MEDICAL ENTOMOLOGY STUDIES - III.

A REVISION OF THE SUBGENUS *CULEX* IN THE ORIENTAL REGION (DIPTERA: CULICIDAE)[1].

By

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ABSTRACT

This revision of the genus *Culex*, subgenus *Culex* of the Oriental region is based largely on the study of material from Southeast Asia and adjacent areas. More than 28,000 specimens [9,053 ♂, 13,075 ♀, 6,087 whole larvae (L)] have been examined. These included 6,105 adults with correlated pupal and/or larval skins (2,071 p, 4,034 lp) associated through individual rearings.

Forty-two species are recognized and of these, 5 are new; 37 are revalidated and redescribed. The 5 new species are: *luzonensis* from the Philippines, *selangorensis* from Peninsular Malaysia, *longicornis* from Thailand, *kinabaluensis* from Sabah, Malaysia and *philippinensis* from the Philippines. The descriptions of 37 species are based on all stages (female, male, pupa and fourth instar larva) and those of the other 5 species: *longicornis*, *epidesmus*, *diengensis*, *propinquus* and *orientalis* are based only on the adults and/or associated pupae and larvae. Keys to all available stages and illustrations of every species are provided. The taxonomic treatment of the subgenus includes a revised morphological description, followed by a review of the distribution, taxonomic discussion, internal classification, bionomics and medical importance and the descriptions of individual species follow essentially the same format. The various groups, subgroups and complexes are briefly defined and characterized.

New synonyms proposed here are: *neolitoralis* Bram (= *alis* Theobald); *annulus* Theobald (= *vishnui* Theobald); *neovishnui* Lien (= *pseudovishnui* Colless); *fuscifurcatus* Edwards and *kangi* Lien (= *jacksoni* Edwards); *neomimulus* Lien (= *mimulus* Edwards) and *afridii* Qutubuddin (= *infula* Theobald). Two previous nominal forms are resurrected from synonymy: *edwardsi* Barraud from *barraudi* Edwards and *infula* Theobald from *bitaeniorhynchus* Giles.

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INTRODUCTION

The subgenus *Culex* is dominant, diverse and widespread in the Oriental region. It contains several species which are locally abundant as serious pests of man and domestic animals and as vectors of periodic bancroftian filariasis, Japanese encephalitis virus and other arboviruses. In Southeast Asia and other adjacent tropical or subtropical areas of the Oriental region, this subgenus is taxonomically the best known of all *Culex* subgenera as it has been subject to several local studies [Baisas 1938, 1974 (Philippine Islands); Barraud 1934 (Indian peninsula); Bonne-Wepster 1954 (Indonesia); Borel (Indochina); Bram 1967 (Thailand) and Delfinado 1966 (Philippine Islands)] and numerous restricted studies on the taxonomy, bionomics, genetics, ecology and disease relationships. Among the previous taxonomic studies, the revision of the subgenus by Barraud (1934) is the most comprehensive; it has a broad coverage of species occurring not only in India, Burma and Sri Lanka, but also those from Southeast Asia and other adjacent areas to the west in the Middle East, Mediterranean and Ethiopian areas and to the north and northeast in the Palearctic region.

Although most of the previous subgeneric revisions have contributed substantially to a better knowledge of several common Oriental species, preliminary studies of much material from several countries of Southeast Asia and adjacent areas, including India and Sri Lanka by Sirivanakarn (1970, 1973) indicate that numerous taxonomic problems still exist, particularly with respect to the identity and the specific status of several nominal forms. Some of these problems are fairly obvious, especially in the case of several closely similar species in the *Vishnui*, *Mimeticus* and *Bitaeniorhynchus* Subgroups. A critical study of almost all the original and subsequent descriptions in the literature, in conjunction with a detailed comparative study of the types, numerous topotypic and other specimens also revealed that a number of species have been inadequately described or only superficially known. In fact, many of the distinct forms can still be easily confused and can not be readily separated on the basis of the previous keys and descriptions. There is apparently little or no information in the previous treatment of almost every species on the range of morphological variation which is essential in determining the specific status of closely similar forms and in interpreting the affinity and diversity of the various taxa.

This study is an attempt to revise the subgenus *Culex* on a broader regional basis, particularly covering Southeast Asia and adjacent areas. A number of species which are known only from India, Japan and Korea are also included for comparative purposes and to provide a more comprehensive revision. In this revision, 42 species of *Culex (Culex)* are recognized and of these, 5 are new and 37 are revalidated and redescribed. In treating the previous nominal species, the following taxonomic changes have been made: (1) *neolitoralis* Bram is synonymized with *alis* Theobald, (2) the current synonymy of *annulus* Theobald with *vishnui* Theobald by Reuben (1969) is followed, (3) *neovishnui* Lien is synonymized with *pseudovishnui* Colless, (4) *fuscifurcatus* Edwards and *kangi* Lien are synonymized with *jacksoni*, (5) *neomimulus* Lien is synonymized with *mimulus* Edwards, (6) *infula* Theobald is resurrected from the previous synonymy with *bitaeniorhynchus* Giles, (7) *afridii* Qutubuddin is synonymized with *infula* Theobald and (8) *edwardsi* Barraud is removed from the previous synonymy of *barraudi* Edwards by Bram (1967a). The 5 additional new species recognized are: *luzonensis* and *philippinensis* from the Philippines, *selagorensis* and *kinabaluensis* from Malaysia and *longicornis* from Thailand.

MATERIAL AND METHODS

A considerable portion of the *Culex (Culex)* material for this study was accumulated at the Southeast Asia Mosquito Project (now the Medical Entomology Project or MEP), Department of Entomology, Smithsonian Institution and the entomological collections at that institution. Most of this material came from collections made by the SEATO Medical Research Laboratory, U. S. Army Medical Component, in Thailand; the Malaysia Mosquito Project directed by S. Ramalingam, University of Malaya in Malaysia and Singapore; the U. S. Army Medical units in South Vietnam, Japan, Korea, the Ryukyu Islands and the Philippines. Numerous additional specimens, largely field caught adults, have been obtained from the recent collections in Sri Lanka by the "Biosystematic Studies of the Insects of Ceylon" project directed by Karl V. Krombein; in Java, Indonesia by S. Ramalingam and from the loans made to the project by the British Museum (Natural History); Field Museum of Natural History; California Academy of Sciences, San Francisco; Academy of Natural Sciences, Philadelphia; Bernice P. Bishop Museum, Honolulu; Department of Entomology, University of Utah and Instituut Voor Tropische Hygiene, Amsterdam. A small portion of the specimens of a few to several species have been received as gifts or as requested from many persons in several countries, including India, Burma, Bangladesh, Pakistan, the Republic of South Africa, Italy, Taiwan, Hong Kong, the Philippines, Cambodia, Malaysia, Indonesia, Japan and Thailand.

I have re-examined most of the existing types and topotypic specimens of the previous nominal species or forms of *Culex (Culex)* originally described and subsequently reported from the Oriental region except for the type of *annulirostris* Skuse from Australia. The majority of the types of the Oriental species are at the British Museum (Natural History). Included among the type material are several adult specimens identified by Edwards, Barraud and others from various localities. Several of these specimens have also been re-examined and confirmed for inclusion in distribution data. In addition, I have also examined for comparative purposes, the adults, with or without associated immature stages of several extralimital species from the Palearctic, Ethiopian, Australasian, Micronesia and the South Pacific in the reference collections of the U. S. National Museum and the British Museum.

The description and the terminology of the adults used here are essentially similar to Bram (1967a), Sirivanakarn (1972) and other *Culex* papers published by the latter author. The pupal and larval terminology and the wing venation system of the adults follow Belkin (1962). To simplify the description of certain features of the male genitalia, the setae of the subapical lobe are designated as *a*, *b*, *c*, etc., as in Belkin (1962). The lateral plate of the phallosome complex is simply described using self-explanatory descriptive terms such as apical, tergal, sternal, mesal, lateral, apical tergal, apical sternal, basal, lateral basal, etc. as seen from the lateral and tergal views. As for the paraproct of the proctiger, I have introduced a new term "subbasal process" for the small peglike structure situated above the basal sternal process. This process articulates with the lateral basal process of the outer division of the lateral aedeagal plate and is particularly well developed in the *Sitiens* Group. The completely labeled illustrations of the various parts of the male genitalia to which these terms apply are in Figures 2, 4, 9, 21, 24, 32, 36 and 38. These should be consulted and checked against the descriptions or key for clarification of the exact position and location of the various parts and processes which have

been frequently used in the diagnosis of practically all species.

In the section on type-data, the status of the type-specimens, holotype or lectotype and stages or sexes and all associated specimens or slides of all nominal forms (if clearly indicated in the original or subsequent designations) are here included and specified. An asterisk (*) indicates that I have personally examined the type. Unless the names of the countries have not been changed, the type-localities as stated in the original descriptions are exactly followed. Country names which have been changed and are currently used are enclosed in the brackets following the former names noted by the original authors. All other available data, including breeding sites, elevations, dates of collections and names of collectors as labeled or mentioned in the original descriptions are fully given. The abbreviations of the names of institutions in which the types are deposited follow the listing of Stone, Knight and Starcke (1959).

In listing the specimens under the distribution of species, only the names of the countries, provinces and/or localities and the number of specimens examined are given. All other distribution records from the literature are placed at the end of the list and only those from the Oriental region are discussed in the taxonomic discussion as to their validity and reliability. In several instances, I have also taken into account the pattern of distribution, sympatry and allopatry in attempting to define the spatial relationship between closely similar species and to speculate on the probable origin of the various taxa. The data on the bionomics and the medical importance are briefly summarized.

TAXONOMIC TREATMENT

SUBGENUS *CULEX* LINNAEUS

Culex Linnaeus, 1758: 602. Type-species: *Culex pipiens* Linnaeus 1758, Europe. Selection of Latreille 1810: 442.

Lasioconops Theobald, 1903: 235. Type-species: *Lasioconops poicilipes* Theobald 1903, Bonny, Nigeria.

Heptaphlebomyia Theobald, 1903: 336. Type-species: *Heptaphlebomyia simplex* Theobald 1903, Salisbury, Southern Rhodesia.

Pseudoheptaphlebomyia Ventrillon, 1905: 427. Type-species: *Pseudoheptaphlebomyia madagascariensis* Ventrillon 1905, Tananarive, Madagascar.

Leucomyia Theobald, 1907: 372. Type-species: *Leucomyia gelidus* Theobald 1901, Selangor, Malaya.

Oculeomyia Theobald, 1907: 515. Type-species: *Oculeomyia sarawaki* Theobald 1907, Sarawak, Borneo.

Theobaldiomyia Brunetti, 1912: 462. Type-species: *Culex gelidus* Theobald 1901.

For complete synonymy, see Stone, Knight and Starcke 1959.

FEMALE. Medium to large sized species, somtimes small; wing length usually exceeding 3.0 mm. *Head.* Decumbent scales of vertex narrow, crescent-shaped, occupying an extensive area in center and along dorsal eye margin; erect scales numerous, coarse, color varied; broad appressed scales usually pale, forming a distinct lateral patch at sides of eyes. Eyes contiguous above antennal pedicels; frontal narrow scale tuft well developed; frontal and dorsolateral ocular bristles strong and dark; subocular bristles weak, dark or pale. Palpus 4-segmented, 0.20-0.25 of proboscis length, usually

entirely dark scaled, with or without sprinkling of some pale scales; apex of segment 4 dark or tipped with pale scales. Proboscis usually as long as or slightly longer than forefemur, sometimes slightly shorter; labium with or without distinct median pale ring; labial basal bristlelike setae dark and short, about 0.5 of palpal length. Antenna slightly longer than proboscis; pedicel with a small conspicuous patch of semierect scales and setae on inner dorsal surface; flagellomeres 1-13 subequal, with numerous short setae; flagellar whorls 2-13 poorly developed, each with 5-6 moderately long hairlike setae; flagellomere 1 with or without a few scales. *Cibarial Armature.* Well developed; cibarial bar broadly concave, with or without slight median projection; cibarial teeth 20-30, closely spaced in middle, more widely spaced towards lateral flanges, length and size of teeth varied; cibarial dome very well developed, imbricate, very similar in all species. *Thorax.* Mesonotum with a conspicuous double row of acrostichal bristles from anterior promontory to about level of wing base; dorsocentral, fossal antealar and supraalar bristles well developed; mesonotal scales narrow, crescent-shaped, color varied, moderately to very dense on scutal disc, less dense on prescutellar space and towards posterior lateral caudal margin; scutellar lobes with narrow scales, forming distinct patch in middle; bristles on scutellar lobes strong and dark; paratergite bare. Anterior pronotum *(apn)* with several narrow scales and strong setae; posterior pronotum *(ppn)* usually with several narrow scales and sometimes also short setae on upper surface, posterior margin with a row of 4-6 strong bristles, sometimes also with an adjacent row of 5-7 weaker bristles; prosternum *(pst)* usually entirely bare, sometimes with a small patch of pale scales and short setae. Pleural scale patches present, usually 1 on propleuron *(ppl)*, 2 on sternopleuron *(stp)* and 1 on mesepimeron *(mep);* postspiracular *(psp)* and prealar *(pra)* with or without scales; variable number of scales usually present among upper mesepimeral bristles; 1-2 lower mesepimeral bristles present or absent. *Legs.* Color of scales on anterior surface of femora varied, usually entirely dark on fore- and midfemora, sometimes with speckling of pale scales or pale stripes; tarsi with or without apical and basal pale bands; pretarsal claws of all legs small, equal and simple; pulvilli always very well developed. *Wing.* All veins usually dense and entirely dark scaled, sometimes with speckling of pale scales or with pale scales aggregating into distinct pale spots. *Abdomen.* Terga II-VII usually with basal pale bands and basolateral pale spots, sometimes with apical pale bands, apicolateral pale patches or entirely dark; sterna largely pale scaled or with banding pattern as on terga. *Genitalia.* Very similar in most species; segment IX largely retracted into segment VIII, tergum IX a moderately broad band, with lateral row of strong setae on each side of median bare area; cerci short, broad, more or less rounded apically, with numerous strong and weak setae; postgenital plate more or less triangular, caudal margin broadly rounded, truncate or slightly emarginate at middle, with 2 lateral rows of setae in apical half and numerous minute spicules; posterior cowl a very narrow band with numerous minute spicules; sigma broad, largely membranous, with numerous minute spicules; insula with a dense tuft of 8-10 strong setae; vaginal sclerite or atrial plate U- or V-shaped, usually very well sclerotized.

MALE. Generally similar to female, except for smaller size, less numerous scales on wing veins. *Head.* Palpus 5-segmented, usually exceeding proboscis by at least full length of segment 5; segment 3 with or without median pale band dorsally, ventral surface with row of short hairlike or scalelike setae from base to apex, apical 0.2-0.5 with ventral lateral rows or tuft of strong bristles; segments 4 and 5 upturned, usually

strongly plumose, with several strong bristles on lateral and mesal surfaces, dorsal surface with or without basal pale band, ventral surface usually with a line of pale scales; apex of segment 5 dark or pale scaled. Proboscis as in female, median ventral tuft of long hairs present or absent, if present, length and number of hairs varied. Flagellar whorls of antenna strongly long plumose; accessory minor whorls and modified scale tufts absent. *Thorax*. Propleural bristles usually more numerous than in female. *Legs*. Pretarsal claws of fore- and midlegs enlarged, with subbasal denticles, outer claw larger than inner claw; claw of hindleg small and simple. *Abdomen*. Tergal banding patterns, if present usually better developed than in female; sterna with numerous long setae.

MALE GENITALIA. *Segment IX*. Tergum narrow, tergal lobes poorly developed, broadly rounded, with 1 or 2 rows of moderately strong setae; number of setae varied; sternum large, more or less rectangular, articulating with tergum by a narrow sclerotized band, scales or setae on sternum absent. *Basimere*. Conical, lateral tergal margin convex, tergomesal margin concave; strong bristles restricted to lateral tergal surface, weaker bristles or setae numerous, evenly spread over tergal area; scales absent. *Subapical lobe*. Usually short, projecting mesad; proximal and distal divisions clearly divided or close together; proximal division with 3 strong rodlike setae *(a-c)*; distal division with a lateral group of 1 leaflet *(g)* and 1 seta *(h)* and a mesal group of 3-4 flattened bladelike and fine hairlike setae *(d-f)*. *Distimere*. More or less sickle-shaped, gently curved in middle, distal portion tapered and slightly recurved towards apex; 1 dorsal and 1 ventral seta present beyond midpoint; claw subapical, short, distally flattened and apically blunt. *Phallosome*. Aedeagus usually complex, sometimes simple; distal portion of lateral plate usually with distinct inner (most sternal) and outer (most tergal) divisions; teeth and processes on each division variously developed; basal sternal portion (or lip of gonopore) very well developed, laterally compressed, represented by a broad, simple and rounded lobe which is well detected in lateral view; upper tergal bridge narrow, bow-shaped, placed below midpoint of lateral plate; lower tergal bridge broad, basal or subbasal in position. *Proctiger*. Apical crown usually large with numerous fine and coarse spicules; basal sternal process of paraproct varied from very short, rudimentary to very long and thick, curved sternad, sometimes completely absent; a short subbasal sternal process slightly distad of basal present or absent; cercal sclerite well sclerotized; cercal setae present, number varied; basal lateral sclerotization a narrow, oval sclerotized plate, more or less continuous with basal portions of paraproct, rest entirely membranous.

PUPA. Size varied. Integument of cephalothorax and abdomen usually pale, yellowish or cream-colored, sometimes dark brown or with striking color pattern. All setae developed, branching and length varied. *Trumpet*. Tubular; at least 0.5 mm in total length; index 5-15; meatus rather thick, more or less cylindrical; pinna lightly to strongly oblique, lightly to strongly widened or flared or about same diameter as meatus, without slit extending to meatus on ventral surface. *Cephalothorax*. All setae shorter than trumpet; setae 1 and 3-C subequal in length, 2-5 branched; 2-C shorter, 3-6 branched; 4-C shorter than or as long as 5-C, 2-4 branched; 5-C 2-6 branched; 6-C small, dorsad or laterad of 7-C, usually 2-4 branched; 7-C double, 2-3 times as long as 6-C; 8-C 2-6 branched; 9-C 2-4 branched. *Metanotum*. Seta 10-C multiple or at least triple; 11-C double; 12-C 2-5 branched. *Abdomen*. Seta 1-I large, multiple and strongly dendritic; 1-II short, single or multiple;

1-III-VII 0.5 of the length of segments following, number of branches varied; 2-III-VI single, minute, always mesad of 1-III-VI, 2-VII usually laterad of 1-VII, sometimes variable in position; 3-I-III usually double, sometimes single; 5-II 3-8 branched; 5-III 4-14 branched; 5-IV 2-8 branched, slightly shorter or as long as segment V; 5-V-VI usually double and longer than segments following, sometimes shorter and more branched; 6-III, IV much weaker than 6-I, II, 1-6 branched; 6-V, VI usually longer than 6-III, IV, 1-7 branched; 7-I, II 1-3 branched; 9-I single or double; 9-II-VI minute, indistinct; 9-VII 2-5 branched, lightly dendritic, shorter or as long as 9-VIII; 9-VII 5-10 branched, usually strongly dendritic; segment IX with a single minute seta laterad of genital lobe; male genital lobe (basimere) at most 0.3 of paddle length. *Paddle.* Broad, oval; pigmentation of inner and outer parts usually pale, sometimes varied; external margin very lightly spiculate in basal 0.5, distally smooth or without fringe of spicules, apical margin rounded, or sometimes slightly emarginated at apex of midrib; midrib well developed, usually lightly pigmented, sometimes dark; apical setae 1, 2-P small, short, usually single; 2-P sometimes absent or not developed.

LARVA. *Head.* Broader than long; maximal width (distance between lateral margins of ocular bulge) usually nearly approximates the width of prothorax, sometimes greatly reduced (*Bitaeniorhynchus* Subgroup); labrum developed as distinct transverse bar, sometimes poorly developed or not apparent; ocular bulge usually prominent; seta 1-C filiform or spiniform, sometimes strongly flattened and apically blunt; minute setae 16, 17-C laterad of collar absent. Antenna shorter or as long as dorsal length of head; several spicules present, more or less restricted to basal 0.5 of shaft; seta 1-A large, fan-shaped, multibranched and strongly pectinate; 2, 3-A single, bristlelike, usually subapical, sometimes apical. Mouthbrush elements filamentous. Mental plate usually with distinct lateral teeth on each side of median tooth, sometimes teeth not differentiated. *Thorax.* Spiculation usually absent; setae 1-3-P subequally strong and long, usually single; 4-P shorter than 1-3-P, usually double, sometimes single or more branched; 5, 6-P single, strong, 7-P double or triple; 8-P double; 14-P single. *Abdomen.* Spiculation usually absent; chaetotaxy varied; setae 6-I, II and 7-I strongly developed; 6-I, II usually triple, sometimes 4 branched; 7-I single or double; 6-III-VI moderately to strongly developed; 1-III-VI weakly to strongly developed. Comb scales varied in number and size, seta 2-VIII usually single, sometimes double or more branched. Saddle usually completely sclerotized, rarely incomplete; posterior margin lightly spiculate; seta 1-X usually weakly developed; 2, 3-X strong; 4-X (ventral brush) strong, usually with 6 pairs of setae, all inserted within grid; anal gills shorter or longer than saddle. *Siphon.* Shape, length and color varied; index 3-14; acus very well developed; pecten teeth varied from a few to several, denticulation varied; siphonal tufts variously developed, 3-7 pairs in number; seta 2-S single, length and thickness varied; median caudal filament of spiracular apparatus usually present, sometimes absent.

DISTRIBUTION. The subgenus *Culex* is worldwide in distribution. In Southeast Asia and in most parts of the Oriental region, the subgenus has been recorded from every country wherever a mosquito survey is made. A number of the Oriental species have also been reported from the Ethiopian, Palearctic (Mediterranean, Middle East, China, Siberia, Soviet Union, Japan and Korea) and the Australasian regions (including Micronesia and South Pacific). Of the 2 major groups (*Pipiens* and *Sitiens*), the *Sitiens* Group is exclusively Old World with an extensive range of distribution largely restricted to the tropics of the Ethiopian, Oriental and Australasian regions while the *Pipiens* Group is

worldwide.

The distribution of the species of the subgenus *Culex* in Southeast Asia and other adjacent areas within the Oriental region are shown in a table (Appendix A). Without any claim to completeness and accuracy, I have attempted to include most of the extralimital records from the literature for every species treated in this revision. For a more detailed account of the distribution of the groups, subgroups, and species, see the discussion in each category.

DISCUSSION. The majority of Oriental *Culex (Culex)* species are very well characterized in the adults by the presence of conspicuous ornamentation on the palpus, proboscis, thorax, legs, wing and abdomen. With the exception of closely similar species in certain subgroups or complexes, adults of many species can be readily recognized or differentiated by external characters. The male genitalia are important at the subgeneric, species group, subgroup and specific levels using characters of the phallosome, proctiger and subapical lobe. In the females, the cibarial armature may be of some value in the diagnosis of certain species with extremely similar external characters. The female genitalia are of little or no practical value in differentiating species or subgenera. In the immature stages, both the pupae and larvae show a number of good subgeneric and specific characters that are very useful in the diagnosis of several species with extremely similar adults and male genitalia. For an accurate identification or determination of species in certain subgroups or complexes, all stages must be examined.

All members of *Culex (Culex)* in the Oriental region are separated from members of other *Culex* subgenera (including *Barraudius, Acalleomyia, Culiciomyia, Eumelanomyia, Lophoceraomyia* and *Lutzia*) by the following combination of characters: adults by (1) presence of a distinct double row of acrostichal bristles, (2) presence of at least 3 distinct scale patches on the pleuron and in the majority of species by, (3) presence of a pale ring in the middle of proboscis, (4) presence of conspicuous basal and apical bands on tarsomeres 1-4 of the legs and (5) presence of basal and/or apical bands on abdominal terga II-VII; females by presence of 20-30 teeth in the cibarial armature; male sexual characters by (1) palpus longer than proboscis, (2) absence of lateral ventral row of lanceolate scales on palpal segment 3 and (3) absence of modified scale tufts on antennal flagellum; male genitalia by (1) complex phallosome, (2) large proctiger crown, and in most species by, (3) presence of a long basal sternal process in the paraproct of the proctiger; pupa by (1) pinna of trumpet without slit extending into meatus, (2) seta 10-C usually multiple, rarely double or triple and (3) seta 9-VIII well removed from caudolateral angle of segment VIII; larva by (1) absence of setae 16 and 17-C, (2) setae 1-3-P usually subequally long and strong, (3) seta 14-P single, (4) siphon with 3-7 pairs of hair tufts, (5) ventral brush (4-X) of saddle usually with 6 pairs of setae, and in the majority of species by, (6) dark, flat, spiniform seta 1-C and (7) usually single seta 2-VIII.

Prior to this study, 45-47 species and 2-3 subspecies of *Culex (Culex)* have been considered as valid taxa in the Oriental and the eastern Palearctic regions (Stone, Knight and Starcke 1959; Stone 1961, 1963, 1967 and 1970). In this study, I recognize 42 species in the subgenus. Almost all of the previous nominal species from Southeast Asia and adjacent areas in the Oriental and the eastern Palearctic regions [including India, Bangladesh (East Pakistan), Burma, Sri Lanka (Ceylon) as revised by Barraud (1934) and from Japan and Korea by LaCasse and Yamaguti (1950)], are treated. The only exceptions are 3 species from mainland China: *huangae* Meng, *permixtus* Hsieh and Liao and *cheni* Ho, which are omitted because I have not been able to examine their types

or topotypic specimens. In addition, 2 other species are not included: *nilgiri-us* Barraud from India and *boninensis* Bohart from the Bonin Islands, Micronesia, both of which do not appear to belong to the subgenus *Culex*. The true affinity of these 2 species can not be determined at this time, however, it appears most probable that *nilgiricus* belongs to the subgenus *Eumelanomyia* and that *boninensis* probably represents a distinct subgenus judging by the male genitalia and adult characters.

Internal classification. The Oriental members of the subgenus *Culex* fall into 2 distinct groups, *Pipiens* and *Sitiens* as defined by Edwards (1932: 200-12) on the basis of conspicuous coloration in the external characters of the adults. Except for minor modifications in the arrangements of species within each group and further subdivisions (e.g. into subgroups) by subsequent authors dealing with local studies, (Baisas 1938; Colless 1957a; Mattingly and Rageau 1958; Belkin 1962 and Bram 1967a), Edwards' scheme of recognizing 2 major groups in the subgenus is still applicable to the Oriental *Culex (Culex)* fauna. As evident from the comparative study of the male genitalia and the immature stages, there are a number of borderline cases among some Oriental species which do not appear to fit perfectly into either group. Both groups are highly complex, and although they should, perhaps be considered separate subgenera, many more subgenera would then have to be recognized. This would evidently create confusion rather than clarification and should not be pursued until all groups and subgroups in the subgenus are thoroughly re-examined on a global basis. In this study, I am attempting only to recognize subgroups within the 2 major groups by adopting a scheme of internal classification similar to that developed by Edwards (1932) and other subsequent authors. Each of the subgroups is represented by one or more species, some of which are further segregated into complexes whenever it becomes appropriate. As a result, several changes in the realignment of species have been made.

Among the 42 Oriental species treated here, 6 belong to the *Pipiens* Group and 36 to the *Sitiens* Group. The *Pipiens* Group comprises 4 subgroups: (1) *Pipiens* Subgroup with *quinquefasciatus* which is widespread throughout tropical parts of the world, (2) *Trifilatus* Subgroup with *vagans* and *hutchinsoni*, both are exclusively Oriental, (3) *Theileri* Subgroup with *theileri*, very well known in the Ethiopian region and (4) *Univittatus* Subgroup with *univittatus*, a dominant Ethiopian form and *fuscocephala* which is exclusively Oriental. The *Sitiens* Group is more dominant and extremely diverse, comprising 6 subgroups: (1) *Gelidus* Subgroup represented only by *gelidus*, which is exclusively Oriental, (2) *Bitaeniorhynchus* Subgroup with *bitaeniorhynchus*, which I am restricting to the type form; *infula, luzonensis, selangorensis, pseudosinensis, longicornis, epidesmus, cornutus, sinensis, geminus* and *kinabaluensis*, all are exclusively Oriental except *bitaeniorhynchus* which is apparently widespread, extending from the Oriental to the Ethiopian, northeastern Palearctic (Japan and Korea) and certain parts of the Australasian region; *infula* and *sinensis* which are widespread in the Oriental region, (3) *Sitiens* Subgroup with *sitiens*, a dominant coastal form, widespread in the tropical parts of the Oriental, Australasian (including: South Pacific, Micronesia) and in the eastern parts of the Ethiopian region; *alis*, a litoral brackish water species which is known from Christmas Island and Southeast Asia; *whitmorei* which is widely spread throughout the Orient with extension into Japan, Korea and New Guinea; *annulirostris* in the Philippines and widespread in Micronesia, South Pacific and Australasian region, (4) *Vishnui* Subgroup with *vishnui, pseudovishnui* and *tritaeniorhynchus;* all are widespread in Southeast Asia; *alienus* and *perplexus* in Malaysia and Thailand; *philippinensis* and *incognitus* known only in the Philippines and *whitei*

from India, Bangladesh, Thailand, Peninsular Malaysia, the Philippines and Ceram, Lombok, Indonesia, (5) *Barraudi* Subgroup with *barraudi* from India and Thailand and *edwardsi* from India, New Guinea and northern Australia and (6) *Mimeticus* Subgroup with *mimeticus* which is a rare Oriental form but widespread westward into the Mediterranean and Middle East; *fasyi* in the Philippines; *jacksoni* in India, Sri Lanka, Hong Kong, Taiwan and probably also in China; *tsengi* in Taiwan; *diengensis* in Java, Indonesia; *mimuloides* in India; *mimulus*, widespread in Southeast Asia, India, Sri Lanka, New Guinea and northern Australia; *murrelli* widespread in Thailand, Peninsular Malaysia and probably also in India; *propinquus* in Singapore and *orientalis* from Japan and Korea, and perhaps also in China, Siberia and USSR.

BIONOMICS. All Oriental species of *Culex (Culex)* whose immature stages are known breed in ground pools and occasionally in artificial containers. Several species are restricted to more or less permanent types of ground water, such as ponds, swamps, bogs or obstructed streams which contain algal mats (e.g. *Bitaeniorhynchus* and *Mimeticus* Subgroups). The medically important species in the *Vishnui* Subgroup frequently breed in open country such as rice fields or cleared land developed for other agricultural purposes. Two species, *sitiens* and *alis*, which are litoral, show a high tolerance for brackish or even salt water in rock pools, puddles or artificial containers along sea beaches. *Culex quinquefasciatus*, which is the dominant domestic species in large or small cities, shows a very broad range of tolerance for polluted ground waters in drains, septic tanks and in the multitude of artificial containers. The rest of the species are fresh water breeders.

Females of most species of *Culex (Culex)* require a blood meal to complete the gonotrophic cycle. They are primarily crepuscular or nocturnal biters and feed on the blood of mammals, birds and possibly other vertebrates. Host feeding patterns for the majority of species are not known from all areas within the distribution range except for a number of common species which have been investigated in Malaya by Colless (1959) and in India by Reuben (1971a, 1971b) and Christopher and Reuben (1971). Hosts include cow and pig for *tritaeniorhynchus, gelidus* and *fuscocephala*; pig and bird for *sitiens, pseudovishnui* and *vishnui*; bird and man for *quinquefasciatus* and bird for *mimulus* and *bitaeniorhynchus*. Although man is the frequent host for *quinquefasciatus*, Colless (1959) reported that other species, including *tritaeniorhynchus, gelidus* and *fuscocephala* which naturally feed on cow and pig, will also attack man in the absence of those hosts.

MEDICAL IMPORTANCE. The subgenus *Culex* is the most important of all *Culex* subgenera from the public health standpoint. In Southeast Asia, the subgenus contains several species which are abundant and closely associated with man and his domestic animals through the blood feeding habits of the females. Many species are now known to play an important role as actual or potential vectors of pathogens of human diseases, including bancroftian filariasis and Japanese encephalitis virus (JE). *Culex quinquefasciatus*, (or *fatigans* of some authors), which is the notorious pest of man in cities and towns, is considered to be the principal vector of urban periodic bancroftian filariasis in several countries of Southeast Asia. Several epidemiological studies have shown conclusively that *tritaeniorhynchus* is the primary vector of Japanese encephalitis in Japan, Okinawa, Taiwan, Sarawak, Borneo and India. In studies dealing with virus isolation and experimental transmission from the Oriental region other species including *gelidus*, *fuscocephala*, *vishnui* and *pseudovishnui* have also been considered to be probable or potential vectors of Japanese encephalitis.

KEYS TO GROUPS AND SPECIES

ADULTS

1. One or 2 lower mesepimeral bristles present; proboscis without distinct median pale ring; tarsomeres without basal or apical pale bands (*PIPIENS* GROUP). 2
   Lower mesepimeral bristles absent; proboscis with distinct median pale ring; tarsomeres with basal and apical pale bands (*SITIENS* GROUP). 7

PIPIENS GROUP

2(1). Anterior surface of midfemur without median longitudinal pale stripe. 3
   Anterior surface of midfemur with median longitudinal pale stripe. 5

3(2). Abdominal terga without basal transverse pale bands; pleuron with striking pattern of dark and pale stripes. . . . . *fuscocephala*
   Abdominal terga with basal transverse pale bands, pleuron without striking pattern of dark and pale stripes. 4

4(2). Mesonotal integument reddish brown; pleural integument with distinct pattern of dark and pale stripes on sternopleuron and mesepimeron. . . . . *hutchinsoni*
   Mesonotal integument yellowish or pale brown; pleural integument without pattern of dark and pale stripes as above. *quinquefasciatus*

5(2). Postspiracular area and base of prealar knob with distinct scale patches. 6
   Postspiracular area and base of prealar knob without scale patches. . . . . *vagans*

6(5). Large species (wing length about 5.0 mm.); basal pale bands of abdominal terga very broad and strongly produced at middle. *theileri*
   Smaller species (wing length about 3.5 mm.); basal pale bands of abdominal terga narrow and even in width. . . . . *univittatus*

SITIENS GROUP

7(1). Wing with pattern of pale spots or streaks on at least 2 areas of costa and one area of other veins. 33
   Wing without pattern of pale spots or streaks as above. 8

Gelidus, Bitaeniorhynchus, Sitiens, Vishnui and *Barraudi* Subgroups

8(7). Abdominal terga II-VIII largely yellowish or golden. . . . *epidesmus*
   Abdominal terga II-VIII with dark and pale bands or entirely dark. . 9

9(8). Abdominal terga II-VI entirely dark or without basal, apical pale bands or apicolateral pale patches. 10
Abdominal terga II-VI with basal or basal and apical pale bands or apicolateral pale patches. 11

10(9). Dark areas on abdominal terga with light sprinkling of some pale scales; size large, wing length exceeding 4.0 mm. . *selangorensis*
Dark areas on abdominal terga without any scattered pale scales; size small or medium, wing length not exceeding 4.0 mm. *perplexus*, *whitei* and *incognitus*, in part

11(9). Abdominal terga II-VI with basal pale bands only. 18
Abdominal terga II-VI with apical bands and/or apicolateral pale patches and basal pale bands. 12

12(11). Wing with dark scales on all veins. 13
Wing with a mixture of dark and pale scales. 16

13(12). Anterior surfaces of fore- and midfemora largely dark scaled or with very light sprinkling of few pale scales; prosternum without any scales. 14
Anterior surfaces of fore- and midfemora moderately to strongly speckled with numerous pale scales; prosternum with a small patch of pale scales. 15

14(13). Apical bands on abdominal terga III-VI strongly widened towards sides, forming a large apicolateral pale patch; anterior surface of fore- and midfemora usually without speckling of pale scales on dorsal surface. . . . . *pseudosinensis*
Apical bands on abdominal terga III-VI slightly widened towards sides, forming a small apicolateral pale patch; anterior surface of fore- and midfemora with a very light speckling of some pale scales on dorsal surface. . . . . *geminus*

15(13). Clypeus with a distinct patch of pale scales on lateral surface; apical pale bands on abdominal terga IV-VI broader than basal. . . . . *cornutus*
Clypeus without any scales on lateral surface; apical pale bands on abdominal terga IV-VI as broad as basal bands. . . . . *sinensis*

16(12). Abdominal terga II-VII with broad apical bands; legs (femora, tibia) and wing heavily speckled with pale scales; scales on wing veins R_1, R_2 and R_3 broad ovate. . . . . *bitaeniorhynchus*
Abdominal terga II-IV usually largely dark or with narrow apical bands, apicolateral yellowish patches and median basal pale spots or complete basal pale bands; tergites V-VII with narrow or broad apical and/or basal bands; legs and wing lightly to moderately speckled with pale scales; scales on wing veins R_1, R_2 and R_3 narrow clavate. 17

17(16). Basal pale bands on abdominal terga IV-VI usually broader or as broad as apical bands (separation tenuous, also use male genitalia). . . . . *luzonensis*

Basal pale bands on abdominal terga IV-VI usually narrower than apical bands. . *infula, longicornis* (inseparable, use male genitalia)

18(11). Erect scales in center of vertex of head whitish; anterior 0.7 of mesonotum densely covered with pure white scales. 19
Erect scales in center of vertex of head pale beige, dingy white or dark; anterior 0.7 of mesonotum covered with beige, yellow, golden or dark scales. 20

19(18). Anterior surfaces of fore- and midfemora without speckling of pale scales; scales on prescutellar space, lateral mesonotal areas behind wing base and on scutellum entirely dark brown. . *gelidus*
Anterior surfaces of fore- and midfemora with extensive speckling of pale scales; scales on prescutellar space, lateral mesonotal areas behind wing base and on scutellum predominantly pale whitish. . . . . *whitmorei*

20(18). Cell R_2 of wing (in both sexes) at most as long as vein R_{2+3}; *Male:* palpal segments 4 and 5 weakly plumose. . . . . *alis*
Cell R_2 of wing 1.5-2.0 times as long as vein R_{2+3}; *Male:* palpal segments 4 and 5 strongly plumose. 21

21(20). Midfemur with longitudinal pale stripe on anterior surface; postspiracular area with a small patch of semierect scales on lower anterior surface. 22
Midfemur entirely dark or with sprinkling of pale scales not forming definite stripe as above; postspiracular area without any scales on lower anterior surface. 23

22(21). *Female:* longitudinal pale stripe on anterior surface of midfemur broken up into a row of white spots at middle; *Male:* proboscis without ventral tuft of long hairs at base of median pale ring. *barraudi*
Female: longitudinal pale stripe on anterior surface of midfemur complete; *Male:* proboscis with distinct ventral tuft of long hairs at base of median pale ring. . . . . *edwardsi*

23(21). Anterior surface of fore- and midfemora with speckling of several pale scales at least on apical dorsal surface. 24
Anterior surface of fore- and midfemora entirely dark. 27

24(23). Wing scales entirely dark; mesonotal integument chestnut brown or blackish; speckling of pale scales on femora contrasting sharply with dark scaled areas. 25
Wing with a few to several scattered pale scales; mesonotal integument light brown; speckling of pale scales on femora not contrasting sharply with dark scaled areas. . . *vishnui,* in part

25(24). Hindfemur largely pale; anterior surface of foretibia without a row of yellow spots among dorsal bristles. 26
Hindfemur with an even mixture of light and dark scales or largely dark; anterior surface of foretibia usually with a distinct row of yellow spots among dorsal bristles (also use keys to

male genitalia and larva). . . . . *annulirostris*

26(25). Hindfemur with discrete pale stripe from base to 0.75 of length; speckling of pale scales on fore- and midfemora largely restricted to apical 0.5. . . . . *whitei*, in part
Hindfemur freckled or with several dark scales scattering among pale ones; speckling of pale scales on fore- and midfemora covering almost entire length (separation tenuous, also use male genitalia or larvae). . . . . *sitiens*

27(23). Erect scales on vertex and scales on anterior 0.7 of mesonotum largely dark brownish. 28
Erect scales on vertex pale beige or yellow in center; dark posterolaterally; scales on anterior 0.7 of mesonotum largely pale beige, yellow or golden with mottling of some brown scales. 29

28(27). *Female:* Mesonotal scales very fine and entirely dark brown; all cibarial teeth very fine, elongate and distally filamentous; Male: ventral surface of palpal segment 3 with a row of fine hairlike setae. . . . . *tritaeniorhynchus*
Female: Mesonotal scales rather coarse and partially pale, particularly on supraalar area; cibarial teeth short, thickened and apically blunt or abruptly pointed; *Male:* ventral surface of palpal segment 3 with a row of scalelike setae (separation from other species in couplet 30(29) not always reliable, use larva and pupa). . . . . *vishnui*, in part

29(27). Large species, wing length usually exceeding 4.0 mm.; forefemur with distinct subapical yellow spot; *Male*: palpal segment 3 with dense fine hairlike setae on ventral surface. . . *kinabaluensis*
Small-medium sized species, wing length less than 0.4 mm., forefemur without subapical yellow spot; *Male:* palpal segment 3 with a row of scalelike setae on ventral surface. . . . 30

30(29). *Females* (inseparable, use keys to larva and pupa).
vishnui, in part, *pseudovishnui*, *perplexus*, *alienus*, *philippinensis*, *incognitus* and *whitei*
Males (separation not always reliable, use keys to larva and pupa). 31

31(30). Proboscis without ventral tuft of hairs at base of median pale ring.
pseudovishnui
Proboscis with ventral tuft of some long hairs at base of median pale ring. 32

32(31). Palpal segment 3 completely dark. . *perplexus* and *incognitus*, in part
Palpal segment 3 with median pale band.
vishnui, in part, *alienus*, *philippinensis*, *incognitus*, in part and *whitei*

Mimeticus Subgroup

33(7). Wing with basal costal pale spot in addition to 2, 3 other costal spots; male palpal segments 4 and 5 weakly plumose. . . *orientalis*
Wing without basal costal pale spot; male palpal segments 4 and 5 strongly plumose. 34

34(33). First or median costal spot of wing involving veins Sc and/or C only; basal pale bands of abdominal terga broad or at least 0.25 of segment length. 35
First or median costal spot of wing involving veins C, Sc, R_1, Rs and sometimes also M and Cu, basal pale bands of abdominal terga narrow, usually less than 0.25 of segment length. 39

35(34). Furcation of vein M proximad of furcation of vein R_{2+3}. . *mimuloides*
Furcation of vein M at same level of furcation of R_{2+3}. 36

36(35). Veins R_{4+5} and Cu_1 largely pale scaled from near base almost to tip. . . . . *diengensis*
Veins R_{4+5} entirely dark scaled or with pale streak restricted to the middle; Cu_1 with short median pale streak. 37

37(36). Third or apical costal pale spot of wing involving apical portion of vein R_1 only; median costal pale spot largely involving vein Sc. . . . . *tsengi*
Third or apical costal pale spot of wing involving apical portions of veins C, R_1 and sometimes also R_2; median costal spot involving veins C and Sc. 38

38(37). Mesonotal scales predominantly brownish; midtibia with longitudinal pale stripe on anterior surface; male proboscis with distinct ventral tuft of several long hairs. . . . . *jacksoni*
Mesonotal scales predominantly pale; midtibia without longitudinal pale stripe on anterior surface; male proboscis with or without indistinct ventral tuft of a few long hairs.
mimeticus and *fasyi* (inseparable, use male genitalia)

39(34). Wing veins Cu, Cu_2 and 1A each with a row of pale scale spots (Fig. 66). . . . . *propinquus*
Wing veins Cu, Cu_2 and 1A each with continuous pale scale line or streak. 40

40(39). First median costal spot usually involving veins C, Sc, R_1 and R_S, sometimes extending to M and Cu. . . . . *mimulus*, in part
First median costal spot involving veins C, Sc and R_1 only.
murrelli and *mimulus*, in part, (inseparable, use larva)

MALE GENITALIA[1]

1. Inner division of lateral plate of phallosome without spiculation on apical sternal portion; subapical lobe more or less clearly divided into proximal and distal divisions (*PIPIENS* GROUP). . . 2
Inner division of lateral plate of phallosome covered with numerous minute spicules and/or denticles on apical sternal portion; subapical lobe usually not clearly divided into proximal and distal divisions (*SITIENS* GROUP). 7

PIPIENS GROUP

2(1). Basal sternal process of proctiger absent or very poorly developed. . . . . *quinquefasciatus*
Basal sternal process of proctiger present, in form of a long and thick rod, curved sternad. 3

3(2). Setae *d-f* of subapical lobe situated on a distinct mesal lobe on sternal surface; apical 0.25 of distimere strongly curved and distinctly annulate or serrated dorsally. 4
Setae *d-f* of subapical lobe not situated on a distinct mesal lobe; apical 0.25 of distimere gently curved and not annulate or serrate dorsally. 5

4(3). Inner division of phallosome simple, represented by a broad heart-shaped leaf projecting laterad; tergal arm of outer division tapered into a sharp point. . . . . *univittatus*
Inner division of phallosome composed of several strong toothlike processes laterally; tergal arm of outer division uniformly thick, with truncate apex. . . . . *fuscocephala*

5(3). Inner division of phallosome straight or slightly divergent laterad, with 2, 3 teeth on apical lateral margin; lateral spine of outer division weak and short (Fig. 9). . . . . *theileri*
Inner division of phallosome sharply bent or angled, without teeth on apical lateral margin; lateral spine of outer division strong and long (Figs. 4, 7). 6

6(5). Outer division of phallosome with a broad rounded lateral basal process; inner division sharply angled; tergal arm of outer division distally tapered in a sharp point. . . . . *hutchinsoni*
Outer division of phallosome with a slender lateral basal process; inner division strongly curved, but not angled; tergal arm of outer division swollen subapically. . . . . *vagans*

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[1] *propinquus* unknown.

