175c) with 4 spines, the one nearest spur longest.

Wing (fig. 338, 470): Pattern as figured; pale spots small and moderately distinct; pale spot over r-m crossvein; a small, nearly transverse, poststigmatic pale spot in cell R5, not meeting vein M1; distal pale spot in cell R5 longitudinally oval, lying subapically in cell closer to vein M1 than to anterior wing margin; cell M1 with 2 oval pale spots, distal one nearly meeting wing margin; cell M2 with a pale spot near basal arculus, a small pale spot lying behind medial fork, none ahead of mediocubital fork, and a round pale spot at wing margin in tip of cell; cell M4 with a round pale spot at wing margin in tip of cell; anal cell with a pale spot lying behind stem of MCu and a single large pale spot in distal portion of cell. Macrotrichia sparse, confined to distal third of wing and a few extending into anal cell; costal ratio 0.53; radial cells short, second with distinct lumen. Halter pale.

Abdomen: Pale brown. Spermathecae (fig. 175b) elongate oval with long slender necks; subequal, each 0.046 (plus 0.012 neck) x 0.036 mm; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 175g): Ninth sternum without distinct caudomedian excavation, ventral membrane not spiculate; ninth tergum short and tapering to large, pointed apicolateral processes. Basistyle with ventral root foot-shaped, posterior heel short, anterior toe long and slender, dorsal root short and slender; dististyle slender with bent, pointed tip. Aedeagus with low, broad, basal arch, caudolateral shoulders each with a strongly sclerotized spurlike process similar to those of Clavipalpis Group

of species; distal portion tapering to slender process with serrate tip. Parameres (fig. 175f) each with sclerotized basal knob, curved on basal portion, midportion slightly sinuate to nearly straight, without distinct ventral lobe, distal portion slender, abruptly bent ventromesad and ending in sharp point with lateral fringing spines.

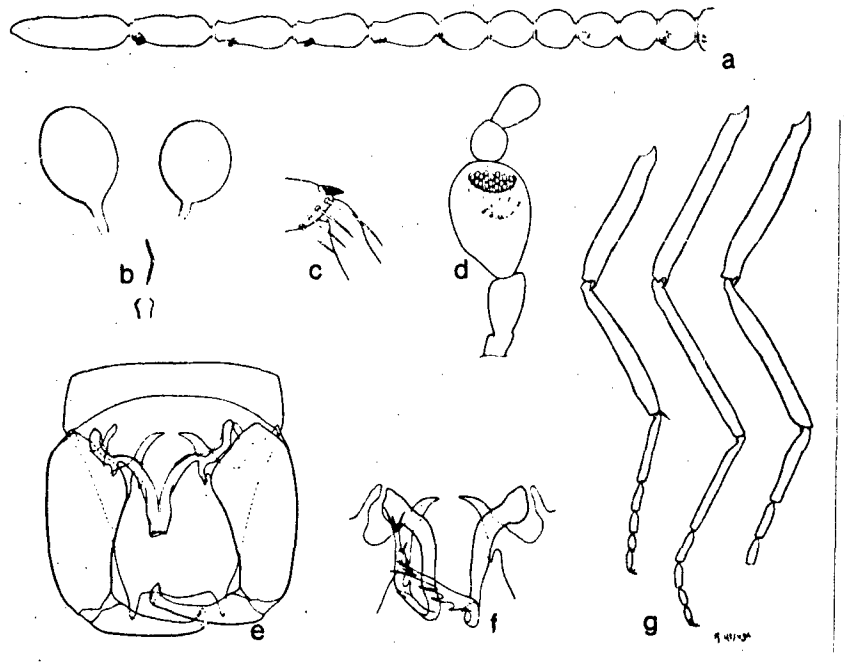


Fig. 175. *Culicoides pseudopalpalis*: a. antenna; b. spermathecae; c. tibial comb; d. palpus; e. male genitalia, parameres omitted; f. parameres; g. legs.

Distribution.--Indonesia.

Types.--Holotype female, allotype male, Indonesia, Sumbawa, 22.x.1969, D.G. Nicholls, light trap (deposited in Australian National Insect Collection, Canberra). Paratypes, 7 males, 24 females, as follows:

INDONESIA: Bali, Badung, Mengwi, 13-14.iii.1980, V.H. Lee, light trap, 1 female; Pedang Bay, 35 km NE Denpasar, 17.x.1969, D.G. Nicholls, light trap, 1 male, 8 females. Flores, Manggarai, Nangalili, Wai Jamal near Padang, 5-6.xii.1977, V.H. Lee, light trap, 1 female. East Lombok, Selong, Kerekong, 11-12.v.1978, V.H. Lee, light trap, 1 female. Sumbawa, same data as types, 6 males, 13 females.

Discussion.--Culicoides autropalpalis from eastern Australia is very similar to *pseudopalpalis* but is a much larger species (wing length 0.92 mm), the antennal sensory pattern is quite consistently 3,11-13, the pit on the third palpal segment is deeper and the pore is smaller, and the wing macrotrichia are much more numerous. Some of the New Guinea specimens reported by Tokunaga (1962b) as *palpalis* Lee and Reye (those having sensilla on antennal segment 14) may represent *pseudopalpalis*.

Culicoides yasumatsui Tokunaga
(Figs. 176, 339, 471)

Culicoides yasumatsui Tokunaga, 1941: 113 (male; Caroline Islands; fig. wing, palpus. male genitalia); Tokunaga and Murachi, 1959: 332 (male, female described; fig. male genitalia; Caroline Islands, distr.).
Culicoides lingensis Tokunaga, 1963c: 129 (female; New Britain; fig. wing). NEW SYNONYMY.

Female.--Wing length 0.86 (0.81-0.95, n = 10) mm.

Head: Eyes bare, contiguous. Antenna (fig. 176a) with lengths of flagellar segments in proportion of 20-10-11-11-12-12-12-13-26-27-29-30-41, antennal ratio 1.55 (1.49-1.62, n = 10); sensilla coeloconica present on segments 3,10,12,14 (sometimes also present on 5,7 and/or 9). Palpus (fig. 176b) with lengths of segments in proportion of 11-18-24-10-12; third segment short and moderately swollen, with sensilla scattered on a slight concavity on distal half of segment; palpal ratio 1.8 (1.6-2.0, n = 10). Proboscis moderately short, P/H Ratio 0.65; mandible with 10 (9-12, n = 20) small teeth.

Thorax: Dark brown; mesonotum with pattern of large pale areas. Legs (fig. 176e) dark brown; knee spots blackish; on fore- and midlegs femora with narrow basal and tibiae with narrow basal and subapical pale rings; hindtibia with narrow basal and distal pale ring; hindtibial comb (fig. 176d) with 4 (n = 8) spines, the one nearest spur longest.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 176g): Ninth sternum without caudomedian excavation, ventral membrane not spiculate; ninth tergum long and tapering to rather narrowly separated, pointed apicolateral processes, caudal margin between them transverse. Basistyle with ventral root foot-shaped, posterior heel and anterior toe equally developed, dorsal root long and blunt; dististyle slender, curved slightly to the bent, pointed tip. Aedeagus with moderately broad basal arch extending to about half of total length, a submedian pair of moderately long, well sclerotized spurs on posterior side of arch; distal process parallel-sided, with truncated, somewhat serrate tip. Parameres (fig. 176f) each with strong basal knob; stem moderately stout, slightly bent at base, nearly straight in midportion, with low, rounded, hyaline ventral lobe; slender distally and bent ventrad to a flattened subapical part bearing a fringe of 7-8 long, sharp spines of increasing lengths toward the mesally bent, pointed tip.

Distribution.--Indonesia, Malaysia, New Britain, New Hebrides, Sabah, Sarawak, Singapore, Thailand.

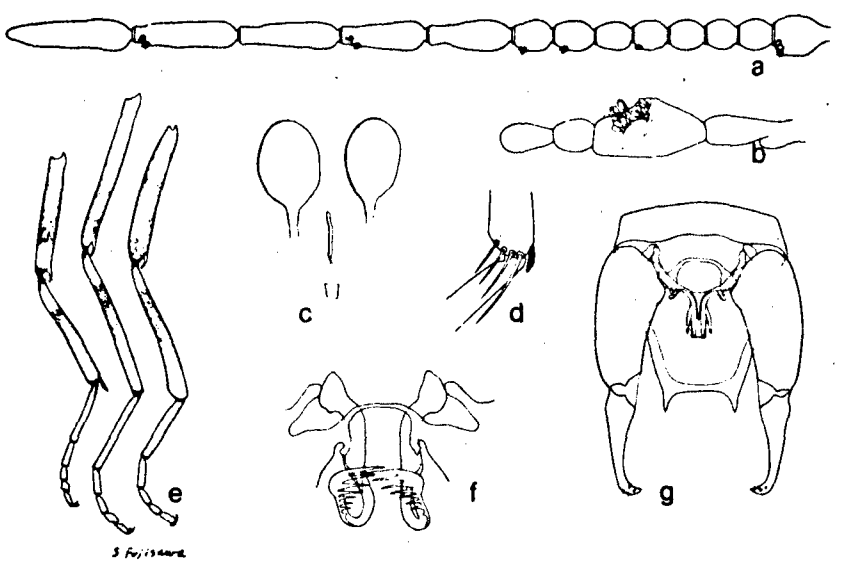


Fig. 176. *Culicoides yasumatsui*: a. antenna; b. palpus; c. spermathecae; d. tibial comb; e. legs; f. parameres; g. male genitalia, parameres omitted.

Types.--Syntype males and females of *yasumatsui*, Caroline Islands, Truk Group, Pata I., Satote-Epin, iv.1940, S. Yoshimura and K. Yasumatsu (in coll. Kyoto Univ., Japan). Holotype female of *lingensis*, Linga Linga Plantation, Willaumez Pen., New Britain, 10.iv.1956, J.L. Gressitt, light trap (Type in B.P. Bishop Museum).

Southeast Asia Records.--

INDONESIA: Flores, Manggarai, Reo, Golok and Gincu (Lee). Java (Central), Cilacap, Adipala, Bunton (Lee); (West) Garut, Pameungpeuk (Zubaedah); Pandeglang, Ujung Kulon (Watters); Serang, Anyer Beach Hotel (Lee, biting man). Sulawesi (Central), Ganggai, Batui, Kamiwangi and Dongin, 17.v.1978 (Lee). Sumba, Waingapu Bay (Boeadi). Sumbawa (Nicholls).

MALAYSIA: Pahang, Kuantan, Telok Sisek (Wharton). Kedah, Langkaw Island (Traub). Perak, Pulau Pangkor (Traub).

SABAH: Labuan Island (Colless).

SARAWAK: Santubong (Maa).

SINGAPORE: Pasir Panjang (Colless)
THAILAND: Phangnga Prov., Pulau Panjang (collector unknown).

Discussion.--The antennal sensory pattern of 3,10,12,14, general wing pattern, spermathecal shape, and structure of the male genitalia, particularly the posterior spurs on the basal arch of the aedeagus, ally *C. yasumatsui* with *delfinadoae* n. sp. which, however, has the distal pale wing spot emarginated anterodistally.

Schultzei Group

Culicoides schultzei Group; Khamala and Kettle, 1971: 10 (Gutsevich, 1973: 123; Wada and Kitaoka, 1977: 172.
Culicoides subgenus *Remmia* Glukhova, 1977: 116. Type-species, *Ceratopogon schultzei* Enderlein (orig. desig.).

Diagnosis.--Medium size species with moderately hairy wings; wing with numerous distinct pale spots including pale spot over r-m crossvein centering on the vein; cell M2 with pale spot in front of mediocubital fork, behind medial fork and a subapical pale spot just past mediocubital fork. Second radial cell with apex in a very dark spot forming a stigma; radial cells not completely formed. Eyes usually bare, moderately separated. Antennal sensillar pattern 3,7-10 or 3,8-10. Third palpal segment short and moderately swollen, with round, moderately deep, sensory pit not opening by a smaller pore. Mandible 12 fine teeth. Legs dark, knee spots dark, femora with subapical and tibiae with subbasal pale rings; hindtibial comb with 4 spines, the one nearest the spur longest. Spermathecae 2 plus vestigial third and sclerotized ring, ovoid with well-developed slender sclerotized necks. Male genitalia with ninth tergum short and tapering to long, pointed, usually approximated, apicolateral processes; basistyle short and stout, without strong spines on mesal surface, with long slender dorsal roots; dististyle slender and pointed at tip; aedeagus with high basal arch, basal arms nearly straight, without sharp caudal processes on shoulders, distal process simple, moderately short and stout; parameres separate, with moderately developed basal knob, midportion slender without ventral lobe, tapering to slender tip bearing minute apical hairs (not lateral fringing spines).

Included Species.--One Oriental species. Khamala and Kettle (1971) placed 3 species in this group in East Africa: *schultzei*, *kingi* Austen, and *rhizophorensis* Khamala and Kettle. Glukhova (1977), in erecting the subgenus *Remmia* for *C. schultzei* and comparing *Remmia* with *Oecacta* Poey assumed diagnostic characters for *Oecacta* that are not based on the type-species *furens* (Poey). We cannot find significant characters for a subgeneric separation of *Remmia* from *Oecacta*, and moreover since *Oecacta* has served as such a dumping ground for species with the second radial cell ending in a dark spot we prefer to work on species group level in this section of the genus without assigning species to a definite subgenus.

Biology.--One Southeast Asian species has been reared: *C. oxystoma* Kieffer, a common and widespread species in unspecialized aquatic and semi-aquatic sites such as exposed margins of streams, drains, ponds and puddles low in organic matter and fairly rich in oxygen. It is a biting pest of man and domestic animals, especially cattle.

Culicoides oxystoma Kieffer
(Figs. 177, 340, 472)

Culicoides oxystoma Kieffer, 1910: 193 (female; Calcutta; fig. palpus, proboscis); Edwards, 1922: 164 (Malaya, India; descr. notes; fig. wing); Smith and Swaminath, 1932: 183 (Assam); Tokunaga, 1937: 295 (Japan, Formosa; redescribed; figs.); Buckley, 1938: 145 (Malaya; biology; vector cattle filaria); Causey, 1938: 406 (Siam; descr. notes; fig. male genitalia); Macfie, 1941: 69 (Malaya; descr. notes); Tokunaga, 1950: 65 (Japan; variation): Arnaud, 1956: 120 (Japan; redescribed; figs.; distribution); Howarth, 1985: 68 (Laos, pupa described).

Culicoides kiefferi Patton, 1913: 336 (all stages; Madras; fig. larva, pupa, female, legs, male antenna).

Culicoides mesopotamiensis Patton, 1920: 246 (Mesopotamia; female; fig. habitus); Khalaf, 1957: 338 (compared with *schultzei*).

Culicoides pattoni Kieffer, 1921c: 7 (new name for *C. kiefferi* Patton 1913 not Goetghebuer 1910).

Culicoides housei Causey, 1938: 407 (Siam; male; fig. wing, genitalia).

Culicoides punctigerus Tokunaga, 1951: 101 (male, female; Java; fig. wing, male genitalia).

Culicoides alatus Das Gupta and Ghosh, 1956c: 162 (male, female; Calcutta); Sen and Das Gupta, 1959: 617 (redescribed; figs.); Das Gupta and Ghosh, 1961: 118 (comparative notes).

Culicoides schultzei (Enderlein), misident.; Okada, 1954: 5 (N. China, Manchuria, Korea; syn. *oxystoma* K.); Khalaf, 1957: 336 (Iraq; redescribed; notes on possible synonyms: *oxystoma*, *kingi*, *kiefferi*, *pattoni*, *mesopotamiensis*); Tokunaga, 1959: 210 (New Guinea; male, female redescribed; figs.; syns.: *oxystoma*, *kiefferi*, *punctigerus*); Wirth and Hubert, 1961: 22 (Taiwan; syns.: *oxystoma*, *kiefferi*, *pattoni*, *housei*, *punctigerus*, *alatus*; descr. notes); Delfinado, 1961: 653 (Philippines; fig. wing); Hubert and Wirth, 1961: 236 (Okinawa I.; in key); Tokunaga, 1962b: 482 (New Guinea; fig. male genitalia); Kitaoka et al., 1963: 52 (Japan; biting cattle; fig. female habitus); Kitaoka and Morii, 1963: 198 (breeding habitats; Japan); Murray and Dyce, 1970: 44 (Australia N. Terr.; feeding); McDonald and Lu, 1972: 414 (female diagnosis; figs.; Taiwan); Standfast and Dyce, 1972: 225 (Australia; potential arbovirus vector); McDonald et al., 1973: 646 (female diagnosis; figs.; Okinawa); Sun, 1974: 71 (Taiwan; laboratory colonization); Murray, 1975: 216 (summary of biology; distribution map; vector potential); Kitaoka, 1977: 196 (Nansei Islands); Debenham, 1978: 258 (bibliography; summary of biology, vector status); Lee, 1978: 95 (Rep. China; diagnosis; figs.); Muller et al., 1981: 578 (Australia; female blood meal sources.

Female.--Wing length 0.96 (0.72-1.11, n = 22) mm.

Head: Eyes (fig. 177h) broadly separated, bare. Antenna (fig. 177a) with lengths of flagellar segments in proportion of 18-12-12-12-12-12-13-14-19-19-21-22-28, antennal ratio 1.03 (0.96-1.11, n = 16); sensilla coeloconica present on segments 3,8-10. Palpus (fig. 177b) with lengths in proportion of 10-24-24-12-13; third segment short and moderately stout, with a broad, moderately deep, sensory pit; palpal ratio 2.1 (1.9-2.4, n = 19). Proboscis (fig. 177h) moderately short, P/H Ratio 0.67; mandible (fig. 177e) with 12 (10-15, n = 43) well-developed teeth.

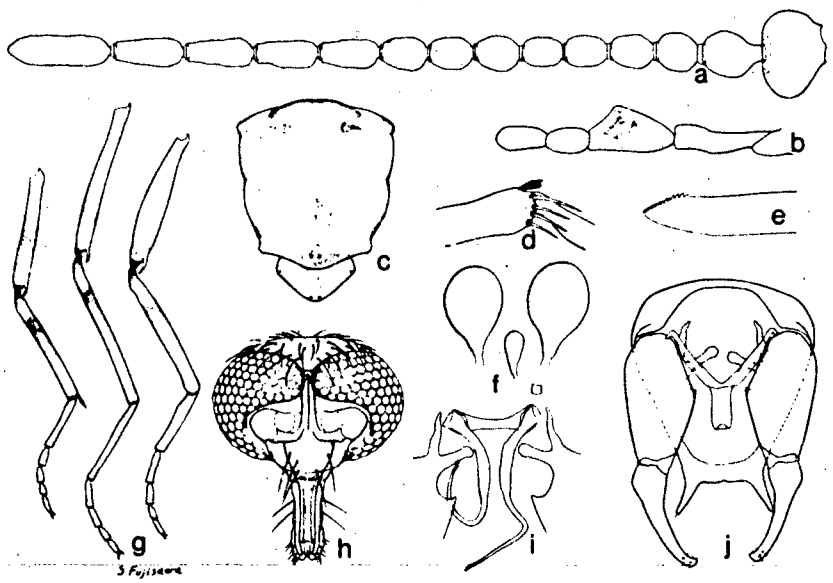


Fig. 177. *Culicoides oxystoma*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. mandible; f. spermathecae; g. legs; h. head, anterior view; i. parameres; j. male genitalia, parameres omitted.

Thorax: Dark brown; mesonotum (fig. 177c) with prominent pattern of small brown punctures on a bright gray pruinose background, each puncture centering on a seta base, the punctures in a broad median longitudinal band and on irregular lateral areas more or less fusing in continuous dark brown patches. Legs (fig. 177g) brown; knee spots blackish; femora pale at bases, with narrow subapical pale rings except in some specimens hindfemur entirely dark at apex; tibiae with narrow sub-basal pale rings and pale from middle to apices; hindtibial comb (fig. 177d) with 4 (n = 20) spines, the one nearest the spur longest.

Wing (fig. 340, 472): Pattern as figured; variable in extent of pale markings between dark extreme and pale extreme; pale spot over r-m crossvein not large, continued broadly to costal margin; anterior wing margin with 3 very dark areas, one proximad of pale spot over r-m crossvein, second extending to tip of second radial cell and third in middle of anterior margin of cell R5; cell R5 with 1 or 2 poststigmatic pale spots, one anteriorly at end of second radial cell, and often a second one lying behind the cell; cell R5 with an oblique double pale spot extending transversely across cell at about its own width from tip of cell, also a separate pale spot lying slightly distad of anterior poststigmatic spot and midway between it and vein M1; cell M1 with 2 pale spots, the second lying about its own length from wing margin, the proximal one sometimes broadly continued across vein M2 into anterior side of cell M2; cell M2 with a pale spot at wing base, a large spot broadly extending across mediocubital stem into anal cell, a spot lying behind medial fork, one lying just in front of mediocubital fork, and one at tip of cell but not reaching wing margin; cell M4 with a variable pale spot lying transversely across cell, usually somewhat reniform but sometimes divided into 2 separate pale spots; anal cell with 1 pale spot in distal portion and irregular pale areas at base and along caudal wing margin; veins M1, M2, M3+4, and Cu1 with pale areas at wing margin, veins M1 and M2 more or less pale-margined. Macrotrichia scanty and confined to distal half of wing and a few posteriorly into anal cell; costal ratio 0.53 (0.49-0.56, n = 22); radius unbranched, the radial cells incompletely formed, all trace of first radial cell absent, only the posterior and distal closure of what would be the second radial cell present, forming an incomplete broad and distally truncated cell. Halter pale to somewhat infuscated.

Abdomen: Brown. Spermathecae (fig. 177f) subequal, each 0.048 x 0.035 mm; shape pyriform with neck varying from short and slender to considerably long and tapering; third spermatheca sometimes partly or completely developed to same size and shape as the other two.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 177j): Ninth sternum with broad, deep, caudomedian excavation, ventral membrane spiculate; ninth tergum tapering to long or moderately long, moderately approximated, fingerlike, apicolateral processes, the caudal margin between them not notched mesally. Basistyle short and stout, ventral root long and clubbed, not foot-shaped, dorsal root longer and pointed; dististyle slender and nearly straight, with bent, pointed tip. Aedeagus with basal arch low and broad, extending to about half of total length of aedeagus, basal arms slightly curved and fairly stout; distal process stout and parallel-sided, tip turned ventrally giving the appearance of a V-shaped distal emargination from the profile view of the dorsal channel. Parameres (fig. 177i) separate, each with well developed basal knob; stem moderately slender, curved gradually from the knob, somewhat straighter in midportion; no ventral lobe; distally gradually directed ventrad and mesad and tapered to slender point bearing a few very fine distal fringing hairs.

Distribution.--Southern Asia from Turkey and Israel, Iraq and Iran, east to Pakistan, Afghanistan, Ussuri SSR, India, Sri Lanka, Japan, Philippines, Indonesia, New Guinea and northern Australia.

Types.--Type of *oxystoma* presumably lost; types of *kiefferi* and *mesopotamiensis*, location unknown; of *housei*, holotype male on balsam slide in USNM; of *alatus*, holotype female in Zoological Survey of India, Calcutta, 3 female paratypes in USNM; of *punctigerus*, syntypes in Saikyo University, Kyoto, Japan.

Southeast Asia Records.--

CAMBODIA: Phnom Penh (Delfinado).

INDONESIA: Bali, Badung, Kuta, Jimbaran Carik (Lee). Flores, Manggarai, Reo, Robek Gincu (Nasir). Java, Bogor (Adiwinata); Kalasan, Yogyakarta (Yasumatsu); Jakarta, West Jakarta, Kapuk (Aep); Central Java, Klaten, Bonarum, Demangan (Soeroto); Pameungpeuk (Delfinado). Kalimantan (South), Astambul, Tanah Intan, Pondok Delapan (Lee). East Lombok, Selong, Bagik Payung (Lee). Sulawesi (Central), Bangga, Batui, Kamiwangi (Bambang); (North), Dumoga Bone Nat. Park, 220 m (Heppner); Southeast), Kendari, Unaha, Transmigrasi (Bambang); (South), Ujung Pandang, Bontoala, Baraya, Unhas (Aep). Sumatra, Bengkulu, Pekik Nyaring (Mathis); North Lampung, Kotabumi, Way Abung III, Mulyorejo (Lee); (West), Sawahlunto, Tanjung Godang, Sungai Tenang (Lee). Sumba, Kabaru, 96 km E Waingapu (Boeadi). Timor (East), Dili, Comoro, Kampung Marinir (Soeroto); Dili, Bidou (Woeroto).

LAOS: Sayaboury Prov., Sayaboury (Howarth); Muong Phieng (Howarth). Sedone Prov., Pakse (Howarth); Paksong (Howarth). Vientiane Prov., Vientiane (Howarth, Quate); Van Na Pheng, Ban Keun (Howarth). Luang Prabang (Quate).

MALAYSIA: Kedah, Simpang Kuala, Alor Star, near pigs (Garcia); Sungei Patani (Traub). Kelantan, Kota Bharu, cattle shed (Garcia). Negri Sembilan, Pekan Lama (Garcia). Pahang, Ulu Gali, cattle shed (Garcia). Perak, Pulau Pangkor (Traub). Perlis, Kangar Rest House (Traub). Selangor, Kuala Lumpur (Barnett, Hubert, Traub); Kepong Forest Res. (McClure); Puchong, from swine shed (Garcia); Rantau Panjang, 6 km N Klang (Traub); Subang (McClure). Trengganu, Dungun, Bukit Best (Hubert).

PHILIPPINES: Luzon, Pampanga Prov., Angeles, Clark Air Base (Balatbat). Mindanao, Cotabato Prov., Kidapawan (Kalaw); Davao Prov., Davao (Fontanilla); Milbuk (Milliron). Luzon, Rizal Prov., Tala (Delfinado).

SINGAPORE: Coast road (Nicholls); Kg. Chantek Bahru (Colless), airport, reared from ponded stream (Laird).

SABAH: Keningau (Colless).

THAILAND: Bangkok (Causey). Chiang Mai Prov., Amphoe Chiang Dao, Ban Thung Ka La (Yasumatsu); A. Hang Dong, Ban Rong Ku (Yasumatsu); A. Saraphi, Ban San Kob Tong (Yasumatsu); Chiang Mai (Notananda); Doi Suthep (Thurman). Bangkok Prov., A. Makasan and Pratoomvan (Manop R.). Chiang Rai Prov., A. Muang, Ban Kua Tae (Yasumatsu); Ban Teen Doi (Yasumatsu). Khon Kadu (Elbel). Khon Kaen Prov., A. Chum Phae and Khon Kaen (Manop R.); Khon Kaen Rice Exp. Sta. (Yasumatsu). Loei Prov., A. Thai Li (Manop R.). Lopburi Prov. (Manop R.). Nakhon Phanom Prov. (Manop R.). Nakhon Ratchasima Prov., A. Pak Chong (Manop R.); Nakronprathom Prov. (Manop R.). Nong Khai Prov., A. Nong Kai and A. Ta Bo (Manop R.). Nonthaburi Prov. (Manop R.). Pechaburi Prov. (Manop R.). Prabuddhabat Prov., A. Saraburi (Manop R.). Phangnga Prov., Pulau Panjang (Colless). Samuthprakan Prov. (Manop R.). Sakhon Nakkhon Prov. (Manop R.). Songkla (collector ?). Thonburi Prov., A.

Bangkoknoi and A. Thonburi (Manop R.). Ubon Ratachathani Prov., Phibun Mangsahan (Yasumatsu). Udon Thani Prov., A. Phen, Ban Nong Kiang (Yasumatsu).

VIETNAM: Phan Rang (Leech). Saigon (Spencer).

Discussion.--Many workers have noted the extreme variability in the markings of *C. oxystoma* and other species of the Schultzei Group. The following extremes of variation include characters that were originally utilized in naming new species, which we consider to be at most merely varieties, most of which occur, sometimes with noteworthy frequency in some localities, throughout the range of the complex.

Wing pattern: Varying from a rather dark form (var. *pattoni* in which the pale spot behind the second radial cell is lacking, the branches of the media are not pale-bordered and the pale spots in cell M4 and anal cell are not extensive, to a form with extensively pale wings with the pale spot behind the second radial cell extensive and the branches of the media pale-bordered (var. *oxystoma*). In some specimens the proximal pale spot in cell M1 extends broadly across vein M2 into cell M2. The macrotrichia are usually more extensive in the paler-winged forms.

Mesonotal pattern: Japanese specimens have the brown punctures of the mesonotum fused in very dark and distinct, broad vittae (var. *oxystoma*). In the other extreme of variation (var. *mesopotamiensis*) in populations from the arid parts of the Middle and Near East, the mesonotum is quite pale with very small, inconspicuous brown punctures.

Male genitalia: The apicolateral processes vary considerably in length and in their separation. A form with the parameres distally shortened and blunt (*housei*) is considered merely to be an aberration, since one male specimen of *schultzei* in the USNM from Nigeria has the same type of thickening of the paramere, but is intermediate between the typical condition and that figured by Causey for *housei*.

Paratype examples of *alatus* Das Gupta and Ghosh were examined and found to be typical examples of *oxystoma*.

We have been unable to find any geographical correlations, other than those mentioned above, important enough to form the basis for recognition of subspecies, although a closer study of variation, especially of quantitative characters, might be successful in recognizing geographically distinct populations. The variability of characters along with the extensive geographic range of this species indicate to us an evolutionarily young and ecologically successful species. Its abundance throughout its range, its unspecialized larval habitat in mud puddles, and its avid bloodsucking habit also indicate an ecologically dominant species.

In Africa a complex of species has evolved which are very similar to *C. oxystoma* and indeed may include *oxystoma* in the northern part of the continent. Some of these species have been confused with *oxystoma* by various workers. From about 1960 until the present most of the Asian and Australian literature treated the species under the name *C. schultzei* (Enderlein). But in 1975 Kremer et al. gave a critical redescription of *C. schultzei* pointing out three important characters by which *schultzei* may be distinguished from related species: the presence of two separate round pale spots in cell M4 of the wing, the apices of veins M2, M3+4, and Cu1 dark at the wing margin through vein M1 is pale-margined on its distal portion, and the long tapering male ninth tergum with long, tapering, divergent,

apicolateral processes with bases narrowly separated on the midline. By contrast, Asian *C. oxystoma* females have a single pale spot in cell M4 with the broad anterior margin snugly butting against vein M3+4, the apices of veins M2, M3+4, and Cu1 are pale at the wing margin, and the male ninth tergum is shorter with the apicolateral processes more slender and their bases more widely separated. Kremer et al. sank *C. irroratus* Goetghebuer as a synonym, their paratype material of *irroratus* having a wing pattern and male ninth tergum that perfectly matched Enderlein's figures. In *C. kingi* Austen (1912) from the Sudan there are two separate pale spots in cell M4, with the anterior one streak-like, lying against vein M3+4, but otherwise the species closely resembles *oxystoma*. It is entirely possible that closer comparison may reveal that *oxystoma* occurs in the northern parts of Africa, and that many of the references to *schultzei* from West, North, and East Africa may pertain to *oxystoma* instead.

Biology.--Hubert reared *C. oxystoma* frequently near Kuala Lumpur, Malaysia, from sunny and partially shaded buffalo wallows, mud at margins of ponds, drainage ditch margins, mud among sweet potato plants at the ends of a drain, partially shaded edge of a grassy swamp, and bottom of a culvert. This species was previously reared most frequently from exposed mud at the margins of mud puddles (Patton 1913, Edwards 1922, Kitaoka and Morrii 1963, Howarth 1985).

Buckley (1938), in his search for the vector of *Onchocerca gibsoni* of cattle at Kuala Lumpur, Malaysia, found *C. oxystoma* to be the commonest species biting cattle during the day, but in night collections it was less numerous than *shortti*, *peregrinus*, and *orientalis*. The species preferred to bite the lower parts of the body. Buckley concluded that *oxystoma*, along with *shortti*, *orientalis*, and *pungens*, were vectors of this filaria in Malaysia. He reared large numbers of *oxystoma* and *peregrinus* Kieffer "from mud and slime taken from the sides of drains or small streamlets."

Braverman et al. (1974) in Israel found "*schultzei*" [probably *oxystoma*] more frequently in breeding sites such as drainage channels with little organic matter and rich in oxygen and less often in sites with organic pollution and low in oxygen.

Sun (1974) was able to rear *C. oxystoma* in the laboratory for 5-6 generations. Larvae were maintained on yeast-blood agar medium with aeration in finger bowls. Adults were kept in 11 x 15 cm cages set over culture dishes lined with filter paper; moist towels surrounding the cages kept the humidity to about 80%. The life cycle required about 28-32 days.

Howarth (1985) described the pupa of *C. oxystoma* and reared the species from 12 sites in Laos, sunny and shaded but all without vegetation, clay or gravel. Most were silty, with varying amounts of sand, pollution, and wetness.

Shortti Group

Culicoides shortti Smith and Swaminath (Figs. 178, 341, 473)

Culicoides shortti Smith and Swaminath, 1932: 183 (female; Assam; figs.); Macfie, 1937a: 113 (Malaya; descr. notes); Buckley, 1938: 148 (Malaya; biology; vector of cattle filaria); Macfie, 1941: 69 (Malaya; descr. notes; fig. male genitalia); Howarth, 1985: 75 (pupa descr.; figs.; Laos).

Culicoides shorti (sic) Smith and Swaminath; Causey, 1938: 413 (Siam; descr. notes).

Culicoides fortis Sen and Das Gupta, 1959: 622 (female; India; fig. mesonotum, wing, spermathecae). NEW SYNONYMY.

Female.--Wing length 0.82 (0.72-0.89, n = 15) mm.

Head: Eyes bare, narrowly to widely separated. Antenna (fig. 178a) with lengths of flagellar segments in proportion of 19-11-11-11-11-12-12-13-15-16-19-19-30, antennal ratio 0.99 (0.95-1.04, n = 14); sensilla coeloconica present on segments 3,8-10, approximately three sensilla with long hairs per segment on segments 8-10. Palpus (fig. 178b) with lengths in proportion of 11-19-27-11-14; third segment short and moderately swollen in midportion, tapered distally with a broad, irregularly open sensory pit; palpal ratio 2.5 (2.0-2.9, n = 13). Proboscis moderately short, P/H Ratio 0.65; mandible with 13 (10-15, n = 29) fine teeth; cibarium with anterior patch of 20 minute spinules.

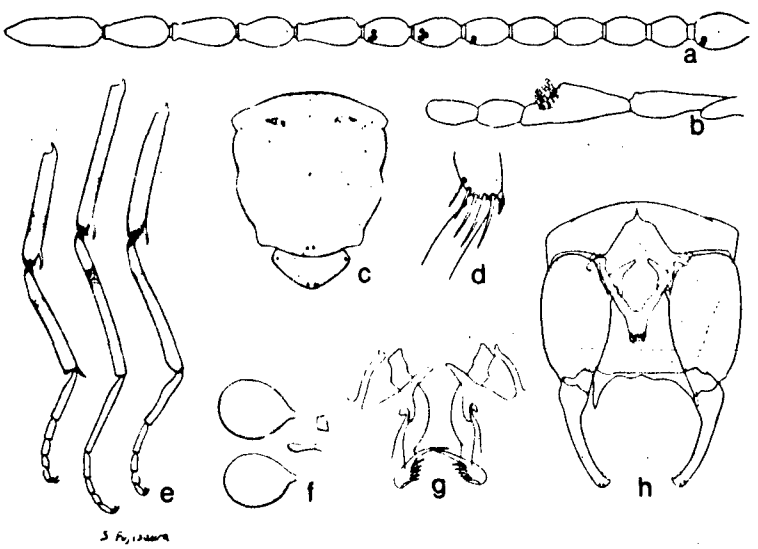


Fig. 178. *Culicoides shortti*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Thorax: Dark brown; mesonotum (fig. 178c) with prominent pattern of small separate, brown punctures on a gray pruinose background. Legs (fig. 178e) pale brown; knee spots blackish; femora slightly paler at bases, fore- and midfemora with narrow, sometimes faint, subapical pale rings; all tibiae with narrow sub-basal

and hindtibia with broad apical pale rings, fore- and midtibiae with faintly pale apices; hindtibial comb (fig. 178d) with 5 (n = 16) spines, second from the spur longest.

Wing (fig. 341, 473): Pattern as figured; pale spot over r-m crossvein small, more broadly extended to costal margin; moderately dark stigmal spot covering radial cells including apex of second radial cell; cell R5 with 2 more or less separate poststigmatic pale spots, the anterior one small and rounded, the posterior one located proximad of the other, longitudinally elongate and extending proximad behind second radial cell; distal portion of cell R5 with 2 separate pale spots, a transverse one halfway to wing tip, extending from wing margin nearly or quite to vein M1, and a second small round one lying at extreme tip of cell; cell M1 with 3 pale spots, distal one small and lying at extreme wing margin; cell M2 with a large spot at base, mostly lying across stem of media, a pale spot lying behind medial fork, none in front of mediocubital fork, but a subapical one lying in front of midportion of vein M3+4, all these spots connected by a very narrow pale streak, also a larger pale spot at wing margin in extreme tip of cell M2; cell M4 with a large pale spot not meeting vein M3+4 but continued broadly to wing margin; anal cell with 1 or usually 2 pale spots in distal portion, a large pale area at base continued broadly across mediocubital stem; tips of veins not pale. Macrotrichia scanty on distal half of wing and continued in two rows proximad nearly to base of cell M2 and in an irregular row along posterior slide of anal cell; costal ratio 0.57 (0.55-0.60, n = 15); second radial cell complete, moderately broad, with small but distinct lumen. Halter somewhat infuscated.

Abdomen: Brown. Spermathecae (fig. 178f) slightly unequal in size, 0.051 x 0.029 mm and 0.047 x 0.027 mm; ovoid, tapering slightly to narrow, elongate, sclerotized necks; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 178h): Ninth sternum with deep caudomedian excavation, ventral membrane not spiculate; ninth tergum with apex moderately broad, the apicolateral processes large and pointed, the caudal margin between them slightly notched. Basistyle with ventral root foot-shaped, the posterior heel moderately large, anterior toe much longer and slender; dististyle slightly curved, slender, with bent pointed tip. Aedeagus V-shaped, basal arch high, extending to 2/3 of total length of aedeagus, with nearly straight basal arms; distal process very short, with truncated, distally serrate tip. Parameres (fig. 178g) each with stout basal knob; stem moderately stout, curved basally, nearly straight in midportion, with a low ventral lobe extending along most of midportion; distal portion slender, bent ventromesad and tapering to pointed tip with a fringe of about 5 fine spines in a group well back from tip.

Distribution.--Cambodia, India, Indonesia, Laos, Malaysia, Thailand, Vietnam.

Types.--Location or existence of type of *shortti* unknown; type of *fortis* in Zoological Survey of India, Calcutta, one female paratype in USNM.

Southeast Asia Records.--
CAMBODIA: Phnom Penh (Delfinado).

INDONESIA: Bali, Badung, Pedungan (Lee). Java (Central), Cilacap, Adipala, Karang Sari (Lee); (West), Bekasi, Bekasi (Lee), Bogor (Adiwinata); Djakarta (Rees); Garut, Pameungpeuk (Zubaedah); Serang, Anyer Beach Hotel (Lee). Sumatra, Genkulu, Bukit Peninjauan (Mathis); Bengkulu, Pekik Nyaring (Mathis).

LAOS: Luang Prabang (Quate). Sayaboury Prov., Sayaboury (Howarth). Sedone Prov., Pakse and Paksong (Howarth). Vientiane Prov., Ban Keun, Ban No Pheng (Howarth).

MALAYSIA: Kedah, Sungei Patani (Traub). Negri Sembilan, Pekan Lama (Garcia); Port Dickson, Telok Pelandok (Quate, Traub). Pahang, Kuala Lipis, Kg. Berchang, near carabao (Garcia); Kuala Singgora (Wharton); Kuantan, Telok Sisek (Wharton); Ulu Gali, cattle shed (Garcia). Perak, Pulau Pangkor (Traub). Selangor, Kuala Lumpur (Hubert, Barnett, Traub); Segambut (Barnett); Serdang (Barnett); Subang Forest Res. (McClure).

THAILAND: Bangkok (Causey). Chiang Mai Prov., Amphoe Hang Dong, Ban Rong Ku (Yasumatsu); A. Muang, Ban Mae Khao Tom (Yasumatsu); Doi Inthanon, Doi Pa-Morn (Yasumatsu). Chiang Rai Prov., Chiang Rai (Causey); A. Muang, Ban Kua Tae and Ban Teen Doi (Yasumatsu). Khon Kadu (Elbel). Khon Kaen Prov., A. Chum Phae, and Ban Phai (Manop R.). Loei Prov., A. Dan Sai, Loei and Thai Li (Manop R.). Lopburi (Manop R.). Nakhon Ratchasima Prov., A. Muang and A. Pak Chong (Manop R.). Nong Khai (Manop R.). Samuthprakan (Manop R.). Udon Thani Prov., A. Muang and Pen (Manop R.).

VIETNAM: Ban Me Thuot (Quate). Dak Song, 870 m (Quate). Di Linh, Djiring, 1,200 m (Quate). Pleiku, 700 m (Quate).

Discussion.--The presence of 3 pale spots in series in cells R5 and M1 will distinguish *C. shortti* from all Oriental species but *circumbasalis* Tokunaga, *erairai* Kono and Takahashi, and *javai* Tokunaga. *Culicoides circumbasalis* belongs to the Ornatus Group, as it has sensilla coeloconica on antennal segments 3-14. *Culicoides javae* is very closely related to *shortti* but differs, according to Tokunaga's description, by having a subapical pale ring on the hindfemur, the spermathecae spherical without sclerotized necks, mesonotum with pattern of large patches, palpus with definite sensory pit, and antennal ratio 0.91.

Culicoides erairai Kono and Takahashi (1940) from Japan and Manchuria is closely related to *shortti* with nearly identical wing pattern and male genitalia, but has the mesonotum without dark punctures, sensilla coeloconica on antennal segments 3,7-10, the posterior poststigmatic pale spot in cell R5 not so elongated in axis of cell, and the apex of the male aedeagus is rounded. *Culicoides shortti* and *C. erairai* are apparently closely related to the North American *C. stellifer* (Coquillett), which differs only in minor characters, with antennal sensory pattern 3,8-10 as in *shortti*, but the mesonotum without dark punctures and the pupal respiratory horn not so strongly spinose.

Gutsevich (1973) and Wada and Kitaoka (1977) place *erairai* in the Similis Group but in our opinion *erairai*, *shortti*, and *stellifer* should be located elsewhere because of the presence of five tibial spines, the moderately broad eye separation, the short tapering distal process and lack of shoulder spurs on the aedeagus, and different arrangement of the *d* tubercles on the pupa. In all of these characters, these three species closely resemble *C. furens* (Poey), the type species of the subgenus *Oecacta*, more than species of *Diphaomyia*.

Culicoides fortis Sen and Das Gupta is separated from *shortti* in the authors' key by the presence in *fortis* of only two pale spots in cell M1. From the examination of a female paratype of *fortis* deposited in the USNM we believe that this species is a synonym of *shortti* (NEW SYNONYMY).

A few specimens from Kuala Lumpur, Malaysia, differ in the reduction or lack of the distal pale spots at the wing tip in cells R5 and M1, antennal sensilla coeloconica sometimes present on segment 7, the wing slightly shorter, and the third palpal segment slightly shorter with a more definite pit. Since some of these features may be present as variations in otherwise typical specimens of *shortti* and since males differing from typical *shortti* have not been found in accompanying collections, we doubt if these correlated differences are specific.