SITIENS GROUP

7(1). Inner division of lateral plate of phallosome represented by a large, simple forcepslike process; outer division not developed. *sinensis*
Inner division of lateral plate of phallosome complex, outer division well developed. 8

8(7). Inner division of phallosome represented by a short, slender, spinose fingerlike process; outer division simple, broad and rounded on outer margin. . . . . *gelidus*
Inner division of phallosome represented by a broad, elongate, finely spiculose or toothed process; outer division with distinct teeth or spines or represented by a strong toothlike or leaflike spine. 9

9(8). Inner division of phallosome with 2-6 strong fingerlike processes or teeth forming a prominent crown on apical tergal and lateral surface. 18
Inner division of phallosome without a prominent apical tergal crown of fingerlike processes or teeth as above, but with a lobe bearing 2-4 foliform processes or elongate toothlike spines below apical margin or apical tergal angle. 10

10(9). Basal sternal process of proctiger well developed, about 0.1 mm. or more in length; outer division of phallosome in form of a broad lobe, bearing a strong mesal spine. 11
Basal sternal process of proctiger poorly developed or absent, if present, its length varying between 0.01-0.08 mm; outer division of phallosome in form of a broad simple leaflike spine or simple toothlike spine. 12

11(10). Leaf *g* of distal division of subapical lobe broad, foliate; inner division of phallosome with a tergal lobe bearing 1-2 narrow, elongate spines. . . . . *epidesmus*
Leaf *g* of distal division of subapical lobe narrow, lanceolate; inner division of phallosome with a tergal lobe bearing 2-3 broad foliform spines. . . . . *cornutus*

12(11). Basal sternal process of proctiger absent; outer division of phallosome represented by a strong toothlike spine. . *annulirostris*
Basal sternal process of proctiger usually present, its length varying from 0.01-0.08 mm; outer division of phallosome represented by a broad leaflike spine. 13

13(12). Apical sternal portion of inner division of phallosome (in lateral view) very long and narrow, somewhat fingerlike. . . . *longicornis*
Apical sternal portion of inner division of phallosome quadrate or in form of a stout beak. 14

14(13). Apical sternal angle of inner division produced into a long, curved beak sternad, apical tergal angle blunt or slightly produced. . . 15

Apical sternal and tergal angles of inner division more or less equally produced into a short beak. 16

15(14). Apical margin of sternal portion of inner division smoothly curved; apical tergal angle usually blunt or rounded and without any denticles. . . . . *bitaeniorhynchus*
Apical margin of sternal portion of inner division depressed proximally; apical tergal angle moderately or strongly produced and usually with some denticles. . . . . *infula*

16(13). Foliform processes of inner division situated close to apical tergal angle. . . . . *selangorensis*
Foliform processes of inner division situated far below apical tergal angle. 17

17(16). Apical sternal portion of inner division very stout and smoothly curved on apical margin, apical sternal angle (or process) longer than apical tergal angle. . . . . *luzonensis*
Apical sternal portion of inner division slender and lightly depressed on apical margin, apical sternal angle (or process) about as long as apical tergal angle. . . . . *pseudosinensis*

18(9). Basimere enlarged, sacklike; distimere modified. 19
Basimere normal, slender, conical, distimere normal or typically sickle-shaped. 20

19(18). Subapical lobe with several strong specialized setae in distal division; distimere as in Fig. 80. . . . . *orientalis*
Subapical lobe with 6 narrow and short bladelike and rodlike setae in distal division; distimere as in Fig. 69. . . . . *diengensis*

20(18). Inner division of phallosome (in lateral view) broadly expanded to form a distinct lobe sternad. 21
Inner division of phallosome not expanded sternad to form a distinct lobe. 23

21(20). Basal sternal process of proctiger absent; sternal expanded portion of inner division of phallosome with distinct denticles distally. . . . . *alis*
Basal sternal process of proctiger present; sternal expanded portion of inner division of phallosome without distinct denticles. 22

22(21). Basal sternal process of proctiger slender and short; outer division of phallosome represented by a large, simple, broad leaflike spine. . . . . *whitmorei*
Basal sternal process of proctiger strong, thick and long; outer division of phallosome represented by a rounded lobe bearing 2-3 strong heavy spines on mesal and sternal surfaces. . . *sitiens*

23(20). Outer division of phallosome with 6-8 strong and dark teeth and several weak denticles on lateral and mesal surfaces. . . . *whitei*

Outer division of phallosome with only 1-3 strong teeth on lateral and mesal surfaces. 24

24(23). Outer division of phallosome without sternal spine; apical tergal crown of inner division with 2-3 short fingerlike processes. *kinabaluensis*
Outer division of phallosome with distinct sternal spine; apical tergal crown of inner division with 4-6 short or long fingerlike processes. 25

25(24). Sternal spine of outer division of phallosome long, prominent and gently divergent laterad. 26
Sternal spine of outer division of phallosome short, indistinct or strong, distinct and strongly curved basad. 29

26(24). Basal sternal process of proctiger slender, pale, at most 0.05 mm in length or completely absent. 27
Basal sternal process of proctiger thick, dark, usually 0.08-0.10 mm in length. . . . . *edwardsi*

27(26). Basal sternal process of proctiger not developed or absent. . *jacksoni*
Basal sternal process of proctiger present, at least 0.03 mm in length. 28

28(27). Basal sternal process of proctiger about 0.05 mm; apical fingerlike processes of inner division of phallosome slender and relatively long. . . . . *mimeticus*
Basal sternal process of proctiger shorter, about 0.03 mm in length; apical fingerlike processes of inner division of phallosome thicker and shorter. . . . . *fasyi* and *tsengi*

29(25). Basal sternal process of proctiger absent or poorly developed. *philippinensis*
Basal sternal process of proctiger present or well developed. . . . 30

30(29). Basal sternal process of proctiger slender and pale; leaf *g* of subapical lobe narrow, bladelike. . . . . *mimuloides*
Basal sternal process of proctiger thick and dark; leaf *g* of subapical lobe, broad, foliate. 31

31(30). Fingerlike processes of apical tergal crown of inner division of phallosome largely porrect or with apices directed dorsad. . . 32
Fingerlike processes of apical tergal crown of inner division of phallosome all divergent laterad. . . . . *barraudi*

32(31). Setae *d-f* of subapical lobe all flattened, bladelike, subequal in length and size. 33
Setae *d-f* of subapical lobe more or less differentiated in length and size. 34

33(32). Subapical claw of distimere short, distally broad and bilobed, length about 0.006 mm. . . . . *mimulus*
Subapical claw of distimere long, slender and simple, length about 0.01 mm. . . . . *murrelli*

34(32). Apical tergal crown of inner division of phallosome with strong and long fingerlike processes; apical sternal portion of inner division irregular, denticulated and not distally expanded to form a prominent triangular lobe (tergal view). 35
Apical tergal crown of inner division of phallosome with weak and short fingerlike processes; apical sternal portion of inner division simple and distally expanded to form a prominent triangular lobe (tergal view). . . . . *tritaeniorhynchus*

35(34). Distal division of subapical lobe with 4 setae in group *d-f*; outer division of phallosome with a large, rounded and prominent lateral basal process. . . . . *geminus*
Distal division of subapical lobe usually with 3 setae in group *d-f*; outer division of phallosome with a small, slender or elongate, knoblike lateral basal process. 36

36(35). Lateral basal process of outer division of phallosome short and relatively broad. 37
Lateral basal process of outer division of phallosome elongate and more slender than above. 38

37(36). Fingerlike processes of inner division of phallosome very strong and relatively long.
vishnui and *incognitus* (inseparable, use larva and pupa)
Fingerlike processes of inner division of phallosome moderately strong and relatively short (separation tenuous, use larva and pupa). . . . . *perplexus*

38(36). Sternal surface of subapical lobe with numerous minute setae forming a distinct patch. . . . . *pseudovishnui*
Sternal surface of subapical lobe with fewer minute setae forming an indistinct patch. . . . . *alienus*

PUPAE[1]

1. Seta 1-II multiple, strongly dendritic or with more than 10 branches; trumpet usually pale yellowish; paddle entirely pale to almost transparent. (*PIPIENS* GROUP). 2
Seta 1-II single, forked or with less than 10 branches, if more, then trumpet dark brownish or paddle with conspicuous darkened areas (*SITIENS* GROUP). 7

PIPIENS GROUP

2(1). Seta 8-C double or triple; setae 6-III-V double or triple. 3
Seta 8-C 4-6 branched; setae 6-III-V 4-6 branched. 5

3(2). Seta 1-C double; seta 6-VI double or triple; small species, abdomen 2.2 mm. . . . . *hutchinsoni*
Seta 1-C 3-4 branched; seta 6-VI 4, 5 branched; medium species, abdomen about 3.0 mm. 4

[1] *epidesmus*, *propinquus* and *longicornis* unknown; *orientalis*, not included.

4(3). Pinna of trumpet distinctly widened and strongly oblique; seta 5-IV usually double. . . . . *quinquefasciatus*
Pinna of trumpet not distinctly widened and lightly oblique; seta 5-IV usually triple. . . . . *vagans*

5(4). Small species, abdomen 2.5-2.7 mm; seta 5-IV 4-6 branched. . . 6
Large species, abdomen 3.5 mm or more; seta 5-IV triple. . *theileri*

6(5). Setae 5-V, VI double. . . . . *fuscocephala*
Setae 5-V, VI usually triple. . . . . *univittatus*

SITIENS GROUP

7(1). Trumpet asymmetrically funnel-shaped; pinna strongly widened or flared towards apex. 8
Trumpet cylindrical-shaped; pinna same diameter as meatus or slightly widened towards apex. 17

8(7). Trumpet whitish or lightly darkened on meatus; cephalothorax and abdomen very pale whitish; seta 1-III 8-11 branched. 9
Trumpet yellowish brown to dark brown; cephalothorax and abdomen strongly yellowish to dark brown or with pattern of dark alveolar spots, if entirely pale then seta 1-III 2-5 branched. 10

9(8). Seta 8-C 3,4 branched; seta 9-VII 5 branched; 9-VIII 7-9 branched. *sinensis*
Seta 8-C double; seta 9-VII double or triple; 9-VIII 5 branched. *cornutus*

10(8). Abdominal segments III-VIII entirely pale; paddle entirely pale without darkened or infuscated areas; seta 1-III 2-5 branched. *kinabaluensis*
Abdominal segments III-VIII strongly yellow or dark brown or with pattern of dark alveolar spots; paddle usually with darkened or infuscated areas; seta 1-III 8-13 branched. 11

11(10). Seta 10-C and setae 3-I-III usually single. . . . . *bitaeniorhynchus*
Seta 10-C and setae 3-I-III double. 12

12(11). Abdominal segments pale yellow with pattern of dark alveolar spots. 13
Abdominal segments strongly yellowish or entirely dark brown without pattern of dark alveolar spots. 14

13(12). Inner part of paddle darkened; basal external margin of outer part not darkened or infuscate. . . . . *selangorensis*
Inner part of paddle pale or transparent; basal external margin of outer part darkened or infuscate. . . . . *infula*, in part

14(12). Seta 1-V 4-8 branched; 4-VII 3,4 branched. 15
Seta 1-V double or triple; 4-VII usually double. 16

15(14). Outer and inner parts of paddle entirely pale or transparent. *pseudosinensis*
Outer and inner parts of paddle slightly dark tinged. . . . . *geminus*

16(14). Cephalothorax and abdomen entirely dark brown or yellowish with darkened areas or spots on posterior abdominal segments; paddle usually with infuscate areas; seta 5-IV 3-5 branched. *infula*, in part
Cephalothorax and abdomen uniformly yellowish, without darkened areas or spots on posterior abdominal segments; paddle always entirely pale or transparent; seta 5-IV usually double. . *luzonensis*

17(7). Seta 8-C double or triple. 18
Seta 8-C 4-6 branched. 31

18(17). Seta 1-II 20 branched; paddle with dark spot on apex of midrib. *gelidus*
Seta 1-II 1-10 branched; paddle without dark spot on apex of midrib. 19

19(18). Setae 6-V, VI usually single or double. 20
Setae 6-V, VI 3, 4 branched. 24

20(19). Trumpet relatively short, index about 5; apical margin of pinna blunt or angulate. 21
Trumpet relatively longer, index usually more than 6; apical margin of pinna truncate or lightly emarginate. 22

21(20). Pinna of trumpet strongly oblique; setae 1-III, IV 4-6 branched. *sitiens*
Pinna of trumpet weakly oblique; setae 1-III, IV double or triple. . *alis*

22(20). Seta 5-IV usually 4 branched; 1-II 4-9 branched. . . . . *whitei*
Seta 5-IV double or triple; 1-II single or double. 23

23(22). Seta 1-III 2-4 branched; 1-IV 3, 4 branched. . . *mimeticus* and *fasyi*
Seta 1-III 5-8 branched; 1-IV 4-6 branched. . . . *jacksoni* and *tsengi*

24(19). Seta 5-IV 7-8 branched; 5-V 3-5 branched. . . . . *perplexus*
Seta 5-IV 2-5 branched; 5-V double. 25

25(24). Seta 5-VI single. . . . . *diengensis*
Seta 5-VI double. 26

26(25). Seta 1-C double; seta 1-II double. . . . . *mimuloides*
Seta 1-C 3, 4 branched; seta 1-II 4-7 branched. 27

27(26). Seta 1-VI triple; 1-VII double or triple. 28
Seta 1-VI 4, 5 branched; 1-VII 4 branched. 29

28(27). Color of cephalothorax and abdomen more or less uniformly yellowish white; seta 1-III 9, 10 branched; 1-IV 7-9 branched. *mimulus*, in part

Color of cephalothorax and abdomen with darkened areas; setae 1-III, IV 5, 6 branched. . . . . *murrelli*

29(27). Setae 4, 5-VII single; 4-VIII usually single. . . . . *philippinensis*
Setae 4, 5-VII double; 4-VIII double. 30

30(29). Seta 8-C triple; 5-C usually 4 branched. . . . . *alienus*
Seta 8-C double; 5-C usually triple. . . . . *vishnui*

31(17). Setae 5-V, VI 6-8 branched, their length much shorter than segments following. . . . . *whitmorei*
Setae 5-V, VI double, their length as long as or longer than segments following. 32

32(31). Setae 6-IV-VI double or triple. 33
Setae 6-IV-VI 4-7 branched. 34

33(32). Trumpet pale yellowish and relatively slender and long, index about 12; seta 1-II 2-4 branched. . . . . *mimulus*, in part
Trumpet brownish and relatively thick and short, index about 8; seta 1-II 4-10 branched. . . . . *barraudi* and *edwardsi*

34(32). Trumpet long and thin, index 10-15. . . . . *incognitus*
Trumpet shorter and thicker, index 6-8. 35

35(34). Seta 9-C 3, 4 branched; 1-C 4 branched; medium or large species, abdomen 3.0-3.5 mm. . . . . *annulirostris*
Seta 9-C double; 1-C usually triple; small species, abdomen less than 3.0 mm. 36

36(35). Trumpet dark brown; seta 1-II usually more than 10 branched. *tritaeniorhynchus*
Trumpet pale yellowish; seta 1-II less than 10 branched. *pseudovishnui*

LARVAE[1]

1. Labrum or preclypeus of head capsule present as a distinct transverse bar separated from frontoclypeus. 2
Labrum or preclypeus of head capsule not developed as distinct bar separated from frontoclypeus. 9

2(1). Seta 1-C pale, slender and distally strongly tapered or filamentous. 3
Seta 1-C dark, stout, spiniform or foliform and abruptly pointed or blunt apically. 5

[1] *epidesmus*, *longicornis*, *diengensis* and *propinquus* unknown; *orientalis* not included.

PIPIENS GROUP

3(2). Setae 5, 6-C double; mental plate with 6, 7 lateral teeth on each side of median tooth; siphon slender more or less cylindrical and distally tapered. . . . . *fuscocephala*
Setae 5, 6-C 4-6 branched; mental plate with 10-12 lateral teeth on each side of median tooth; siphon thick, fusiform and distinctly swollen in middle. 4

4(3). Setae 2, 3-A placed apically or nearly so; siphon short, index about 3, basal 0.5 strongly swollen. . . . . *quinquefasciatus*
Setae 2, 3-A distinctly subapical; siphon longer, index about 5, basal 0.5 slightly swollen. . . . . *vagans*

5(2). Siphon short, fusiform, strongly swollen in middle and with a strong subapical spine on dorsal surface; setae 1-M and T remarkably strong. . . . . *hutchinsoni*
Siphon usually long, cylindrical and tapered distally, if short and swollen as above, then without subapical spine on dorsal surface; setae 1-M and -T short and weak. 6

6(5). Seta 7-I double. 7
Seta 7-I single. 16

7(6). Comb scales pointed apically and with a strongly differentiated apical spine. . . . . *theileri*
Comb scales rounded apically and with even fringe of fine spicules. 8

8(7). Seta 6-VI single; pecten teeth of siphon with 3 lateral denticles; siphon pale whitish. . . . . *univittatus*
Seta 6-VI double; pecten teeth of siphon with 8-9 lateral denticles; siphon yellowish to brownish. 26

SITIENS GROUP

9(1). Setae 2, 3-A located half way between apex and base of seta 1-A, seta 4-P short and minute, rather indistinct. 10
Setae 2, 3-A apical, subapical or closer to apex than to base of seta 1-A; seta 4-P strong and distinct. 11

10(9). Siphon with 5 pairs of subventral tufts. . . . . *sinensis*
Siphon with 4 pairs of subventral tufts. . . . . *cornutus*

11(9). Mental plate with 5-7 large, distinct lateral teeth on each side of a large median tooth. 12
Mental plate without distinct lateral and median teeth; all teeth minute and not differentiated as above. 13

12(11). Setae 1-3-P double; setae 6-I, II 5-7 branched; 7-I double. *kinabaluensis*
Setae 1-3-P single; setae 6-I, II triple; 7-I single. . . . . *geminus*

13(11). Comb scales small, 6-12 in number, their length 0.05-0.08 mm; siphon with distinct row of 7-10 pecten teeth. *pseudosinensis* and *selangorensis*
Comb scales large, usually 4, 5 in number, their length over 0.1 mm; siphon with or without distinct row of 3-5 pecten teeth. .14

14(13). Siphon usually with 4 pairs (or total 8) of subventral tufts. *bitaeniorhynchus*
Siphon with 3 pairs (or total 6) of subventral tufts. 15

15(14). Antennal shaft practically bare or with a small number of very weak spicules in basal half. . . . . *luzonensis*
Antennal shaft distinctly barbed with several strong spicules in basal half. . . . . *infula*

16(6). Siphon short, fusiform, middle part distinctly swollen, index 3-4. . . . . *gelidus*
Siphon longer, more or less cylindrical; index at least 5. . . . 17

17(16). Seta 4-P double or multiple. 18
Seta 4-P single. 29

18(17). Seta 1-C markedly flattened, or somewhat foliform, with blunt apex; anal gills short, stubby and rounded, about 0.2 of saddle length. 19
Seta 1-C slender or spiniform, with acuminate apex; anal gills long, tubular, as long as or longer than saddle length. 20

19(18). Saddle complete; setae 2, 3-A distinctly subapical; setae 4 and 8-P strong, as long as 1-3-P. . . . . *sitiens*
Saddle incomplete; 2, 3-A apical or almost so; setae 4 and 8-P weak, much shorter than 1-3-P. . . . . *alis*

20(18). Comb with 4-8 large spiniform scales in single row, seta 4-P double or multiple. 21
Comb with 16-20 or more smaller scales in 3, 4 rows, seta 4-P always double. 22

21(20). Siphon strongly tapered and upcurved distally; siphonal tufts very strong, 2-3 branched each, 4, 5 times as long as siphonal width at point of attachment; 4-P always double. . . . . *whitmorei*
Siphon lightly or moderately tapered, straight or slightly curved in apical 0.25; siphonal tufts weaker, 4-6 branched each, as long as or slightly longer than siphonal width at point of attachment; 4-P double or multiple. . . . . *pseudovishnui*

22(20). Seta 5-C 4-6 branched; 6-C triple. . . . . *mimuloides*
Seta 5-C usually double or triple; 6-C double. 23

23(22). Pleural areas of thorax spiculate; proximal pairs of siphonal tufts closely spaced, all in line on ventral surface. . . . . *vishnui*
Pleural areas of thorax not spiculate; proximal pairs of siphonal tufts more or less widely spaced, in a double row subventrally. . . 24

24(23). Siphon strongly tapered distally, 2, 3 proximal pairs of siphonal tufts 3-5 times as long as siphonal width at point of attachment, rest gradually shorter. 25
Siphon more or less uniform in width along entire length or lightly tapered distally; all siphonal tufts shorter, subequal, shorter or slightly longer than siphon width at point of attachment. *perplexus*

25(24). Comb scales 13-20 in number, median apical spine of scales strongly differentiated from lateral fringe of spicules. . . *alienus*
Comb scales 30-40 in number, median apical spine of scales poorly differentiated from lateral fringe of spicules. *philippinensis*

26(8). Siphon thick and relatively short, index 3-5; siphonal tufts very strong, 6-12 branched each and closely spaced. *annulirostris*
Siphon slender and relatively longer, index 7-11; siphonal tufts weak, 2-4 branched each and widely spaced. 27

27(26). Seta 6-C double; siphon brownish, slender, length usually 1.4-1.6 mm; ventral valve of spiracular apparatus small, dark brown. . . . . *tritaeniorhynchus*
Seta 6-C triple; siphon yellowish, thick, length 1.6-2.4 mm; ventral valve of spiracular apparatus large, blackish. 28

28(27). Setae 1-III-V single and strong, as long as setae 6-III-V, siphonal tufts rather inconspicuous. . . . . *whitei*
Setae 1-III-V 2-4 branched and considerably shorter than setae 6-III-V; siphonal tufts distinct. . . . *barraudi* and *edwardsi*

29(17). Comb with a mixture of large, spinelike and small, normal scales. . . . . *incognitus*
Comb with a single type of scale, all small. 30

30(29). Siphon with some prominent spines on ventral surface in apical half. 31
Siphon without any spines as above. 32

31(30). Setae 6-I, II usually 4, 5 branched; siphonal tufts weak, all subequal, shorter or as long as siphonal width at point of attachment. . . . . *jacksoni*
Setae 6-I, II triple; 2, 3 proximal pairs of siphonal tufts strongest, 2-3 times as long as siphonal width at point of attachment, rest gradually shorter. . . . . *tsengi*

32(30). Comb scales with strong median apical spine; 4 proximal pairs of siphonal tufts very strong, closely spaced, 2, 3 times as long as siphonal width at point of attachment, forming a prominent row. . . . . *mimeticus* and *fasyi*
Comb scales normal or with poorly developed median apical spines; all siphonal tufts weak, subequal, widely spaced, shorter or as long as siphonal width at point at attachment, not forming a prominent row as above. 33

33(32). Siphon long and thin; index 9-14; comb scales with pointed apical fringes. . . . . *mimulus*
Siphon short and relatively thick; index 6, 7; comb scales with rounded apical fringes. . . . . *murrelli*

PIPIENS GROUP

FEMALE. As described for the subgenus, with the following distinctive group characters. *Head.* Proboscis entirely dark scaled, median portion sometimes pale ventrally but not extended dorsad to form a distinct pale ring. *Cibarial Armature.* As described for the subgenus. *Thorax.* Mesonotal integument pale brown to dark brown, mesonotal scales pale beige, yellowish, golden to dark brown, more or less uniform in color on anterior 0.7 of mesonotum and on areas laterad of prescutellar space; scales on prescutellar space and scutellar lobe largely pale whitish. Pleuron with distinct pale scale patches on *ppl*, upper corner and posterior border of *stp* and upper part of *mep*, sometimes also on *psp* and base of *pra*; 1, 2 lower *mep* bristles present. *Legs.* Tarsomeres 1-5 of all legs entirely dark, or without distinct apical and basal pale bands. *Wing.* All scales narrow and entirely dark except for a short pale scale line on posterior surface of base of vein C. *Abdomen.* Terga II-VII usually with complete basal pale band, sometimes without such band or completely dark. *Genitalia.* As described for the subgenus.

MALE. Generally as described for female except for the following characters. *Head.* Palpal segment 3 usually entirely dark scaled, sometimes slightly pale at middle on dorsal surface, ventral surface with 1, 2 rows of short, fine hairlike setae along the whole length, apical 0.25-0.50 usually with ventrolateral tuft of several strong bristles; segments 4 and 5 strongly plumose, entirely dark on dorsal surface, ventral surface with scattered pale scales which may form a distinct line or streak at base. Proboscis usually pale at middle ventrally, but not forming a complete light ring; median ventral hair tuft proximad of false joint usually absent, sometimes present.

MALE GENITALIA. In general as described for the subgenus with the following distinctive group characters. *Basimere.* Slender, conical and without special modification. *Subapical lobe.* Proximal and distal divisions more or less clearly divided, bases of setae *a-c* in proximal division not overlapped with those of setae *d-f* in distal division; setae *d-f* 2-4 in number, sometimes placed on a distinct lobe on sternal surface; leaflet *g* present, variously developed. *Distimere.* Normal, typically sickle-shaped; 1, 2 ventral tiny setae present, dorsal one absent. *Phallosome.* Inner division of lateral plate simple, not spiculate, represented by a single, narrow or broad pointed divergent ventral arm, sometimes straight, with 3-4 strong lateral spical spines or teeth; outer division with a strong and long mesal tergal arm, 1 lateral and 1 sternal spine, latter poorly or well developed, usually divergent laterad; lateral basal process knoblike, poorly or well developed, apex pointed or rounded. *Proctiger.* Apical crown dark and large, composed of numerous coarse and fine spicules; basal sternal process poorly or well developed.

PUPA. Cephalothorax and abdomen pale whitish or light yellowish with darkened areas not forming definite pattern. *Trumpet.* Varied in length; meatus usually more or less cylindrical, sometimes slightly widened distally; pinna lightly or strongly oblique. *Cephalothorax.* Seta 8-C 3-6 branched; 9-C double or triple. *Metanotum.* Seta 10-C 4-10 branched; 11-C double. *Abdomen.* Seta 1-II multiple or between 10-20 branched; 1-III 5-10 branched; 1-IV 5-8 branched; 1-V 4-7 branched; 1-VI 4-6 branched; 1-VII 4, 5 branched; 5-IV

2-6 branched; 5-V, VI double or triple; 6-III 2-6 branched; 6-IV 2-4 branched; 6-V 2-5 branched; 6-VI 2-5 branched; 9-VII 3, 4 branched; 9-VIII 6-8 branched; 4-VIII double. *Paddle.* Broad, inner and outer parts pale whitish; midrib pale or lightly pigmented.

LARVA. *Head.* Labrum or preclypeus developed as a distinct transverse bar separated from frontoclypeus; ocular bulge prominent; seta 1-C fine, filiform or stout spiniform; 4-C usually long, about 2 times as long as distance between bases of the pair, single or double; 14-C very small indistinct. Antenna shorter or as long as head; setae 2, 3-A apical or subapical. Mental plate with 6-12 lateral teeth on each side of median tooth. *Thorax.* Spiculation absent; setae 1-3-P strong, subequal in length and single; 4-P varied, 2-5 branched; 7-P double or triple. *Abdomen.* Seta 7-I single or double; 6-I, II usually triple; comb scales small, numerous, forming a broad oval patch, usually with rounded apical fringe of fine spicules, sometimes pointed, with a strongly differentiated median apical spine. Saddle complete; seta 1-X 1-3 branched, 2-X 2-4 branched; 4-X (ventral brush) usually with 6 pairs of setae, sometimes 7; anal gill slender, usually 1-2 times as long as saddle length. *Siphon.* Varied in shape and length; index 3-7; pecten very well developed; siphonal hair tufts 4-6 pairs in number, length, branches and position varied; seta 2-S slender and short.

DISCUSSION. The Oriental members of the *Pipiens* Group all show better group characters in the adults and the male genitalia than in the pupae and larvae. Adults of both sexes in the *Pipiens* Group can be readily separated from the members of the *Sitiens* Group by: (1) presence of 1 or 2 lower mesepimeral bristles; (2) absence of distinct pale ring in the middle of proboscis and (3) absence of basal or apical pale bands at the joints of tarsomeres 1-4 of all legs. The males in the *Pipiens* Group are distinguished by (1) absence of basal and/or apical pale bands on dorsal surface of palpal segments 4 and 5; (2) ventral surface of palpal segment 3 with rows of short and fine hairlike setae and (3) absence of median or submedian ventral tuft of long hairs proximad of false joint of proboscis (except *fuscocephala*). The male genitalia in the *Pipiens* Group are very similar to those in the *Sitiens* Group in the basimere, distimere and proctiger, but are strongly differentiated from the latter in the following features: (1) absence of minute spiculation in the inner division (ventral arm) of the phallosome, (2) presence of a strong and long tergal arm on mesal surface of the outer division and (3) subapical lobe more or less clearly divided into proximal and distal divisions. The pupae of the *Pipiens* Group largely overlap with those in the *Sitiens* Group, especially in respect to the chaetotaxy. The only pupal character which appears to be more or less diagnostic of the *Pipiens* Group is the branching of abdominal seta 1-II which is multiple or composed of more than 10 branches as indicated in the key. The larvae of the *Pipiens* Group also exhibit considerable overlap with those in the *Sitiens* Group. Except for specific and subgroup characters, there is apparently no single feature or a combination of characters of the larvae in the *Pipiens* Group to clearly separate them from those in the *Sitiens* Group. The similarity in the immature stages of the *Pipiens* and *Sitiens* Groups is an indication of their close affinity and probable monophyletic origin.

The *Pipiens* Group contains several species which are largely restricted to the Ethiopian region but is represented by a small number of species in other parts of the world. Within the Oriental and eastern Palearctic regions, the group consists of 8 taxa: *pipiens pallens* Coquillett 1898, *quinquefasciatus* Say 1823 (or *fatigans* Wiedemann 1828 of authors), *huangae* Meng 1958, *hutchinsoni* Barraud 1924, *fuscocephala* Theobald 1907, *theileri* Theobald 1903, *univittatus*

Theobald 1901 and *vagans* Wiedemann 1828. It is also possible that *pipiens molestus* Forskal 1775 may have been introduced into Japan (Y. Wada, personal communication). The taxonomy and the relationships of the *pipiens* forms in Japan have not yet been sufficiently investigated. From the previous reports in the literature (LaCasse and Yamaguti 1950, Bekku 1956), it appears most likely that the typical or true *pipiens* does not occur in Japan. In this study, only 6 Oriental taxa in the *Pipiens* Group are treated. *Culex pipiens pallens* is excluded because the specimens from Japan, Korea and northern China, which I have examined are inadequate, consisting only of adults and whole larvae. On the other hand, this *pipiens* taxon has never been found to extend into Southeast Asia and other parts of the Oriental region and is most probably restricted to the cold temperate climate similar to that of the typical *pipiens* of northern Europe in the western Palearctic. *Culex huangae* Meng is also omitted because the type and topotypic specimens are not available for study.

Edwards (1932), in an attempt to develop a scheme of interspecific classification, placed *quinquefasciatus* (as *fatigans*), *vagans*, *theileri* and *univittatus* in the *pipiens* series and *fuscocephala* and *hutchinsoni* in a group of uncertain affinity. Subsequently, only a few attempts have been made to classify species in the *pipiens* series of Edwards. Mattingly and Rageau (1958) placed *vagans* in their *trifilatus* subgroup. Mattingly et al. (1951) and Mattingly (1957, 1967), in the discussions on the systematics of *pipiens*, recognized a *pipiens* complex to include *quinquefasciatus* Say (or *fatigans* Wiedemann) and *australicus* Dobrotworsky and Drummond as subspecies of *pipiens;* and *molestus* Forskal, *pallens* Coquillett and *comitatus* Dyar and Knab as forms of *pipiens* sensu lato. Since there has not been a consensus as to the subspecific or specific status of these forms, it seems more practical here to categorize the *pipiens* complex as a subgroup of the *Pipiens* Group and to include within it certain nominal taxa which are treated as full species, such as *globocoxitus* Dobrotworsky 1953 from Australia.

In this study, I recognize 4 subgroups for the 6 Oriental species treated. Two of these subgroups, *pipiens* or *pipiens* complex of Mattingly (1957, 1967) and Belkin (1962) and *trifilatus* of Mattingly and Rageau (1958), are retained. The subgroups *theileri* and *univittatus* are proposed for the first time to include certain Oriental taxa which I believe represent distinct lineages. These 6 species are segregated into the 4 subgroups as follows: (1) *Pipiens* Subgroup with *quinquefasciatus;* (2) *Trifilatus* Subgroup with *vagans* and *hutchinsoni*; (3) *Theileri* Subgroup with *theileri* and (4) *Univittatus* Subgroup with *fuscocephala* and *univittatus*. The only other Oriental species, *huangae* from China, appears to belong to the *Trifilatus* Subgroup on the basis of the description and figure of the male genitalia by Meng (1958).

PIPIENS SUBGROUP

The *Pipiens* Subgroup is characterized in the male genitalia by (1) setae in group *d-f* of distal division of the subapical lobe 3 in number, placed between setae *a-c* of proximal division and leaf *g* of distal division; (2) inner division of phallosome represented by a simple, broad or narrow leaflike ventral arm which is divergent laterally; (3) outer division with a short, inconspicuous lateral spine and (4) basal sternal process of the proctiger rudimentary or poorly developed.

The *Pipiens* Subgroup includes the typical *pipiens* and other nominal intraspecific forms (*molestus, pallens, comitatus,* etc.) from the temperate region, *quinquefasciatus* from the tropics and subtropics of the world,

australicus from Australia (Dobrotworsky 1965) and the South Pacific (Belkin 1962) and *globocoxitus* from Australia (Dobrotworsky 1965). In Southeast Asia and adjacent areas, the *Pipiens* Subgroup is represented only by *quinquefasciatus* which I am treating as a full species in spite of the fact that some authors consider it as subspecies of *pipiens*. My conclusion on the taxonomic status of this form is based largely on the constant differences in the male phallosome and palpus, behavioral and ecological attributes and characteristic distribution. As pointed out by Mattingly (1967), a more thorough review of the morphology of the various forms in the *pipiens* complex based on all stages is still critically needed. For an extensive review of the *pipiens* complex, see Mattingly et al. (1951) and Mattingly (1957, 1967).

The members of the *Pipiens* Subgroup show closer affinity to those in the *Trifilatus* Subgroup than to other subgroups. Belkin (1968), in discussing the New Zealand fauna in comparison with those in Australia and the South Pacific, pointed out that the *Pipiens* (complex) and *Trifilatus* Subgroup are not really distinct morphologically and zoogeographically. Although this seems to suggest that the members of the 2 subgroups probably belong to a single natural lineage, I believe it would be clearer, on the basis of the differences in the male phallosome and other features of the genitalia, to distinguish the *Pipiens* Subgroup from the *Trifilatus* Subgroup.

1. *CULEX (CULEX) QUINQUEFASCIATUS* SAY
(Figs. 1, 2, 3, 14)

Culex quinquefasciatus Say 1823: 10 (adult).
Culex fatigans Wiedemann 1828: 10 (♀); Edwards 1913a: 55 (♂*, taxonomy); Edwards 1921: 345 (♂, ♀, L, Keys); Barraud 1924b: 1264 (♂*, ♀); Barraud 1924c: 430 (L*); Barraud and Covell 1928: 671-9 (♀ cibarial armature*); Borel 1930: 339 (♂*, ♀, L*); Stone 1956 (1957): 342 (Synonymy).
Culex cingulatus Doleschall 1856: 405 (adults; preoccupied by Fabricius 1805).
Culex doleschalli Giles 1900: 338 (new name for *C. cingulatus* Doleschall); Barraud 1934: 420 (synonymy with *C. fatigans*).
Culex albolineatus Giles 1901: 609 (♀); Barraud 1924b: 1264 (synonymy with *C. fatigans*).
Culex quasipipiens Theobald 1901b: 136 (♀*); Edwards 1913a: 55 (synonymy with *C. fatigans*).
Culex fouchowensis Theobald 1901b: 137 (♂*, ♀*); Edwards 1913a: 55 (synonymy with *C. fatigans*).
Culex reesi Theobald 1901b: 145 (♂*, ♀*); Edwards 1913a: 55 (synonymy with *C. fatigans*).
Culex sericeus Theobald 1901b: 147 (♀*); Edwards 1913a: 55 (synonymy with *C. fatigans*).
Culex christophersi Theobald 1907: 453 (♂, ♀); Edwards 1913a: 55 (synonymy with *C. fatigans*).
Culex minor Theobald 1908: 298 (♂, ♀); Barraud 1924b: 1264 (synonymy with *C. fatigans*).
Culex hensemaeon Dyar 1920: 178 (♀); Edwards 1932: 208 (synonymy with *C. fatigans*).
For complete synonymy, see Stone, Knight and Starcke (1959).
Culex (Culex) fatigans Wiedemann, Edwards 1932: 208 (taxonomy); Barraud 1934: 420 (♂*, ♀, L*).

Culex (Culex) quinquefasciatus Say, Bohart 1945: 79 (♂, L); LaCasse and Yamaguti 1950: 220 (♂*, ♀*, L*); Belkin 1962: 195 (♂*, ♀, P*, L*); Stone 1963; 135 (catalog supplement); Delfinado 1966: 148 (♂*, ♀, P, L); Baisas 1974: (♂, ♀*, P, L*).

Culex (Culex) pipiens quinquefasciatus Say, Stone, Knight and Starcke 1959: 254 (catalog); Bram 1967a: 192 (♂*, ♀*, P*, L*).

FEMALE (Fig. 1, 14). Wing: 2.5-4.3 mm (average 3.5 mm). Forefemur: 1.1-2.0 mm (average 1.6 mm). Proboscis: 1.3-2.2 mm (average 1.8 mm). Abdomen: 1.9-3.2 mm (average 2.5 mm). Usually medium sized species. *Head.* Narrow decumbent scales on vertex pale, yellow or beige; erect scales usually dark brown, sometimes pale, yellow or golden in center, dark on posterolateral area; lateral patch of broad appressed scales whitish. Palpus 0.2-0.25 of proboscis length, entirely dark scaled or sometimes with some pale scales on apex of segment 4. Proboscis entirely dark scaled on dorsal surface, ventral surface dark or sometimes pale from base to middle. Antennal pedicel with a minute patch of semi-erect scales on inner dorsal surface; flagellomere 1 with or without a few scales on inner surface, flagellar whorl very weakly plumose, with 5-6 dark bristles. *Cibarial Armature.* Cibarial bar concave with slight projection at middle; cibarial teeth short, abruptly pointed and subequal, about 30 in number. *Thorax.* Mesonotal integument brown; mesonotal scales narrow, predominantly yellowish to brownish; scales on prescutellar space and caudal margin of scutellar lobes pale whitish; acrostichals, dorsocentrals and supraalar bristles dark and strong; midscutellar lobe with 7 bristles; lateral scutellar lobe with 4-5 bristles. Pronotum same color as mesonotum; *apn* with several narrow scales and short setae; *ppn* with 4 strong posterior bristles and 3-4 short setae cephalad, upper surface with patch of several narrow scales. Pleuron slightly paler or same color as mesonotum, without distinct pattern of dark bands or stripes; *ppl* with 4-5 bristles and a small pale scale patch at base; *stp* with 2 moderately broad, pale scale patches on upper corner and lower posterior border; *mep* with similar scale patch at level of upper corner of *stp* and several pale scales among upper *mep* bristles; lower *mep* bristle strong and dark, usually 1, sometimes 2. *Legs.* Anterior surface of forecoxa with broad scale patch and several moderately strong setae, scales on upper surface pale, rest dark; mid- and hindcoxae with narrow anterior scale patches; anterior surfaces of fore- and midfemora with narrow pale bands at bases and entirely dark scaled distally; anterior surface of hindfemur with a distinct pale stripe from base to near apex; all tibiae and tarsi entirely dark on anterior and dorsal surfaces, pale on ventral surfaces; all pretarsal claws small and simple. *Wing.* All scales dark and very dense on all veins; scales on veins R_2, R_3 and R_{4+5} narrow, linear and elongate; length of cell R_2 1.5-2.0 of vein R_{2+3}; remigial bristles short and dark, 4-5 in number. *Halter.* Peduncle pale, without scales; capitellum cup-shaped, covered with several pale beige scales. *Abdomen.* Tergum I with dark median scale patch; terga II-VII with evenly broad or slightly medianly produced basal pale bands; basolateral pale spots present, distinct, apparently not connected with basal transverse bands dorsad; sterna predominantly pale yellowish or sometimes with dark scaled areas in middle and apicolateral margin. *Genitalia.* Tergum IX with lateral row of 10-12 setae; cerci short, apically blunt, with several strong setae restricted to lateral tergal surface; postgenital plate broad, with rounded caudal margin, apical half with a lateral row of 5-6 bristles; vaginal sclerite dark, well sclerotized, U-shaped; insula with a dense tuft of about 10 strong setae.

MALE (Fig. 1). In general similar to female except for sexual characters. *Head.* Palpus variable in length, exceeding proboscis by 0.5-1.0 of segment 5; segment 3 dark scaled on dorsal surface, with ventrolateral rows of 4-12 strong bristles in apical 0.25-0.30; segments 4 and 5 upturned, moderately to strongly long plumose, dorsal surface dark scaled, ventral surface of segment 4 with white scale line from base to 0.75 of total length, ventral surface of segment 5 with white scale patch restricted to base. Proboscis with submedian false joint distad of mid point of labium, scales on ventral surface usually pale in middle; median ventral tuft of long hairs proximad of false joint absent. *Legs.* Pretarsal claws of fore- and midlegs enlarged, unequal, each with subbasal denticle; claws of hindleg small, equal and simple.

MALE GENITALIA (Fig. 2). *Segment VIII.* Tergum VIII shallowly emarginate at middle, lateral caudal margin with several strong bristles. *Segment IX.* Tergum IX with broadly rounded tergal lobe, bearing 1 or 2 irregular rows of 10-12 strong setae, sometimes with 6-9 setae; sternum IX broad, roughly rectangular, without scales or setae. *Basimere.* Slender, conical, 0.28-0.34 mm in length, strong bristles largely confined to lateral tergal surface; inner tergal surface with 3-4 rows of subequal setae from near base to level of subapical lobe. *Subapical lobe.* Clearly divided into proximal and distal divisions; setae *a-c* of proximal division stout, rodlike and with hooked apices; distal division with a strong, flattened seta and 2 narrower and shorter setae in group *d-f*, all clearly separated from bases of setae *a-c* in proximal division; leaf *g* broad with acuminate or blunt apex; seta *h* strong, flattened and long. *Distimere.* Normal, sickle-shaped; dorsal subapical surface without crest of spicules or serration; 2 tiny ventral setae present slightly beyond midpoint of curvature; dorsal seta absent; subapical claw (or spiniform) short. *Phallosome (Aedeagus).* Outer division with a strong and long mesal, tergal arm which tapers into a point apically, tergal arms on both lateral plates nearly parallel, lateral spine very short, inconspicuous; sternal spine moderately strong, distinct, strongly divergent laterad; inner division simple, represented by a broad leaflike ventral arm which is strongly divergent laterad; DV/D ratio usually 1 (0.7-1.0). *Proctiger.* Apical crown large, dark, with several flat, apically blunt spicules laterally and numerous pointed spinelike spicules mesally; paraproct broad with some small tubercles below crown; basal sternal process very short, unpigmented, about 0.03 mm in length, sometimes absent or not developed; cercal sclerite narrow; cercal setae 2-3 in number; basolateral sclerotization very well developed.

PUPA (Fig. 2). Abdomen: 2.5-3.3 mm. Paddle: 0.7-0.9 mm. Trumpet: 0.52-0.78 mm. Pigmentation generally cream-colored or pale yellowish. *Trumpet.* Darker than underlying integument, relatively short, narrowest at base, broader towards apex, pinna long and strongly oblique, apical margin truncate or lightly emarginate. *Cephalothorax.* Seta 1-C usually triple (2-4); 2-C 3,4 branched; 3-C double or triple; 4-C 3,4 branched; 5-C usually 4,5 branched, 6-C double or triple; 7-C double; 8-C usually triple (2-3); 9-C double. *Metanotum.* Brown in middle, pale towards lateral margin; seta 10-C 9-10 branched; 11-C double; 12-C usually triple (2-4). *Abdomen.* Segments I-IV darkened in middle, pale towards lateral margin, other segments pale; setae 6-I, II single; 7-I, II double; 1-II multiple, or usually more than 10 branched (8-16); 3-I-III double; 1-III, IV usually 6 branched (5-7); 1-V-VII usually 4,5 branched (3-5); 5-IV usually double (2-5); 5-V, VI usually double (1-3); 6-III-VI usually double (2-4); 9-VII 3-6 branched, 9-VIII 4-8 branched, pectinate, slightly longer than 9-VII; 4-VIII double. *Paddle.* Broad and pale, without distinct color pattern, external buttress moderately strong and distinct; distal margin

indistinct; midrib lightly darkened; setae 1, 2-P present, minute, subequal and single.

LARVA (Fig. 3). Head: 0.76-0.90 mm. Siphon: 1.2-1.7 mm; index 3-5. Saddle: 0.4 mm; siphon/saddle ratio 3-4. *Head.* Rather large and more or less rounded; labrum (or preclypeus) narrow; seta 1-C pale, filiform; 4-C single, strong, about 2 times as long as distance between bases of the pair; 5, 6-C strong, subequal and usually 4, 5 branched (3-6); 7-C large, fan-shaped, usually 9, 10 branched (8-12). Antenna short and straight, about 0.5 of length of head; middle part of shaft not distinctly curved outwards; pigmentation varying from pale to darker than head capsule; seta 1-A 22 branched, situated slightly beyond 0.5 of antennal shaft; 2, 3-A weak and pale, situated almost at apex; 4, 6-C weak and rather short. Mental plate with 10-12 lateral teeth on each side of median tooth. *Thorax.* Seta 4-P double; 7-P usually double (1-2); 8-P usually double, sometimes single; 1-M single, about 0.75 of 3-M; 3-M single; 4-M double; 8-M 5, 6 branched; 9-M 4, 5 branched; 1-T short, about 0.5 of 2-T; 7-T 6, 7 branched; 9-T 6 branched; 12-T single; 13-T 4, 5 branched (3-6). *Abdomen.* Setae 1-I, II as conspicuous as seta 5-I; 1-I 4, 5 branched; 1-I 4, 5 branched; 1-II double or triple; 6-I, II usually triple (3-4); 7-I double; 1-III-VI single or double, rather strong, about 0.75 of length of setae 6-III-VI; 6-III-VI all double; 13-III-V weak, about 0.5 of 1-III-V, usually triple (2-3); seta 1-VII usually 4 branched (3-4); 4, 7, 10 and 12-VII all single; 13-VII 3, 4 branched. Seta 1-VIII usually 4, 5 branched (4-6); 2-VIII single; 3-VIII usually 6, 7 branched (5-7); 4-VIII single; 5-VIII usually 4 branched (3-4); comb scales short, small, numerous, 30-44, all with rounded and even fringe of fine spicules apically and laterally. Posterior dorsal margin of saddle weakly spiculated; seta 1-X usually single (1-2) and strong; 2-X usually double (2-4); anal gills slender, 1.0-1.5 times as long as saddle. *Siphon.* Relatively short and stout, fusiform, middle portion distinctly swollen, distal portion tapered; pecten with 5-10 fine teeth of increasing length in basal 0.4 of siphon, 2-3 most distal teeth with 3 basal denticles and 1 elongate apical denticle; siphonal tufts strong, widely spaced, usually 4 pairs, sometimes 3; first 2 proximal pairs strongest, usually 4, 5 branched (2-7), situated subventrally, 3rd pair weaker and shorter, dorsolateral, usually double or triple (1-3); 4th pair as long as 3rd pair, subapical and subventral in position, usually 4, 5 branched (3-5); median caudal filament of spiracular apparatus poorly developed.

TYPE-DATA. (1) *Culex quinquefasciatus* Say, Type (lost), type-locality restricted to vicinity of New Orleans, *Louisiana,* USA by Belkin, Schick and Heinemann (1966: 4); (2) *Culex fatigans* Wiedemann, Lectotype ♀, East Indies (INDONESIA), collection Winthem (NMW; selection of Belkin 1968: 68); (3) *Culex cingulatus* Doleschall, Type non-existent, Ambarawa, *Java,* INDONESIA (LU); (4) *Culex albolineatus* Giles, Lectotype ♀*, Shahjahanpur, *(United Provinces),* INDIA (BM; present selection); (5) *Culex quasipipiens* Theobald, Lectotype ♀*, Sambalpur, *(Central Provinces)* INDIA (BM; selection of Bram 1967b: 327); (6) *Culex fouchowensis* Theobald, Lectotype ♂*, Foochow, *Fukien,* CHINA (BM; selection of Bram 1967a: 196); (7) *Culex reesi* Theobald, Type non-existent, HONG KONG (BM); (8) *Culex sericeus* Theobald, Type (lost), HONG KONG (LU); (9) *Culex christophersi* Theobald, Lectotype ♂*, INDIA (BM; selection of Bram 1967b: 327); (10) *Culex minor* Theobald, Types ♂ and ♀, Sylhet and Lungleh, Lushai Hills, *Assam* and Calcutta, *Bengal,* INDIA (IM); (11) *Culex hensemaeon* Dyar, Holotype ♀*, Los Banos, Laguna, *Luzon,* PHILIPPINES (USNM).

DISTRIBUTION. Widespread throughout the tropics and subtropics of the world. Material examined. 4,065 specimens: 1,463♂, 1,911♀, 698 L; 740 individual rearings (86 pupal, 654 larval).

INDIA. *Assam:* Dooma Dooma; Pupsi; Jorhat; Chabua; Dibrugarh; Sookerating; *Bengal:* Calcutta, Dum Dum, N. Salt Lake, Botanical garden, Sukna, Darjeeling Dist.; *Bihar:* Purnea; 138♂, 180♀, 29 L, 8 p, 12 lp.

BANGLADESH. Sylhet; 15♂, 26♀, 7 L, 2 p, 26 lp.

SRI LANKA. *Central Province:* Nuwara, Eliya District; Kande-ela Reservoir; Peradeniya, Kandy District; 2♂, 6♀, 7 lp.

BURMA. Rangoon; Myo Kwet Thit; 2♂, 10♀, 1 L, 4 lp.

THAILAND. Chiang Mai; Nan; Lampang; Tak; Udon Thani; Nakhon Sawan; Nakhon Ratchasima; Ang Thong; Ayutthaya; Bangkok; Thon Buri; Phet Buri; Chon Buri; Trat; Prachuap Khiri Khan; Surat Thani; etc.; 139♂, 88♀, 401 L, 22 p, 35 lp.

VIETNAM. Saigon; Nha Trang; Phu Tho; Dalat; Soc Trang; Phu Bei; Gia Dinh; Khanh Hae; Pleiku; Can-Tho; 45♂, 95♀, 15 L, 19 lp.

CAMBODIA. Phnom Penh; 9♂, 55♀.

LAOS. Vientiane; 1♀.