Alan Dyce (pers. comm.) has shown us an undescribed Australian species of the Williwilli Group (by antennal sensory pattern, palpus, and male genitalia) with wing markings nearly identical with those of *C. shortti*.

Biology.--Buckley (1938) in Kuala Lumpur found *C. shortti* to be the third most common *Culicoides* biting cattle in daytime collections, and much the dominant species at night. Ventral parts of the host were preferred as feeding sites. The larval habitats were not discovered in spite of intensive search. The species is a vector of *Onchocerca gibsoni* in cattle in Malaysia.

Howarth (1985) reared *C. shortti* from exposed mud at the margins of buffalo wallow in Laos, and described the pupa. He took females several times biting man, including inside houses at evening, and stated that the species appears to be an important pest of cattle.

Culicoides fadzili Kitaoka
(Fig. 179)

Culicoides fadzili Kitaoka, 1983: 23 (female; Malaysia; fig. wing, antenna, palpus, spermathecae).

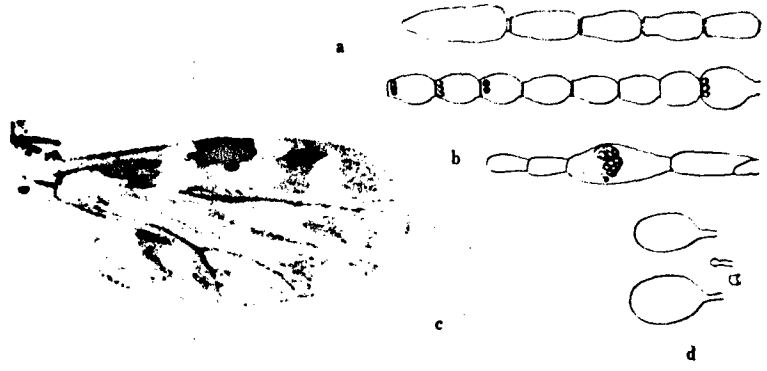


Fig. 179. *Culicoides fadzili*, female: a. antenna; b. palpus; c. wing; d. spermathecae (from Kitaoka 1973).

Diagnosis.--Female only; wing length 0.82 mm; costal ratio 0.56 (fig. 179c). Closely related to *C. shortti* Smith and Swaminath, but distinguished by the lack of punctiform dots on the mesonotum and presence of 4 rather than 5 spines in the hindtibial comb. Eyes nearly contiguous, with wedge-shaped space above. Antennal ratio 1.00; sensilla coeloconica present on segments 3,8-10, 3 per segment (fig. 179a). Palpal ratio 2.4, third segment with sensilla in 2 irregular shallow pits (fig. 179b). Proboscis moderately long, P/H Ratio 0.71; mandible with 13 teeth. Thorax uniformly brownish. Fore- and midfemora with pale subapical bands, all tibiae with sub-basal pale bands and pale apical portions. Spermathecae (fig. 179d) subequal, each 0.043 x 0.027 mm; vestigial third and ring present.

Costalis Group

Culicoides novairelandi Tokunaga
(Figs. 180, 342, 474)

Culicoides novairelandi Tokunaga, 1962b: 512 (female; New Ireland, Solomon Islands; fig. wing).

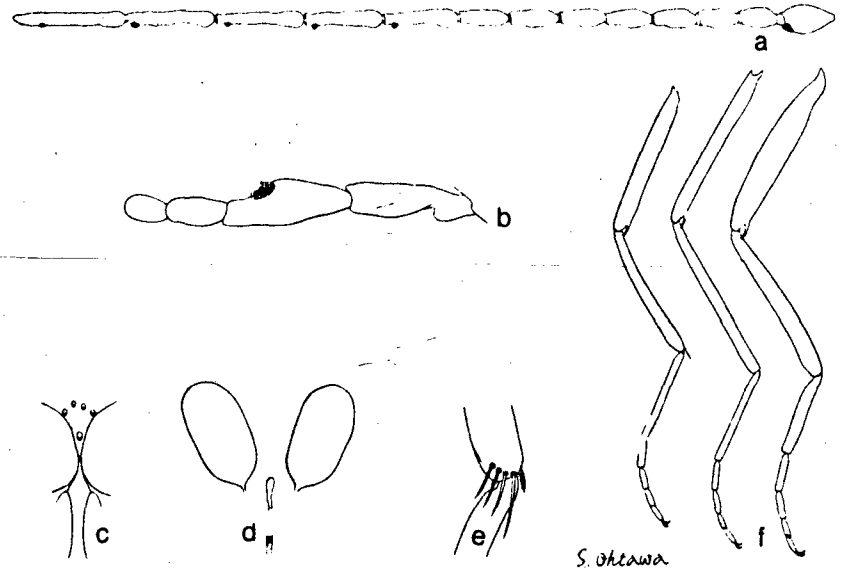


Fig. 180. *Culicoides novairelandi*: a. antenna; b. palpus; c. eye separation; d. spermathecae; e. tibial comb; f. legs.

Female.--Wing length 1.02 mm.

Head: Eyes (fig. 180c) meeting in a point, bare. Antenna (fig. 180a) with lengths of flagellar segments in proportion of 40-30-30-35-35-36-36-36-62-63-68-71-85, distal segments greatly elongated, antennal ratio 1.25; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 180b) with lengths of segments in proportion of 15-36-50-20-20; third segment slightly swollen in midportion, spindle-shaped, with moderately large, shallow round sensory pit at distal third; palpal ratio 2.9. Proboscis short, P/H Ratio 0.64; mandible with 15 teeth.

Thorax: Yellowish brown; mesonotum, postscutellum and pleuron with evidence of dark brown pattern as seen in slide-mounted specimens. Legs (fig. 180f) grayish brown; knee spots blackish on fore- and hindlegs; midknee yellowish on both sides of joint; hindtibia with broad base and apex pale; hindbasitarsus brownish; hindtibial comb (fig. 180e) with 4 spines, one nearest the spur longest.

Wing (fig. 342, 474): Pattern as figured; wing base with large pale spot angularly produced behind midportion to extend to half the length of mediocubital stem; large round pale spot over r-m crossvein broadly meeting costal margin and extending caudad halfway across cell M2; poststigmatic pale spot covering distal 0.6 of second radial cell but extending only slightly past tip of cell, not quite meeting vein M1 posteriorly; distal pale spot in cell R5 moderately large, oval, nearly meeting anterodistal wing margin; cell M1 with 2 oval, elongate, pale spots, proximal one broadly extending over vein M1 into cell M2, the distal one faintly meeting wing margin; distal pale spots in cells M2 and M4 faint but broadly meeting wing margin; anal cell with 1 faint round pale spot in distal portion; apices of veins dark. Macrotrichia moderately conspicuous and numerous over entire wing except radial field; costal ratio 0.66; radial cells distinct but narrow, the second tapering distally, vein R4+5 thus running in a straight line from r-m crossvein to costa, second radial cell only slightly longer than first. Halter infuscated.

Abdomen: Pale grayish brown; with long bristly hairs, especially numerous posteriorly. Spermathecae (fig. 180d) elongate oval with relatively blunt ends and straight sides, with very slender sclerotized necks 0.007 mm long; subequal, without neck each 0.065 x 0.033 mm; a long, tubular, sclerotized ring present.

Male.--Unknown.

Distribution.--Indonesia, Malaysia, New Ireland, Philippines, Singapore, Solomon Islands.

Type.--New Ireland, Kavieng, 4.vi.1959, Peters (Bishop Mus. Type no. 3247).

Southeast Asia Records.--

INDONESIA: Bali, Pedang Bay, 35 km NE Denpasar (Nicholls). Flores, Manggarai, Reo, Golok and Robek (Lee). Sulawesi (Central), Banggai, Batui, Kamiwangi (Bambang).

MALAYSIA: Negri Sembilan, Port Dickson, Telok Pelandok (Traub). Selangor, Bukit Jugra (Rudnick, biting man 30 m high in tree platform).

PHILIPPINES: Mindanao, Davao Prov., Calian (Clagg).

SINGAPORE: Pasir Panjang (Colless).

Discussion.--The systematic position of this species is difficult to assess, although it is similar to species of the Ornatus Group. From the typical members of the Ornatus Group whose second radial cell ends in a pale area, *C. novairelandi* is distinguished by the very elongate distal antennal segments, sensory pattern 3,11-15, wing pattern with a large pale spot falling over midportion of vein M2, and absence of the sclerotized ring on the duct from the spermathecae.

We are indebted to Alan Dyce for comparison with type material in the Bishop Museum and identification of our Southeast Asian material. The male described by Tokunaga (1962b: 511) as "sp. allied to *longiradialis* n. sp." and later (Tokunaga, 1963c: 137, 1976: 46) stated to represent the male of *novairelandi* is a different species (Dyce, in litt.).

Chaetophthalmus Group

Culicoides majorinus Chu
(Figs. 181, 343, 475)

Culicoides majorinus Chu, 1977: 99 (female; Tibet; fig. wing, antenna, palpus, eye separation, spermathecae, scutellum); Wirth, Choudhuri, and Das Gupta, 1985: 106 (male, female; India; figs.).

Female.--Wing length 1.75 mm.

Head: Eyes moderately separated, with dense long interfacetal hairs. Antenna (fig. 181a) with lengths of flagellar segments in proportion of 40-32-35-35-35-35-35-35-53-50-56-65-72, antennal ratio 1.05; sensilla coeloconica present on segments 3,11-15. Palpus (fig. 181b) with lengths of segments in proportion of 8-20-45-15-15; third segment moderately swollen distally, with a large, shallow, round sensory pit; palpal ratio 3.5. Proboscis long, P/H Ratio 0.98; mandible with 20 teeth.

Thorax: Dark brown; mesonotum without apparent pattern in slide-mounted specimen, with stout setose hairs. Legs (fig. 181h) dark brown, without pale markings; tibial comb (fig. 181c) with 5 spines, the second from the spur longest; fourth tarsomeres not cordiform.

Wing (fig. 343, 475): Pattern as figured; deeply infuscated, especially along veins; dark brown stigma formed by deep infuscation of second radial cell and of veins bordering first radial cell; a single small pale spot on anterior wing margin distad of second radial cell. Macrotrichia relatively sparse, but very strong and setiform, extending deeply into cell M2 and to base of anal cell; costal ratio 0.64. Halter infuscated.

Abdomen: Brown. Spermathecae (fig. 181d) oval without necks; subequal, each 0.070 x 0.050 mm.

Male.--Similar to the female with usual sexual differences; wing length 1.25 mm; breadth 0.54 mm. Genitalia (fig. 181f): Ninth sternum with deep caudomedian excavation, ventral membrane bare; ninth tergum rounded distally with distinct caudomedian notch and short, slender apicolateral processes. Basistyle stout with short, slender, dorsal and ventral roots; dististyle gradually narrowed and

curved to slender rounded tip. Aedeagus (fig. 181e) with slender basal arms, rounded basal arch extending nearly to half of total length, tapering distad to slender simple tip. Parameres (fig. 181g) separate, each swollen and angulate in midportion, with nearly straight, slightly tapering, anterolateral arm; tapering distally to straight slender tip; distal portions of parameres closely approximated.

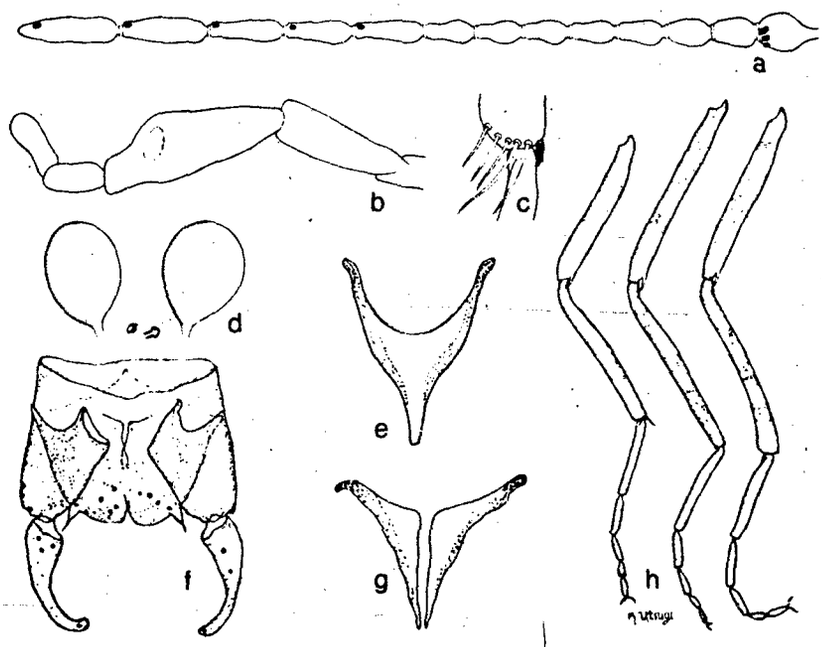


Fig. 181. *Culicoides majorinus*: a. antenna; b. palpus; c. tibial comb; d. spermathecae; e. aedeagus; f. male genitalia, aedeagus and parameres omitted; g. parameres; h. legs.

Type.--Holotype female, Na-ke, Tibet, vi.1962 (in collection of Department of Parasitology, Second Military Medical College, Shanghai).

Distribution.--India, Sabah, Tibet.

Southeast Asia Records.--
SABAH: Mt. Kinabalu, Kambaranga, 2,840 m, 1.xi.1958 (Quate and Maa).

Discussion.--This species is readily distinguished by its large size, uniformly dark brown body and poorly marked wing with large stigma and a single pale spot lying just past end of costa.

Culicoides majorinus is the only known Southeast Asia species in the Chaetophthalmus Group, according to Wirth et al. (1985). It is most closely related to *C. yadongensis* Chu (synonym: *spinulosus* Chu, preoccupied by *spinulosus* Khamala and Kettle, 1971: 87. See Chu, 1984: 24), but that species has an unmarked wing, as usual in this group.

Subgenus **Meijerehelea** Wirth and Hubert

Culicoides subgenus *Meijerehelea* Wirth and Hubert, 1961: 23. Type species, *Ceratopogon guttifer* Meijere (orig. desig.).
Guttifer Group; Tokunaga, 1960: 74 (group characters; included species).

Diagnosis.--Eyes slightly to broadly separated, bare. Antenna with distal segments elongated, antennal ratio 1.26-1.52, segment 14 not tapering distally like others in series but subcylindrical, with many extra sensilla coeloconica distally; sensilla usually present on segments 3-14, sometimes absent on some or all of segments 7 to 10. Palpal pit large and typically shallow. Cibarial armature usually a compact group of 8-10 strong teeth on midline. Numerous well-developed, even mandible teeth. Wing with second radial cell dark, wing spotting characteristic and similar in all species except for basal and poststigmatic pale spots in cell R5; pale spot over r-m crossvein narrow caudad, usually expanded anteriorly; distal pale spot in cell R5 round and lying at extreme tip of cell; anal cell with zigzag basal pale area and two distal pale spots; cell M1 with two pale spots, cell M2 without pale spot immediately in front of mediocubital fork but with two pale spots lying distal to this fork; veins more or less narrowly pale margined. Halter dark. One spermatheca present, saclike to sagittate, sometimes with duct very elongated. Male genitalia with parameres abruptly bent at base with large basal knob directed laterad, stem relatively short, without ventral lobe, tip simple and usually relatively stout.

Included Species.--Six Oriental species: *C. arakawae* (Arakawa), *duodenarius* Kieffer, *guttifer* (Meijere), *hegneri* Causey, *histrio* Johannsen, and *prolixipalpis* n. sp. Also two Palaearctic species, *japonicus* Arnaud and *toyamaruae* Arnaud, and two Subsaharan species, *distinctipennis* (Austen) and *leucostictus* Kieffer belong to this group, and *guttifer* and *histrio* extend into the Australasian Region.

Species of the subgenus *Meijerehelea* are known to be pests of considerable importance. *Culicoides arakawae* has been reported numerous times in Japan as a pest of poultry and the vector of *Leucocytozoon* disease (Akiba et al. 1959, Kitaoka and Morii 1963). Standfast and Dyce (1982) reported the isolation of Thimiri virus from females of *C. histrio* collected in Northern Australia. This virus was first isolated in India from a Paddy Bird (*Ardeola grayii*) by Carey et al. (1971).

Biology.--Larval breeding habitats include surface mud of rice paddies and irrigation ditches (Tokunaga et al. 1961, Kitaoka and Morii 1963) for *C. arakawae*, shady margins of muddy pools (Edwards 1922) for *guttifer*, a stream bed (new record) for *prolixiipalpis*, exposed mud at the margins of larger streams (Howarth 1985) for *hegneri*, and in mangrove flats and tidal marshes (Reye and Lee 1961, Kettle and Elson 1978) for *histrio*. As corrected by Tokunaga et al. (1961) the

supposed breeding of *C. arakawae* in poultry manure (Tokunaga 1937) was not based on fact, and this record must be disregarded. A record by Johannsen (1931) of *C. guttifer* reared from a tree hole was probably based on a misidentification.

Culicoides arakawae (Arakawa)
(Figs. 182, 344, 345, 476)

Ceratopogon arakanae [sic] Matsumura in litt.; Arakawa, 1910: 411 (Japan).
Ceratopogon arakawae Arakawa; Matsumura, 1915: 56 (Japan; pest of poultry).
Culicoides arakanae (Arakawa); Okada, 1941a: 14 (Japan; synonymy, distribution).
Culicoides arakawae (Arakawa); Tokunaga, 1950: 66 (Japan); Okada, 1954: 3 (distribution; N. China); Arnaud, 1956: 92 (male, female redescribed; figs. synonymy); Tokunaga, 1960: 74 (diagnosis; in Guttifer Group); Tokunaga et al., 1961: 53 (larva, pupa described; figs.; reared from rice paddies; Japan); Kitaoka and Morii, 1963: 198 (biology, larval habitats; Japan); Kitaoka, 1977: 191 (Nansei Is.; in key; distribution).
Culicoides arakawai (Arakawa); Delfinado, 1961: 640 (Philippines; fig. wing); Wirth and Hubert, 1961: 23 (Taiwan; synonyms: *daleki*, *micropunctatus*); McDonald and Lu, 1972: 400 (female diagnosis; figs.; Taiwan); Lee, 1978: 32 (Rep. China; diagnosis; figs.); Howarth, 1985: 87 (pupa descr.; larval habitat; Laos).
Culicoides sugimotonis Shiraki, 1913: 289 (Formosa); Tokunaga, 1937: 290 (male, female described; Japan, Formosa; figs.; syn. *alboguttatus*, *arakawae*); Tokunaga, 1940a: 145 (syn. *shimai*); Tokunaga, 1941b: 93 (Manchuria).
Culicoides alboguttatus Kieffer, 1921b: 563 (female; Formosa).
Culicoides shimai Sasaki, 1928: 687 (female, larva; in fowl dung; Japan).
Culicoides daleki Smith and Swaminath, 1932: 185 (female; Assam); Macfie, 1937a: 112 (Malaya); Causey, 1938: 402 (Siam; male, female; fig. genitalia); Sen and Das Gupta, 1959: 624 (India).
Culicoides micropunctatus Tokunaga, 1951: 105 (female; fig. wing; Java).

Female.--Wing length 1.11 (0.93-1.20, n = 13) mm.

Head: Eyes broadly separated, bare. Antenna (fig. 182a) with lengths of flagellar segments in proportion of 21-12-13-14-14-13-13-15-32-33-33-35-45, antennal ratio 1.52 (1.46-1.59 n = 13); sensilla coeloconica present on segments 3-14. Palpus (fig. 182b) with lengths of segments in proportion of 12-29-37-14-15; third segment moderately swollen distally, with a very broad, shallow, sensory pit; palpal ratio 2.5 (2.3-2.7, n = 11). Proboscis long, P/H Ratio 0.95; mandible with 12 (10-14, n = 23) teeth in curved row.

Thorax: Dark brown; mesonotum with pruinose gray markings as in fig 182c; most prominent are a wide median dark brown longitudinal vitta from anterior margin to prescutellar sensory area, and two narrow sublateral vittae extending from behind humeral pits to near ends of scutellum. Legs (fig. 182e) dark brown; forefemur sometimes indistinctly paler subapically, mid- and hindfemora entirely dark; tibiae with sub-basal narrow pale rings; hindtibial comb (fig. 182d) with 4 (4-5, n = 21) spines, the one nearest spur longest.

Wing (fig. 344, 345, 476): Pattern as figured; small pale spots present over basal arculus and r-m crossvein, the latter spot usually broadened between radius and costal margin; cell R5 with 2 small, round, separate, poststigmatic pale spots, posterior one located slightly proximad of the anterior one; cell R5 often with a third small round pale spot midway between these spots and base of cell, this spot lying near or touching vein R5 and separated from vein M1 (this spot exhibits great variation, being present in fullest extent or reduced size in only a small proportion of individuals from any 1 locality, and may be absent on 1 wing and present on the other in a given individual); apex of cell R5 with a small round pale spot at extreme tip; 2 small round pale spots in cell M1, distal one not quite attaining wing margin; cell M2 with a large pale streak lying on anterior side of stem of mediocubital fork, an oval spot behind medial fork, and 2 pale spots in distal portion of cell past mediocubital fork, none immediately anterior to mediocubital fork; anal cell with a zigzag pale area at base and 2 pale spots in distal portion; veins M1, M2, M3+4, and Cu1 very faintly pale margined. Macrotrichia long and numerous, extending to base of wing in anal cell; costal ratio 0.60 (0.58-0.63, n = 13); second radial cell moderately broad. Halter deeply infuscated.

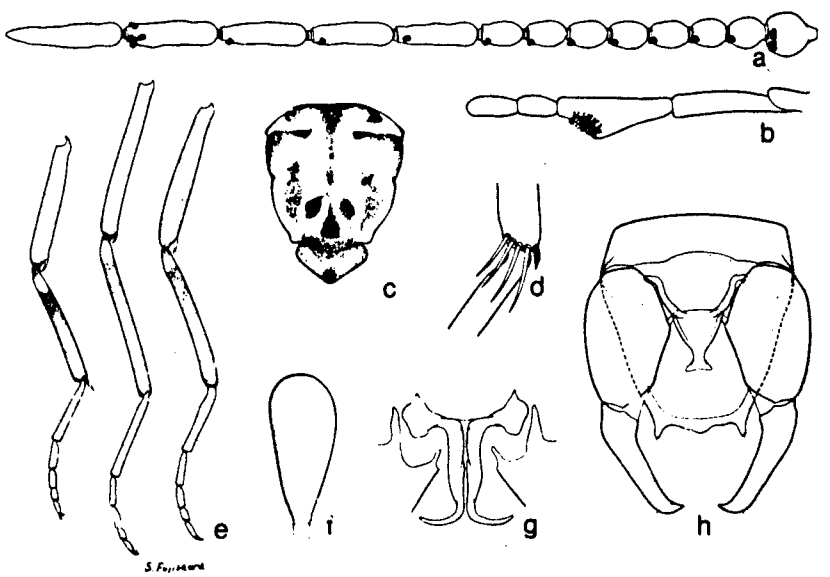


Fig. 182. *Culicoides arakawae*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermatheca; g. parameres; h. male genitalia, parameres omitted.

Abdomen: Dark brown. Spermatheca (fig. 182f) in form of an elongate sac, 0.137 x 0.058 mm, broadest near the rounded distal end, tapering gradually to the entrance of the duct; duct about 1.5 times as long as spermatheca.

Male.--Similar to the female with usual sexual differences. Genitalia (fig. 182h): Ninth sternum with shallow caudomedian excavation, ventral membrane with a few fine spicules near sternum; ninth tergum narrow distally, with a pair of short, pointed apicolateral processes, caudal margin between them convex. Basistyle with ventral and dorsal roots slender and pointed; dististyle moderately stout, nearly straight, very little narrowed distally, with bent pointed tip. Aedeagus with basal arch extending to a third of total length, basal arms bent laterad at base; distal process gradually tapered to slender subapical neck, expanded tip with concave caudal margin. Parameres (fig. 182g) each with slender basal arm bent laterad with a greatly expanded basal knob; stem slender and nearly straight, very slightly swollen at base, distal portion only slightly narrowed to moderately slender tip bent ventrolaterad.

Distribution.--Southern and eastern Asia from India to Manchuria and Japan, south to Indonesia.

Types.--Lectotype female of *arakawae* (designated by Arnaud 1956) "Japan Matsumura," University of Hokkaido collection. Holotype female of *micropunctatus* in alcohol, Tjinjiroean, Java, xi.1941, in Entomological Laboratory, Saikyo University, Kyoto, Japan. Existence of types of *alboguttatus*, *daleki*, *shimai*, and *sugimotonis* not confirmed.

Southeast Asia Records.--

BRUNEI: Kg. Selimbigar (Colless).

INDONESIA: Bali, Badung, Kuta, Jimbaran Carik (Lee); Badung, Tag Tag (Lee). Flores, Manggarai, Nangalili, Joneng Area, Wai Tiong (Lee); Manggarai, Reo, Gincu, Robek (Nasir); Reo, Golok (Lee). Java (Central), Ambarawa, Bejalon (Sudjadi); (West), Bekasi, Teluk Buyung (Nasir); Garut, Pameungpeuk (Zubaedah); Jakarta, Pulo Mas (Lee); Jakarta Utara, Pulau Putri (Lee). Kalimantan (South), Banjar, Astambul, Tanah Intan, Titian Mantang (Lee); Banjar, Martapura, Bincau (Lee); Astambul, Sungai Baru (Lee). Lombok (East), Selong, Kerekong (Lee); (West) Mataram, Gerung, Dasan Geras (Lee). Sulawesi (Southeast), Kendari, Wawotoba, Lalohao (Bahang). Sumatra (South), Baturaja (Lee). Sumbawa (Nicholls).

LAOS: Sayaboury Prov., Sayaboury (Howarth); Xieng Hon (Howarth). Sedone Prov., Pakse (Howarth). Vientiane Prov., Ban Na Pheng, Ban Keun (Howarth).

MALAYSIA: Negri Sembilan, Port Dickson, Telok Pelandok (Traub). Pahang, Kuala Singgora (Wharton). Perak, Kuala Kengrong, Girik (Traub); Pulau Pangkor (Traub). Perlis, Kangar Rest House (Traub). Selangor, Batu Caves (McClure); Kuala Lumpur (Hubert, Traub); Rantau Panjang, Klang (Traub); Subang, reared from buffalo wallow (Hubert).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Pampanga Prov., Clark Air Base, Angeles (Balatbat). Luzon, Rizal Prov., Tala (Delfinado).

SABAH: Labuan Island (Colless). Ranau (Maa). Tambunan (Colless).

SINGAPORE: Singapore (Course).

THAILAND: Ayudhaya (Manop R.). Bangkok (Causey); Huaykwang (Scanlon); Makasan (Manop R.). Chiang Mai (Notonanda); Ban Tin Doi (Gressitt); Amphoe Hang Dong, Ban Rong Ku (Yasumatsu); Doi Sutep (Thurman); A. Saraphi, Ban San Kab Tong (Yasumatsu). Chiang Rai, A. Muang, Ban Pa Bong and Ban Teen Doi (Yasumatsu). Khon Kaen Prov., A. Ban Phai, Chum Phae and Khon Kaen (Manop R.). Loei Prov., A. Dan Sai, Ban Na Muang (Elbel); A. Loey and Thai Li (Manop R.). Lopburi (Manop R.). Minburi (Manop R.). Nakhon Phanom (Manop R.). Nakhon Ratchasima Prov., A. Nakhon Ratchasima and Pak Chong (Manop R.). Nakronprathom (Manop R.). Nong Khai Prov., A. Nong Khai and Ta Bo (Manop R.). Nonthaburi (Manop R.). Pechaburi (Manop R.). Rachaburi Prov., Ban Pong (Manop R.). Sakhon Nakhon (Manop R.). Samuthprakan (Manop R.). Saraburi Prov., Prabuddhabat (Manop R.). Thonburi (Manop R.). Udonthani Prov., A. Nong Han and Pen (Manop R.).

VIETNAM: Dan Nang (Hicks). 14 km W Phan Rang (Leech). Chu Lai (Hicks). Saigon (Spencer).

Discussion.--Tokunaga (1937, 1940a) made no mention of the variations in the wing markings of Japanese *arakawae*, in which the small pale spot may appear behind the first radial cell, and in 1951 he described the species *micropunctatus* from Java for a single female with this spot present and antennal ratio 1.3-1.4. Since only 1 specimen was involved we believe this variation is not significantly distinct from that described for *arakawae*.

Biology.--The feeding preference of *C. arakawae* for fowls so often reported in the Japanese literature is also reflected in our records. Tokunaga et al. (1961) described the larva and pupa of this species from material collected in rice paddies in Japan. Hubert has reared the species once in Malaysia, at Subang near Kuala Lumpur in mud at the edge of a partially shaded buffalo wallow. Kitaoka and Morii (1963) found the larvae in Japan most numerous in surface mud 1 cm deep and in fewer numbers up to 20 cm deep in rice paddies and irrigation ditches. Howarth (1985) reared *C. arakawae* in Laos from exposed mud at the sunny margin of a buffalo wallow and from the sunny margin of a large stagnant backwater of the Mekong River.

Culicoides guttifer (Meijere)
(Figs. 183, 346, 477)

Ceratopogon (*Culicoides*) *guttifer* Meijere, 1907: 209 (female; Java; fig. wing).

Culicoides guttifer (Meijere); Edwards, 1922: 163 (Malaya; reared from muddy pools; fig. wing; syn.: *leucostictus*); Johannsen, 1931: 429 (Sumatra; reared from tree hole); Macfie, 1934b: 214 (Sumatra; Macfie, 1934: 190 (Malaya); Causey, 1938: 401 (male, female redescribed; Siam; figs.); Tokunaga, 1959: 216 (redescribed; New Guinea; figs.); Delfinado, 1961: 640 (Philippines; diagnosis; fig. wing); Tokunaga, 1960: 74 (diagnosis); Tokunaga, 1962b: 468 (New Guinea; Tokunaga, 1976: 42 (New Guinea; in key; syns.: *leucostictus*, *histrio*, *micropunctatus*); Debenham, 1978: 261 (bibliography); Howarth, 1985: 89 (pupa descr.; larval habitat; Laos).

Female.--Wing length 1.02 (0.95-1.09, n = 13) mm.

Head: Eyes narrowly separated, bare. Antenna (fig. 183a) with lengths of flagellar segments in proportion of 19-13-14-15-14-14-14-15-28-28-31-32-41, antennal ratio 1.35 (1.29-1.43, n = 10); sensilla coeloconica present on segments 3-14, often absent on segments 7-10. Palpus (fig. 183b) with lengths of segments in proportion of 13-21-29-12-13; third segment moderately swollen, with a broad, shallow, sensory pit; palpal ratio 2.1 (2.0-2.4, n = 9). Proboscis moderately long, P/H Ratio 0.83; mandible with 13 (11-16, n = 24) teeth.

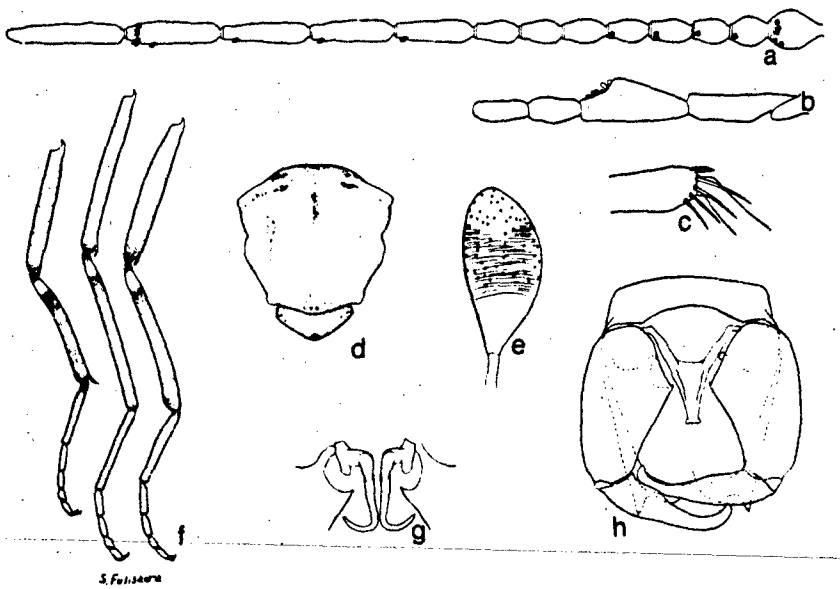


Fig. 183. *Culicoides guttifer*: a. antenna; b. palpus; c. tibial comb; d. thoracic pattern; e. spermatheca; f. legs; g. parameres; h. male genitalia, parameres omitted.

Thorax: Dark brown; mesonotum (fig. 183d) with grayish pruinose pattern, appearing mainly as three narrow dark brown vittae, median one extending from anterior margin to prescutellar area and two sublateral ones extending from behind humeral pits to near ends of scutellum. Legs (fig. 183f) dark brown; knee spots blackish; forefemur with faint narrow subapical pale ring, tibiae with sub-basal narrow pale rings; hindtibial comb (fig. 183c) with 4 (4-5, n = 13) spines, the one nearest spur longest.

Wing (fig. 346, 477): Pattern as figured; small pale spots present over basal arculus and r-m crossvein, latter spot very narrow on crossvein, following it and extending only as far as vein M1 caudad, but broadly expanded anteriorly between radius and costa; 2 separate small poststigmatic pale spots in cell R5, posterior one small and round and located slightly proximad of the other, a small round pale spot in cell R5 touching vein M1 posteriorly and located halfway between poststigmatic pale spots and base of cell; apex of cell R5 with a small round pale spot at extreme tip; 2 round pale spots in cell M1, distal one not quite meeting wing margin; cell M2 with a spot near base, one lying behind medial fork and 2 spots in distal portion past mediocubital fork, but none immediately anterior to mediocubital fork; a round pale spot at wing margin in cell M4; anal cell with a zig-zag pale area at base and 2 pale spots in distal portion; veins M1, M2, M3+4, and Cu1 very faintly pale margined. Macrotrichia long and fairly numerous, scanty on disc of wing anterior to anal cell; costal ratio 0.64 (0.62-0.66, n = 13); second radial cell relatively long and narrow. Halter deeply infuscated.

Abdomen: Dark brown. Spermatheca (fig. 183e) one, sacklike in form, broadest slightly distad of midportion, tapering to both ends, but more gradually to the duct entrance; surface with minute hyaline punctures on distal two-thirds, midportion with broad band of fine transverse rugulae; spermatheca measuring 0.111 mm long and 0.050 mm broad on the average; duct very long, about three or four times as long as length of spermatheca.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 183h): Ninth sternum with moderately deep caudomedian excavation, ventral membrane spiculate; ninth tergum rather broad apically, with moderately long, slender, pointed apicolateral processes, caudal margin between them with deep median cleft flanked by low rounded submedian lobes. Basistyle with ventral root not developed, dorsal root short and simple; dististyle moderately stout, curving to sharp distal point. Aedeagus with basal arch extending to 0.4 of total length, basal arms nearly straight but abruptly bent laterad at extreme bases; distal portion tapered gradually to broad, distally concaved, ventrally directed tip. Parameres (fig. 183g) each with basal portion abruptly bent laterad with large basal knob; stem slender and nearly straight on basal portion, distally bent and only slightly narrowed to relatively stout, simple tip directed ventrolaterad.

Distribution.--Brunei, Indonesia, Laos, Malaysia, Philippines, Sabah, Sarawak, Thailand, Vietnam.

Type.--Unique female holotype, Semarang, Java, January, Jacobson collector (in Zool. Museum Amsterdam).

Southeast Asia Records.--

BRUNEI: Kg. Selimbigar (Colless).

INDONESIA: Bali, Badung, Kuta, Jimbaran, Carik (Lee); Badung, Mengwi (Lee); Gianyar, Tangan Juda (Sweatman). Java (Central), Ambarawa, Pojok Sa (Sudjadi); (West), Bogor (Adiwinata); Pandeglang, Ujung Kulon (Watters). Flores, Manggarai, Reo, Robek, Kampang Ojang Beach (Lee). Kalimantan (South), Banjar, Astambul, Martapura, Bincau (Lee); Astambul, Pengiuran (Lee); Astambul,

Tanah Intan, Simpang Empat, Kampung Baru (Lee); Tanah Intan, Karang Anyar (Lee). Lombok (East), Selong, Bagik Payung and Kerekong (Lee); (West), Mataram, Bilekedit, Gerung, Dasan Geras (Lee). Maluku, P. Buru, Savanjaya (Bambang). Sulawesi (Central), Banggai, Batui, Dongin (Bambang), (Southeast), Kendari, Ranometo, Wolasi (Bambang). Sumatra, Bengkulu, Cenggori (Mathis). Timor (East), Dili, Comoro (Soeroto).

LAOS: Sayaboury Prov., Sayaboury, Phieng (Howarth). Sedone Prov., Pakse (Howarth). Vientiane Prov., Ban Na Pheng (Howarth).

MALAYSIA: Negri Sembilan, Port Dickson, Telok Pelandok (Traub). Pahang, Kuala Singgora (Traub). Perak, Pulau Pangkor (Traub). Selangor, Kiang, Carey Island, monkey baited trap (Garcia); Klang, Rantau Panjang (McClure, Traub); Serdang (Barnett); Kuala Lumpur (Hubert, Traub); Ulu Gombak Forest Res. (McClure).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Rizal Prov., Tala (Delfinado). Mindanao, Agusan, Esperanza (Yoshimoto); Milbuk (Milliron). Palawan, Brookes Point, Uring Uring (Nocna Dan Exped.); Ransang River (Quate); Tarumpitas Point (Quate).

SABAH: Labuan Island (Colless; Quate). Ranau (Maa). Tambunan (Colless). Tawau (Quate; Kalabakan River (Quate).

SARAWAK: Bau Dist., Pangkalan Tebang (Maa). Santubong (Maa); Kuching (Maa).

SINGAPORE: Singapore, in fowl house (Colless); Kg. Chantek Bahru (Colless).

THAILAND: Bangkok (Causey); Makasan and Pratoomvan (Manop R.). Chiang Mai (Notananda). Loei, Thai Li (Manop R.). Nakhon Phanom (Manop R.). Nakhon Ratchasima Prov., A. Muang and Pak Chong (Manop R.). Nong Khai (Manop R.). Phangnga Prov., Pulau Panjang (collector ?). Rachaburi, Banpong (Manop R.). Sakhon Nakhon (Manop R.). Thonburi, Bangkoknoi (Manop R.).

VIETNAM: Saigon (Spencer).

Discussion.--This species is readily distinguished from *arakawae* (Arakawa) and *histrio* Johannsen, the other species of the Guttifer Group having a third poststigmatic pale spot in cell R5 behind the radial cells, by the location of this spot lying in contact with vein M1, the location of the second or posterior poststigmatic pale spot separate from and lying proximad of the first or anterior one, and by the shape of the spermatheca, which is elongate and saclike, tapering to both ends.

Biology.--The Singapore record from fowl house suggests that *guttifer* resembles *arakawai* in its fowl-biting preference for blood meals. The discrepancy in larval habitat between Edwards' (1922) record from muddy pool margins and Johannsen's (1931) tree hole record suggests a misidentification, although Edwards' figure of the *guttifer* wing in his paper indicates that his identification was correct.

Hubert reared this species several times in Kuala Lumpur, Malaysia; from mud among sweet potato plants at the edge of a drain, from a drainage ditch margin, from the partially shaded margin of a grassy swamp, and from mud at the bottom of a culvert, where it was usually associated with larvae of *C. peregrinus* Kieffer, *oxystoma* Kieffer, and *huffi* Causey. Howarth (1985) in Laos reared *C. guttifer* three times from sunny to shaded mud at pool and stream margins.

Culicoides hegneri Causey
(Figs. 184, 347, 478)

Culicoides hegneri Causey, 1938: 402 (male, female; Siam; figs.); Delfinado, 1961. 641 (Philippines; fig. wing); Howarth, 1985: 90 (pupa descr.; larval habitat; Laos).

Female.--Wing length 0.99 (0.82-1.19, n = 9) mm.

Head: Eyes broadly separated, bare. Antenna (fig. 184a) with lengths of flagellar segments in proportion of 18-14-12-14-14-14-13-15-27-23-30-31-38, antennal ratio 1.34 (1.27-1.47, n = 6); sensilla coeloconica present on segments 3,11-14. Palpus (fig. 184b) with lengths of segments in proportion of 14-19-22-10-12; third segment moderately swollen, with moderately broad, shallow sensory pit; palpal ratio 2.3 (2.1-2.9, n = 7). Proboscis moderately long, P/H Ratio 0.82; mandible with 14 (13-15, n = 19) teeth; cibarium without armature of sclerotized teeth.

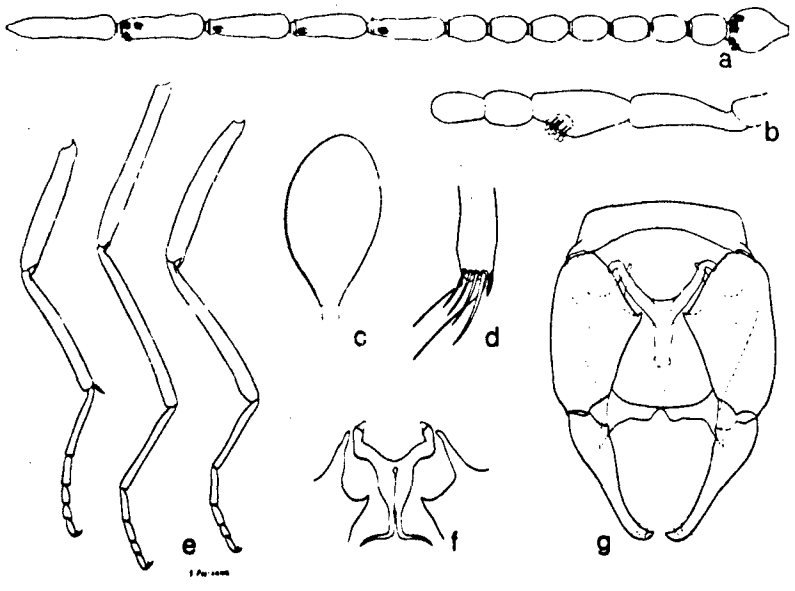


Fig. 184. *Culicoides hegneri*: a. antenna; b. palpus; c. spermatheca; d. tibial comb; e. legs; f. parameres; g. male genitalia, parameres omitted.

Thorax: Brownish, mesonotal pattern not discernible in slide-mounted specimens. Legs (fig. 184e) pale brown, fore- and hindknees darker, tibiae with faint sub-basal pale rings and hindtibia pale at apex; hindtibial comb (fig. 184d) with 4 (n = 8) spines, the one nearest spur longest.

Wing (fig. 347, 478): Pattern as figured, pale spots much larger and much fainter than in other members of the group; dark stigmal spot over second radial cell; pale spots over basal arculus and r-m crossvein, latter spot broadly continued to costal margin; cell R5 with one large, transverse, poststigmatic pale spot and a pale area at extreme tip of cell; 2 pale spots in cell M1, distal one reaching wing margin; cell M2 with pale spot near base lying adjacent to mediocubital stem, 1 behind medial fork but not adjacent to mediocubital fork, and 2 in distal part of cell past this fork; cell M4 with a large spot meeting wing margin; anal cell with a basal pale spot near anal vein and a double pale spot in distal part of cell. Macrotrichia long but rather sparse, extending to base of wing in anal cell; costal ratio 0.60 (0.58-0.62, n = 9); second radial cell relatively short and moderately broad. Halter infuscated.

Abdomen: Brown. Spermatheca (fig. 184c) one, lightly sclerotized, sac-shaped, tapering moderately to both ends, measuring about 0.100 mm x 0.050 mm, the duct short, about as long as length of spermatheca.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 184g): Ninth sternum with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum with moderately broad apex, apicolateral processes long and pointed, caudal margin between them with small median cleft and very small submedian lobes. Basistyle with ventral root not developed, dorsal root long and slender; dististyle nearly straight, slender distally with bent pointed tip. Aedeagus with basal arch extending to half of total length, basal arms slender; distal portion slender with rounded tip. Parameres (fig. 184f) fused a short distance at bases of stems; each with small basal knob directed anterolaterad; stem slender, scarcely swollen at base, very slender distally and bent abruptly laterally and then ventrally toward the simple, filiform tip.

Distribution.--Indonesia, Laos, Malaysia, Philippines, Sarawak, Sri Lanka, Taiwan, Thailand.

Type.--Holotype female, Thailand, Chiang Rai, 1933, O.R. Causey (Type in USNM).

Southeast Asia Records.--

INDONESIA: Bali, Badung, Kuta, Jimbaran Carik (Lee); Badung, Mengwi (Lee); Gianyar, Tangan Juda (Sweatman). Java (Central), Klaten, Bonarum, Demahgan, Klaten (Soeroto); (West), Bogor (Adiwinata); Bekasi (Lee); Garut, Pameungpeuk (Zubaedah); Yogyakarta, Bantul, Imogiri, Girirejo, Karang Tengah (Soeroto). Kalimantan (South), Banjar, Astambul, Tanah Intan, Titian Mantang (Lee). Lombok (East), Selong, Bagik Payung (Lee); (West), Mataram; Bilekedit, Gerung, Dasan Geras (Lee). Sulawesi (Southeast), Kendari, Unaha (Bambang). Sumatra, Bengkulu, 45 km S Benkulu, Gunung Agung (Mathis).

LAOS: Sayaboury Prov., Sayaboury, Nam Houng River (Howarth); 22 km S Muong Phieng (Howarth). Sedone Prov., Muong Pakse (Howarth). Vientiane Prov., Van Vieng (Howarth).

MALAYSIA: Pahang, King George V Nat. Park, Tahan River (McClure). Perak, Kuala Kengrong, Girik (Traub). Selangor, Klang (McClure). Trengganu, Dungun, Bukit Besi (Hubert).

PHILIPPINES: Leyte, Mahaplag (Delfinado). Luzon, Pampanga Prov., Clark Air Base, Angeles (Balatbat); Rizal Prov., Tala (Delfinado). Mindanao, Cotabatc Prov., Pikit (Werner); Agusan, Esperanza (Yoshimoto).

SARAWAK: Umah Akeh, Baram River (Colless).

THAILAND: Bangkok (Causey). Chiang Mai (Notananda). Chiang Rai (Causey). Khon Kaen, Choom Phae (Manop R.). Loei Prov., Dan Sai (Elbel, Manop R.); Thai Li (Manop R.). Nong Khai (Manop R.). Udonthani (Manop R.).

Discussion.--This species is not a typical member of the Guttifer Group, differing from the other species in having antennal sensilla coeloconica only on segments 3,11-14, the pale wing spots larger and much less distinct, the spermatheca more ovoid, and the male parameres fused at the base and with very slender tips. Causey's figure of the male parameres is in error, as reference to the slide from which the figure was drawn shows the tips to have been broken off, though they are still present but displaced on the slide. Causey's figures usually suffered because they were made from extremely flattened mounts which often distorted or broke the specimens. Two female specimens in the USNM collection from Taiwan, San-Kon Li, Chao-Chow, 16.ii.1954, C.C. Lin, light trap in stable, extend the range of *C. hegneri* considerably.

Biology.--Howarth (1985) in Laos reared *C. hegneri* from 6 sites, all sunny or partly shaded exposed mud at the margins of large streams and rivers.

Culicoides histrio Johannsen
(Figs. 185, 348, 479)

Culicoides guttifer (Miejere), var. *histrio* Johannsen, 1946: 190 (Guam, fig. male parameres).

Culicoides histrio Johannsen; Wirth, 1964: 119 (Synonym *mackayensis*); Debenham, 1978: 264 (review of literature, distribution); Kettle and Elson, 1978: 264 (larva, pupa descr.; Australia; figs.); Kettle and Elson, 1980: 180 (in key to pupae); Edwards, 1980: 201 (survey methods; Queensland); Kay and Lennon, 1982: 210 (seasonal prevalance; Australia); Standfast and Dyce, 1982: 212 (Thimiri virus isolation; Australia).

Culicoides mackayensis Lee and Reye, 1953: 383 (female; Queensland; figs.); Reye and Lee, 1961: 233 (habits; Australia); Tokunaga, 1960: 74 (diagnosis; in Guttifer Group); Tokunaga, 1962b: 470 (New Ireland); Lee, Reye, and Dyce, 1963: 367 (biology; Australia); Tokunaga, 1976: 42 (New Guinea; in key).

Culicoides guttifer (Meijere), misident.; Tokunaga and Murachi, 1959: 327 (Palau, Truk Is.; figs.; description).

Female.--Wing length 0.90 (0.78-0.98, n = 10) mm.

Head: Eyes narrowly separated, bare. Antenna (fig. 185a) with lengths of flagellar segments in proportion of 19-11-12-13-13-13-13-15-24-25-26-30-38, antennal ratio 1.26 (1.23-1.31, n = 10); sensilla coeloconica present on segments 3-14. Palpus (fig. 185b) with lengths in proportion of 11-23-32-12-12; third segment moderately swollen, with a very broad, moderately deep sensory pit; palpal ratio 2.2 (2.0-2.5, n = 10). Proboscis moderately long, P/H Ratio 0.82; mandible with 12 (11-15, n = 20) fine teeth.

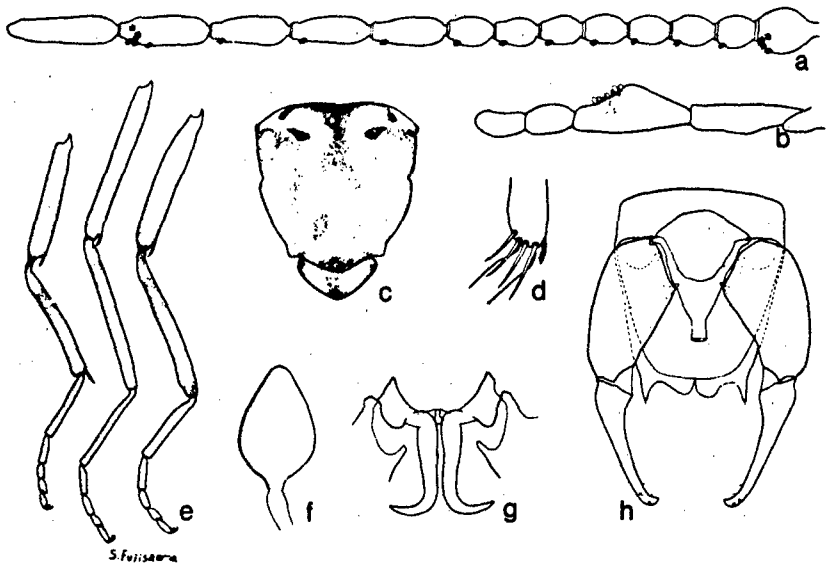


Fig. 185. *Culicoides histrio*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermatheca; g. parameres; h. male genitalia, parameres omitted.

Thorax: Dark brown; mesonotum with grayish pruinose pattern (fig. 185c) most prominent are a broad dark brown median longitudinal band from anterior margin bifid a short way in front of prescutellar space, and a pair of narrower sublateral lines extending from humeral pits nearly to ends of scutellum. Legs (fig. 185e) dark brown; all legs with dark knee spot; fore- and midlegs with indistinct, narrow, subapical pale rings on femora and distinct sub-basal pale rings on tibiae; hindfemur dark to apex, hindtibia with narrow sub-basal pale band; hindtibial comb (fig. 185d) with 4 (4-5, n = 11) spines, the one nearest spur longest.

Wing (fig. 348, 479): Pattern as figured; small pale round spots present over basal arculus and r-m crossvein, the latter extending broadly to costal margin and narrowly to vein M1; poststigmatic pale spot in cell R5 V-shaped, with distoposterior extension toward vein M1; cell R5 also with a small round pale spot halfway between poststigmatic spot and base of cell near vein M1, and a small round pale spot at extreme tip of cell; 2 pale spots in cell M1, distal one broadly meeting wing margin; cell M2 with 2 pale spots past mediocubital fork and one lying behind medial fork, but none immediately in front of mediocubital fork; a small round pale spot near wing margin in cell M4; a pale spot straddling stem of mediocubitus connected to a pale irregular area in base of anal cell; 2 pale spots in distal portion of anal cell; veins M1, M2, M3+4, and Cu1 narrowly and faintly pale-margined. Macrotrichia numerous and long, extending to base of anal cell; costal ratio 0.60 (0.59-0.62, n = 10); second radial cell short and broad. Halter infuscated.

Abdomen: Dark brown. Spermatheca (fig. 185f) one, its conical form very distinctive; measuring 0.068 x 0.041 mm; duct very short, not longer than length of spermatheca, often appearing much shorter.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 185h): Ninth sternum with moderately deep caudomedian excavation, ventral membrane with a few spicules; ninth tergum moderately broad distally, with long, slender, pointed, apicolateral processes, caudal margin between them with slight mesal cleft and a pair of low submedian lobes. Basistyle with ventral and dorsal roots short and relatively stout, simple; dististyle slender, nearly straight, with bent, pointed tip. Aedeagus with basal arch extending to a third of total length, basal arms moderately slender and bent laterad at base, distal portion tapered to moderately slender, truncated tip. Parameres (fig. 185g) each with broadly expanded, laterally directed, basal knob, stem moderately stout but scarcely swollen on basal portion, tapering distally to simple point abruptly bent laterad and ventrad (hitherto unknown male described from Labuan Island, Sabah).

Distribution.--Australia, Indonesia, Malaysia, Micronesia, New Ireland, Philippines, Sabah, Sri Lanka, Thailand.

Types.--Holotype male of *histrio*, allotype and paratypes, Piti, Guam, 13.ix.1936, O.H. Swezey (in Cornell University collection, paratypes in Hawaiian Sugar Planters Association Experiment Station). Holotype female of *mackayensis*, Mackay, Queensland, 15.vii.1952, E.J. Reye, net in mangrove (in Australia National Insect Collection, Canberra).

Southeast Asia Records.--

INDONESIA: Bali, Badung, Denpasar, Pedungan (Lee); Badung, Tuban, Pertamina Cottage (Lee). Flores, Manggarai, Reo, Robek, Golok (Lee). Java (Central). Cilacap, Adipala, Karang Sari (Lee). Sulawesi (North), Lake Mooat, 20 km NE Kotamobagu, 1,050 m (Heppner); (South), Ujung Pandang, Bontoala, Baraya, Unhas (Aep). Sumatra, Riau, Bintan, Tanjung Uban, Metinggi (Sumitro, biting man). Sumba, Waingapu Bay (Boeadi). Sumbawa, Alas (Nicholls).

MALAYSIA: Negri Sembilan, Port Dickson, Telok Pelandok (Traub). Perlis, Kangar Rest House (Traub). Selangor, Klang, Rantau Panjang (McClure, Quate, Traub); Klang, Telok Gong, mangrove, swamp forest (Garcia).
PHILIPPINES: Tawi Tawi, Lapid Lapid at Manalik Channel (Noona Dan Exped.).
SABAH: Tawau (Quate).
THAILAND: Phangnga Prov., Pulau Panjang (collector ?).

Discussion.--The synonymy of *mackayensis* was proposed by Wirth (1964) after examination of the types of *C. histrio*. Tokunaga and Murachi's (1959) synonymy of *mackayensis* with *guttifer* was erroneous.

The wing pattern of *C. histrio* is quite distinctive, differing from that of *guttifer* by the distoposterior extension of the poststigmatic pale spot in cell R5. The sagittate form of the spermatheca is also distinctive, resembling that of the Ethiopian species *distinctipennis* (Austen) and *leucostictus* Kieffer. *Culicoides leucostictus* (synonym: *praetermissus* Carter, Ingram, and Macfie) has a wing pattern very similar to that of *histrio*, but differs in having the antennal sensory pattern 3-15, and the male genitalia have a rounded caplike papilla on the aedeagus.

This species has a very extensive range, from Sri Lanka in the Oriental Region to Micronesia and to Sydney, New South Wales, in Australia. From the locality records it appears to be a mangrove, tidal marsh, breeding species.

Biology.--At Townsville, Queensland, Reye and Lee (1961) found *histrio* frequenting the mangrove flat area inside the mouth of the Ross River. Engorged females taken in a poultry-baited trap at that location showed on precipitin tests that the host was bird. Biting activity was nocturnal (1800-0600 hours). Edwards (1980) at Tingalpa Creek, Queensland, found that the species was abundantly attracted to light traps, but was taken in very small numbers in a truck trap.

Kettle and Elson (1978) described the larva of *C. histrio* from specimens taken at Pinkenba in the Brisbane, Queensland, metropolitan area, a coastal locality. They described the pupae of this species that were reared by Wirth in 1956 from Careel Bay near Sydney, New South Wales. The pupae were taken from soft muck at the margin of a small pool in the *Juncus* marsh just above high tide level (Wirth, unpublished notes).

Culicoides prolixipalpis Wirth and Hubert, new species
(Figs. 186, 349, 480)

Female.--Wing length 1.00 mm.

Head: Eyes broadly separated, bare. Antenna (fig. 186a) with lengths of flagellar segments in proportion of 25-25-25-25-25-25-26-27-42-42-50-50-70, antennal ratio 1.33; sensilla coeloconica present on segments 3,11-14. Palpus (fig. 186b) with lengths of segments in proportion of 20-70-75-25-20; segments very long and slender; third segment widest near apex, with a small, shallow, round, nearly apical sensory pit; palpal ratio 5.0. Proboscis very elongate, P/H Ratio 1.32; mandible with 16 teeth.

Thorax: Brown; mesonotum with pruinose gray pattern suggested in slide-mounted specimens. Legs (fig. 186e) pale brown, hind pair darker; tibiae with sub-basal pale rings, knee spots blackish; hindtibial comb (fig. 186d) with 4 spines, the one nearest spur longest.

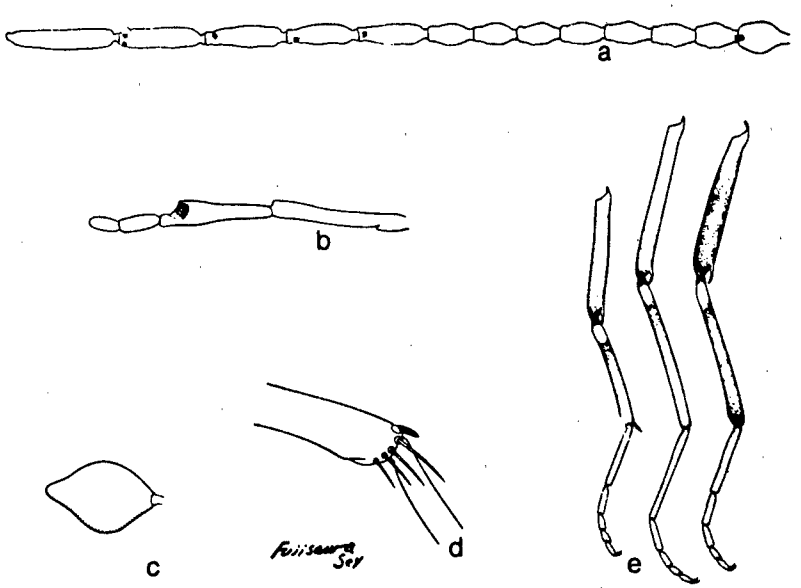


Fig. 186. *Culicoides prolixipalpis*: a. antenna; b. palpus; c. spermatheca; d. tibial comb; e. legs.

Wing (fig. 349, 480): Pattern as figured; small pale spots present over basal arculus and r-m crossvein, latter spot narrow posteriorly and barely covering media, much broadened anteriorly on costal margin; 2 separate, subequal, round poststigmatic pale spots in cell R5, posterior one located proximad behind apex of second radial cell and lying halfway between the latter and vein M1; cell R5 with a small round pale spot at extreme apex, broadly meeting wing margin and a small round pale spot near base broadly touching vein M1; cell M1 with 2 small pale spots, distal one not reaching wing margin; cell M2 with small pale spot halfway between basal arculus and r-m crossvein, a large pale spot behind medial fork, none in front of mediocubital fork, but 2 pale spots in distal portion, the apical one not reaching wing margin; cell M4 with very small, round, pale spot distally at wing margin; anal cell with faint pale streak in basal portion, 2 separate round pale

spots in distal portion. Macrotrichia not numerous, very sparse on proximal portion of wing; costal ratio 0.67; second radial cell relatively long and narrow, with distinct, narrow lumen. Halter deeply infuscated.

Abdomen: Brown. Spermatheca (fig. 186c) one, sagittate in form, broadest at proximal third, with narrow base and pointed tip; 0.083 x 0.056 mm.

Male.--Unknown.

Distribution.--Indonesia, Malaysia.

Types.--Holotype female, Malaysia, Selangor, Ulu Langat, 5.viii.1961, C. Manikumar, reared from stream bed (Type in USNM). Paratypes, 4 females.

INDONESIA: South Kalimantan, Banjar, Amtamoul, Tanah Intan, Pulo Empat, 11-12.xi.1978, V.H. Lee, light trap, 1 female.

MALAYSIA: Same data as type, 2 females. Trengganu, Dungun, Bukit Besi, 26-28.ii.1961, A.A. Hubert, light trap, 1 female.

Discussion.--The wing pattern of *C. prolixipalpis* is nearly identical to that of *guttifer* (Meijere), the spermatheca resembles that of *histrio* Johannsen, but the extremely elongated proboscis and very slender palpus are very characteristic.

Subgenus **Beltranmyia** Vargas

Culicoides, subgenus *Beltranmyia* Vargas, 1953: 34. Type-species, *Culicoides crepuscularis* Malloch (orig. desig.).

Diagnosis.--Medium size species with hairy, usually well-marked wings. Eyes narrowly to widely separated, bare. Antenna usually with sensory pattern 3-15, sometimes with reduced or variable sensilla coeloconica; antennal ratio greater than 1.0. Cibarial armature a pigmented dome with about 10 small teeth. Wing varying from faintly marked to prominent pattern, most species with abundant macrotrichia and second radial cell dark to tip. Female with one large, sclerotized, usually elliptical spermatheca. Male genitalia with ninth tergum bearing well-developed, pointed, usually slender, apicolateral processes; ninth sternum with ventral membrane often spiculate; basistyle with ventral root reduced or absent, dorsal root slender; parameres usually separate, each with basal knob usually bearing distinct anterior process; paramere tapering distally to slender, simple, twisted point.

Included Species.--Numerous species in the Holarctic Region; two species in South Africa, and one Palaearctic species extends into southern Asia; Southeast Asia with one endemic species.

Culicoides circumscriptus Kieffer
(Figs. 187, 350, 481)

Culicoides circumscriptus Kieffer, 1918: 49 (Tunis); Tokunaga, 1937: 378 (redescribed; figs.; Japan); Kettle and Lawson, 1952: 440 (immature stages; figs.; larval habitat; Britain); Arnaud, 1956: 97 (redescribed; figs.; Japan); Becker, 1958b: 785 (larval habitat; behavior; Britain); Campbell and Pelham-Clinton, 1960: 241 (redescribed; figs.; Britain); Kremer, 1965: 219 (redescribed; figs.; distribution); Gutsevich, 1973: 209 (redescribed; figs.; USSR); McDonald et al., 1973: 636 (female diagnosis; figs.; Okinawa); Braverman et al., 1974: 304 (larval habitat; Israel); Howarth, 1985: 92 (records; notes; Laos).

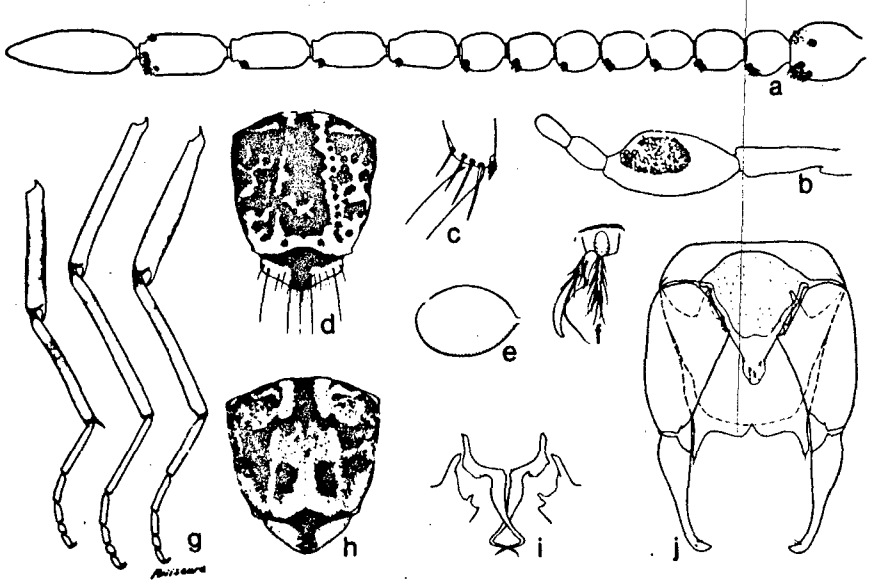


Fig. 187. *Culicoides circumscriptus*: a. antenna; b. palpus; c. tibial comb; d,h. thoracic pattern; e. spermatheca; f. tarsal claw and empodium; g. legs; i. parameres; j. male genitalia, parameres omitted.

Female.--Wing length 0.96 (0.88-1.06, n = 9) mm.

Head: Eyes bare, narrowly separated. Antenna (fig. 187a) with lengths of flagellar segments in proportion of 21-12-12-12-13-13-13-14-20-21-21-23-36, antennal ratio 1.10 (1.09-1.14, n = 5); sensilla coeloconica present on segments 3-14. Palpus (fig. 187b) with lengths of segments in proportion of 12-20-42-11-12; third segment considerably swollen, slightly tapering to base, with deep sensory

pit, up to half the length of segment, opening by a moderately large, round pore; palpal ratio 2.0 (2.0-2.1, n = 8). Proboscis moderately long, P/H Ratio 0.91; mandible with 15 (14-16, n = 13) teeth; cibarial armature a pigmented dome with 10 small teeth.

Thorax: Brown; mesonotum with many small brown punctures (fig. 187d), varying to fused brown patches (fig. 187h). Legs (fig. 187g) pale brown; fore- and midfemora with subapical, and all tibiae with sub-basal, narrow pale rings, knee spots blackish; hindtibial comb (fig. 187c) with 4 (n = 9) spines, the one nearest the spur longest. Empodium and claw as in fig. 187f.

Wing (fig. 350, 481): Pattern as figured; second radial cell very dark to apex; wing with very extensive large round pale spots centered mainly in the cells; an irregular transverse pale band at wing base from costa to posterior wing margin; a large round pale spot centering on r-m crossvein, containing a dark spot in center just distad of crossvein, extending from costa nearly to mediocubitus; a broad poststigmatic pale spot in cell R5 extending broadly from wing margin to vein M1; a large round to quadrate pale spot subapically in cell R5, broadly meeting anterior wing margin, located well proximad of tip of cell, usually meeting vein M1 posteriorly; cell M1 with 2 elongate pale spots, distal one lying a considerable distance from wing margin; cell M2 with 2 elongate pale spots in distal portion, distal one broadly meeting wing margin; cell M4 with a large pale spot filling distal portion of cell to wing margin; anal cell with a large, transverse double pale spot in distal portion extending from mediocubitus to wing margin; veins M1 and M2 pale-margined distally, often extensively pale nearly to the forks, the pale area interconnected to the pale spots in cells. Macrotrichia long and numerous, extending to base of wing; costal ratio 0.56 (0.54-0.58, n = 9); second radial cell moderately broad, with distinct but narrow lumen. Halter pale.

Abdomen: Pale brown. Spermatheca (fig. 187e) one, oval, slightly tapering to slender sclerotized neck; 0.089 x 0.056 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 187j): Ninth sternum with broad, deep, caudomedian excavation, ventral membrane spiculate; ninth tergum moderately broad and slightly tapering, with well-separated, long, slender, apicolateral processes, caudal margin between them slightly bilobed mesad. Basistyle with obsolete ventral root, dorsal root moderately long and slender; dististyle slender and nearly straight, with bent pointed tip. Aedeagus with rounded basal arch extending to at least half of total length, basal arms slender; distal process moderately broad at base, tapering to blunt, rounded apex. Parameres (fig. 187i) each with basal arm abruptly bent laterad, arm with long slender anterior process from lateral end; main portion slightly swollen basally, tapering distallyto simple, slender point abruptly twisted laterad, then ventrad.

Distribution.--Eurasia, North Africa, China, India, Japan, Laos, Thailand.

Type.--Described from Tunis, location of type unknown.

Southeast Asia Records.--
LAOS: Sayaboury Prov., Sayaboury (Howarth).

THAILAND: Chiang Mai Prov., Chiang Mai (Notonanda); Amphoe Hang Dong, Ban Rong Ku (Yasumatsu). Chiang Rai Prov., A. Muang, Ban Teen Doi (Yasumatsu). Khon Kaen Prov., A. Choom Pae (Manop R.). Loey Prov., A. Dan Sai (Manop R.). Nakronrajasrima (Manop R.). Rajiburi (Niphan).

Discussion.--There is considerable variation in this species in wing markings, mesonotal pattern, and in the shape of the third palpal segment, as discussed by Campbell and Pelham-Clinton (1980). The Thailand specimens agree more with European material in the USNM than with Japanese specimens in their palpal structure and show a wide range in extent of wing markings.

Biology.--This species has often been reared from saline or brackish coastal habitats in Europe (see references in synonymy). Tokunaga (1937) reared it from salt water pools above high tide level in Japan. Braverman et al. (1974) reared it from a wide variety of wet muddy sites, rich in organic matter and low in oxygen, in Israel. Kettle and Lawson (1952) gave good descriptions and figures of the immature stages from British material.

Culicoides halonostictus Wirth and Hubert, new species
(Figs. 188, 351, 482)

Female.--Wing length 1.16 mm; breadth 0.50 mm.

Head: Eyes bare, separated by diameter of one ommatidial facet. Antenna (fig. 188a) with lengths of flagellar segments in proportion of 17-11-10-10-11-11-12-12-17-18-19-21-26, antennal ratio 1.07; sensilla coeloconica present on segments 3-14, several per segment except on 11. Palpus (fig. 188b) with lengths of segments in proportion of 10-21-31-11-11; third segment moderately swollen, slightly tapering to base with a moderately deep sensory pit, up to a third the length of segment, opening by a large round pore on distal third of segment; palpal ratio 2.1. Proboscis long, P/H Ratio 1.00; mandible with 13-14 teeth; cibarial armature a pigmented dome bearing 10 small teeth.

Thorax: Brown; mesonotum with pattern of dark brown punctures, some more or less fused in brown patches. Legs (fig. 188e) brown; knee spots blackish, prominent; femora pale at base, fore- and midfemora with subapical pale ring; tibiae with prominent sub-basal pale rings; hindtibial comb (fig. 188d) with 4 spines, the one nearest spur longest.

Wing (fig. 351, 482): Pattern as figured; nearly identical with wing pattern of *C. circumscriptus*, with the following differences: proximal pale spot in cell M1 and the subapical pale spot in cell M2 each with a central dark spot so that the pale spot forms a narrow oval halo around it (from which the species takes its name). Macrotrichia long and numerous, extending to base of wing; costal ratio 0.56; second radial cell moderately broad,with distinct but narrow lumen. Halter infuscated.

Abdomen: Pale brown. Spermatheca (fig. 188c) one, oval, slightly tapering to duct opening, without sclerotized neck; 0.087 x 0.058 mm.

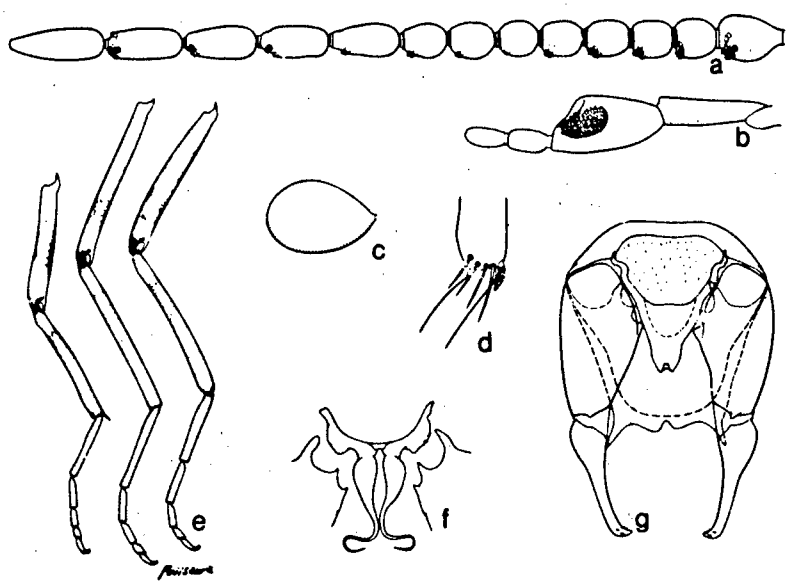


Fig. 188. *Culicoides helonostictus*: a. antenna; b. palpus; c. spermatheca; d. tibial comb; e. legs; f. parameres; g. male genitalia, parameres omitted.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 188g): Ninth sternum with broad deep caudomedian excavation, ventral membrane spiculate; ninth tergum moderately broad and slightly tapering, with well-separated, long, slender, slightly diverging, apicolateral processes, caudal margin between them convex with distinct median cleft. Basistyle with obsolete ventral root, dorsal root moderately long and slender; dististyle slender and nearly straight, with bent pointed tip. Aedeagus with basal arch extending to nearly 0.75 of total length, basal arms slender, a poorly sclerotized connection between arms of distal third of arch; distal process short and broad, with broad rounded apex bearing a short, slender, more strongly sclerotized process abruptly bent ventrad. Parameres (fig. 188f) joined at bases by a narrow sclerotized band forming a low, rounded basal arch; anterior process of basal arm not as slender as in *circumscriptus*; stem more swollen at base than in *circumscriptus*, tapering distally to simple slender point twisted laterad, ventrad, and then mesad.

Distribution.--Indonesia, Thailand.

Types.--Holotype female, allotype male, Thailand, Nonthaburi, 20.xii.1958, Manop R., light trap (Type in USNM). Paratypes 1 male, 3 females.

INDONESIA: Bali, Pedang Bay, 35 km NE Denpasar, 17.x.1969, D.G. Nicholls, light trap, 1 male. Sumbawa, 22.x.1969, D.G. Nicholls, light trap, 1 female.

THAILAND: Minburi, 24.xii.1958, Manop R., light trap, 1 female. Nakronprathom, 18.xii.1958, Manop R., light trap, 1 male.

Discussion.--The name of this species is derived from the Greek *halos*, *halono-* (a halo such as around the sun or moon), and *stiktos* (spotted).

Culicoides halonostictus is nearly identical with *circumscriptus* but is described as a new species because of the very characteristic wing pattern, in which the two distal pale wing spots each bears a central dark area thus forming a distinct pale halo around the dark center. In the female of *halonostictus* the proboscis is longer (P/H Ratio 1.00 vs 0.91 in *circumscriptus*), and the wing is longer (1.16 mm vs 0.96 mm). The male aedeagus of *C. halonostictus* bears a small, strongly sclerotized, ventrally directed peg which we have not observed in males of *circumscriptus*.

Subgenus **Monoculicoides** Khalaf

Culicoides, subgenus *Monoculicoides* Khalaf, 1954: 46. Type species, *Ceratopogon nubeculosus* Meigen (orig. desig.).

Diagnosis.--Large species; mesonotum usually with numerous small dark punctures on a lighter background. Wing usually with pattern of gray streaks and spots, second radial cell entirely dark. Eyes broadly separated, a pair of distinct frontal tubercles present between frontal carina and mesal margins of first antennal segments in the female; distal antennal segments not very long, sensilla coeloconica present on segments 3,8-10, and rarely on some additional segments of proximal series. Primary subgeneric characters are in the genitalia: Female with only one spermatheca, this usually elongate, usually with hyaline perforations, and frequently saclike or arcuate. Male with parameres fused basally; aedeagus bifid at tip; ventral root of basistyle short and simple, dorsal root long and moderately slender; apicolateral processes on ninth tergum well developed.

Included Species.--Numerous species in the Holarctic Region, 1 Subsaharan species, and 1 Oriental species: *C. homotomus* Kieffer.

Culicoides homotomus Keiffer
(Figs. 189, 352, 483)

Culicoides homotomus Kieffer, 1921a: 158 (Taiwan); Arnaud, 1956: 105 (male, female redescribed; figs.; distribution, Japan); Wirth and Hubert, 1961: 25 (diagnosis; Taiwan); McDonald and Lu, 1972: 404 (female diagnosis; figs.; Taiwan); Lee, 1978: 52 (Rep. China; diagnosis; figs.).
Culicoides osakensis Iwata, 1935: 7 (Japan).
Culicoides denmeadi Causey, 1938: 403 (female; Thailand; fig. wing); Wirth and Jones, 1957: 3 (notes). NEW SYNONYMY.
Culicoides nubeculosus (Meigen), misident.; Tokunaga, 1937: 280 (male, female; figs.; Japan, Taiwan; syn. *osakensis*).

Female.--Wing length 1.55 (1.31-1.78, n = 8) mm.

Head: Eyes very broadly separated (fig. 189c); bare. Antenna (fig. 189a) with lengths of flagellar segments in proportion of 26-18-20-20-20-20-21-21-23-24-24-22-37, antennal ratio 0.79 (0.77-0.84, n = 4); sensilla coeloconica present on segments 3,8-10. Palpus (fig. 189b) with lengths of segments in proportion of 15-27-43-18-21; third segment slender, only slightly swollen subapically, with an irregular indented sensory area just past subapical constriction; palpal ratio 3.3 (2.8-3.6, n = 8). Proboscis moderately long, P/H Ratio 0.77; mandible with 14 (12-16, n = 8) teeth.

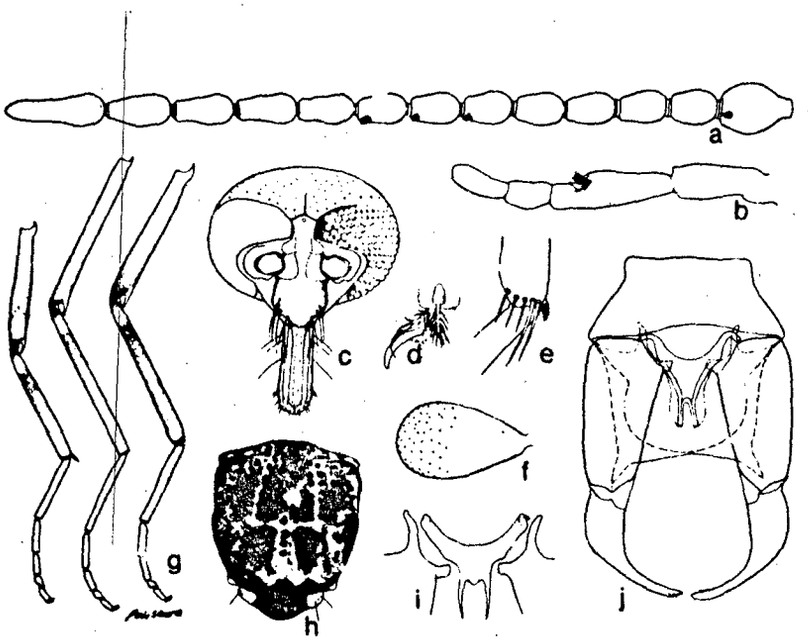


Fig. 189. *Culicoides homotomus*: a. antenna; b. palpus; c. head, anterior view; d. tarsal claw and empodium; e. tibial comb; f. spermatheca; g. legs; h. thoracic pattern; i. parameres; j. male genitalia, parameres omitted.

Thorax: Dark brown; mesonotum (fig. 189h) with pattern of numerous, more or less fused, small brown punctures. Legs (fig. 189k) brown; forefemur with faint subapical pale ring; knee spots blackish; tibiae with distinct sub-basal bands; hindtibial comb (fig. 189e) with 5 spines, second from spur longest. Empodium and claws as in fig. 189d.

Wing (fig. 352, 483): Pattern as figured; essentially a pattern of dark streaks and patches on a yellowish white background; pale areas extensively interconnected and centered as follows: A transverse pale band at level of r-m crossvein, extending from costa to mediocubitus; a broad pale poststigmatic band past end of

costa to vein M1; a subapical transverse pale band narrowly connected along anterior wing margin to narrow apical pale area of wing; cell M1 with extensive pale area at base and an elongate apical pale area, the two separated by a very dark spot; cell M2 with base extensively pale, connected to large pale area covering basal arculus and basal half of anal cell; a large pale area lying immediately behind medial fork; a large pale area in front of mediocubital fork extending distad nearly to tip of vein M3+4; a pale spot at wing margin at apex of cell M2, the latter 2 pale spots separated by a transverse very dark area extending caudad along apex of vein M3+4; veins M1 and M2 extensively pale bordered except at bases; branches of mediocubital fork pale-bordered except at tip of vein M3+4; a very dark triangular spot in middle of cell M4; anal cell with a large double pale area in distal half of cell in addition to the pale proximal half; thus there are 4 very dark broken transverse bands across wing, first proximad of r-m crossvein from costa through middle of anal cell, second blackish over radial cells and broad to base of vein M2, ending in a dark spot in cell M4; third a very dark transverse spot on anterior wing margin past poststigmatic pale spot with separate small very dark spots subapically in cells M1 and M2, and the fourth consisting of faint dark subapical streaks in cells R5, M1, and M2. Macrotrichia not very numerous; costal ratio 0.56 (0.56-0.58, n = 8); second radial cell relatively narrow but with distinct lumen. Halter infuscated.

Abdomen: Dark brown. Spermatheca (fig. 189f) one, elongate, saclike with very broad opening to duct, without distinct neck; 0.102 x 0.062 mm.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 189j): Ninth sternum moderately long, with slight caudomedian excavation, ventral membrane not spiculate; ninth tergum with sides nearly parallel; with very large, triangular, flaring apicolateral processes with slender points, caudal margin between them concave. Basistyle with ventral root very short, dorsal root long and slender; dististyle swollen at base, markedly curving to tip, distal half very slender. Aedeagus with basal arch rounded, extending to a third of total length; main portion triangular in outline, tapering to slender median process which is deeply divided distally in two sharp points; aedeagus without ventral spinules. Parameres (fig. 189i) fused in a small H-shaped sclerite, the anterolateral diverging arms of the "H" much stronger than the very slender, sinuate filaments arising submesally from the main arch and curving ventrad in sharp points.

Distribution.--Cambodia, China, Japan, Malaysia, Taiwan, Thailand.

Types.--Syntypes of *homotomus*, two females, Daitotei, Formosa, Sauter collector, in Deutsches Entomologischen Institut, Berlin. Holotype female of *denmeadi*, Chiang Rai, Siam, O.R. Causey, in USNM. Syntypes of *osakensis*, males, females, Minakata-cho, Osaka, Japan, 1.iv.1930, M. Iwata, in collection of Saikyo University, Kyoto, Japan.

Southeast Asia Records.--
CAMBODIA: Phnom Penh (Delfinado).
MALAYSIA: Kedah, Simpang Kuala, Alor Star, ex pigs (Garcia).

THAILAND: Bangkok (Scanlon). Chiang Mai (Causey, type). Minburi (Manop R.). Nong Kai (Manop R.). Rachaburi (Manop R.). Udonthani (Manop R., Scanlon).

Discussion.--The synonymy of C. *denmeadi* Causey is made by direct comparison of the female type and by close comparison of males and females from Taiwan and Thailand. The illustrations are taken from the original drawings made for Arnaud's (1956) *Culicoides* of Japan. *Culicoides homotomus* is closely related to the North American *variipennis* (Coquillett), a proven vector of the bluetongue virus disease of sheep and cattle. *Culicoides homotomus* has been collected while biting water buffalo in Taiwan.

Subgenus **Pontoculicoides** Remm

Culicoides, subgenus *Pontoculicoides* Remm, in Remm and Zhogolev, 1968: 840. Type-species, *Culicoides tauricus* Gutsevich (orig. desig.).
Culicoides, subgenus *Callotia* Vargas and Kremer, 1972: 242. Type- species, *Culicoides saevus* Kieffer (orig. desig.).

Diagnosis.--Small species with unmarked wings. Eyes broadly separated, bare. Antennal segments 11-15 without sensilla coeloconica; antennal ratio approximately 1.0. Wing without pale or dark spots; two radial cells; macrotrichia numerous. Female with 3 large, well sclerotized spermathecae of irregular, slightly elongate shape, opening to duct large. Male genitalia with ninth tergum short, bearing long, slender apicolateral processes; ventral root of basistyle absent, dorsal root bifid in two processes; aedeagus with high basal arch, distal process short or absent; parameres separate, of characteristic shape, each appearing as elongate, slightly sinuate rod with simple, bluntly pointed tip.

Included Species.--Distribution in Eurasia and Africa; seven species: *engubandei* de Meillon, *ibericus* Dzhafarov, *kamrupi* Sen and Das Gupta, *micromaculithorax* Khalaf, *saevus* Kieffer, *sejfadinei* Dzhafarov, and *tauricus* Gutsevich.

Culicoides kamrupi Sen and Das Gupta
(Figs. 190, 353)

Culicoides albipennis Smith and Swaminath, 1932: 184 (male, female; Assam; figs.). Preoccupied by *Culicoides albipennis* Kieffer, 1919: 32.
Culicoides kamrupi Sen and Das Gupta, 1959: 617 (new name for *albipennis* Smith and Swaminath, not Kieffer); Howarth, 1985: 93 (pupa descr.; larval habitat; Laos).

Female.--Wing length 1.09 mm.
Head: Eyes bare, moderately separated. Antenna (fig. 190a) with lengths of flagellar segments in proportion of 22-16-16-16-16-17-18-20-25-28-29-35-55, antennal ratio 1.22; sensilla coeloconica present on segments 3,8-10. Palpus (fig.

190b) with lengths of segments in proportion of 10-30-40-20-35; third segment moderately swollen distally, with a large, round, moderately deep sensory pit; palpal ratio 2.2. Proboscis moderately short, P/H Ratio 0.70; mandible with 12 teeth.