MALAYSIA. *Peninsular Malaysia: Selangor:* Kuala Lumpur; Ulu Gombak; Segambut; Sea Port Estate; Brinchang; Petaling; Sg. Bertek Klang; Rantau Panjang; *Trengganu:* Kuala Brang; Dungun; Kemaman; *Pahang:* Kg. Lamir; Pdg. Tungku K. Lipis; Sungai Temau; C. Highlands Road; Kg. Sungai Ular; Kuala Pahang; *Perak:* Lahat; Tg. Rambutan; Chiore F. R.; *Perlis:* Golf Course; *Kelantan:* Tumpat; Gua Musang; *Malaysia: Sabah:* Kota Kinabalu (Jesselton); Simpangan; Sandakan; Ling Kabau; Papar; Luhan, Ranau; Kudat; Tagasan; Tawau; Pulau Gaya; Tuaran; Mt. Kinabalu; Kuala Penyu; Labuk Sugai; Lahad Datu; Pulau Labuan; 272♂, 367♀, 44 L, 37 p, 140 lp.

SINGAPORE. Pulau Hantu; Pulau Blakang Mati; 13♂, 11♀, 14 L, 14 lp.

INDONESIA. *Kalimantan:* Tarakan; *Sumatra:* Bengkulu; *Java:* Djakarta; Pelabuhan Ratu; Bogor; Bandung; Sindanglaja; Solo; 87♂, 79♀.

PHILIPPINES. *Luzon:* Manila; Los Banos; Subic Naval Base; Rizal, Alabang; Bagiou Benguet; Bagiuo; Camp Stotsenberg; Camp Nichols; Camp Eldridge; San Fernando; Pangasinan; Dalton; N. Vizcaya; San Fabian; Camansi; San Juan; Bacnotan; La Union, Balaoan; Bitabag; Carlatan; Naguilian; Agoo, La Union; Laguna; Saragosa; Camarines; *Mindoro:* Caminawit; San Jose; *Samar:* Osmena; *Palawan:* Iwahig; *Panay:* Illoilo; *Leyte:* Tacloban; Jinamoc; Dulag; *Sanga Sanga Is.:* Lapit Lapit; *Jolo; Mindanao:* Zamboanga; Pettit Barrack; Cotabato; *Corregidor Is.:* Fort Mill; 482♂, 558♀, 143 L, 7 p, 189 lp.

TAIWAN. *Taipei:* Chung Ho; Chung Yuan; *Taichung:* Shalu; Wuchi; Tunghai, Lungtan; *Pingtung:* Kao-Hsiung; Shin Lin; Nan Tou; Tai Tung; *Orchid Is.; Miaoli, San-I;* 61♂, 202♀, 2 L, 10 p, 202 lp.

CHINA. Yunnan, Kunming (Cazier, 1945); Hunan, Achian; Hainan, Canton; Chekiang; Shanghai; Soochow; Tientsin; Sha-Sze (Yngtseze River); 81♂, 117♀, 8 L

JAPAN. *Ryukyus:* Okinawa; Iwo Jima; Iriomote; Ie Shima; 117♂, 116♀, 34 L, 6 lp.

TAXONOMIC DISCUSSION. The nomenclature and the taxonomic status of this tropical *pipiens* form remain hightly controversial. It has been referred to either as *quinquefasciatus* Say or *fatigans* Wiedemann in numerous taxonomic and other studies without a universal consensus as to which name is the proper one. Stone 1956 (1957) suggested that the name *"quinquefasciatus"* instead of *"fatigans"* must be applied in accordance with the rules of priority if both names are considered as synonyms. Since it has been widely or generally accepted that the 2 names are apparent synonyms as discussed by Stone, I am, therefore, using the name *"quinquefasciatus"* for this form. As indicated in the discussion of the *Pipiens* Subgroup, I am also recognizing it as a species

in spite of the arguments and discussions in favor of the single polytypic species concept of *pipiens* and of the contention that *quinquefasciatus* should be treated as subspecies as proposed by Mattingly (1957, 1967) and others. Although *quinquefasciatus* and other *pipiens* forms (e.g. *molestus*, *pallens*) are to a various degree capable of crossing in the laboratory, they obviously maintain themselves as distinct entities in nature even where they come into contact. In the present circumstance, it seems most practical to consider *quinquefasciatus* as a species instead of a subspecies of *pipiens*.

Culex quinquefasciatus can be separated from typical *pipiens* and other *pipiens* forms (including *molestus* and *pallens*) from northern Europe (England, France, Sweden), Egypt, China, Japan and Korea in the male genitalia by (1) tergal arms of outer divisions of phallosome parallel or subparallel and distally strongly tapered into a point (divergent and uniformly thick, with truncate or lightly swollen apex in other *pipiens* forms); (2) ventral arm of inner division of phallosome very large and broad (relatively smaller, shorter and narrower in other *pipiens* forms except *pallens*) and (3) DV/D ratio (Fig. 2) usually more than 0.7 (less than 0.7 in other *pipiens* forms). The *quinquefasciatus* males also differ from other *pipiens* forms in having a shorter palpus, presence of fewer and weaker ventral lateral bristles in apical 0.25-0.30 of palpal segment 3 and in having fewer and weaker bristles in palpal segments 4 and 5. Among the *pipiens* forms, *quinquefasciatus* is apparently more similar to *pallens* from Japan and China in the phallosome morphology than to typical *pipiens* from Europe or *molestus* from Egypt and Mediterranean areas.

The Southeast Asian populations of *quinquefasciatus* are, as elsewhere in the tropics, very large and extremely variable in all stages. It is possible that there may be some local differentiation into various forms among allopatric and sympatric populations of *quinquefasciatus*. In Thailand, Peninsular Malaysia and the Philippines, I have seen several males which are extremely small with the wing length reduced to about 2.0 mm. These minute males also exhibit a great reduction in the number and length of bristles on palpal segments 3, 4 and 5 but show no obvious differences from normal males in the genitalia or other associated stages. It seems most probable that these variations are environmentally induced, probably due to shortage of water and increased temperature in the breeding sites, resembling the situation frequently encountered in laboratory colonies (P. F. Mattingly, personal communication).

BIONOMICS. *Culex quinquefasciatus* is the most common domestic species, occurring abundantly in houses and in practically all types of human and animal shelters in urban communities throughout Southeast Asia. It is found breeding in any type of habitat which contains water ranging from fresh and clear to brackish, turbid and polluted with decayed organic matter from garbage and human wastes accumulated in ground pools, ditches, drains, sewages, dumping areas, latrines, septic tanks and in various kinds of artificial containers. In urban situations, the larvae and pupae of *quinquefasciatus* are extremely dense and have frequently been collected in great numbers from foul or strongly polluted stagnant pools, drains, ditches, pits and sewage. The immatures have also been frequently collected from the multitude of artifical containers, such as bottles, cans, flower pots, vases, bowls, jars, cement tanks, etc., inside or outside the houses. In general, *quinquefasciatus* is uncommon in small containers, but common in large ones. The adults are fairly abundant throughout the year and are commonly found resting during the day in shade, on walls, dark corner spots, in cabinets, wardrobes, bathrooms, under tables and chairs inside houses. The females are vicious biters at night indoors or outdoors and feed principally on blood of man from sunset until dawn. They also frequently

attack birds such as fowls and, to a lesser extent, other domestic animals, including dogs, cats and pigs. Various aspects on the bionomics of the adults and immatures of *quinquefasciatus* (or *fatigans* of several authors) have been intensively investigated by de Meillon and coworkers at the World Health Organization (WHO) Filariasis Research Unit (FRU) in Rangoon, Burma and by several other WHO regional officers in various parts of Southeast Asia. For more extensive and detailed information on the bionomics, consult Horsfall (1955), de Meillon et al. (1967), de Meillon, Grab and Sebastian (1967), de Meillon and Sebastian (1967a, 1967b), de Meillon, Sebastian and Khan (1966, 1967a, 1967b, 1967c, 1967d), Lindquist et al. (1967) and Kurihara and Sasa (1965).

MEDICAL IMPORTANCE. *Culex quinquefasciatus* is one of the most serious pests of man in the tropics and has been incriminated as the principal vector of nocturnal periodic bancroftian filariasis in various parts of the Oriental region. In Southeast Asia, it has been reported to be naturally and experimentally infected with this pathogen in Bangladesh (Aslamkhan and Wolfe 1972), Burma, Singapore, Vietnam, Malaysia, Indonesia, the Philippines, Hong Kong and Taiwan but has never been found to be a vector in Thailand (Ramalingam et al. 1968). In some parts of Southeast Asia, it has also been reported to be a host of certain arboviruses, most notably Chikungunya and Japanese encephalitis but there is apparently no conclusive evidence to indicate that it plays a role in the natural transmission of these diseases. This may in part be due to the fact that it rarely bites reservoir animals such as pigs infected with Japanese encephalitis virus. In Thailand, Rudnick and Hamon (1961) and Robin et al. (1963) isolated several strains of Chikungunya from *quinquefasciatus* but later study combined with epidemiological observations by Halstead, Scanlon et al. (1969) suggested that it is not an important vector of this disease. Laboratory transmission studies of Japanese encephalitis reported by Hodes (1946) and Reeves and Hamon (1946) indicate that it is less efficient than *gelidus* (D. J. Gould, personnal communication). Although Nguyen et al. (1974) isolated 3 strains of Japanese encephalitis from wild caught adults in Vietnam, it is believed that *quinquefasciatus* is not important in the transmission of Japanese encephalitis in this country. Subsequent studies have shown that *quinquefasciatus* is a relatively inefficient vector of Japanese encephalitis virus.

TRIFILATUS SUBGROUP

The *Trifilatus* Subgroup is characterized by the following combination of male genitalia characters: (1) setae in group *d-f* of distal division of subapical lobe 3, 4 in number, placed between setae *a-c* of proximal division and leaf *g* of distal division; (2) distimere without distinct serration or annulation on subapical dorsal surface; (3) ventral arm of inner division of phallosome relatively narrow, simple, diverging laterad; (4) outer division with a long lateral spine; (5) tergal arm of outer division usually with subapical swelling or twisted apex and (6) basal sternal process of proctiger well developed.

Mattingly and Rageau (1958: 241-50) in recognizing the *Trifilatus* Subgroup, placed the following 8 species within this subgroup: *trifilatus* Edwards 1914 and *tamsi* Edwards 1934 from the Ethiopian region; *torrentium* Martini 1925 from the western Palearctic; *vagans* Wiedemann 1828 from the eastern Palearctic; *pervigilans* Bergroth 1889, *pacificus* Edwards 1916 and *iyengari* Mattingly and Rageau 1958 from the South Pacific and *miraculosus* Bonne-Wepster 1937 from New Guinea. It also includes 2 other species: *rotoruae* Belkin 1968 and *asteliae* Belkin 1968 from New Zealand, considered by Belkin

(1968) as members of the *pervigilans* complex. In addition, I consider *hutchinsoni* Barraud 1924 from the Oriental region as another member of this subgroup, making a total of 11 species for the entire subgroup.

The distribution of the *Trifilatus* Subgroup is widely disjunct, over a very large area, covering the western and eastern Palearctic, Ethiopian, Oriental and Australasian regions and the South Pacific (including New Zealand). In the Ethiopian where several other related lineages are represented, this subgroup is still poorly known and it is possible that more members may be discovered when the fauna is thoroughly examined.

2. *CULEX (CULEX) VAGANS* WIEDEMANN
(Figs. 4, 5, 14)

Culex vagans Wiedemann 1828: 545 (♂, ♀); Edwards: 1922b: 473 (♀); Ho 1931: 162 (♂*, ♀).

Culex tipuliformis Theobald 1901b: 325 (♀*); Barraud 1924b: 1269 (♂*, ♀); Barraud 1924c: 430 (L*); Edwards 1932: 211 (synonymy).

Culex virgatipes Edwards 1914b: 126 (♂, ♀); Edwards 1921: 341 (distribution); Barraud 1924b: 1269 (synonymy with *C. tipuliformis*).

Culex exilis Dyar 1924: 127 (♂); Edwards 1932: 211 (synonymy): Monchadskii 1951: 260 (distribution).

Culex (Culex) vagans Wiedemann, Edwards 1932: 211 (taxonomy); Barraud 1934: 416 (♂*, ♀, L*); Feng 1938: 303 (biology, distribution); LaCasse and Yamaguti 1950: 216 (♂*, ♀*, P*, L*); Monchadskii 1951: 283 (distribution); Hsieh and Liao 1956: 123 (distribution); Hara 1957: 55 (♀ genitalia*); Chu 1958: 110 (distribution).

FEMALE (Fig. 14). Wing: 4.3-5.0 mm (average 4.6 mm). Forefemur: 1.6-2.3 mm (average 2.0 mm). Proboscis: 1.8-2.5 mm (average 2.3 mm). Abdomen: 2.9-3.2 mm (average 3.0 mm). Medium or large sized species; generally as described for the *Pipiens* Group, with the following distinctive features. *Head.* Erect scales on vertex pale yellowish in center and towards anterior dorsal eye margin, dark brown posterolaterally and towards occiput; narrow decumbent scales pale, forming a distinct ocular line; lateral patch of broad scale whitish, very distinct. Palpus entirely dark scaled or with a row of pale scales on inner dorsal surface of segment 4. *Cibarial Armature.* Essentially similar to *quinquefasciatus*. *Thorax.* Mesonotal scales very narrow and fine, predominantly yellowish brown or golden, pale whitish on anterior promontory and on lateral margin; scales on prescutellar space and scutellar lobes whitish. Pleural integument without pattern of dark and pale stripes; *ppl* with a small pale scale patch at base and 10 setae; *stp* with 2 distinct pale scale patches, one of which is on the upper corner, the other on lower posterior border; *mep* with distinct pale scale patch at same level as upper corner of *stp* and several pale scales among mep bristle; 1 lower *mep* bristle present. *Legs.* Anterior surface of forefemur with a distinct, narrow, linear white stripe from base to apex along anterior margin; anterior surface of midfemur with a distinct narrow white stripe along whole length in middle; anterior surface of hindfemur largely pale in basal half, continuous as a narrow stripe in apical half; all tibiae with a distinct longitudinal white line on anterior surface; tarsomeres 1-5 of fore- and midlegs entirely dark; tarsomere 1 of hindleg with a distinct longitudinal white line on anterior surface, rest dark. *Abdomen.* Tergum II with a median basal pale streak, not extended laterad to form a complete band; terga

III-VII with broad, transverse basal pale bands; tergite VIII largely yellowish. *Genitalia.* Essentially as described for *quinquefasciatus.*

MALE. In general similar to female. *Head.* Palpus long, exceeding proboscis by a little more than the length of segment 5; segment 3 largely dark scaled on dorsal surface, with or without some pale scales on lateral surface beyond middle; apical half of segment 3 with ventrolateral rows of about 36 dark bristles; segments 4 and 5 strongly long plumose and upturned; dorsal surface with narrow basal pale bands; ventral surface of segment 4 with a distinct white scale line; ventral surface of segment 5 with scattered pale scales in basal 0.3-0.4. Proboscis without median ventral tuft of long hairs; ventral surface slightly pale in middle.

MALE GENITALIA (Fig. 4). *Segment IX.* Tergum narrow, with broadly rounded tergal lobe which bears 2 irregular rows of 8-10 weak setae. *Basimere.* Slender, roughly conical, about 2.8 mm in length. *Subapical lobe.* Proximal and distal divisions clearly divided; setae *a-b* of proximal division, stout, subequal; seta *c* thinner, all with hooked apices; setae *d-f* of distal division 3 in number, placed clearly distad of setae *a-c*; leaf *g* broad, foliate, with rounded apex; seta *h* strong and long. *Distimere.* Normal, sickle-shaped; ventral surface with 1, 2 tiny setae beyond middle; dorsal surface without any seta; claw slender and moderately long; subapical dorsal surface without distinct serration. *Phallosome.* Outer division of lateral plate with a strong lateral spine, divergent laterad; tergal arm long, with twisted or slightly swollen apex; sternal spine not developed or inconspicuous; lateral basal process small and slender; inner division with a slender, smoothly curved ventral arm. *Proctiger.* Basal sternal process well developed, moderately long, curved sternad; paraproct narrow; cercal sclerite well sclerotized; cercal setae 3-4 in number; basal lateral sclerotization well developed.

PUPA (Fig. 4). Abdomen: 3.0 mm. Paddle: 0.85 mm. Trumpet: 0.65 mm; Index 5. Chaetotaxy as figured, very similar to *quinquefasciatus,* differing particularly in the following. *Trumpet.* Relatively longer and more or less cylindrical along the whole length; pinna slightly oblique. *Metanotum.* Seta 10-C 5-7 branched; 12-C 3-6 branched. *Abdomen.* Seta 1-II 10-14 branched; 1-III usually 8 branched (7-10); 5-IV usually triple (2-3); 6-III double or triple; 6-IV, V usually triple; 6-VI 4, 5 branched (3-5). *Paddle.* Seta 2-P stronger than 1-P, usually bifid (1-2).

LARVA (Fig. 5). Head: 0.9 mm. Siphon: 1.8 mm; index 5 or more. Saddle: 0.4 mm; siphon/saddle ratio 4.5. General characters and detailed chaetotaxy as figured, distinctive in the following features. *Head.* Labrum narrow; seta 1-C filiform or distally filamentous; 5, 6-C usually 5 branched (4-7); 7-C 8, 9 branched. Antenna about 0.7 of head length, pigmentation dark from base to apex; seta 1-A 20 or more branched, strongly pectinate; 2, 3-A subapical. Mental plate with 9, 10 lateral teeth on each side of median tooth. *Thorax.* Seta 4-P double; 7, 8-P double; seta 1-M nearly as long as 3-M, single; 2-M short, double or triple; 3-M single; 4-M double; 8-M 5-7 branched; 9-M 4, 5 branched; seta 1-T minute, usually triple (3-4); 2-T longer, double; 3-T usually 5 branched (4-5); 7-T 7-9 branched; 9-T 5, 6 branched; 12-T single; 13-T 5, 6 branched. *Abdomen.* Seta 1-I, II distinct, same length as 5-I, II; 1-14 branched; 1-II bifid; 6-I, II 3, 4 branched; 7-I double; 1-III-VI, strong, about 0.5 of 6-III-VI, all double; 6-III-VI double; 13-III-V nearly as strong as 1-III-V, all usually 4 branched (3-5). Seta 1-VIII usually 5 branched (5-7); 2, 4-VIII single; 3-VIII 7-9 branched; 5-VIII usually 4 branched (4-5); comb scales 34-37, all small, subequal in size and with even fringe of fine spicules apically and laterally. Seta 1-X of saddle strong, single, about 0.5 of saddle length; 2-X double;

anal gills 1.5-2 times as long as saddle.

TYPE-DATA. (1) *Culex vagans* Wiedemann, Types ♂, ♀, (Foochow, Barraud 1934), CHINA, Trentepohl, collection Winthem (NE); (2) *Culex tipuliformis* Theobald, Holotype ♀*, Bakloh, *N.W. Province*, [? PAKISTAN] (BM); (3) *Culex virgatipes* Edwards, Holotype ♂* with attached genitalia mount, HONG KONG (BM): (4) *Culex exilis* Dyar, Holotype ♂*, Vladivostok, [*Maritime Territory*], USSR (USNM).

DISTRIBUTION. Widespread in the northeastern Palearctic (China; USSR, Siberia; Korea and Japan) with extension into the south as far as India, south China, Hong Kong and Okinawa. Material examined. 129 specimens: 58♂, 49♀, 22 L; 20 individual rearings (1 pupal, 19 larval).

INDIA. W. Himalaya, Kasauli; Solon, Simla Hill; Punjab, Mahdapur; Assam, Ledo; 7♂, 4♀, 3 L, 1 p.

CHINA. Peking; Shanghai; Canton; Foochow; 10♂, 10♀, 7 L.

HONG KONG. 2♂, 2♀.

JAPAN. Nagasaki; Hokkaido; Yokohama; 5♂, 3♀, 5 L. *Ryukyus:* Okinawa, 1.5 mi. N.W. of Futeuma; Iriomote, Yabu Village; 11♂, 8♀, 19 lp.

KOREA. Seoul; Kimpo; Tong Jon; Saemal; Chorwan; Chail Li; T'Andong; 18♂, 12♀, 7 L.

USSR. Far East, South Primorje; Ussuri River; 5♂, 9♀. Siberia. Okeanskya; 1♀.

Additional records from the literature: INDIA: Kashmir; Delhi; USSR: Siberia; Vladivostok (Barraud 1934: 418; Monchadskii 1951: 211); PAKISTAN; BANGLADESH (Aslamkhan 1971).

TAXONOMIC DISCUSSION. *Culex vagans* is widespread and fairly common in Japan, Korea and China but is not known to extend its range into Southeast Asia south of Hong Kong. The adults of *vagans* are clearly marked by the presence of striking longitudinal pale stripes on femora and tibiae of fore- and midlegs and a similar stripe on the tibia of hindleg, resembling the features noted in *theileri* and *univittatus*. This conspicuous feature separates *vagans* from all other species in the *Trifilatus* Subgroup and most of the *Pipiens* Group. It can be readily distinguished from *theileri* and *univittatus* in the adults by the absence of scale patches on postspiracular area and at the base of prealar knob. The male genitalia of *vagans* are apparently identical to *miraculosus* Bonne-Wepster 1937 from New Guinea and *torrentium* Martini 1925 from England, which I have also examined for comparison.

The pupa and larva of *vagans* are very similar to *quinquefasciatus* in chaetotaxy and in several general characters. The pupa can be separated from the latter by (1) longer and more or less cylindrical trumpet; (2) weakly oblique pinna; (3) seta 6-VI usually 4, 5 branched and (4) seta 5-IV usually triple. The larva is distinguished from *quinquefasciatus* by (1) setae 2, 3-A subapical; (2) longer siphon; (3) middle portion of siphon lightly swollen and (4) presence of 4, 5 pairs of siphonal tufts.

Except for the variation in size, all adult specimens of *vagans* which I have seen from various parts of its range are similar and essentially conform to a single type. In the larvae, the only variation noted are in the length of the siphons which are shorter and thicker in specimens from India, but longer and more slender in material from the Ryukyus, Japan and Korea. It is probable that this variation is environmentally induced.

BIONOMICS. *Culex vagans* is a typical ground pool breeder and appears to be restricted to high elevations in hills or mountainous areas. The immatures of *vagans* were collected from various types of ground pools, including stream pools, marshes, lakes, ponds and pools in stream-beds or at the margin of

streams, which usually contain green algae (Barraud 1934; Hsiao 1946; Hsiao and Bohart 1946; LaCasse and Yamaguti 1950). In recent collections from Okinawa and Iriomote of the southern Ryukyus, all specimens of *vagans* were taken from unshaded stream pools in the hills. In Japan, it was reported to be collected at elevations of over 1,500 m and was found to be more common in the north than in the south (LaCasse and Yamaguti 1950). Little is known about the adult biology and medical importance of *vagans*. In Japan and Korea it was reported to enter houses and bite man at night (Hsiao and Bohart 1946; Barnett and Toshioka 1951). It was reported to be experimentally and naturally infected with *Wuchereria bancrofti* (Cobbold) (Bohart 1946, Manson-Bahr 1959, Hsiao 1948, Hsiao and Bohart 1946).

3. *CULEX (CULEX) HUTCHINSONI* BARRAUD
(Figs. 6, 7, 8, 14)

Culex hutchinsoni Barraud 1924b: 1261 (♂*, ♀).
Culex (Culex) hutchinsoni Barraud, Edwards 1932: 212 (taxonomy); Barraud 1934: 423 (♂*, ♀); Colless 1955: 316 (♂, ♀, L*); Bram 1967a: 188 (♂*, ♀*, P*, L*); Basio 1972: 205 (♂*, ♀*).

FEMALE (Fig. 6, 14). Wing 2.9-3.6 mm (average 3.2 mm). Forefemur: 1.4-1.7 mm (average 1.5 mm). Proboscis: 1.6-1.9 mm (average 1.7 mm). Abdomen: 2.3 mm. Relatively small species, general coloration reddish brown. *Head.* Narrow decumbent scale on vertex yellowish brown or golden, not forming distinct ocular line; all erect scales entirely dark brown or sometimes slightly pale towards apices; lateral patch of broad scales whitish, distinct. Palpus rather short, about 0.15 of proboscis length and entirely dark scaled; no scattered pale scales on apex of segment 4. Proboscis entirely dark scaled. *Cibarial Armature.* Cibarial bar with 30-34 very short and pointed teeth. *Thorax.* Mesonotal integument reddish brown; mesonotal scales narrow, fine, moderately dense and predominantly golden or yellowish brown except for lighter ones on anterior promontory, antealar and supraalar areas; scales on prescutellar space and scutellar lobes sparse and pale whitish. Pronotal integument dark brown; *apn* with narrow golden brown scales and bristles; *ppn* dark brown, with 5, 6 strong posterior bristles and 5, 6 tiny setae cephalad, upper surface with several scattered brown scales. Pleural integument usually with pattern of dark spots or bands on *ssp, psp,* base of prealar knob, lower posterior border of *stp,* upper and lower *mep,* other areas lighter, concolorous with mesonotal integument; scale patches present on *ppl,* upper corner and lower posterior border of *stp,* upper *mep* and a few scattered pale scales among upper *mep* bristles; 1 lower *mep* bristle present. *Legs.* Anterior surface of fore- and midfemora dark scaled; anterior surface of hindfemur with pale longitudinal stripe from base to near apex; all tibiae and tarsi entirely dark. *Wing.* Scales dark and dense on all veins; scales on veins R_2, R_3 and R_{4+5} narrow, linear and fine. *Abdomen.* Tergum I with median patch of dark scales; tergum II with median basal pale streak, not forming complete band; terga III-VII with narrow complete basal pale bands; tergum VIII largely pale yellowish; lateroterga II-VII with basolateral pale spots extending posteriorly as streak to the apical margins of segments; sterna largely yellowish. *Genitalia.* Tergum IX with a lateral row of 4-7 setae; postgenital plate rounded on caudal margin; vaginal sclerite poorly sclerotized, U-shaped; insula with a dense tuft of 10 setae.

MALE (Fig. 6). Generally similar to female. *Head.* Narrow decumbent scales on vertex paler, almost whitish. Palpus exceeding proboscis by full length of segment 5; middle portion of segment 3 slightly pale on lateral dorsal surface, but not forming distinct ring, apical 0.25 with ventrolateral tuft of 5-7 dark bristles; segments 4 and 5 slightly upturned, weakly to moderately plumose, dorsal surface dark scaled, ventral surface with pale scales more or less restricted to bases. Proboscis entirely dark scaled; median ventral tuft of long hairs absent.

MALE GENITALIA (Fig. 7). *Segment IX.* Tergum narrow; tergal lobe with 4-6 moderately long setae. *Basimere.* Small, slender, conical, about 0.25 mm in length. *Subapical lobe.* Setae *a-c* of proximal division slightly overlapped with setae *d-f* of distal division; setae *a-c* subequal in length and with hooked apices; setae *d-f* of distal division consist of 1 fine, hairlike seta and 3 rodlike setae, latter all hooked apically; leaf *g* broad with acuminate apex; seta h strong, long and apically hooked. *Distimere.* Normal; 2 tiny ventral setae present beyond the middle; claw small; subapical dorsal surface without crest of spicules. *Phallosome.* Very similar to *vagans;* differing as follows: tergal arm of outer division shorter and tapered into a point apically; sternal spine present in addition to lateral spine; lateral basal process strong and rounded; ventral arm of inner division strongly bent or angled laterad. *Proctiger.* Apical crown medium sized, consisting of numerous pointed spicules; basal sternal process of paraproct well developed, pigmented, curved sternad; cercal sclerite well sclerotized; cercal setae 2 in number.

PUPA (Fig. 7). Abdomen: 2.3 mm. Paddle: 0.6 mm. Trumpet: 0.52 mm; index 6-7. Complete chaetotaxy as figured; cephalothorax and abdomen pale, cream-colored or yellowish white. *Trumpet.* Slender, relatively long and uniformly cylindrical; pinna lightly oblique. *Cephalothorax.* Setae 1-and 3-C usually double (2-3); 4, 5-C subequally long, usually 4 branched (3-5); 8-C usually triple (2-5); 9-C double. *Abdomen.* Seta 1-II strongly dendritic, 20 or more branched; 1-III 5, 6 branched; 1-IV-VII 4, 5 branched; 5-IV usually triple (2-3); 5-V-VI double; 6-III-V usually double (1-3); 6-VI double or triple; 9-VII usually triple (2-3); 4-VIII double; 9-VIII usually 6, 7 branched (6-9). *Paddle.* Pale, or same color as preceding abdominal segment; midrib very lightly pigmented; external buttress distinct, distal outer margin indistinct; setae 1, 2-P minute, subequal; 1-P single or branched; 2-P single.

LARVA (Fig. 8). Head: 0.7 mm. Siphon: 0.78 mm; index 2-3. Saddle: 0.3 mm; siphon/saddle ratio about 2.5. Readily distinguished from all other members of the *Pipiens* Group by the short and stout siphon which bears a characteristic subapical spine on dorsal surface. *Head.* Seta 1-C brownish, spiniform; 4-C single and long, its apex reaching slightly beyond anterior margin of frontoclypeus; 5, 6-C usually triple (3-5); 7-C usually 8 branched (8-10). Antennal shaft entirely pale except for basal dark ring; spicules very fine; setae 2, 3-A slightly subapical. Mental plate with 10-12 lateral teeth on each side of median tooth. *Thorax.* Seta 3-P weak and short, about 0.5 of 1, 2-P; 4-P as long as 3-P, 4, 5 branched; 7-P usually double (2-3); 8-P double; seta 1-M very strong and as long as 3-M, 5-9 branched; 3-M single; 4-M double; 8-M 6, 7 branched; 9-M 5 branched; seta 1-T strong, as long as 2-T, usually 4 branched (4-5); 2-T double; 3-T usually 6 branched (5-8); 7-T 10-12 branched; 9-T 6, 7 branched; 12-T single; 13-T 6-8 branched. *Abdomen.* Setae 1-I, II strong, very conspicuous, 3-5 branched; 6-I, II triple; 7-I single; 6-III-VI single; 6-IV usually triple (3-4); 6-V usually 4 branched (3-4); 1-III-VI 4, 5 branched. Comb scales 32-35, in oval patch, all small, similar in size, with lateral and apical fringe of evenly fine spicules. Saddle with few spicules on

lateral posterior margin; seta 1-X single, as long as saddle; 2-X double; anal gills as long as or slightly longer than saddle. *Siphon.* Short and stout, resembling *quinquefasciatus* in shape, with characteristic dorsal subapical spine in apical 0.25; pecten teeth slender, 4-8 in number, distal teeth with 2 small basal denticles and a long tapering apical spine; siphonal tufts moderately strong, widely spaced; usually 4 pairs, sometimes 4.5 pairs; first proximal pair subventral, situated among pecten, 5-7 branched; 2nd proximal pair subventral, distad of pecten, 4-6 branched; 3rd distal pair lateral, 3-5 branched; 4th pair subventral, 2-4 branched; median caudal filament of spiracular apparatus poorly developed.

TYPE-DATA. Lectotype ♂*, Nongpoh, *Assam,* INDIA, larvae from roadside pools, July 1922, P. J. Barraud (BM; selection of Bram 1967a: 192).

DISTRIBUTION. Known only from India, Pakistan, Thailand, Cambodia, Vietnam, Peninsular Malaysia and Singapore. The Philippine record by Basio (1972) is doubtful. Material examined. 192 specimens: 62♂, 54♀, 76 L; 59 individual rearings (11 pupal, 48 larval).

INDIA. *Assam:* Nongpoh, Khasi Hills District; 1♂, 1♀ (type-series).

PAKISTAN. *Lahore:* 8♂, 2♀.

THAILAND. *Chiang Mai:* Chang Khien; Doi Sutep; San Sai; Ban San Khayom; 8♂, 7♀, 8 lp; *Lampang:* Ban Pang Pako; 11♂, 14♀, 6 L, 19 P, 6 lp; *Phrae:* Ampur Sa; 1♂, 1♀; *Udon Thani:* Ban Nong Bua; 1♂, 2♀, *Nakhon Ratchasima:* Pak Chong, Khao Yai; 2♂, 1♀; *Dhon Buri:* Ban Khun Non, Wat Choo Arm; Bang Kok Noi, Wat Sai; 17♂, 13♀, 46 L, 9 p, 12 lp; *Chon Buri:* Sriracha; Ban Huey Luk; 2♂, 2♀, 3 L, 1 p, 2 lp; *Prachuap Khiri Khan:* Muang; Huey Som Lang; 2♀.

CAMBODIA. Pailin; 1 L.

VIETNAM. An Khe; Gia Rai; Lai Kha; Bien Hao; Antuc; 1♂, 1♀, 10 L.

MALAYSIA. *Peninsular Malaysia* (Malaya): *Selangor:* Kapang; Kuala Lumpur airport; 3♂, 2♀, 3 lp; *Perak:* Tg. Rambutan; 4♂, 6♀, 5 L, 1 p, 7 lp; *Pahang:* Kuantan; 6♂, 3♀, 1 lp.

SINGAPORE. West Coast; Buona Vista; Kranji; Pulau Blakang Mati; 5♂, 5♀, 5 L, 8 lp.

Additional records from the literature. PHILIPPINES (Basio 1972).

TAXONOMIC DISCUSSION. *Culex hutchinsoni* is very similar to *quinquefasciatus* in the general external characters of the adults but is very different from the latter in the male genitalia and larval stages. The only external characters of the adults which usually distinguish *hutchinsoni* from *quinquefasciatus* are: the relatively smaller size; the reddish brown mesonotum and the presence of pattern of dark bands or spots above and below the white scale patches on the upper corner of sternopleuron and upper part of mesepimeron. The dark bands or spots on the pleuron of the adult, resemble those of *fuscocephala* , but are less striking and not very clearly marked.

Culex hutchinsoni shows a stronger affinity with the members of the *Trifilatus* Subgroup than with the others in the type of male phallosome and on this basis I am assigning it to this subgroup. It can be readily separated from other members of the *Trifilatus* Subgroup and all other *pipiens* forms by the following characters: in the male genitalia by (1) outer division of the phallosome with a prominent sternal spine in addition to lateral spine; (2) lateral basal process of outer division rather thick and prominent; (3) ventral arm of inner division narrow and strongly angled or bent laterad and (4) setae in group *d-f* of distal division of the subapical lobe 4 in number; the pupa by (1) seta 1-II 20 or more branched and (2) setae 6-III-V usually double; and in the larva by (1) the dark, spiniform seta 1-C; (2) seta 4-P weak, 4, 5 branched; (3) setae 1-M and T

strong, very distinct; (4) seta 7-I single and (5) siphon, short, thick, more or less similar to *quinquefasciatus* in shape and with a prominent subapical spine on dorsal surface.

BIONOMICS. *Culex hutchinsoni* is apparently a rather uncommon, rural, inland species. The breeding habitat includes various types of ground pools such as ponds, wells, ditches, rock pools and animal foot prints. It has also been found breeding in artificial containers such as discarded oil drums and plastic cans. In most instances, the breeding habitats such as rice fields and vegetable plantations were fully exposed to sunlight. The elevation ranges from near sea level to about 300 m or possibly higher. It was usually found in association with *Culex (Lophoceraomyia) infantulus* Edwards and *rubithoracis* (Leicester), and *C. (Lutzia) fuscanus* Wiedemann in the collections from ground pools and with *Aedes (Stegomyia) albopictus* (Skuse) in the collection from artificial containers. Several adults were collected from light traps. An engorged female from Thailand was collected biting but no specific data were available on the host. Nothing is known about the medical importance of *hutchinsoni*.

THEILERI SUBGROUP

The *Theileri* Subgroup is characterized by the following combination of male genitalic characters: (1) setae in group *d-f* of distal division of subapical lobe 3 in number, situated between setae *a-c* of proximal division and leaf *g* of distal division; (2) distimere with a very weak crest of minute spicules on subapical dorsal surface; (3) ventral arm of inner division of phallosome more or less straight, or slightly divergent and with 3-4 strong apical teeth or spines; (4) outer division with or without a short sternal spine; (5) tergal arm of outer division distally tapered into a point and (6) basal sternal process of proctiger well developed.

The proposed *Theileri* Subgroup includes only *theileri* Theobald 1903, originally described from the Ethiopian region. It is apparently a common species with a very broad range of extension northwards and eastwards into the Mediterranean, Middle East, northern Palearctic (USSR) and the Oriental region. Some nominal taxa which are currently synonyms of *theileri* may prove to be distinct. The *Theileri* Subgroup may also include other Ethiopian species such as *andersoni* and *simpsoni* (Edwards 1941), but no attempt is made to assign any of these to this subgroup largely because I have not studied them in sufficient detail.

4. *CULEX (CULEX) THEILERI* THEOBALD
(Figs. 9, 10)

Culex theileri Theobald 1903: 187 (♂*, ♀*); Barraud 1924b: 1266 (♂*, ♀); Barraud 1924c: 429 (L*).

Culex creticus Theobald 1903: 189 (♀); Edwards 1932: 210 (synonymy).

Culex pettigrewii Theobald 1910b: 15 (♀); Edwards 1911: 262 (synonymy).

Culex onderstepoortensis Theobald 1911a: 265 (♀*); Edwards 1932: 210 (synonymy).

Culex theileri var. *annulata* Theobald 1913: 321 (♀); Edwards 1932: 210 (synonymy).

Culex tipuliformis of Edwards 1912: 31 (synonymy); Edwards 1921: 339 (L*, distribution); Kirkpatrick 1925: 115 (♂*, ♀, P*, L*).

Culex (Culex) theileri Theobald, Edwards 1932: 210 (taxonomy); Barraud 1934: 414 (♂*, ♀, L*); Edwards 1941: 305 (♂, ♀, P); Hopkins 1952: 289 (L*).

FEMALE (Fig. 9). Wing: 5.0 mm. Forefemur: 2.3 mm. Proboscis: 2.5 mm. Abdomen: 3.4 mm. Large species; readily distinguished from other Oriental species in the *Pipiens* Group by the presence of broad scale patch on postspiracular area and by the presence of longitudinal pale stripes on the anterior surface of femora and tibiae of legs. *Head.* Narrow decumbent scales of vertex yellowish in center, golden brown or bronzy on lateral area; erect scales entirely brownish; lateral patch of broad scales yellowish white. Palpus about 0.2 of proboscis length; palpal segments 3 and 4 with pale scale line on inner dorsal surface or sometimes largely pale scaled. Proboscis slightly pale in middle but not forming distinct ring. Flagellomere 1 of antenna with a few pale scales on inner surface. *Cibarial Armature.* Not studied. *Thorax.* Mesonotal integument light to dark brown; mesonotal scales rather coarse, golden brown or bronzy in center of disc, yellowish white on marginal areas, prescutellar space and scutellar lobes. Pleural integument same color as mesonotum; *ppl* with pale scale patch, extending anteriorly to prosternum, *ppl* bristles strong, 20 or more; *stp* with an extensive scale patch covering upper corner, upper and lower posterior borders and base of prealar knob; *psp* with a distinct broad scale patch; *mep* with anterior scale patch contiguous with scale patch on upper corner of *stp* and several loosely packed scales among upper *mep* bristles; 1 or 2 lower *mep* bristles present. *Legs.* Anterior surface of forefemur with a complete longitudinal pale stripe or a linear row of white spots from base to apex; anterior surface of midfemur with a median longitudinal stripe along the whole length; anterior surface of hindfemur with a broad longitudinal white stripe bordered above and below by dark scales; all tibiae with anterior white stripes along whole length; tarsi of fore- and midlegs usually entirely dark; tarsomere 1 of hindleg with distinct white stripe on anterior surface, remaining tarsomeres entirely dark. *Wing.* Posterior surface of vein C with pale scale line in basal 0.5; scales on all other veins entirely dark; scales on R_2, R_3 and R_{4+5} narrow, linear, elongate. *Halter.* Peduncle pale, without scales; capitellum or knob dark scaled. *Abdomen.* Tergum I with median scale patch which is completely or partially pale; terga II-VII with broad basal pale bands which are usually strongly produced posteriorly as yellow triangular patches; sometimes also with yellowish dots in middle; tergum VIII entirely yellowish scaled; lateroterga II-VI with elongate basolateral pale patches connecting with basal pale bands; sterna predominantly yellowish or with sprinkling of some dark scales. *Genitalia.* Not studied.

MALE. Description based on specimens from India and South Africa. In general as described for female. *Head.* Palpus exceeding proboscis by full length of segment 5; segment 3 with scattered pale scales in apical 0.5 and ventral lateral rows or tuft of numerous strong bristles from basal 0.25 to apex; segments 4 and 5 strongly plumose; dorsal and ventral surfaces with distinct pale scale lines. Proboscis slightly pale on mid-ventral surface; labium without median ventral tuft of long hairs.

MALE GENITALIA (Fig. 9). As described and figured by Barraud (1934: 415-6) with the following distinctive features. *Segment IX.* Tergal lobe with irregular rows of 10-12 moderately strong setae. *Basimere.* Slender, conical, about 0.3 mm in length. *Subapical lobe.* Setae *a-c* of proximal division subequally long and stout; setae *d-f* of distal division consisting of 1 flattened, apically blunt blade like seta and 1 narrower, apically pointed hairlike seta; leaf *g* broad or narrow; seta *h* long and strong. *Distimere.* Normal: 1, 2

ventral tiny setae present in apical 0.25; subapical claw slender. *Phallosome.* Tergal arm of outer division slightly divergent laterad and distally tapered into a point apically; lateral spine absent; sternal spines poorly developed or absent; lateral basal process slender, thumb-like; ventral arm of inner division straight or slightly divergent laterad, with 3 strong apical teeth or spines. *Proctiger.* Crown large and dark, consisting of numerous coarse and fine spicules; basal sternal process well developed, about 0.05 mm in length; paraproct narrow; cercal sclerite broad, well sclerotized; cercal setae 4, 5 in number.

PUPA. Abdomen: 4.0 mm. Paddle: 1.1 mm. Trumpet: 0.91 mm; index 7. Based on specimens from India and South Africa. Cephalothorax and abdomen yellowish white. All setae developed, as figured for *quinquefasciatus* (Fig. 2). *Trumpet.* Relatively long, cylindrical or gradually increased in diameter distally; pinna weakly oblique, apical margin truncate. *Cephalothorax.* Seta 1-C 3, 4 branched; 2-C 4 branched; 3-C double; 4-C triple; 5-C 5, 6 branched; 6-C 4 branched, as long as 4-C; 7-C double; 8-C 4-6 branched; 9-C double. *Metanotum.* Seta 10-C 5, 6 branched; 11-C usually double (1-3); 12-C 3, 4 branched. *Abdomen.* Setae 6-I, II single; 7-I, II double; 1-II usually more than 10 branched (8-14); 1-III, 7-9 branched; 1-IV 6, 7 branched; 1-V 4-6 branched; 1-VI-VII 3, 4 branched; 5-IV usually triple (3-4); 5-V usually double (2-3); 5-VI double; 6-III-VI usually 4, 5 branched (3-6); 6-V, VI stronger and longer than 6-III, IV; 9-VII 4-6 branched; 4-VIII single or double; 9-VIII 8 branched. *Paddle:* Large, broad and very pale; midrib weak and lightly pigmented; external buttress distinct, apical margin rounded, indistinct; seta 1-P stronger than 2-P.

LARVA (Fig. 10). Head: 1.04 mm. Siphon: 1.8 mm; index 5. Saddle: 0.48 mm; siphon/saddle ratio 3.3. Description based on specimens from India and South Africa. *Head.* Labrum broad; seta 1-C dark, spiniform; 4-C single, shorter than distance between bases of the pair; 5-C 3, 4 branched; 6-C usually double (2-3); 7-C 6, 7 branched. Antennal shaft strong, and long, distinctly curved outwards at middle, about 0.7 of head length; pigmentation largely pale whitish except for basal dark ring and dark apical portion beyond base of seta 1-A; 1-A strong, dark, multibranched; 2, 3-A distinctly subapical. Mental plate with 6 lateral teeth on each side of median tooth. *Thorax.* Setae 1-3-P single, strong, subequal; 4-P shorter than 1-3-P, double; 7-P triple; 8-P double; 1-M minute, triple, about 0.25 of length of 3-M; 3-M single. *Abdomen.* Ventral surface of segments I-VI with median patch of distinct spicules; setae 6-I, II triple; 7-I double; 1-III-VI moderately strong, usually 4 branched (3-4); 13-III-V as long as 1-III-VI, 4, 5 branched; 6-III-VI all triple. Comb scales 20-26, all similar in size, individual scale with a strong median apical spine and lateral fringe of evenly fine spicules. Saddle pale whitish; seta 1-X weak, triple; 2-X 3, 4 branched; 4-X with 7 pairs of setae, all within grid; anal gills slender, shorter or slightly longer than saddle. *Siphon.* Relatively thick and very pale except for basal dark ring; distal portion slightly tapering; pecten teeth strong, 12-15 in number, distal tooth with 1, 2 basal denticles and an elongate simple apical spine; siphonal tufts strong, inserted beyond pecten, 5-6 pairs in number; first 3-4 proximal pairs subequally long, 7-12 branched, in a prominent row on ventral surface, their length about as long as siphonal width at point of insertion; 2 distal pairs weaker, 8-10 branched, inserted laterally or subventrally; 2-S short and slender; median caudal filament of spiracular apparatus absent.

TYPE-DATA. (1) *Culex theileri* Theobald, Lectotype ♀*, Pretoria, *Transvaal,* (SOUTH AFRICA), D. Theiler (BM; present selection); (2) *Culex creticus* Theobald, Holotype ♀*, *Crete,* GREECE (BM); (3) *Culex pettigrewii* Theobald,

Holotype ♀, Ukhrul, Manipur, *Assam*, INDIA, 6,400 ft., August 1908, Pettigrew (IM); (4) *Culex onderstepoortensis* Theobald, Holotype ♀*, Onderstepoort, *Transvaal*, (SOUTH AFRICA) (BM); (5) *Culex theileri* var. *annulata* Theobald, Holotype ♀. Onderstepoort, *Transvaal*, (SOUTH AFRICA) (BM).

DISTRIBUTION. Widely disjunct, covering the Ethiopian, Mediterranean and Middle East with extension eastward into the Oriental region as far as India, Burma and southern China and northward into USSR. Material examined 140 specimens: 51♂, 69♀, 20 L; 7 individual rearings (5 pupal, 2 larval).

CHINA. Yunnan, Kunming; 5♀; locality unknown; 2 L.

INDIA. Western Himalayas, Kasauli; Kashmir; 1♂, 1♀, 1 p.

NEPAL. Katmandu; 1 L.

PAKISTAN. Montgomery: 2 L.

AFGHANISTAN. Kunduz Prov.; Bamiyan Prov.; Herat Prov.; 23♂, 26♀.

IRAQ. Abu Ghraib; Shubaicha; Duquq; Rawanduz, Nahia; Erbil, Towne; 2♂, 11 L.

IRAN. Sharaf Khaneh; Semnan; Maragneh; Do Rud; 5♂, 4♀.

SPAIN. Canary Is., Tenerife, Santa Cruz; 1♂ (genitalia).

PALESTINE (ISRAEL). 1♂, 1♀.

TUNISIA. Mateur; Bizerte; 10♂, 20♀.

YEMEN. El-Amra, nr. Ta'iss; 2♂, 2 lp.

GREECE. Macedonia; 1♀.

ALGERIA. Oued Taria; Mocta Douz; La Mocta; Le Kraub; 2♂, 2♀.

KENYA. 2♂, 2♀ (as *tipuliformis* Theobald).

SOUTH AFRICA. Johannesburg; 2♂, 7♀, 4 L; 4 p (from mass rearing).

Additional records from the literature: INDIA: Punjab; WEST PAKISTAN (Baluchistan); BURMA (Barraud 1934: 416); SOUTH AFRICA: Cape; Natal; Orange Free State; Transvaal; SOUTH WEST AFRICA; SOUTHERN RHODESIA; ABYSSINIA; ETHIOPIA; ERITREA; CONGO; TANGANYIKA; S. W. ARABIA; MOROCCO; EGYPT; ITALY: Sardinia; FRANCE: Corsica; SPAIN; PORTUGAL (Edwards 1941: 306; Aitken 1954: 488; Mattingly and Knight 1956: 121; Senevet and Andarelli 1959: 201); USSR: Ukraine; south shores of Crimea; Northern Caucasus; Transcaucasia, Central Asia (Monchadskii 1951: 275).

TAXONOMIC DISCUSSION. The new record of *theileri* from China is based on 5 females which were found among several *quinquefasciatus* specimens in the USNM collection by Cazier from Kunming, Yunnan in 1945. In the previous studies by Barraud (1924b, 1934), this species has been reported only from the north of India and Burma. It is quite possible that it may also extend its range into other parts of Southeast Asia south of the Chinese border.