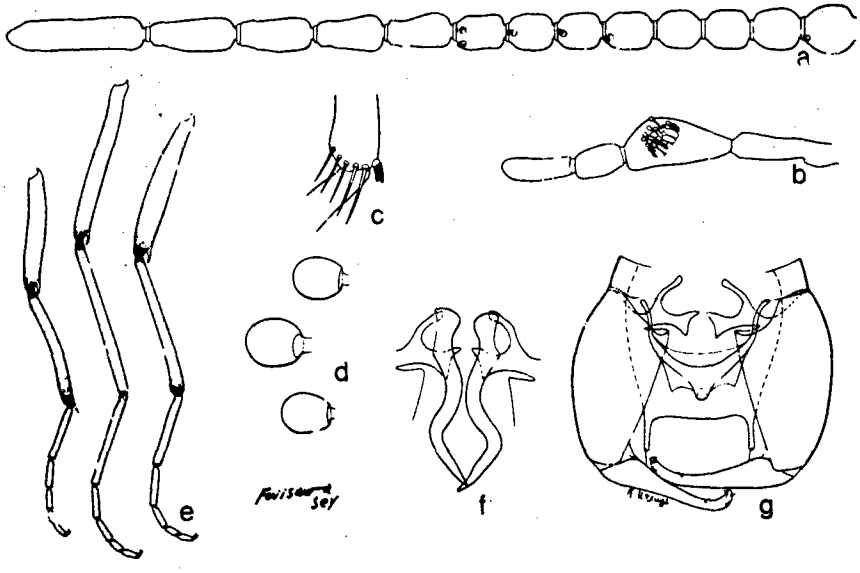


Fig. 190. *Culicoides kamrupi*: a. antenna; b. palpus; c. tibial comb; d. spermathecae; e. legs; f. parameres; g. male genitalia, parameres omitted.

Thorax: Light brown in slide-mounted specimens, mesonotum with small dark brown punctures. Legs (fig. 190e) pale brown, knee spots darker; hindtibial comb (fig. 190c) with 5 spines, the one nearest spur longest.

Wing (fig. 353): Uniformly grayish hyaline, without pattern, stigma over second radial cell slightly infuscated; macrotrichia very scanty, confined to wing tip and a few in rows along the veins on distal third of wing; costal ratio 0.59; second radial cell moderately broad, with indistinct lumen. Halter slightly infuscated.

Abdomen: Brown. Spermathecae (fig. 190d) 3, subspherical to slightly oval, without necks, the opening to the ducts large; midspermatheca slightly larger, 0.035 x 0.030 mm, the other 2 each 0.032 x 0.026 mm.

Male.--Similar to the female with usual sexual differences. Genitalia (fig. 190g): Ninth sternum narrow; ninth tergum relatively short and broad, slightly tapering distad, with widely separated, moderately long, slender apicolateral processes, the caudal margin between them transverse. Basistyle slender; ventral root ab-

sent, dorsal root bifid with anterior arm long and slender, posterior arm long with expanded tip forming two angulate corners distally; dististyle slender, slightly curved distally to pointed tip. Aedeagus with very high basal arch, basal arms very slender and curved; distal process short, moderately broad, with rounded tip. Parameres (fig. 190f) each with large basal knob; midportion moderately stout, slightly sinuate, recurved distally to relatively stout, pointed, simple tip. (Plesiotype from Vientiane, Laos, Howarth, coll.).

Distribution.--India, Laos, Thailand.

Types.--No type specimens were maintained (Sen, in litt., pro Smith).

Southeast Asia Records.--
LAOS: Vientiane Prov., Vientiane, 12.iii.1967, F.G. Howarth, reared, 2 males, 4 females.
THAILAND: Cholburi, Bangphra, i.1963, J.E. Scanlon, light trap, 2 females.

Discussion.--*Culicoides kamrupi* is the only Southeast Asia representative of the subgenus *Pontoculicoides*. The easiest separation of the species of this subgenus is in the shapes of the female spermathecae and the male parameres. Of the related species, *C. saevus* Kieffer most nearly resembles *kamrupi*, especially in the shape of the spermathecae, but in *saevus* the eyes are more widely separated, the third palpal segment is more swollen, and the wing is hairier.

Biology.--Howarth (1985) gave detailed notes on the larval habitat and biology in Laos. Pupae were found in exposed mud at the margin of the Mekong River, a large river at Vientiane. Larvae were common in shallow water at the river margin, all swimming towards or parallel to the shore, apparently in search of a pupation site. Howarth was of the opinion that *C. kamrupi* is a river bottom species similar to *C. denningi* Foote and Pratt, whose biology in Canadian rivers was reported by Fredeen (1969). The pupal morphology confirms that *kamrupi* and *denningi*, though falling in separate subgenera, are closely related compared to other *Culicoides* pupae.

Systematic Position Uncertain

Culicoides agas Wirth and Hubert, new species
(Figs. 191, 484)

Female.--Wing length 1.22 mm.
Head: Dark brown. Eyes (fig. 191c) moderately separated, with long interfacetal hairs. Antenna (fig. 191a) with lengths of flagellar segments in proportion of 25-22-22-22-22-23-25-26-45-45-43-43-56, antennal ratio 1.31; sensilla coeloconica present on segments 3,7-12. Palpus (fig. 191b) with lengths in proportion of 15-53-65-23-23; third segment moderately swollen at distal third, with sensilla borne in an irregular pit; palpal ratio 3.3. Proboscis relatively long, P/H Ratio 0.86; mandible with 17 teeth.

Thorax: Uniformly dull brown, with light grayish pollinosity in dry specimens. Legs (fig. 191g) uniformly brownish; tibial comb (fig. 191e) with five long spines, the one nearest the spur longest. Fourth tarsomere (fig. 191f) distinctly cordiform, flattened ventrally.

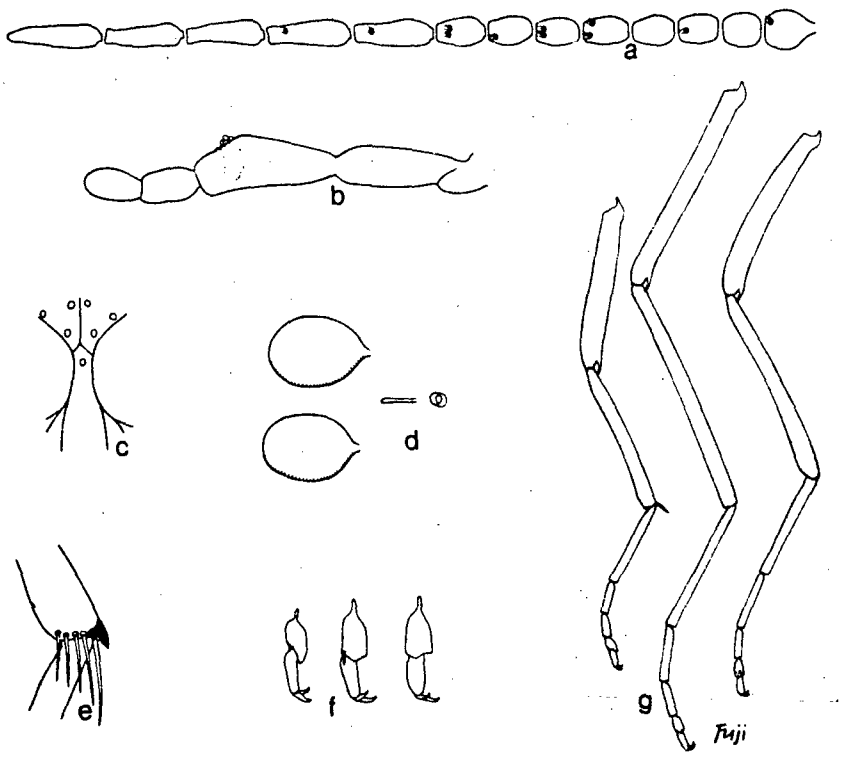


Fig. 191. *Culicoides agas*: a. antenna; b. palpus; c. eye separation; d. spermathecae; e. tibial comb; f. fourth and fifth tarsomeres and claws; g. legs.

Wing (fig. 484): Pattern as figured; without distinct pale or dark markings, all the veins infuscated brownish. Macrotrichia sparse and consisting of strong, spinelike setae, covering wing except in radial field and at bases of anal and medial cells; costal ratio 0.68; radial cells slitlike, in some specimens appearing as a single, slitlike radial cell.

Abdomen: Brownish; last segment short and strongly sclerotized. Spermathecae (fig. 191d) two, ovoid, with short, slender necks; subequal, each measuring 0.058 x 0.046 mm; vestigial spermatheca and ring present.

Male.--Unknown.

Distribution.--Indonesia, Solomon Islands.

Types.--Holotype female, Hatumull Village, N coast of Ceram, 8.iii.1972, T. Kurihara, biting man 8 PM on sandy beach (Type in USNM). Paratypes, 24 females:

INDONESIA: Ceram, same data as type, 9 females.

SOLOMON ISLANDS: Bouganville Island, 25.vii.1944, A.B. Gurney, 19 females.

Discussion.--The specific name *agas* is, according to Dr. Kurihara, the name given to this species by the Indonesians on Ceram, for whom it is a severe pest. Dr. Kurihara stated that the females bite man only within a few yards of the seashore, and never come inland. The type series was taken biting man about 1 1/2 hours after sunset. We are greatly indebted to Dr. Kurihara for making this series available to us and for the notes on the collection.

Rondani (1875) gave the name *Ceratopogon agas* to an unmarked reddish brown midge with hairy wings and long, narrow cells, that was taken in Sarawak in 1875 by D. Beccari sucking blood from the bare headparts of the brush turkey, *Meleagris gallopavo*. Examination of two female syntypes of *agas* Rondani donated to the U.S. National Museum through the kindness of Dr. Delfa Guiglia enables us to place the species in the genus *Forcipomyia*, subgenus *Lasiohelea*.

Culicoides agas is closely related to *C. immaculatus* Lee and Reye based on examination of the male genitalia of *agas* collected on Guadalcanal Solomons, by Eric Reye. The male of *agas* will be described in a forthcoming publication by A.L. Dyce. The distinguishing common features of the genitalia are the elongate, pincerlike dorsal and ventral roots of the basistyle, and the elongate parameres with strong, bladelike distal portions recurved ventrally. *Culicoides immaculatus* differs from *agas*, however, in its densely hairy wings, bare eyes, and antennal sensillar pattern of 3-10.

Culicoides coronalis Lee and Reye
(Figs. 192, 354, 485)

Culicoides coronalis Lee and Reye, 1955: 234 (female; Queensland; figs.).

Female.--Wing length 0.95 mm.

Head: Eyes (fig. 192d) narrowly separated, with distinct interfacetal hairs (fig. 192c). Antenna (fig. 192a) with lengths of flagellar segments in proportion of 30-22-21-20-20-20-20-22-33-33-35-35-60, antennal ratio 1.12; sensilla coeloconica present on segments 3,7-10. Palpus (fig. 192b) with lengths of segments in proportion of 10-20-43-20-23; third segment swollen distally, with a large, round, moderately deep, sensory pit; palpal ratio 2.0. Proboscis moderately long, P/H Ratio 0.75; mandible with 14 teeth.

Thorax: Brown, without evident pattern. Legs (fig. 192g) yellowish brown, tibiae brownish distally; tibial comb (fig. 192i) with 6 spines, the one nearest the spur longest.

Wing (fig. 354, 485): Pattern as figured; pattern obscure, darker along veins, indistinctly paler between; a darker area lying over r-m crossvein and extending across first radial cell to costa; a less distinct darker area on anterior margin at

about half the length of cell R5; second radial cell not deeply infuscated but slightly darker than the large pale area lying behind it; large, indistinct pale areas in apices of cells R5, M1, M2, and M4; an indistinct pale area at wing base and in base of anal cell, and an indistinct pale area lying in front of mediocubital fork. Macrotrichia sparse but consisting of short, spinelike setae, covering all of wing except radial field; costal ratio 0.64; radial cells rather long, both with distinct lumen. Halter slightly infuscated.

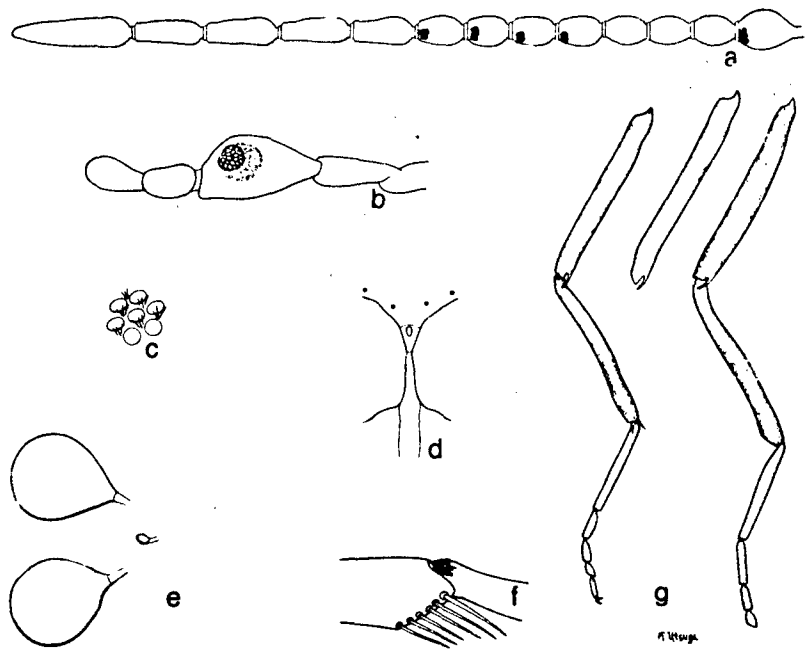


Fig. 192. *Culicoides coronalis*: a. antenna; b. palpus; c. eye pubescence; d. eye separation; e. spermathecae; f. tibial comb; g. legs.

Abdomen: Pale brown; distal segments characteristically narrowed and somewhat more strongly sclerotized so that abdomen appears subconical distally. Spermathecae (fig. 192e) 2, ovoid, tapering to short, slender necks; subequal, each 0.045 x 0.036 mm; vestigial third spermatheca present, sclerotized ring absent.

Male.--Unknown.

Distribution.--Indonesia, Philippines, Queensland.

Types.--Holotype female and 3 female paratypes, Prince of Wales Island, North Queensland, 31.xii.1952, J. Menner, on sandy beach (Australia National Insect Collection, Canberra).

Southeast Asia Records.--
INDONESIA: Sumba, Waingapu Bay (Boeadi).
PHILIPPINES: Palawan, Brookes Point, Uring Uring (Noona Dan Exped.).

Discussion.--The Indonesian material corresponds well with the original description and with notes on the types made by Wirth in Sydney in 1957. The type series is slightly larger (wing length 1.04 mm) and there are five spines on the hindtibial comb. This species is readily distinguished by the peculiar wing pattern with obscure pale markings and a dark spot lying over the r-m crossvein, and by the sparse, short, spinelike macrotrichia on the wings.

Culicoides kusaiensis Tokunaga
(Figs. 193, 355, 486)

Culicoides kusaiensis Tokunaga, 1940c: 215 (Kusaie, Caroline Islands; male, female; figs.); Tokunaga, 1940b: 181 (Ponape Island); Tokunaga and Murachi, 1959: 325 (male, female redescribed; Caroline and Marshall Islands; figs.); Lambrecht, 1970: 1777 (notes; Seychelles Islands); Wirth and Messersmith, 1977: 306 (Seychelles Islands).

Female.--Eyes bare, moderately widely separated. Antenna (fig. 193a,c) with lengths of flagellar segments in proportion of 14-9-9-10-10-22-22-22-20-23-25-28-31, antennal ratio 1.48 (1.42-1.57, n = 9); sensilla coeloconica present on segments 3,5,7,9,11-14. Palpus (fig. 193d) with lengths of segments in proportion of 10-22-29-11-12; third segment moderately swollen toward apex, with large, shallow, round pit; palpal ratio 2.3 (2.1-2.4, n = 9). Proboscis moderately long, P/H Ratio 0.90; mandible with 11 (9-13, n = 22) teeth.

Thorax: Brown; mesonotum (fig. 193h) without prominent pattern. Legs (fig. 218g) pale brown, unbanded; hindtibial comb (fig. 193f) with 5 (n = 11) spines, the one nearest the spur longest.

Wing (fig. 355, 486): Without pattern, veins slightly infuscated, especially over radius; macrotrichia moderately numerous on distal 2/3 of wing, sparse on proximal portion, the macrotrichia stout and setiform; costal ratio 0.66 (0.65-0.68, n = 10); both radial cells rather long and narrow, with distinct lumen. Halter knob deeply infuscated.

Abdomen: Brown. Spermathecae (fig. 193i) two, ovoid, tapering to short, slender, sclerotized necks; subequal, each 0.087 x 0.061 mm.

Male.--Similar to female with usual sexual differences, except for unusual modifications of the antenna (fig. 193b): flagellum without plume, but with short verticils on the proximal segments as in the female; flagellum with four distinct proximal segments, midportion more or less fused in a nodulus with 3-6 partial constrictions; distal three segments very elongate, their combined length 1.3-1.6 times that of proximal segments of flagellum; sensilla coeloconica present on seg-

ments 3,5,7,13,14. Genitalia (fig. 193j): Ninth sternum narrow, with broad shallow caudomedian excavation, ventral membrane with fine dense spicules; ninth tergum short, tapered to broad triangular apicolateral processes, caudal margin between them with broad mesal notch. Basistyle stout, ventral root obsolete, dorsal root long and slender; dististyle distinctly curved, slightly bent hooklike subapically, with sharp distal point. Aedeagus with broad, high basal arch extending to 0.6 of total length, basal arms slender and curved; main body with a broadly rounded caudal margin ventrally, internally (dorsally) with a very slender median sclerotized process with a pair of sharp, subapical lateral points. Parameres (fig. 193e) each with stout basal knob with slender anterior process extending from anterolateral corner; main body stout, nearly straight basally, slightly expanded distally and then abruptly bent ventrally in a broad, flattened distal blade.

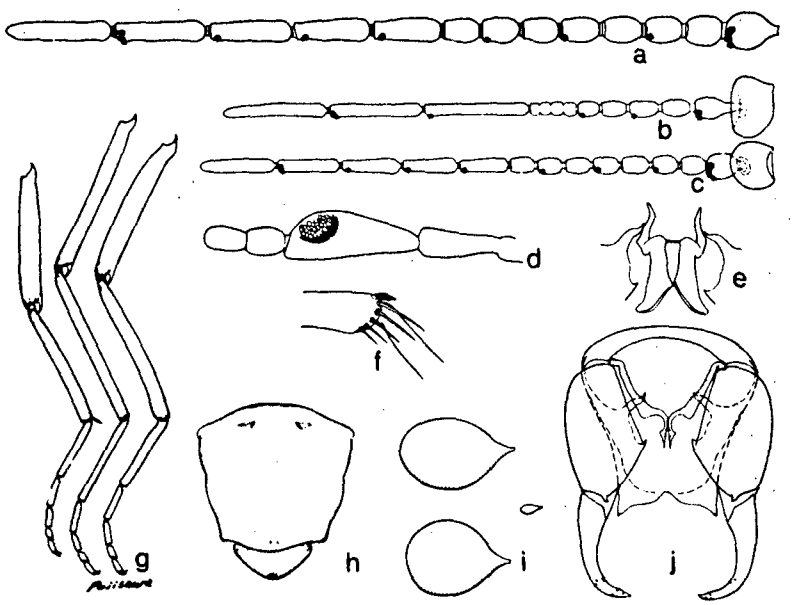


Fig. 193. *Culicoides kusaiensis*: a,c. female antenna; b. male antenna; d. palpus; e. parameres; f. tibial comb; g. legs; h. thoracic pattern; i. spermathecae; j. male genitalia, parameres omitted.

Distribution.--Micronesia; Indonesia, Malaysia, Sabah, Seychelles Islands.

Types.--Holotype male, allotype, paratypes, Malem, Kusaie Island, Carolines, 14.xii.1937, T. Esaki (deposited in Kyushu University Entomological Laboratory, Hakata, Japan).

Southeast Asia Records.--
INDONESIA: Sumatra, Sibolga (Ikemoto).
MALAYSIA: Negri Sembilan, Port Dickson, Telok Pelandok (Traub). Perak, Pulau Pangkor (Traub).
SABAH: Labuan Island (Colless).

Discussion.--Many of the Labuan Island specimens were taken resting on damp rocks and in shallow caves along the beach. Possibly the reduction of the male antennal plume is an adaptation for mating without swarming common in many chironomids living along wave- and wind-swept seashores. Lambrecht (1970) took females of *C. kusaiensis* biting man on the beach in the Seychelles Islands. This species is closely related to another Micronesian species, *C. ardentissimus* Tokunaga, in which the male antennal plumes are normal.

Culicoides longipalpis Delfinado
(Figs. 194, 356, 487)

Culicoides longipalpis Delfinado, 1961: 645 (female; Philippines; figs.).

Female.--Wing length 0.96 (0.91-1.04, n = 3) mm.
Head: Eyes narrowly separated by a narrow wedge-shaped space, bare. Antenna (fig. 194a) with lengths of flagellar segments in proportion of 18-12-12-13-13-13-13-14-24-25-27-28-40, antennal ratio 1.39 (1.33-1.46, n = 3); sensilla coeloconica present on segments 3,11-15. Palpus (fig. 194b) with lengths of segments in proportion of 10-22-29-9-12; third segment swollen nearly to base, with sensilla scattered on distal 0.7 of segment; palpal ratio 3.2 (2.8-3.9, n = 4). Proboscis moderately long, P/H Ratio 0.81; mandible with 13 (13-14, n = 6) teeth.
Thorax: Brownish; mesonotum (fig. 194c) paler on disc, with faint submedian pale brown vittae, blackish on margins; scutellum narrowly dark brown in middle. Legs (fig. 194e) pale brown; fore- and hindknees darker with adjacent pale band on tibiae, midknees broadly pale at joint; hindtibia with apex narrowly pale; hindtibial comb (fig. 194d) with 4-5 (n = 4) spines, the one nearest the spur longest.
Wing (fig. 356, 487): Pattern as figured; dark brown with small, distinct, pale spots; pale spot just distad of basal arculus; pale spot over r-m crossvein broader on costal margin, barely attaining media; poststigmatic pale spot triangular, broader cephalad, proximal half lying over apex of second radial cell, reaching halfway across cell R5 posteriorly; distal pale spot in cell R5 round, lying well back from apex of cell and not attaining anterior wing margin; a small oval pale spot straddling vein M1 at proximal third of vein; cell M1 with 1 oval pale spot, lying at distal third of cell; cell M2 with pale spot immediately behind medial fork, another just adjacent, in front of mediocubital fork, and a third distal pale spot near wing margin; cell M4 with a round pale spot in distal portion reaching wing margin; anal cell with a small round pale spot in basal portion near anal vein and a double pale spot in distal portion. Macrotrichia long and coarse and moderately numerous over distal 2/3 of wing and in posterior half of anal cell; costal ratio 0.67 (0.66-0.69, n = 3); only 1 radial cell present, moderately broad distally. Halter pale.

Abdomen: Spermathecae (fig. 194f) two plus vestigial third, ring absent; ovoid with short necks; subequal, each 0.040 x 0.030 mm.

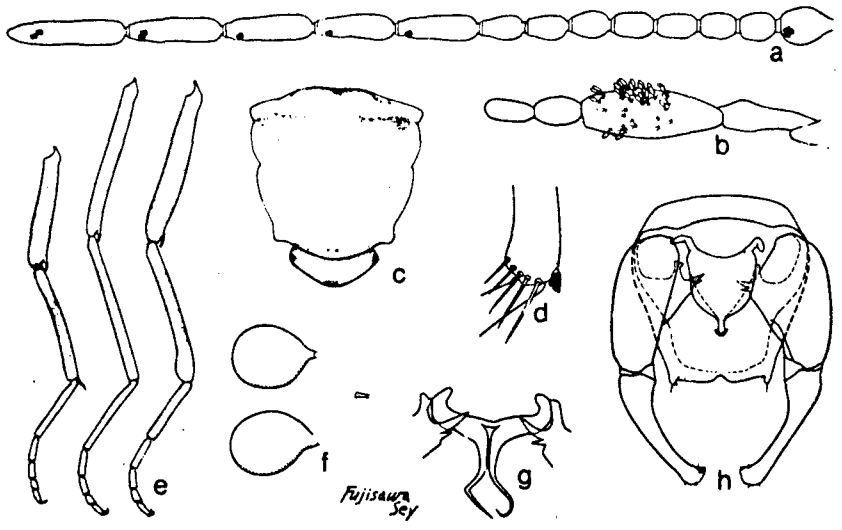


Fig. 194. *Culicoides longipalpis*: a. antenna; b. palpus; c. thoracic pattern; d. tibial comb; e. legs; f. spermathecae; g. parameres; h. male genitalia, parameres omitted.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 194h): Ninth sternum a narrow band without caudomedian excavation, ventral membrane not spiculate; ninth tergum short and broad, with short, widely separated, apicolateral processes, caudal margin between them with slight median notch. Basistyle with dorsal and ventral roots short and stout; dististyle moderately long and slender, with slightly expanded, rounded tip. Aedeagus with basal arch short, extending to less than a 1/4 of total length, broad and platelike in midportion with broadly rounded shoulders, tapering distally to a short, slender, papillate distal process. Parameres (fig. 194g) fused narrowly at bases, each with short curved anterolateral process, short and slender in midportion, tapering and curving to slender, simple point curving ventrad and then ventromesad.

Distribution.--Indonesia, Philippines.

Types.--Holotype female, eastern slope of Mt. McKinley, 1,000 m, Davao Prov., Mindanao, Philippines, 25.ix.1946, F.G. Werner, at light (in Field Museum of Natural History).

Southeast Asia Records.--

INDONESIA: Sulawesi (North), Lake Mooat, 20 km NE Kotamobagu, 1,500 m (Heppner).

PHILIPPINES: Leyte, Mahaplag, 10.vii.1964, M. Delfinado, light trap, 1 male, 1 female. Mindanao, Mt. Katanglad, Bukidnon (Quate); Mt. McKinley, Davao Prov. (Werner, type series).

Discussion.--The systematic position of this species is difficult to assess. Delfinado placed it in the subgenus *Oecacta* as she understood it, and it has some features in common with the Shermani Group, such as the very hairy wing with definite pale spots, antennal sensory pattern 3,11-5. The single radial cell and scattered palpal sensilla would ally it with *Haemophoructus*, but the costa is too short and the macrotrichia too numerous on the wing. The pale apex of the second radial cell and antennal sensory pattern might locate it in the subgenus *Hoffmania*, but the numerous macrotrichia, presence of only 4-5 tibial spines, and wing pattern with pale spot straddling vein M1 rather than vein M2 are together not characteristic of that group.

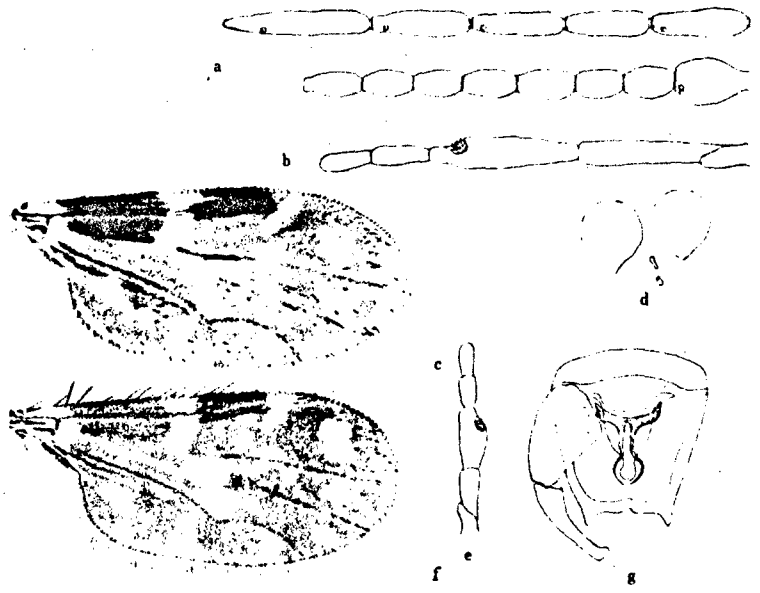


Fig. 195. *Culicoides perakensis*: a-d. female; e-g. male: a. antenna; b,e. palpus; c,f. wing; d. spermathecae; g. genitalis (from Kitaoka 1983).

Culicoides perakensis Kitaoka
(Fig. 195)

Culicoides perakensis Kitaoka, 1983: 21 (male, female; Malaysia; fig. wing, antenna, palpus, spermathecae; male genitalia).

Diagnosis.--Female wing length 0.87-0.91 mm; costal ratio 0.67. Closely related to *Culicoides longipalpis* Delfinado in wing markings (fig. 195c) but distinguished by the slender third palpal segment with sensory pit (fig. 195b) instead of scattered sensilla. Eyes separated by width of 2 facets, bare. Antennal ratio 1.12; sensilla coeloconica present on 3,11,13-15 (fig. 195a). Palpal ratio 5.0, third segment with small round shallow, subapical pit. Proboscis long, P/H ratio 1.1-1.2; mandible with 13-14 teeth. Thorax light brown, mesonotum without appreciable vittae. Legs light brownish, forefemur with pale apex; all tibiae with pale basal bands; hindtibial comb with 4 spines, one nearest spur longest. Spermathecae (fig. 195d) subequal, each 0.046 x 0.038 mm, vestigial third spermatheca and ring present. Male genitalia (fig. 195g) with ninth tergum short and tapering with short, pointed apicolateral processes; aedeagus with low basal arch, convex lateral margins, and short, rather stout, rounded apex; parameres narrowly fused at bases, each with stout anterolateral process, tapering and curving to slender pointed tip.

Type.--Holotype female, Gunong Besont, Forest Reserve, Perak, Malaysia, 18.iii.1974, B. Knudsen (in National Science Museum Tokyo, Japan).

Culicoides pseudocordiger Wirth and Hubert, new species
(Figs. 196, 357, 488)

Culicoides sp. 18; Noordin and Zachariah, 1976: 183 (Brunei; biting man).

Female.--Wing length 0.87 (0.84-0.92, n = 4) mm.

Head: Eyes (fig. 196d) contiguous, separated above by a narrow wedge shaped space; bare. Antenna (fig. 196a) with lengths of flagellar segments in proportion of 16-10-10-11-11-11-11-11-17-18-21-22-28, antennal ratio 1.14; sensilla coeloconica present on segments 3-14. Palpus (fig. 196d) with lengths of segments in proportion of 12-16-23-10-13; segments very short and stout, third segment with sensilla scattered on distal half; palpal ratio 1.6. Proboscis short, P/H Ratio 0.60; mandible with 12 (10-14, n = 8) teeth.

Thorax: Brown; mesonotum (fig. 196c) with pattern of punctiform dots at the seta bases. Legs (fig. 196f) pale brown, knee spots blackish; femora with narrow bases pale, tibiae with narrow subbasal pale rings, hindtibia with apex broadly pale; hindtibial comb (fig. 196g) with 6 spines, the one nearest the spur longest; fourth tarsomere distinctly cordiform.

Wing (fig. 357, 488): Pattern as figured; 3 small very dark spots, one over medial stem proximad of r-m crossvein, a large one covering distal portion of first radial cell and all of second, and a very small one in cell R5 just distad of poststigmatic pale spot. A large pale spot covering proximal half of medial stem; a large pale spot over r-m crossvein extending from costal margin to media; a double poststigmatic pale spot in cell R5 with short proximal extension behind second

radial cell; cell R5 with distal portion pale except a dark line bordering vein M1; vein M1 pale-bordered for most of its length distally, the vein itself forming a dark line; cell M1 with 1 elongate distal pale spot extending to wing margin, without separate basal pale spot but with the extensive pale streak which fills proximal 2/3 of cell M2 extending anteriorly across base of vein M2 partway into proximal portion of cell; cell M2 with a large distal pale spot broadly meeting wing margin; cell M4 also with large pale spot meeting wing margin; cell M2 with the proximal pale streak filling space between medial and mediocubital forks; anal cell with large pale area at base, a large distal pale spot in distal portion anteriorly, and a pale streak along posterior margin to apex of cell. Macrotrichia moderately numerous to sparse on distal third of wing; costal ratio 0.60 (0.59-0.61, n = 4); radial cells narrow with distinct lumen, the second narrowed distally. Halter pale.

Abdomen: Brown. Spermathecae (fig. 196h) 2, ovoid with short slender necks; subequal, each 0.049 x 0.036 mm.

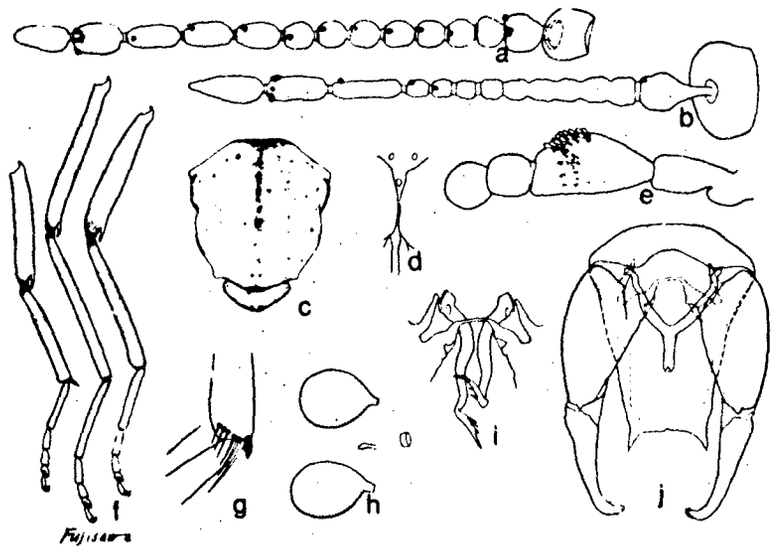


Fig. 196. *Culicoides pseudocordiger*: a. female antenna; b. male antenna; c. thoracic pattern; d. eye separation; e. palpus; f. legs; g. tibial comb; h. spermathecae; i. parameres; j. male genitalia, parameres omitted.

Male.--Similar to female with the usual sexual differences; antenna (fig. 196b) with segments 4-8 fused; sensilla coeloconica present on 3,11-14. Genitalia (fig. 196j): Ninth sternum with shallow caudomedian excavation, ventral membrane

not spiculate; ninth tergum long and slightly tapered distally, apicolateral processes long and triangular, caudal margin between them nearly straight. Basistyle with ventral and dorsal roots well-developed, ventral root with blunt posterior lobe and long toe-like anteromesal extension, dorsal root long and slender; dististyle nearly straight, tapered distally with apex bent to slender tip. Aedeagus with rounded basal arch extending to more than half of total length, basal arms slender, distal process short with blunt rounded tip. Parameres (fig. 196i) each with strongly sclerotized clubbed base, the moderately stout midportion slightly sinuate, without ventral lobe, distal portion attenuated to pointed tip bearing lateral fringe of three moderately long hairs.

Distribution.--Brunei, Malaysia, Sabah, Sarawak.

Types.--Holotype female, allotype male, Telok Sisek, Kuantan, Pahang, Malaysia, 14.vi.1958, R.H. Wharton, light trap (Type in USNM). Paratypes, 11 females.

BRUNEI: Muara Beach, ii.1971, C.Y. Chow, 1 female.

INDONESIA: Sumatra, Sibolga, 24.xi.1980, T. Ikemoto, 1 female (Tokyo).

MALAYSIA: Pahang Kuantan, 16.viii.1973, R. Parsons, light trap, 4 females. Perak. Pulau Pangkor, 1.iv.1959, R. Traub, light trap, 2 females.

SABAH: Labuan Island, x.1951, D.H. Colless, biting man, 3 females.

SARAWAK: Kuching, Santubong, 18-30.vi.1958, T. Maa, 4 females.

Discussion.--*Culicoides pseudocordiger* bears a superficial resemblance to *C. cordiger* Macfie in its cordiform fourth tarsomeres, as well as its general wing pattern and short antennae, but the male genitalia are not typical of the Ornatus Group. Its exact group relations are uncertain, the antennal sensory pattern excluding it from the Schultzei and Williwilli Groups, to which it might otherwise provisionally be referred. According to Alan Dyce (in litt.) this species has many morphological characters similar to those of *C. subimmaculatus* Lee and Reye and *molestus* (Skuse) from Australia.

Culicoides uncistylus Wirth and Hubert, new species
(Figs. 197, 358, 489)

Female.--Unknown.

Male.--Wing length 1.15 mm, breadth 0.45 mm.

Head: Eyes bare; separation not determined due to poor slide mount. Antenna with flagellum missing. Palpus (fig. 197a) with lengths of segments in proportion of 8-13-20-10-12; third segment moderately swollen in midportion, with sensilla borne in an irregular, open sensory area subapically.

Thorax: Unicolorous brownish; mesonotum with numerous long, stout bristly hairs. Legs damaged, brownish; femora without pale bands; fore- and hindtibiae with narrow basal pale band; midtibia missing; hindtibia with apex pale, tibial comb (fig. 197b) with 4 long spines, second from spur longest.

Wing (fig. 358, 489): Without prominent pattern, only a small area just past tip of costa somewhat paler, but without definite pale spot; membrane uniformly dark grayish brown due to coarse dark microtrichia. Macrotrichia numerous, extending nearly to base of wing in cell M2 and anal cell; costal ratio 0.60; radial cells well-formed, second moderately broad. Halter brown.

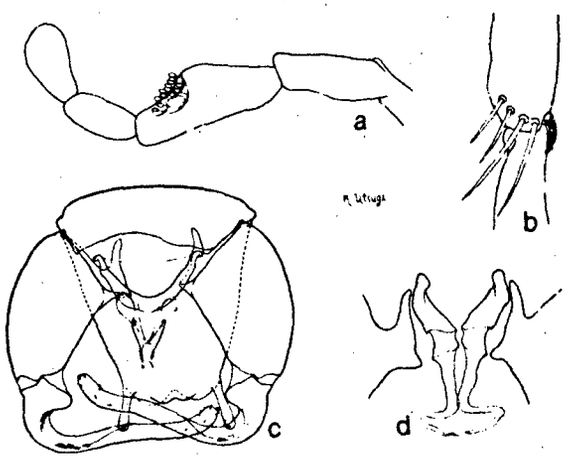


Fig. 197. *Culicoides uncistylus*, male: a. palpus; b. tibial comb; c. genitalia, parameres omitted; d. parameres.

Abdomen: Brown. Genitalia (fig. 197c) large. Ninth sternum with slight caudomedian excavation, ventral membrane not spiculate; ninth tergum moderately long and tapering, apicolateral processes long and slender, fingerlike, not tapering from bases, broadest at the rounded apices, at least five times as long as greatest breadth, slightly diverging, the caudal margin between their bases bilobate with distinct median cleft. Basistyle short and stout, tapering, ventral root not developed, dorsal root moderately long and slender; dististyle greatly modified, swollen at extreme base, then abruptly bent mesad and continuing as a nearly straight, slightly sinuate appendage 1.5 times as long as basistyle, with breadth subequal throughout to the slightly bent, rather blunt tip. Aedeagus with rounded basal arch extending to nearly half of total length, basal arms moderately slender and forming nearly a semicircle; distal process slender at base, swollen in midportion and tapering to moderately stout, bifid tip. Parameres (fig. 197d) separate; each with proximal half strongly sclerotized with two obliquely transverse sclerotized collars as figured, narrowed in turn distad of each collar; extreme base with strongly sclerotized anterior process articulating with

dorsal root of basistyle; distal portion gradually and evenly tapering, straight at base, then abruptly bent laterad, caudad and then ventrad and ending in a simple slender point.

Distribution.--Philippines.

Type.--Holotype male, Philippines, Mindanao, Agusan, Esperanza, 4-11.xi.1959, C. Yoshimoto, light trap (in B.P. Bishop Museum).

Southeast Asia Records.--Known only from the holotype male.

Discussion.--The species takes its name from the sharply hooked male dististyle which is greatly swollen at the extreme base, and long and slender and not tapered on the slightly sinuate distal portion.

It is difficult to assess the systematic position of *uncistylus*, since it is known only from the poorly preserved male. The poorly marked, hairy wing, tibial comb with 4 spines, second from the spur longest, the poorly developed ventral root on the basistyle, and the structure of the parameres, suggest that it may belong to the Shermani Group, but species of that group usually have a deep palpal pit opening by a smaller pore.

Culicoides yoshimurai Tokunaga
(Figs. 198, 359)

Culicoides yoshimurai Tokunaga, 1941a: 114 (Truk Atoll; female; fig. wing); Tokunaga and Murachi, 1959: 330 (male, female descr.; Caroline Islands; figs.); Tokunaga, 1962b: 471 (female redescr.; fig. wing; New Guinea, New Britain, New Ireland).

Female.--Wing length 0.69 mm.

Head: Eyes (fig. 198d) narrowly separated, with sparse interfacetal hairs. Antenna (fig. 198a) with flagellum pale yellowish; lengths of flagellar segments in proportion of 16-16-16-16-16-16-16-16-20-20-21-23-43, antennal ratio 1.15; sensilla coeloconica present on segments 9,8-10. Palpus (fig. 198b) dark brown, lengths of segments in proportion of 12-30-25-12-10; third segment moderately swollen with a moderately broad and deep, irregularly open, sensory pit; palpal ratio 1.56. Proboscis short, P/H Ratio 0.72; mandible with 13 fine teeth.

Thorax: Dark brown, with prominent pattern of yellowish brown patches. Legs (fig. 198h) dark brown, fore- and midtibiae with narrow basal pale rings; hindtibial comb with 4 spines, the one nearest the spur longest.

Wing (fig. 198c, 359): Pattern as figured; pale spot over r-m crossvein small, not extending anteriorly past radial vein; a very dark stigmal spot covering both radial cells and extending to costal margin; cell R5 with 3 distinct round pale spots, one lying immediately past second radial cell on anterior margin of wing, second located at nearly same level about midway between first spot and vein M1, and the third located in midportion of distal part of cell; cell M1 with 1 pale spot, located at midlength of cell; cell M2 with a long pale streak in proximal portion, a small pale

spot lying behind medial fork, another in front of base of mediocubital fork, and a small pale spot near wing margin in distal portion of cell; cell M3+4 with a round pale spot in distal portion, separate from wing margin; anal cell with a large double pale spot in distal portion; tips of veins not pale. Macrotrichia scanty, confined to a few in distal portion of cell R5 and near wing margin in cells M1 and M2; second radial cell unusually broad with large lumen; costal ratio 0.68. Halter dark brown.