Culex theileri is among the most clearly marked species of the *Pipiens* Group. It can be readily separated from other Oriental species in the *Pipiens* Group in the adults by (1) large size (wing length usually 5.0 mm or more); (2) presence of a broad scale patch on postspiracular area; (3) presence of an extensive continuous scale patch on sternopleuron and base of prealar knob; (4) presence of very striking longitudinal pale stripes on the femora and tibiae of all legs and (5) basal bands of abdominal tergites usually broad and strongly produced posteriorly as triangular yellowish patches. The male genitalia of *theileri* are very constant in practically all characters noted and can be distinguished from other Oriental species most readily by the presence of 3-4 strong lateral teeth on the apex of ventral arm (inner division) of the phallosome. In the immature stages, the pupa can be separated by (1) large size; (2) relatively long and uniformly thick trumpet; (3) pinna of trumpet weakly oblique; (4) cephalothoracic seta 8-C 4-6 branched and (5) abdominal setae 6-III-VI usually 4, 5 branched. The larva is differentiated by (1) seta 1-C of head dark,

stout and spiniform (2) comb scale apically pointed or with a strong median apical spine; (3) siphon relatively thick, long and distally slightly tapered; (4) presence of 5 or 6 pairs of moderately long siphonal tufts, 3 or 4 proximal pairs of which are closely spaced and forming prominent rows on ventral surface and (5) ventral brush (4-X) of saddle with 7 pairs of setae.

Among the Ethiopian species, the male phallosome of *theileri* resembles those of *andersoni* Edwards 1914 and *simpsoni* Theobald 1905 as described and figured by Edwards (1941: 305-6), indicating that they are closely related.

BIONOMICS. According to Barraud (1924b, 1934), *theileri* was reported to be common at a very high elevation, ranging from 1,000-3,000 m in the Himalayan areas of North India where it was found to utilize large ground pools, stream pools and marshes as breeding habitats. Elsewhere in the Ethiopian, Mediterranean and in several countries to the west of India, it was reported from a broad range of elevations and was found breeding in pools, dipping tanks, stagnant or slowly moving streams, ditches, drains, backwaters of rivers, swamps and ponds (Hopkins 1952: 291, Aitken 1954: 489, Senevet and Andarelli 1959: 201, Lofti 1970: 402). In northern Afghanistan, it was reported to be locally common and the immatures were frequently collected from polluted ground pools (R. A. Ward, personal communication). The South African material collected for this study all came from rearing pupae and larvae in ground pools. Nothing is known about adult biology, feeding habit and medical importance of *theileri* in India and adjacent countries to the west. In South Africa, the females feed mainly on blood of cattle and occasionally on man and birds (Anderson 1967). In virus isolation studies by McIntosh et al. (1967) in South Africa, *theileri* was found to be naturally infected with Sindbis and West Nile viruses. Jupp et al. (1966) have demonstrated in the laboratory that it is an efficient vector of Sindbis virus but not of West Nile virus.

UNIVITTATUS SUBGROUP

The *Univittatus* Subgroup is characterized by the following male genitalic characters: (1) setae in group *d-f* of distal division of subapical lobe consisting of 1 long bladelike seta and 1 shorter hairlike seta, situated on accessory mesal lobe on sternal surface of basimere; (2) subapical dorsal surface of distimere with distinct annulation or serration; (3) ventral arm of inner division of phallosome simple or composed of 5,6 strong and long fingerlike processes; (4) outer division without lateral and sternal spines; (5) tergal arm of outer division apically pointed or truncate and (6) basal sternal process of proctiger dark, heavy and long.

The *Univittatus* Subgroup as proposed here includes *univittatus* Theobald 1901 and *fuscocephala* Theobald 1907. This subgroup is strongly differentiated from other subgroups in the male genitalia by the development of accessory mesal lobe in the distal division of subapical lobe of the basimere and in the presence of distinct annulation or serration on subapical dorsal surface of the distimere. It may also include several other Ethiopian forms, especially those in the *decens* series of Edwards (1932, 1941), but no attempt is now made to determine their affinity.

Culex univittatus was originally described from the Ethiopian region and has subsequently been reported from several localities in the Mediterranean, Middle East and eastward as far as India (Barraud 1934) in the Oriental region. It is probably a complex of more than one form on the basis of the studies by Jupp (1971, 1972) in South Africa. *Culex fuscocephala* is exclusively Oriental

and is one of the commonest species in Southeast Asia. It shows a striking difference from *univittatus* in the ventral arm of inner division of the phallosome but is very similar to the latter in all other details of the male genitalia.

5. *CULEX (CULEX) UNIVITTATUS* THEOBALD
(Figs. 9, 10)

Culex univittatus Theobald 1901b: 29 (♂*, ♀*); Edwards 1913a: 58 (♂, ♀).
Culex perexiguus Theobald 1903: 199 (♂, ♀); Edwards 1921: 342 (♂, ♀, L*); Edwards 1922: 471 (distribution); Barraud 1924b: 1263 (♂*, ♀); Barraud 1924c: 431 (L*); Kirkpatrick 1925: 125 (♂*, ♀, P*, L*); Edwards 1932: 210 (synonymy).
Heptaphlebomyia simplex Theobald 1903: 337 (♀*); Edwards 1932: 210 (synonymy).
Culex pallidocephala Theobald 1904: 73 (♂); Edwards 1941: 306 (synonymy).
Heptaphlebomyia montforti Ventrillon 1905: 448 (♂*, ♀); Edwards 1932: 210 (synonymy).
Culex goughii Theobald 1911a: 268 (♀*); Edwards 1912: 32 (♀, synonymy).
Culex (Culex) univittatus Theobald, Edwards 1932: 210 (taxonomy); Barraud 1934: 418 (♂*, ♀, L*); Edwards 1941: 301 (♂*, ♀, P); Hopkins 1952: 291 (L*); Mattingly and Knight 1956: 104 (taxonomy); Senevet and Andarelli 1959: 208 (♂*, ♀*, P, L); Jupp 1971: 340 (♂*, ♀*, L); Jupp 1972: 103 (♂*, ♀, taxonomy).

FEMALE (Fig. 9). Wing: 3.0 mm. Forefemur: 1.44 mm. Proboscis: 1.6 mm. Small to medium sized species; distinguished from other Oriental members of the *Pipiens* Group by the presence of a scale patch on postspiracular *(psp)* area and by the presence of longitudinal pale stripe on midfemur, mid- and hindtibiae. *Head.* Narrow decumbent scales on vertex pale beige to whitish; erect scales moderately long, largely pale in center, dark on posterolateral areas; sometimes entirely dark; lateral patch of broad scales whitish, very distinct. Palpus with pale scales forming streak on segments 3 and 4, rest dark. Proboscis dark dorsally, slightly pale on mid-ventral surface. *Cibarial Armature.* Not studied. *Thorax.* Mesonotal integument brown; mesonotal scales largely yellowish brown, pale beige or whitish on marginal area, prescutellar space and scutellar lobes. Pronotum (*apn, ppn*) with similar scales as mesonotum. Pleuron same color as mesonotum without distinct pattern of dark and light bands; scale patches present on *psp, ppl, stp* and *mep;* scale patches on upper corner and lower posterior border of *stp* extensive but not contiguous; upper one extended dorsad to base of prealar knob; 1 lower *mep* bristle present. *Legs.* Scales on anterior surface of forecoxa largely pale; anterior surface of forefemur entirely dark; anterior surface of midfemur usually with complete median longitudinal pale stripe which is sometimes broken up into a chain of pale spots; anterior surface of hindfemur largely pale in basal 0.5, continued as narrow pale stripe to near apex; apices of all femora with distinct apical white spots; foretibia entirely dark anteriorly; mid- and hindtibiae with longitudinal pale stripes on anterior surfaces; all tarsi entirely dark. *Wing.* All scales dark except for pale scale line on posterior surface in basal 0.5 of vein C and a few scattered pale scales on Sc and R; scales on veins R_2, R_3 and R_{4+5} narrow. *Abdomen.* Terga II-VII with even basal pale bands and basolateral pale spots; sterna largely pale yellowish. *Genitalia.* Not studied.

MALE. In general as described for female. *Head.* Palpus slender,

exceeding proboscis by full length of segment 5; segment 3 with ventrolateral tuft of about 10 bristles in apical 0.5; segments 4 and 5 strongly plumose, essentially as in *quinquefasciatus*. Proboscis without median ventral tuft of long hairs. *Legs*. Anterior surface of midfemur without distinct longitudinal pale stripe. *Abdomen*. Basal bands on terga II-VII broader than in female.

MALE GENITALIA (Fig. 9). Essentially similar to *fuscocephala* in the details of basimere, subapical lobe, distimere and proctiger, differing particularly in the following: *Phallosome*. Inner division of lateral plate represented by a broad, simple leaflike ventral arm which is strongly bent or angled proximally; its innermost sternal margin provided with a slender and sharp spine of variable length; outer division with a strong tergal arm which is distally tapered into a sharp point; lateral basal process very slender and elongate.

PUPA. As figured for *fuscocephala* (Fig. 12) to which it is extremely similar in the shape and relative length of trumpet and in most features of chaetotaxy, differing particularly as follows: *Abdomen*. Hair 5-V triple; 5-VI usually triple, sometimes double; 5-VII triple.

LARVA (Fig. 10). Head: 0.8 mm. Siphon: 1.4 mm; index 6. Saddle: 0.35 mm; siphon/saddle ratio 4. In general similar to *fuscocephala*, differing particularly in the following features. *Head*. Head seta 1-C darker, stouter, more or less spiniform. Antenna longer; spicules on antennal shaft stronger. *Abdomen*. Setae 1-III-VI shorter, double or triple; 6-III double; 6-IV triple; 6-V double; 6-VI single. Seta 1-X of saddle triple. *Siphon*. Siphonal tufts 5 pairs in number, 2 proximal and 1 subapical pairs inserted subventrally, other 2 pairs in apical 0.5 inserted laterally; all subequal, 3,4 branched each and about as long as or slightly shorter than siphonal width at point of attachment.

TYPE-DATA. (1) *Culex univittatus* Theobald, Lectotype ♂*, *Salisbury*, Mashonaland, S. RHODESIA, March 1900, G. A. K. Marshall (BM; selection of White 1975: 320). (2) *Culex perexiguus* Theobald, Lectotype ♂, Sidon, Palestine (LEBANON) (BM; selection of White 1975: 318). (3) *Heptaphlebomyia simplex* Theobald, Holotype ♀, *Salisbury*, Mashonaland, S. RHODESIA (BM). (4) *Culex pallidocephala* Theobald, Lectotype ♂, Sennar, Blue Nile, SUDAN (BM; selection of Edwards 1941: 306). (5) *Heptaphlebomyia montforti* Ventrillon, Lectotype ♂, Ankajobé, MADAGASCAR (BM; selection of White 1975: 321). (6) *Culex goughii* Theobald, Lectotype ♂, Onderstepoort, *Transvaal*, (South AFRICA) (BM; selection of White 1975: 321).

DISTRIBUTION. Widespread, covering the Ethiopian (southern and eastern Africa), Mediterranean, Middle East, Iraq, Iran, Afghanistan, Pakistan with a small extention into the Oriental region as far as Punjab, India.

Material examined: 25♂, 31♀, 17 L; 17 from mass rearing (17 l, 17 p); 1 individual rearing (1 larval).

INDIA. Punjab: Amritsar, 1♀, 1 lp.

PAKISTAN. Peshawar, 1♂.

AFGHANISTAN. Helman Province: Garwagin Village; 8♂, 10♀.

TUNISIA. 3♂, 4♀.

ISRAEL. 1♂, 1♀.

ALGERIA. 1♂, 3♀.

SOUTH AFRICA. Johannesburg; 11♂, 13♀, 17 L, 17 p, 17 l.

Additional records from the literature: INDIA: United Province; PAKISTAN (Baluchistan, Sind, N. W. Frontier): Lahore (Barraud 1934: 420); IRAN: Kazeroon; Bandar-Abbas (Lofti 1970: 402); SOUTH AFRICA: Cape; Transvaal; Orange Free State; SOUTH WEST AFRICA; PORTUGUESE EAST AFRICA; RHODESIA; NYASALAND; ANGOLA; ZANZIBAR; MAURITIUS; MADAGASCAR; KENYA; UGANDA; SUDAN; GOLD COAST; NIGERIA; GAMBIA; CONGO; FRANCE; SPAIN;

ITALY; GREECE; EGYPT; OMAN (Edwards 1941: 308; Senevet and Andarelli 1959: 214; Mattingly and Knight 1956: 122); USSR: Turkmenia; SYRIA; LEBANON (Monchadskii 1951: 279).

TAXONOMIC DISCUSSION. The assignment of the Oriental specimens described above to *univittatus* is provisional, based on the study of the limited material previously described by Barraud (1934: 418-20) from India and its comparison with the types and specimens from South Africa. Except for the smaller size, the Indian form of *univittatus* does not appear to show any significant difference in the male genitalia and in the pupal and larval chaetotaxy from the type or from specimens from the Middle East, the Mediterranean and the Ethiopian area (particularly South Africa). Although 2 distinct taxa, *univittatus* (s. str.) and *neavei* Theobald 1906 have been recognized by Jupp (1971) in South Africa on the basis of the male genitalia and external characters of the adults, I have not been able to determine which of the 2 South African forms the Indian specimens should belong to. It appears most probable from the studies by Jupp (1971, 1972), that this species is highly complex and that it may consist of more than 2 taxa. The Indian specimens as well as those from other adjacent areas in Pakistan and Afghanistan appear to be conspecific and probably represent a distinct species. Because of the limited reared material, the exact status of this Oriental form can not be determined at present.

Culex univittatus in the Oriental part of its range is a relatively slender, small or medium-sized species. It can be readily separated from other Oriental forms of the *Pipiens* Group by the following combination of characters: In the adults by (1) presence of scale patch on the postspiracular area; (2) scale patches on the upper corner and lower posterior border of sternopleuron not contiguous and (3) presence of longitudinal pale stripes on the anterior surface of midfemur and tibiae of mid- and hindlegs; the male genitalia by (1) the ventral arm of inner division of the phallosome broad, leaflike and with a distinct spine on the mesal surface; (2) tergal arm of outer division tapered into a point apically; (3) lateral basal process of the outer division slender and elongate; (4) basal sternal process of the proctiger dark, thick and long; (5) setae *d-f* of distal division of the subapical lobe 2 in number and situated on a distinct mesal lobe on the sternal surface and (6) subapical dorsal surface of the distimere distinctly annulated or serrated; the pupa by (1) the slender and uniformly cylindrical trumpet; (2) seta 8-C 4-6 branched; (3) abdominal setae 6-III-VI 4, 5 branched; (4) seta 5-IV 5 branched and (5) seta 5-V triple; and the larva by (1) the dark and spiniform seta 1-C of head; (2) siphon pale, slender and relatively long and (3) siphonal tufts 5 pairs in number, widely spaced and about as long as siphonal width at the point of attachment.

BIONOMICS. *Culex univittatus* is a typical ground pool breeder. In India, it was reported to breed frequently in marshy pools, borrow pits, stagnant drains and canals, shallow wells and less frequently in domestic collections of water and rice fields (Barraud 1934: 420). In the Ethiopian region, the larvae of *univittatus* were reported to be common in marshy pools and in pools at the edge of swamps and were also found in stagnant or semi-stagnant streams and ditches, borrow pits, etc. (Hopkins 1952: 293). Nothing is known about the adult biology and medical importance of *univittatus* in India and other adjacent countries to the west. In South Africa, it was reported to feed on birds and mammals exclusive of man (Anderson 1967) and has been considered to be an important vector of Sindbis and West Nile viruses (McIntosh et al. 1967, Jupp and McIntosh 1967).

6. *CULEX (CULEX) FUSCOCEPHALA* THEOBALD
(Figs. 11, 12, 13, 14)

Culex fuscocephala Theobald 1907; 420 (♀); Theobald 1910a: 363 (distribution); Edwards 1913b: 234 (taxonomy); Barraud 1924b: 1270 (♂*, ♀); Barraud 1924c: 432 (L*); Borel 1930: 342 (♂*, ♀, L*).
Culex uniformis Leicester 1908: 159 (♀); Edwards 1917: 225 (synonymy).
Culex minimus Leicester 1908: 160 (♂, ♀); Edwards 1932: 212 (synonymy).
Culex taytayensis Banks 1909: 545 (♂, ♀); Edwards 1913b: 234 (synonymy).
Culex luteola Theobald 1910a: 378 (♀*); Edwards 1913b: 234 (synonymy).
Culex inelegans Dyar 1920: 179 (♂); Barraud 1934: 424 (synonymy).
Culex fuscitarsis Barraud 1924b: 1272 (♂*, ♀); Bram 1967a: 184 (synonymy).
Culex (Culex) fuscocephalus Theobald, Edwards 1932: 212 (taxonomy); Barraud 1934: 424 (♂*, ♀, L*); Bonne-Wepster and Brug 1937: 8 (♂, ♀*); Feng 1938: 303 (biology, distribution); Bonne-Wepster and Brug 1939: 1277 (L*); Bohart 1945: 78 (♂*, L); Bonne-Wepster 1954: 133 (♂, ♀*, L*); Hsieh and Liao 1956: 123 (distribution); Chu 1958: 110 (distribution); Lien 1962: 633 (distribution); Safyanova et al. 1964: 1177 (distribution).
Culex (Culex) fuscitarsis Barraud, Edwards 1932: 212 (taxonomy); Barraud 1934: 426 (♂*, ♀).
Culex (Culex) fuscocephala Theobald, Delfinado 1966: 143 (♂*, ♀, L); Bram 1967a: 184 (♂*, ♀*, P*, L*); Baisas 1974: 90 (♂, ♀, P, L).

FEMALE (Fig. 11, 14). Wing: 2.4-3.4 mm (average 2.8 mm). Forefemur: 1.1-1.5 mm (average 1.4 mm). Proboscis: 1.4-2.0 mm (average 1.7 mm). Abdomen: 2.2 mm. Small species, easily distinguished from other members of the *Pipiens* Group by the presence of a striking pattern of dark and light bands on upper sternopleuron *(stp)* and mesepimeron *(mep)* and by the absence of abdominal tergal pale bands. *Head.* Narrow decumbent scales of vertex very fine and yellowish; erect scales short, predominantly dark; lateral patch of broad scales whitish, very distinct. Palpus very thin and rather short, about 0.15 of proboscis length, entirely dark scaled. Proboscis dark scaled on dorsal surface, paler on lateral and ventral surfaces, but not extended dorsad to form a distinct ring. *Cibarial Armature.* Cibarial bar small; cibarial teeth very fine, long and distally filamentous, all subequal in length, about 40 in number. *Thorax.* Mesonotal integument brown; mesonotal scales very fine and dense, vestiture smooth, predominantly yellowish or brownish in middle of mesonotal disc, pale beige to whitish on marginal areas, prescutellar space and scutellar lobes. *Apn* with narrow, yellowish scales and weak setae; *ppn* with 5 posterior bristles and several narrow pale scales scattering on upper surface. Pleuron with characteristic dark bands above and below whitish scale patches on upper corner of *stp* and upper *mep; ppl* with small whitish scale patch and 6, 7 bristles; a few pale scales present among upper mep bristles; 1 lower *mep* bristle present. *Legs.* Forecoxa with anterior scale patch which is dark above, pale on lower surface; anterior surface of fore- and midfemora entirely dark scaled; hindfemur largely pale in basal portion, continued as pale stripe in distal portion; all tibiae and tarsi dark scaled. *Wing.* All scales dark; scales on veins R_2, R_3 and R_{4+5} narrow. *Abdomen.* Terga II-VIII entirely grayish to brownish, basal bands absent; scales at bases of terga occasionally lighter than other areas, but not forming distinct basal bands; basolateral pale spots absent; sterna largely yellowish white. *Genitalia.* Tergum IX with lateral row of 5-9 setae; postgenital plate with distinct median

emargination on caudal margin; vaginal sclerite U-shaped and well sclerotized; insula with a tuft of 6-12 setae.

MALE (Fig. 11). In general as described for female except for the following sexual differences. *Head.* Palpus thin, exceeding proboscis by 1.5 of length of segment 5; segment 3 entirely dark or grayish; apical 0.25 with ventrolateral tuft of 15-20 dark bristles; segments 4 and 5 upturned, strongly plumose and entirely dark scaled on dorsal surface; segment 4 with white scale line on ventral surface; segment 5 without any scale on ventral surface. Proboscis with distinct median ventral tuft of 2-4 long and 2, 3 shorter setae.

MALE GENITALIA (Fig. 12). *Segment VIII.* Tergum shallowly emarginate on median caudal margin and with distinct row of 6-8 dark kinked setae. *Segment IX.* Lateral tergal lobe broadly round, with a row of 8-10 moderately strong setae. *Basimere.* Small, slender, conical. *Subapical lobe.* Seta *a* of proximal division shorter than setae *b-c*; setae *d-f* of distal division consists of 1 long, flattened bladelike seta and 1 strong hairlike seta which are situated on distinct mesal lobe on sternal surface; leaf *g* very large, heart-shaped, placed slightly distad of setae *a-c*; seta *h* strong and long. *Distimere.* Sickle-shaped, basal 0.50-0.75 straight, apical 0.25-0.50 gently or strongly curved, with distinct annulation or crest of weak spicules on dorsal subapical surface; 1 ventral tiny seta present subapically; dorsal seta absent; subapical claw slender and moderately long. *Phallosome.* Inner division of lateral plate with 5-6 heavy toothlike processes, most sternal longest, lateral ones shorter, all divergent laterad; outer division with a strong divergent tergal arm which is uniform in width and apically truncate; lateral basal process strongly expanded as broad leaf, apex bluntly pointed or rounded. *Proctiger.* Crown large; paraproct and cercal sclerite broad, heavily pigmented and strongly sclerotized; basal sternal process very thick, dark and long, curved sternad; cercal setae 2 in number.

PUPA (Fig. 12). Abdomen: 2.5 mm. Paddle: 0.65 mm. Trumpet: 0.52 mm; index about 6. Cephalothorax and abdomen cream-colored or yellowish white. Complete chaetotaxy as figured; all setae developed, the following are distinctive. *Trumpet.* Dark, uniformly cylindrical; pinna weakly oblique, apical margin truncate. *Cephalothorax.* Seta 1-C usually 4 branched (3-4); 8-C usually 5 branched (3-6). *Abdomen.* Seta 1-II 20 or more branched; 5-IV 4-6 branched; 5-V, VI double; 6-III-VI usually 4, 5 branched (2-5); 9-VII 4, 5 branched (3-6); 5-VII double; 4-VIII double or triple; 9-VIII 8-10 branched. *Paddle.* Very pale to almost transparent; midrib weak and lightly pigmented; external buttress distinct; apical external margin indistinct; setae 1, 2-P present, minute.

LARVA (Fig. 13). Head: 0.65 mm. Siphon: 1.2-1.4 mm; index 5-6. Saddle: 0.32 mm; siphon/saddle ratio 4-5. Complete chaetotaxy as figured. *Head.* Seta 1-C filiform and pale; 4-C single, 1-2 times as long as distance between bases of the pair; 5, 6-C usually double (2-3); 7-C 6, 7 branched. Antenna about 0.7 of head length; middle proximal portion pale whitish or yellow, basal and apical portions dark; spicules numerous and distinct; seta 1-A dark, about 20 branched; 2, 3-A subapical. Mental plate with 6, 7 lateral teeth on each side of median tooth. *Thorax.* Seta 3-P shorter or as long as 1, 2-P; 4-P as long as 3-P, double; 7-P triple; 8-P double, 1-M short, tiny, double; 3-M single; 4-M double; 8-M 5 branched; 9-M 4 branched; 1-T short, 3, 4 branched; 7-T 6, 7 branched; 9-T 5 branched; 12-T single or double; 13-T 5-8 branched. *Abdomen.* Setae 1-I, II 2-4 branched; 6-I, II triple; 7-I double; 1-III-VI single and very long, same magnitude as 6-III-VI; 6-III, V and VI single; 6-IV 1-4 branched; 13-III-V 4-6 branched. Comb scales small, all similar in size, about 40, individual scales with rounded even fringe of fine spicules. Saddle

same color as siphon; posterior apical margin lightly spiculated; setae 1, 2-X double; 4-X with 6 pairs of setae; anal gill 1-2.5 times as long as saddle. *Siphon.* Slender, moderately long and pale yellowish except for basal dark ring; pecten teeth 11-12, in close-set row; distal teeth with 2-4 basal denticles and a fine apical denticle; siphonal tufts 3-4 pairs in number, all weak, short and subequal, about 0.5 of siphonal width at point of insertion; each double or triple; 1 or 2 proximal pairs subventral; 1 median pair lateral, 1 distal pair subventral; seta 2-S weak and short; median caudal filament well developed.

TYPE-DATA. (1) *Culex fuscocephala* Theobald, Holotype ♀*, *Peradeniya,* CEYLON (SRI LANKA), 1902, Green (BM); (2) *Culex uniformis* Leicester, Type (lost), Batu Gajah *(Perak),* MALAYA (PENINSULAR MALAYSIA), G. F. Leicester (BM); (3) *Culex minimus* Leicester, Type (lost), Kuala Lumpur *(Selangor),* MALAYA (PENINSULAR MALAYSIA.), G. F. Leicester (BM); (4) *Culex taytayensis* Banks, Holotype ♀*, Tay Tay *(Luzon),* PHILIPPINES (BM); (5) *Culex luteola* Theobald, Holotype ♀*, *Peradeniya,* CEYLON (SRI LANKA), 1900, Green (BM); (6) *Culex inelegans* Dyar, Holotype ♂* with slide of genitalia, Los Banos *(Luzon),* PHILIPPINES, June 1915, Baker (USNM); (7) *Culex fuscitarsis* Barraud, Lectotype ♂* (No. 1701) with slide of genitalia, Pachmari, *Central Provinces,* INDIA, July 1915, V. H. Dowson (BM; selection of Bram 1967a: 188).

DISTRIBUTION. Exclusively Oriental; widespread throughout Southeast Asia with extension into the west as far as India and Sri Lanka; to the north in South China; to the northeast as far as Okinawa, to the east in the Philippines, and to the south in Java, Sulawesi, Kalimantan (Borneo) and Sumatra. Material examined. 3,793 specimens: 1,145♂, 1,809♀, 839 L; 1,072 individual rearings (376 pupal, 696 larval).

INDIA. *Assam:* Dooma Dooma; Chabua; Rupsi; Jorhat (D. E. Hardy, 1943); *Bengal:* Lalmanirhat; Calcutta, Dum Dum, N. Salt Lake; Darjeeling, Sukna; Old Jalpaiguri; *Bihar:* Purnea; Andaman Is.; *Central Prov.*: Pachmarhi (as *fuscitarsis* Barraud 1924); 54♂, 64♀, 45 L, 8 p, 6 lp.

BANGLADESH. Sylhet; 3♂, 13♀, 6 p.

SRI LANKA. *Central Province:* Peradeniya, Kandy District (type locality); *Northern Province:* Vavuniya District; *Sabaragamuwa Province:* Ratnapura District, Uggalkaltota; *Southern Province:* Hambantota District, Palatupana; 11♂, 15♀.

BURMA. Rangoon; Myo Kwet Thit; 6♂, 12♀, 6 p, 1 lp.

THAILAND. Chiang Mai; Chiang Rai; Mae Hong Son; Lamphun; Lampang; Non; Khon Kaen; Prae; Udon Thani; Nakhon Ratchasima; Nakhon Nayok; Sara Buri; Kanchanaburi; Ayatthaya; Bangkok; Thon Buri; Pathum Thani; Chon Buri; Chanthaburi; Trat; Rangong; Krabi; Phuket; Surat Thani (Koh Samui); Nakhon Si Thammarat; Narathiwat; 424♂, 789♀, 533 L, 250 p, 268 lp.

VIETNAM. Saigon; Danang; Nha Trang; Gia Dinh; Phu loi; Phu Bei; Dia Loc Run; 10♂, 37♀, 31 L, 4 p.

CAMBODIA. Ari Gsartr; Phnom Penh; 6♂, 12♀.

LAOS. Muang Sing; 1♀.

MALAYSIA. *Peninsular Malaysia* (Malaya): *Selangor:* Puchong Rd.; Kepong; Sentul; Ulu Klang; Segambut; Serdang; *Pahang:* Bukit Pakoh; Kuala Lipis; Bentong Rd.; Kuantan; Sungai Lembing; *Trengganu:* Marang; *Perak:* Kuala Kangsar; Taiping; Tapah; C. Highlands Rd.; *Perlis:* Kg. Sg. Bharu; Padang Besar; Kg. Prok Buah; Kg. To´ Kayaman; Kg. Baru; Kubang Tiga; Kedah: Changlun; Kg. Peng Besar; Bt. Kayu Hitam; Kg. Bagan; *N. S. (Negeri Sembilan):* Kg. Parit Tinggi; Malacca; *Malaysia* (N. Borneo): *Sabah:* Kota Kinabalu (Jesselton); Papar; Tuaran; Beaufort; 166♂, 204♀, 73 L, 40 p, 132 lp.

SINGAPORE. 1♂, 2♀.

INDONESIA. *Java:* Djakarta; Bogor; *Sumatra:* Bengkulu; 10♂, 16♀.

PHILIPPINES. *Luzon:* Quezon; Subic Naval Base; Olongapo; Laguna; Dalton, N. Vizcaya; Camarines Norte; Batangas; Calaccad; Trinidad Mtn. Prov.; Mt. McKinley; Busunga; Calatagan; Kolambugan; Rizal, Wack Wack, Alabang; Los Banos; Pangasinan; Agoo La Union; San Fernando; Camp Stotsenberg; Camp Nichols; *Mindoro:* San Jose; *Palawan:* Quezon; Iwahig; *Samar:* San Antonio; Osmena; *Leyte:* Gulf; Abuyog; Lago Lago; Dulag; Palo; Carigara; Tacloban; Mahaplag; Negros: Dumaguete; *Mindanao:* Ori Missamis; Dansalan; Kabakan; Parang; Ludlow Barracks; Davao; Zamboanga; Mercedes; Pasanonco; *Tawi Tawi Is.:* Tarawakan; Kamagong; *Basbas Is.; Isabela:* Basilan; 426♂, 604♀, 136 L, 62 p, 257 lp.

TAIWAN. Loh Yei; Ping Tung; Sze Chun; 7♂, 14♀, 19 L, 6 lp.

HONG KONG. 3♂, 2♀, 2 L.

CHINA. Canton; 5♂, 11♀.

JAPAN. *Ryukyus:* Iriomote; 13♂, 13♀, 26 lp.

Additional records from the literature: INDIA. Andaman Is.; Punjab (Barraud 1934); NEPAL (Peters and Dewar 1956); PAKISTAN (Aslamkhan 1971); INDONESIA: Sumba; Flores; Timor (Bonne-Wepster 1954); CHINA: Fukien; Kiangsu (Feng 1938); Amoy (Hsieh and Liao 1956); Hainan (Chu 1958).

TAXONOMIC DISCUSSION. *Culex fuscocephala* is one of the most common and widespread Southeast Asian species. The adults can be readily recognized by the slender build, relatively small size, pleural markings and in most specimens by the absence of basal abdominal bands. All of these features are very uniform except for the abdominal terga which occasionally exhibit very indistinct basal pale bands on the posterior segments. The Indian form, which was described by Barraud (1924b: 1272) as *fuscitarsis* on the basis of the presence of basal pale bands on the abdominal terga, apparently falls into the range of variation of *fuscocephala* populations from northern Thailand. Neither the Indian *fuscitarsis* specimens nor those from a few collections in northern Thailand show any differences in other adult features, the male genitalia and in the immature stages from typical *fuscocephala* specimens in several Southeast Asian areas. On this basis, I am convinced that they are conspecific with the typical *fuscocephala*. In addition to the conspicuous diagnostic characters of the adults, *fuscocephala* is also strongly differentiated from other species of *Culex (Culex)* in the female cibarial armature, the presence of a median ventral tuft in the male proboscis, the type of the male phallosome and in several features of the immature stages.

BIONOMICS. *Culex fuscocephala* is locally abundant, especially in open rural areas such as rice fields. The immature stages have been most frequently collected from general ground pools, ditches, ponds, wells, rockpools, puddles, foot prints and marshy depressions. They have also been taken from container habitats such as earthenware jars and coconut shells. Both larvae and pupae are very abundant almost throughout the year and have been frequently found in association with those of *C. tritaeniorhynchus, C. vishnui, C. pseudovishnui; Anopheles vagus* Dönitz, *An. kochi* Dönitz, *An. subpictus* Grassi and *An. nigerrimus* Giles and occasionally with *C. quinquefasciatus* and *C. gelidus*. The adults are also abundant and have been frequently collected outdoors among herds of domestic animals such as cows, water buffalo and pigs. Numerous adults have also been caught in light traps and animal baited traps. The females prefer to feed on blood of cows and pigs (Colless 1959; Reuben 1971c); but may also attack man in the absence of the preferred hosts.

MEDICAL IMPORTANCE. *Culex fuscocephala* is one of the common pests

of domestic animals such as pigs and cows in rural communities of Southeast Asia. It has been reported to be naturally infected with *Brugia malayi* (Brug) by Carter (1948) in Sri Lanka and with *Wuchereria bancrofti* by Rozeboom and Cabrera (1964) in Luzon, the Philippines, but whether or not it may play a role in the transmission of these pathogens remains to be determined. In Thailand, *fuscocephala* has been reported to be an efficient vector of Japanese encephalitis (Muangman et al. 1972) and has been found to be naturally infected with 2 strains of this virus (Gould et al. 1974).

SITIENS GROUP

FEMALE. *Head.* Proboscis with distinct median pale ring. *Cibarial Armature.* As described for the subgenus, apparently without distinctive group character. *Thorax.* Color of mesonotal scales varied from predominantly pale whitish to dark brownish on anterior 0.7 to level of anterior wing base; scales on supraalar and posterior dorsocentral areas usually dark; scales on prescutellar space and scutellar lobes partially or entirely pale, sometimes entirely dark. Pleural scale patches usually present on *ppl,* upper corner and lower posterior border of *stp,* poorly developed or absent on *mep;* some scattered scales present among upper *mep* bristles; lower *mep* bristle absent. *Legs.* Anterior surface of fore- and midfemora usually entirely dark, sometimes with speckling of pale scales; anterior surface of hindfemur usually with pale stripe extending from base to about 0.75 of total length, sometimes dark with speckling of pale scales as on fore- and mid femora; tarsomeres 1-4 of all legs with distinct basal and apical pale bands. *Wing.* All veins usually with dark scales only, or sometimes speckled, with a mixture of dark and pale scales or with pale scales aggregating into conspicuous pale spots, producing a striking pattern. *Abdomen.* Terga II-VII usually with basal transverse pale bands, sometimes with apical or apical and basal pale bands, rarely entirely dark. *Genitalia.* As described for the subgenus, apparently without distinctive group characters.

MALE. *Head.* Palpal segment 3 with median pale band on dorsal surface, ventral surface with 1-2 rows of short, distally flattened scalelike setae or fine hairlike setae along the whole length, apical 0.25-0.50 with ventrolateral tuft of strong bristles; segments 4 and 5 usually strongly long plumose and with basal pale bands on dorsal surface; apex of segment 5 usually pale to tip, sometimes entirely dark. Proboscis usually with ventral tuft of long hairs proximad of median pale ring, rarely absent entirely.

MALE GENITALIA. *Basimere.* Slender, conical, rarely modified. *Subapical lobe.* Proximal and distal divisions not clearly divided, setae in group *d-f* of distal division usually 3-4 in number, their bases largely overlapped with those of setae *a-c* in proximal division. *Distimere.* Normal, sickle-shaped, rarely modified; 1 dorsal and 1 ventral tiny setae present beyond middle. *Phallosome.* Lateral plate usually with complex inner and outer divisions, sometimes simple, with inner division only *(sinensis);* apical portion of inner division with numerous minute spicules and/or several denticles and usually with prominent crown of 3-6 strong porrect, fingerlike processes or teeth on apical tergal surface; outer division simple or complex with 1,2 mesal spines and variable number of lateral spines, all divergent laterad; sternal spine poorly or well developed, usually strongly bent basad, sometimes projecting dorsolaterad; lateral basal process variously developed. *Proctiger.* Basal sternal process varied, usually well developed, sometimes poorly developed or

absent; subbasal process usually present, poorly or well developed.

PUPA. *Trumpet.* More or less cylindrical or asymmetrically funnel-shaped; pigmentation varied from yellowish to dark brown. All setae developed, essentially as in the subgenus. *Abdomen.* Seta 1-II usually 1-7 branched or less than 10 branched, rarely more branched (*gelidus* and *tritaeniorhynchus*). *Paddle:* Usually entirely pale, sometimes with distinct color pattern; setae 1, 2-P present.

LARVA. Essentially as described for the subgenus with the following group characters. *Head.* Labrum developed as distinct transverse bar or not (*Bitaeniorhynchus* Subgroup); seta 1-C stout, flattened, spiniform or sometimes foliform. *Thorax.* Seta 4-P variously developed, usually double, sometimes single or multiple; 7-P always triple; 8-P usually double, rarely single. *Abdomen.* Seta 7-I usually single, sometimes double; comb scales varied in number, size and in apical fringe of spicules. Saddle complete, rarely incomplete; posterior caudal margin lightly to moderately spiculated; seta 1-X usually weak, double or triple, sometimes single; 4-X always with 6 pairs of setae; anal gills usually slender and longer than saddle, sometimes very short, stubby or rounded. *Siphon.* Length and shape varied, usually long, slender and distally tapered; pecten usually well developed with 10 or more teeth, sometimes poorly developed with 3-5 teeth; siphonal tufts 3-8 pairs in number, length, branching and arrangement varied, usually strong and conspicuous.

DISCUSSION. Members of the *Sitiens* Group are separated from those in the *Pipiens* Group in the adults by the presence of conspicuous pale markings on the palpus (particularly in males), proboscis and tarsi of legs as indicated in the key and as characterized above. In the majority of Oriental species, the males are also strongly characterized by the presence of a ventral tuft of long hairs in the middle of proboscis and by having the short setae on ventral surface of palpal segment 3 more or less scalelike in appearance. In the male genitalia, the presence of numerous minute spicules in the apical portion of the inner division of the phallosome, which is probably not homologous with the ventral arm in the *Pipiens* Group, is also characteristic of the *Sitiens* Group. The pupae and larvae of the *Sitiens* Group exhibit much overlap with the *Pipiens* Group. Except for the *Bitaeniorhynchus* Subgroup, the pupae and larvae of the rest of *Sitiens* Group are poorly characterized at the group level but can be distinguished from the *Pipiens* Group by several combinations of characters.

The *Sitiens* Group is largely confined to the tropics of the Ethiopian, Oriental and Australiasian regions and to the islands of the South Pacific and Micronesia with a small extension into the Mediterranean, Middle East and north and northeastern Palearctic. Within the Oriental region, the group is dominant and diverse, comprising several species most of which are restricted to Southeast Asia and adjacent areas. In this study 36 species of the *Sitiens* Group are recognized in the Oriental region and among these 5 are considered as new.

Edwards (1932) subdivided the *Sitiens* Group into 4 series: *Bitaeniorhynchus*, *Sitiens*, *Gelidus* and *Mimeticus*. This classification was based almost exclusively on the conspicuous coloration of the adults. In subsequent local studies (Baisas 1938, Belkin 1962 and Bram 1967a), Edwards' scheme has been largely followed with only slight modifications, especially in the realignment of species in the *Sitiens* series and in using the terms "group" or "subgroup" in preference to "series". In adopting subgroup categorization, the only change which has been made was that by Bram (1967a) who, following the interpretation of the *Vishnui* Group of Colless (1957a), subdivided the *Sitiens* series of Edwards into *Vishnui* and *Sitiens* Subgroups. Except for the alignment of certain species in the *Vishnui* Sugroup, the subdivision by Bram is justified.

I recognize 6 subgroups for the 36 Oriental species in the *Sitiens* Group. One of these: the *Barraudi* Subgroup is proposed for the first time, the other 5 subgroups: *Gelidus, Bitaeniorhynchus, Sitiens, Vishnui* and *Mimeticus* as categorized by Edwards (1932), Belkin (1962) and Bram (1967a) are retained except for a few changes in the arrangement of species. Each of the subgroups which contains 3 or more species, is further segregated into various complexes and the attempt is made to briefly characterize them in all stages. This scheme of classification is as follows: (1) *Gelidus* Subgroup with *gelidus;* (2) *Bitaeniorhynchus* Subgroup represented by: (a) *bitaeniorhynchus* complex with *bitaeniorhynchus, infula, luzonensis, selangorensis, pseudosinensis* and *longicornis;* (b) *sinensis* complex with *sinensis, cornutus* and *epidesmus* and (c) *geminus* complex with *geminus* and *kinabaluensis;* (3) *Sitiens* Subgroup represented by: (a) *sitiens* complex with *sitiens* and *alis;* (b) *whitmorei* complex with *whitmorei* and (c) *annulirostris* complex with *annulirostris;* (4) *Vishnui* Subgroup represented by: (a) *vishnui* complex with *vishnui, pseudovishnui, perplexus, alienus, philippinensis,* and *incognitus;* (b) *tritaeniorhynchus* complex with *tritaeniorhynchus* and (c) *whitei* complex with *whitei;* (5) *Barraudi* Subgroup with *barraudi* and *edwardsi;* (6) *Mimeticus* Subgroup represented by: (a) *mimeticus* complex with *mimeticus, fasyi, jacksoni, tsengi, mimuloides* and *diengensis* and (b) *mimulus* complex with *mimulus, murrelli, propinquus* and *orientalis.*

All of the 6 subgroups except *Gelidus* are related on the basis of the male genitalia. The *Gelidus* Subgroup as recognized here is monotypic, including only *gelidus* which is unique in the type of male phallosome and in the ornamentation of the head and mesonotum of the adults and in the larval siphon, but essentially conforms to the *Sitiens* Group in several other characters. The *Bitaeniorhynchus* Subgroup is most complex and heterogeneous in the color of the adults and in the types of male phallosome, but all species involved are basically similar in the pupal and larval stages. It shows overlap with the other 4 subgroups (*Sitiens, Vishnui, Barraudi* and *Mimeticus*) in the male genitalia and in the external adult characters but is very distinct in the larva and pupa. The *Sitiens, Vishnui, Barraudi* and *Mimeticus* subgroups are essentially similar in most features of the male genitalia but are slightly or strikingly differentiated from one another in the ornamentation of the adult (e.g. presence of pattern of pale spots on the wing in *Mimeticus* subgroup), in the special modification of certain features of the male phallosome and in the immature stages. For further discussion and characterization of individual subgroups, see the treatment under each category.

GELIDUS SUBGROUP

The *Gelidus* Subgroup is characterized by the following combination of characters: in the adults by (1) narrow decumbent scales and erect scales in center of vertex of head pure white; (2) anterior 0.7 of mesonotum covered with pure white scales; (3) scales on posterior 0.3 of mesonotum, prescutellar space and on scutellar lobes deep brown to black; (4) *apn* and *ppn* without scales; (5) anterior surface of fore- and midfemora entirely dark; (6) scales on all wing veins dark and narrow and (7) abdominal terga II-VII with basal pale bands; the male by (1) ventral surface of palpal segment 3 with short and fine hairlike setae; (2) apex of palpal segment 5 entirely dark and (3) proboscis without median ventral tuft of long hairs; the male genitalia by (1) distimere distinctly swollen at middle; (2) inner division of phallosome represented by a slender spiculose, fingerlike process; (3) outer division broad and more or

less rounded, without sharp denticles or spines and (4) basal sternal process of proctiger very thick, dark and long, curved sternad; the pupa by (1) trumpet relatively short, cylindrical or gradually distally widened and dark brown; (2) seta 1-II 20 branched and (3) paddle with distinct dark spot towards apex of midrib and in the larva by (1) labrum distinct; (2) seta 1-C dark, slender and spiniform; (3) seta 7-I single; (4) siphon short, stout, more or less fusiform (somewhat resembling *quinquefasciatus* and *hutchisoni*) and (5) spiracular chamber of siphon with distinct erect spicules.

DISCUSSION. The interpretation of the *Gelidus* Subgroup by Edwards (1932: 203) which was later followed by Bram (1967a: 247) was considered to comprise 4 species: *gelidus* Theobald 1901 and *whitmorei* (Giles 1904) from the Oriental region; *vicinus* (Taylor 1916) from Northern Australia and New Guinea and *bihamatus* Edwards 1926 from Timor, Indonesia. This classification which was based largely on the resemblance in the coloration of the head and anterior 0.7 of the mesonotum is not justified on the basis of the present study and a detailed comparison of the male genitalia. The *Gelidus* Subgroup in the present sense is restricted to *gelidus* which is differentiated from other subgroups by the unique phallosome and the peculiar swelling in the middle of distimere of the male genitalia and by the larval characters as summarized above. The affinity of *whitmorei* is apparently with the members of the *Sitiens* Subgroup to which it is now being transferred and that of *vicinus* and *bihamatus* is uncertain. The latter 2 species are probably restricted to the Australasian region and appear to form a distinct group or subgroup with affinity close to the *Sitiens* and *Bitaeniorhynchus* Subgroups as pointed out by Sirivanakarn (1974).

The relationship between the *Gelidus* Subgroup and other subgroups in the *Sitiens* Group is not clear. The adults of *gelidus* essentially conform to the *Sitiens* Group characters but the male genitalia and the larva are so strongly differentiated that it might well be considered as a distinct group separated from the rest of the *Sitiens* Group.

7. *CULEX (CULEX) GELIDUS* THEOBALD
(Figs. 15, 17, 18, 19)

Culex gelidus Theobald 1901b: 20 (♀*); Giles 1902: 421 (♀); Theobald 1903: 180 (distribution); Blanchard 1905: 316 (♀); Leicester 1908: 147 (♂, ♀); Barraud 1924a: 990 (♂*); Barraud 1924c: 428 (L*); Borel 1930: 327 (♂*, ♀, L*); Barraud and Christophers 1931: 282 (distribution).

Culex gelidus var. *cuneatus* Theobald 1901b: 22 (♀*); Theobald 1910a: 313 (distribution); Edwards 1932: 203 (synonymy).

Leucomyia gelida (Theobald), Theobald 1907: 372 (♂*, taxonomy); Theobald 1910a: 312 (distribution).

Leucomyia gelida var. *bipunctata* Theobald 1907: 374 (♂); Edwards 1932: 203 (synonymy).

Theobaldiomyia gelidus Theobald, Brunetti 1912: 462 (taxonomy).

Culex (Culex) gelidus Theobald, Edwards 1932: 203 (taxonomy); Barraud 1934: 407 (♂*, ♀, L*); Bonne-Wepster and Brug 1937: 74 (♂, ♀*); Baisas 1938: 212 (♂*, ♀*, L*, P*); Bonne-Wepster and Brug 1939: 1271 (L*); Monchadskii 1951: 262 (L*); Bonne-Wepster 1954: 119 (♂, ♀*, L*); Delfinado 1966: 144 (♂*, ♀, L*); Bram 1967a: 247 (♂*, ♀*, P*, L*); Baisas 1974: 92 (♂, ♀, P, L).

FEMALE (Fig. 15, 17). Wing: 2.3-3.2 (average 2.8 mm). Forefemur:

1.4 mm. Proboscis: 1.7 mm. Abdomen: 2.7 mm. Small to medium sized species; most clearly marked by the predominantly white scales on vertex of head and on anterior 0.7 of mesonotum. *Head.* Narrow decumbent scales on vertex pure white; erect scales numerous, largely pure white in center and on anterior ocular line, black on posterolateral area; lateral patch of broad scales beige or dingy white anteriorly, dark blue or brown posteriorly. Palpus entirely dark scaled, rather short, about 0.2 of proboscis length. Proboscis with narrow median pale ring. *Cibarial Armature.* Cibarial teeth about 25 in number, all apparently long, very fine and distally filamentous, in a concave row which is slightly produced at middle. *Thorax.* Mesonotal integument dark brown; anterior 0.7 of mesonotum densely covered with pure white scales, strongly contrasted with dark brown scales on prescutellar space, supraalar and posterior dorsocentral areas in posterior 0.3; scales on scutellar lobe entirely dark brown; middle of fossa with or without dark scales aggregating into distinct spot. Integument of pronotum dark brown; *apn* and *ppn* without any scales. Pleural integument dark brown on *ppl, ssp, psp* and upper *stp;* paratergite dark brown, rest of integument pale brown; pleural scale patches poorly developed or reduced; scales on *ppl* and upper *mep* absent; *stp* with a few scattered scales on upper corner and a minute scale patch on lower posterior border. *Legs.* Anterior surface of fore- and midfemora entirely dark scaled; anterior surface of hindfemur slightly pale on lower surface, dark on upper lateral surface; all tibiae entirely dark anteriorly; tarsomeres 1-4 of all legs with narrow apical and basal pale bands. *Wing.* All scales dark brown, plume scales on veins R_2, R_3 and R_{4+5} narrow, linear. *Abdomen.* Terga II-VI with complete basal pale bands which are strongly produced in middle; terga VII-VIII with narrow even basal pale bands; sterna II-VII, entirely pale yellow; sternum VIII largely dark. *Genitalia.* Essentially similar to most species; tergum IX with lateral row of 6, 7 setae; cerci with relatively few and weak setae; postgenital plate rounded or lightly emarginate on caudal margin; vaginal sclerite typically V-shaped; insula with a dense tuft of 10-12 setae.

MALE (Fig. 17). In general as described for female. *Head.* Palpus exceeding proboscis by the full length of segment 5; segment 3 with median pale band on dorsal surface; ventral surface with 1, 2 rows of short, fine hairlike setae, apical 0.4 with ventral lateral tuft of 10-20 dark and long bristles; segments 4 and 5 moderately to strongly plumose, dorsal surface with basal pale bands, apex of segment 5 dark to tip. Proboscis without ventral long hairs proximad of median pale ring.

MALE GENITALIA (Fig. 18). *Segment IX.* Tergum narrow, tergal lobe with a row of 6-7 moderately strong setae. *Basimere.* Normal, conical, setae adjacent to subapical lobe rather dense. *Subapical lobe.* Seta *b* of proximal division thicker and longer than setae *a* and *c;* setae *d-f* of distal division consists of 1 club-shaped blade and 2 narrower and apically pointed blades; leaf *g* broad, short, heart-shaped; seta *h* rather weak and apically hooked. *Distimere.* More or less sickle-shaped ; basal part even in width and straight, middle part distinctly swollen, apical part tapered and slightly recurved; subapical claw slender and moderately long; 1 dorsal and 1 ventral tiny setae present, ventral distad of dorsal. *Phallosome.* Lateral plate relatively simple; inner division represented by an elongate, fingerlike, strongly spiculose process, divergent laterad; outer division represented by a simple, broad rounded sclerite which is finely spiculose on outer and inner apical surfaces, inner tergal surface (in lateral view) produced into a short finely spiculose process, projecting basad. *Proctiger.* Apical crown medium sized, composed of several dark and strong spicules; paraproct very narrow; basal sternal process very

thick, long and dark pigmented, strongly curved sternad; cercal sclerite largely membranous; cercal setae 2 in number.

PUPA (Fig. 18). Abdomen: 2.5 mm. Paddle: 0.65 mm. Trumpet: 0.45 mm; index 4-5. Cephalothorax and abdomen yellowish white. Complete chaetotaxy as figured; the following are characteristic. *Trumpet.* Brownish; relatively short, distally widened; apical margin truncate; pinna broad, oblique. *Cephalothorax.* Seta 1-C usually 4, 5 branched (3-5); 3-C stronger than 1-C, usually triple (3-4); 8, 9-C usually triple (2-4). *Metanotum.* Seta 10-C 8-10 branched; 11-C usually double (2-3); 12-C 4, 5 branched. *Abdomen.* Seta 1-II multiple, about 20 branched; 5-IV usually 4 branched (3-4); 5-V usually triple (2-3); 5-VI usually double (2-3); 6-III-V usually triple (2-4); 6-VI usually 4 branched (3-4); 6-V, VI strong, about 2 times as long as 6-III, IV; 9-VII 4 branched; 4-VIII double or triple; 9-VIII 6-8 branched. *Paddle.* Largely pale whitish, with distinct dark spot towards apex of midrib; midrib weak, lightly pigmented; setae 1, 2-P present, minute.

LARVA (Fig. 19). Head: 0.7 mm. Siphon: 1.0 mm; index about 3.5. Saddle: 0.36 mm; siphon/saddle ratio 3. As figured. *Head.* Frontoclypeus with darkened spots along lateral posterior margin, rest yellowish white; seta 1-C dark, stout, spiniform; 4-C distinct, single, its length 1.5-2.0 times as long as distance between bases of the pair; 5, 6-C strong, subequal and triple; 7-C 7, 8 branched; 14-C single, minute and indistinct. Antennal shaft pale except for basal dark ring; spicules strong, relatively few in number; setae 2, 3-A subapical and pale. Mental plate with 8-10 lateral teeth on each side of median tooth. *Thorax.* Spiculation not developed; seta 4-P strong, double; 7-P usually triple (3-4); 8-P single or double; 8-M 5-7 branched; 9-M 5, 6 branched; 7-T usually 7 branched (5-8), 9-T 6, 7 branched; 12-T usually triple (2-4); 13-T 8-12 branched. *Abdomen.* Spiculation not developed; setae 6-I, II triple; 7-I single; 1-III, IV long, usually double (1-3); 1-V, VI usually 4 branched (3-5); 6-III-VI double; 13-III-V 4, 5 branched; 4, 7, 10, and 12-VII all single. Comb scales about 40, in broad oval patch; all rather short and small, with even apical fringe of fine spicules; seta 1-VIII usually 7 branched (5-7); 2 and 4-VIII single; 3-VIII 6-9 branched; 5-VIII 4, 5 branched. Saddle same color as siphon; posterior caudal margin with or without spicules; 1-X single; 2-X usually double (2-3); anal gills variable in length, dorsal pairs usually longer then ventral, 1-2 times as long as saddle. *Siphon.* Stout, short, more or less fusiform in shape; lightly to strongly brownish; pecten with 8-12 fine distally curved teeth, 4-5 distal teeth barbed with 1 strong basal denticle and 5-6 weaker distal denticles; siphonal tufts 4 regular pairs, 4, 5 branched each (3-7), all inserted subventrally, first proximal pair among or distad of pecten, its length slightly shorter than siphonal width at point of attachment, other siphonal tufts gradually shorter; seta 2-S dark and slender; median caudal filament of spiracular apparatus well developed; inner wall of spiracular chamber with a forked or simple spicule.

TYPE-DATA. (1) *Culex gelidus* Theobald, Lectotype ♀*, Kelang, *Selangor,* MALAYA (PENINSULAR MALAYSIA), A. L. Butler (BM; selection of Bram 1967a: 251); (2) *Culex gelidus* var. *cuneatus* Theobald, Lectotype ♀*, Straits Settlements, Taiping, *Perak,* MALAYA (PENINSULAR MALAYSIA), L. Wray (BM; selection of Bram 1967a: 251); (3) *Leucomyia gelida* var. *bipunctata* Theobald, Holotype ♂*, INDIA (BM).

DISTRIBUTION. Widespread throughout Southeast Asia with extension to the west in India, Burma and Sri Lanka, to the north in South China and to the south and southeast as far as Java, the Molluccas and New Guinea in Indonesia.

Material examined. 2,163 specimens: 694♂, 1,146♀, 323 L; 248 individual

rearings (105 pupal, 143 larval).

INDIA. *Bengal:* Calcutta; Lalmanirhat; Salt Lake; Dum Dum; *Assam:* Chabua; Rupsi; Jorhat; Dinjam; Dibrugarh; 25♂, 67♀, 15 L, 5 p.

SRI LANKA. Ratanapura; Anu; 2♂, 12♀.

BURMA. Rangoon: 13♂, 23♀, 12 L, 8 p, 12 lp.

THAILAND. Chiang Mai; Lampang; Udon Thani; Ayuthaya; Dhon Buri; Bangkok; Chon Buri; Trat; Rayong; Nhon Tha Buri; Phet Buri; Ranong; Krabi; Phuket; Satun; Narathiwat; 396♂, 545♀, 205 L, 78 p, 52 lp.

CAMBODIA. Phnom Penh; Ari Gsatr; 6♂, 27♀.

VIETNAM. Saigon; Vinh Long; Danang; Cam Ranh Bay; Can Tho; Gia Dinh; Phu Lam; Bien Hoa; My-Ca; Pleiku; Soc Trang; 18♂, 28♀, 14 L, 3 p, 1 lp.

MALAYSIA. *Peninsular Malaysia: Selangor;* Kuala Lumpur; Rantau Panjang; Ulu Gombak; Segambut; Bt. Kutu; Puchong; Kepong; Klang Rd.; Salak; *Perak:* Kuala Dipang; Pusing; Senlu; *Perlis:* Kg. Gunong; Chenderiang; C. Highland Rd.; Kuala Kangsar; *Pahang:* Kuantan; *Kelantan:* Tumpat; *Kedah:* Sintok; 59♂; 130♀, 34 L; 10 p, 53 lp; *Malaysia: Sarawak:* Kuching; *Sabah:* K. Belud; Kota Kinabalu (Jesselton); Papar; Tawau; Tenom; 11♂, 10♀, 2 lp.

INDONESIA. *Sumatra:* Kmp Pantai Pandjang; Belakang Pandok; Kebon Ros; Tand Jungkarang; Bengkulu; *Kalimantan (Borneo):* Tarakan; Kalabakan; *Java:* Djakarta; *Sulawesi:* Makassar; *Molluccas:* Morotai; 8♂, 50♀.

PHILIPPINES. *Luzon:* Los Banos; S. Fernando; La Union; Bulacan; Camp Stotsenberg; Camp Nichols; S. Fabian; Rizal, Wack Wack; *Mindoro:* San Jose; *Samar:* S. Antonio; Osmena; *Palawan:* Panitan; Tinabog; Calaccad; Iwahig; *Leyte:* Dulag; Abuyog; Carigara; Tacloban; Bay Bay; Mahaplag; *Basilan:* Isabela; *Calicoan Is.:* Sanga Sanga; Lapit Lapit; *Tawi Tawi Is.:* Kamagong; Tarawakan; Mindanao: Parang; Kabakan; Pangasinan; *Jolo Jolo Is.:* Sulu; 156♂, 254♀, 43 L; 1 p, 23 lp.

Additional records from the literature. CHINA: Canton (Kwangtung); Hainan Is.; HONG KONG (Feng 1938: 300, Chu 1958: 109). FORMOSA (TAIWAN); INDIA: Bombay; Deccan; Madras, Nilgiri Hills; Southwest Coast; Bengal: Chittagong, Sukna; Bihar; Assam: Nongpoh, Dimapur (Barraud 1924a: 991; Barraud 1934: 409). INDONESIA: Simaloer; Lombok; Soemba, Alor, New Guinea (Brug and Bonne-Wepster 1947: 187).

TAXONOMIC DISCUSSION. *Culex gelidus* is extremely uniform, exhibiting constant diagnostic characters in all stages without any indication of local or geographic differentiation. The only variations noted in the adults are the presence of absence of dark scale spots in the middle of the fossae and the dark streak in the middle of acrostichal line on the anterior 0.7 of the mesonotum. These variations are nothing more than the normal ones observed in several series of reared or field caught specimens from different localities.

Culex gelidus is one of the most common and best known Southeast Asian species. The adults are conspicuously marked, with predominantly pure white scales on the head and on the anterior 0.7 of mesonotum. The only other Oriental species which exhibits more or less similar ornamentation is *whitmorei*. The adults of *gelidus*, however, differ from *whitmorei* rather strikingly in (1) absence of speckling of pale scales on the anterior surface of mid- and hind-femora; (2) scales on posterior 0.3 of mesonotum (including prescutellar space and scutellar lobes) entirely dark (pale whitish in *whitmorei*) and (3) scales on wing vein R_{4+5} narrow and considerably less dense (broad and very dense in *whitmorei*). In addition, *gelidus* adults also differ strikingly from all other Oriental members of the *Sitiens* Group in the absence of scales on *apn* and *ppn* and in the considerable reduction of scales on propleuron and stenopleuron. The female cibarial armature of *gelidus* is also distinctive and can be distin-

guished from all other *sitiens* species except *tritaeniorhynchus* in having filamentous teeth. The male genitalia of *gelidus* are unique in the relatively simple phallosome which separates it from the rest of the *Sitiens* Group. The immature stages show much overlap with all other members of the *Sitiens* Group in the pupal and larval chaetotaxy. The pupa can be readily recognized by the relatively short and brownish trumpet; seta 1-II multiple and by the presence of dark spot towards apex of the paddle; and the larva by the short, stout and fusiform siphon and by the presence of distinct erect spicules on the inner wall of spiracular chamber. The presence of spicules in the spiracular chamber of the larval siphon has not been known or described in any other species of *Culex*. This character has been found to be useful in separating *gelidus* larva from those of *quinquefasciatus* which it strongly resembles in the shape of the siphon.

BIONOMICS. *Culex gelidus* has been found closely associated with man and his domestic animals, such as cows, water buffalo and pigs in rural or urban communities of Southeast Asia. The recorded breeding sites of *gelidus* include: puddles, pools, ponds, ditches, drains, streams, rice fields and marshy depressions which usually contain abundant aquatic vegetation such as water lilies, hyacinths, duckweeds and grasses. The water ranges from fresh and clear to strongly colored with contamination from decayed organic matter and mud particles. On occasion, it has also been found breeding in tanks, barrels, earthenware pots and coconut shells. The immatures and adults occur throughout the year, but to date nothing is known about their relative abundance during different seasons as well as the factors which affect their population size. Adults of *gelidus* have been frequently collected in number from light and animal baited traps. They occasionally enter houses at dusk and several females were caught biting man. The natural or preferred hosts of *gelidus* are cows and pigs (Colless 1959; Macdonald et al. 1967), but man is also readily attacked as an alternative host. In Malaya and Sarawak it was also reported to feed on other animals including: water buffalo, goats, deer, chickens and wild birds (Gould et al. 1962; Hill et al. 1969).

MEDICAL IMPORTANCE. Adults of *gelidus* were reported to be naturally infected with *Brugia malayi* in Sri Lanka by Carter (1948) and with *Wuchereria bancrofti* in Travancore, India by Iyengar (Raghavan 1961) but the incidence of these pathogens were very low, indicating that this species does not play a role in the natural transmission of these diseases. In epidemiological and experimental transmission studies of Japanese encephalitis virus, *gelidus* has been incriminated as a vector of this disease in Malaya (Gould et al. 1962) and Sarawak (Macdonald et al. 1967). In Thailand, Simasathien et al. (1972) reported that more strains of JE virus were isolated from *gelidus* than from *tritaeniorhynchus* and suggested that it may be more important than the latter in the transmission of the disease in that country. In the recent studies on virus isolations, *gelidus* was reported to be naturally infected with 3 strains of JE virus and 2 strains of Tembusu virus in Chiang Mai, Thailand (Gould et al. 1974) with 2 strains of JE virus in Saigon, Vietnam (Nguyen et al. 1974). These data strongly suggest that *gelidus* is probably one of the most important vectors of JE virus in Southeast Asia.

BITAENIORHYNCHUS SUBGROUP

The *Bitaeniorhynchus* Subgroup is characterized by the following combination of characters: in the adults by (1) large size (wing length usually over 4.0 mm); (2) erect scales of vertex varying from partially pale in center and dark

on posterolateral areas to completely dark; (3) anterior 0.7 of mesonotum varying from predominantly pale beige, whitish, yellowish or golden to dark brown; (4) scales on posterior 0.3 of mesonotum laterad of prescutellar space dark brown; (5) scales on prescutellar space and scutellar lobes partially pale to completely dark brown; (6) *apn* and *ppn* with several narrow scales; (7) anterior surface of femora and tibiae varying from lightly to heavily speckled with pale scales or completely dark; (8) wing scales entirely dark or lightly to heavily speckled; (9) abdominal terga II-VII with apical or basal pale bands or both sometimes absent or completely dark; the male by (1) ventral surface of palpal segment 3 with numerous dark short, hairlike setae; (2) apex of segment 5 and bristles largely pale yellowish and (3) proboscis with prominent median ventral tuft of several long hairs; the male genitalia by (1) distimere normal, sickle-shaped; (2) inner division of phallosome varied; simple or complex, with or without prominent apical tergal crown of 4-5 strong fingerlike processes or teeth, sometimes with a subapical tergal lobe bearing 2-4 foliform processes; (3) outer division simple and broad, leaflike or with distinct median, lateral and sternal spines, sometimes largely degenerate or not developed *(sinensis)* and (4) basal sternal process of proctiger varying from short, slender and pale to very long, thick and dark; the pupa by (1) trumpet asymmetrically funnel-shaped; (2) seta 1-II usually single to triple or at most 5 branched and (3) paddle varying from largely pale to partially darkened and in the larva by (1) head capsule comparatively smaller than in other subgroups; (2) labrum (or preclypeus) not apparent or very poorly developed; (3) teeth of mental plate varied from relatively few, strong and distinct to numerous, minute and indistinct; (4) setae 2 and 4-VIII 2-7 branched; (5) comb scales varied, usually large, spinelike, 4-5 in number, sometimes small, 10-11 in number; (6) siphon slender, long, with 3-5 pairs of subventral tufts; (7) median caudal filament of spiracular apparatus well developed and (8) anal gills long and tracheate.

DISCUSSION. The *Bitaeniorhynchus* Subgroup as interpreted here corresponds to the *Bitaeniorhynchus* Series of Edwards (1932: 202-3) and to the *Bitaeniorhynchus* Subgroup of Belkin (1962: 202) and Bram (1967a: 257). This subgroup occupies a very broad range of distribution, covering the Ethiopian, Oriental and Australasian regions, Micronesia and the South Pacific. All members of the subgroup are inland species with breeding habitats more or less restricted to fresh water ground pools and stagnant streams which contain masses of green algae. The *Bitaeniorhynchus* Subgroup is apparently better represented within the Oriental region than anywhere else. In this study 11 species have been recognized. It is quite possible that more species will be discovered in certain parts of the Indomalayan areas, such as Borneo, small and major islands of Indonesia, and the Philippines, when more extensive collections are made.

The members of the *Bitaeniorhynchus* Subgroup are strongly differentiated from the rest of the *Sitiens* Group in the pupa and larva. The pupa is readily recognized by the relatively large size and the short, asymmetrically funnel-shaped trumpet and the larva by the reduced head capsule, the absence of labral bar (sclerite), setae 2 and 4-VIII 2-7 branched (single in all other members of the *Sitiens* Group), the reduction in number and size of the pecten teeth and the tracheate anal gills. The adults of the majority of species are well marked by the coloration of the mesonotum, legs, wing and abdomen. Some also exhibit a strong sexual dimorphism in coloration not usually found in the other species of *Culex*. The male genitalia exhibit a vast array of modification in the phallosome, from simple to complex, overlapping with that in the

other subgroups of the *Sitiens* Group. The extreme diversity of forms and the very broad range of distribution seem to suggest that the *Bitaeniorhynchus* Subgroup has existed for a long time and probably represents the original ancient stock of the *Sitiens* line from which other subgroups, including: *Sitiens, Vishnui, Barraudi, Mimeticus* and perhaps also *Gelidus* were derived.

On the basis of comparative male genitalia and larval stage, the 11 Oriental members of the *Bitaeniorhynchus* Subgroup apparently fall into 3 more or less distinct complexes: *bitaeniorhynchus, sinensis* and *geminus*.

The *bitaeniorhynchus* complex includes: *bitaeniorhynchus* (type form), *infula, luzonensis, selangorensis, pseudosinensis* and *longicornis*. This complex is characterized in the male genitalia by (1) the rudimentary or short and slender basal sternal process of the proctiger; (2) apical spiculate portion of the inner division of the phallosome enlarged, elongated, in form of a long beak or stout, resembling the blade of an ax; (3) tergal surface of the inner division with a distinct lobe, bearing 2-4 foliform processes subapically or at some distance from the apical tergal angle of apical spiculate portion and (4) outer division represented by a very broad, acuminate leaf; in the larva by (1) setae 2 and 3-A apical or slightly subapical and (2) mental plate with numerous delicate, indistinct lateral teeth whose apices are in straight line. The members of the *bitaeniorhynchus* complex show much overlap with one another in one or more stages and some of them may be difficult to differentiate. To insure correct identification, all stages of each member in this complex should be examined.

The *sinensis* complex includes *sinensis, cornutus* and *epidesmus* and is characterized in the male genitalia by (1) the large, heavy and long basal sternal process of the proctiger; (2) apical spiculate portion of inner division of phallosome slender, distally tapered or broad and rounded; (3) tergal surface of the apical spiculate portion with or without a slender lobe bearing 1-2 narrow, elongate teeth subapically and (4) outer division not developed or developed as a broad lobe bearing a strong mesal spine and a variable number of denticles or tubercles laterally; in the larva by (1) setae 2 and 3-A situated far below the apex and (2) mental plate with 10-12 distinct lateral teeth. The larva of the *sinensis* complex as characterized here is based only on those of *sinensis* and *cornutus*. The larva of *epidesmus* is still unknown, however, its male genitalia are extremely similar to *cornutus* to which it is undoubtedly related.

The *geminus* complex includes *geminus* and *kinabaluensis*, both of which are related to *squamosus* (Taylor 1913) from New Guinea (Assem and Bonne-Wepster 1964: 128) and the Solomon Islands (Belkin 1962: 214) and to *albinervis* Edwards 1929 from the Fiji Islands (Belkin 1962: 212). Both Southeast Asian species in this complex and *squamosus* strongly resemble those of the *Sitiens, Vishnui* and *Mimeticus* Subgroups in the male phallosome, but are exceedingly similar to the *bitaeniorhynchus* and *sinensis* complexes in the pupa and larva. The *geminus* complex is characterized in the male genitalia by (1) the presence of a long and thick basal sternal process of the proctiger; (2) apical spiculate portion of inner division of phallosome not enlarged or distally expanded; (3) tergal surface of the apical spiculate portion with a prominent crown of 3-6 strong, fingerlike processes projecting beyond upper margin of apical sternal portion and (4) outer division represented by a broad lobe bearing mesal, lateral or also sternal spines; in the larva by (1) setae 2 and 3-A apical or subapical and (2) mental plate with a number of strong distinct lateral teeth on each side of a large median tooth, followed by several delicate indistinct lateral teeth towards lateral angle.

8. *CULEX (CULEX) BITAENIORHYNCHUS* GILES
(Figs. 15, 20, 21, 22)

Culex bitaeniorhynchus Giles 1901a: 607 (adult); Edwards 1913b: 231 (taxonomy, in part); Edwards 1921: 337 (distribution, in part); Edwards 1922a: 282 (♂*, ♀, taxonomy, in part); Barraud 1923a: 936 (L*); Barraud 1924a: 984 (♂*, ♀, in part); Borel 1930: 316 (♂*, ♀, L*, in part); Ho 1931: 149 (♂*, ♀).

Taeniorhynchus ager Giles 1901b: 196 (♂, ♀); Edwards 1912: 30 (♀*); Edwards 1913b: 231 (synonymy).

Culex karatsuensis Mochizuki 1913: 28 (♂*, ♀*, E); Edwards 1932: 202 (synonymy).

Culex (Culex) bitaeniorhynchus Giles, Edwards 1932: 202 (taxonomy); Barraud 1934: 391 (♂*, ♀*, L*, in part); Bonne-Wepster and Brug 1937: 73 (♂, ♀); Baisas 1938: 211 (♂*, ♀*, P*, L*, in part); Bohart 1945: 78 (♀, L); Bohart and Ingram 1946: 77 (♂*, ♀, L*); Mohan 1950: 167 (biology); LaCasse and Yamaguti 1950: 201 (♂*, ♀*, P*, L*); Asanuma and Nakagawa 1953: 93 (P*); Delfinado 1966: 140 (♂*, ♀, P, L*, in part); Bram 1967a: 258 (♂*, ♀*, P*, L*, in part); Sirivanakarn 1973: 235 (taxonomy); Baisas 1974: 88 (♂*, ♀*, P*, L*).

FEMALE (Fig. 15, 20). Wing: 4.3 mm. Forefemur: 2.0 mm. Proboscis: 2.0 mm. Abdomen: 3.0-3.2 mm. Medium to large sized species; distinguished from other members of the *Bitaeniorhynchus* Subgroup by the extensive speckling of pale scales on anterior surface of femora and tibiae of legs, the extensive speckling of pale scales on all wing veins, veins R_2, R_3 and R_{4+5} with relatively broad plume scales and by the presence of only broad apical pale bands on abdominal terga II-VII in both sexes. *Head.* Narrow decumbent scales of vertex pale, yellowish or beige; erect scales numerous and coarse, usually pale, golden or bronzy in center, dark brown on posterolateral areas, sometimes predominantly dark brown; lateral patch of broad appressed scales largely pale along eye margin, dark posteriorly. Palpus about 0.2 of proboscis length, segments 3 and 4 with sprinkling of pale scales, apex of segment 4 usually tipped with pale whitish scales. Proboscis relatively thick, as long as or slightly shorter than forefemur; labium with a broad median light ring and usually also with a narrow apical light ring; basal portion proximad of median ring lightly sprinkled with pale scales. *Cibarial Armature.* Cibarial bar concave and lightly produced at middle; cibarial teeth about 30 in number, median 4-6 teeth narrow and pointed apically, lateral teeth shorter, thick and coarse, apically blunt or truncate. *Thorax.* Anterior 0.7 of mesonotum usually predominantly pale, beige, yellowish or golden scaled, with or without mottling of some dark brown scales, forming a pair of dark spots in middle of fossae or distinct blotches and streaks elsewhere; sometimes predominantly brownish with indefinite pale areas; scales on posterior 0.3 of mesonotum dark brownish on posterior dorsocentral and supraalar areas; prescutellar space largely dark scaled in middle, pale towards posterior margin; mid-scutellar lobe dark scaled anteriorly, pale scaled on caudal margin; lateral scutellar lobes entirely pale scaled. *Apn* and *ppn* with several narrow dark, golden or bronzy scales; ppn with 2 rows of 4-6 strong and 5-7 weak bristles on posterior border. Pleuron with a small pale scale patch on *ppl*, upper corner and posterior border of *stp; mep* usually bare or with a few pale scales on upper anterior surface; a few scales usually present among upper *mep* bristles; *ppl* bristles 10-12

in number. *Legs*. Anterior surface of all femora heavily and extensively speckled with pale scales; anterior surface of all tibiae moderately speckled; tarsomeres of all legs usually lightly speckled; tarsomere 1-4 with narrow apical and broad basal pale bands. *Wing*. All wing veins with an equal mixture of pale yellow and dark scales or extensively and heavily speckled; squame and plume scales on veins R_2, R_3 and R_{4+5} broad, ovate. *Abdomen*. Median caudal scale patch of tergum I usually pale, sometimes entirely dark; terga II-VII with evenly broad, yellow or beige apical bands, varying from 0.3 to 0.5 of segment length; basal pale band absent or not developed; basolateral pale spots present; dark scaled areas lightly to heavily sprinkled with pale scales; tergum VIII with a narrow apical and broad basal pale bands; sterna II-VII largely pale yellowish except for dark scaled patches on lateral apical portion. *Genitalia*. Terga IX with lateral row of 4-7 bristles; postgenital plate broadly rounded or slightly emarginate on caudal margin; vaginal sclerite well sclerotized, V or U-shaped; insula with a tuft of 10-12 setae.

MALE (Fig. 20). In general similar to female except for less dense scales and less speckling of wing and for having more numerous *ppl* bristles (about 20). *Head*. Palpus very long, exceeding proboscis by nearly length of segments 4 and 5 combined; segment 3 with a broad median pale band and light sprinkling of pale scales proximad or distad of band on dorsal surface, ventral surface with numerous short, dark and hairlike setae along the whole length, apical 0.4-0.5 with ventral lateral tuft of about 30 strong bristles, upper inner surface with a row of 8-10, widely spaced, weak and long setae in apical 0.5; segments 4 and 5 upturned, strongly long plumose, with distinct basal pale band and a few scattered pale scales distad of band on dorsal surface, bristles and scales in apical 0.4-0.5 of segment 5 largely pale yellowish. Proboscis with prominent ventral tuft of several long hairs at base of median light ring. Antenna slightly shorter than proboscis, flagellar whorls strongly plumose.

MALE GENITALIA (Fig. 21). *Segment IX*. Tergal lobe with 4-8 strong setae. *Basimere:* Slender, conical; about 0.32 mm in length. *Subapical lobe*. Setae *a-c* of proximal division rather short, setae *a, b* stout; seta *c* very slender, distad of *a-b*, all with hooked apices; setae in group *d-f* of distal division consist of 1 narrow, lanceolate seta; 3 apically hooked, flattened, rodlike setae and 1 small, hairlike seta, all placed mesad and distad of setae *a-c* of proximal division; leaf *g* rather short, narrow and lanceolate, seta *h* strong, as long as leaf *g*. *Distimere*. Typically sickle-shaped; apical 0.25 smooth, without crest of spicules or serration; 1 tiny ventral and 1 dorsal setae present beyond middle, ventral distad of dorsal; subapical claw moderately long, apparently bilobed. *Phallosome*. Apical spiculate portion of inner division of lateral plate prominent, with apical sternal angle strongly produced sternad into a beak, its length (measured from the posterior margin of inner division to apex of beak) about 0.05-0.06 mm; apical tergal angle short, obtuse or slightly produced; apical margin usually smoothly curved, sometimes very lightly depressed distad of apical tergal angle; inner tergal surface with a distinct lobe bearing 2-3 budlike processes, situated far below apical tergal angle; outer division in form of a simple and broad acuminate leaf which is variable in size; lateral basal process distinct, knoblike. *Proctiger*. Apical crown medium sized, composed of about 5 flat and blunt spicules and numerous spinelike spicules; basal sternal process very short, slender and pale, 0.04 mm in length, sometimes not developed or absent; cercal setae tiny, 3-4 in number.

PUPA (Fig. 21). Abdomen: 4.0 mm. Paddle: 1.0 mm. Trumpet: 0.9 mm. Cephalothorax and abdomen yellowish white; integument immediately

surrounding alveoli of all setae of abdomen, metanotum and sometimes also cephalothorax usually very dark, producing a striking spotted pattern. Complete chaetotaxy as figured, the following are characteristic. *Trumpet.* Asymmetrically funnel-shaped and strongly bent upwards, apical margin of pinna straight, about 0.3-0.5 mm in length. *Cephalothorax.* All setae weak, short, some of which are rather indistinct; seta 1-C usually double (1-3); 2-C triple; 3-C 1-3 branched; 4-C 2-4 branched; 5-C 2-5 branched; 6-C triple; 7-C usually double (2-3); 8-C 1-3 branched; 9-C usually double (1-2). *Metanotum.* Seta 10-C usually 7, 8 branched (6-10); 11-C usually single (1-2); 12-C weak, very short, 2-4 branched. *Abdomen.* Setae 3-I-III usually single, rarely double; 1-II single or forked distally into 4, 5 branches; 6-I-VI all single; 6-V, VI very strong and dark; 1-III 6-9 branched; 1-IV 4-6 branched; 1-V, VI and 5-IV, VI subequal, dark, flattened, shorter than segments following and usually double (2-3); 1-VII single or double; 9-VII flattened and dark, 3-5 branched; 4-VIII usually double (1-3); 9-VIII 5-8 branched. *Paddle.* Very broad, semispherical; inner part darkened or infuscated; outer part pale; basal external margin of outer part pale; midrib weak and pale; setae 1, 2-P present, very minute.

LARVA (Fig. 22). Head: 0.65 mm. Siphon: 2.0 mm, index 7-10. Saddle: 0.45 mm; siphon/saddle ratio 4.4. *Head.* Relatively small; ocular bulge not prominent; labral sclerite absent or not developed; anterior margin of frontoclypeus strongly emarginate or concave; seta 1-C pale, long and apically pointed, its length as long as or slightly exceeding distance between bases of the pair; 3-C slightly laterad of 1-C; 4-C single or double, about as long as distance between bases of the pair; 5-C usually triple (2-4); 6-C double; 7-C 4-7 branched; 8-C triple; 9-C 4, 5 branched; 10-C double; 11-C very distinct, usually single (1-2); 12-C very weak, triple; 13-C single or double; 14-C single, filiform; 15-C double or triple. Antenna slender and relatively short, about 0.5 of head length; pigmentation of antennal shaft variable from entirely pale to lightly darkened from base to apex; spicules strong, widely scattered and more or less restricted to basal 0.5, seta 1-A plumose, about 20 branched; 2, 3-A slightly subapical or almost apical. Mental plate black, outer profile triangular and with numerous delicate, closely packed lateral teeth on each side of a poorly differentiated median tooth. Mouth brush filamentous and much less numerous than most forms of *Culex (Culex).* *Thorax.* Not spiculate; seta 0-P weak, pale, 10-15 branched; 1-3-P single; 4-P about 0.5 of the length of 1-3-P, usually single or double (1-3); 7-P usually triple (3-4); 8-P as long as 4-P, usually double (1-3); 9, 10-P weak, short and usually double (1-2); 1-4-M weak and short; 1-M single; 2-M 4 branched; 3-M single; 4-M 2-4 branched; 8, 9-M 4-8 branched; 1-4-T pale, indistinct; 2-T triple; 3-T 4 branched, 4-T 4, 5 branched, 7-T usually 6, 7 branched (5-8); 9-T usually 6 branched (5-6); 12-T single or double; 13-T 4, 5 branched. *Abdomen:* Not spiculate; most dorsal setae 1-4 and ventral setae 10-13 of segments I-VII very weak and inconspicuous; 4-I short, weak and pale, 7-9 branched; 6-I, II strongly pectinate, usually triple (3-4); 7-I single; 1-III-VI very short and weak, double or triple, 4-V pale, 5-8 branched; 4-VI pale, 3-5 branched; 6-III-VI strongly pectinate; 6-III 3-5 branched; 6-IV-VI usually triple (2-4); 1-VII double; 4-VII 2-4 branched; 7-VII double; 10-VII 3-4 branched, 12-VII double; 13-VII usually triple. Comb scales usually 4, 5, sometimes 6, 7 in single row; all large, subequal, with prominent, long and simple apical spine and a broad basal sclerotized plate, fringe of fine spicules restricted to base; seta 1-VIII usually 6 branched (6-7); 2 and 4-VIII 2-4 branched; 3-VIII usually 6 branched (5-7); 5-VIII 4 branched. Saddle complete; lateral posterior margin unspiculated; seta 1-X double or triple; 2-X usually triple (1-4); 4-X with 6 pairs of setae; anal gill strongly tracheate,

1-2.5 times as long as saddle. *Siphon:* Slender, long and distally tapered, color yellowish white; pecten very poorly developed, usually with 3-5 indistinct teeth (3-8); larger teeth with 2-3 denticles; siphonal tufts usually 4 pairs (total 8) in number, sometimes 3.5 pair (total 7), all weak, widely spaced, pairing more or less regular, 2,3 branched each, inserted subventrally, slightly shorter than siphonal width at point of attachment; seta 2-S dark, spiniform and relatively long; median caudal filament of spiracular apparatus very well developed.

TYPE-DATA. (1) *Culex bitaeniorhynchus* Giles, Type (lost), Travancore, *(Madras State),* INDIA (NE): (2) *Taeniorhynchus ager* Giles, Lectotype ♂* with attached genitalia mount, *Madras,* INDIA, Paddy field, 24 December 1899, Capt. Cornwall (BM; selection of Bram 1967a: 263); (3) *Culex karatsuensis* Mochizuki, Type unspecified, Karatsu, *Kyushu,* JAPAN (LU).

DISTRIBUTION. Very widespread throughout the Oriental region with the range extending north into the Palearctic (China, Japan, Korea and possibly also in USSR), east and south into the Australasian region (New Guinea and Northern Australia); Micronesia and the South Pacific and west into the Middle East and the Ethiopian region. Material examined. 1,980 specimens: 712♂, 872♀, 392 L; 516 individual rearings (199 pupal, 317 larval).

PAKISTAN. Lahore: Kahna Kacha; 5♀.

INDIA. *Bombay; Madras:* Travancore (type locality); *Assam:* Chabua; Dibrugarh; Jorhat; Dooma Dooma; Ledo; Lalmanirhat; *Bengal:* Calcutta; Dum Dum; *N. W. Prov.:* Shahjahanpur; *Andaman Is.*; 35♂, 50♀, 5 L, 2 p, 1 lp.

BANGLADESH. Sylhet: 6♀.

SRI LANKA. *Central Province:* Kandy District, Laksapana; Peradeniya; *North Central Province:* Anuradhapura District, Padaviya, Irrigation Bungalow; *Sabaragamuwa Province:* Ratnapura District, Panamure; Uva, P. Madulsima; Suduganga; 18♂, 23♀.

THAILAND. Chiang Mai; Lampang; Mae Hong Son; Ubon Ratchathani; Udon Thani; Nakhon Ratchiasima; Nakhon Nayok; Sara Buri; Pathum Thani; Nontha-buri; Bangkok; Than Buri; Rat Buri; Kanchanaburi; Chon Buri; Rayong; Trat; Prachuap Khiri Khan; Rangong; Surat Thani; Satun; Songkhla; Narathiwat; 361♂, 379♀, 250 L, 177 p, 177 lp.

VIETNAM. Saigon; Dalat; Danang; Phu Bei; Long Khanh; Qui Nhon; An Khe; Cu Chi; Con Son; Quang Tinh; 16♂, 15♀, 14 L, 3 p, 2 lp.

CAMBODIA. Ari Gsatr; 2♂.

MALAYSIA. *Peninsular Malaysia: Selangor:* Kuala Lumpur; Rantau Panjang; Seremban; Ulu Langat F. R.; Ulu Gombak; *Pahang:* Bukit Pakoh; Pdg. Tungku K. Lipis; Kuantan; Pulau Tioman; *Perak:* Kuala Kangsar; Lang Gunong; Chenderiang; *Perlis:* Kg. To Kayaman; *Penang Is.; Kelantan:* Bertam; *N. S. (Negeri Sembilan):* Bahau; Kg. Ulu Serting; Pedas; *Johore:* Kangkar Dohol; *Malaysia: Sabah:* Mt. Kinabalu; Semporna; 83♂, 81♀, 34 L, 8 p, 31 lp.

INDONESIA. *Sumatra:* Bengkulu; *Java:* Djakarta; Bogor; Solo; 9♂, 10♀.

PHILIPPINES. *Luzon:* Subic Naval Base; Agoo La Union; Concepcion, Tarlac; Olongapo; Camarines; Rizal, Camp Nichols, Mariguina, Wack Wack, Camp Stotsenberg; Sapangbato; Pampanga; Dalton, N. Vizcaya, Bagiuo; Trinidad; Paranaque; *Mindoro:* San Jose; *Palawan:* Irahuan; *Samar:* Osmena: *Leyte:* Gulf; Lago Lago, Bay Bay; *Cebu:* Toledo Rd.; *Negros:* La Carlota; *Mindanao:* Kolambugan; Parang; Zamboanga; Torrey Barrack; Kabakan; *Jolo Jolo Is.; Tawi Tawi:* Kamagong, Tarawakan; 103♂, 142♀, 24 L, 3 p, 60 lp.

TAIWAN. Ping Tung; Takeng; Nan Tou; 9♂, 17♀, 17 L.

HONG KONG. 6♂, 13♀, 6 p, 1 lp.

CHINA. Hainan; Peiping; Canton; Soo Chow; Chengtu; 8♂, 9♀.

JAPAN. Honshu: Saitama Sagiyama; Yodo; Kyoto; Tokyo; Okayama; Nara;

Nagasaki; 12♂, 29♀, 13 L. *Ryukyus:* Okinawa; Iriomote; 52♂, 75♀, 24 L, 45 lp. KOREA. Seoul; Koje-do; Songdo; Chinhae; 10♂, 18♀, 11 L.

Additional records from the literature: BURMA: Mandalay; INDIA: Andaman Is. (Barraud 1924: 986); BANGLADESH (Aslamkhan 1971); SINGAPORE (Colless 1959); IRAN: Khosh-hengam, Bandar-Abbas (Lotfi 1970: 399-403); ETHIOPIAN REGION: Tanganyika; Uganda; Sudan; Kenya; Belgian Congo (Edwards 1941: 290-1); USSR (Monchadskii 1951); INDONESIA: Sumba; Flores; Alor; Timor; Ceram; New Guinea (Bonne-Wepster 1954: Assam and Bonne-Wepster 1964); SOUTH PACIFIC: New Caledonia; AUSTRALIA: Northern Territory; Queensland; New South Wales (Belkin 1962: 215-7); MICRONESIA: Palau (Bohart 1956 (1957): 84-5).

TAXONOMIC DISCUSSION. *Culex bitaeniorhynchus* is the most common and widespread species of the *Bitaeniorhynchus* Subgroup in Southeast Asia and adjacent areas. The single type female of *bitaeniorhynchus* originally described by Giles (1901b: 607), was lost. The only other type which is still in existence and was apparently the one used by Edwards (1922) in referring to typical *bitaeniorhynchus* is that of *ager* (Giles 1901). The latter nominal form had been considered as one of the synonymys of this species (Edwards 1913b, 1922, 1932; Barraud 1934), but whether or not it is actually conspecific with the true *bitaeniorhynchus* can not be definitely determined in the absence of the original type. In this study, I am following Edwards (1922) in using the name "*bitaeniorhynchus*" for this form, but am excluding all other varietal names or synonyms except *ager* (Giles) and *karatsuensis* Mochizuki from the previous synonymy.

The above description has been based on the study of material from the Oriental region and from Japan, Korea and China in the eastern Palearctic. Records of the species elsewhere may require confirmation in the light of present taxonomic interpretation.

Culex bitaeniorhynchus can be distinguished from other members of its subgroup in all stages by the following combination of characters. In the adults by (1) anterior surface of femora, tibiae and tarsomeres 1 of all legs heavily and extensively speckled with pale scales; (2) all wing veins with extensive speckling of pale scales; (3) wing veins R_2, R_3, R_{4+5} with very broad squame and plume scales; (4) abdominal terga II-VII with evenly broad apical pale bands only and (5) dark scaled areas of all abdominal terga usually heavily sprinkled with pale scales; in the male genitalia by (1) distal division of subapical lobe of the basimere with a distinct lanceolate leaf in addition to leaf *g*; (2) apical spiculate portion of phallosome prominent, typically long, beaklike with more or less smoothly curved apical margin and with blunt or smoothly rounded apical tergal angle; (3) basal sternal process of the proctiger usually absent or poorly developed and unpigmented; in the pupa by (1) presence of pattern of dark alveolar spots on all abdominal segments, metanotum and sometimes also on cephalothorax; (2) inner part of paddle darkened or lightly infuscate; (3) seta 11-C usually single; (4) setae 3-I-III usually single; in the larva by (1) siphon usually with 4 pairs of subventral tufts; (2) comb scales large, usually 4, 5 in number; (3) setae 1-4 and 10-13 of segments I-VI usually very weak, pale and rather indistinct; (4) seta 4-V usually 5-8 branched and (5) seta 4-VI usually 3-5 branched.

The adults of *bitaeniorhynchus* exhibit much variation in the color of the mesonotal scales in both sexes. Specimens normally have the scales on the anterior 0.7 of mesonotum predominantly pale beige to white, contrasting rather sharply with the dark scaled areas on the posterior 0.3. However, these scales are sometimes predominantly dark with variable amount of pale

scales forming spots or streaks, particularly on posterior acrostichal and dorsocentral lines cephalad of prescutellar space. In Southeast Asia the pale form is predominant and has been found to be quite homogeneous, especially in the northern parts of its range, including China, Japan and Korea.

The typical *bitaeniorhynchus* is closely related to *infula, luzonensis, selangorensis, pseudosinensis* and *longicornis,* with which it overlaps in one or more stages, and apparently falls into a distinct complex. Within Southeast Asia (except the Ryukyus), it has been frequently found generally or closely sympatric with every member of this complex. In southern and central Thailand, Malaysia, the majority of *bitaeniorhynchus* specimens are usually found in the same habitats as the dark and pale forms of *infula* but whether or not it may occasionally hybridize with the latter species is unknown.

BIONOMICS. *Culex bitaeniorhynchus* is a rural species and is more or less restricted to breeding in large, semi-permanent or permanent ground pools such as swamps, rice fields, marshy depressions, irrigation ditches, ponds, logs and obstructed streams. On several occasions, the pupae and larvae have also been collected from puddles, foot prints and small ground pools at margins of swamps, streams, rivers and canals. These breeding sites are under shade or fully exposed to sunlight, in or near forest, in plains or mountainous areas at a broad range of elevation. The water is usually fresh and clear and always filled with a dense mass of filamentous green algae. The larvae are dependent on algae as food and shelter. Mohan (1950), in a study of a laboratory colony of *bitaeniorhynchus* (type form) reported that the presence of green algae was absolutely essential for the normal development and survival of the larvae and in inducing females to deposit eggs. In Thailand, Vietnam and Peninsular Malaysia, adults of both sexes have been caught in number in light traps and several females have been taken biting or landing on man. The females apparently feed on blood of a variety of hosts, including man, cows, buffalo, pigs, dogs and chickens (Colless 1959; Reuben 1971b; Sasa and Sabin 1950) and rabbits (Mohan 1950). In Madras, India (Christopher and Reuben 1971), Singapore (Colless 1959) and in Japan (Sasa and Sabin 1950), it has been reported to feed amost exclusively on birds and rarely on other animals, including man. Further study on the local differences in the blood feeding habits of *bitaeniorhynchus* females is still needed, especially in Southeast Asia where, as pointed out by Colless (1959) and Sirivanakarn (1973), other closely similar forms are also present, including those which are presently recognized as *infula.*

MEDICAL IMPORTANCE. In the Oriental region, *bitaeniorhynchus* has been reported to be naturally infected with *Wuchereria bancrofti* in Travancore, India (Iyengar 1938) and with *Brugia malayi* in Sri Lanka (Carter 1948). In the Berau region, Netherlands New Guinea, it has been shown to be highly susceptible to *Wuchereria bancrofti* in the laboratory and has been considered to be an efficient vector of this pathogen (de Rook 1957b; de Rook and van Dijk 1959). In Malaya, Williamson and Zain (1937) reported laboratory infection and development of sporozoites of *Plasmodium vivax* (Grassi and Feletti), but Russell and Mohan (Mohan 1950) in India found it to be extremely resistant to this malarial parasite. In the Philippines and Queensland, Australia, a strain of Sindbis virus was isolated from *bitaeniorhynchus* (Rudnick et al. 1962; Doherty et al. 1963) and in Korea it has been incriminated as a possible vector of Japanese encephalitis. The latter report has never been verified or confirmed, however, as it feeds principally on birds which are not the natural reservoir of this virus, it is probably not significant as a vector of this disease.

9. *CULEX (CULEX) INFULA* THEOBALD
(Figs. 23, 24, 25)

Culex infula Theobald 1901a: 370 (♀*); Giles 1902: 407 (♀); Blanchard 1905: 298 (♀); Leicester 1908: 146 (♀); Edwards 1913b: 231 (synonymy with *bitaeniorhynchus* Giles).

Taeniorhynchus tenax Theobald 1901b: 198 (♀*); Giles 1902: 365 (♀); Theobald 1903: 258 (♀*); Leicester 1908: 167 (♀); Edwards 1913b: 231 (synonymy with *bitaeniorhynchus* Giles); Edwards 1922a: 283 (♂*, ♀, as variety of *bitaeniorhynchus*); Barraud 1924a: 985 (♂*, ♀, as variety of *bitaeniorhynchus*); Barraud 1934: 393 (♀, L, as variety of *bitaeniorhynchus*).

Grabhamia ambiguus Theobald 1903: 248 (♂); Edwards 1913b: 231 (synonymy with *bitaeniorhynchus* Giles); Edwards 1922a: 283 (as variety of *bitaeniorhynchus*); Barraud 1924a: 985 (adult, as variety of *bitaeniorhynchus*); Baisas 1938: 211 (adult, as variety of *bitaeniorhynchus*).

Grabhamia taeniarostris Theobald 1907: 299 (♀); Edwards 1913b: 231 (synonymy with *bitaeniorhynchus* Giles).

Taeniorhynchus tenax var. *ocellata* Theobald 1907: 488 (♀); Edwards 1913b: 231 (synonymy with *bitaeniorhynchus* Giles).

Oculeomyia sarawaki Theobald 1907: 515 (♀*); Edwards 1913b: 231 (synonymy with *bitaeniorhynchus* Giles).

Taeniorhynchus domesticus Leicester 1908: 169 (♂, ♀); Edwards 1922a: 283 (as variety of *bitaeniorhynchus*); Barraud 1924a: 984 (synonymy with *bitaeniorhynchus* Giles).

Culex (Culex) afridii Qutubuddin 1956: 140 (♂*). NEW SYNONYMY.

Culex bitaeniorhynchus Giles (in part), Edwards 1921: 337 (adult, L); Edwards 1922a: 282 (♂*, ♀); Barraud 1924a: 984 (♂*, ♀).