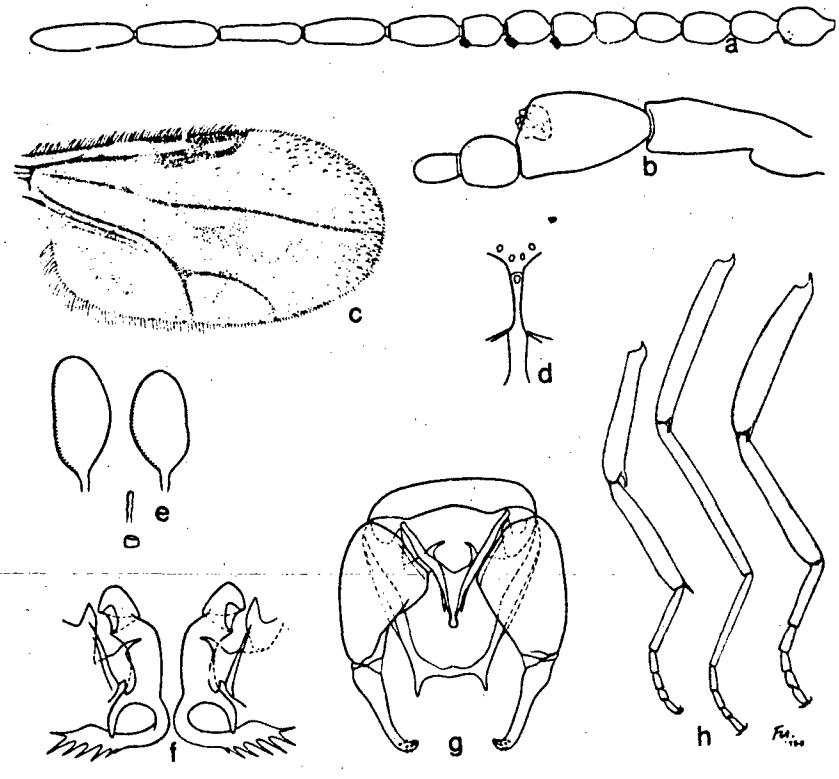


Fig. 198. *Culicoides yoshimurai*: a. antenna; b. palpus; c. wing; d. eye separation; e. spermathecae; f. parameres; g. male genitalia; h. legs.

Abdomen: Dark brown. Spermathecae (fig. 198e) 2, oval with long slender necks; subequal, each 0.043 x 0.026 mm; vestigial third spermatheca and sclerotized ring present.

Male.--Similar to female with usual sexual differences. Genitalia (fig. 198g): Ninth sternum narrow with shallow caudomedian excavation, ventral membrane not spiculate; ninth tergum short and broad, tapering distinctly to moderately separated, long, slender, pointed, apicolateral processes. Basistyle short and stout, with foot-shaped ventral root, dorsal root simple; dististyle slender, with abruptly bent, slender tip. Aedeagus with basal arch rounded, extending to about half of total length, basal arms slender; distal portion tapering to slender simple tip. Parameres (fig. 193f) each with stout basal knob; stout in midportion with well-developed ventral lobe; distal portion bearing 5-6 fringing spines on proximal expanded part, tapering distally to a slender pointed tip.

Distribution.--Caroline Islands, New Britain, New Guinea New Ireland, Philippines.

Types.--Female syntypes, Olej, Tol Island, Truk Atoll, Caroline Islands, in Kyoto University, Japan.

Southeast Asia Records.--
INDONESIA: Sulawesi (North), Lake Mooat, 20 km NE Kotamobagu, 1,500 m (Heppner).
PHILIPPINES: Leyte, Mahaplag (Delfinado).

Discussion.--Tokunaga (1962b) mentions that Micronesian specimens differ slightly fron New Guinea material in having more extensive wing markings, with the two poststigmatic pale spots in cell R5 usually more or less fused, and the antennal ratio 1.36-1.57. Our Philippine material, described above, agrees with Tokunaga's New Guinea description, except that in our Philippine specimens the antennal sensory pattern is 3,8-10, in the New Guinea description it was 3,7-10. According to Alan Dyce (in litt.) the membrane on the distal portion of the area between the ninth sternum and the basal arch of the aedeagus bears a group of strong spines, but these are not apparent in the male from Mt. Temwetemwensekir, Ponape, that we have described and figured.

Culicoides insulanus Macfie (1933) from Samoa and the Society Islands as redescribed by Wirth and Arnaud (1969) is apparently closely related to *C. yoshimurai*, having the same wing pattern but with more diffuse pale spots, but *insulanus* is readily distinguished as follows: legs with prominent broad pale bands on both sides of fore- and midknees and at base and apex of hindtibia; halter pale; antennal ratio 1.35; palpal ratio 1.43; P/H Ratio 0.60; female mandible with 8-10 teeth; and male parameres without ventral swelling or lobe.

REFERENCES CITED

Akiba, K.
1960. Studies on the *Leucocytozoon* found in the chicken in Japan. II. On the transmission of *Leucocytozoon caulleryi* by *Culicoides arakawae*. Jap. J. Vet. Sci. 22: 317.
1970. Leucocytozoonosis of chickens. Nat. Inst. Anim. Hlth. Quart. 10 (Suppl.): 131-147.
1975. Major parasitic diseases of chicken and their treatments. 2. Ceratopogonidae, nematodes (In Japanese). Anim. Husb. 29: 285-289.

Akiba, K., H. Kawashima, S. Inui, and S. Ishii
1958. Studies of *Leucocytozoon* of chickens in Japan. I. Natural infection of *L. caulleryi*. Bull. Nat. Inst. Anim. Hlth. 34: 163-180.

Akiba, K., S. Kitaoka, and T. Yajima
1959. Studies on the leucocytozoonosis of chickens in Japan. III. Transmission of *Leucocytozoon caulleryi* by *Culicoides arakawae*. Jap. J. Vet. Sci. 21: 127-128.

Amosova, I.S.
1957. Some new or little known *Culicoides* Latr. (Diptera, Heleidae) from Ussuri Land (In Russian, English summary). Ent. Obozr. 36: 233-247.

Annandale, N.
1913. Indian blood-sucking midges. Rec. Indian Mus. 9: 246-247.

Arakawa, S.
1910. Kakei no Shin-Gaichu O-nukaka (*Ceratopogon arakanae* Mats.) ni tsuite. Konchu-Sekae 14: 411-414.

Arnaud, P.H., Jr.
1956. The heleid genus *Culicoides* in Japan, Korea and Ryukyu Islands. Microentomology 21: 84-207.

Atchley, W.R.
1967. The *Culicoides* of New Mexico (Diptera: Ceratopogonidae). Univ. Kansas Sci. Bull. 46: 937-1020.
1970. A biosystematic study of the subgenus *Selfia* of *Culicoides* (Diptera: Ceratopogonidae). Univ. Kansas Sci. Bull. 49: 181-336.

Austen, E.E.
1912. Notes on African blood-sucking midges (Family Chironomidae, subfamily Ceratopogonidae), with descriptions of new species. Bull. Ent. Res. 3: 99-108, 1 plate.

Banks, C.S.
1919. The bloodsucking insects of the Philippines. Philippine J. Sci. 14: 169-189.

Becker, P.
1958. The behavior of larvae of *Culicoides circumscriptus* Kieffer (Diptera: Ceratopogonidae) towards light stimuli as influenced by feeding, with observations on the feeding habits. Bull. Ent. Res. 49: 785-802.

Bennett, G.F.
1960. On some ornithophilic blood-sucking Diptera in Algonquin Park, Ontario, Canada. Canad. J. Zool. 38: 377-389.
1961. On the specificity and transmission of some avian trypanosomes. Canad. J. Zool. 39: 17-33.
1970. Development of trypanosomes of the *T. avium* complex in the invertebrate host. Canad. J. Zool. 48: 945-957.

Bennett, G.F., P.C.C. Garnham, and A.M. Fallis
1965. On the status of the genera *Leucocytozoon* Ziemann, 1898 and *Haemoproteus* Kruse, 1890 (Haemosporiida: Leucocytozoidae and Haemoproteidae). Canad. J. Zool. 43: 927-932.

Bergner, J.F., Jr., and L.A. Jachowski
1968. The filarial parasite, *Macacanema formosana*, from the Taiwan monkey and its development in various arthropods. Formosan Sci. 22: 1-68.

Bezzi, M.
1917. Studies in Philippine Diptera. II. Philippine J. Sci. 12: 107-161.

Bidlingmayer, W.L.
1961. Field activity studies of adult *Culicoides furens*. Ann. Ent. Soc. Am. 54: 149-156.

Bingham, E.
1968. Environmental conditions relating to harmful insects of mainland Southeast Asia. U.S. Army Natick Labs. Tech. Rept. 69-28-ES, 61 pp.

Blanton, F.S., and W.W. Wirth
1979. The sand flies (*Culicoides*) of Florida (Diptera: Ceratopogonidae). Arthropods of Florida 10: 1-204.

Boorman, J., and O.O. Dipeolu
1979. A taxonomic study of adult Nigerian *Culicoides* Latreille (Diptera: Ceratopogonidae) species. Occas. Publ. Ent. Soc. Nigeria 22: 1-121.

Bowne, J.G., A.J. Luedke, N.M. Foster, and M.M. Jochim
1966. Current status of Bluetongue in cattle. J. Am. Vet. Med. Assoc. 148: 1177-1180.

Bowne, J.G., A.J. Luedke, M.M. Jochim, and N.M. Foster
1964. Current status of Bluetongue in sheep. J. Am. Vet. Med. Assoc. 144: 759-764.

Braverman, Y., J. Boorman, and M. Kremer
1976. Faunistic list of *Culicoides* (Diptera, Ceratopogonidae) from Israel. Cah. O.R.S.T.O.M. Ser. Ent. Med. Parasit. 14: 179-185.

Braverman, Y., P.F.L. Borham, R. Galun, and M. Ziv
1977. The origin of blood meals of biting midges (Diptera: Ceratopogonidae) and mosquitoes (Diptera: Culicidae) trapped in turkey runs in Israel. Rhod. J. Agric. Res. 15: 101-104.

Braverman, Y., J.C. Delecolle, K. Frish, M. Rugina, and M. Kremer
1981. New records of *Culicoides* species (Diptera: Ceratopogonidae) from Golan Heights, Israel and Sinai Peninsula. Israel J. Ent. 15: 13-20.

Braverman, Y., K. Frish, and M. Rubina
1979. Preliminary results of blood sucking arthropod survey in the Sinai Peninsula. Refuah Vet. 36: 121-123.

Braverman, Y., and Galun
1973. The medical and veterinary importance of the genus *Culicoides* (Diptera, Ceratopogonidae). Refuah Vet. 30: 62-68.
Braverman, Y., R. Galun, and M. Ziv
1974. Breeding sites of some *Culicoides* species (Diptera, Ceratopogonidae) in Israel. Mosquito News 34: 303-308.
Braverman, Y., and P.E. Hulley
1979. The relationship between the numbers and distribution of some antennal and palpal sense organs and host preference in some *Culicoides* (Diptera: Ceratopogonidae) from southern Africa. J. Med. Ent. 15: 419-424.
Buckley, J.J.C.
1938. On *Culicoides* as a vector of *Onchocerca gibsoni* (Cleland and Johnston 1919). J. Helminth. 16: 121-158.
Buerger, G.
1967. Sense organs on the labra of some blood-feeding Diptera. Quaest. Ent. 3: 283-290.
Callot, J., M. Kremer, and J.L. Geiss
1972. Iconographie de l'armature cibariale de 22 espèces de *Culicoides* (Diptéres, Cératopogonidés). Ann. Parasit. Hum. Comp. 47: 759-762.
Campbell, J.A., and E.C. Pelham-Clinton
1960. A taxonomic review of the British species of *Culicoides* Latreille (Dipt.: Ceratopogonidae). Proc. R. Soc. Edinburgh, Ser. B. 67: 181-302.
Campbell, J.G.
1954. Bangkok haemorrhagic disease of chickens: An unusual condition associated with an organism of uncertain taxonomy. J. Path. Bacteriol. 68: 423-430.
Campbell, M.M.
1974. The biology and behaviour of *Culicoides brevitarsis* Kieffer with particular reference to those features essential to its laboratory colonisation. Ph.D. Thesis. Queensland Univ., Brisbane, Australia. 255 pp.
1975. Some aspects of the biology of *Culicoides brevitarsis*. News Bull. Ent. Soc. Qld. 3: 97-99.
Campbell, M.M., and D.S. Kettle
1975. Oogenesis in *Culicoides brevitarsis* Kieffer and the development of a plastron-like layer on the egg. Aust. J. Zool. 23: 203-218.
1975b. Sugar feeding and longevity in *Culicoides brevitarsis* Kieffer (Diptera: Ceratopogonidae). J. Aust. Ent. Soc. 14: 333-337.
1976. Number of adult *Culicoides brevitarsis* Kieffer (Diptera: Ceratopogonidae) emerging from bovine dung exposed under different conditions in the field. Aust. J. Zool. 24: 75-85.
1979a. Swarming of *Culicoides brevitarsis* Kieffer (Diptera: Ceratopogonidae) with reference to markers, swarm size, proximity of cattle, and weather. Aust. J. Zool. 27: 17-30.
1979b. Abundance and temporal and spatial distribution of *Culicoides brevitarsis* Kieffer (Diptera: Ceratopogonidae) on cattle in South-East Queensland. Aust. J. Zool. 27: 251-260.

Cannon, L.R.G., and E.J. Reye
1966. A larval habitat of the biting midge *Culicoides brevitarsis* Kieffer (Diptera: Ceratopogonidae). J. Ent. Soc. Qld. 5: 7-9.
Carpenter, S.J.
1951. Studies of *Culicoides* in the Panama Canal Zone (Diptera, Heleidae). Mosquito News 11: 202-208.
Carter, H.F., A. Ingram, and J.W.S. Macfie
1920. Observations on the Ceratopogonine midges of the Gold Coast with descriptions of new species. Ann Trop. Med. Parasit. 14: 187-210.
Causey, O.R.
1938. *Culicoides* of Siam with descriptions of new species. Am. J. Hyg. 27: 399-416.
Chaika, S.Y.
1978. The ultrastructure of the chemoreceptor sensilla of the biting midges (Diptera, Ceratopogonidae) (In Russian). Vestn. Mosk. Univers. Ser. Biol. 1978: 21-28.
Chanthawanich, N.
1961. *Culicoides* of the Ban Phra Region, Thailand. Dept. Zool. Chulalongkorn Univ. Grad. School. Master's Thesis. 82 pp.
Chastel, C., J. Rageau, and E. Abonnenc
1966. Presence de *Culicoides anophelis* Edwards, 1922 (Diptera: Ceratopogonidae) au Cambodge. Bull. Soc. Path. Exot. 59: 151-155.
Chen, K.-C., and L.-L. Tsai
1962. The blood-sucking midges (Ceratopogonidae) of Fukien (In Chinese). Acta Ent. Sinica 11: 394-400.
Chu, F.I.
1977. New species and records of *Culicoides* (Diptera: Heleidae) from Tibet, China (In Chinese). Acta Ent. Sinica 20: 99-105.
1984. Two new names of Chinese *Culicoides* (Diptera, Ceratopogonidae) (In Chinese). Entomotaxonomia 6: 24.
1986. The biting midges of Cambodia, with descriptions of two new species (Diptera: Ceratopogonidae) (In Chinese and English). Entomotaxonomia 8: 251-261.
Chu-Wang, I., R C. Axtell, and D.L. Kline
1975. Antennal and palpal sensilla of the sand fly *Culicoides furens* (Poey) (Diptera: Ceratopogonidae). Int. J. Ins. Morph. Embry. 4: 131-149.
Clastrier, J.
1958. Notes sur les ceratopogonidés. IV. Ceratopogonidés d'Afrique Occidentale Francaise. Arch. Inst. Pasteur Algér. 36: 192-258.
1959. Notes sur les ceratopogonidés. VI. Ceratopogonidés d'Afrique Occidentale Francaise (3). Arch. Inst. Pasteur Algér. 37: 167-197.
1961. Le Parc National du Niokolo-Koba (Deuxieme Fascicule). XXVII. Diptera Ceratopogonidae. Mém. inst. Française d'Afrique Noire 62: 257-272.
Corbet, A.S.
1941. The distribution of butterflies in the Malay Peninsula (Lepid.). Proc. R. Ent. Soc. London (A) 16: 101-116.

Corbet, A.S., and H.M. Pendlebury
1956. The butterflies of the Malay Peninsula. Oliver and Boyd, Edinburgh. 2nd Ed. Rev. 537 pp., 57 plates.

Cornet, M.
1974. Caractéres morphologiques utilisés pour l'identification des *Culicoides* (Diptera, Ceratopogonidae). Cah. O.R.S.T.O.M. Ser. Ent. Med. Parasit. 12: 221-229.

Cornet, M., and R. Chateau
1970. Les *Culicoides* de l'Ouest Africain (2e note). Espèces apparentes a *C. similis* Carter, Ingram et Macfie, 1920 (Diptera, Ceratopogonidae). Cah. O.R.S.T.O.M. Ser. Ent. Med. Parasit. 8: 141-173.

Das Gupta, B., and N. Pal
1976. Malarial oocysts in *Culicoides* sp. in Darjeeling. Trans. R. Soc. Trop. Med. Hyg. 70: 89-90.

Das Gupta, S.K.
1962a. Some *Culicoides* of Calcutta and the neighbouring areas. Sci. Cult. 28: 537-539.
1962b. *Culicoides* (Dipt., Ceratopogonidae) from suburbs of Calcutta. Ent. Mon. Mag. 98: 253-254.
1963a. Report on a collection of Sikkim *Culicoides* (Diptera: Ceratopogonidae). Proc. Calcutta Zool. Soc. 16: 33-43.
1963b. Report on a collection of *Culicoides* (Diptera: Ceratopogonidae). Bull. Ent. no. 4: 38-40.
1964. *Culicoides (Trithecoides) anophelis* Edwards (Insecta: Diptera: Ceratopogonidae) as an ectoparasite of insect vectors. Proc. Zool. Soc. Calcutta 17: 1-20.

Das Gupta, S.K., and S.M. Ghosh
1956a. Notes on *Culicoides palpifer*, a new species (Family Ceratopogonidae, Order Diptera). Bull. Calcutta Sch. Trop. Med. 4: 122.
1956b. Observations on parasitisation of anopheline mosquitoes by *Culicoides anophelis*. Bull. Calcutta Sch. Trop. Med. 4: 122-123.
1956c. On a new blood-sucking species *Culicoides alatus*, n. sp. (Family Ceratopogonidae, Order Diptera). Bull. Calcutta Sch. Trop. Med. 4:162-163.
1957. *Culicoides anophelis* Edw. as an ectoparasite of culicine mosquitoes. Bull. Calcutta Sch. Trop. Med. 5: 26-27.
1961. Report on biting midges (Diptera - Ceratopogonidae) with additional notes on a few species. Bull. Calcutta Sch. Trop. Med. 9: 117-119.

Davies, F.G.
1978. Bluetongue studies with sentinel cattle in Kenya. J. Hyg. Camb. 80: 197-204.

Davies, J.B., and J.R. Linley
1966. A standardized flotation method for separating *Leptoconops* (Diptera, Ceratopogonidae) and other larvae from sand samples. Mosquito News 26: 440.

Debenham, M.L.
1978. An annotated checklist and bibliography of Australasian Region Ceratopogonidae (Diptera: Ceratopogonidae). School Pub. Hlth. Trop. Med. Univ. Sydney Commonw. Dept. Hlth. Monogr. Ser. Ent., Monogr. No. 1, 671 pp.
Delfinado, M.D.
1961. The Philippine biting midges of the genus *Culicoides* (Diptera: Ceratopogonidae). Fieldiana: Zool. 33: 627-675.
Dobby, E.H.G
1954. Southeast Asia. Univ. London Press, London.
Doherty, R.L.
1972. Arboviruses of Australia. Austral. Vet. J. 48: 172-180.
Doherty, R.L., J.G. Carley, H.A. Standfast, A.L. Dyce, and W.A. Snowden
1972. Virus strains isolated from arthropods during an epizootic of bovine ephemeral fever in Queensland. Austral. Vet. J. 48: 81-86.
Dorsey, C.K.
1947. Population and control studies of the Palau gnat on Peleliu, Western Caroline Islands. J. Econ. Ent. 40: 805-814.
Downes, J.A.
1968. Notes on the organs and processes of sperm-transfer in the lower Diptera. Canad. Ent. 100: 608-617.
Downes, J.A., and W.W. Wirth
1981. Chapter 28. Ceratopogonidae. pp. 393-421, In: J.F. McAlpine et al., Eds. Manual of Nearctic Diptera, Vol. 1, 674 pp. Agric. Canada Res. Br. Monogr. 27. Ottawa.
Driggers, D.P., R.J. O'Conner, J.T. Kardatzke, J.L. Stup, and B.A. Schiefer
1980. The U.S. Army miniature solid state mosquito light trap. Mosquito News 40: 172-180.
Du Toit, R.M.
1944. The transmission of blue-tongue and horse-sickness by *Culicoides*. Onderstepoort J. Vet. Sci. Anim. Ind. 19: 7-15.
Dyce, A.L.
1979. *Culicoides radicitus* a synonym of *Culicoides brevitarsis* (Diptera: Ceratopogonidae). J. Austral. Ent. Soc. 18: 52.
1980. Redescription of *Culicoides orientalis* (Diptera: Ceratopogonidae). Pacif. Ins. 21: 286-292.
1983. Review of published records of *Culicoides* species in subgenus *Avaritia* (Diptera: Ceratopogonidae) from the New Guinea subregion. Int. J. Ent. 25: 270-274.
Dyce, A.L., and M.D. Murray
1967. Autogeny in *Culicoides waringi* Lee and Reye and *Culicoides mackerrasi* Lee and Reye (Diptera: Ceratopogonidae) from Australia with notes on breeding places and behaviour. J. Austral. Ent. Soc. 6: 119-126.
Dyce, A.L., H.A. Standfast, and B.H. Kay
1972. Collection and preparation of biting midges (Fam. Ceratopogonidae) and other small Diptera for virus isolation. J. Austral. Ent. Soc. 11: 91-96.

Dyce, A.L., and W.W. Wirth
1983. Reappraisal of some Indian *Culicoides* species in the subgenus *Avaritia* (Diptera: Ceratopogonidae). Int. J. Ent. 25: 221-225.
Edwards, F.W.
1922. On some Malayan and other species of *Culicoides* with a note on the genus *Lasiohelea*. Bull. Ent. Res. 13: 161-167.
1926a. Diptera Nematocera from the mountains of Borneo. Sarawak Mus. J. 3: 243-278, 2 plates.
1926b. Fauna Buruana. Diptera, subordo Nematocera. Treubia 7: 134-144.
1929. Philippine Nematocerous Diptera II. Notulae Ent. 9: 1-14.
1933. Diptera Nematocera from Mount Kinabalu. J. Fed. Malay States Mus. 17: 223-296.
Edwards, F.W., H. Oldroyd, and J. Smart
1939. British Blood-sucking Flies. British Museum (Nat. Hist.), London, 156 pp., 45 plates.
Edwards, P.B.
1980. Effect of season and sampling method on *Culicoides* (Diptera: Ceratopogonidae) species caught at two estuarine sites in southeast Queensland. J. Austral. Ent. Soc. 19: 201-209.
Eyles, D.E., and M. Warren
1963. *Hepatocystis* from *Macaca irus* in Java. J. Parasit. 49: 891.
Fadzil, M., and T.S. Cheah
1974. The occurrence of *Culicoides arakawae* Arakawa, 1910 in peninsular Malaysia and its possible significance. Kajian Vet. Malaysia 6: 89.
1975. *Culicoides arakawae* (Arakawa 1910): A possible vector of *Akiba caulleryi* in peninsular Malaysia (preliminary report). Kajian Vet. Malaysia 7: 32-36.
Fain, A., and R. Domrow
1980. A new species of *Myianoetus* Oudemans (Acarina: Anoetidae) from a ceratopogonid fly in Australasia. Austral. Ent. Mag. 7: 41-44.
Fallis, A.M., and D.M. Wood
1957. Biting midges (Diptera: Ceratopogonidae) as intermediate hosts for *Haemoproteus* of ducks. Canad. J. Zool. 35: 425-435.
Fearnside, C.J.
1900. Parasites found on mosquitoes. Indian Med. Gazette 35: 129.
Fiedler, O.G.H.
1951. The South African biting midges of the genus *Culicoides* (Ceratopogonidae, Dipt.). Onderstepoort J. Vet. Res. 25: 3-33.
Forattini, O.P.
1957. *Culicoides* da Região Neotropical (Diptera, Ceratopogonidae). Arq. Fac. Hig. Saude Pub. Univ. São Paulo 11: 161-526.
Fox, I.
1948. *Hoffmania*, a new subgenus in *Culicoides* (Diptera: Ceratopogonidae). Proc. Biol. Soc. Wash. 61: 21-28.

1955. A catalogue of the bloodsucking midges of the Americas (*Culicoides*, *Leptoconops* and *Lasiohelea*) with keys to the subgenera and Nearctic species, a geographic index and bibliography. J. Agric. Univ. Puerto Rico 39: 214-285.

Fredeen, F.J.H.
1969. *Culicoides* (*Selfia*) *denningi*, a unique river-breeding species. Canad. Ent 101: 539-544.

Fujisaki, K.
1983. Serological and parasitological studies on Leucocytozoonosis of chickens in South East Asian countries, especially in Malaysia. JARQ 17: 131-137.

Fukuda, T., T. Goto, S. Kitaoka, K. Fujisaki, and H. Takamatsu
1979. Experimental transmission of fowl pox by *Culicoides arakawae*. Nat. Inst. Anim. Hlth. Quart. 19: 104-105

Gad, A.M.
1951. The head-capsule and mouthparts in the Ceratopogonidae. Bull. Soc. Fuouad Ier d'Ent. 44: 17-75.

Gallliard, H., and H. Gaschen
1937. Parasitisme d'*Anopheles hyrcanus* par les *Culicoides* au Tonkin. Ann. Parasit. Hum. Comp. 15: 320-322.

Garnham, P.C.C., R.B. Heisch, and D.M. Minter
1961. The vector of *Hepatocystis* (=*Plasmodium*) *kochi*; the successful conclusion of observations in many parts of tropical Africa. Trans. R. Soc. Trop. Med. Hyg. 55: 497-502.

Giles, F.E., and W.W. Wirth
1985. A new genus and species of biting midge (Diptera: Ceratopogonidae) and a new species of *Culicoides* from Malaysia. Int. J. Ent. 27: 364-368.

Glukhova, V.M.
1967. On the technique of collecting and cultivation of larvae of bloodsucking midges (Diptera, Ceratopogonidae) (In Russian). Parazitologiya 1: 171-175.
1968a. Comparative morphology of larvae of biting midges of the genus *Culicoides* (Diptera, Ceratopogonidae) (In Russian, English summary). Parazitologiya 2: 105-114.
1968b. Systematic review of larvae of the genus *Culicoides* (Diptera, Ceratopogonidae) (In Russian, English summary). Parazitologiya 2: 559-567.
1977. The subgeneric classification of the genus *Culicoides* Latreille, 1809 (Diptera, Ceratopogonidae), including morphological characters of the larva (In Russian). Parazit. Sb. 27: 112-118.
1979. Description of larvae of midges of the genus *Culicoides* (Ceratopogonidae) (In Russian, English summary). Parazitologiya 3: 461-467.
1982. Structure of the mouthparts of the blood-sucking midges of the subgenus *Trithecoides* of the genus *Culicoides* (Ceratopogonidae) (In Russian, English summary). Parazitologiya 16: 155-159.

Goetghebuer, M.
1932. Ceratopogonidae et Chironomidae. Resultats Scientifiques du Voyage aux Indes Orientales Neerlandaises 4(7): 5-7.
Gravely, F.H.
1911. Mosquito sucked by a midge. Rec. Indian Mus. 6: 45.
Gressitt, J.L.
1970. Biogeography of Laos. pp. 573-626. In: J.L. Gressitt et al., Eds. Cerambycid Beetles of Laos. Pacific Ins. Monogr. 24: 1-651.
Griffiths, R.B.
1963. Veterinary preventive medicine in South-east Asia. Br Vet. J. 119: 362-366, 1 plate.
Gutsevich, A.V.
1970. On the subdivision of the genus *Culicoides* Latr. (Diptera, Ceratopogonidae) into subgenera (In Russian, English summary). Parazitologiya 4: 414-417.
1973. Bloodsucking midges (Diptera) (In Russian). Akad. Nauk, USSSR Zool. Inst. Fauna USSR 3(5): 1-269.
Hase, A.
1934. Ueber heftige, blasige Hautreaktionen nach Culicoidesstichen. Ztschr. Parasitenk. 6: 119-128.
Hill, M.A.
1947. The life-cycle and habits of *Culicoides impunctatus* Goetghebuer and *Culicoides obsoletus* Meigen, together with some observations on the life-cycle of *Culicoides odibilis* Austen, *Culicoides pallidicornis* Kieffer, *Culicoides cubitalis* Edwards, and *Culicoides chiopterus* Meigen. Ann. Trop. Med. Parasit. 41: 55-115.
Holz, J., and R.T. Adiwinata
1958. Ueber Sandfliegen in Indonesien. Hemero Zoa 65: 21-42.
Hopkins, C.A.
1952. Notes on the biology of certain *Culicoides* studied in the British Cameroons, West Africa, together with observations on their possible role as vectors of *Acanthocheilonema perstans*. Ann. Trop. Med. Parasit. 46: 165-172.
Howarth, F.G.
1974. Bionomics and systematics of the biting midge genus *Culicoides* of Laos (Diptera: Ceratopogonidae). Ph.D. Dissertation, Univ. Hawaii. 250 pp.
1985. Biosystematics of the *Culicoides* of Laos (Diptera: Ceratopogonidae). Int. J. Ent. 27: 1-96.
Hubert, A.A., and W.W. Wirth
1961. Key to the *Culicoides* of Okinawa and the description of two new species (Diptera, Ceratopogonidae). Proc. Ent. Soc. Wash. 63: 235-239.
Inaba, Y., H. Kurogi, and T. Omori
1975. Akabane disease: Epizootic abortion, premature birth, stillbirth, and congenital arthrogryposis-hydranencephaly in cattle, sheep and goats caused by Akabane virus. Austral. Vet. J. 51: 584-585.

Iwata, M.
1935. On blood-sucking Diptera (In Japanese). Trans. Ent. Soc. Hiroshima 2: 5-9.
Iyengar, M.O.T.
1938. Natural parasites of mosquitoes in India. Proc. Nat. Inst. Sci. India 4: 237-239.
Jamnback, H.A.
1965a. The *Culicoides* of New York State. N.Y. St. Mus. Bull. 399: 1-154.
1965b. Structure of the antennae and mouthparts as related to feeding habits of *Culicoides* (Diptera: Ceratopogonidae). Proc. 12th Int. Congr. Ent. London, p. 817.
Jobling, B.
1928. The structure of the head and mouth-parts of *Culicoides pulicaris* L. Bull. Ent. Res. 18: 211-236.
Johannsen, O.A.
1931. Ceratopogoninae from the Malayan Subregion of the Dutch East Indies. Arch. Hydrobiol. Suppl. Bd. 3: 403-448.
1946. Diptera. Some new species of Nemocerous Diptera from Guam. Insects of Guam II. B.P. Bishop Mus. Bull. 189: 187-193.
Jones, R.H.
1961. Descriptions of pupae of thirteen North American species of *Culicoides* (Diptera: Ceratopogonidae). Ann. Ent. Soc. Am. 54: 729-746.
1978. *Culicoides* and *Leptoconops* (Family Ceratopogonidae). pp. 31-35. In: R.A. Bram, Ed. Surveillance and collection of arthropods of veterinary importance. U.S. Dept. Agric., Agric. Handb. 518, 125 pp.
Jones, R.H., A.J. Luedke, T.E. Walton, and H.E. Metcalf
1981. Bluetongue in the United States; an entomological perspective toward control. World Animal Review no. 38: 2-8.
Kay, B.H.
1973. Seasonal studies of a population of *Culicoides marmoratus* (Skuse) (Diptera: Ceratopogonidae) at Deception Bay, Queensland. J. Austral. Ent. Soc. 12: 42-58.
Kay, B.H., and T. Lennon
1982. Seasonal prevalence and bionomics of biting midges (Ceratopogonidae) at Ocean Shores, New South Wales. J. Austral. Ent. Soc. 21: 207-216.
Kettle, D.S.
1951. The spatial distribution of *Culicoides impunctatus* Goet. under woodland and moorland conditions and its flight range through woodland. Bull. Ent. Res. 42: 239-291, 1 plate.
1962. The bionomics and control of *Culicoides* and *Leptoconops* (Diptera, Ceratopogonidae = Heleidae). Annu. Rev. Ent. 7: 401-418.
1965. Biting ceratopogonids as vectors of human and animal diseases. Acta Tropica 22: 356-362.
1977. Biology and bionomics of bloodsucking ceratopogonids. Annu. Rev. Ent. 22: 33-51.

Kettle, D.S., and M.M. Elson
1975a. The undescribed male and immature stages of *Culicoides interrogatus* Lee and Reye. J. Austral. Ent. Soc. 14: 23-29.
1975b. The immature stages of *Culicoides belkini* Wirth and Arnaud (Diptera: Ceratopogonidae), with notes on pupal terminology. J. Med. Ent. 12: 256-258.
1976. The immature stages of some Australian *Culicoides* Latreille (Diptera: Ceratopogonidae). J. Austral. Ent. Soc. 15: 303-332.
1978. The immature stages of more Australian *Culicoides* Latreille (Diptera: Ceratopogonidae). J. Austral. Ent. Soc. 17: 171-187.
1980. Descriptions of four pupae of Australian *Culicoides* Latreille (Diptera: Ceratopogonidae). J. Austral. Ent. Soc. 19: 11-18.

Kettle, D.S., M.M. Elson, and A.L. Dyce
1976. *Culicoides gladysae* sp. n. (Diptera Ceratopogonidae) from eastern Australia, with descriptions of its larva and pupa and a re-examination of *C. mykytowyczi* Lee and Reye and *C. moreensis* Lee and Reye. J. Austral. Ent. Soc. 15: 173-182.

Kettle, D.S., and J.W.H. Lawson
1952. The early stages of British biting midges, *Culicoides* Latreille (Diptera: Ceratopogonidae) and allied genera. Bull. Ent. Res. 43: 421-467.

Kettle, D.S., C.H. Wild, and M.M. Elson
1975. A new technique for rearing individual *Culicoides* larvae (Diptera: Ceratopogonidae). J. Med. Ent. 12: 263-264.

Khalaf, K.T.
1954. The speciation of the genus *Culicoides* (Diptera, Heleidae). Ann. Ent. Soc. Am. 47: 34-51.
1957. Heleids from Iraq with descriptions of new species (Diptera: Heleidae (Ceratopogonidae)). Bull. Soc. Ent. Egypte 41: 335-350.

Khamala, C.P.M., and D.S. Kettle
1971. The *Culicoides* Latreille (Diptera: Ceratopogonidae) of East Africa. Trans. R. Ent. Soc. London 123: 1-95.

Kieffer, J.J.
1910. Étude sur les Chironomides des Indes Orientales, avec description de quelques nouvelles espéces d'Egypte. Mem. Indian Mus. 2: 181-242, 4 plates.
1913. Chironomidae et Cecidomyiidae. In: Voyage de Ch. Alluaud et R. Jeannel en Afrique orientale (1911-1912). Résultats scientifiques. Diptera, 1, pp. 1-43.
1916. H. Sauter's Formosa-Ausbeute. Tendipedidae (Dipt.). Suppl. Ent. 5: 114-117.
1917. Chironomides d'Australie conservés au Musee national hongrois de Budapest. Ann. Hist.-nat. Mus. Natl. Hungar. 15: 175-228.
1918. Chironomides d'Afrique et d'Asie conservés au Museum National Hongrois de Budapest. Ann. Hist.-nat. Mus. Natl. Hungar. 16: 31-136.
1919. Chironomides d'Europe conservés au Musée national Hongrois de Budapest. Ann. Hist.-nat. Mus. Natl. Hungar. 17: 1-160.
1921a. Étude sur les Chironomides de Formose. Ann. Soc. Linn. Lyon 68: 149-163.

1921b. Chironomides des Philippines et de Formosa. Philippine J. Sci. 18: 557-593.

1921c. Notes synonymiques (Dipt.). Bull. Soc. Ent. France 1921: 7.

Kitaoka, S.

1973. Description of four new species and the hitherto unknown males of four species of the *Culicoides* (Ceratopogonidae, Diptera) from Amami-Oshima, Japan. Nat. Inst. Anim. Hlth. Quart. 13: 211-219.

1975. Five new species of *Culicoides* (Diptera: Ceratopogonidae) of the Nansei Islands. Nat. Inst. Anim. Hlth. Quart. 15: 192-200.

1977. Biting midges (Ceratopogonidae). pp. 187-200. In: M. Sasa et al., Eds. Animals of Medical Importance in the Nansei Islands in Japan. 410 pp. Tokyo.

1980. Six new species and males of some species of Japanese *Culicoides* (Diptera: Ceratopogonidae). Nat. Inst. Anim. Hlth. Quart. 20: 11-22.

1983. Five new species of the genus *Culicoides* (Diptera: Ceratopogonidae) from West Malaysia. Nat. Inst. Anim. Hlth. Quart. 23: 92-98.

1985a. Japanese *Culicoides* (Diptera: Ceratopogonidae) and keys for the species. I. (In Japanese). Bull. Natl. Inst. Anim. Hlth. 87: 73-89.

1985b. Japanese *Culicoides* (Diptera: Ceratopogonidae) and keys for the species. II. (In Japanese). Bull Natl. Inst. Anim. Hlth. 87: 91-108.

Kitaoka, S., and T.S. Cheah

1983. Seasonal incidence and feeding preferences of *Culicoides* species caught in chicken houses and cattle sheds at Ipoh in peninsular Malaysia (Diptera: Ceratopogonidae). Malaysian Vet. J. 7: 245-253.

Kitaoka, S., and T. Morii

1963. Observations on the breeding habitats of some biting midges and seasonal population dynamics in the life cycle of *Culicoides arakawai* in Tokyo and its vicinity. Nat. Inst. Anim. Hlth. Quart. 3: 198-208.

Kitaoka, S., T. Morii, and M. Kosuge

1965. Field experiments on the repellents to chicken-biting midges (In Japanese, English summary). Jap. J. Sanit. Zool. 16: 244-248.

Kitaoka, S., K. Munakata, and A. Yajima

1963. Biting midges of *Culicoides* collected from cowsheds in seven prefectures in Japan (In Japanese). Bull Nat. Inst. Anim. Hlth. 46: 52-58.

Kitaoka, S., and H. Suzuki

1974. The fauna and host preference of *Culicoides* (Diptera: Ceratopogonidae) in southern Amami-Oshima (In Japanese). Jap. J. Sanit. Zool. 25: 171-176.

Kline, D.L., and R.C. Axtell

1977. Distribution of *Culicoides hollensis*, *C. furens* and *C. bermudensis* in relation to plant cover in a North Carolina salt marsh (Diptera: Ceratopogonidae). J. Med. Ent. 13: 545-552.

Kono, H., and H. Takahasi

1940. A revision of the *Culicoides*-species of Saghalien and Hokkaido (Ceratopogonidae, Diptera). Insecta Matsumurana 14: 69-77.

Kremer, M.

1966. Contribution a l'étude du genre *Culicoides* Latreille, particulièement en France. Encycl. Ent. 39: 1-299.

1972. Redescription de *Culicoides imicola*, *C. alticola* et *C. tropicalis* Kieffer sur des exemplaires déterminès par l'auteur (Diptera, Ceratopogonidae). Bull. Mus. Nat. Hist. Nat. Paris (3 ser.) no. 58 (Zool. 44): 645-655.

Kremer, M., C. Rebholtz-Hirtzel, and J.C. Delecolle

1975. Étude des types de *Culicoides* (Diptera, Ceratopogonidae) de Goetghebuer et des autres Ceretopogonidae déposés au Musée de Tervuren. Rev. Zool Africaine 89: 769-820.

Laird, M.

1946. A ceratopogonine midge (*Culicoides anophelis* Edwards, 1922) sucking engorged blood from a mosquito (*Armigeres lacuum* Edwards, 1922) at Palmalmal, New Britain. Trans. Proc. R. Soc. New Zealand 76: 158-161.

Lalor, N.P. O'Gromon

1912. Note on a parasitic fly which infests malaria carrying *Anopheles* in Lower Burma. Paludism no. 5. 42-43.

Lambrecht, F.L.

1970. New records of bloodsucking insects from Seychelles Islands, Indian Ocean. Ann. Ent. Soc. Am. 63: 1776-1777.

Lawson, J.W.H.

1951. The anatomy and morphology of the early stages of *Culicoides nubeculosus* Meigen (Diptera: Ceratopogonidae = Heleidae). Trans. R. Ent. Soc. London 102: 511-570.

Lee, D.J., and E.J. Reye

1953. Australasian Ceratopogonidae (Diptera, Nematocera) part 6. Australian species of *Culicoides*. Proc. Linn. Soc. N.S.W. 77: 369-394.

1955. Australasian Ceratopogonidae (Diptera: Nematocera). Part VII. Notes on the genera *Alluaudomyia*, *Ceratopogon*, *Culicoides* and *Lasiohelea*. Proc. Linn. Soc. N.S.W. 79: 233-246.

1963. Australian Ceratopogonidae (Diptera, Nematocera). Part X. Additional Australian species of *Culicoides*. Proc. Linn. Soc. N.S.W. 87: 352-363.

Lee, D.J., E.J. Reye, and A.L. Dyce

1963 (1962). "Sandflies" as possible vectors of disease in domesticated animals in Australia. Proc. Linn. Soc. N.S.W. 87: 364-376.

Lee, T.S.

1978. Diptera. Biting Midges. Chinese Economic Entomology (In Chinese). Vol. 13: 1-124. Acad. Sinica Zool. Edit. Committee. Science Publishers, Peking.

1979. Biting midges of Tibet, China; Diptera: Ceratopogonidae (In Chinese, English summary). Acta Ent. Sinica 22: 98-107.

Lekagul, Boonsong, and J.A. McNeely

1978. Mammals of Thailand. Assoc. Cons. Wildlife, Bangkok, 746 pp.

Lever, R.J.A.W.

1943. Further notes on the fauna of the British Solomon Islands. Trop. Agric. (Trinidad) 20: 40-42.

Lewis, G.E.D., and R. Ho

1965. Malaysian Geographies for Today. Book 3: Asia. 406 pp. Kuala Lumpur.

Linley, J.R.
1965. Descriptions of the pupae of *Culicoides barbosai*, *C. insignis*, and *C. borinqueni* (Diptera: Ceratopogonidae). Ann. Ent. Soc. Am. 58: 57-63.
1968. Colonization of *Culicoides furens*. Ann. Ent. Soc. Am. 61: 1486-1490.
1969. Studies on larval development in *Culicoides furens* (Poey) (Diptera: Ceratopogonidae). I. Establishment of a standard rearing technique. Ann. Ent. Soc. Am. 62: 702-711.
1970a. Description of the pupa of *Culicoides floridensis*. Ann. Ent. Soc. Am. 63: 1016-1019.
1970b. The immature stages of *Culicoides arboricola* Root and Hoffman (Diptera: Ceratopogonidae). J. Med. Ent. 7: 717-721.
1979. Nutrient agar mixtures for culture of food organisms for predaceous *Culicoides* larvae (Diptera: Ceratopogonidae). J. Med. Ent. 16: 171-172.

Linley, J.R., A.L. Hoch, and F.P. Pinheiro
1983. Biting midges (Diptera: Ceratopogonidae) and human health. J. Med. Ent. 20: 347-364.

Linley, J.R., and D.S. Kettle
1964. A description of the larvae and pupae of *Culicoides furens* Poey and *Culicoides hoffmani* Fox (Diptera: Ceratopogonidae). Ann. Mag. Nat. Hist. (13) 7: 129-149.