Culex (Culex) bitaenorhynchus Giles (in part), Edwards 1932: 202 (taxonomy); Barraud 1934: 391 (♂*, ♀, L*); Delfinado 1966: 140 (♂*, ♀, P, L*). Bram 1967a: 258 (♂*, ♀*, P*, L*); Sirivanakarn 1973: 235 (♂*, ♀*, P, L, *tenax* and *domesticus* forms of *bitaeniorhynchus*).

Culex (Culex) aurantapex of Edwards (in part), Edwards 1932: 202 (taxonomy); Stone, Knight and Starcke 1959: 242 (catalog).

FEMALE (Fig. 23). In general very similar to *bitaeniorhynchus* from which it is distinguished by the following characters. *Head.* Narrow decumbent scales of vertex yellowish to dark brown; erect scales usually entirely dark or sometimes pale golden in center, dark posterolaterally. *Cibarial Armature.* As figured and as described for *bitaeniorhynchus*. *Thorax.* Anterior 0.7 of mesonotum varying from predominantly pale beige, yellow or golden (*tenax* form, Sirivanakarn 1973) to predominantly deep chestnut brown or black scaled (*domesticus* form, Sirivanakarn 1973), with or without dark and pale scales forming streaks, spots or blotches along acrostichal line, middle of fossa, areas cephalad of prescutellar space at level of anterior wing base or elsewhere; posterior 0.3 of mesonotum usually entirely dark brown scaled; scales on prescutellar space and scutellar lobe completely dark brown or partially pale as in *bitaeniorhynchus*. *Legs.* Anterior surface of all femora usually lightly to moderately speckled, sometimes heavily and extensively speckled; tibiae lightly speckled, tarsomere 1 of all legs completely dark or very lightly speckled. *Wing.* Lightly to moderately speckled, usually restricted to basal 0.5-0.75 of veins C, Sc, R and Cu, sometimes heavily and extensively speckled; plume scales and squamae of veins R_2, R_3 and R_{4+5} broad,

clavate, but relatively narrower than in *bitaeniorhynchus*. *Abdomen*. Median caudal scale patch of tergum I completely dark or partially pale; terga II-IV or II-V largely dark or with narrow apical pale bands which are usually connected with larger yellowish apicolateral patches at sides; basal pale bands usually absent, if present, narrow or broad, complete or incomplete or represented by a small median basal spot or streak; terga VI-VII or V-VII always with distinct apical pale bands which vary from 0.2-0.5 of segment length; basal pale bands present or represented by median spot or completely absent; tergum VIII with broad apical and basal pale bands or completely yellowish. *Genitalia*. Essentially as described and figured for *bitaeniorhynchus*.

MALE (Fig. 23). In general as described for female; sexual dimorphism usually developed, particularly in the following features. *Abdomen*. Terga II-VII usually with complete basal pale bands or sometimes with median basal pale spots; apical bands usually present, narrow, sometimes absent; basal bands, if complete, usually broader than apical.

MALE GENITALIA (Fig. 24). Extremely similar to *bitaeniorhynchus*, differing particularly in the following. *Phallosome*. Apical spiculate portion of inner division of phallosome more strongly pigmented, apical margin (in lateral view) with distinct emargination proximad of apical tergal angle; apical tergal angle usually produced into a point. *Proctiger*. Basal sternal process usually present and relatively stronger, varying from 0.04-0.05 mm in length.

PUPA. Essentially as figured for *bitaeniorhynchus;* cephalothorax and abdomen variable from generally pale yellowish white with pattern of dark alveolar spots to deep yellow or golden without pattern of dark alveolar spots; abdominal segments V-VIII with or without pairs of dark brown lateral spots and dark median basal spots; sometimes cephalothorax and abdomen uniformly dark brownish. Details of chaetotaxy essentially similar to *bitaeniorhynchus*, differing particularly in the following. *Metanotum:* Seta 11-C usually double (1-3). *Abdomen*. Setae 3-I-III double, rarely single. *Paddle*. Inner and outer parts of paddle usually entirely pale or transparent, sometimes inner part lightly darkened; external margin in basal 0.5 of outer part darkened or infuscate, sometimes pale.

LARVA (Fig. 25). Extremely similar to typical *bitaeniorhynchus*, differing in the following combination of characters. *Head*. Seta 4-C usually 3-4 branched (2-4); 5-C triple or 4 branched; setae 11 and 13-C usually double or triple, rarely single. *Thorax*. Seta 0-P usually dark, distinct, 15-20 branched; 4-P double or triple (2-4); 1-4-M usually dark and distinct; 3-M usually double or triple, rarely single; 4-M usually 4, 5 branched (3-5); 1-4-T usually dark and distinct; 2-5 branched; 3-T 4-6 branched; 12-T at least double (2-4); 13-T usually 6 branched (4-9). *Abdomen*. Most dorsal setae 1-4 and ventral setae 10-13 of segments I-VII usually very dark and distinct, rarely pale; 3-I usually 4 branched (3-5); 4-I, II dark, 10-16 branched; 1-III-VI usually 3, 4 branched, 1-V sometimes 5 branched; 1-VII usually 5 branched (3-6); 4-V usually 10-12 branched (9-14); 4-VI usually 6, 7 branched (5-8). Comb scales usually 5, 6 in number (4-7). Saddle seta 2-X usually 4 branched (3-5). *Siphon:* Subventral tufts 3 pairs (total 6) in number, sometimes 2.5 pairs.

TYPE-DATA. (1) *Culex infula* Theobald, Holotype ♀*, Taipang, Straits Settlements, *Perak*, MALAYA (PENINSULAR MALAYSIA), L. Wray, Jr. (BM); (2) *Taeniorhynchus tenax* Theobald, Holotype ♀*, Taipang, Straits Settlements, *Perak*, MALAYA (PENINSULAR MALAYSIA), L. Wray, Jr. (BM); (3) *Grabhamia ambiguus* Theobald, Holotype ♂* with attached genitalia mount, Quilon, Travancore, *(Madras State)*. INDIA. Capt. James (BM); (4) *Grabhamia taeniarostris* Theobald, Holotype ♀*, *Peradeniya*, CEYLON (SRI LANKA),

January 1900, Green (BM); (5) *Taeniorhynchus tenax* var. *ocellata* Theobald, Holotype ♀*, Kuching, Sarawak, BORNEO (BM); (6) *Oculeomyia sarawaki* Theobald, Holotype ♀* (in extremely poor condition), *Sarawak*, BORNEO, Dr. Barker (BM). (7) *Taeniorhynchus domesticus* Leicester, Lectotype ♂* with slide of genitalia, Fed. Malay State (PENINSULAR MALAYSIA), G. F. Leicester (BM 1912: 350; selection of Bram 1967a: 263); (8) *Culex (C.) afridii* Qutubuddin, Holotype ♂* with slide of genitalia, *Dacca*, EAST PAKISTAN (BANGLADESH), October 1952, M. Qutubuddin (BM).

DISTRIBUTION. Thailand, Malaysia, Vietnam, Burma, Bangladesh, Indonesia and the Philippines. Also reported from India, Sri Lanka and Micronesia (Palau).

Material examined: 847 specimens: 349♂, 398♀, 102 L; 169 individual rearings (63 pupal, 106 larval).

INDIA. *Bombay:* Kawar, N. Kanara; Deccan, Belgaum; Nagargali; *Assam;* 10♂, 10♀.

BANGLADESH. Dacca; 1♂ (as *afridii* M. Qutubuddin, 1951); Sylhet; 1♂, 2♀, 1 p.

SRI LANKA. *Central Province:* Kandy District, Laksapana; Suduganga; 3♂, 1♀.

BURMA. Rangoon; 1♂, 3♀, 3 p.

THAILAND. Chiang Mai; Lampang; Tak; Bangkok; Pathum Thani; Chanthaburi; Chon Buri; Nakhon Si Thammarat; Prachuap Khiri Khan; Trang; Narathiwat; 41♂, 47♀, 29 L, 16 p, 22 lp.

VIETNAM. Danang; Saigon; Pleiku; Phu Bei; Qui Nhon; Dalat; 15♂, 41♀, 4 L, 3 p, 9 lp.

MALAYSIA. *Peninsular Malaysia: Selangor:* Kuala Lumpur; Segambut; Puchong; Rantau Panjang; Pacific Tin, Kuala Selangor; Ulu Gombak; Bt. Kutu; *Trengganu:* Dungun; Marang; Kuala Brang; *Pahang:* Bukit Pakoh; Pdg. Tungu, K. Lipis; Kuantan; Temerloh; Gunong Benom; *Perak:* Tanjong Tulang F. R., Kuala Kangsar; Chior F. R.; *Perlis:* Kg. Gunong; *Penang Is.; Kelantan:* Gua Musang; Tumpat; *Malacca:* Malacca; *Kedah:* Kg. Sungei Lintang; *N. S.:* Rantau; Kg. Inas; Pedas; Kg. Sengala; *Johore:* Kangkar Dohol; 121♂, 138♀, 50 L, 40 p, 51 lp; *Malaysia: Sabah:* Kota Belud; Beaufort; Keningau; Tambunan; Kuala Papar; Tawau; Kinarut; Mt. Kinabalu; Semporna; Lahad Datu; Kuala Penyu; 19♂, 30♀, 4 lp.

INDONESIA. *Kalimantan* (Borneo): Tarakan; 6♂, 3♀; *Sumatra:* Kmp Pantai; Bengkulu; Kebonros; *Java:* Djakarta; Solo; Maur; Bogor; Garut; 38♂, 31♀.

PHILIPPINES. *Luzon:* Concepcion, Tarlac; Agoo La Union; Dalton, N. Vizcaya, Bagiuo; Laguna; Rizal, Camp Nichols, Wack Wack, Paranaque; Abatan, Buguias; Subic Bay; Olongapo; Calaccad; *Siasi Sulo:* Calon; *Mindoro:* San Jose; *Samar:* Osmena; *Leyte:* Rizal; Palo; Lago Lago Bay Bay; Dulag; Loreto Dinagut; Tacloban; Panamuan; Gulf; Jinamoc; *Negros:* Cadiz; *Mindanao:* Pangasinan; Camp Gregg; San Ramon; Kabakan; Parang; Kolambugan; Ft. Pikit; *Tawi Tawi:* Kamagong, Tarawakan; 93♂, 90♀, 19 L, 20 lp.

TAXONOMIC DISCUSSION. The present treatment of the specific status of *infula* is only provisional, pending a more thorough analysis of the material from progeny rearing. In this interpretation, the 2 nominal forms, *tenax* Theobald 1901 and *domesticus* Leicester 1908, which were earlier recognized by Sirivanakarn (1973: 235-51) as distinct forms of *bitaeniorhynchus* and other names, including *ambiguus* Theobald 1903, *taeniarostris* Theobald 1907, *tenax* var. *ocellata* Theobald 1907, *sarawaki* Theobald 1907 and *infula* Theobald 1901 are all combined and tentatively treated as a single species. The name *infula* is used because it has priority over all other names. This interpretation is

based largely on the study of several series of reared specimens from Malaysia where most of these nominal forms were originally described. In spite of the striking differences in the color of the mesonotal scales and the pattern of abdominal banding of the adults as described above and as indicated by Sirivanakarn (1973), subsequent study has shown that there is apparently no difference in the male genitalia, pupal and larval chaetotaxy among all of the Malaysian forms, indicating that they are probably conspecific. In Addition, *afridii* Qutubuddin 1956 from East Pakistan which was described from the single type male is also synonymized with this species on the basis of similarity in the male genitalia and external characters of the adult.

Culex infula can be distinguished from other forms of the *bitaeniorhynchus* complex by the following combination of characters. In the adults by (1) usually light or moderate speckling of the legs and wing; (2) scales on wing veins R_2, R_3 and R_{4+5} narrow, clavate; (3) terga II-IV or II-V in females usually with distinct apicolateral yellowish patches not extending dorsad to form distinct apical band; basal bands usually absent or sometimes represented by a small median basal pale spot; (4) abdominal terga V-VII or VI-VII usually with distinct apical and basal bands; (5) abdominal terga VIII with apical and basal bands or completely yellowish; (6) male abdominal terga II-VII usually with both apical and basal bands. In the male genitalia by (1) long beak-like apical spiculate portion of inner division of the phallosome; (2) apical spiculate portion with distinct depression on apical margin and obtuse apical tergal angle; (3) basal sternal process of the proctiger usually developed, varying from 0.04-0.05 mm in length and (4) one of the setae *d-f* in distal division of the subapical lobe usually differentiated as a narrow lanceolate leaf. In the pupa by (1) seta 11-C usually double; (2) setae 3-I-III usually double and (3) inner part of paddle pale or not infuscate. In the larva by (1) setae 1-4-T dark and distinct; (2) setae 1-4 and 10-13 of segments I-VII usually dark and very distinct; (3) 4-V 10-12 branched; 4-VI usually 6, 7 branched; (4) comb scales 4, 5 in number and (5) siphon usually with 3 pairs (total 6) of subventral tufts.

Culex infula is extremely variable and exhibits overlap in one or more stages with the typical *bitaeniorhynchus* and other members of the *bitaeniorhynchus* complex. In the adults, there is a marked dimorphism into the pale and dark forms in both sexes in the color of the head and the mesonotum. The pale form *(tenax)* has the erect scales of the head partially pale and the scales on the anterior 0.7 of mesonotum predominantly pale, contrasting sharply with those on posterior 0.3. The dark form *(domesticus, infula)* is strikingly different from the pale one in having the scales on the head and mesonotum entirely dark brown to almost black and can be readily recognized even by the naked eye. In Malaysia, Thailand, Vietnam, Indonesia and the Philippines, the dark form is apparently more common than the pale form. There is also a marked sexual dimorphism in the pattern of the abdominal banding; the males usually have both apical and basal pale bands whereas the females have only the apical bands, particularly on terga II-IV or II-V. In the immature stages, the *infula* pupae exhibit considerable variation in the color of cephalothorax and abdomen, overlapping with the typical *bitaeniorhynchus* and *pseudosinensis* but resemble the latter in the diagnostic chaetotaxy. The larvae resemble *pseudosinensis, luzonensis* and *selangorensis* in having 3 pairs of siphonal tufts, but differ from these species and the typical *bitaeniorhynchus* in having dorsal thoracic setae and most dorsal and ventral abdominal setae relatively stronger, darker and with more numerous branches.

BIONOMICS. *Culex infula* is apparently as common as the typical *bitaeniorhynchus* in various parts of Southeast Asia and as indicated for the latter, it is

restricted to breeding in large, algae filled ground pools. In the majority of collections, the larvae and pupae of *infula* have been found with *bitaeniorhynchus* in the same breeding sites. In Malaya (Peninsular Malaysia), it was reported to represent roughly 55 per cent of the *bitaeniorhynchus* populations (Sirivanakarn 1973). Of this, the dark form *(domesticus)* is apparently more common than the pale form *(tenax)*. A number of adults of *infula* have been caught in light traps and biting man or other animals. The blood feeding habits and the preferred host(s) of *infula* females are not definitely known. It would be of interest to determine whether this particular taxon shows a preference in blood feeding habit different from that of typical *bitaeniorhynchus*.

10. *CULEX (CULEX) LUZONENSIS* NEW SPECIES
(Figs. 23, 24)

Culex (Culex) bitaeniorhynchus Giles (in part), Sirivanakarn 1973: 235 (♂*, ♀, P, L, as Luzon form).

FEMALE (Fig. 23). Wing: 4.7 mm. Forefemur: 2.2 mm. Proboscis: 2.0 mm. Abdomen: 3.0 mm. As briefly characterized by Sirivanakarn (1973: 244) for the Luzon form of *bitaeniorhynchus*, with the following corrections and additional features. *Head.* Erect scales of vertex vary from partially pale yellowish or golden in center, dark on posterolateral area to completely dark brown. Palpus largely dark scaled; apex of segment 4 with or without a few pale scales. Proboscis apparently slightly shorter than forefemur. *Thorax.* Anterior 0.7 of mesonotum usually predominantly dark brown scaled and with extensive mottling of pale yellowish or golden brown scales in middle cephalad of prescutellar space; posterior 0.3 of mesonotum blackish; scales on prescutellar space largely dark except for some pale ones posteriorly; mid-scutellar lobe largely dark scaled except for some pale ones on caudal margin; lateral scutellar lobe entirely dark scaled. *Legs.* Anterior surface of femora and tibiae of fore- and midlegs usually moderately to heavily speckled, sometimes almost completely dark; anterior surface of hindfemur lightly speckled; hindtibia speckled as in fore- and midlegs; tarsomere 1 of all legs usually lightly speckled, sometimes entirely dark. *Wing.* Usually lightly speckled, particularly in basal parts of veins C, Sc, R and stems of other veins; scales on veins R_2, R_3 and R_{4+5}, narrow, linear or broad clavate. *Abdomen.* Median caudal scale patch of tergum I largely dark or partially pale towards base; terga II-VII with broad incomplete or complete basal triangular pale bands and narrow apical bands, the latter connected with very large apicolateral yellowish patches on terga III-V or III-VI; basal and apical bands on terga VI-VII sometimes equally broad; tergum VIII usually with broad basal and narrow apical pale bands; sterna III-VI largely yellowish, sternum VII broadly pale at base, dark towards apex.

MALE (Fig. 23). In general as described for female, differing in having scales on anterior 0.7 of mesonotum predominantly pale, yellowish to golden with variable amount of dark scales forming spots or streaks and in having banding pattern on abdominal terga II-V largely basal and complete. Palpus and proboscis essentially similar to typical *bitaeniorhynchus* and *infula*.

MALE GENITALIA (Fig. 24). As figured and described by Sirivanakarn (1973: 250); very similar to other members of the *bitaeniorhynchus* complex in the basimere, distimere and proctiger, differing particularly in the following. *Subapical lobe.* None of setae in group *d-f* of distal division is differen-

tiated as a broad, lanceolate leaf. *Phallosome.* Apical spiculate portion of inner division very stout, more or less quadrate in shape and dark pigmented, apical margin smoothly curved, apical sternal angle produced into a short and stout beak which is about 0.04 mm in length; apical tergal angle irregular, usually provided with several denticles; tergal lobe with 2-3 broad, blunt tipped foliform processes, placed at a distance far below apical tergal angle. *Proctiger.* Basal sternal process of paraproct relatively longer, thicker and darker, about 0.08 mm in length; cercal setae vary from 2 to 5 in number.

PUPA. As described and figured for typical *bitaeniorhynchus*, differing from it particularly in the following. Cephalothorax and abdomen uniformly yellowish; pattern of dark alveolar spots entirely absent. *Metanotum.* Seta 11-C usually double, rarely single. *Abdomen.* Setae 3-I-III double; setae 1-VI-VIII usually single (1-2). *Paddle.* Outer and inner parts entirely pale, midrib more pigmented.

LARVA. As described and figured for typical *bitaeniorhynchus* to which it is extremely similar, differing particularly in the following. *Head.* Basal 0.5 of antennal shaft with considerably weaker and fewer spicules, sometimes without distinct spicules. *Abdomen.* Comb scales smaller, shorter and with distinct basal fringe of spicules; number of scales varies from 5 to 9 (average 6), in 1 or 2 irregular rows. *Siphon:* Subventral tufts usually 3 pairs (total 6), sometimes 3.5 pairs (or total 7); pairing very irregular.

TYPE-DATA. Holotype ♂ (D-IX-33) with associated pupal skin and genitalia slide, Imugan, Dalton, N. Vizcaya, *Luzon,* PHILIPPINES, elevation 925 m, larva from a large carabao wallow, 12 Jan. 1969, Celestino (USNM); Allotype ♀ (D-IX-41) with associated pupal and larval skins, same data as holotype (USNM); Paratypes: 8♂ (D-IX-35, D-IX-40, D-IX-44, D-IX-47, D-IX-48, D-IX-49, D-IX-50, D-IX-51) and 9♀ (D-IX-34, D-IX-38, D-IX-39, D-IX-43, D-IX-45, D-IX-46, D-IX-52, D-IX-54, D-IX-55) with associated pupal and larval skins; 2♂ (D-IX-30), D-IX-32) and 2♀ (D-IX-29, D-IX-31) with associated pupal skins; same data as holotype (USNM, BM, BBM).

DISTRIBUTION. Known only from Luzon in the Philippines. Material examined. 48 specimens: 20♂, 24♀, 4 L; 32 individual rearings (7 pupal, 25 larval).

PHILIPPINES. *Luzon:* N. Vizcaya, Dalton, Imugan (type-locality); 14♂, 19♀, 7 P, 25 lp; Bagiuo, Mountain Province; 5♂, 5♀, 4 L; Subic Naval Base; 1♂.

TAXONOMIC DISCUSSION. *Culex luzonensis* is apparently restricted to mountainous areas of Luzon in the Philippines where it has been found to be sympatric with the typical *bitaeniorhynchus.* It can be separated from the latter species and other members of the *bitaeniorhynchus* complex by the following combination of characters: in the adults by (1) presence of light to moderate speckling of the legs and wing and (2) presence of narrow apical and broad basal pale bands on abdominal terga II-VII; in the male genitalia by (1) characteristic shape of apical spiculate portion of inner division of the phallosome and (2) basal sternal process of the proctiger relatively thick, strongly pigmented and about 0.08 mm in length; in the pupa by (1) absence of pattern of dark alveolar spots on the abdomen and cephalothorax; (2) paddle largely pale, without darkened or infuscate area; (3) seta 11-C double and (4) setae 3-I-III double and in the larva by (1) antennal shaft with relatively few and weak or indistinct spicules; (2) setae 1-5 and 9-13 of abdominal segments I-VI very weak and indistinct (3) comb scales 5-9 in number and (4) siphon with 3 pairs (total 6) of subventral tufts.

Except for the diagnostic male genitalic characters, all stages of *luzonensis* exhibit much overlap with *infula* and as in the latter species, the adults of

luzonensis also show a marked dimorphism in the pale or dark scales on the anterior 0.7 of the mesonotum. The associated larvae and pupae of both dark and pale forms are virtually similar and there is no apparent indication of correlated differences in any features among several reared specimens I have examined. For a definite separation of *luzonensis* from *infula*, all stages, including the male genitalia should be thoroughly examined.

BIONOMICS. The larvae and pupae of *luzonensis* from the type locality at Dalton, N. Vizcaya were collected from a large carabao wallow containing some green algae and other aquatic vegetation at an altitude of 925 m. This breeding site was under partial shade and was noted to be in a native village. Several adults have been obtained from general field catches in Bagiuo and a few females were found to be fully engorged with blood but no data is available as to their specific host. Nothing is known about the biology of the adult and its relation to disease.

11. *CULEX (CULEX) SELANGORENSIS* NEW SPECIES
(Figs. 23, 24)

Culex (Culex) bitaeniorhynchus Giles (in part), Sirivanakarn 1973: 235 (♂*, ♀, L, as Selangor form)

FEMALE (Fig. 23). Wing: 4.3 mm. Forefemur: 2.2 mm. Proboscis: 2.0 mm. Abdomen: 3.24 mm. As characterized for the Selangor form of *bitaeniorhynchus* by Sirivanakarn (1973: 243); distinguished from typical *bitaeniorhynchus* and other members of the *bitaeniorhynchus* complex and subgroup by the absence of basal or apical pale bands on abdominal terga II-VII and by the following additional characters. *Head.* Narrow decumbent scales of vertex beige or yellowish; erect scales yellowish in center, dark posterolaterally. Palpus entirely dark scaled. *Thorax.* Anterior 0.7 of mesonotum always predominantly pale yellowish or golden scaled, with or without dark scaled streaks and spots on anterior acrostichal line and in middle of fossa; scales on posterior 0.3 of mesonotum, prescutellar space and scutellar lobes entirely dark brown. *Legs.* Anterior surface of femora and tibiae usually lightly sprinkled with pale scales, sometimes almost completely dark; tarsomere I of all legs entirely dark. *Wing.* Scales on all wing veins entirely dark; speckling of pale scales absent; plume scales and squames on veins R_2, R_3 and R_{4+5} narrow, clavate. *Abdomen.* Tergum I with dark median caudal scale patch; terga II-VII almost completely dark except for very light sprinkling of a few pale scales, particularly on terga III-VI; basolateral pale spots present, particularly on terga III-VII; tergum VIII with narrow basal pale band or completely dark; sterna III-VII with broad basal yellowish bands; sternum VIII entirely dark.

MALE (Fig. 23). In general similar to female except for the presence of broad median pale streaks or incomplete basal pale bands on abdominal terga II-IV and complete basal pale bands on abdominal terga V-VII. Palpus and proboscis as in *bitaeniorhynchus* and *infula* except for the following. *Head.* Ventrolateral bristles in apical 0.5 of palpal segment 3 weaker and less dense, about 20 in number; upper mesal surface of palpal segment 3 with a row of only 5 long hairs which are more widely spaced. Proboscis with a considerably weaker ventral tuft of long hairs proximad of median light ring; the number of hairs is about 10.

MALE GENITALIA (Fig. 24). As figured and described by Sirivanakarn (1973: 250); extremely similar to *bitaeniorhynchus* and *infula*, differing particu-

larly in the following features. *Subapical lobe.* None of the setae in group *d-f* of distal division differentiated as a lanceolate seta; leaf *g* shorter and narrower. *Phallosome.* Apical spiculate portion of inner division, quadrate or somewhat resembling the blade of an ax; apical sternal angle produced into a short beak which is 0.012-0.030 mm in length; apical tergal angle irregular and usually with some coarse denticles; apical margin smoothly curved; tergal lobe with 3-4 short and pointed foliform processes situated close to apical tergal angle. *Proctiger.* Basal sternal process short, 0.03-0.04 mm in length and strongly pigmented.

PUPA. Extremely similar to *bitaeniorhynchus* and *infula,* differing in the following combination of characters. Cephalothorax and abdomen yellowish white; pattern of dark alveolar spots present, particularly on metanotum and abdominal segments, but less striking than in typical *bitaeniorhynchus. Metanotum.* Seta 11-C double or triple. *Abdomen.* Seta 3-I usually double, sometimes triple; 3-II-III always double; 1-V usually 4, 5 branched (3-5); 5-IV-V usually 5 branched (4-6); 5-VI usually 4 branched (3-5). *Paddle.* Inner part lightly darkened, as in *bitaeniorhynchus;* outer part pale, basal external margin pale.

LARVA. Essentially as figured for *pseudosinensis* (Fig. 27) from which it is virtually indistinguishable, differing from *bitaeniorhynchus, infula* and *luzonensis* particularly in the presence of 8-11 much smaller comb scales in 2 or 3 rows and in the following additional characters. *Head.* Seta 14-C single, sometimes bifid. *Thorax.* Seta 4-P single or double; seta 1-4-M and seta 1-5-T extremely weak and inconspicuous. *Abdomen.* Most dorsal setae 1-4 and ventral setae 10-13 of segments I-VII extremely weak, short and very inconspicuous; setae 1-III-VII usually double, sometimes triple; seta 4-V 5, 6 branched; 4-VI 4 branched. Comb scales, usually 9 in number (8-11), in 2 or 3 rows, all small, with distinct apical spine and basal fringe of several fine spicules. Seta 2-X of saddle usually 4 branched (4-5). *Siphon.* Basal 0.1 always with a distinct row of 7-8 pecten teeth; subventral tufts 3 pairs (total 6) in number; pairing regular.

TYPE-DATA. Holotype ♂ (1386-14) with associated pupal and larval skins and genitalia slide, Bukit (Bt.) Kutu, *Selangor,* PENINSULAR MALAYSIA, elevation 310 m, larva from stagnant pool along stream margin, 15 June 1968, S. W. James and others (USNM); Allotype ♀ (1386-12) with associated pupal and larval skins, same data as holotype (USNM); Paratypes: 1♂ (1386-13) with associated pupal and larval skins and genitalia slide; 3♀ (1386-10, -11, -15) with associated pupal and larval skins, same data as holotype (USNM).

DISTRIBUTION. Presently known only from Selangor and Pahang, Peninsular Malaysia, Malaysia. Material examined. 13 specimens: 5♂, 6♀, 2 L, 7 individual rearings (1 pupal, 6 larval).

MALAYSIA. *Peninsular Malaysia: Selangor*-Bukit (Bt.) Kutu; 3♂, 4♀, 6 lp (type-series). *Pahang:* Gunong Benom; 2♂, 2♀, 2 L, 1 p.

TAXONOMIC DISCUSSION. *Culex selangorensis* is most distinctive in the females which differ from the rest of *Bitaeniorhynchus* Subgroup in the absence of apical or basal bands on abdominal terga II-VII. The male is sexually dimorphic, differing from the female in the presence of incomplete or complete basal pale bands on the abdominal terga. In the male genitalia, the phallosome is distinct from typical *bitaeniorhynchus, infula* and *luzonensis* but is slightly different from that of *pseudosinensis* in the shape of the apical spiculate portion of the inner division. The pupa resembles typical *bitaeniorhynchus* rather closely in pigmentation except for less striking pattern of dark alveolar spots and diagnostic chaetotaxy. The larva is virtually indistinguishable from *pseu-*

dosinensis.

BIONOMICS. All specimens of *selangorensis* came from 2 collections made in stagnant ground pools with scarce green algae at the elevation of 185-330 m in Selangor and Pahang, Peninsular Malaysia. The immatures from the 2 localities were not found to be associated with any other forms of the *Bitaeniorhynchus* Subgroup. Nothing is known about the adult biology or its medical importance.

12. *CULEX (CULEX) PSEUDOSINENSIS* COLLESS
(Figs. 26, 27)

Culex (Culex) pseudosinensis Colless 1955: 311 (♂*, ♀, L*); Bram 1967a: 265 (♂*, ♀*, L*).

FEMALE (Fig. 26). Wing: 4.5 mm. Forefemur: 2.0 mm. Proboscis: 2.1 mm. Abdomen: 3.4 mm. General facies as figured; distinguished from other members of the *bitaeniorhynchus* complex by the absence of speckling on the wing and by the presence of broad basal and narrow apical pale bands on abdominal tergites II-VII. *Head*. Narrow decumbent scales of vertex narrow, linear, pale beige or yellowish; erect scales in center largely pale golden, dark brown to black on posterolateral areas; lateral patch of broad scales pale beige. Palpus dark scaled except for some pale scales at tip of segment 4. Proboscis with a broad median yellow ring; no scattered pale scales proximad of median ring on dorsal surface; apex of labium with light scales, forming an indistinct apical ring. *Thorax*. Anterior 0.7 of mesonotum predominantly pale yellow, beige to almost whitish; middle of fossae with or without a pair of dark scale spots; scales on posterior 0.3 of mesonotum largely dark brown except on midscutellar lobe which are sometimes partially pale on caudal margin. *Legs*. Anterior surface of fore- and midfemora usually entirely dark, sometimes with a few scattered pale scales in apical 0.5; anterior surface of hindfemur entirely dark; anterior surface of tibiae and tarsomeres 1 of all legs entirely dark or not speckled. *Wing*. Scales on all wing veins entirely dark; speckling of pale scales absent; scales on veins R_2, R_3 and R_{4+5} narrow, clavate. *Abdomen*. Median scale patch of tergum I entirely dark; terga II-VII usually with complete basal and apical pale bands; basal bands even in width or broadened laterally, sometimes incomplete or represented by a median basal spot on terga II-III; apical bands narrow or sometimes indistinct dorsally, strongly widened laterally; tergum VIII with basal pale band only; dark scaled areas on terga II-VI lightly sprinkled with pale scales; sterna II-VII usually with broad basal pale bands and apical dark bands.

MALE (Fig. 26). In general similar to female in coloration of head, thorax, legs and wing, differing in having broader basal abdominal pale bands and in having apical bands represented largely by apicolateral yellowish patches, particularly on abdominal terga II-V; palpus, proboscis and antenna essentially as described for typical *bitaeniorhynchus*.

MALE GENITALIA (Fig. 27). Very similar to other members of the *bitaeniorhynchus* complex, differing particularly in the following features. *Subapical lobe*. All setae in group *d-f* of distal division slender, hairlike or flattened, rodlike but none differentiated as lanceolate blade. *Phallosome*. Apical spiculate portion of inner division more or less resembling *luzonensis* and *selangorensis*, differing from both in having apical dorsal margin distinctly depressed proximally and in the absence of small denticles or teeth adjacent

to apical tergal angle; tergal lobe slender, elongate, with 2-3 small subequal foliform processes on its apex, situated far below apical tergal angle; outer division represented by a large, broad, leaflike spine. *Proctiger.* Basal sternal process always developed, slender and pale, varying from 0.04-0.05 mm in length.

PUPA. Abdomen: 3.6 mm. Paddle: 0.78 mm. Trumpet: 0.70 mm. Very similar to other forms of the *bitaeniorhynchus* complex, differing conspicuously in having integument of cephalothorax and abdomen entirely dark brown and in the following combination of characters. *Cephalothorax.* Trumpet darker than underlying integument; all setae relatively weak, short and indistinct; seta 8-C single or double; 9-C usually triple (2-3). *Metanotum.* Seta 11-C usually double (2-3). *Abdomen.* Setae 3-I-III usually double, rarely single; 1-V 6-8 branched; 1-VI-VII double or triple; 5-IV 4-8 branched; 5-V-VI 3, 4 branched. *Paddle.* Pale, contrasting sharply with abdomen or sometimes uniformly lightly darkened on outer and inner parts, midrib moderately strong and more pigmented.

LARVA (Fig. 27). Head: 0.65 mm. Siphon: 1.8 mm; index 7-9. Saddle: 0.36 mm; siphon/saddle ratio 4-5. As figured; extremely similar to typical *bitaeniorhynchus* and other forms in that complex. *Head.* Seta 4-C relatively long, about 2 times as long as distance between bases of the pair; 5-C usually triple (3-4); 6-C always double; 7-C usually 7 branched (5-8); 11-C double or triple; 14-C single, spiniform, or sometimes bifid. *Thorax.* Setae 1-4-M and 1-5-T extremely weak and rather indistinct, as in *bitaeniorhynchus.* *Abdomen.* Dorsal setae 1-4 and ventral setae 10-13 of segments I-VI very weak and indistinct, as in *bitaeniorhynchus;* 6-I-II usually triple (3-4); 6-III 3, 4 branched; 6-IV usually 4 branched (4-5); 6-V 3, 4 branched; 6-VI triple; 1-III-VI 1-3 branched. Comb scales relatively small and short, usually 8 (6-11), in 2 rows; individual scale with a strong apical spine and basal fringe of 5-6 fine spicules, basal sclerotized plate of scale oval and not as broad as in typical *bitaeniorhynchus.* Seta 2-X of saddle 4, 5 branched; anal gills 1-1.5 times as long as saddle. *Siphon.* Pecten always present in a distinct row in basal 0.1-0.2, number of teeth 8-10; subventral tufts 3 pairs (total 6) in number.

TYPE-DATA. Holotype ♀* with associated pupal and larval skins, Adelphi Estate, SINGAPORE, 5 March 1953, D. H. Colless (BM).

DISTRIBUTION. Known only from Singapore, Peninsular Malaysia, Malaysia and southern Thailand. Material examined. 45 specimens: 20♂, 20♀, 5 L; 22 individual rearings (7 pupal, 15 larval).

THAILAND. *Narathiwat:* Waeng; 2♂, 1♀, 4 p.

MALAYSIA. *Peninsular Malaysia: Johore-Labis;* Kangkar Dohol; 7♂, 7♀, 2 L, 7 lp; *Trengganu:* Dungun; 4♂, 3♀, 1 L, 3 p; *Selangor:* Petaling; 2♂, 6♀, 3 lp; *Kedah:* Bt. Kayu, Hitam; 1♂, 1 lp; *Perak:* Tapah; 1♂; *Kelantan:* Limau Kasturi; 2 L.

SINGAPORE. Adelphi Estate (type-locality); 3♂, 3♀, 4 lp (type-series).

TAXONOMIC DISCUSSION. *Culex pseudosinensis* exhibits constant diagnostic features in all stages except for the variation in the presence or absence of light speckling on the anterior surface of fore- and midfemora of the legs and in the pattern of abdominal banding of the adults. In Peninsular Malaysia, *pseudosinensis* adults can be easily confused with the pale form of *infula* which exhibits a similar pattern of abdominal banding. It can, however, be separated from the latter by the complete absence of speckling on the wing and by the considerably less speckling of the femora of legs. The apical portion of inner division of the male phallosome of *pseudosinensis* is of a quadrate type as in *selagorensis* and *luzonensis* but differs from the latter 2 species slightly in the

shape. The pupa of *pseudosinensis* is most distinctive, particularly in the uniform dark brownish coloration of the cephalothorax and abdomen in all material examined. The *pseudosinensis* larva can be readily separated from most *bitaeniorhynchus* forms but is virtually indistinguishable from that of *selangorensis*. This evidence strongly suggests that *pseudosinensis* and *selangorensis* are very closely related and appear to form a distinct lineage separated from other members of the *bitaeniorhynchus* complex.

Culex pseudosinensis is currently known only from Singapore, Peninsular Malaysia and Thailand. The record of this species from South Vietnam by Bram (1967a: 265-8) is doubtful and requires confirmation as this was based on a male (genitalia missing) which probably belongs to *infula* (*tenax* form).

BIONOMICS. The most frequent breeding sites of *pseudosinensis* are stagnant pools in or along stream margins under partial or heavy shade of secondary tropical forest at the elevation ranging from sea level to 60 m. As in other members of the *bitaeniorhynchus* complex, these breeding sites always contain green algae. On one occasion, in Malaya, it was collected from a marshy depression fully exposed to sunlight near a rubber plantation. All adults came from rearing the pupae or larvae. Nothing is known about the biology of the adult and its medical importance.

13. *CULEX (CULEX) LONGICORNIS* NEW SPECIES
(Fig. 24)

FEMALE. Wing: 4.14 mm. Forefemur: 2.0 mm. Proboscis: 1.9 mm. Abdomen: 2.9 mm. In general similar to other members of the *bitaeniorhynchus* complex, differing in the following combination of characters. *Head.* Narrow decumbent scales on vertex finer and largely pale beige or yellowish-white; erect scales finer and predominantly pale in center, dark on posterolateral areas; lateral patch of broad scales whitish, very distinct. *Thorax.* Mesonotal scales finer and predominantly yellowish-white on anterior 0.7, dark brown on posterior 0.3. *Legs.* Anterior surface of femora and tibiae heavily and extensively speckled; tarsomere 1 of all legs lightly speckled. *Wing.* Heavily and extensively speckled. *Abdomen.* Median caudal scale patch of tergum I entirely dark; terga II-VII with complete broad basal and narrow apical pale bands; apical bands on terga II-III or II-IV sometimes very narrow to almost indistinct, all apparently connected with large apicolateral yellowish patches at sides; apical bands on terga V-VII as broad as basal; sterna largely pale scaled.

MALE. Generally similar to female except for broader basal and apical bands on abdominal terga II-VII and less speckling of legs and wing; palpus and proboscis essentially similar to other forms of *bitaeniorhynchus* complex.

MALE GENITALIA (Fig. 24). Essentially similar to other forms of *bitaeniorhynchus* complex in basimere, distimere and proctiger, differing particularly in the following features. *Phallosome.* Apical spiculate portion of inner division with a very dark, slender and long hornlike apical sternal process, its length measured from posterior margin of inner division to apex about 0.12 mm; apical tergal angle very irregular, with several dark denticles; tergal lobe with 3-4 stout foliform processes situated very close to apical tergal angle; outer division represented by a short and small laterally divergent spine. *Proctiger.* Apical crown relatively smaller; basal sternal process of paraproct short, slender and pale, about 0.02 mm in length.

PUPA and LARVA. Unknown.

TYPE-DATA. Holotype ♂ (M85-13-193) with slide of genitalia, Doi Sutep, *Chiang Mai,* THAILAND, elevation 925 m, 21 Nov. 1951, D. C. and E. B. Thurman (USNM); Allotype ♀ (M85), same data as holotype (USNM).

DISTRIBUTION. Known only from Chiang Mai, Thailand. Material examined. 8 specimens: 5♂, 3♀.

THAILAND. *Chiang Mai:* Doi Sutep, near wat, at top of mountain; 1♂, 1♀ (M85; holotype and allotype), 2♂ (M85; M193; genitalia lost); 1♀ (M193); Huey Keo; Wat Soda Ram; 1♂, 1♀ (M88); Chiang Mai, 1♂ (MLT5, genitalia lost).

TAXONOMIC DISCUSSION. The types and other identified specimens of *longicornis* were discovered among numerous specimens of typical *bitaeniorhynchus* in the collections by D. C. and E. B. Thurman from Chiang Mai, Thailand during 1951-52. The associations of sexes and other specimens of this species are only presumptive, but appear to be correct on the basis of the adult external characters and the collection data. The immature stages of *longicornis* are not known and the assignment of this species to the *bitaeniorhynchus* complex is only provisional.

Culex longicornis can be readily differentiated from all other forms of the *bitaeniorhynchus* complex by the type of the phallosome of the male genitalia as described and illustrated. The adults of *longicornis* are generally very similar to the usual pale form of typical *bitaeniorhynchus* in having the anterior 0.7 of the mesonotum predominantly pale and in the extensive speckling of the legs and wing but differ rather strikingly from the latter in the presence of basal and apical pale bands on abdominal terga II-VII, resembling that of *luzonensis, pseudosinensis* and *infula*.

BIONOMICS. The breeding sites of *longicornis* are not known, but presumably are ground pools which contain algal mats as in other members of the *Bitaeniorhynchus* Subgroup. All field caught adults from the Thurmans' collections were captured near ponds and marshes containing algae in mountainous areas at an altitude of 925 m. Nothing is known about the adult biology or medical importance of *longicornis*.

14. *CULEX (CULEX) SINENSIS* THEOBALD
(Figs. 15, 28, 29, 30)

Culex gelidus var. *sinensis* Theobald 1903: 180 (♀).
Culex sepositus Leicester 1908: 152 (♀); Edwards 1913b: 231 (synonymy).
Taeniorhynchus tenax of Leicester 1908: 167 (♀), Edwards 1913b: 231 (synonymy).
Leucomyia sinensis Theobald 1910a: 313 (taxonomy).
Culex sinensis Theobald, Edwards 1913b: 231 (taxonomy); Edwards 1921: 337 (♂, ♀); Barraud 1924a: 986 (♂*, ♀).
Culex tripunctatus Mochizuki 1913: 24 (♂*, ♀*, E); Edwards 1932: 203 (synonymy).
Culex (Culex) sinensis Theobald, Edwards 1932: 203 (taxonomy); Barraud 1934: 394 (♂*, ♀, L); Stackelberg 1937: 231 (♂*); Bonne-Wepster and Brug 1937: 78 (♂, ♀*); Baisas 1938: 209 (♀, E); Bonne-Wepster and Brug 1939: 1274 (L*); Bohart and Ingram 1946: 79 (♂*, ♀, L*); LaCasse and Yamaguti 1950: 206 (♂*, ♀*, P*, L*); Monchadskii 1951: 275 (L*); Bonne-Wepster 1954: 116 (♂, ♀*, L*); Hara 1957: 55 (♀ genitalia); Delfinado 1966: 151 (♀); Bram 1967a: 268 (♂*, ♀*, L*).

FEMALE (Fig. 15, 28). Wing: 3.8 mm. Forefemur: 1.8 mm. Probos-

cis: 1.8 mm. Abdomen: 3.5 mm. Medium sized and relatively slender species; distinguished from other members of the *Bitaeniorhynchus* Subgroup by the presence of pale scale patches on prosternum; femora of all legs moderately to heavily speckled; completely dark scales on all wing veins and by the presence of narrow and even apical and basal pale bands on abdominal terga II-VII. *Head.* Narrow decumbent scales of vertex fine and entirely whitish; erect scales largely pale yellowish or golden except for dark ones on posterolateral areas; lateral patch of broad scales whitish, very distinct. Palpus entirely dark except for scattered white scales on apex of segment 4. Proboscis without scattered pale scales distad or proximad of median pale ring on dorsal surface; apex of labium without any pale scales. *Cibarial Armature.* Cibarial bar with a concave row of about 20 short teeth; 4-5 median teeth very fine, lateral teeth stronger, apically pointed, blunt or truncate. *Thorax.* Prosternum with distinct patches of pale scales on upper surface. Anterior 0.7 of mesonotum usually predominantly pale yellowish to whitish, with or without some dark scales forming spots and streaks in middle of fossae, anterior acrostichal and dorsocentral areas; scales on posterior 0.3 of mesonotum and prescutellar space entirely dark; scales on midscutellar lobe dark anteriorly, pale on caudal margin; lateral scutellar lobes entirely pale scaled. Pleuron with distinct scale patches on *ppl,* upper corner and posterior border of *stp* and anterior upper *mep*; a few scattered pale scales among upper *mep* bristles; *ppl* bristles 7-8. *Legs.* Anterior surface of femora of all legs moderately to heavily speckled with pale scales; anterior surface of all tibiae lightly speckled; tarsomeres 1 completely dark or not speckled; tarsomeres 1-4 with broad basal and narrow apical pale bands. *Wing.* Scales on all wing veins completely dark; scales on veins R_2, R_3 and R_{4+5} narrow, clavate or linear. *Abdomen.* Tergum I with dark median caudal scale patch, terga II-VII usually with narrow, more or less even transverse apical and basal pale bands; apical bands usually broader and more distinct than basal, connected with slightly broader apicolateral pale patches at side; basal bands usually composed of 1 or 2 rows of pale scales which are sometimes not visible from above due to retraction of adjoining segments; basolateral pale spots present, extending to 0.50-0.75 of segment length; tergum VIII with basal pale band only; dark scaled areas not speckled; sterna III-VII with very broad basal pale bands and apicolateral dark areas. *Genitalia.* Tergum IX with lateral row of 6-8 strong setae; postgenital plate rounded on caudal margin; vaginal sclerite V or U-shaped, strongly sclerotized; insula with a tuft of 10-12 setae.

MALE (Fig. 28). Essentially as described for female; sexual dimorphism in general color not developed; *ppl* bristles about 20. *Head.* Palpus slender, exceeding proboscis by about 1.5 of the length of segment 5; segment 3 with median pale band on dorsal surface, apical 0.3 with ventral lateral row of about 15 bristles, upper mesal surface without any bristles; segments 4 and 5 strongly plumose, each with distinct basal pale band on dorsal surface, scales and bristles in apical 0.5 of segment 5 pale yellowish. Proboscis with prominent ventral tuft of long, pale hairs at base of median light ring. Antennal flagellum strongly plumose.

MALE GENITALIA (Fig. 29). *Segment IX.* Tergal lobe with a row of 5-6 setae. *Basimere.* Slender, conical, about 0.3 mm in length. *Subapical lobe.* Setae *a-b* of proximal division subequal, strong, stout, rodlike and apically hooked, seta *c* very thin and slender; setae *d-f* of distal division composed of 1 tiny hairlike seta and 3-4 stronger, rodlike setae, the distal most of which is strongest and longest; leaf *g* narrow, lanceolate; seta *h* strong and apparently flattened. *Distimere.* Normal, sickle-shaped, similar to other members of

the *Bitaeniorhynchus* Subgroup. *Phallosome.* Very distinctive; lateral plate simple, represented by a straight, distally tapered and minutely spiculose portion of inner division which is strongly sclerotized and dark brown in color; outer division not developed. *Proctiger.* Apical crown dark, medium to large in size, consisting of several flat and blunt spicules laterally and numerous spinelike spicules mesally; paraproct narrow; basal sternal process very thick, dark and long, about 0.08 mm or more, apically rounded and strongly curved sternad; cercal sclerite very thin; cercal setae 1-3 in number.

PUPA (Fig. 29). Abdomen: 3.0 mm. Paddle: 0.78 mm. Trumpet: 0.71 mm. Cephalothorax and abdomen whitish to cream-colored. *Trumpet.* Darker than underlying integument; similar to other members of the *Bitaeniorhynchus* Subgroup in asymmetrically funnel-shape, differing slightly in being more slender and distally moderately widened; length of pinna about 0.3 mm. Complete chaetotaxy as figured, the following setae are characteristic: *Cephalothorax.* Setae 8, 9-C usually 3, 4 branched. *Metanotum.* Seta 10-C 4-9 branched; 11-C usually double (2-3). *Abdomen.* Setae 3-I-III double; 1-II single or forked into 2-4 branches; 1-III 8-10 branched, 1-IV 3-6 branched; 1-V 2-4 branched; 1-VI, VII double; 5-IV triple; 5-V, VI double, as long as or shorter than segment following; 6-III-VI all single; 7-VI, VII double or triple; 9-VII usually 5 branched (4-5); 9-VIII 7-9 branched; 4-VIII 3-5 branched; 10-III-VII double or triple. *Paddle.* Whitish to almost transparent except for midrib which is lightly pigmented.

LARVA (Fig. 30). Head: 0.65 mm. Siphon: 1.6-1.8 mm; index 8. Saddle: 0.36 mm; siphon/saddle ratio 4.6. Generally conforming to the *Bitaeniorhynchus* Subgroup characters, distinctive in the following. *Head.* Labral sclerite not apparent or represented by an extremely narrow bar not clearly separated from anterior margin of frontoclypeus; frontal margin of head capsule broadly convex or slightly emarginate; seta 1-C dark, flattened, moderately long and tapered into a sharp point, its length about 0.5 of distance between bases of the pair; 4-C long, single, 2, 3 times as long as distance between bases of the pair; 5-C double or triple; 6-C double; 7-C usually 5 branched (4-5). Antenna short, about 0.5 of head length; shaft entirely pale except for narrow basal dark ring; spicules minute and relatively few, more or less restricted to basal 0.5 on mesal surface; seta 1-A strongly plumose; 2, 3-A far removed from apex or at mid point between base of seta 1-A and apex. Mental plate black, with 10-12 distinct lateral teeth on each side of a median large tooth, upper lateral teeth strong, gradually reduced in size towards lower lateral angle of plate. *Thorax.* Seta 4-P short, minute and usually double (2-3); 8-P single. *Abdomen.* Majority of dorsal and ventral setae very weak, indistinct; 6-I-III triple; 6-IV-VI double; I-III-VI 3, 4 branched. Comb scales large, 4-6, in single irregular row, all subequal, about 0.08-0.10 mm in length; individual scale with strong, prominent apical spine and basal fringe of minute spicules. Saddle same color as siphon; seta 1-X usually 4 branched (3-4); 2-X 2-4 branched; ventral brush (4-X) with 5, 6 pairs of setae; anal gills very slender, long, tracheate, 4-5 times as long as dorsal saddle length. *Siphon.* Slender, long and cream-colored; pecten with 1-3 teeth at extreme base; siphonal tufts 5 or 6 pairs (total 10 or 12), all subventral and each usually triple (2-4), their length about equal to siphonal width at point of attachment; seta 2-S dark, remarkably long and strong.

TYPE-DATA. (1) *Culex gelidus* var. *sinensis* Theobald, Holotype ♀*, Shaohyling, (Chekiang), CHINA (BM); (2) *Culex sepositus* Leicester, Type non-existent, Kuala Lumpur, *Selangor,* MALAYA (PENINSULAR MALAYSIA); (3) *Taeniorhynchus tenax* Leicester, Type non-existent, Kuala Lumpur,

Selangor, MALAYA (PENINSULAR MALAYSIA); (4) *Culex tripunctatus* Mochizuki, Type unspecified, Fukuoka, *Kyushu,* JAPAN (LU).

DISTRIBUTION. Widespread throughout the Oriental region with the range extending north and northeast into the Palearctic region (China, USSR, Japan and Korea). Material examined. 248 specimens: 57♂, 164♀, 27 L; 11 individual rearings (7 pupal, 4 larval).

INDIA. *Bengal:* Purneah District, Katihar; Kierpur; Lalmanirhat; 11♂, 18♀; *Karwa*: N. Canara; 1♂; *Assam:* Chabua; Dooma Dooma; Rupsi; Jorhat; Dibrugarh; 4♂, 11♀, 7 L.

SRI LANKA. Peradeniya; Anu District; 1♂, 1♀.

CHINA. Fuchow; Fukien, Yun Chun, Amoy region; Yunnan, Tengyueh; Hainan; 2♂, 7♀.

HONG KONG. 6♂, 8♀.

THAILAND. Chiang Mai; Chiang Rai; Udon Thani; Ubon Ratchathani; Ayuthya; Nonthaburi; Bangkok; Trat; Prachuab Khiri Khan; Nakhon Si Thammarat; Trang; Narathiwat; 13♂, 58♀, 11 L, 7 p.

VIETNAM. Da Nang; Cu Chi; Pleiku; Dan Tieng; Vungtau; Phu loi; Qui Nhon; Cam Ranh; Quang Tin; 7♀, 9 L.

MALAYSIA. *Peninsular Malaysia: Selangor*-Ulu Gombak; locality not specified; *Perak;* 3♂, 6♀, 4 lp.

INDONESIA. *Java:* Pelabuhan Ratu, Mt. Salat, Djarkata; *Sumatra:* Bengkulu; *Aroe Island;* 8♂, 16♀.

PHILIPPINES. *Luzon:* Pampanga, Rizal, Wack Wack; Bulucan; Calacad, locality not specified; 3♂, 13♀.

JAPAN. *Okayama;* 2♀, *Ryukyus:* Okinawa-Nago; Chizuka; Hentona; 2♂, 9♀.

KOREA. Chinhae; 3♂, 8♀.

Additional records from the literature. BURMA: Bhamo (Barraud 1934: 395); BANGLADESH (Aslamkhan 1971); INDONESIA: Flores (Bonne-Wepster 1954: 117); REPUBLIC OF CHINA: Taiwan (Lien 1962: 635); CHINA: Chekiang, Hupeh, Kiangsi, Kwangtung (Feng 1938: 300); USSR: Maritime Province (Stackelberg 1937: 231; Monchadskii 1951: 275).

TAXONOMIC DISCUSSION. *Culex sinensis* is apparently uncommon but is one of the most widespread Oriental species. It can be readily recognized in the adults by (1) the presence of a distinct scale patch on the prosternum; (2) presence of pale scale speckling on the anterior surface of femora and tibiae of all legs; (3) entirely dark scales on all wing veins; (4) abdominal terga II-VII with narrow, even apical and basal pale bands and (5) relatively slender and small size; the male genitalia by (1) the simple phallosome and (2) basal sternal process of the proctiger very thick and long; the pupa by (1) the uniformly pale coloration of cephalothorax, abdomen and paddle; (2) the slender, asymmetric funnel-shaped trumpet; (3) seta 11-C double; (4) setae 3-I-III double; (5) seta 4-VIII, 3-5 branched and (6) setae 7-VI-VII double or triple and in the larva by (1) setae 2, 3-A far removed from apex; (2) seta 4-P minute; (3) siphon with 5 or 6 pairs of subventral tufts and (4) seta 2-S remarkably strong and long. Of all diagnostic features of *sinensis,* the simple male phallosome is unique among the members of the *Bitaeniorhynchus* Subgroup.

The *sinensis* adults are variable; the color of scales on the anterior 0.7 of the mesonotum varies from usually predominantly pale to largely dark with indefinite pale spots, blotches or streaks, similar to the pattern of variation noted in some members of the *bitaeniorhynchus* complex. In the abdominal tergal banding, the apical and basal pale bands are always well developed on terga IV to VII, but very poorly developed on terga II-III and in most specimens, the apical bands are broader and more distinct than basal. Although

sinensis is widespread, I have not been able to determine from the limited amount of available reared material whether there is differentiation into geographical races.

BIONOMICS. The larvae and pupae of *sinensis* have been collected in fresh water ground pools such as puddles, ponds and ditches in rice fields and in stream pools at a broad range of elevation. These habitats contain abundant vegetation, including green algae. In Thailand, several females were caught biting man indoors and outdoors (Scanlon and Esah 1965) and in light traps. A number of females from Vietnam, Sumatra, Indonesia and from Luzon in the Philippines were found to be fully engorged with blood, but no information was available whether they were caught biting man or other animals. The biology of *sinensis* is poorly known in Japan (LaCasse and Yamaguti 1950: 206-11). Evidence from adult collections in Thailand seems to indicate that it is probably a semi- or peridomestic species, but apparently not sufficiently common or abundant to be considered as pest or potential disease carrier. Nothing is known about its medical importance.

15. *CULEX (CULEX) CORNUTUS* EDWARDS
(Fig. 31)

Culex cornutus Edwards 1922a: 283 (♂*, ♀); Barraud 1923a: 937 (L*); Barraud 1924a: 988 (♂*, ♀).

Culex (Culex) cornutus Edwards, Edwards 1932: 202 (taxonomy); Barraud 1934: 396 (♂*, ♀, L*).

FEMALE. Wing: 4.2 mm. Forefemur: 1.8 mm. Proboscis: 2.0 mm. Abdomen: 2.9 mm. Based on one specimen in the type series and 5 other topotypic specimens from India. In general as figured for *sinensis* to which it is extremely similar, differing slightly in the following features. *Head.* Clypeus with variable amount of semierect pale scales (absent in *sinensis*). Palpus lightly sprinkled with pale scales on segments 3-4. Proboscis with relatively broader median pale ring and with a light sprinkling of pale scales proximad of ring on dorsal surface. *Cibarial Armature.* As described for *sinensis*. *Thorax.* Anterior 0.7 of mesonotum usually predominantly golden brown to dark brown with mottling of some yellowish scales not forming definite spots or streak, sometimes predominantly pale yellow but not whitish; scales on posterior 0.3 of mesonotum same color as those on anterior 0.7; scales in middle of prescutellar space and on scutellar lobes largely pale yellowish. Scale patches on *ppl, stp* and especially on *mep* well developed and relatively broad. *Legs.* Speckling of pale scales restricted to anterior surface of fore- and midfemora; anterior surface of hindfemur largely pale with light sprinkling of dark scales; all tibiae and tarsi not speckled. *Abdomen.* Terga IV-VII with apical bands broader than basal; terga II-III with incomplete basal bands and very narrow, complete apical bands. *Genitalia.* Essentially similar to *sinensis*.

MALE. In general as described for female, differing from *sinensis* in the following: *Head.* Palpus relatively longer, exceeding proboscis by more than 1.5 of segment 5; segment 3 with larger ventral lateral tuft of 30 or more strong bristles in apical 0.5, upper mesal surface with a row of 5-6 long, dark and fine hairs in apical 0.25 (absent in *sinensis*); segments 4 and 5 more strongly plumose.

MALE GENITALIA (Fig. 31). Very similar to *sinensis* in basimere, sub-

apical lobe and distimere, differing particularly in the phallosome and proctiger as follows. *Phallosome.* Inner and outer divisions of lateral plate well developed; inner division broad and rounded on upper margin, with distinct apical tergal angle produced tergad, somewhat resembling shape of tongue; lower tergal surface with a slender tergal lobe bearing 4-5 long, stout and apically pointed rodlike processes; outer division with a strong, heavy mesal spine and a very broad, rounded lateral basal process. *Proctiger.* Apical crown relatively smaller and largely consisting of narrow and fine spicules; basal sternal process longer and thicker, about 0.12 mm in length; cercal setae 2-3 in number.

PUPA. Based on 2 topotypic specimens associated with above male and female. Extremely similar to *sinensis* and as figured for that species; differing slightly in the following features. *Trumpet.* Longer, about 0.9 mm in length; pinna length about 0.35 mm. *Cephalothorax* and *Metanotum.* Seta 8-C double; 10-C double or triple. *Abdomen.* Seta 9-VII double or triple; 9-VIII 5 branched; 4-VIII double or triple.

LARVA. Based on 2 skins associated with the above male and female from the type locality. Extremely similar to *sinensis* and as figured for that species; differing from it in the following features. *Head.* Antenna longer; spicules in basal 0.5 of shaft stronger and more distinct. *Thorax.* Seta 4-P single, more distinct; 8-P double. *Abdomen.* Comb scales longer, 0.12-0.15 mm, 4-5 in number; basal plates of scales without distinct fringes of spicules. Seta 4-X (or ventral brush) with 6 pairs of setae. *Siphon.* Subventral tufts 4-5 pairs.

TYPE-DATA. Lectotype ♂* (814), Tavargatti jungle, Belgaum, Deccan, *Bombay,* INDIA, August 1921, P. J. Barraud (BM, present selection).

DISTRIBUTION. Known only from India and Pakistan. Material examined. 14 specimens: 6♂, 7♀, 1 L; 4 individual larval rearings.

INDIA. *Bombay:* Deccan, Tavargatti jungle; 1♂, 1♀ (type-series), 1♂, 1♀; Trombay; Karwa, N. Canara, S. W.; 4♂, 5♀, 1 l, 3 lp (P. J. Barraud; H. Cogill).

PAKISTAN. Lahore; 1 L (J. Maldonado, Sept. 1957).

Additional records from the literature: INDIA: Belgaum, Hog Island, Bombay; Ennore, Madras (Barraud 1934: 396).

TAXONOMIC DISCUSSION. The above descriptions of all stages of *cornutus* are based on the types and other specimens collected by P. J. Barraud in India. The Pakistan record is based on a whole larva from Lahore where additional specimens, especially reared adults are critically needed for confirmation.

Culex cornutus is closely related to *sinensis* on the basis of similarity in adult external characters, pupal and larval stages. The adults of *cornutus* can be differentiated from *sinensis* by (1) presence of semierect scales on lateral surface of clypeus; (2) largely pale scales on the anterior surface of hindfemur; (3) predominantly darker scales on the anterior 0.7 of mesonotum and in the male by (4) presence of 5-6 long hairs on the upper mesal surface of palpal segment 3. The male genitalia of *cornutus* are quite different from *sinensis* in the type of phallosome and in the relatively longer and thicker basal sternal process of the proctiger. The pupa and larva of *cornutus* are only slightly different from *sinensis.* It is possible that some confusion may be encountered in separating the pupa and larva of the 2 species except through association with the adults including the male from individual rearing.

As in *sinensis,* adults of *cornutus* exhibit variation in the extent of the abdominal tergal banding and in the color of scales on the mesonotum. Barraud (1923a: 937) noted that larvae from a jungle pool in Tavargatti (type-locality) differed from those from marshy fields at Trombay, Bombay Harbor in usually

having 6 pairs of subventral tufts on the siphon. The males which were reared from these 2 larval forms are, however, identical in the genitalia (Barraud loc. cit.), suggesting that only one form is probably involved. Because of the lack of larval specimens and associated males from Tavargatti, I was not able to determine whether the 2 larval forms are in fact conspecific. The larval characters, particularly the number of siphonal tufts noted above, have been based only on the specimens from Trombay.

BIONOMICS. The larvae of *cornutus* were collected from pools in marshy fields and in heavy jungle (Barraud 1923a, 1934), but no information was available whether these habitats contained green algae. The single larva from Lahore was collected in a borrow pit. The types and other topotypic adults came from field catches and from rearing the larvae in the field. Nothing is known about the adult biology and disease relationships of *cornutus*.

16. *CULEX (CULEX) EPIDESMUS* (THEOBALD)
(Fig. 31)

Taeniorhynchus epidesmus Theobald 1910b: 22 (♀); Edwards 1913b: 231 (treated as *Culex epidesmus* (Theobald)).

Grabhamia ochracea of Theobald 1905b: 25 (♀); Edwards 1913b: 231 (rejected as junior homonym of *G. ochracea* Theobald 1901; synonymy).

Taeniorhynchus luteoabdominalis Theobald 1910b: 23 (♀); Edwards 1913b: 231 (synonymy).

Culex epidesmus (Theobald), Edwards 1913b: 231 (taxonomy); Barraud 1924a: 982 (♂*, ♀); Senior-White 1927: 61 (distribution).

Culex (Culex) epidesmus (Theobald), Edwards, 1932: 20 (taxonomy); Barraud 1934: 389 (♂*, ♀).

FEMALE. Wing: 4.5 mm. Forefemur: 2.2 mm. Proboscis: 2.3 mm. Abdomen: 3.5 mm. Relatively large species, distinguished from other members of the *Bitaeniorhynchus* Subgroup by the predominantly yellowish or golden scales on head, mesonotum, legs, wing and abdomen. *Head.* Narrow decumbent scales of vertex and occiput whitish or yellowish; erect scales largely yellowish or golden in center, brownish posterolaterally; lateral patch of broad scales whitish. Clypeus with or without lateral patch of semierect scales. Palpus extensively speckled or predominantly pale. Proboscis with a very broad median yellow ring and extensively pale scaled proximad of ring on dorsal and ventral surfaces; apical portion distad of ring dark scaled except for a few pale scales on apex of labium. *Cibarial Armature.* Not studied. *Thorax.* Prosternum with pale scale patches. Anterior 0.70-0.75 of mesonotum largely pale yellowish or whitish with indefinite mottling of dark scales forming streaks and spots in middle; a pair of dark fossal spots present or absent; scales on prescutellar space and scutellar lobes whitish or silvery; scales on supraalar and postdorsocentral areas largely brownish. *Apn* and *ppn* golden to brown scaled. Pleural scale patches on *ppl*, *stp* and *mep* very well developed. *Legs.* Scales on anterior surface of forecoxa largely pale; femora, tibiae and tarsomere 1 of all legs largely pale yellowish, with light or moderate sprinkling of dark scales; apical and basal pale bands on tarsomeres 1-4 very broad; tarsomeres 5 entirely dark. *Wing.* Scales narrow and very dense; scales on apical portion of veins C, R_1, R_2, R_3 and R_{4+5} largely pale yellow, forming a broad apical pale area; rest of wing veins with equal mixture of dark and pale scales or sometimes largely dark, with light to moderate sprinkling of pale scales.

Abdomen. Color of terga I-VIII variable, usually entirely bright yellow to golden; tergum II sometimes with a pair of dark lateral spots or dark basal bands; terga III-V with narrow subbasal dark bands or broad basal dark bands; tergum VI sometimes with a pair of median dark spots; terga VII-VIII always entirely pale; sterna entirely yellow, with or without dark lateral patches or spots. *Genitalia.* Not studied.

MALE. In general as in female, differing in having scales on head, thorax, legs and abdomen more extensively pale yellowish. *Head.* Palpus exceeding proboscis by a little more than full length of segment 5; segment 2 with broad apical pale band; segment 3 largely pale from basal 0.1 to apex; segments 4 and 5 very strongly plumose; bristles on lateral and mesal surfaces of segment 5 largely whitish to yellowish. Proboscis with prominent yellow ventral tuft of several long hairs proximad of median pale ring; portions basad and distad of ring of labium largely pale.

MALE GENITALIA (Fig. 31). Exceedingly similar to *cornutus,* differing slightly in the following details. *Subapical lobe.* Leaf *g* of distal division broader and longer. *Phallosome.* Apical spiculate portion of inner division with a slender tergal lobe bearing 2 narrow elongate teeth, outer division with smaller mesal spine and variable number of tubercles distad of a large lateral basal process. *Proctiger:* Cercal setae 4 in number.

PUPA and LARVA. Unknown.

TYPE-DATA. (1) *Taeniorhynchus epidesmus* Theobald, Holotype ♀, Bhogaon, Purnea District, *Bihar,* INDIA, October 1908, C. Paiva (IM; Barraud 1934: 389); (2) *Grabhamia ochracea* Theobald, Lectotype ♀*, INDIA, Christophers (BM; present selection); (3) *Taeniorhynchus luteoabdominalis* Theobald, Holotype ♀, Kathihar, Purnea District, *Bihar,* INDIA (IM).

DISTRIBUTION. Known only from India. Material examined. 15 specimens: 7♂, 8♀.

INDIA. Locality not specified; 2♀ (original type-series of *G. ochracea* Theobald); *Bihar:* Pusa; 2♂, 2♀; *Bengal; Assam;* 5♂, 3♀.

BANGLADESH. Sylhet; 1♀.

Additional records from the literature: INDIA: Western Himalayas: Simla; United Provinces; Punjab (Barraud 1924a: 982; 1934: 389); SRI LANKA (Senior-White 1927: 61-76); PAKISTAN; BANGLADESH (Aslamkhan 1971).

TAXONOMIC DISCUSSION. *Culex epidesmus* exhibits a strong affinity with *cornutus* on the basis of similarity in the male genitalic characters, but is strikingly different from the latter in the predominantly yellow scales on the head, male palpus and proboscis, mesonotum, legs, wing and abdomen. These outstanding features are constant in the specimens I have examined. Variations exhibited by *epidesmus* adults are the presence or absence of dark spots or bands on some abdominal terga, but these do not appear to be correlated with any particular modification in the male genitalia. It seems most likely that only a single species is involved.

As noted by Barraud (1924a, 1934), *epidesmus* is rare but widespread in the northern parts of India. The record from Sri Lanka by Senior-White (1927) is very doubtful as it has never been confirmed by subsequent studies.

BIONOMICS. The breeding habitat of *epidesmus* is not definitely known. The larval collection by Senior-White (1927) at Marlbe Estate, N.W.P, Sri Lanka, was made in a buffalo wallow in an uncultivated rice field but subsequent visits to the same locality failed to recover any specimens of this species. All of the adults from India apparently came from general field catches. Nothing is known about the adult biology and the medical importance of *epidesmus.*

17. *CULEX (CULEX) GEMINUS* COLLESS
(Fig. 32)

Culex (Culex) geminus Colless 1955: 314 (♂*, ♀, L*)

FEMALE. Wing: 4.5 mm. Forefemur: 2.0 mm. Proboscis: 2.2 mm. Abdomen: 3.06 mm. As described and figured for *pseudosinensis* (Fig. 26) to which it is very similar, differing slightly in the following characters. *Head.* All erect scales of vertex dull brown except for extreme apices which are slightly pale. *Legs.* Anterior surface of fore- and midfemora lightly sprinkled with pale scales; rest of legs uniformly dark. *Abdomen.* Terga II-VII with narrow apical pale bands which are more or less even in width or slightly widened laterally; basal pale bands on terga II-IV absent or indistinct and those on terga V-VII represented by a few rows of pale scales; dark areas on all terga without speckling of pale scales.

MALE. Essentially as described for female, differing in having distinct basal pale bands on abdominal terga II-VII and distinct apical bands on terga V-VII; terga II-IV with or without very narrow apical bands. *Head.* Palpus exceeding proboscis by a little more than full length of segment 5; segment 3 usually with median pale band on dorsal surface, sometimes absent or with a few scattered pale scales, apical 0.5-0.6 with ventral lateral tuft of about 25 bristles, upper mesal surface with a row of about 8 weak bristles in apical 0.5; segments 4 and 5 with basal pale bands on dorsal surface; apical 0.5 of segment 5 pale to tip. Proboscis with a ventral tuft of about 10 long hairs basad of median light ring.

MALE GENITALIA (Fig. 32). As described and figured by Colless (1955: 314-5); differing from *pseudosinensis* and other members of the *Bitaeniorhynchus* Subgroup particularly in the following features. *Segment IX.* Lateral tergal lobe with a row of 5-6 relatively weak setae. *Subapical lobe.* Setae *a-c* of proximal division subequally long; seta *b* strongest; setae *a* and *c* similar in size; setae *d-f* of distal division flattened, rodlike or bladelike, 4 in number, the most distal longest, the other 3 subequal in length, all apparently with blunt apices; leaf *g* very broad and rounded apically. *Phallosome.* Very distinctive, resembling members of *Vishnui* Subgroup; apical portion of inner division with a distinct crown of 3-4 dark, stout and apically pointed fingerlike processes, the most mesal one longest, the rest gradually shorter, all curved and with apices pointing beyond apical margin of sternal portion of inner division; outer division with 1 strong toothlike mesal spine, 1 laterally divergent spine and 1 sternal spine; sternal spine sharply angled basally with apex pointing basad; lateral basal process of outer division large and rounded. *Proctiger.* Apical crown medium sized, composed of several dark spinelike spicules only; basal sternal process of paraproct dark, stout and long, about 0.1 mm in length; cercal setae 2 in number.

PUPA. As figured for typical *bitaeniorhynchus* (Fig. 21); differing in the following characters. Cephalothorax and abdomen varying from deep yellow to dark brown; pattern of dark alveolar spots absent. *Cephalothorax.* Seta 9-C 3,4 branched. *Metanotum.* Seta 10-C double. *Abdomen.* Setae 3-I-III double; 1-IV, V 4-7 branched; 1-VI 3,4 branched; 5-IV 4 branched; 5-V 2,3 branched; 5-VI triple; 7-VI, VII double or triple; 4-VIII 3-5 branched. *Paddle.* Inner and outer parts more or less uniformly slightly darkened; basal external margin of outer part not infuscated; midrib moderately pigmented.

LARVA (Fig. 32). As figured for typical *bitaeniorhynchus* and *pseudosin-*

ensis, differing in the following characters. *Head.* Seta 1-C distally tapered into a fine point; 5-C usually 4 branched (3-4). Mental plate small, with 5, 6 strong, apically blunt lateral teeth on each side of median tooth. *Abdomen.* Comb scales small, 7 -11, in 2 irregular rows; individual scale with prominent apical spine and basal fringe of fine spicules; seta 2-VIII 4-7 branched; 4-VIII 4-6 branched. Seta 2-X of saddle triple. *Siphon.* Pecten with 7-9 distinct teeth; subventral tufts 3 pairs (total 6).

TYPE-DATA. Holotype ♂* with associated pupal and larval skins and slide of genitalia, Adelphi Estate, SINGAPORE, 7 April 1953, D. H. Colless (BM).

DISTRIBUTION. Known only from Singapore and Peninsular Malaysia. Material examined. 7 specimens: 4♂, 1♀, 2 L; 3 individual rearings (1 pupal, 2 larval).

MALAYSIA. *Peninsular Malaysia: Selangor*-Banting; 1♂, 1♀, 2 L, 1 p, 1 lp.

SINGAPORE. Adelphi Estate; 1♂, 1 lp (holotype); locality not specified; 2♂ (D. H. Given, 1924).

Additional records from the literature: MALAYSIA: Selangor, Kg. Sijangkang (Colless 1955: 314-5).

TAXONOMIC DISCUSSION. *Culex geminus* is strongly differentiated from the rest of the *Bitaeniorhynchus* Subgroup in the type of phallosome and in the mental plate of the larva. On this basis it apparently falls into a distinct complex. The adults of *geminus* are extremely similar to those of *pseudosinensis* in the coloration of mesonotum, the absence of pale scale speckling on the wing and in the pattern of abdominal banding. The slight differences in the speckling of the legs and the extent of apical as well as basal abdominal bands between the 2 species are fairly constant, but for positive identification, the male genitalia and the associated larval stages should also be examined.

BIONOMICS. The immature stages of *geminus* were collected in a jungle pool in association with the specimens of *pseudosinensis* (Colless 1955) and those from Selangor, Malaysia, were collected in a ditch in association with *Culex (Lophoceraomyia) alphus* Colless. These breeding sites are at sea level and contain numerous green algae. The feeding habit of the females and their medical importance are unknown.

18. *CULEX (CULEX) KINABALUENSIS* NEW SPECIES
(Figs. 33, 34)

FEMALE. Wing: 4.5-5.2 mm. (average 5.0). Forefemur: 2.1 mm. Proboscis: 2.3 mm. Abdomen: 2.9 mm. Large species, distinguished from all other members of the *Bitaeniorhynchus* Subgroup by the absence of speckling on femora of legs and wing; the presence of only basal pale bands on abdominal terga II-VII and by the following characters. *Head.* Erect scales of vertex yellowish along dorsal midline in center, dark on anterior and posterolateral areas. Palpus entirely dark except for white scales at extreme apex of segment 4. Proboscis without scattered pale scales proximad or distad of median yellow ring; apex of labium without any pale scales forming distinct ring. *Thorax.* Scales on anterior 0.7 of mesonotum largely brownish in middle, pale yellowish on marginal areas, including: anterior promontory, humerus, scutal angle and posterior border of fossae, continued as a distinct pale patch mesad of supraalar bristles; scales on prescutellar space and scutellar lobes pale beige to whitish. *Apn* with several narrow scales which are usually whitish

anteriorly, dark brown laterally; *ppn* with a broad narrow scale patch which is largely dark. Pale scale patches on *ppl, stp* and *mep* of pleuron well developed. *Legs*. Anterior surface of femora of fore- and midlegs usually dark, sometimes with a few pale scales scattering in apical 0.25; apex of forefemur with distinct subapical pale spot; hindfemur with a longitudinal pale stripe extending from base to apex anteriorly, bordered by largely dark scales on lateral dorsal surface; all tibiae and tarsomeres 1 not speckled; tarsomeres 1-4 with distinct basal pale bands and very indistinct apical bands. *Wing*. Scales on all wing veins dark; scales on veins R_2, R_3 and R_{4+5} narrow, linear. *Abdomen*. Tergum I with dark median scale patch; terga II-VII with complete basal pale bands only; apical bands absent; basal bands usually moderately broad and even in width, sometimes largely retracted into preceding segments; sterna with broad basal pale bands.

MALE. In general similar to female except for sexual characters. *Head*. Palpus exceeding proboscis by about full length of segment 5; segment 3 with median pale band or several pale scales not forming definite band on dorsal surface, apical 0.25 with ventral lateral tuft of 10-15 bristles, upper mesal surface without any hairs or bristles, ventral surface with a row of short, pale hairlike setae along the whole length; segments 4 and 5 with narrow basal pale rings; apical 0.25 of segment 5 pale to tip. Proboscis with a weak ventral tuft of about 10-20 hairs proximad of median pale ring; no pale scales scattered distad or proximad of median ring.

MALE GENITALIA (Fig. 33). *Segment IX*. Tergal lobe with 1,2 irregular rows of 8,9 strong setae. *Basimere*. Normal, conical, about 0.34 mm in length. *Subapical lobe*. Setae *a-c* of proximal division subequal in length; setae *a* and *b* stout, seta *c* narrower and thinner, setae *d-f* of distal division composed of 1 fine, hairlike seta and 2 apically hooked rodlike setae, the most distal of which is strongest and longest; leaf *g* narrow, bladelike, with acuminate apex. *Distimere*. Normal, sickle-shaped; subapical claw short or moderate in length. *Phallosome*. Generally similar to *geminus;* inner division with apical tergal crown of 2,3 stout and short fingerlike processes projecting laterad; outer division very broad, with a strong mesal spine; lateral and sternal spines not developed, outer lateral margin with variable number of small tubercles or denticles; lateral basal process broadly rounded. *Proctiger*. Apical crown medium to large; composed of several relatively long, flattened spines laterally and numerous fine spinelike spicules mesally; basal sternal process dark, thick, long, curved sternad; cercal setae usually 4, sometimes 3 or 5.

PUPA (Fig. 33). Abdomen: 4.0 mm. Paddle: 1.1 mm. Trumpet: 0.78 mm. In general very similar to other members of the *Bitaeniorhynchus* Subgroup in relatively large sized and in having asymmetrically funnel-shaped trumpet, differing in the following features. Pigmentation of cephalothorax and abdomen cream-color or yellowish without definite darkened areas or pattern of dark alveolar spots. *Trumpet*. Apical length of pinna relatively short, about 0.35 mm. *Cephalothorax*. Seta 8-C long, 2-3 times as long as 9-C, 2-4 branched; 9-C usually double (2-3). *Metanotum*. Seta 10-C 5-8 branched; 11-C double; 12-C weak and short, usually double. *Abdomen*. Setae 3-I-III single or double; 1-III 2-5 branched; 1-IV usually triple (3-4); 1-V-VII single or double; 5-IV double, as long as segment following, sometimes shorter; 5-V, VI usually single (1-2), longer than segment following; 2-VII always mesad of 1-VII; 9-VII triple or 4 branched; 4-VIII usually double (2-3); 9-VIII 9, 10 branched. *Paddle*. Entirely whitish, without darkened or infuscated area; seta 2-P present; 1-P absent.

LARVA (Fig. 34). Head: 0.70 mm. Siphon: 1.8-2.0 mm; index 6-7. Saddle: 4.0 mm; siphon/saddle ratio 4-5. Essentially conforming to the *Bitaeniorhynchus* Subgroup with the following distinctive features. *Head.* Seta 1-C dark brown, distally tapered to a fine point; 4-C triple, slightly shorter than distance between bases of the pair; 5-C triple, 6-C usually double (2-3); 7-C 5-8 branched; 11-C weaker and shorter than 13-C, double; 13-C double; 14-C single, spiniform. Setae 2,3-A subapical. Mental plate with a large and blunt median tooth and about 18 lateral teeth; 3 of the lateral teeth adjacent to median tooth large, those towards lateral angle of plate gradually smaller. *Thorax.* Setae 1,2-P double; 3-P triple; 4-P double, as long as 3-P; 7-P usually triple (3-4); 8-P double. *Abdomen.* Setae 6-I, II 4-6 branched; 7-I double; 6-III-V triple; 6-VI double or triple; dorsal setae 1-5 and ventral setae 9-13 of segment I-VI very weak and indistinct. Comb scales 12-15, in oval patch; all scales subequal and moderately long, each with a strong apical spine and basal fringe of fine spicules; setae 2 and 4-VIII double; 1-VIII 8-9 branched; 3-VIII 8-10 branched; 5-VIII 3,4 branched. Seta 2-X double or triple; 4-X with 6 pairs of setae; anal gills not tracheate, about 1.5 times as long as dorsal saddle length. *Siphon.* Rather thick and moderately long, distally slightly tapered; pecten teeth 3-4 in number, restricted to extreme base, sometimes completely absent; siphonal tufts very weak, short, usually 5 pairs (total 10), all double and subequal, shorter or as long as siphonal width at point of insertion; 2-S dark, slender and moderate in length; median caudal filament poorly developed.

TYPE-DATA. Holotype ♂ (No. S135.14) with associated pupal and larval skins and genitalia slide, Mt. Kinabalu, *Sabah,* MALAYSIA, elevation 950-1,075 m, pool at edge of mountain stream, 20 March 1970, S. W. James et al. (USNM); Allotype ♀ (No. S135.12) with associated pupal and larval skins, same data as holotype (USNM); Paratypes: 1♂ (No. S131.103) with associated pupal skins; 2♀ (No. S131.100, S131.101) with associated pupal skins; 2♂ (No. S131); 2♀ (No. S131); 1♂ (No. S134); 2♀ (No. S134.100, S134.102) with associated pupal skins, same data as holotype (USNM, BM).

DISTRIBUTION. Known only from the type-locality, Mt. Kinabalu, *Sabah,* MALAYSIA. Material examined: 16 specimens: 5♂, 7♀, 4 L; 6 individual rearings (4 pupal, 2 larval); as indicated in the type-data.

TAXONOMIC DISCUSSION. *Culex kinabaluensis* is distinctive in all stages except for the pupa which is only slightly different from the rest of the *Bitaeniorhynchus* Subgroup. On the basis of the male phallosome and larval characters, *kinabaluensis* apparently falls into the *geminus* complex which, as interpreted here, also includes *squamosus* (Taylor) from New Guinea, Australia and the Solomon Islands and *albinervis* Edwards from Fiji as described by Belkin (1962: 212-5).

The adults of both sexes of *kinabaluensis* exhibit much overlap or similarity to most members of the *Sitiens* and *Vishnui* Subgroups in the color of scales on the mesonotum and in the pattern of tergal abdominal bands. There is apparently no adult dimorphism or presence of more than one color form in the material examined. It can be separated from the members of the *Sitiens* and *Vishnui* Subgroups in the female by its relatively larger size, presence of distinct subapical spot on the apex of forefemur and in the male by having fine, hairlike setae on the ventral surface of palpal segment 3 (scalelike or flattened in *Sitiens* and *Vishnui* Subgroups). The male genitalia of *kinabaluensis* differs from *geminus* and other members of the *Sitiens* and *Vishnui* Subgroup in the narrow, bladelike leaf *g* of distal division of subapical lobe; absence of the lateral and sternal spines in the outer division and the shorter and fewer apical fingerlike processes or teeth on the apical tergal margin of inner division of

the phallosome. The pupa and larva are basically similar to all other forms of the *Bitaeniorhynchus* Subgroup except as indicated in the keys and as noted above. The larva strongly resembles *albinervis* and *starckeae* as figured and described by Belkin (1962: 212, 217) from the South Pacific in the form of the mental plate and the comb scales, but is distinct from both in the branching of setae 1 and 2-P and setae 5 and 6-C.

BIONOMICS. The immatures of *kinabaluensis* all came from collections made in ground pools at the edge of a mountain stream at an elevation of 950-1,075 m on Mt. Kinabalu, Sabah. These breeding sites were partially shaded in tropical rain forest and contained no aquatic vegetation. As noted by the collectors, they were found in association with *C. (Culex) mimulus* and *C. (Culiciomyia)? bailyi* Barraud. All adults were obtained from individual and mass rearings from pupae and larvae. Nothing is known about adult feeding behavior and its relation to disease.

SITIENS SUBGROUP

The *Sitiens* Subgroup is characterized by the following combination of characters: in the adults by (1) medium size (wing length usually less than 4.0 mm); (2) erect scales of vertex usually entirely dark or sometimes whitish in center, dark on posterolateral areas; (3) scales on anterior 0.7 of mesonotum usually predominantly dark in middle, pale on marginal areas, sometimes entirely whitish; (4) scales on posterior 0.3 of mesonotum laterad of prescutellar space partially dark and pale or sometimes entirely whitish; (5) scales on prescutellar space and scutellar lobes pale beige to whitish; (6) *apn* and *ppn* with several narrow scales; (7) speckling of legs usually present, restricted to anterior surface of femora; sometimes absent; (8) scales on all wing veins entirely dark and (9) abdominal terga with basal pale bands only; the male by (1) ventral surface of palpal segment 3 usually with short, transparent scalelike setae, or sometimes with dark fine hairlike setae; (2) apex of palpal segment 5 tipped with pale scales and (3) proboscis usually with ventral tuft of long hairs at base of median pale ring; the male genitalia by (1) distimere normal; (2) apical sternal portion of inner division of phallosome with expanded spiculose or spinose lobe and a prominent apical tergal crown of 3-5 long fingerlike or toothlike processes and (3) outer division of phallosome with differentiated mesal and sternal spines or in form of a simple broad leaf or large, strong, acute spine; the pupa by trumpet moderately long (0.52-0.91 mm), more or less cylindrical or slightly widened towards apex and pinna lightly or strongly oblique and in the larva by (1) labrum developed as a distinct transverse bar separated from frontoclypeus; (2) head large, maximal width approximating the width of prothorax; (3) mental plate with 4-10 strong lateral teeth on each side of median tooth; (4) seta 4-P double and strong; (5) setae 2 and 4-VIII single; (6) comb scales usually small, numerous, sometimes few and large; (7) siphon moderately long; shape varied; siphonal tufts strong, 5-8 pairs; (8) median caudal filament of spiracular apparatus poorly developed or absent and (9) anal gills varied from very short, rounded or stubby to long, tubular or fusiform.

DISCUSSION. The *Sitiens* Subgroup is differentiated from the rest of the *Sitiens* Group by the special modification of the complex male phallosome as indicated in the above diagnosis. This subgroup corresponds to the *Sitiens* Subgroup as defined by Belkin (1962: 202) and Bram (1967a: 236). In the Oriental region the *Sitiens* Subgroup is represented by 4 species which apparently

fall into 3 more or less distinct complexes: *sitiens*, *whitmorei* and *annulirostris*.

The *sitiens* complex includes *sitiens* and *alis*, both of which are coastal or brackish water species and are closely related to *litoralis* Bohart 1946 from the Central Pacific; *roseni* Belkin 1962 and *whittingtoni* Belkin 1962 from the South Pacific and *thalassius* Theobald (Edwards 1941: 298) from the Ethiopian region. This complex is chiefly characterized in the male genitalia by the presence of mesal or sternal spines or both in the outer division of the male phallosome; in the pupa by setae 6-III-VI single or double and setae 5-V-VI usually double and in the larva by seta 1-C strongly flattened and striated; seta 7-I single; comb scales small, numerous, in broad oval patch; siphon straight and thick; siphonal tufts strong, 6, 7 pairs, 5-8 branched each, one out of line or inserted laterally in apical 0.25; saddle complete or incomplete; anal gills very short, stubby and rounded.

The *whitmorei* complex as proposed here includes only *whitmorei* and is chiefly characterized in the male genitalia by outer division of the phallosome represented by a single broad leaf; in the pupa by abdominal setae 6-III-VI 5-7 branched and setae 5-V-VI 6-8 branched and in the larva by seta 1-C slender, spiniform; seta 7-I single; comb scales large, 5-8, in 1 or 2 rows; siphon strongly curved upwards and slender; siphonal tufts very long, 7, 8 pairs, double; saddle complete; anal gills slender, tapering, about 1.5 times as long as saddle.

The *annulirostris* complex includes only *annulirostris* as recognized by Belkin (1962: 202). It is chiefly characterized in the male genitalia by outer division of the phallosome represented by a strong, simple, laterally divergent spine; in the pupa by setae 6-III-VI 3-5 branched and setae 5-V-VI usually double and in the larva by seta 1-C slender, spiniform; seta 7-I double; comb scales small, numerous, in broad oval patch; siphon with 5, 6 pairs of subventral tufts, all in a line; saddle complete and anal gills slender, tapering, 1-2 times as long as saddle.

19. *CULEX (CULEX) SITIENS* WIEDEMANN
(Figs. 15, 35, 36, 37)

Culex sitiens Wiedemann 1828: 542 (♀); Theobald 1901a: 360 (♀*); Giles 1902: 400 (♀); Blanchard 1905: 293 (♀); Leicester 1908: 143 (♂, ♀); Edwards 1913b: 232 (taxonomy); Barraud 1924a: 993 (♂*, ♀); Barraud 1924c: 427 (L*); Borel 1930: 330 (♂*, ♀, L*).

Culex impellens Walker 1859: 91 (♀); Theobald 1901a: 362 (♀*); Giles 1902: 405 (♂*, ♀); Theobald 1903: 161 (♂); Blanchard 1905: 294 (♀); Leicester 1908: 142 (♀); Theobald 1910a: 331 (distribution); Edwards 1913b: 232 (synonymy).

Culex microannulatus Theobald 1901a: 353 (♂*, ♀*); Blanchard 1905: 292 (♀); Leicester 1908: 140 (♂, ♀); Theobald 1910a: 329 (distribution, taxonomy); Edwards 1913b: 232 (synonymy).

Culex gnophodes Theobald 1903: 163 (♀); Leicester 1908: 145 (♀); Edwards 1913b: 232 (synonymy).

Culex nigricephala Leicester 1908: 149 (♂, ♀); Edwards 1932: 204 (synonymy).

Culex (Culex) sitiens Wiedemann, Edwards 1932: 204 (taxonomy); Barraud 1934: 398 (♂*, ♀, L*); Brug 1934: 514 (♀); Bonne-Wepster and Brug 1937: 67 (♂, ♀*); Bonne-Wepster and Brug 1939: 1268 (L*); Bohart 1945: 80 (♀); Bohart and Ingram 1946: 18 (♂*, L*); Carter and Wijesundara 1948:

150 (♀, L*); Bonne-Wepster 1954: 123 (♂*, ♀*, L*); Belkin 1962: 205 (♂*, ♀, P*, L*); Delfinado 1966: 151 (♂*, ♀, L*); Bram 1967a: 239 (♂*, ♀*, P*, L*); Baisas 1974: 101 (♂, ♀, L).

Culex (Culex) salinus Baisas 1938: 204 (♂*, ♀*, P*, L); Delfinado 1966: 151 (synonymy).

For complete synonymy, see Stone, Knight and Starcke (1959).

FEMALE (Fig. 15, 35). Wing: 2.4-4.0 mm (average 3.5 mm). Forefemur: 1.4-2.0 mm (average 1.7 mm). Proboscis: 1.6-2.2 mm (average 1.8 mm). Abdomen: 2.3-3.2 mm (average 3.0 mm). Medium sized species. *Head.* Narrow decumbent scales of vertex pale beige; erect scales usually entirely dark brown, sometimes slightly pale anteriorly, dark brown posterolaterally; lateral patch of broad appressed scales whitish. Palpus about 0.2 of proboscis length; segment 4 tipped with some pale scales, rest entirely black. Proboscis with clearly marked median pale ring which occupies about 0.2 of total length; portions proximad and distad of median ring entirely black. *Cibarial Armature.* Cibarial bar strongly sclerotized, with about 30 teeth in a concave row which is slightly produced at middle; median 4-6 teeth minute, terminating into a fine point; lateral teeth coarse and short, closely spaced, with abruptly pointed or truncate apices. *Thorax.* Mesonotal integument dark brown to black; mesonotal scales coarse and usually predominantly dark in middle of disc, pale beige or golden on anterior promontory, humeral and scutal angles, antealar and supraalar areas; posterior margin of fossa, acrostichal and dorsocentral areas cephalad of prescutellar space usually with pale streaks or blotches of golden scales; prescutellar and scutellar scales entirely pale beige or pale yellowish. *Apn* with several narrow dark or golden brown scales; *ppn* with broad patch of narrow scales which are largely dark in middle, pale towards anterior and posterior upper margins. Pleural integument slightly paler than mesonotal except for darkened areas on *psp,* lower *ppn* and *psp* and posterior border of *stp;* pale scale patches on *ppl, stp* and *mep* distinct; scales among upper *mep* bristles absent; *ppl* bristles 7-9. *Legs.* Anterior scale patch of forecoxa pale on upper lateral surface, largely dark or with a mixture of dark and pale scales on anterior lower surface; scale patch on anterior surface of midcoxa dark above, pale below; scale patch on anterior surface of hindcoxa entirely pale; basal 0.5 of forefemur with distinct pale stripe on anterior lower margin, apical 0.5 lightly speckled with few pale scales, rest dark scaled; anterior surface of midfemur usually with light speckling of pale scales in middle; anterior surface of hindfemur largely pale, with light sprinkling of scattered dark scales on upper lateral surface; foretibia largely dark, without row of pale scaled spots among anterior bristles; mid- and hindtibiae largely dark with or without light sprinkling of pale scales; tarsomeres 1-2 or 1-3 with very narrow apical and basal pale bands; tarsomeres 4-5 entirely dark. *Wing.* Scales on all veins numerous and dark; base of vein C with or without a short pale scaled streak on posterior surface; scales on veins R_2, R_3 and R_{4+5} narrow, clavate; cell R_2 1.25-1.50 times as long as R_{2+3}. *Abdomen.* Tergum I with dark median caudal scale patch; terga II-VIII with narrow, even basal pale bands connected with elongate basolateral pale spots; terga VII-VIII also with narrow apical pale band in middle; all sterna with broad basal pale bands and apical dark bands. *Genitalia.* Tergum IX with lateral row of 6-7 setae; postgenital plate broadly rounded on caudal margin; vaginal sclerite strongly sclerotized and dark, U-shaped; insula with a dense tuft of 10-12 setae.

MALE (Fig. 35). As described for female, differing in having 15-16 *ppl* bristles, broader basal pale bands on abdominal terga II-VIII and less dense

scales on wing veins. *Head.* Palpus exceeding proboscis by 1.5 of segment 5; segment 3 with distinct median pale band, ventral surface with a row of short, distally flattened scalelike setae, apical 0.4-0.5 with ventrolateral tufts of 20-30 dark bristles, upper mesal surface without any setae or bristles; segments 4 and 5 strongly plumose, with distinct basal pale rings; apical 0.25 of segment 5 largely pale to tip. Proboscis with a prominent ventral tuft of several long dark hairs proximad of median pale ring.

MALE GENITALIA (Fig. 36). *Segment IX.* Tergal lobe with a row of 5, 6 setae. *Basimere.* Slender, conical, about 0.28 mm in length. *Subapical lobe.* Setae *a*-*b* of proximal division equally long, seta *a* and *b* stout, seta *c* thinner; setae *d*-*f* of distal division consisting of 3 short, narrow flattened setae and 1 long, thick rodlike seta; leaf *g* moderately to very broad, its apex blunt of acuminate; seta *h* strong; sternal surface of lobe with a conspicuous patch of numerous short and fine setae. *Distimere.* Normal, about 0.15 mm in length; 1 dorsal and 1 ventral minute seta present, ventral distad of dorsal; subapical claw very short, distally flattened and apically rounded. *Phallosome.* Apical spiculate portion of inner division with a prominent apical tergal crown of 4-5 strong, fingerlike processes; sternal apical portion more or less broadly expanded, forming a distinct lobe sternad; outer division with a strong mesal spine and a very large sternal spine, the latter strongly curved with its apex pointing basad; lateral spine absent; lateral basal process of outer division large, elongate, apically rounded, knoblike. *Proctiger.* Apical crown dark, medium to large in size, composed of 4, 5 flattened and apically blunt or truncate spicules laterally and numerous strong spinelike spicules mesally; basal sternal process dark, heavy and moderately long, about 0.08 mm; subbasal process well developed, about 0.03 mm; cercal setae 2, 3.