Macfie, J.W.S.
1925. A new bloodsucking midge from Singapore. Bull. Ent. Res. 15: 349-
1932. Some new or little known Ceratopogonidae. Ann. Mag. Nat. Hist. (10) 9: 485-499.
1933. Ceratopogonidae from the Society Islands. Bull. Bernice P. Bishop Mus. 6: 75-80.
1934a. Report on a collection of Ceratopogonidae from Malaya. Ann. Trop. Med. Parasit. 28: 177-194, 279-293.
1934b. Fauna Sumatrensis. Bijdrage no. 75. Ceratopogonidae (Diptera). Tijdschr. Ent. 77: 202-231.
1937a. Notes on Ceratopogonidae (Diptera). Proc. R. Ent. Soc. London (B) 6: 111-118.
1937b. Three new species of *Culicoides* (Diptera, Ceratopogonidae) from Malaya. Ann. Trop. Med. Parasit. 31: 469-472.
1941. Notes on Ceratopogonidae (Diptera). Proc. R. Ent. Soc. London (B) 10: 67-69.

Macnae, W.
1968. A general account of the fauna and flora of mangrove swamps and forests in the Indo-West Pacific Region. Adv. Mar. Biol. 6: 73-270.

Marks, E.N., and E.J. Reye
1966 (revised 1973). An atlas of common Queensland mosquitoes, with a guide to common Queensland biting midges. Brisbane, 102 pp.

Mathis, C., and M. Leger
1909. *Leucocytozoon* de la poule. C.R. Seances Soc. Biol. Fil. 67: 470-472.

Matsumura, S.
1915. Taxonomy of Insects, Part 2 (In Japanese). Tokyo Kei Seisha Shoten, 316 pp., 5 plates.

Matumoto, M., and Y. Inaba
1980. Review: Akabane disease and Akabane virus. Kitasato Arch. Exp. Med. 53: 1-21.
Mayer, K.
1934. Ceratopogoniden-Metamorphosen der Deutchen Limnologischen Sunda Expedition. Arch. Hydrobiol. Suppl. Bd. 13: 166-202.
Mayr, E.
1944. Wallace's Line in the light of recent zoogeographic studies. Quart. Rev. Biol. 19: 1-14.
McClure, H.E.
1974. Migration and Survival of the Birds of Asia. SEATO Medical Research Laboratory, Bangkok. 476 pp.
McClure, H.E., P. Poonswad, E.C. Greiner, and M. Laird
1978. Haematozoa in the Birds of Eastern and Southern Asia. Mem. Univ. Newfoundland. St. John's. 296 pp.
McClure, H.E., and N. Ratanaworabhan
1973. Some Ectoparasites of the Birds of Asia. SEATO Medical Research Laboratory, Tokyo, Japan. 219 pp.
McDonald, J.L., T. Bolinguit, and L.C. Lu
1973. Female *Culicoides* of Okinawa with descriptions of new species (Diptera: Ceratopogonidae). J. Med. Ent. 10: 633-648.
McDonald, J.L., and L.C. Lu
1972. Female *Culicoides* of Taiwan with descriptions of new species (Diptera: Ceratopogonidae). J. Med. Ent. 9: 396-417.
McKenzie, D.P., and J.G. Sclater
1973. The evolution of the Indian Ocean. Sci. Am. 228(5): 63-72.
Meijere, J.C.H. de
1907. Studien über Südostasiatische Dipteren. I. Tijdschr. Ent. 50: 196-254, 2 plates.
1909. Blutsaugende Micro-Dipteren aus Niederlandisch Ostindien. Tijdschr. Ent. 52: 191-204, 1 plate.
Meillon, B. de
1937. Entomological studies. Studies on the insects of medical importance from southern Africa and adjacent territories. Part IV. Pubs. S. Afr. Inst. Med. Res. 7: 301-411.
Miltgen, F., and I. Landau
1982. *Culicoides nubeculosus*, vecteur experimental d'un nouveau trypanosome de Psittaciforme, *Trypanosoma bakeri*, n. sp. Ann. Parasit. Hum. Comp. 57: 423-428.
Miltgen, F., I. Landau, E.U. Canning, J. Boorman, and M. Kremer
1976. *Hepatocystis* de Malaisie. III. Developpement d'*Hepatocystis brayi* chez *Culicoides nubeculosus* et *C. variipennis*. Ann. Parasit. Hum. Comp. 51: 299-302.
Miltgen, F., I. Landau, N. Ratanaworabhan, and S. Yenbutra
1981. *Parahaemoproteus desseri* n. sp.; gamtogonie et schizogonie chez l'hôte naturel: *Psittacula roseata* de Thailande, et sporogonie expérimentale chez *Culicoides nubeculosus*. Ann. Parasit. Hum. Comp. 56: 123-130.

Mitra, R.D.
1952. Modified setae on the palp of blood-sucking midges. Ztschr. Tropenmed. Parasit. 3: 549-552.

Molev, E.V.
1958. The rearing of ceratopogonids of the genus *Culicoides* in laboratory conditions (In Russian). Zool. Zhur. 37: 1563-1568.

Molnar, P., and P. Tapponier
1975. Cenezoic tectonics of Asia: Effects of a continental collision. Science 189: 419-426.

Mukerji, S.
1931a. Morphology of the pharynx of female *Culicoides* and its taxonomic importance. Nature 127: 339-340.
1931b. On a new species of *Culicoides* (*Culicoides clavipalpis* sp. nov.), with notes on the morphology of the mouth-parts and male terminalia of an Indian *Culicoides*. Indian J. Med. Res. 18: 1051-1058.

Mulhern, T.D.
1953. Better results with mosquito light traps through standardizing mechanical performance. Mosquito News 13: 130-133.

Muller, M.J., M.D. Murray, and J.A. Edwards
1981. Blood-sucking midges and mosquitoes feeding on mammals at Beatrice Hill, N.T. Austral. J. Zool. 29: 573-578.

Murray, M.D.
1975. Potential vectors of bluetongue in Australia. Austral. Vet. J. 51: 216-220.

Murray, M.D., and A.L. Dyce
1970. Native insects of Australia as disease vectors--A review of some current studies. Austral. Vet. J. 46: 138-140.

Neal, D.G.
1967. Statistical description of the forests of Thailand. Military R. and D. Center, Bangkok, 343 pp.

Nevill, E.M.
1968. A significant new breeding site of *Culicoides pallidipennis* Carter, Ingram and Macfie (Diptera: Ceratopogonidae). J.S. Afr. Vet. Med. Assoc. 39: 61.
1969. The morphology of the immature stages of some South African *Culicoides* species (Diptera: Ceratopogonidae). Onderstepoort J. Vet. Res. 36: 265-284.

Nevill, E.M., and D. Anderson
1972. Host preferences of *Culicoides* midges (Diptera: Ceratopogonidae) in South Africa as determined by precipitin tests and light trap catches. Onderstepoort J. Vet. Res. 39: 147-152.

Noordin, H.J.B.H., and V.J. Zachariah
1976. Bionomics of biting midges in Brunei. Brunei Mus. J. 3: 183-187.

Ogawa, H., K. Yoda, and T. Kira
1961. A preliminary survey on the vegetation of Thailand. pp. 21-157, 26 plates. In: T. Kira and T. Umesao, Eds. Nature and Life in Southeast Asia. Flora and Fauna Res. Soc. Kyoto, Japan, vol. 1, 454 pp.

Okada, T.
1941. Biting midges collected from the northeastern district of Honsyu, Japan. J. Coll. Agric. Tokyo Imp. Univ. 15: 13-31.
1942. Notes on a biting midge parasitic on Anopheline mosquito with a revision of its allies (Diptera, Heleidae). Trans. Nat. Hist. Soc. Formosa 32: 137-146.
1954. Note on some biting midges of Inner Mongolia, North China, Manchuria, and Korea (Diptera, Heleidae). Jap. J. Appl. Zool. 19: 1-7.

Orszagh, I.
1976. Die Gattung *Culicoides* Latr., 1809 (Diptera, Ceratopogonidae) in Slowakei. Acta F.R.N. Univ. Comenianae Zool. 21: 1-89.

Oritz, I.
1969. Los Dipteros hematofagos del genero *Culicoides* en Venezuela (Diptera: Ceratopogonidae). Part II. Morfologia y Systematica de adultos. Rev. Inst. Nac. Higiene Caracas 2: 33-37.

Patton, W.S.
1913. *Culicoides kiefferi*, n. sp., a new Indian blood sucking midge. Indian J. Med. Res. 1: 336-338.
1920. Some notes on the arthropods of medical and veterinary importance in Mesopotamia, and on their relation to disease. Part IV. Some Mesopotamian Nematocera of economic importance. Indian J. Med. Res. 8: 245-252, 1 plate.

Pendlebury, H.M., and F.N. Chasen
1932. A zoological expedition to Mt. Kinabalu, British North Borneo (1929). J.F.M.S. Museums 17: 1-38, 9 plates.

Petersen, B.
1966. The Noona Dan Expedition, 1961-62. Insects and other land arthropods. Ent. Meddr. 34: 283-304, 4 plates.

Pinheiro, R.P., A.P.A. Travassos de Rosa, J.F.S. Travassos da Rosa, R. Ishak, R.B. Freitas, M.L. C. Gomes, J.W. LeDuc, and O.F.P. Oliva
1981. Oropouche virus. I. A review of clinical, epidemiological, and ecological findings. Am. J. Trop. Med. Hyg. 30: 149-160.

Ratanaworabhan, N.
1975. An illustrated key to the female *Culicoides* of Chiangmai Valley, Thailand. U.S. Army Med. Comp. SEATO, Bangkok, 49 pp.

Remm, H.
1974. Midges (Diptera, Ceratopogonidae) of the fauna USSR (In Russian). Avtoref, Doct. Dis. D. 3-31.

Remm, H., and D.T. Zhogolev
1968. Contributions to the fauna of biting midges (Diptera, Ceratopogonidae) of the Crimea (In Russian, English summary). Ent. Obozr. 47: 826-842 (translation Ent. Rev. 47: 503-513).

Reye, E.J.
1964. The problem of biting midges (Diptera: Ceratopogonidae) in Queensland. J. Ent. Soc. Qld. 3: 1-6.

Reye, E.J., and D.J. Lee
1961. An investigation of the possible role of biting midges (Diptera, Ceratopogonidae) in the transmission of arthropod-borne virus diseases at Townsville. Prov. Linn. Soc. N.S. Wales 86: 230-236.
1963(1962). The influence of the tide cycle on certain species of *Culicoides* (Diptera, Ceratopogonidae). Proc. Linn. Soc. N.S. Wales 87: 377-387.
Richards, P.W.
1936. Biological observations on the rain forest of Mount Dulit, Sarawak. J. Ecol. 24: 1-27, 341-360.
1952. The tropical rain forest. Univ. Press, Cambridge.
Riek, R.F.
1953. Studies on allergic dermatitis of the horse. II. Treatment and control. Austral. Vet. J. 29: 185-187.
1954. Studies on allergic dermatitis (Queensland itch) of the horse: The aetiology of the disease. Austral. J. Agric. Res. 5: 109-129.
Rondani, C.
1875. Fragmentum III. Species in insula Bonnae Fortunae (Borneo), Provicinia Sarawak, annis 1865-68, lectae a March. J. Doria et Doct. O. Beccari. Ann. Mus. Civ St. Nat. Genova 7: 421-464.
Root, F.M., and W.A. Hoffman
1937. The North American species of *Culicoides*. Am. J. Hyg. 25: 150-176, 8 plates.
Rowley, W.A., and M. Cornford
1972. Scanning electron microscopy of the pit of the maxillary palp of selected species of *Culicoides*. Canad. J. Zool. 50: 1207-1210, 3 plates.
St. George, T.D., H.A. Standfast, and C.H. Cybinski
1978. Isolations of Akabane virus from sentinentel cattle and *Culicoides brevitarsis*. Austral. Vet. J. 54: 558-561.
Salm, A.J.
1914. Sur les insectes succeurs de sang de l'Archipel de la Sonde. Arch. Parasit. 16: 401-410.
1918. Nematoceres hematophages de Java. Bull. Soc. Zool. France 42: 135-139.
Sasaki, C.
1928. *Ceratopogon shimai*, a new midge affecting the domestic fowl. Proc. Imp. Acad. Japan 3(10): 687-689.
Schacher, J.F.
1973. Laboratory models in filariasis: A review of filarial life-cycle patterns. Southeast Asian J. Trop. Med. Publ. Hlth. 4: 336-349.
Schmidtmann, E.T., J.F. Abdnd, and M.E. Valla
1981(1980). Nocturnal blood-feeding from pastured calves by the ceratopogonid midge, *Culicoides venustus*, in New York State. Mosquito News 40: 571-577.
Scott, H.G.
1966. Plates of vector-borne diseases in Vietnam. U.S. Dept. H.E.W. P.H.S., Com. Dis. Ctr., Atlanta. 51 pp.

Sen, P., and S.K. Das Gupta
1958. Males of *Culicoides anophelis* Edw. Bull. Ent. Res. 49: 415-416.
1959a. Feeding habits of *Culicoides anophelis* (Diptera: Ceratopogonidae). Bull. Calcutta Sch. Trop. Med. 7: 108-109.
1959b. Studies on Indian *Culicoides* (Ceratopogonidae: Diptera). Ann. Ent. Soc. Am. 52: 617-630.
Sen, S.K., and T.B. Fletcher
1962. Veterinary Entomology and Acarology for India. Indian Council Agric. Res., New Delhi. 668 pp., 50 plates.
Service, M.W.
1970. A battery-operated light trap for sampling mosquito populations. Bull. W.H.O. 43: 635-641.
Shevchenko, A.K., and S.M. Dzhafarov
1968. Sensilla on the antennae of blood-sucking biting midges (Diptera, Ceratopogonidae) (In Russian). Zool. Zhur. 47: 145-146.
Shiraki, T.
1913. Investigation on general injurious insects (In Japanese). Taiwan Sotokufu Noji Shikenjo Tokubetsu Hokoku 8: 286-297.
Sinton, J.A., and C.J.H. Little
1925. The occurrence of *Culicoides* as an ectoparasite of anopheiines. J.R. Army Med. Corps 45: 45-47.
Sloof, R.
1964. A record of *Culicoides* (*Trithecoides*) *culiciphagus* Wirth and Hubert, 1959 (Diptera: Ceratopogonidae) from West New Guinea. Ent. Ber. 24: 39-40.
Sloof, R., and E.N. Marks
1965. Mosquitoes (Culicidae) biting a fish (Periophthalmidae). J. Med. Ent. 2: 16.
Smith, R.O.A.
1929. Two species of *Culicoides* which feed on man. Indian J. Med. Res. 17: 255-257.
Smith, R.O.A., and C.S. Swaminath
1932. Notes on some *Culicoides* from Assam. Indian Med. Res. Mem. 25: 182-186.
Sommerman, K.M., and R.P. Simmet
1965. Car-top insect trap with terminal cage in auto. Mosquito News 25: 172-182.
Standfast, H.A., and A.L. Dyce
1968. Attacks on cattle by mosquitoes and biting midges. Austral. Vet. J. 44: 585-586.
1972. Potential vectors of arboviruses of cattle and buffalo in Australia. Austral. Vet. J. 48: 226-227.
Standfast, H.A., and I.D. Fanning
1968. Entomology. Ephemeral fever epidemic. Rep. Qld. Inst. Med. Res. no. 23: 6-7.
Standfast, H.A., M.J. Muller, and A.L. Dyce
1983. A recent southern extension of the range of *Culicoides wadai* to south-east Queensland. Austral. Vet. J. 60: 383-384.

Standfast, H.A., M.D. Murray, A.L. Dyce, and T.D. St. George
1973. Report on epnemeral fever in Australia. Bull. Off. Int. Epizoot. 79 (no. 5-6): 615-625.
Stanton, A.T.
1912. A *Ceratopogon* parasitic upon Anopheline mosquitoes. Paludism no. 5: 64.
Sudia, W.D., and R.W. Chamberlain
1962. Battery-operated light trap, an improved model. Mosquito News 22: 126-129.
Sun, W.K.C.
1974. Laboratory colonization of biting midges (Diptera: Ceratopogonidae). J. Med. Ent. 11: 71-73.
Supperer, R.
1966. Onchocercosis bei Tieren. Berl. Muench. Tierarz. Wochschr. 79: 10-14.
Taylor, E.H., and R.E. Eibel
1958. Contribution to the herpetology of Thailand. Univ. Kansas Sci. Bull. 38: 1033-1089.
Taylor, F.H.
1913. Report of the entomologist. Rep. Austral. Inst. Trop. Med. 1911: 49-74, 3 plates.
Tokunaga, M.
1937. Sand flies (Ceratopogonidae, Diptera) from Japan. Tenthredo 1: 233-338.
1940a. Biting midges from Japan and neighbouring countries, including Micronesian Islands, Manchuria, North China and Mongolia (Diptera, Ceratopogonidae). Tenthredo 3: 101-165.
1940b. Biting midges from the Micronesian Islands (Diptera, Ceratopogonidae) with biological notes by Teiso Esaki. Tenthredo 3: 166-186.
1940c. Ceratopogonidae and Chironomidae from the Micronesian Islands with biological notes by Teiso Esaki. Philipp. J. Sci. 71: 205-230, 2 plates.
1941a. Biting ceratopogonid midges from the Caroline Islands. Annot. Zool. Japon. 20: 109-117, 1 plate.
1941b. Biting midges from Manchuria (Ceratopogonidae, Diptera). Insecta Matsum. 15: 89-102.
1950. Culicoid flies from Kyushu, Japan (Ceratopogonidae, Diptera). Sanit. Zool. 1: 64-67.
1951. Some Javanese biting midges (Ceratopogonidae, Diptera). Saikyo Univ. Fac. Agric. Sci. Rept. 1: 101-110.
1955. Notes on biting midges from Japan and Korea (Heleidae or Ceratopogonidae, Diptera). Sci. Rep. Saikyo Univ. 7: 1-8.
1959. New Guinea biting midges (Diptera: Ceratopogonidae). Pacific Ins. 1: 177-313.
1960. Notes on biting midges I. Akitu 9: 72-76.
1961. Notes on biting midges. Kontyu 29: 180-185.
1962a. Biting midges of the Ryukyu Islands (Diptera: Ceratopogonidae). Pacific Ins. 4: 153-217.

1962b. Biting midges of the genus *Culicoides* from New Guinea (Diptera: Ceratopogonidae). Pacific Ins. 4: 457-516.
1963a. New Guinea biting midges (Diptera: Ceratopogonidae). 3. Pacific Ins. 5: 211-279.
1963b. Supplementary study of New Guinea biting midges of the genus *Culicoides* (Diptera: Ceratopogonidae). Plant Protect. Bull. 5: 119-143.
1976. Revision on the New Guinea species of *Culicoides* biting midges (Diptera: Ceratopogonidae). Mem. Osaka Aoyama Junior College 5: 35-47.

Tokunaga, M., and T. Esaki
1936. A new biting midge from Palau Islands with its biological notes. Mushi 9: 55-58, 1 plate.

Tokunaga, M., and E.K. Murachi
1959. Insects of Micronesia Diptera: Ceratopogonidae. Bernice P. Bishop Mus. Ins. of Micronesia 12: 103-434.

Tokunaga, M., K. Takiyama, M. Tanaka, and H. Toshikawa
1961. Early stages and breeding places of *Culicoides arakawai* (Diptera: Ceratopogonidae). Sci. Rep. Kyoto Pref. Univ. Agric. 13: 53-59.

Underwood, J.R.
1934. Equine Dhobie Itch, a symptom of filariasis. Vet. Bull. U.S. Army 28: 227-236.

Vargas, L.
1953. *Beltranmyia* n. subgen. de *Culicoides* (Insecta: Heleidae). Revta. Inst. Salub. Inf. Trop. 13: 33-36.
1960. The subgenera of *Culicoides* of the Americas (Diptera, Ceratopogonidae). Rev. Biol. Trop. 8: 35-47.
1973a. The subgenera of *Culicoides* (Diptera: Ceratopogonidae). Revta. Invest. Salud. Publ. 32: 116-129.
1973b. *Wirthomyia*, a new subgenus of *Culicoides* (Diptera: Ceratopogonidae). Mosquito News 33: 112-113.

Vargas, L., and M. Kremer
1972. *Callotia* n. subg. of *Culicoides* (Diptera, Ceratopogonidae). Mosquito News 32: 242-243.

Vidal, J.
1960. La vegetation du Laos. Travaux du Laboratoire Forestir de Toulouse. Tome 5, I vol. 1, art. 3: 1-120.

Wada, Y.
1986. Revision of the *claggi* group of the genus *Culicoides* distributed in Japan, with description of a new species (Diptera: Ceratopogonidae). Jpn. J. Sanit. Zool. 37: 141-152.

Wada, Y., and S. Kitaoka
1977. Preliminary arrangement of Japanese *Culicoides* into groups (Diptera: Ceratopogonidae) (In Japanese, English summary). Trop. Med. 19: 169-176.

Walker, A.R., and P.F.L. Boreham
1976. Saline as a collecting medium for *Culicoides* (Diptera, Ceratopogonidae) in blood feeding and other studies. Mosquito News 36: 18-20.

Wallace, A.R.
1869. The Malay Archipelago. Macmillan, London and New York. 653 pp.
1876. The Geographical Distribution of Animals. 2 vols., 1056 pp. Harper, New York.

Wirth, W.W.
1952a. Heleidae of California. Univ. Calif. Pubs. Ent. 9: 95-266.
1952b. The immature stages of two species of Florida salt marsh sand flies (Diptera, Heleidae). Florida Ent. 35: 31-200.
1964. The synonymy of *Culicoides histrio* Johannsen. Proc. Ent. Soc. Wash. 66: 119.
1973. Family Ceratopogonidae (Heleidae). pp. 346-388. In: M.D. Delfinado and D.E. Hardy. A catalog of the Diptera of the Oriental Region. Univ. Press of Hawaii, Honolulu. Vol. 1, 618 pp.

Wirth, W.W., and P.H. Arnaud, Jr.
1969. Polynesian biting midges of the genus *Culicoides* (Diptera: Ceratopogonidae). Pacific Ins. 11: 507-520.

Wirth, W.W., and F.S. Blanton
1959. Biting midges of the genus *Culicoides* from Panama (Diptera: Heleidae). Proc. U.S. Natl. Mus. 109: 237-482.

Wirth, W.W., P.P. Choudhuri, and S.K. Das Gupta
1985. Descriptive notes and new Asian distribution in the *chaetophthalmus* group of the bloodsucking midge genus *Culicoides* (Diptera: Ceratopogonidae). Oriental Ins. 19: 103-109.

Wirth, W.W., and A.A. Hubert
1959. *Trithecoides*, a new subgenus of *Culicoides* (Diptera, Ceratopogonidae). Pacific Ins. 1: 1-38.
1961. New species and records of Taiwan *Culicoides* (Diptera: Ceratopogonidae). Pacific Ins. 3: 11-26.
1972. A new Oriental species of *Culicoides* breeding in tree rot cavities (Diptera: Ceratopogonidae). J. Wash. Acad. Sci. 62: 41-42.

Wirth, W.W., and R.H. Jones
1957. The North American subspecies of *Culicoides variipennis* (Diptera, Heleidae). Tech. Bull. U.S. Dept. Agric. 1170: 1-35.

Wirth, W.W., and V.H. Lee
1967. New species of *Culicoides* from high altitudes in the Colombian Andes (Diptera: Ceratopogonidae). Proc. U.S. Natl. Mus. 114: 1-22.

Wirth, W.W., and N. Marston
1968. A method for mounting small insects on microscope slides in Canada balsam. Ann. Ent. Soc. Am. 61: 783-784.

Wirth, W.W., and D.H. Messersmith
1977. Notes on the biting midges of the Seychelles (Diptera: Ceratopogonidae). Proc. Ent. Soc. Wash. 70: 293-309.

Wirth, W.W., and S. Navai
1978. Terminology of some antennal sensory organs of *Culicoides* biting midges (Diptera: Ceratopogonidae). J. Med. Ent. 15: 43-49.

Wolff, T.
1966. The "Noona Dan" Expedition 1961-1962. General report and list of stations. Vidensk Meddr Dansk naturhist. Foren. 129: 287-336.

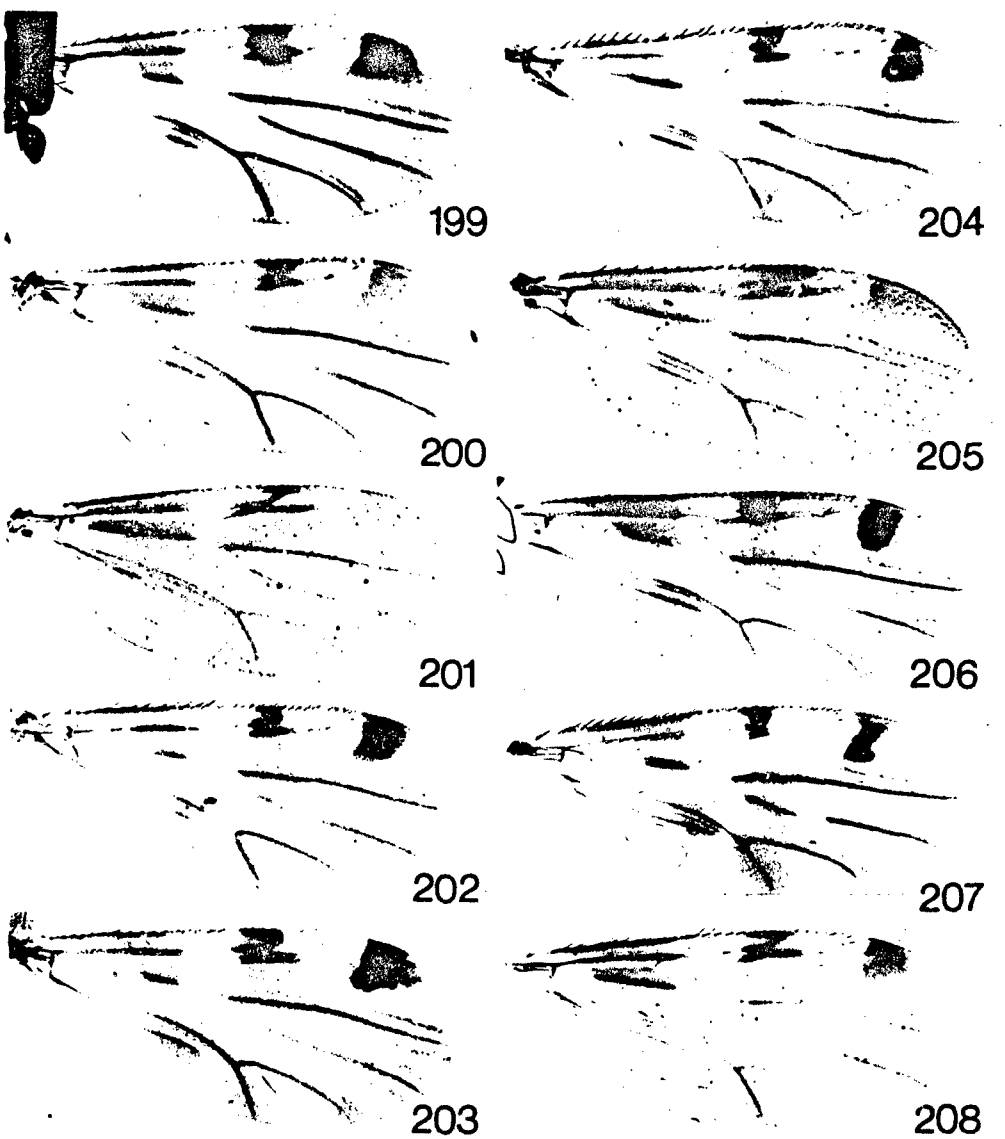
Wongsathuaythong, S., R. Fuangtong, and C. Ketavan
1977. Insect and arachnid allergy in Thailand. J. Med. Assoc. Thailand 60: 274-278.

Wyatt-Smith, J.
1964. A preliminary vegetation map of Malaya with descriptions of the vegetation types. J. Trop. Geog. 18: 200-213.

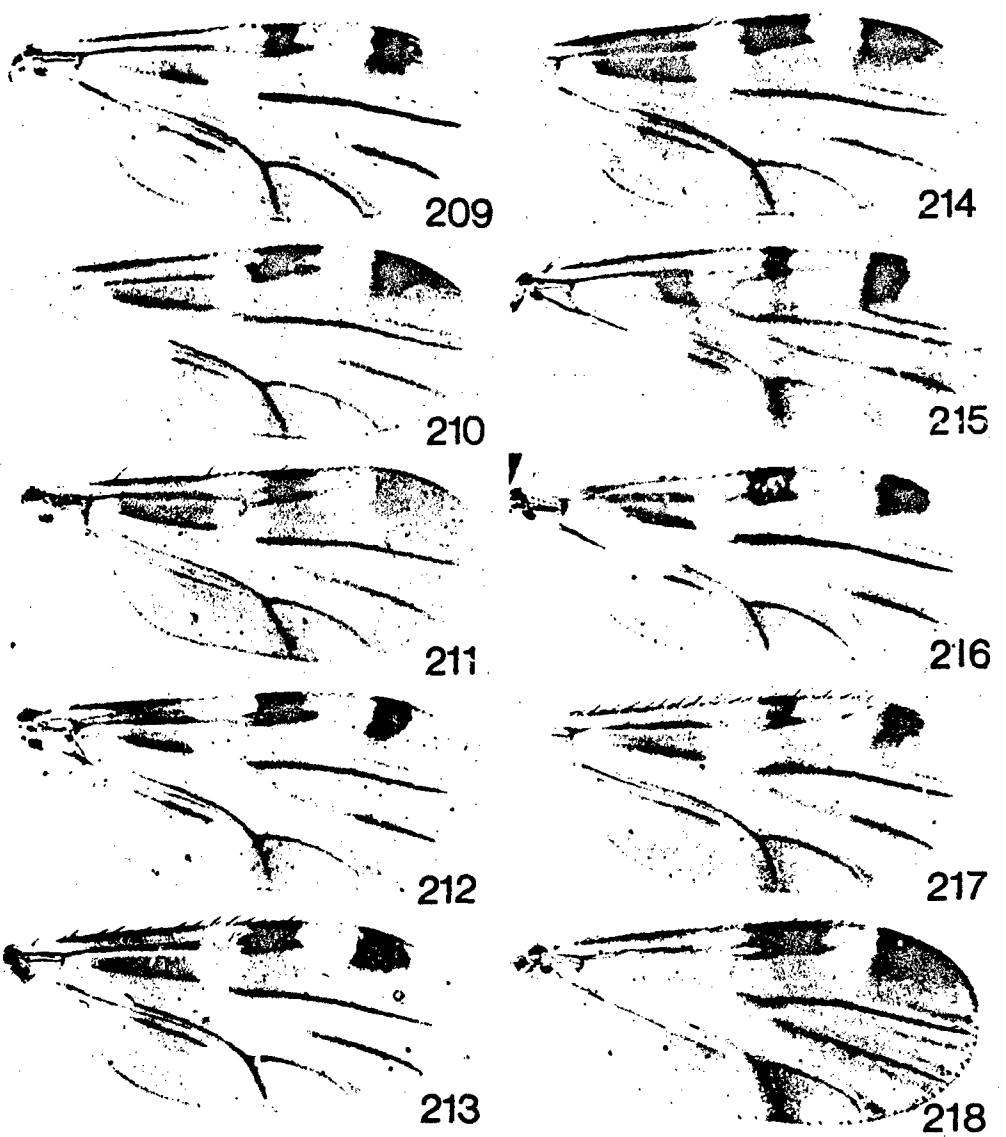
Wyatt-Smith, J., and P.R. Wycherley, Eds.
1961. Nature Conservation in Western Malaysia, 1961. Malayan Nature J. 21st Anniv. Special Issue, 260 pp.

Yasumatsu, K., T. Wongsiri, C. Tirawat, N. Wongsiri, and A. Lewvanich
1980. Contributions to the development of integrated rice pest control in Thailand. Thailand Dept. Agric. Bangkok. 163 pp.

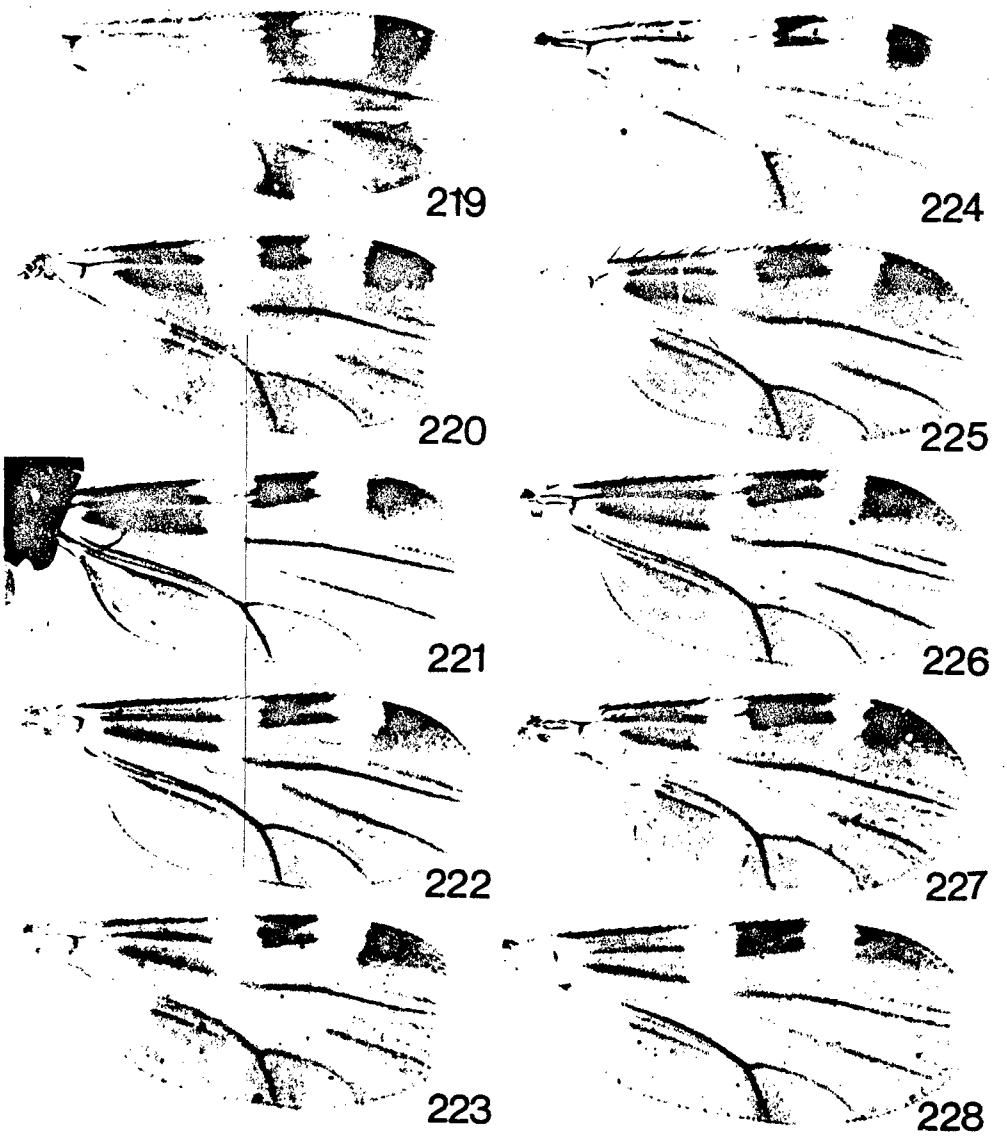
Zeuner, F.E.
1941. Geology, climate, and faunal distribution in the Malay Archipelago. Proc. R. Ent. Soc. London (A) 16: 117-123.



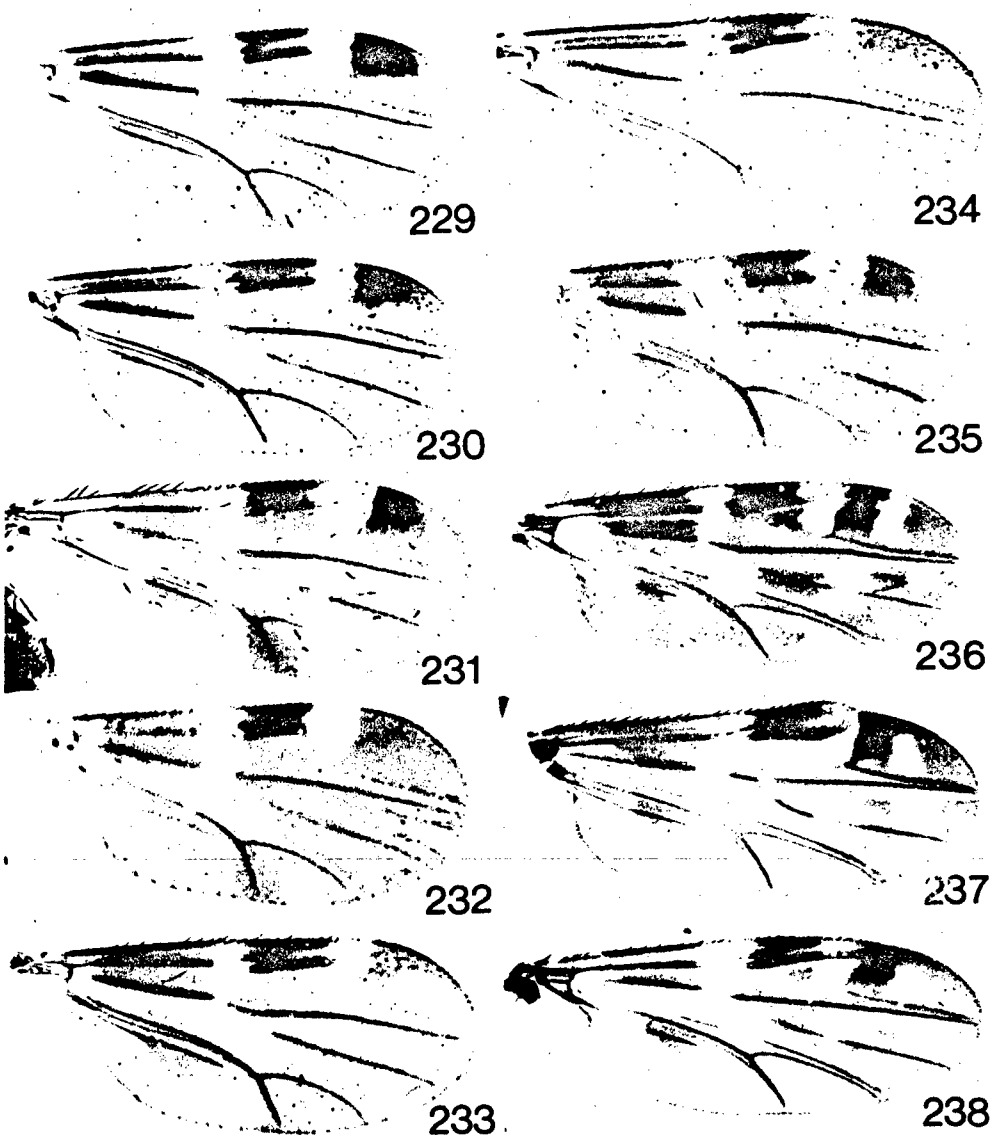
Figs. 199-208. Wings of female *Culicoides*: 199. *anophelis*; 200. *baisasi*; 201. *pendleburyi*; 202. *flavescens*; 203. *paraflavescens*; 204. *acanthostomus*; 205. *nyungnoi*; 206. *paksongi*; 207. *tenuipalpis*; 208. *cylindripalpis*.



Figs. 209-218. Wings of female *Culicoides*: 209. *luteolus*; 210. *macfiei*; 211. *manikumari*; 212. *nanpui*; 213. *palpifer*; 214. *parahumeralis*; 215. *rugulithecus*; 216. *subpalpifer*; 217. *tonmai*; 218. *albibasis*.



Figs. 219-228. Wings of female *Culicoides*: 219. *allantothecus*; 220. *barnetti*; 221. *dungunensis*; 222. *elbeli*; 223. *flaviscutatus*; 224. *flaviscutellaris*; 225. *fordae*; 226. *gewertzi*; 227. *gouldi*; 228. *hinnoi*.



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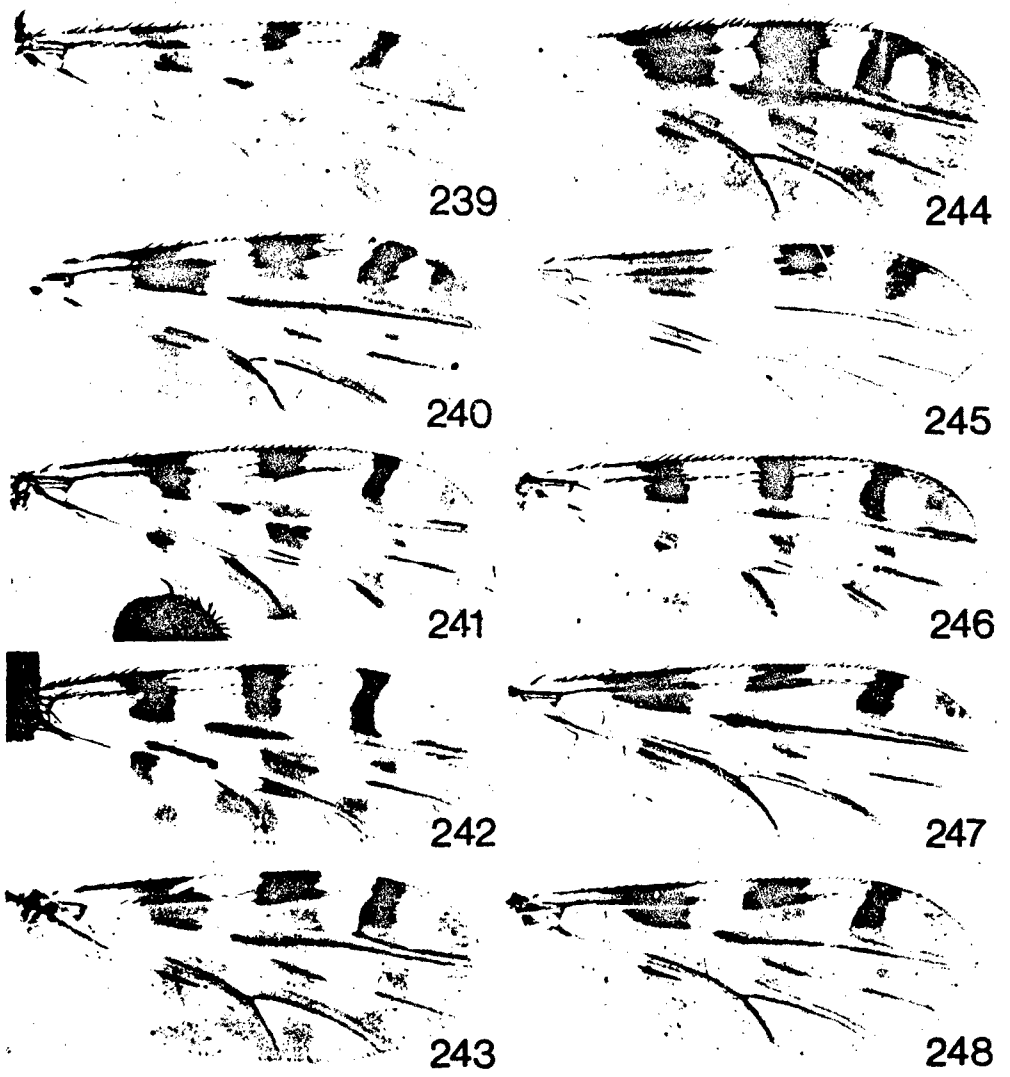

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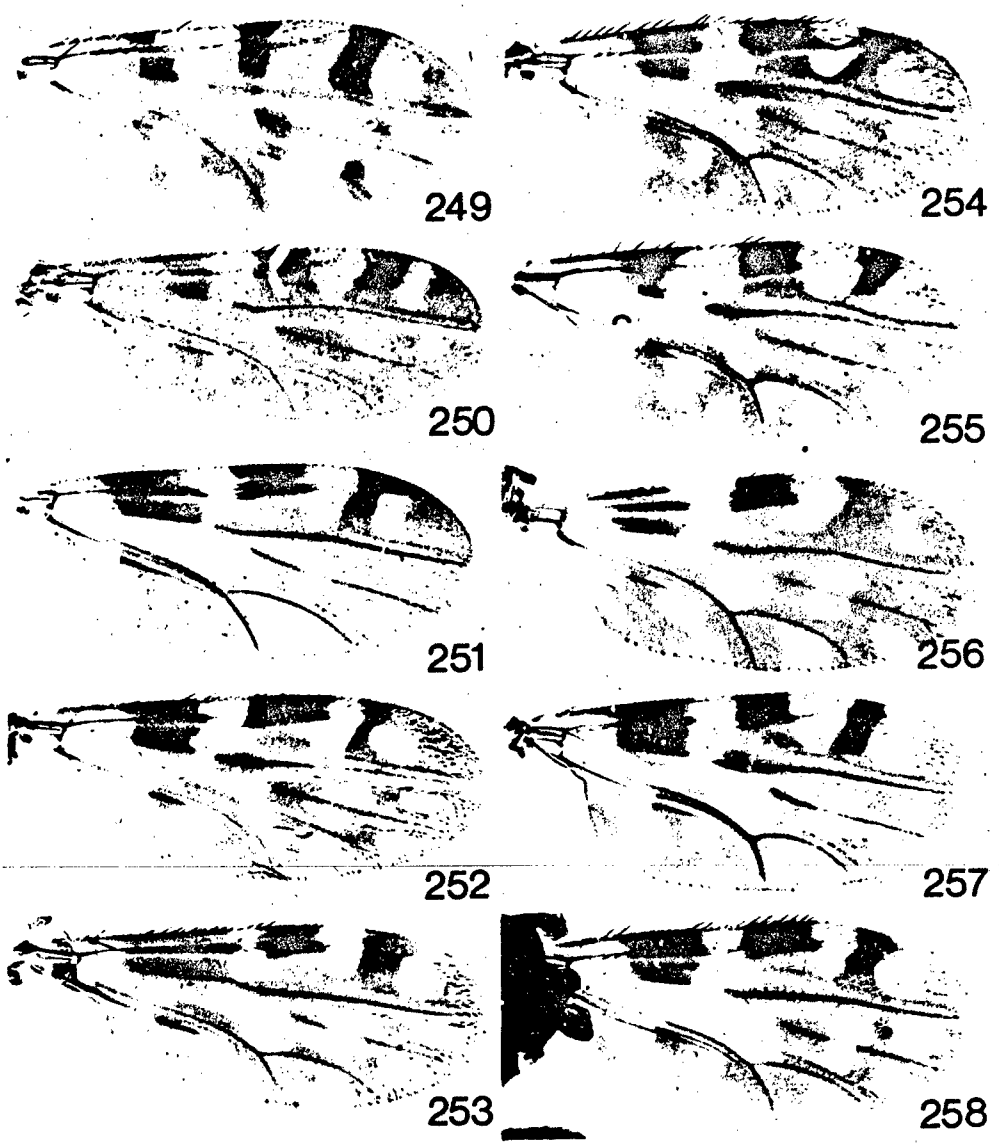

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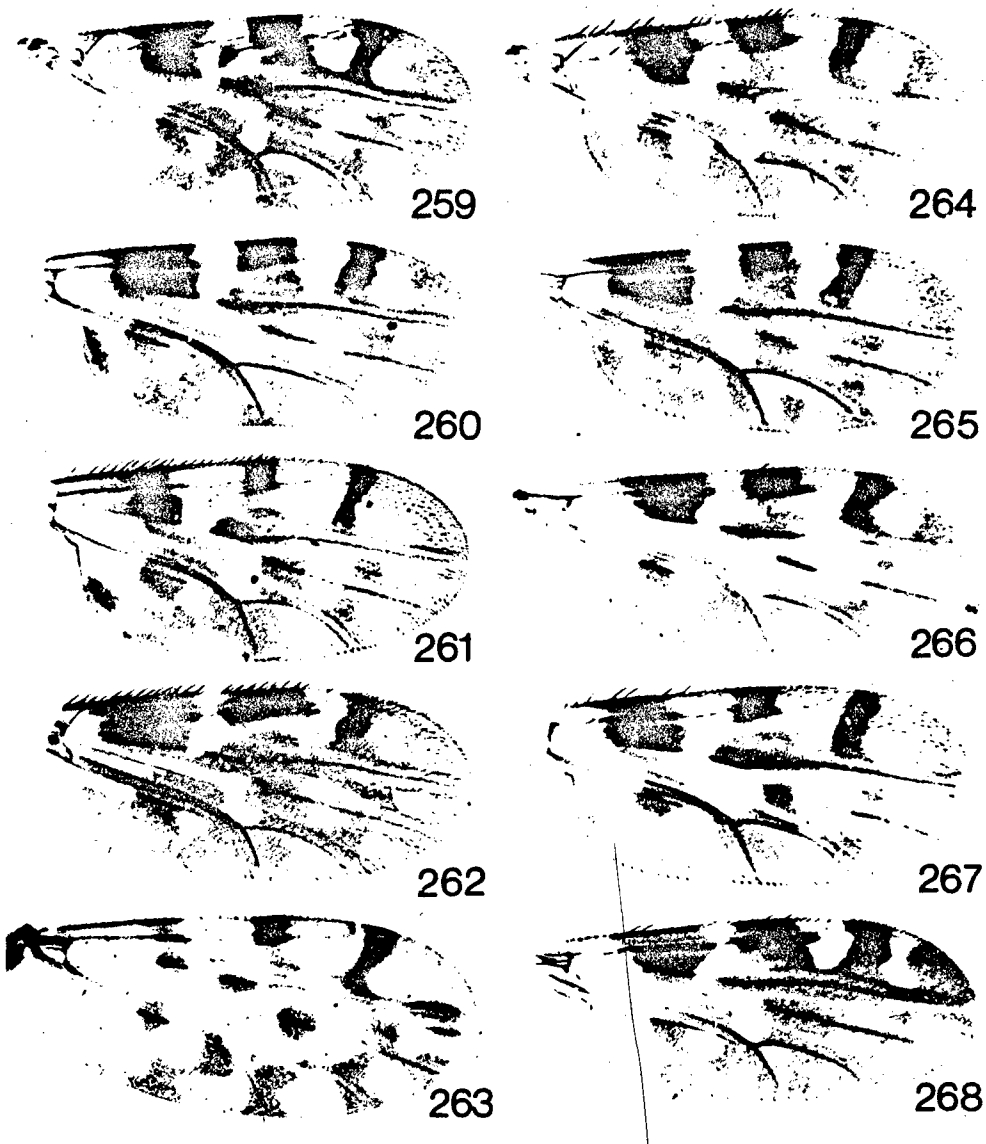

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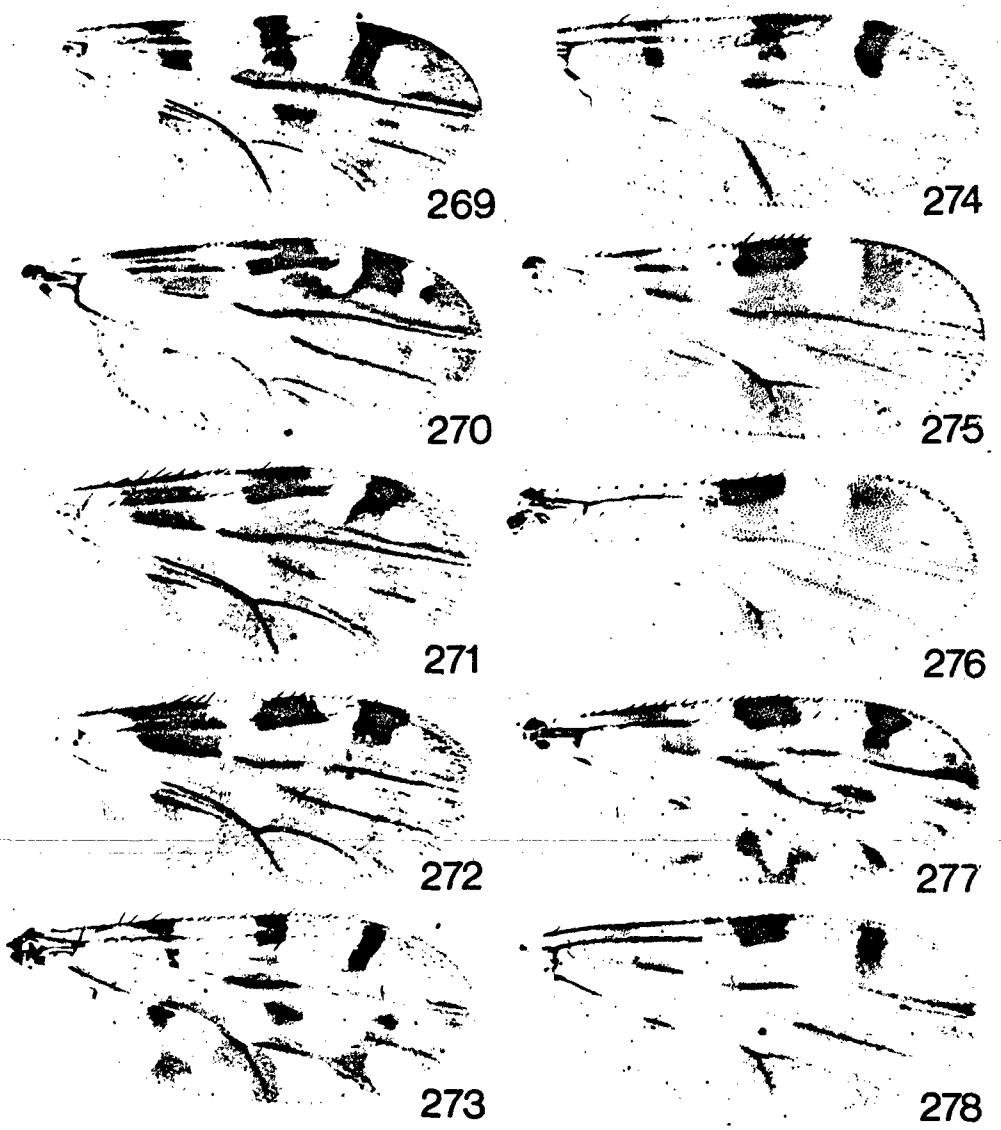

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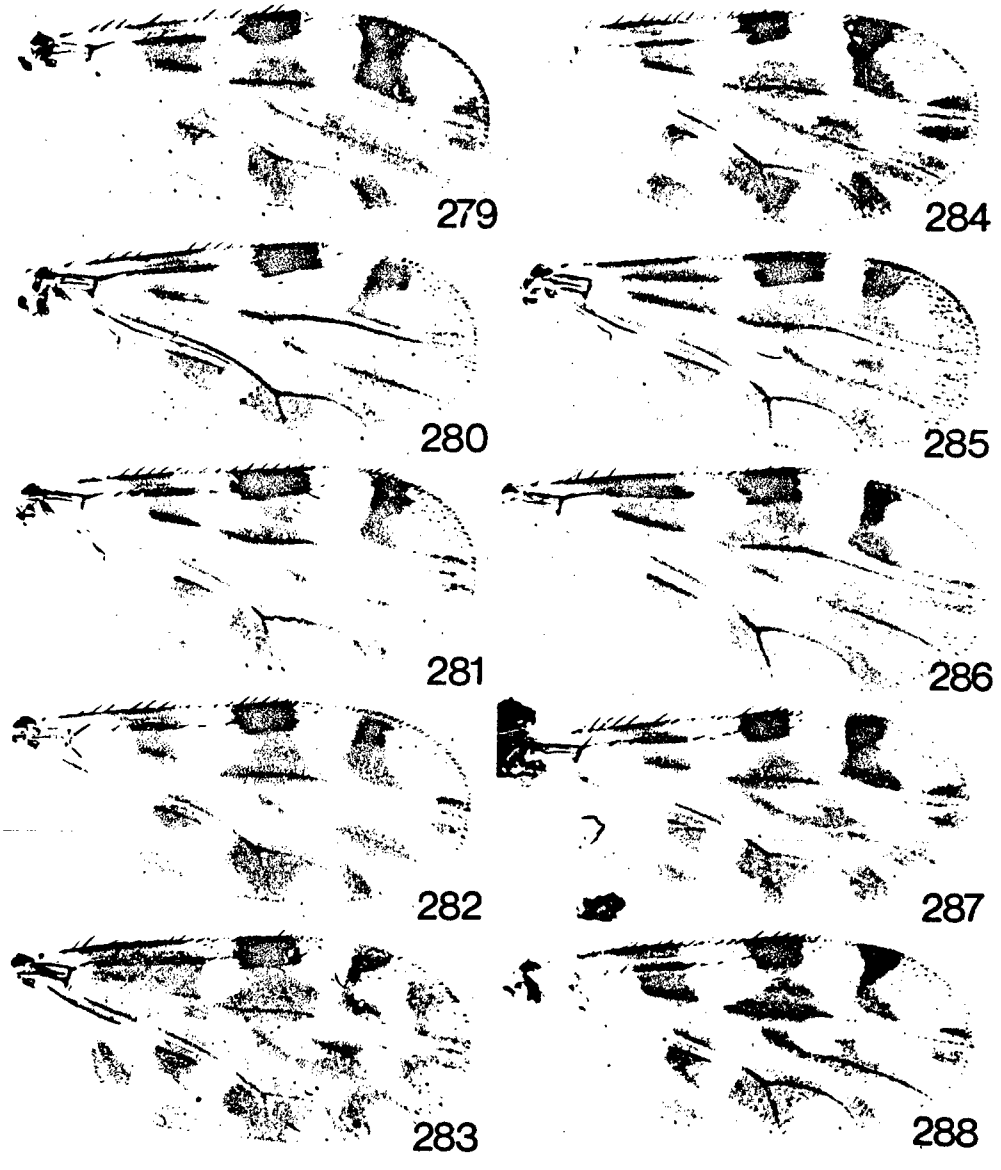

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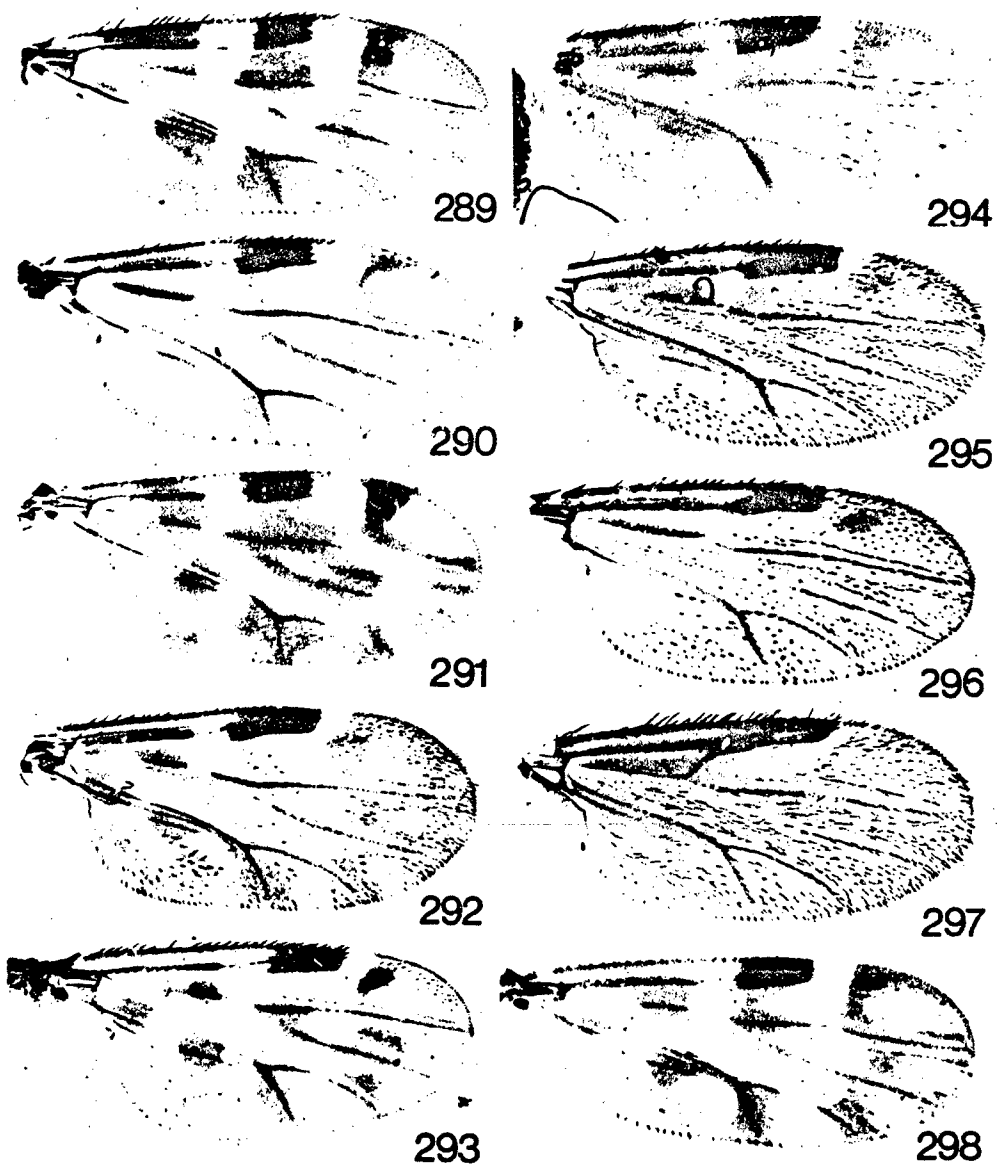

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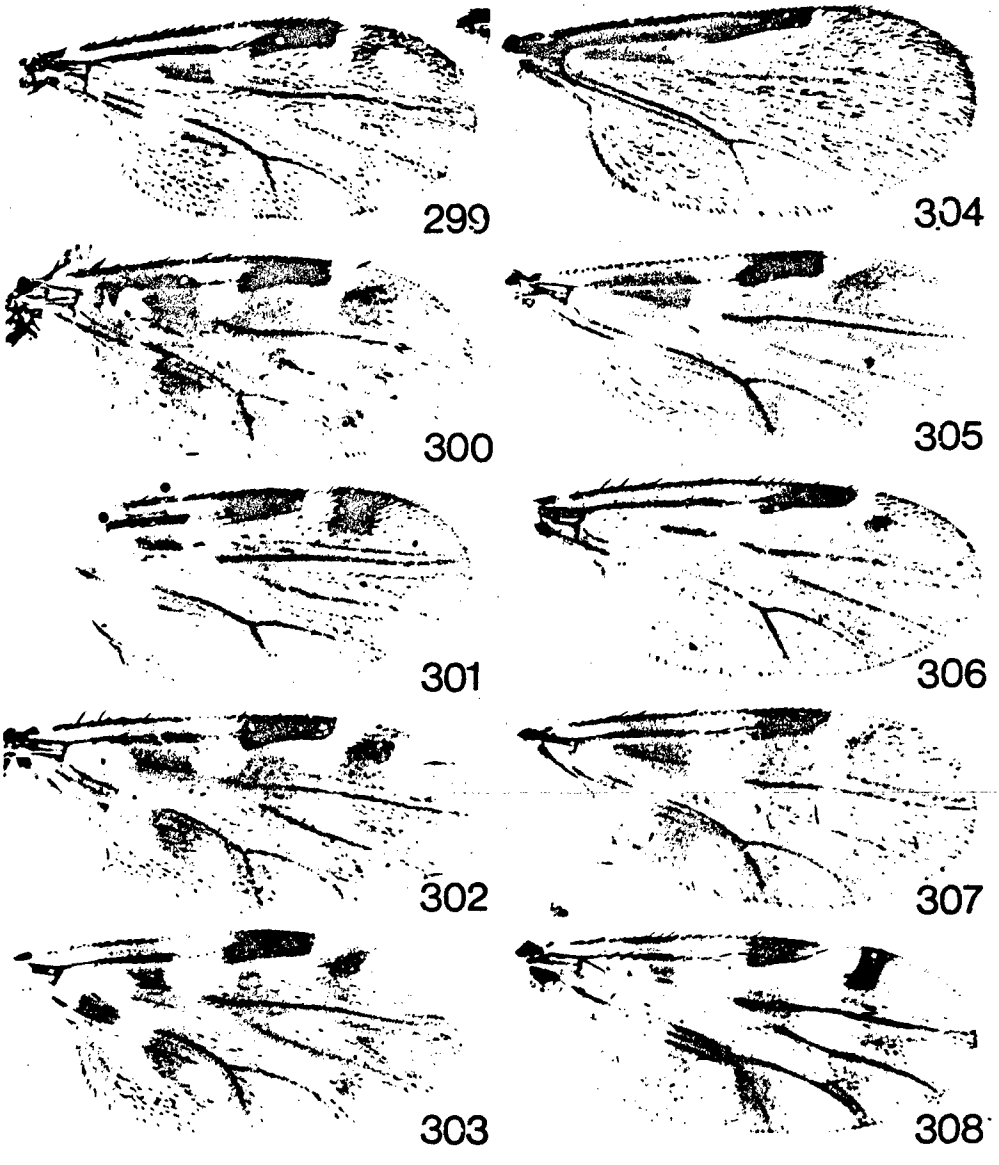

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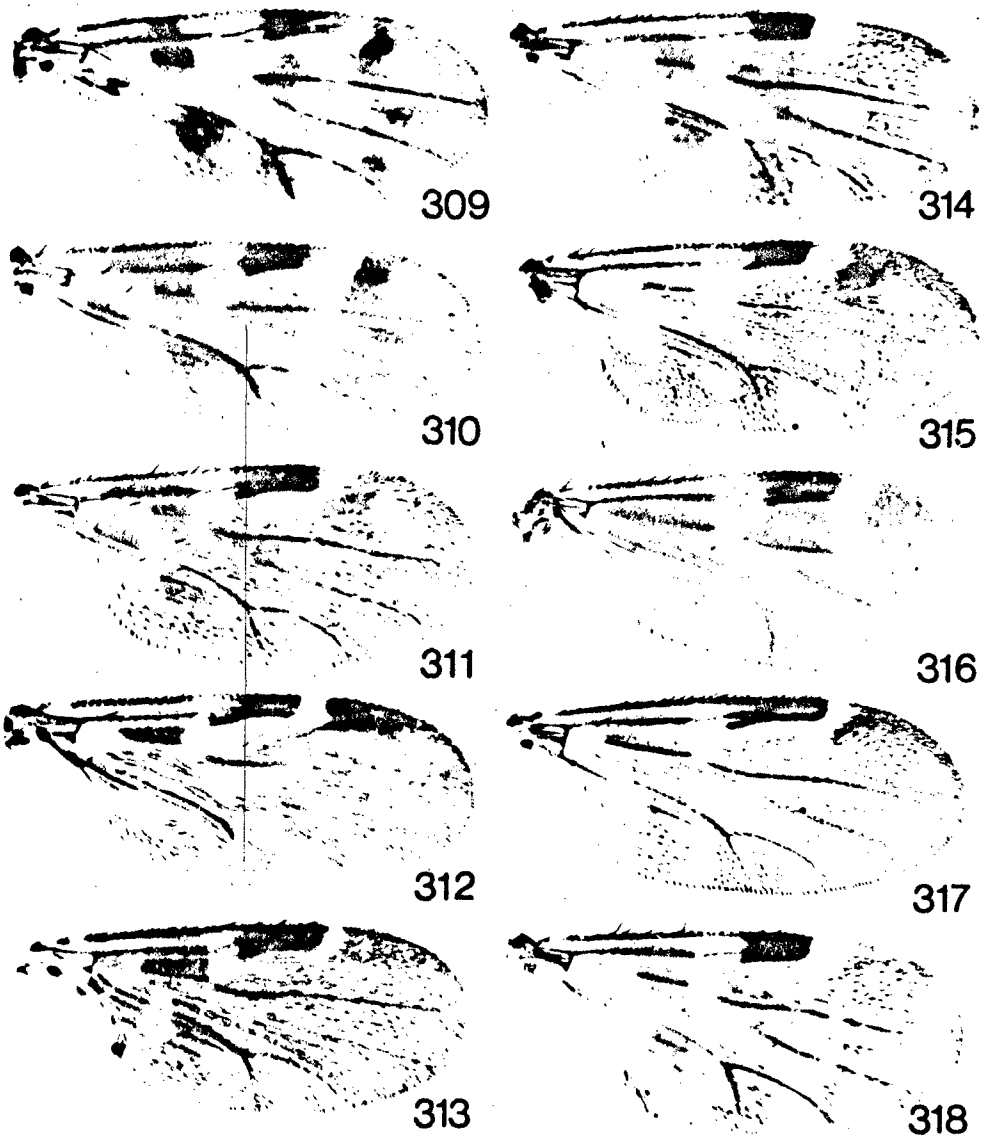

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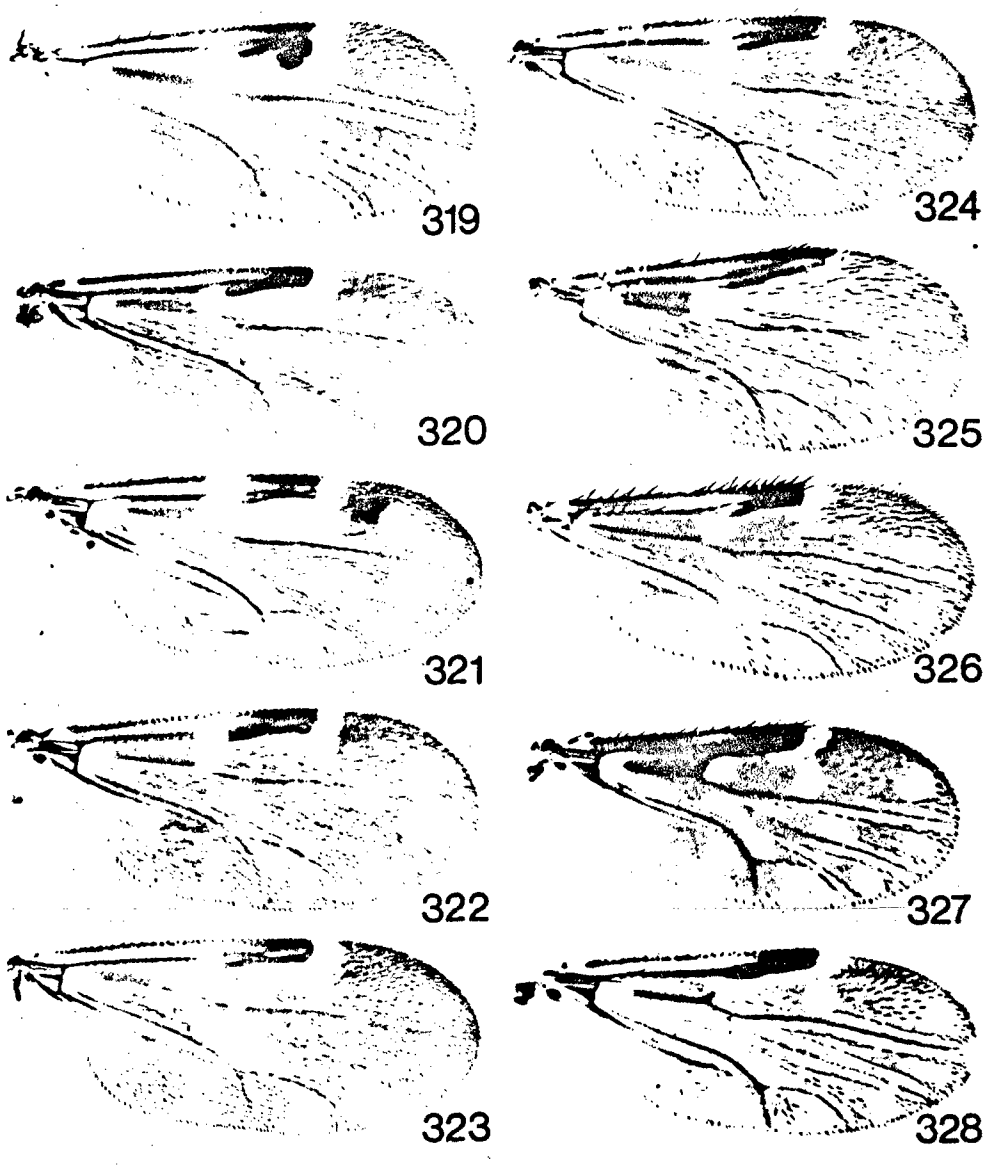

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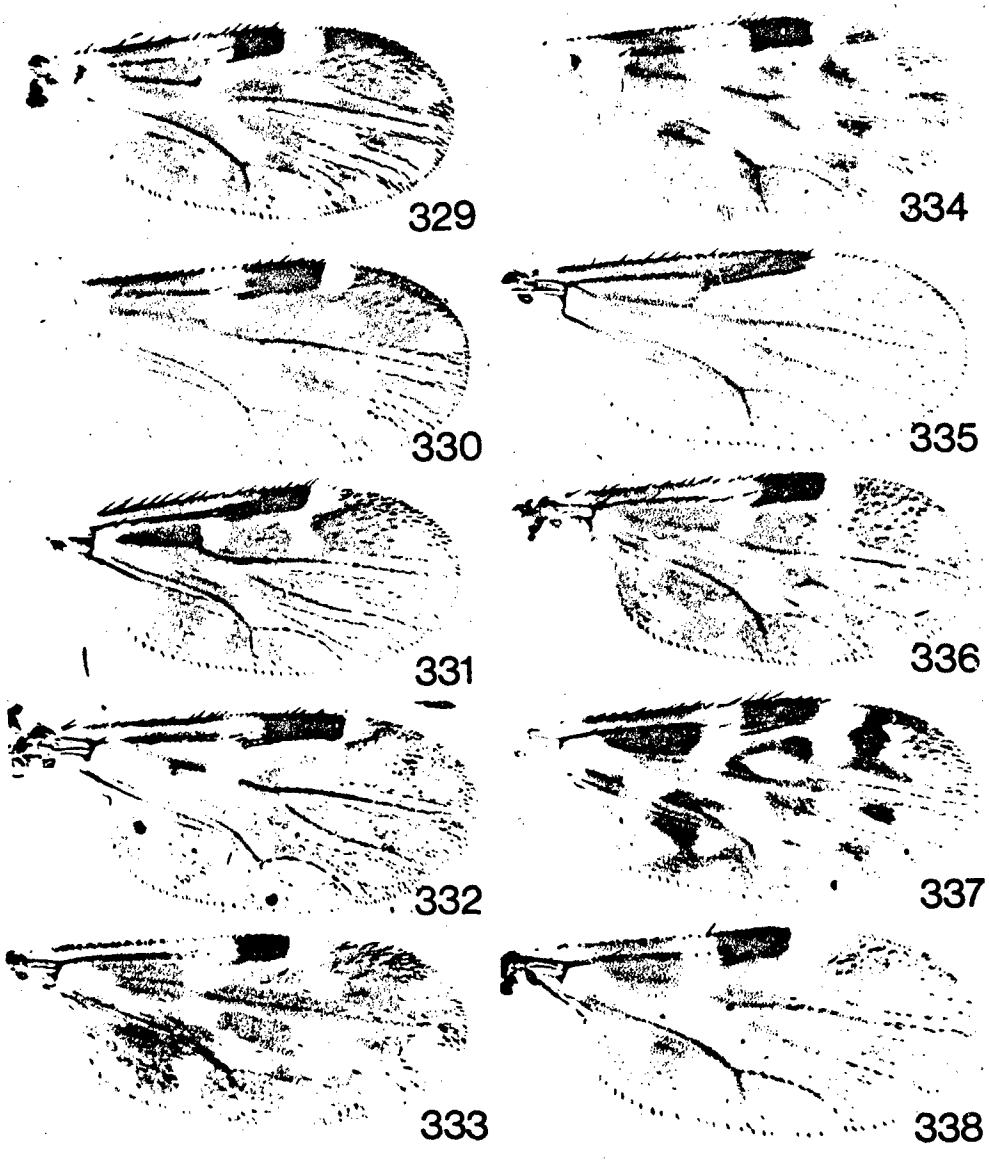

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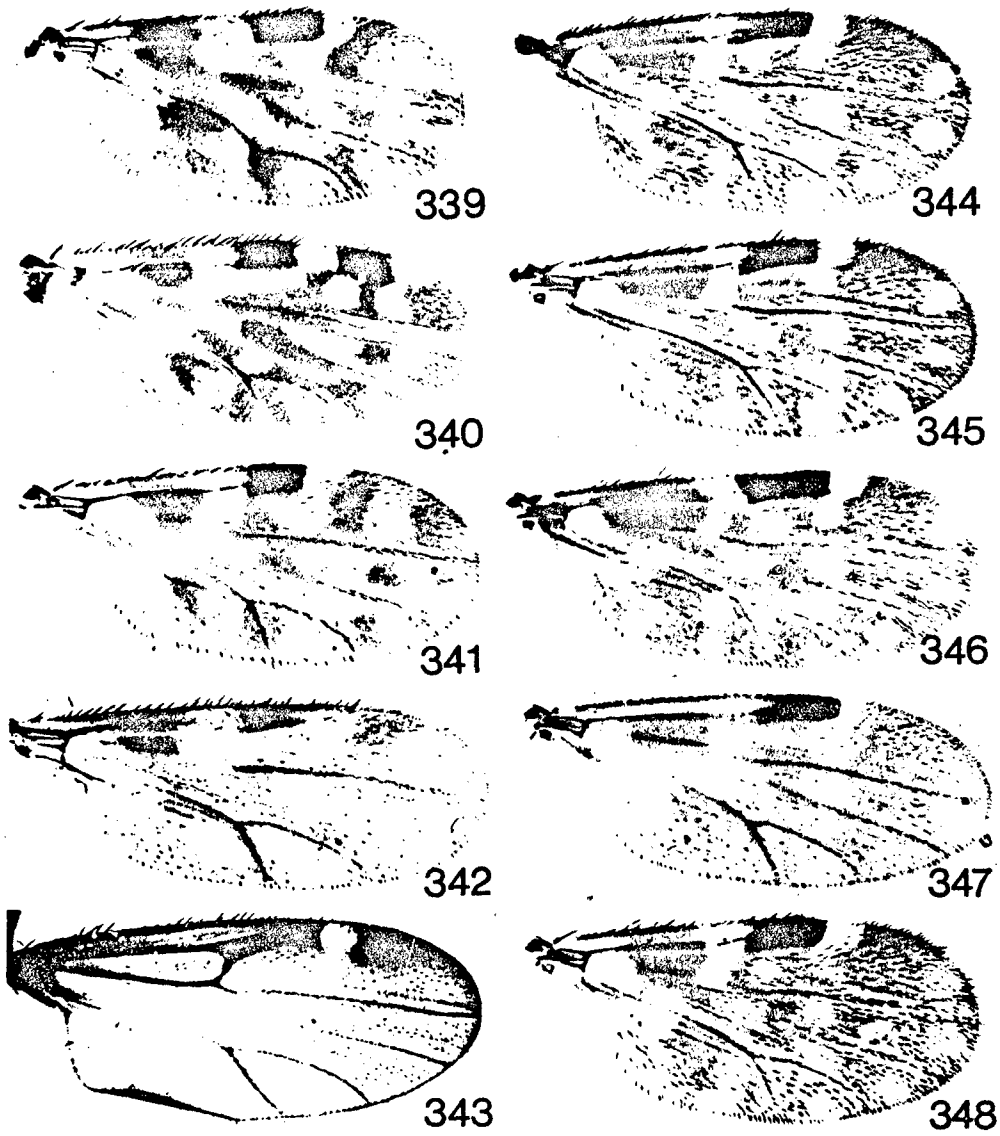

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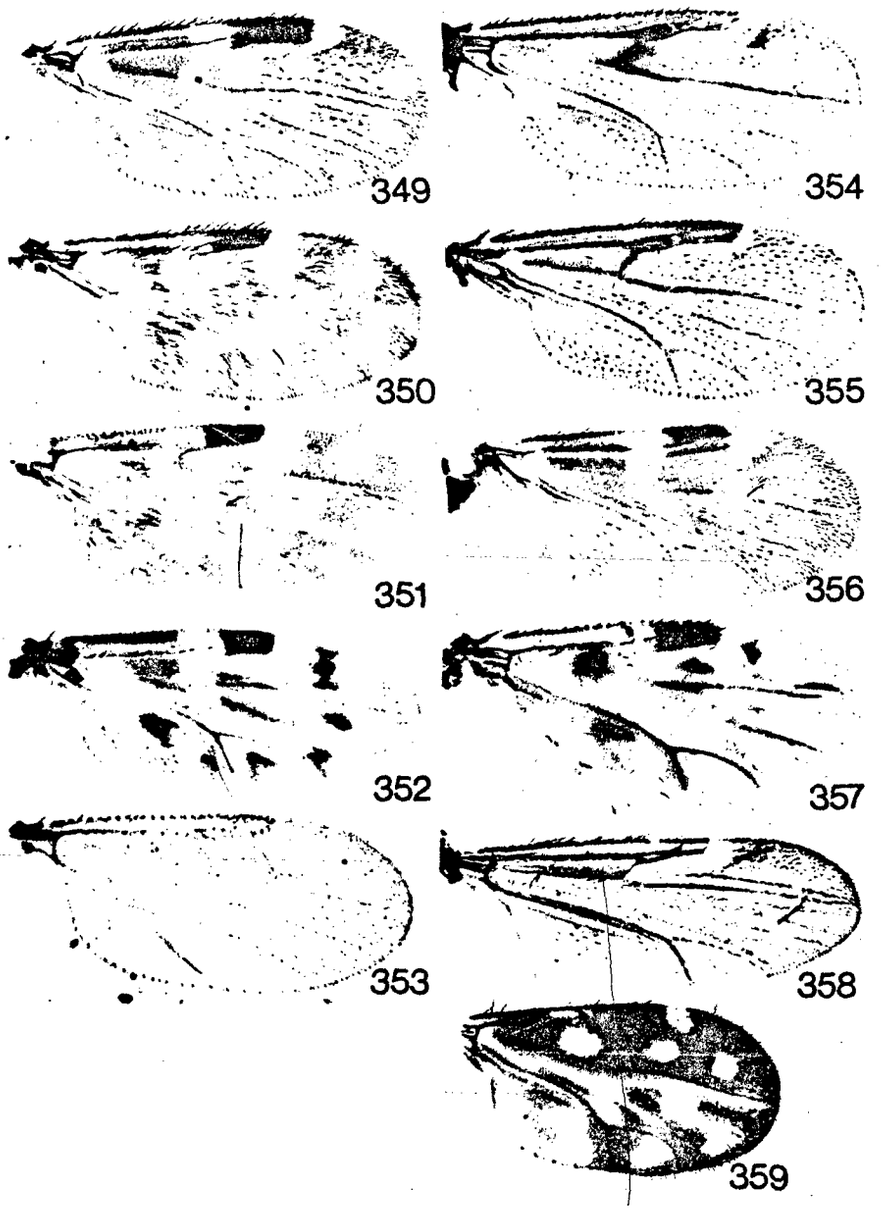

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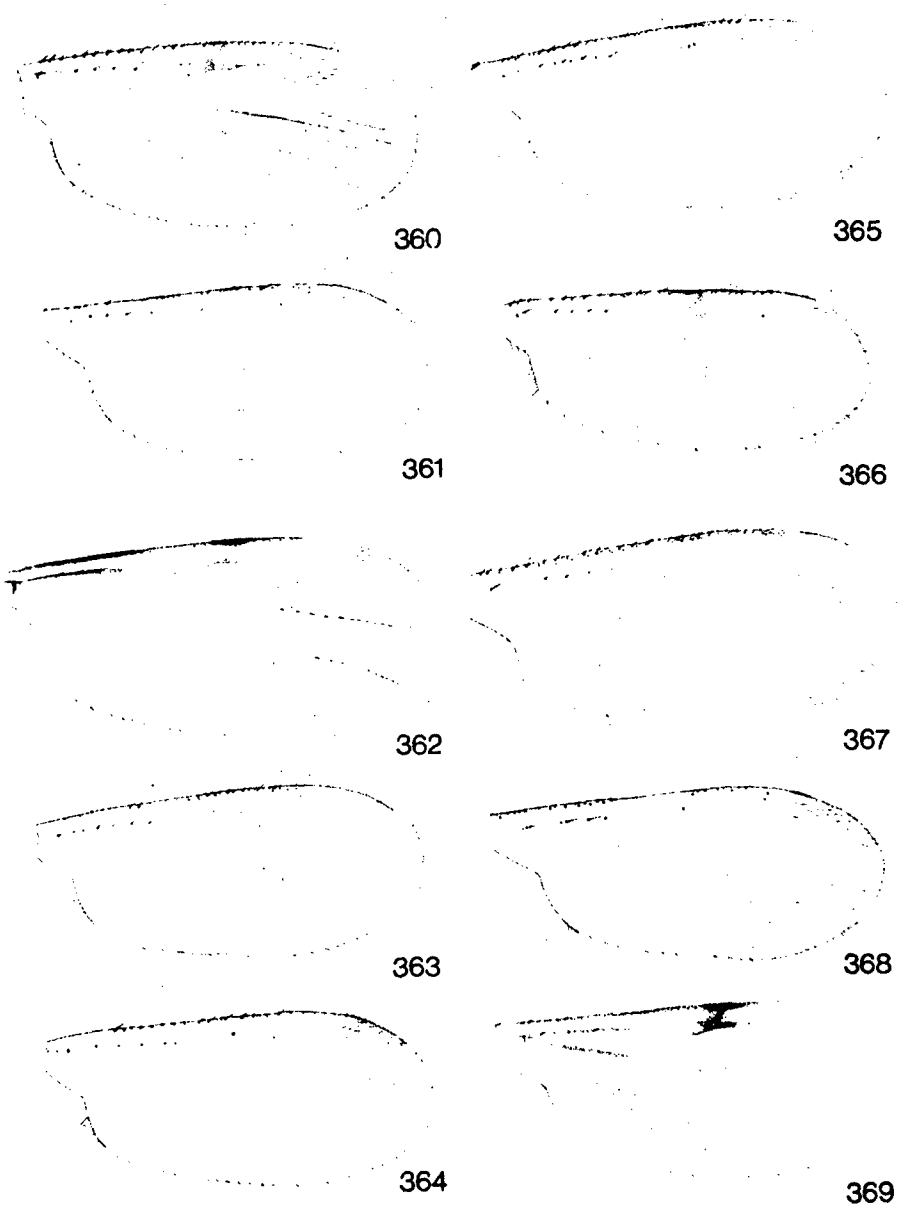

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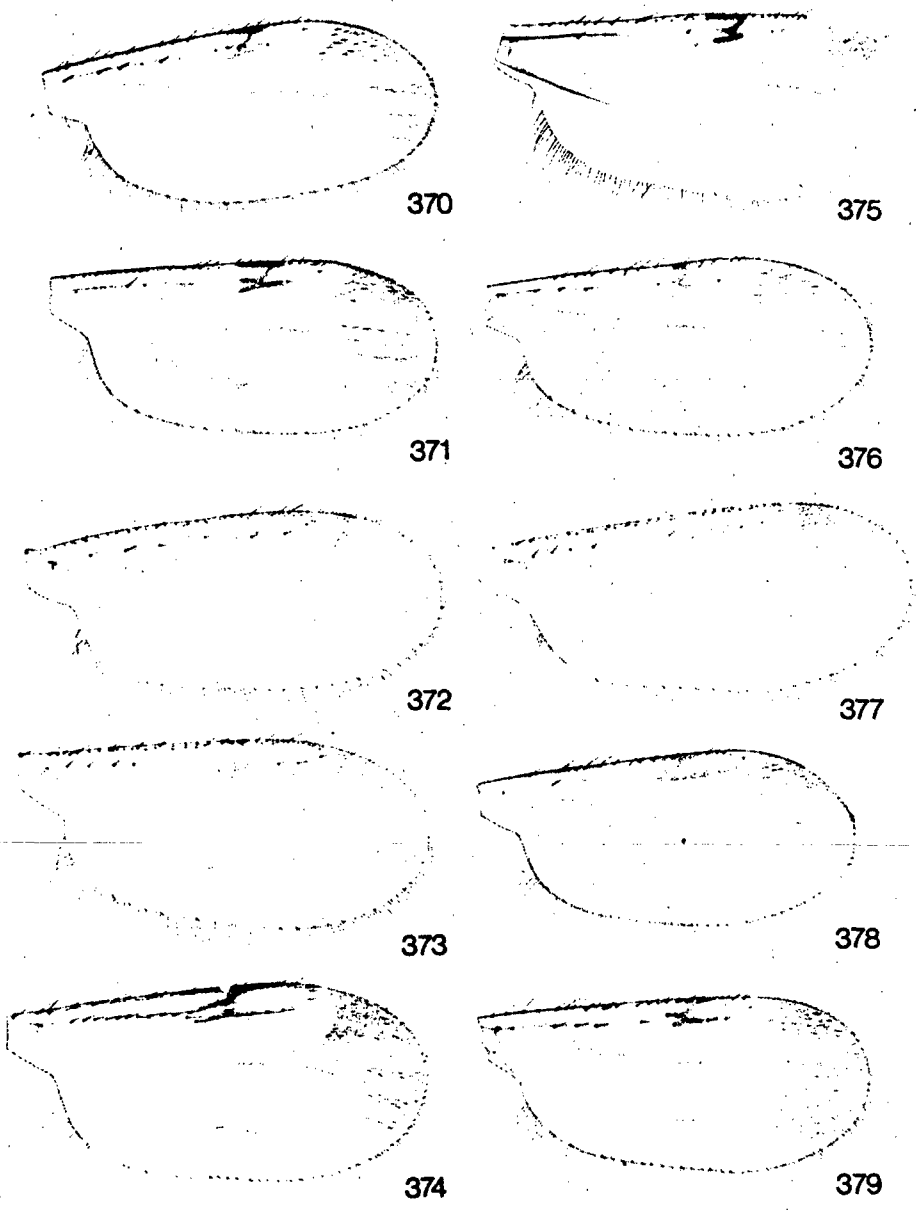

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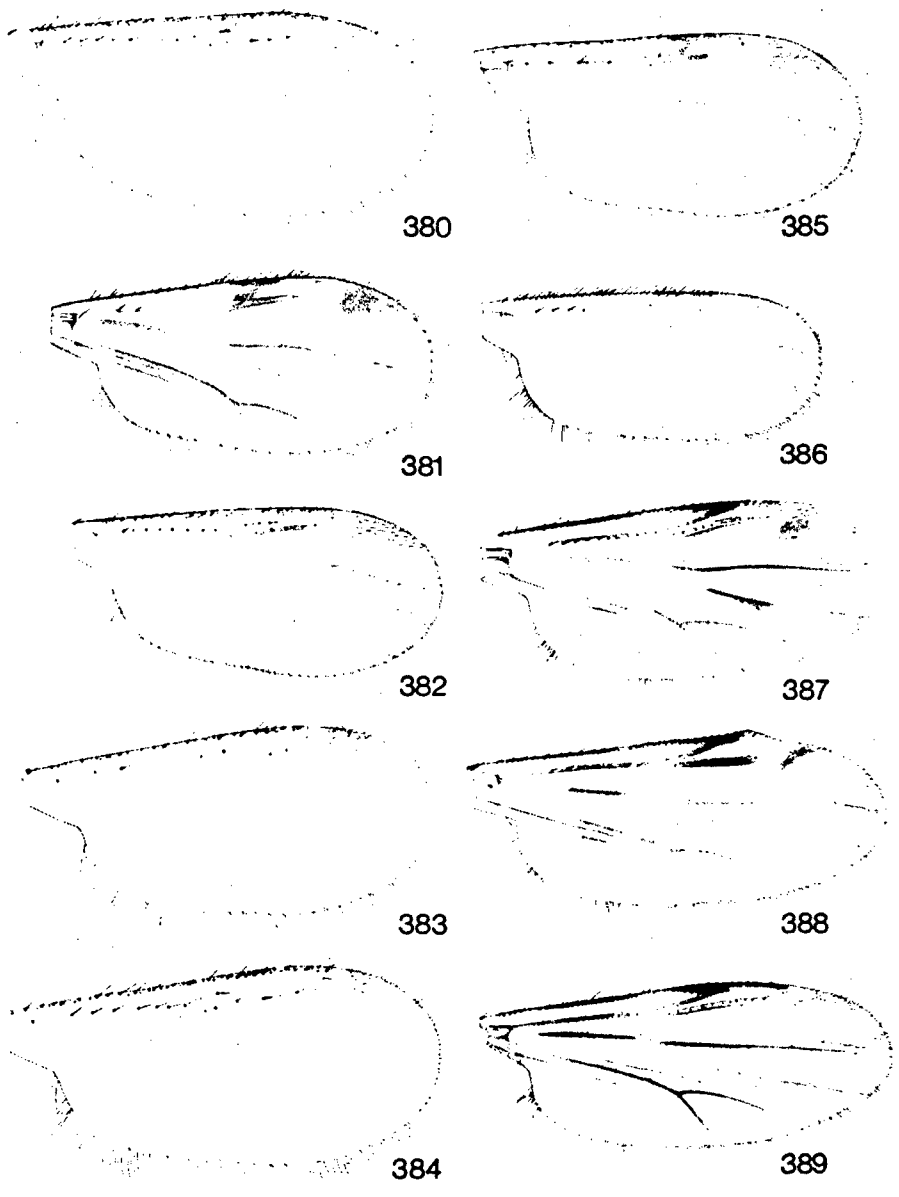

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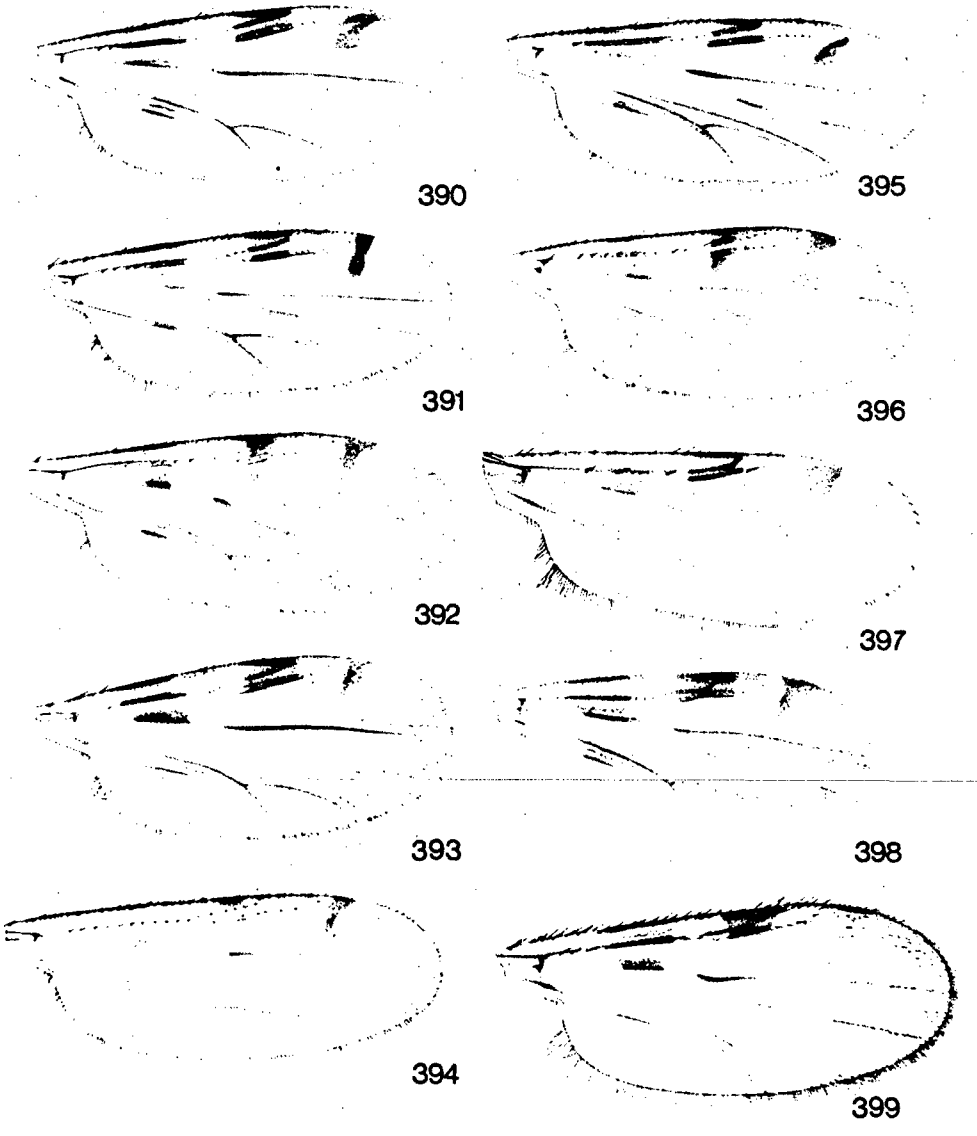

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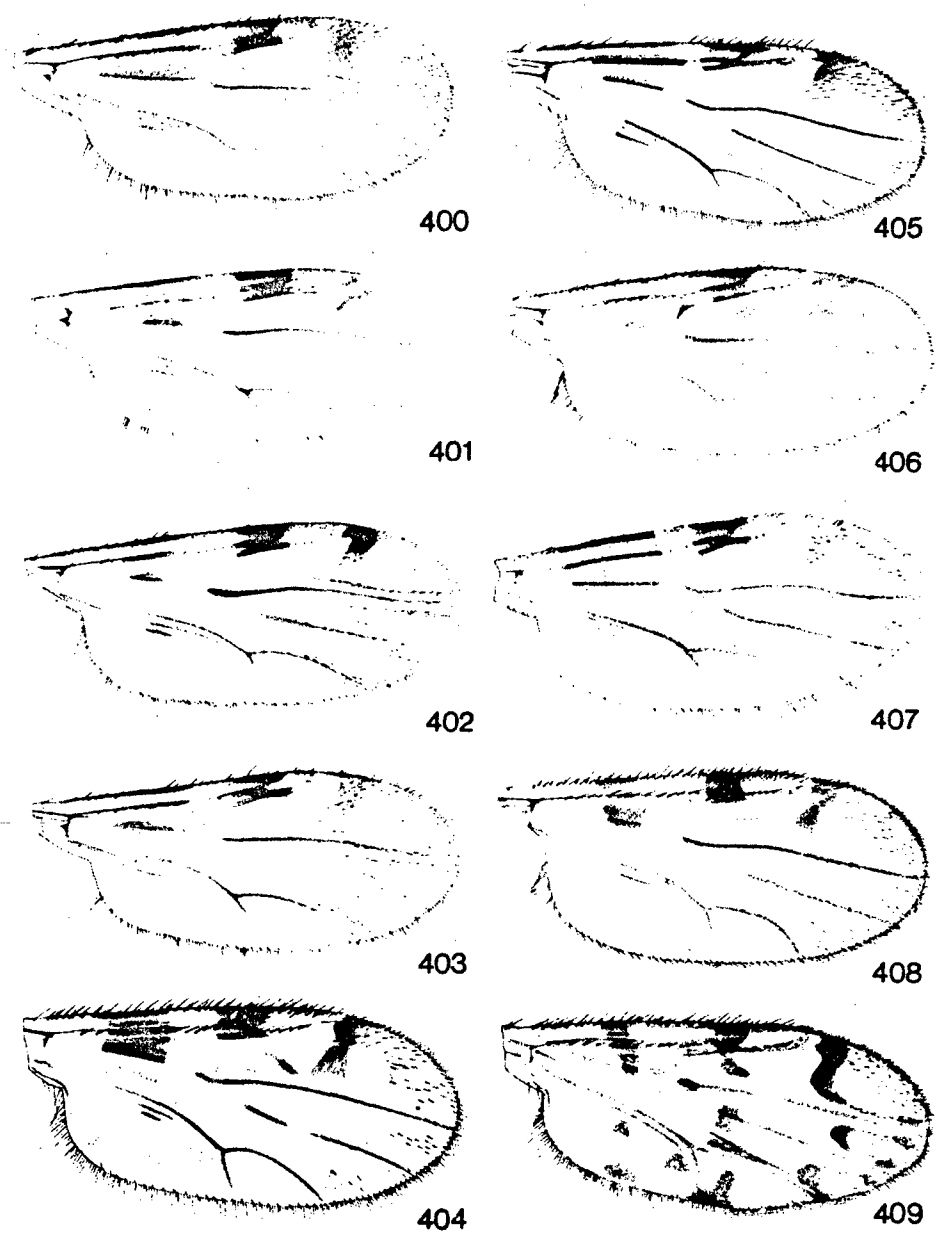

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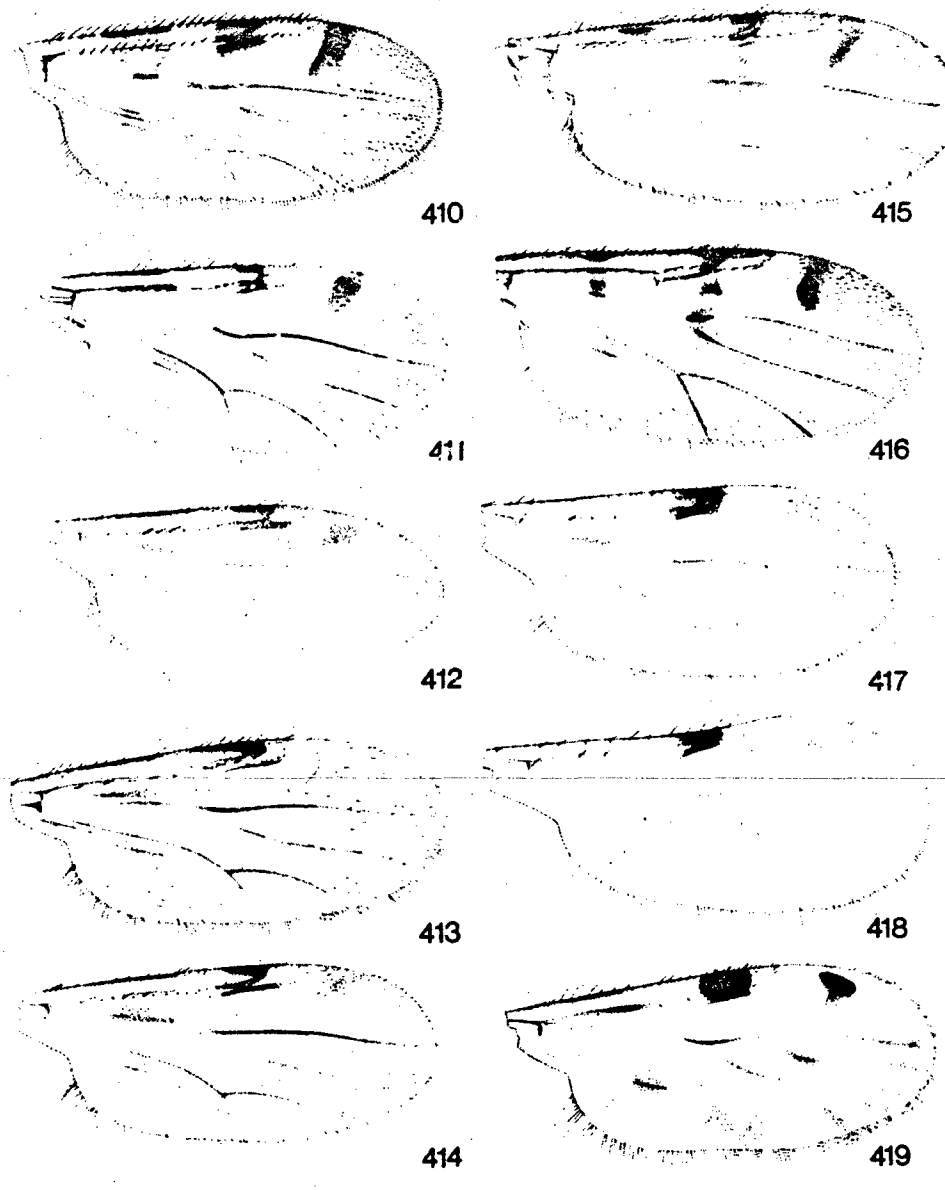

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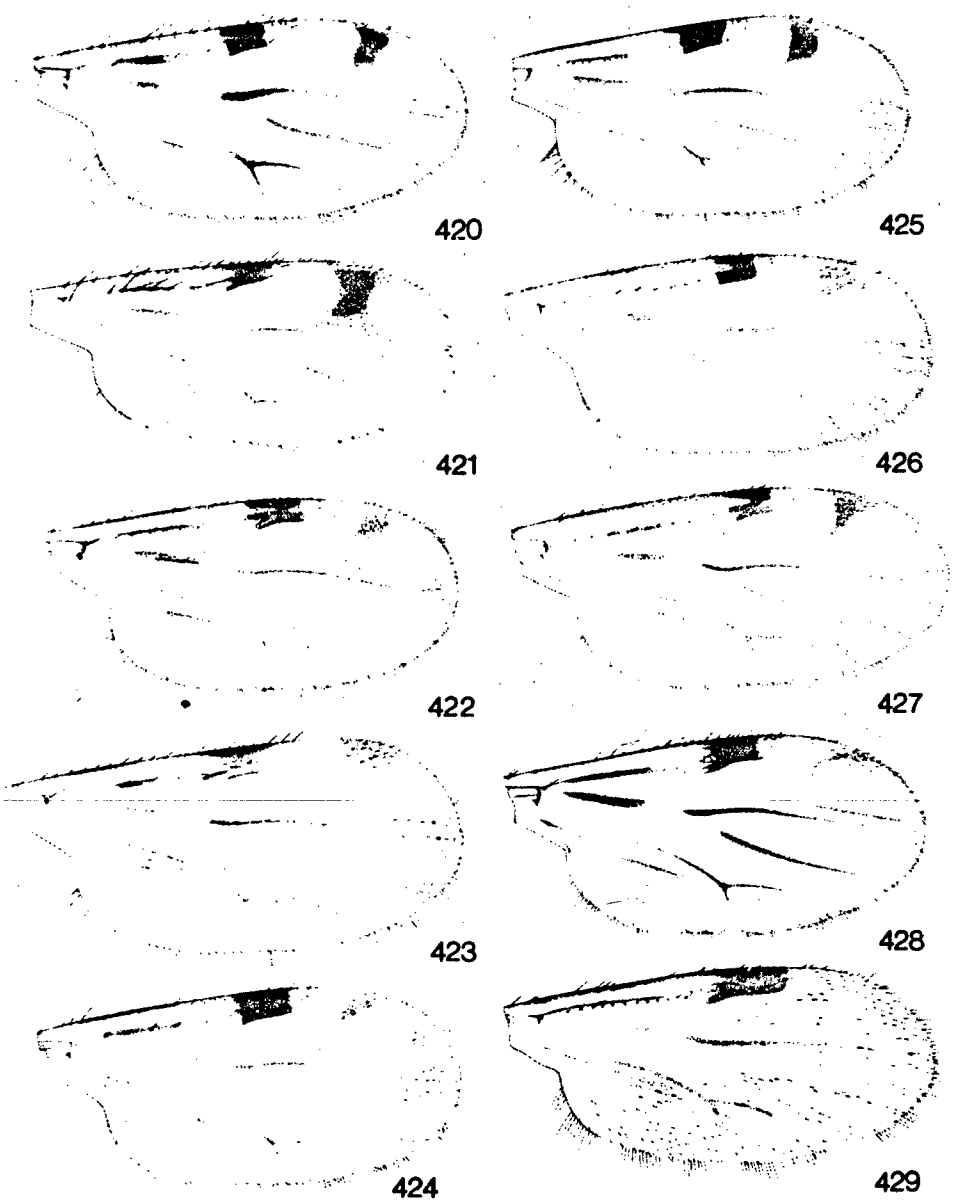

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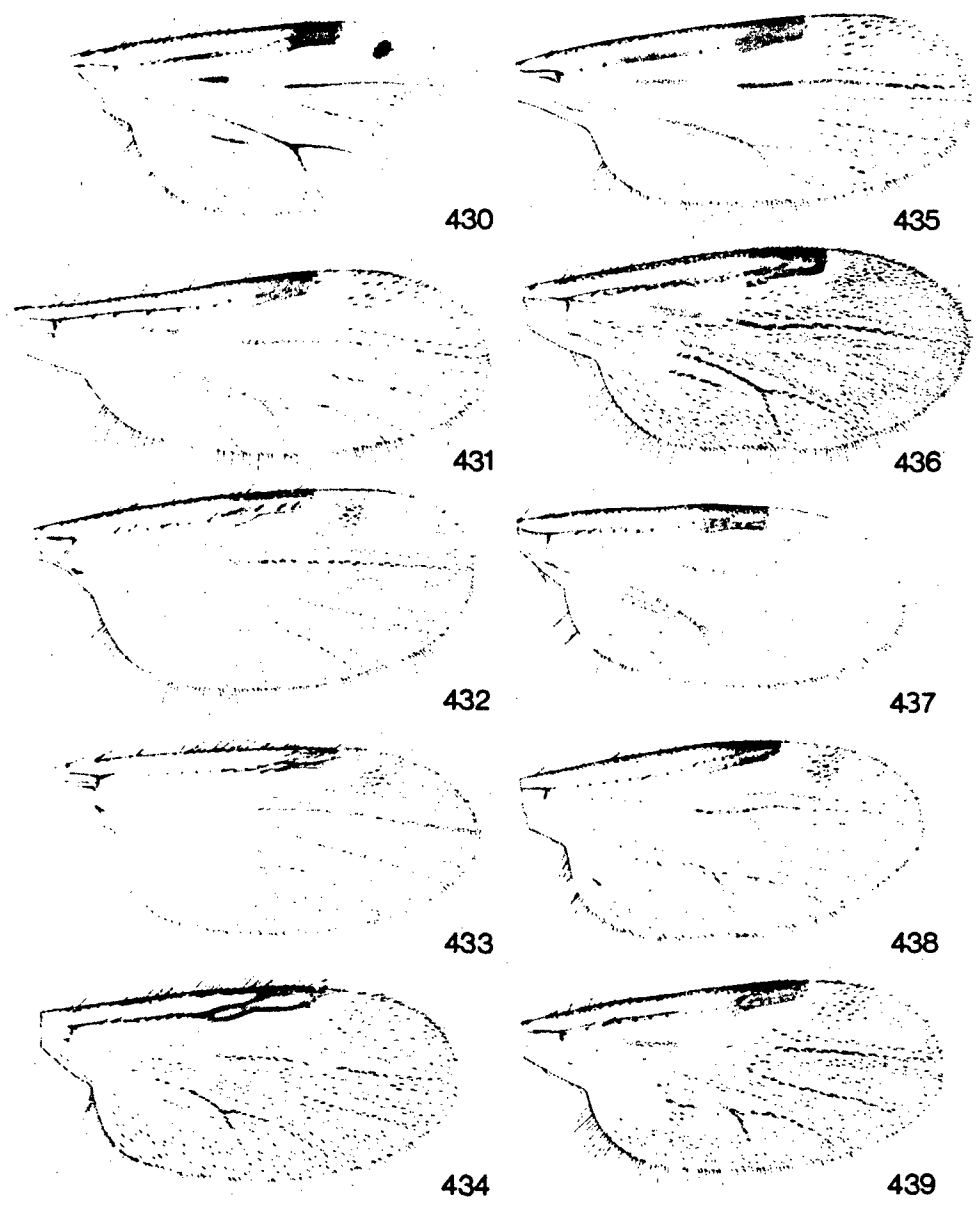

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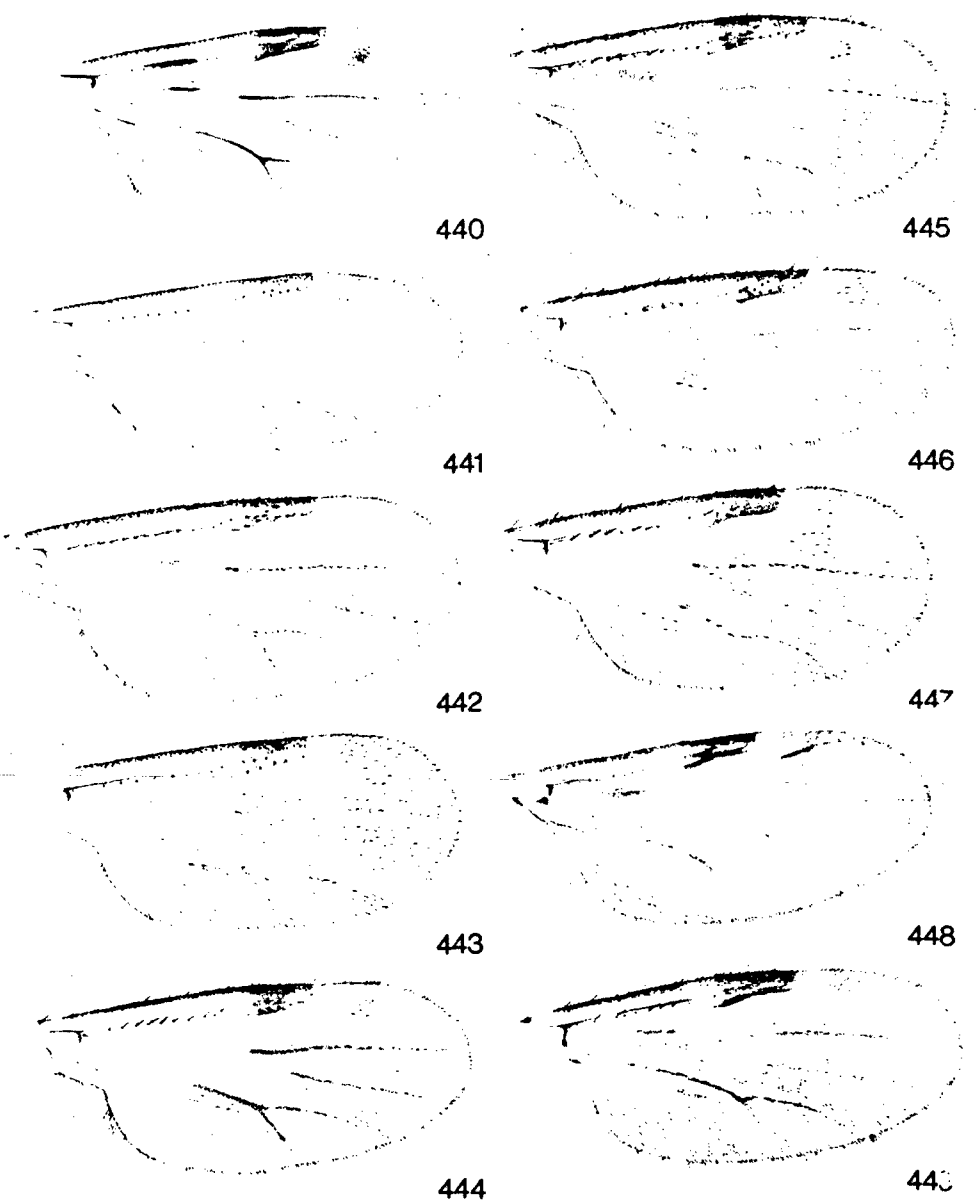

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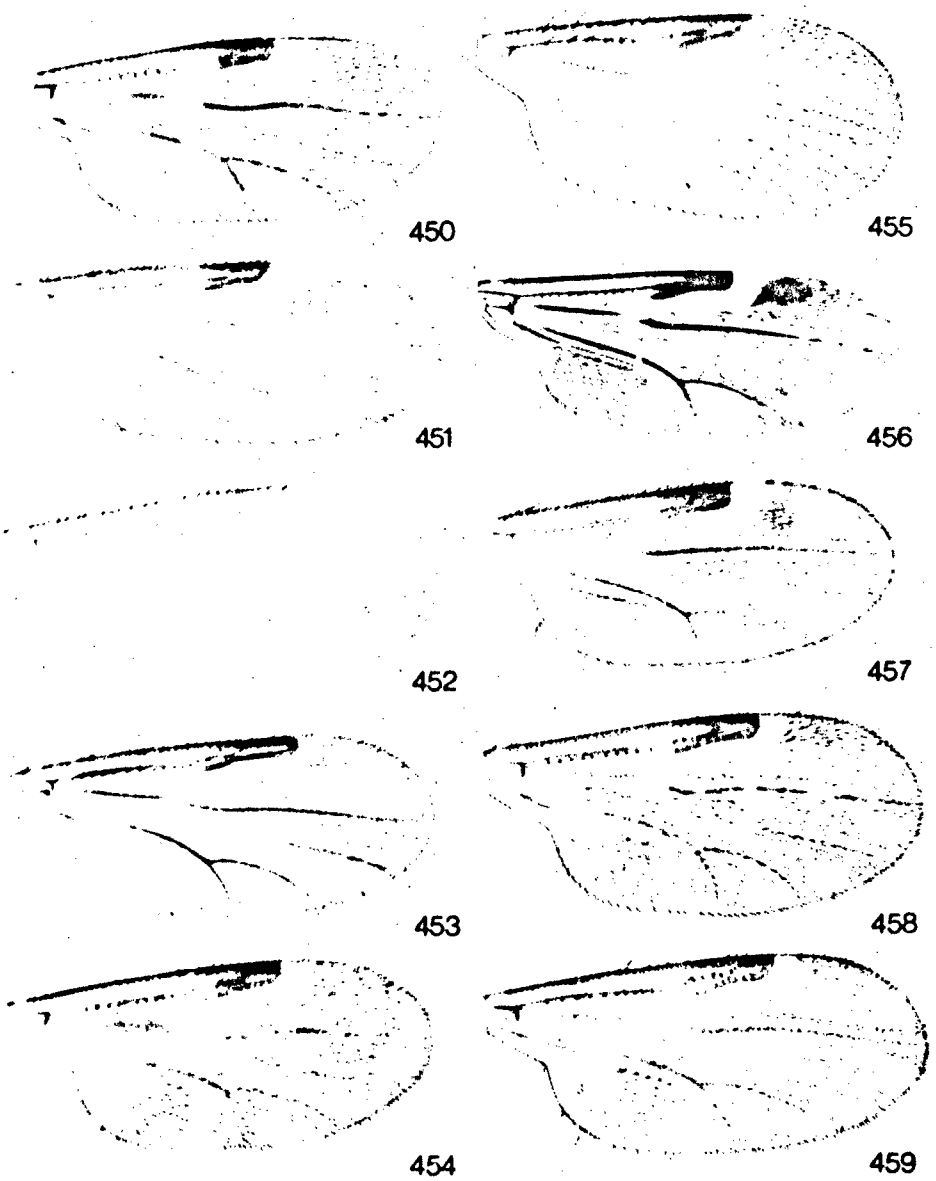

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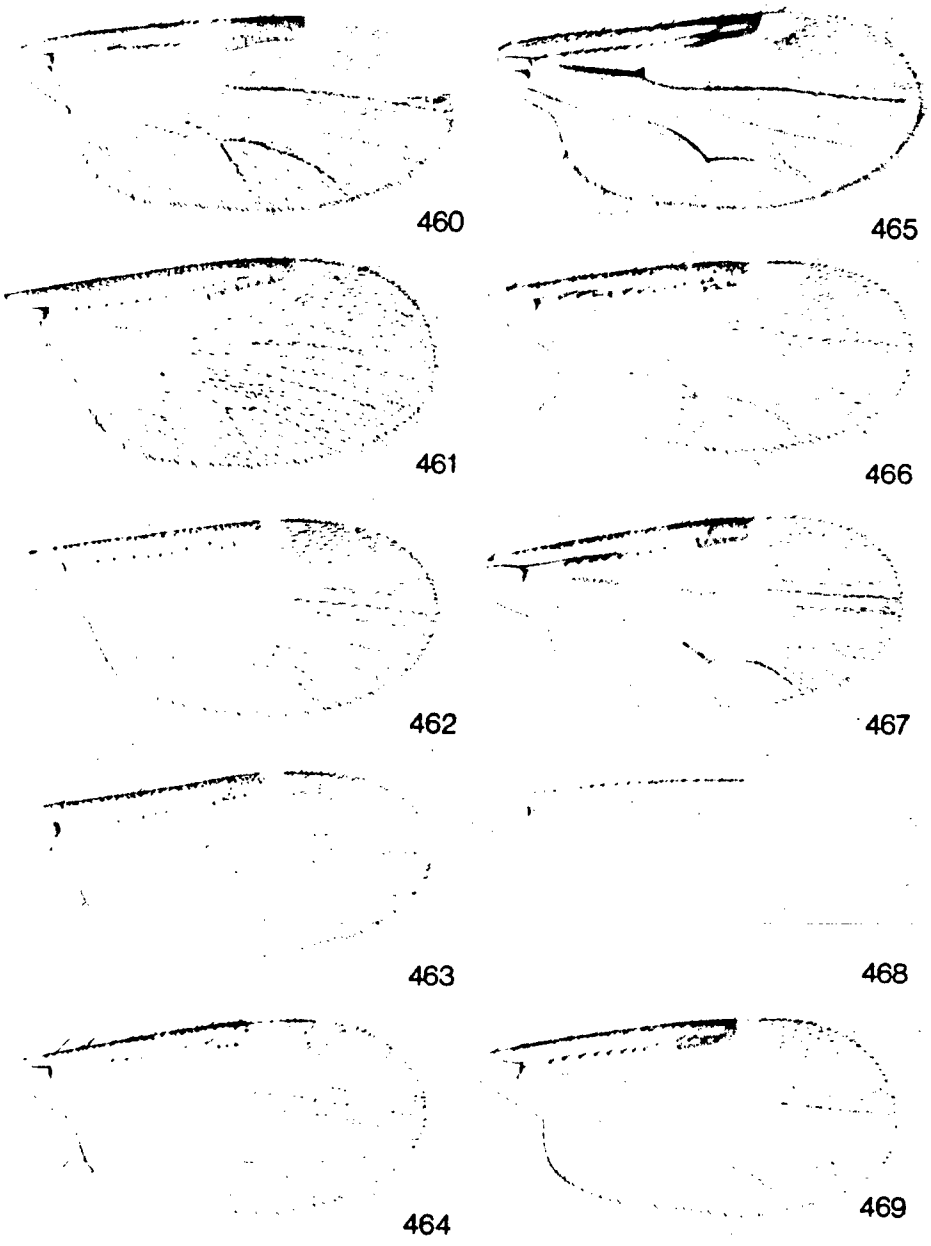

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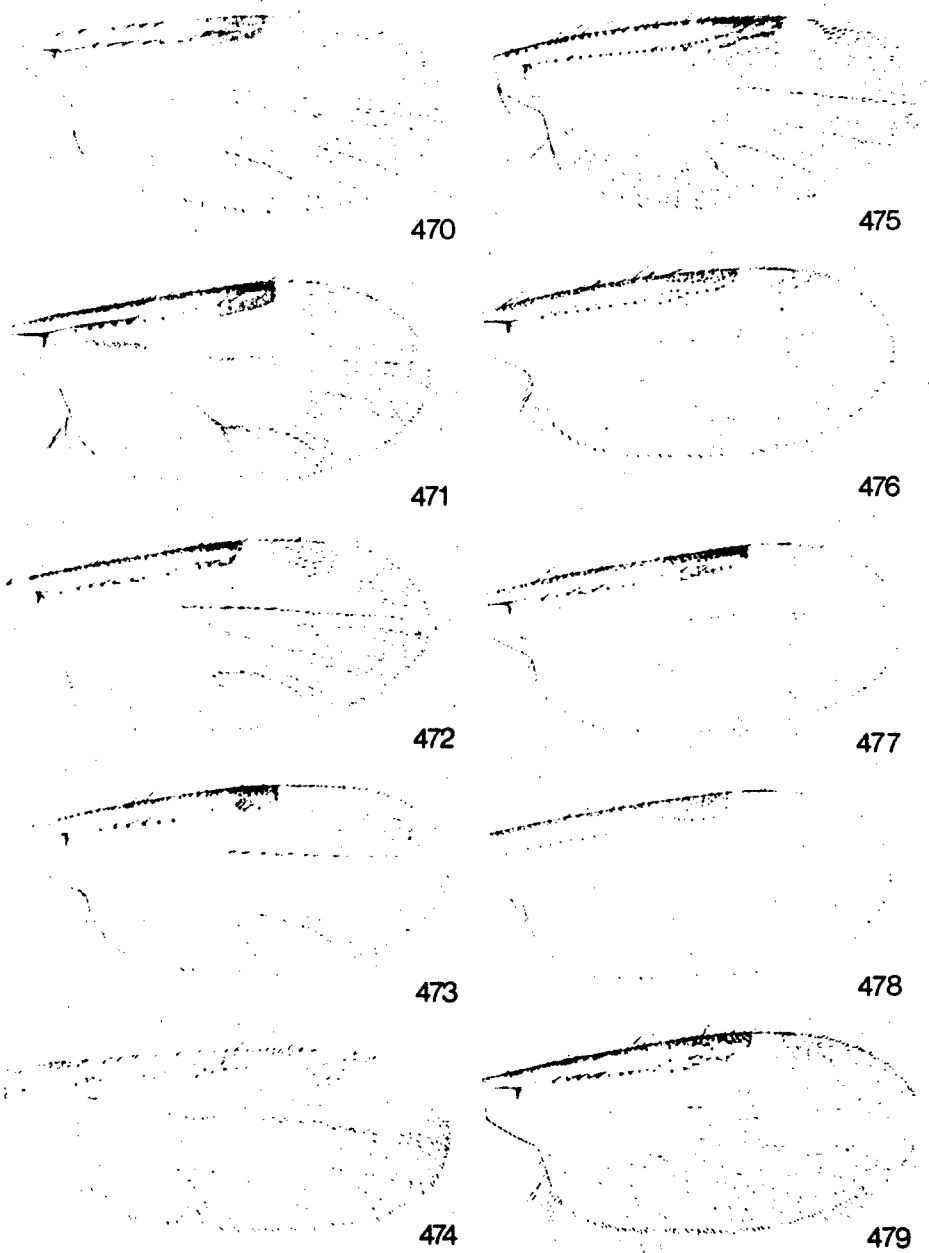

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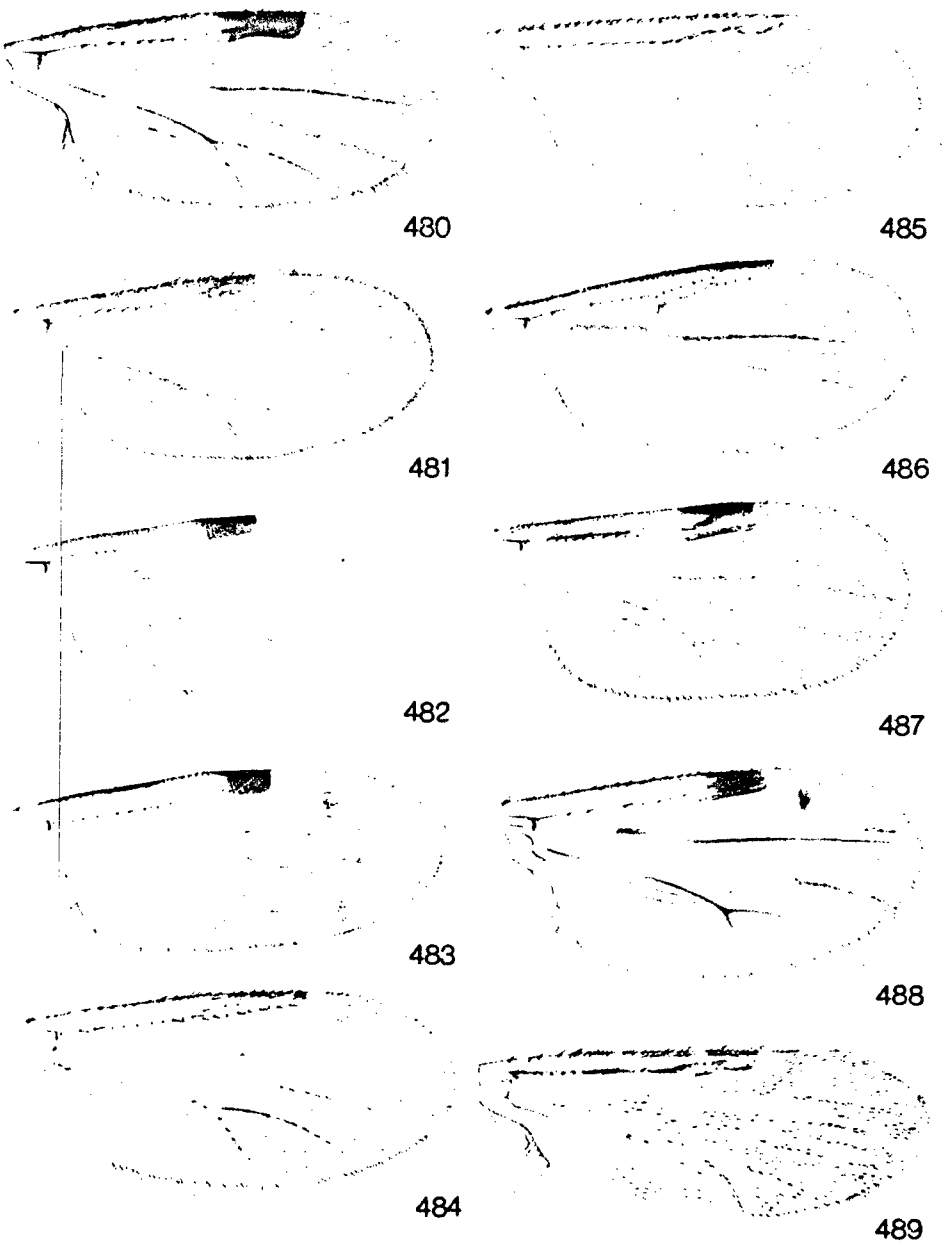

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