PUPA (Fig. 36). Abdomen: 3.2 mm. Paddle: 0.8 mm. Trumpet: 0.62-0.72 mm (average 0.65 mm); index 5-8. Cephalothorax and abdomen generally cream-colored, with indefinite darkened areas along posterior middorsal ridge, leg and wing cases, metanotum and abdominal segment I-IV. *Trumpet.* Meatus narrow at base, gradually widened distally; pinna strongly oblique. *Cephalothorax.* Seta 1-C strong and long, usually double; 2-C short 3, 4 branched; 3-C shorter than 1-C, double; 4-C double or triple; 5-C usually triple (2-5); 8-C as strong as 1-C, usually double, rarely single; 9-C short, double or triple. *Metanotum.* Seta 10-C 6-11 branched; 11-C double; 12-C usually 3, 4 branched (3-5). *Abdomen.* Setae 6-III, IV single; 6-V, VI longer than 6-III, IV, usually double (1-3); 1-II usually forked into 4-8 branches; 1-III-VI weak and short; 1-III usually 6 branched (4-9); 1-IV usually 4 branched (3-5); 1-V usually triple (2-4); 1-VI, VII usually double or triple (2-4); 5-IV double or triple, slightly shorter than segment following; 5-V, VI usually double (2, 3), 1.0-1.5 times as long as segment following; 9-VII usually 4 branched (3-5); 4-VIII double; 9-VIII usually 11 branched (9-12). *Paddle.* Broad and entirely pale except for lightly pigmented midrib; seta 2-P stronger than 1-P, usually single, sometimes bifid; 1-P single.

LARVA (Fig. 37). Head: 0.78 mm. Siphon: 1.2 mm; index 4-5. Saddle: 0.32 mm; siphon/saddle ratio about 4. *Head.* Cream-colored with indefinite darkened areas; seta 1-C strongly flattened, striated and dark, apex blunt or abruptly pointed; 4-C single, about as long as distance between bases of the pair; 5-C usually 5 branched (-8); 6-C usually 4 branched (2-5); 7-C 8-10 branched; 10-C usually double (2-4); 11-C usually triple (3, 4); 12-C 2-4 branched; 13-C double; 14-C single, distinct. Antenna relatively short, 0.5-0.7 of length of head; spicules numerous and fine, mostly restricted to basal portion below seta 1-A; setae 2, 3-A subapical. Mental plate black, with 6, 7 strong

lateral teeth on each side of median tooth. *Thorax.* Setae 1-3-P strong, subequal and single; 4-P shorter than 1-3-P, double; 7-P usually triple (3,4); 8-P usually double (1-3); setae 1 and 3-M single; 4-M double; 8-M 5-7 branched; 9-M 4-6 branched; setae 7 and 9-T 6-8 branched; 12-T single; 13-T usually 4 branched (3-6). *Abdomen.* Seta 6-I usually triple (3,4); 7-I always single; 6-II triple; 6-III-VI double; 3-I-VI single; 1-III-VI usually double or triple (2-4); 4-V 5,6 branched; 4-VI double; seta 1-VII usually 3,4 branched (3-5); 4, 7, 10 and 12-VII all single; 13-VII 2-4 branched. Comb scales small, 34-40 in broad oval patch, all scales with even fringe of numerous fine spicules; seta 1-VIII 6-8 branched; 3-VIII 7-11 branched; 5-VIII 3,4 branched. Saddle complete; ventral posterior margin deeply emarginated or indented; dorsal posterior margin with small patch of distinct spicules; seta 1-X single and rather long; 2-X 3-6 branched; 4-X with 6 pairs of setae; anal gills very short, stubby and rounded, about 0.5 of saddle length. *Siphon.* Relatively thick, short or moderate in length; pigmentation pale yellow except for basal dark ring; pecten teeth varying from 6-15, 3,4 distal teeth barbed with 7,8 graded denticles; siphonal tufts usually 7 pairs, sometimes 5 or 6.5 pairs; 5 proximal pairs strong, 5-8 branched each, in prominent row ventrally or subventrally; most proximal pair longest, 1.5-2.0 times as long as siphonal width at point of attachment, rest gradually shorter; 2 distal pairs weak and short, 3,4 branched, the more proximal pairs inserted laterally near midpoint of length, the most distal pairs subventral and close to apex; median caudal filament of spiracular apparatus poorly developed or absent.

TYPE-DATA. (1) *Culex sitiens* Wiedemann, Holotype ♀, *Sumatra,* INDONESIA (ZMC); (2) *Culex impellens* Walker, Holotype ♀* (in extremely poor condition), Makessar, *Celebes* (Sulawesi), INDONESIA (BM); (3) *Culex microannulatus* Theobald, lectotype ♂* with slide of genitalia, Quilon, Travancore, *(Madras State),* INDIA, S. P. James (BM; selection of Bram 1967a: 243); (4) *Culex gnophodes* Theobald, Holotype♀*, Bruas, Dindings, MALAYA (PENINSULAR MALAYSIA) (BM); (5) *Culex nigricephala* Leicester, Type unspecified, Batu Gajah, *Perak,* MALAYA (PENINSULAR MALAYSIA) (BM; non-existent); (6) *Culex (C.) salinus* Baisas, Holotype ♂ with associated pupal and larval skins, Caloocan, Rizal, *Luzon,* PHILIPPINES, fish pond, 20 March 1937, F. E. Baisas (PBH; destroyed).

DISTRIBUTION. Widespread throughout coastal areas of Southeast Asia and other adjacent tropical areas in the Oriental region with extensions north and northeast as far as southern China and the Ryukyus. Also reported from the Ethiopian region, the Middle East (Arabia and Iran), Micronesia, South Pacific, New Guinea and northern Australia. Material examined. 2,891 specimens: 1,158♂, 1,219♀, 424 L; 392 individual rearings (135 pupal, 257 larval).

INDIA. *Bengal:* Calcutta; Dum Dum; Salt Lake; 1♂, 4♀, 1 p; *Assam:* Jorhat; 1♀.

THAILAND. Chon Buri; Pathum Thani; Samut Sakhon; Samut Prakan; Bangkok; Thon Buri; Trat; Prachuap Khiri Khan; Rangong; Nakhon Si Thammarat; Krabi; Phuket; Surat Thani; 128♂, 205♀, 278 L, 100 p, 76 lp.

VIETNAM. Saigon; Nha Trang; Cam Ranh Bay; Vung Tau; 6♂, 6♀, 29 L, 4 p, 4 lp.

MALAYSIA. *Peninsular Malaysia:* - Selangor; Perak; Perlis; 37♂, 38♀, 4 L, 5 p, 23 lp. *Malaysia:* - Sabah; Sarawak; Brunei; 29♂, 52♀, 4 L, 2 p, 23 lp.

SINGAPORE. 16♂, 17♀, 15 L, 8 p, 15 lp.

INDONESIA. Sumatra; Java; Flores; West Irian (formerly Dutch New Guinea); 13♂, 20♀.

PHILIPPINES. Luzon; Mindoro; Palawan; Leyte; Jolo Jolo; Tawi Tawi; Mindanao; 908♂, 846♀, 81 L, 15 p, 95 lp.

TAIWAN. 6♂, 5♀, 13 L.

HONG KONG. 4♀.

JAPAN. *Ryukyus:* Okinawa; 14♂, 21♀, 21 lp.

Additional records from the literature: IRAN: Bandar-Abbas, (Lofti 1970: 401); INDIA: Bombay, Trombay and Islands; Deccan, Belgaum and Nagargali; Nilgiri Hills, Coonoor; CEYLON (SRI LANKA): Colombo, (Barraud 1924: 994); CHINA: Fukien, Amoy; Kwangtung, Canton; Hainan (Feng 1937: 301; Chu 1958: 110); INDONESIA: Greater and Lesser Sundas; the Molluccas; West Irian (Dutch New Guinea), (Bonne-Wepster 1954: 373; Assem and Bonne-Wepster 1964: 126); CENTRAL PACIFIC: S. Mariana Is., Guam; Yap; Caroline Atolls, Ngulu; Truk, Wena (Moen) (Bohart 1956: 82); SOUTH PACIFIC: Solomon Is.; New Hebrides; New Caledonia; Ellice Islands; Fiji; Wallis; Samoa; Tonga; Niue Island (Belkin 1962: 205); and others.

TAXONOMIC DISCUSSION. *Culex sitiens* is one of the commonest members of the *Sitiens* Group in Southeast Asia, where it has been found, as reported elsewhere, to be restricted to seacoasts, river banks and margins of canals in the estuarine environments. It is also one of the most widespread tropical forms with a very extensive range of distribution covering the Ethiopian, Palearctic, Oriental and Australasian regions and the islands of the Central and South Pacific. The Southeast Asian populations of *sitiens* exhibit much individual variation in all stages but there appears to be no differentiation into recognizable subspecies, geographic forms or races. All Southeast Asian material agrees very well in the diagnostic characters of the adults and male genitalia with that from New Guinea (Bonne-Wepster 1954), the South Pacific (Belkin 1962), Micronesia (Bohart 1956), India (Barraud 1934) and the Ethiopian region (Edwards 1941). The associated pupae and larvae from Southeast Asia also agree very well with the descriptions and figures of this species by Penn (1949) from New Guinea and by Belkin (1962) from the South Pacific.

Culex sitiens can be readily distinguished from other members of its Subgroup and complex in all stages over most parts of Southeast Asia and adjacent areas except in the Philippines where the adults are most liable to be confused with those of *annulirostris*. As indicated in the keys by Bohart (1956 [1957]) and Belkin (1962), the *sitiens* females can be distinguished from *annulirostris* by the absence of a row of pale dots among the bristles on the anterior surface of foretibia (present in *annulirostris*) and by relatively narrower and even basal pale bands on the abdominal terga (usually broader and medially produced in *annulirostris*). These diagnostic characters are further substantiated by the largely pale anterior surface of the hindfemur in *sitiens* against the freckled or pepper and salt appearance in *annulirostris*. The *sitiens* males can be differentiated from *annulirostris* by the translucent scalelike setae on the ventral surface of palpal segment 3 (dark, hairlike in *annulirostris*) and by more numerous long hairs at the base of the median pale ring on the ventral surface of the proboscis.

BIONOMICS. *Culex sitiens* is typically a coastal, brackish water species whose breeding habitats usually include pools, puddles, ponds, wells, ditches, crabhole and rock pools in salt marsh, mangrove and nipa palm swamps. It has also been found breeding in artificial containers such as canoes, boats, cement tanks, jars, cans, etc. in the vicinity of sea beaches, harbors or piers in populated areas. The larvae and pupae are very adaptable and show a high tolerance of salinity, occurring in fresh, brackish and even pure sea water. One of the most remarkable larval features, which is apparently associated

with the adaptation to high salt content, is the considerable reduction in the length and size of the anal gills of the saddle. The adults of *sitiens* have been collected outdoors as well as indoors while resting. Several females from Thailand were caught biting man and in light traps. In Singapore, Colless (1959) reported that the females prefer to feed on birds, pigs and probably cattle. In Malaya, Bennett, Warren and Cheong (1966), Bennett and Warren (1966) incriminated *sitiens* as one of the natural vectors of a malarial parasite of domestic fowl (*Plasmodium juxtanucleare* Versiani and Gomes). In Thailand, a wild caught female was found to be naturally infected with *Brugia malayi* (Iyengar 1953), but this author concluded that *sitiens* was probably not an important vector of this parasite. Elsewhere, *sitiens* has been shown to be capable of transmitting Japanese encephalitis virus in the laboratory (Hodes 1946) but no further data are available in support of its role in the natural transmission of this pathogen.

20. *CULEX (CULEX) ALIS* THEOBALD
(Figs. 38, 39)

Culex alis Theobald 1903: 167 (♂*, ♀); Edwards 1922a: 277 (Key; ♂ genitalia*).
Culex (Culex) alis Theobald, Edwards 1932: 203 (taxonomy); Brug 1934: 517 (♂, ♀*); Brug and Bonne-Wepster 1947: 189 (distribution).
Culex (Culex) litoralis Bohart, Colless 1957b: 465 (L*).
Culex (Culex) neolitoralis Bram 1967a: 236 (♂*, ♀, L*). NEW SYNONYMY.

FEMALE. Wing: 2.3-3.2 mm (average 3.0 mm). Forefemur: 1.1-1.7 mm (average 1.5 mm). Proboscis: 1.3-1.8 mm (average 1.7 mm). Abdomen: 1.8-2.7 mm (average 2.5 mm). In general as figured and described for *sitiens* to which it is very similar, differing in smaller size and in the following characters. *Head.* Erect scales of vertex usually pale yellowish or bronzy in center, black posterolaterally. *Thorax.* Mesonotal scales usually predominantly yellowish or golden with dark scales forming streaks or spots on acrostichal line, middle of fossae and posterior dorsocentral areas. *Legs.* Anterior surface of fore- and midfemora without speckling of pale scales; anterior surface of hindfemur with longitudinal pale stripe extending from base to 0.7 of total length, no dark scales scattered on pale stripe area; tibiae and tarsomere 1 of all legs without speckling of pale scales on anterior surface; apical and basal bands of tarsomeres 1-4 of all legs very narrow and rather inconspicuous. *Wing.* Cell R_2 shorter, as long as or slightly longer than vein R_{2+3}.

MALE. In general as in female, differing from *sitiens* particularly in the following characters. *Head.* Palpus variable in length, usually rather thick and relatively shorter; segments 4 and 5 reduced in length, weakly to moderately plumose, all bristles shorter and weaker; segment 3 with weaker ventrolateral tuft of about 8 bristles in apical 0.25. Proboscis without ventrolateral tuft of long hairs at base of median pale ring. *Wing.* Cell R_2 considerably reduced in length, from 0.5-1.0 of the length of vein R_{2+3}.

MALE GENITALIA (Fig. 38). Differing from *sitiens* particularly in the following. *Subapical lobe.* Setae *d-f* of distal division weaker; leaf *g* narrower; sternal surface mesad of proximal division without a distinct patch of dense spicules. *Distimere.* Basal 0.4 with or without scattering of a variable number of minute spicules on outer lateral surface. *Phallosome.* Apical tergal crown of inner division with 2-4 shorter fingerlike processes; sternal portion

of apical spiculate portion more strongly expanded sternad, forming a prominent lobe, bearing several distinct denticles; outer division very broad, simple, leaflike, mesal spine absent; sternal spine present, very large, broad and gently curved basad. *Proctiger.* Basal sternal process absent or present as a very short protuberance; cercal setae 3.

PUPA (Fig. 38). Abdomen: 2.1-3.5 mm (average 2.8 mm). Paddle: 0.65-0.78 mm (average 0.71 mm). Trumpet 0.46-0.71 mm (average 0.60 mm); index 5-6. Pigmentation variable, usually with conspicuous dark or black areas on cephalothorax, metanotum and abdominal segments I-IV. *Trumpet.* Slender and relatively short; apical 0.5 usually uniform in width, sometimes slightly widened toward apex; pinna slightly to moderately oblique. Complete chaetotaxy as figured, generally very similar to *sitiens,* differing from it as follows. *Cephalothorax.* Seta 8-C weaker and shorter than 9-C, usually double, sometimes single; 9-C usually double (1-3). *Metanotum.* Seta 10-C usually 3, 4 branched (2-6). *Abdomen.* Seta 1-II usually 3, 4 branched (2-10); setae 1-III-VII weaker and shorter; 1-III usually triple (2-4); 1-IV-VII usually double (1-4). *Paddle.* Setae 1 and 2-P minute, subequal and single.

LARVA (Fig. 39). Head: 0.65 mm. Siphon: 0.8 mm; index 3-4. Saddle: 0.33 mm; siphon/saddle ratio 3.0-3.5. As figured, generally similar to *sitiens,* differing from it in the following features. *Head.* Frontoclypeus partially strongly infuscate or blackish; seta 1-C larger, more flattened, somewhat foliform, with blunt or acuminate apex; 4-C situated closer to dorsal midline, its length about 1.5 times as long as distance between bases of the pair; 5-C usually 3, 4 branched (3-6); 6-C 3, 4 branched. Antennal shaft shorter, 0.4-0.6 of head length; proximal portion pale, distal portion blackish; setae 2, 3-A rather short, apical or slightly subapical. Mental plate blackish, with 8-10 lateral teeth on each side of median tooth. *Thorax.* All prothoracic setae relatively weaker and shorter; 7-P usually double, sometimes triple; 8-P variable, from very short, minute, 2-4 branched to as long as 4-P and single (1-2); setae 1-4-M and T shorter and weaker. *Abdomen.* Setae 1-III, IV usually double (2, 3); 1-V strong, always single; 1-VI, VII single or double. Saddle incomplete, sclerotization restricted to dorsal and ventral portions, middle portion membranous; anal gills very short and stubby, as in *sitiens.* *Siphon.* Shorter and darker, concolorous with head capsule; 4, 5 distal pecten teeth barbed with 3, 4 strong basal denticles and 1 strong apical denticle; siphon tufts 6, 7 pairs; 5 proximal pairs very closely spaced, in prominent row on ventral surface; median caudal filament not developed.

TYPE-DATA. (1) *Culex alis* Theobald, Lectotype ♂* with slide of genitalia, *Christmas Island* (Australian Trust Territory), reared from larva in salt pool, 13 December 1902, S. Durham (BM; selection of Bram 1967: 327); (2) *Culex (C.) neolitoralis* Bram, Holotype ♂* (00652-2) with associated pupal and larval skins and genitalia slide, Ban Laem Sing, *Chanthaburi,* THAILAND, larva from brackish rock pool on a beach, 6 November 1965, Somboon Maneechai (USNM).

DISTRIBUTION. Presumably widespread throughout Southeast Asia and other adjacent tropical areas of the Oriental region. Presently recorded from Thailand, Vietnam, Malaysia, Singapore, Taiwan, Indonesia, Christmas Island (Australian Trust Territory) and the Philippines. Material examined. 675 specimens: 204♂, 246♀, 225 L; 273 individual rearings (183 pupal, 90 larval).

THAILAND. *Chanthaburi:* Ban Laem Sing; *Chonburi; Rayong; Surat Thani:* Koh Samui; *Trat:* Koh Chang; 141♂, 133♀, 176 L, 183 p, 40 lp (as *neolitoralis* Bram 1967).

VIETNAM. Con Son; 20♂, 64♀, 23 L.

MALAYSIA. *Peninsular Malaysia: Pahang*-Pulau Tioman; Tg. Gelang;

Trengganu: Kemasik; *Kelantan*-Tumpat; 23♂, 23♀, 16 L, 22 lp. *Malaysia: Sabah*-Sipitang; 4♂, 10♀, 4 L, 5 lp.

SINGAPORE. P. Hantu; 2♂, 3♀, 5 L, 2 lp.

TAIWAN. Orchid Island; 1♂, 3♀, 3 lp.

INDONESIA. *Ceram; West Irian* (Dutch New Guinea); 5♂, 1♀.

PHILIPPINES. *Luzon:* Subic Naval Base; *Samar:* Osmena; 8♂, 9♀, 1 L, 18 lp.

TAXONOMIC DISCUSSION. *Culex alis* has been a poorly known species since it was described by Theobald (1903) from Christmas Island south of Java, Indonesia. This is because Theobald's description was based only on the adult male and female and the male genitalia were neither figured nor described. The only significant diagnostic feature of *alis* given by Theobald (1903) is in the length of Cell R_2 (or anterior fork cell) of the wing, which is shorter than vein R_{2+3} (or its stem). Subsequently, Edwards (1922a) illustrated the phallosome and the proctiger of the male genitalia of a cotype male and provided the key to the adults but did not provide a redescription nor statement about its specific status to clarify its identity. The only other records of *alis* in the literature were those of Brug (1934) and Brug and Bonne-Wepster (1947) from adults collected in Dutch New Guinea (West Irian and Ceram, Indonesia) and by Colless (1957b: 465) from the larvae (as *litoralis* Bohart 1946) in Singapore harbor.

Culex alis as interpreted here is a widespread coastal species and as in *sitiens,* is restricted to breeding in brackish water ground pools. The Southeast Asian species which was described by Bram (1967a: 236) as *neolitoralis* is identical to the type adults of *alis* in the relative length of cell R_2 of the wing and in practically every detail of the male genitalia. This evidence as well as the similarity in larval habitat strongly suggests that both forms are conspecific and on this basis I am synonymizing *neolitoralis* with *alis*. There is a possibility that *whittingtoni* Belkin (1962: 204) from the Solomon Islands may also be conspecific with this species. However, as *whittingtoni* has been known only in the larva, the point cannot be settled. In comparing the larvae of *whittingtoni* with those of *alis,* I have found no difference whatever in the chaetotaxy and other features, including sclerotization of the saddle.

Among the members of the *sitiens* complex, *alis* is very similar to *litoralis* Bohart (1946) from the Central Pacific; *roseni* Belkin (1962: 203) and *whittingtoni* Belkin (1962: 204) from the South Pacific in all known stages. Each of these forms is probably only subspecifically distinct and it is possible that they were originally represented by a single widespread species which was subsequently differentiated into slightly distinct segregates through geographical isolation.

Culex alis can be readily distinguished from *sitiens* (with which it largely overlaps in distribution and breeding sites) by features indicated in the keys and in the above diagnosis. It can be differentiated from *litoralis* and *roseni* in the adult by shorter cell R_2 of the wing and by the reduction in the length and in the plumosity of the male palpal segments 4 and 5. The male genitalia is virtually indistinguishable from *litoralis*, but is distinct from *roseni* in the presence of setae *d-f* in the distal division of the subapical lobe (absent in *roseni*). The pupa differs from *litoralis* in having abdominal setae 6-III-VI single or double (3, 4 branches in *litoralis*). The larva strongly resembles *litoralis* and *roseni* in all features except for the sclerotization of the dorsal as well as ventral halves of the saddle (only dorsal half in *litoralis* and *roseni*).

BIONOMICS. *Culex alis* is typically a brackish water species as *sitiens* but is apparently less common than the latter. The majority of pupal or larval

collections from Thailand and other adjacent countries came from pools among rocks at or near sea beaches in the vicinity of harbors and fishing villages. A few collections came from crabholes and coral holes. Most of the adults were obtained from rearing pupae or larvae in the field and no records are available of their behavior and feeding habits. Nothing is known about the medical importance of *alis*.

21. *CULEX (CULEX) WHITMOREI* (GILES)
(Figs. 15, 40, 41, 42)

Taeniorhynchus whitmorei Giles 1904: 367 (♀).
Taeniorhynchus argenteus Ludlow 1905: 98 (♀); Theobald 1910a: 426 (♀*); Edwards 1913b: 232 (synonymy).
Leucomyia plegepennis Theobald 1907: 375 (♀); Edwards 1913b: 232 (synonymy).
Culex albus Leicester 1908: 148 (♀); Edwards 1913b: 232 (synonymy).
Culex loricatus Leicester 1908: 151 (♀); Edwards 1917: 225 (synonymy).
Culex whitmorei (Giles), Edwards 1913b: 232 (taxonomy); Edwards 1917: 225 (taxonomy); Barraud 1923a: 941 (L*); Barraud 1924a: 988 (♂*, ♀).
Culex (Culex) whitmorei (Giles), Edwards 1932: 203 (taxonomy); Barraud 1934: 406 (♂*, ♀, L*); Stackelberg 1937: 232 (♂*, ♀); Bonne-Wepster and Brug 1937: 77 (♂, ♀*); Baisas 1938: 211 (♂*, ♀, P*, L*); Bonne-Wepster and Brug 1939: 1273 (L*); Bohart 1945: 81 (♀, L); La Casse and Yamaguti 1950: 211 (♂*, ♀*, P*, L*); Monchadskii 1951: 281 (L*); Bonne-Wepster 1954: 120 (♂, ♀*, L*); Hara 1957: 56 (♀ genitalia*); Delfinado 1966: 155 (♂*, ♀, L*); Bram 1967a: 253 (♂*, ♀*, L*).

FEMALE (Fig. 15, 40). Wing: 3.0 mm. Forefemur: 1.4 mm. Proboscis: 1.6 mm. Abdomen: 2.4 mm. Small species; wing length not exceeding 3.5 mm; differing from other members of the *Sitiens* Subgroup in the following features. *Head.* Narrow decumbent scales of vertex pure white, contrasting sharply with dark integument underneath; erect scales relatively short and slender, largely pure white except for a few dark ones on posterolateral areas. Palpus rather slender and short, about 0.2 of proboscis length; segment 4 tipped with white scales on its apex, rest dark. Proboscis with distinct median pale ring which occupies about 0.33 of total labial length. *Cibarial Armature.* Cibarial bar with a double row of short and apically pointed teeth; number of teeth in each row about 20. *Thorax.* Mesonotal integument blackish or chestnut brown; mesonotal scales rather sparse to moderately dense, predominantly pure white except for dark scaled spots in middle of fossa, continuing as whitish patch and streaks on prescutellar space and lateral prescutellar areas; posterior dorsocentral and supraalar areas with dark scaled streaks; scutellar lobes pure white scaled. Scales on *apn* pure white; scale patch of *ppn* dark in middle and on lower surface, pale whitish on anterior and posterior upper surfaces. Pleural integument very dark or same color as mesonotum; pleural scale patches very distinct. *Legs.* Anterior surface of fore- and midfemora moderately to heavily speckled with pale scales; anterior surface of hindfemur largely pale or freckled with numerous dark scales; mid- and hindtibiae with poorly defined narrow pale stripe on anterior surface; apical and basal pale bands on tarsomeres 1-4 of all legs distinct. *Wing.* All scales dark; scales on veins R_{4+5}, M_{1+2}, M_{3+4}, Cu_1 and Cu_2 broader than on other veins. *Abdomen.* Median caudal scale patch of tergum I dark or partially pale; terga II-VII with large median triangular basal pale patches and small apicolateral pale spots,

the latter usually distinct on terga V-VII; sterna largely pale scaled. *Genitalia.* Tergum IX with lateral row of 3-6 setae; postgenital plate rounded on caudal margin; vaginal sclerite broadly curved, resembling an arc of a circle; insula with a tuft of 10-12 setae.

MALE (Fig. 40). *Head.* Palpus usually exceeding proboscis by full length of segment 5, sometimes longer; segment 2 with apical pale band; segment 3 with median pale band, apical 0.25 with ventrolateral tuft of about 10 bristles, ventral surface with a row of several short, translucent scalelike setae; segments 4 and 5 strongly long plumose, with basal pale rings; apical 0.2 of segment 5 pale to tip. Proboscis with very narrow median pale band which is about 0.1 of total length; ventral tuft of long hairs at base of median band absent.

MALE GENITALIA (Fig. 41). Distinctive in the following features. *Subapical lobe.* Setae *a-c* of proximal division long, subequal in length and thickness; setae *d-f* subequally long, rodlike and hooked apically, most distal strongest, the other 2 narrower; leaf *g* long, narrow, club-shaped; seta *h* strong, long, bristlelike. *Phallosome.* Apical spiculate portion of inner division of lateral plate strongly expanded sternad, forming a tonguelike lobe which is finely spiculose; apical tergal surface with a crown of 3, 4 equally long teeth, all of which are straight, projecting dorsolaterad; outer division of lateral plate represented by a simple and broad leaflike process; mesal, lateral and sternal spines absent; lateral basal process small or poorly developed. *Proctiger.* Apical crown large and dark; basal sternal process very slender, moderate in length, about 0.04 mm; subbasal process not developed; cercal setae 3-5.

PUPA (Fig. 41). Abdomen: 2.4 mm. Paddle: 0.67 mm. Trumpet: 0.52 mm; index about 8. Cephalothorax and abdomen generally cream-colored with darkened areas along posterior margin of middorsal ridge, leg and wing cases, metanotum and abdominal segments I-IV. Chaetotaxy as figured, distinctive in the following. *Trumpet.* Slender, rather short, darker than underlying integument; basal 0.5 uniform in width, apical 0.5 slightly widened toward apex; pinna lightly oblique. *Cephalothorax.* Seta 1-C 4, 5 branched; 7-C weak and short, double or triple; 8-C 4-6 branched; 9-C 3, 4 branched. *Abdomen.* Seta 7-I usually 4 branched (3, 4); 7-II usually triple (2, 3); 1-II small, 5-7 branched; 1-III-VII subequally long, about 0.5 of segment following; 1-III 11-15 branched; 1-IV 7-13 branched; 1-V 6-9 branched; 1-VI 7, 8 branched; 1-VII 4-6 branched; 5-IV-VI short, as long as setae 1-IV-VI; 5-IV 6-10 branched; 5-V, VI 6-8 branched; 5-VI 3-7 branched; 6-III-VI subequally long, usually 6 branched (5-7); 9-VII shorter than 9-VIII, 5, 6 branched; 9-VIII very near caudolateral angle, 6-9 branched; 4-VIII usually 3, 4 branched (2-5). *Paddle.* Outer and inner parts whitish or transparent; midrib strong and dark.

LARVA (Fig. 42). Head: 0.65 mm. Siphon: 0.9 mm; index 6. Saddle: 0.32 mm; siphon/saddle ratio about 3. Distinguished from other members of the *Sitiens* Subgroup by the shape and the very long subventral tufts of siphon; presence of 5-8 very large comb scales and by the following. *Head.* Seta 1-C dark, stout, spiniform; 4-C minute, single and about 0.25 of the distance between bases of the pair; 5, 6-C double; 7-C 6-9 branched; 8, 9, 10, 11 and 12-C very weak and short; 13-C usually triple (2-4); 14-C 2-4 branched. Antennal shaft as long as head length or slightly longer; spicules strong and numerous; 1-A strong, dark, fan-shaped and about 20 branched; 2, 3-A dark, strong, bristlelike, subapical. Mental plate small, with 4-6 blunt lateral teeth on each side of median tooth. *Thorax.* Not spiculated; seta 4-P double; 7-P triple; 8-P double; 8, 9-M 5 branched; 7 and 9-T 5 branched; 12-T single; 13-T strong, 5, 6 branched. *Abdomen.* Not spiculated; dorsal setae 1-5 and ventral setae

9-13 of segments I-VI very weak, short, rather inconspicuous; 6-I, II double; 7-I single; 6-III-VI double; 1-III-VI 4, 5 branched; seta 1-VII strong, 4, 5 branched; 4-VII single or double; 7-VII single; 10-VII usually triple (3, 4); 12-VII single. Comb scales large, 5-8, in 1 or 2 rows; individual scale with stout apical spine and basal fringe of fine spicules; 1-VIII weak, 4, 5 branched; 2 and 4-VIII single; 3-VIII 6-9 branched; 5-VIII usually double (2, 3). Saddle complete; seta 1-X double, 2-X single; 4-X with 6 pairs of setae; anal gills about 1.5 times as long as saddle. *Siphon.* Slender and moderately long, distally strongly curved dorsad; pecten with 7-9 teeth in basal 0.25, 3, 4 distal teeth barbed with 9, 10 graded denticles; siphonal tufts usually 8 pairs (total 16), sometimes 7 (total 14); 5, 6 proximal pairs very strong, long, ventral or subventral, usually double, 3, 4 times as long as siphonal width at point of attachment; 2 distal pair small, inserted subventrally or laterally; seta 2-S strong, dark, simple, spiniform or with accessory basal denticles; median caudal filament of spiracular apparatus absent; seta 9 of ventral valve dark and strongly hooked.

TYPE-DATA. (1) *Taeniorhynchus whitmorei* Giles, Holotype ♀*, Camp Stotsenberg, Pampanga, *Luzon,* PHILIPPINES, caught in woods, 1904, E. R. Whitmore (BM); (2) *Taeniorhynchus argenteus* Ludlow, Holotype ♀*. Pampanga, *Luzon,* PHILIPPINES (USMN); (3) *Leucomyia plegepennis* Theobald, Holotype ♀*, Kobe, *Honshu,* JAPAN, 14 September 1903 (BM); (4) *Culex albus* Leicester, Holotype ♀* (in poor condition), Kuala Lumpur, *(Selangor),* MALAYA (PENINSULAR MALAYSIA), 15 December 1903 (BM); (5) *Culex loricatus* Leicester, Holotype ♀*, Kuala Lumpur, *(Selangor),* MALAYA (PENINSULAR MALAYSIA) 1914, G. F. Leicester (BM).

DISTRIBUTION. Widespread throughout the Oriental region, extending north and northeast into China, Korea, Japan and maritime provinces of USSR; east and southeast into New Guinea. Material examined. 902 specimens: 115♂, 700♀, 87 L; 16 individual rearings (4 pupal, 12 larval).

INDIA. *Bombay:* Deccan; Kawar; Tavargatti; *Bengal:* Lalmanirhat; *Assam:* Chabua; Dooma Dooma; Dibrugarh; Rupsi; Tezpur; Ledo; 14♂, 81♀, 23 L.

BANGLADESH. Sylhet; 2♀.

SRI LANKA. *Central Province:* Kandy; *Sabaragamuwa:* Ratnapura; Uggalkaltota; 9♂, 30♀.

THAILAND. Nan; Chiang Mai; Lampang; Lampoon; Nakhon Nayok; Khon Khaen; Chon Buri; Yala; 33♂, 259♀, 9 L, 4 p, 1 lp.

VIETNAM. Saigon; Phu Bei; Ankhe; Vinh Thanh; Plei Ku; Duc My; Cu Chi; Dilinh; Phu Loi; Pailai; Quinhan; Danang; 4♂, 79♀, 27 L.

MALAYSIA. *Peninsular Malaysia: Kedah*-Kg. Peng Besar; *Perak*-Chenderiang; 3♂, 1♀, 3 lp; *Malaysia: Sabah*-Tambunan; 1♂, 3♀.

INDONESIA. *Java:* Djarkata; Bogor; Pelabuhan Rotu; Mt. Salak; 2♂, 34♀, 4 lp.

PHILIPPINES. *Luzon:* Mt. Isarog; Rizal; Samal Batoan; Olongapo; Barrio Dolores; Mabalacat; San Fernando; Tala; Los Banos; Trinidad; Subic Bay; Bagiuo; *Mindoro:* San Jose; *Leyte; Samar:* Guirang; Calaccad; 35♂, 168♀, 25 L, 4 lp.

CHINA. Hainan Is.; 6♂, 13♀.

TAIWAN. Wan-Luan; Chao-Chow; Fengshen, Sze-Chun; 20♀.

JAPAN. *Kyoto;* 4♀, *Ryukyus:* Okinawa: Chizuka; 1♀.

KOREA. Chinhae; 4♂, 9♀, 3 L.

Additional records from the literature: NEW GUINEA (Brug and Bonne-Wepster 1947: 187); BURMA (Barraud 1934: 407); USSR: Maritime Province (Monchadskii 1951: 281); CHINA: Chekiang, Fukien; Kiangsi; Kwangtung (Feng

1938: 301).

TAXONOMIC DISCUSSION. *Culex whitmorei* is distinct in all stages and can be readily separated from all other Oriental species of the *Sitiens* Group and Subgroups as indicated in the keys and as described above. The adults of *whitmorei* are superficially similar to *gelidus* in the color of the scales on the head and mesonotum but differ from the latter rather strikingly in (1) presence of speckling on the anterior surface of the femora of fore- and midlegs; (2) less dense mesonotal scales; (3) scales on prescutellar space and scutellar lobes pale; (4) broad plume scales on wing veins R_{4+5} and branches of M and Cu; (5) large median triangular basal pale patches of the abdominal terga II-VII and in the male by (6) ventral setae of palpal segment 3 distally flattened or scalelike.

Culex whitmorei is now assigned to the *Sitiens* Subgroup to which it exhibits a strong affinity in the phallosome of the male genitalia. In previous studies, *whitmorei* has been considered as a member of the *Gelidus* Subgroup or series according to the scheme of classification by Edwards (1932) which, as discussed under that Subgroup, is apparently unjustified. Because of the distinctive larva, pupa, adult and male genitalic characters, I am placing *whitmorei* in a distinct complex of the *Sitiens* Subgroup. Due to the paucity of reared specimens from most of the areas within the reported range, it is not possible to determine whether there is local or geographical differentiation among the various populations of *whitmorei*. The adults which I have examined are very variable in size; those from Korea and Japan are larger (wing length 3.7 mm) than the ones from Southeast Asian countries but this difference does not appear to be correlated with any modification in the male genitalia or larval stages. The affinities of *whitmorei* with other species within the *Sitiens* Group are not clear. It is rather similar to *pseudovishnui* of the *Vishnui* Subgroup in the larval comb scales but resembles *alis* and its related forms in phallosome of the male genitalia.

BIONOMICS. *Culex whitmorei* is a fresh water ground pool form. The larvae and pupae have been frequently collected in shallow pools, puddles and ditches in rice fields containing numerous grasses. On occasion, they have been found in pools and animal tracks near stream margins. The elevation ranged from sea level to 1,500 m. They have been collected in association with the immatures of *C. tritaeniorhynchus, C. pseudovishnui* and *C. vishnui; An. philippinensis* Ludlow, *An. barbirostris* Van der Wulp and *An. vagus* and *Aedes mediolineatus* (Theobald). The relative abundance of *whitmorei* during different seasons of the year is not known but from the amount of material obtained in several collections in Thailand, Malaysia and in the Philippines it is apparently not as abundant or common as *tritaeniorhynchus* and other forms of the *Vishnui* Subgroup which utilize similar habitats. Several females of *whitmorei* came from light traps, buffalo and human baited traps. They were reported to bite man in early evening and at night (Feng 1938, Hsiao and Bohart 1946, Delfinado 1966), however, the natural or preferred host is unknown. Hsiao (1945, 1948) demonstrated that females can be experimentally infected with *Wuchereria bancrofti*. Despite the report of an isolation of Japanese encephalitis virus from this species in India (Carey et al. 1968), the importance of *whitmorei* as a vector of JE virus has not been subsequently confirmed.

22. *CULEX (CULEX) ANNULIROSTRIS* SKUSE
(Figs. 43, 44)

Culex annulirostris Skuse 1889: 1737 (♀); Edwards 1924: 394 (adult, taxonomy).
Culex (Culex) annulirostris Skuse, Edwards 1932: 204 (taxonomy); Knight and Hurlbut 1949: 30 (♂*, ♀, P, L*, taxonomy); Penn 1945: 81 (P*); Bohart 1956: 80 (♂*, ♀, L*); Belkin 1962: 207 (♂*, ♀, P*, L*); Dobrotworsky 1965: 207 (♂*, ♀*, L*); Delfinado 1966: 139 (♂*, ♀, L*); Baisas 1974: 87 (♂*, ♀*, P, L*).
Culex (Culex) palmi Baisas 1938: 207 (♂*, ♀*, P*, L); Delfinado 1966: 139 (synonymy).
For complete synonymy, see Stone, Knight and Starcke (1959).

FEMALE. Wing: 3.0-4.0 mm (average 3.8 mm). Forefemur: 1.4-2.0 mm (average 1.8 mm). Proboscis: 1.6-2.2 mm (average 2.0 mm). Abdomen: 2.9 mm. Medium to large species; in general as described and figured for *sitiens* to which it is extremely similar, differing in the following features. *Head.* Median pale ring of proboscis broader, 0.25-0.30 of total length. *Cibarial Armature.* Essentially similar to *sitiens*, differing slightly in having lateral teeth more widely spaced. *Legs.* Anterior lower surface of forefemur evenly sprinkled with pale scales along the whole length; anterior surface of foretibia with a row of small yellowish dots among anterior bristles; anterior surface of hindfemur extensively speckled with pale scales. *Wing.* Scales on all veins denser; plume scales on veins R_s, M, R_2, R_3 and R_{4+5} narrower, longer and somewhat linear. *Abdomen.* Terga II-VI or II-V with basal pale bands which are moderately to strongly produced in middle; basal band on tergum II sometimes incomplete or represented by median triangular pale patch; terga VII-VIII with narrow, even basal bands; tergum VIII usually broadly pale towards apex. *Genitalia.* Tergum IX with lateral row of 10-12 setae; postgenital plate truncate or slightly emarginate on caudal margin; vaginal sclerite U-shaped, weakly sclerotized and pale; insula with a dense tuft of 8-10 relatively strong setae.

MALE. Differing from *sitiens* as described for female and in the following. *Head.* Palpal segment 3 with broader median pale band on dorsal surface, ventral surface with 2 or more rows of short, dark and fine hairlike setae along the whole length, ventrolateral tuft with 40 or more bristles from basal 0.25 to apex; apex of segment 5 with broader pale scaled tip. Ventral tuft proximad of median pale ring of proboscis weaker and with fewer hairs which are entirely pale.

MALE GENITALIA (Fig. 43). Differing from *sitiens* and other members of the *Sitiens* Subgroup in the following. *Segment IX.* Tergal lobe with row of 6, 7 setae, sometimes more. *Subapical lobe.* Proximal division usually with 1, 2 weak setae basad of setae *a-c*; seta *a* shorter than setae *b* and *c;* seta *b* longest and strongest; sternal surface with distinct patch of several short setae; leaf *g* of distal division broad, with acuminate apex; seta *h* usually weak and short; 3 setae in group *d-f,* all slender, rodlike, the most distal longest and strongest. *Distimere.* Normal; dorsal subapical crest of spicules usually not developed, sometimes present, very weakly developed. *Phallosome.* Lateral plate strongly sclerotized and heavily pigmented; inner division with a prominent, strongly spinose apical sternal lobe; apical tergal angle usually provided with some strong denticles, subapical tergal surface with a lobe bearing 2-5 short broad foliform processes; outer division represented by a long and large

acute spine, diverging laterad. *Proctiger.* Apical crown large and dark; basal sternal process absent; paraproct and cercal sclerite well sclerotized and moderately pigmented; cercal setae usually 3, sometimes 2.

PUPA (Fig. 43). Abdomen: 3.0-3.5 mm (average 3.2 mm). Paddle: 0.78-0.91 mm (average 0.85 mm). Trumpet: 0.78 mm; index 5-6. Cephalothorax and abdomen generally pale with considerable amount of dark tinge over most parts of the integument. Complete chaetotaxy as figured, particularly distinctive in the following. *Trumpet.* Thick, dark and moderately long; pinna slightly to moderately oblique; apex of pinna with distinct notch dorsad. *Cephalothorax.* Seta 1-C usually 4 branched (3, 4); 4-C 3, 4 branched; 5-C 5 branched; 8-C usually 5 branched (4-6), 9-C 2-4 branched. *Metanotum.* Seta 10-C 6-12 branched; 11-C usually double (2, 3). *Abdomen.* Seta 1-II 5-12 branched; 1-III, IV 8-12 branched; 1-V 7, 8 branched; 1-VI 6, 7 branched; 1-VII 4, 5 branched; 6-III,IV 3, 4 branched (3-5); 6-V, VI usually 5 branched (4, 5); 5-IV-VI shorter than segments following; 5-IV 5-7 branched; 5-V, VI usually double (2, 3). *Paddle.* Very broad and pale; midrib weak and lightly pigmented.

LARVA (Fig. 44). Head: 0.78 mm. Siphon: 1.3-1.8 mm (average 1.6 mm); index 3-7. Saddle: 0.32 mm; siphon/saddle ratio about 4. Very similar to *sitiens,* differing from it in the following characters. *Head.* Seta 1-C dark, slender, spiniform; setae 5, 6 and 7-C and seta 1-A stronger and darker. *Thorax.* All setae darker and stronger. *Abdomen.* All setae darker and stronger; 7-I double; 1-III, IV usually 5 branched (4-6); 1-V, VI usually 6 branched (5-7); 13-III-V usually 5 branched (4-6); seta 1-VII usually 7 branched (4-8). Comb scales 30-45. Saddle complete, with very dark basal ring; ventral caudal margin slightly indented; 1-X usually triple (2-5); 2-X usually 4 branched (3-5); 4-X with 6 pairs of stronger and darker setae; anal gills slender, tubular, tapering into a blunt point apically; 1, 2 times as long as saddle. *Siphon.* Relatively thicker, pecten with 10-15 teeth, 3-4 distal teeth barbed with 10 graded denticles; siphonal tufts 5 or 6 pairs, 6-10 branched each, forming a double prominent row subventrally; proximal 4-5 pairs strong and subequally long, as long as or slightly shorter than siphonal width at point of attachment; most distal pair shortest, about 0.5 of adjacent proximal pair; median caudal filament of spiracular apparatus poorly developed or absent.

TYPE-DATA. (1) *Culex annulirostris* Skuse, Syntypes ♀, Blue Mountain and Berowra, *New South Wales,* AUSTRALIA (MM). (2) *Culex (C.) palmi* Baisas, Holotype ♂, Paranaque, Rizal Province, *Luzon,* PHILIPPINES, from a fresh water pool, 3 October 1935, F. E. Baisas (PBH; lost or destroyed).

DISTRIBUTION. Widespread throughout the Australasian region (Eastern Australia, New Guinea and adjacent islands), Micronesia and South Pacific, with the range extending west into the Philippines and adjacent islands west of New Guinea in Indonesia. Material examined. 319 specimens: 104♂, 138♀, 77 L; 110 individual rearings (9 pupal, 101 larval).

PHILIPPINES. *Luzon:* Subic Naval Base; Mt. Makiling; Manila; San Fernando; Rizal, Wack Wack; San Fabian; Camp Nichol; Los Banos; Mabalacat (Dolores), Balucan; *Panay:* Iloita; *Catanduanas Is.:* Paganiban; *Mindoro:* San Jose; Caminawit Point; *Leyte:* Tacloban; Burauen; Palo; Dulag; *Samar:* Osmena; *Mindanao;* 99♂, 138♀, 77 L, 9 p, 101 lp.

INDONESIA. *Moluccas:* Morotai Is.; *Ceram; West Irian* (Dutch New Guinea): Merauke; 5♂.

Additional records from the literature. INDONESIA: Sulawesi (Celebes); Kepulauan Bangai (Archipelagos); Saemba; Alor; Tenimber Islands (Brug and Bonne-Wepster 1947); PAPUA-NEW GUINEA: Papua (Peters and Christian 1963); MICRONESIA: Islands in Central Pacific (Bohart 1956); SOUTH PACIFIC

(Belkin 1962); AUSTRALIA: Northern Territory, Queensland; New South Wales; (Belkin 1962; Dobrotworsky 1965).

TAXONOMIC DISCUSSION. *Culex annulirostris* is one of the most common and widespread species in the islands of the Philippines which are in the westernmost part of its range. It is also common in the islands in eastern Indonesia west of New Guinea according to Brug and Bonne-Wepster (1947) and Bonne-Wepster (1954). The Philippine material and that from the Moluccas, Ceram and West Irian in Indonesia agrees very well with that from Micronesia (Bohart 1956) and the South Pacific (Belkin 1962). The Philippine populations of *annulirostris* are very variable in the characters of all stages except for the diagnostic ones. Due to the lack of adequately reared material and insufficient field data, no attempt was made to analyse the detailed morphology and to determine whether there is any local differentiation among the *annulirostris* populations in the Philippines.

The synonymy of *palmi* Baisas 1938 from Luzon with *annulirostris* by Delfinado (1966: 138) was apparently based on the description and figures of the male genitalia and other stages by Baisas (1938: 207-9). Although the type specimens of *palmi* no longer exist, its synonymy with *annulirostris* is acceptable judging from the original descriptions and figure of that species by Baisas (loc. cit.).

Culex annulirostris can be readily separated from *sitiens* (to which it is exceedingly similar in the general adult characters) by the male palpus, proboscis and genitalia, larval and pupal stages as indicated in the keys and in the above diagnosis. The separation of the females of the 2 species is very difficult. Caution should be taken in using the characters noted in the key and mentioned above.

The affinity of *annulirostris* appears to be closer to the members of the *sitiens* complex than to any others in the *Sitiens* Group. The unique male phallosome of *annulirostris* is intermediate between certain species of the *Bitaeniorhynchus* Subgroup, especially *starckeae* Stone and Knight 1958 as described and figured by Belkin (1962: 217) from the South Pacific and the members of the *sitiens* complex. In the complex phallosome structure, *annulirostris* exhibits a similarity to *starckeae* in the simple, long and heavy spine of the outer division, but resembles members of the *sitiens* complex in the spinose apical sternal lobe of the inner division. There is also similarity in the development of the outer division of the male phallosome between *annulirostris* and *vicinus* (Taylor 1916) from Australia and *bihamatus* Edwards 1926 from Timor (Sirivanakarn 1974). It appears most probable that all of these species are related and fall into a single natural lineage.

BIONOMICS. *Culex annulirostris* utilizes a variety of ground pools as breeding habitats. In the Philippines, the immatures have been frequently collected from general ground pools, ponds, swamps and rice fields containing emergent vegetation. On occasion, they have been collected also from cacao shells and bamboo stumps. The water is fresh and clear or polluted with decayed organic matter. Baisas (1938: 208) also collected the larvae (as *palmi*) in salt bed pools. In the South Pacific, *annulirostris* has been reported to utilize almost any type of water, fresh or brackish on the ground or artificial containers, in open sunlit as well as in strongly shaded sites (Belkin 1962). Most of the adults from the Philippines have been collected biting and only a few in light traps. The preferred hosts are not known, but man is seldom attacked (Baisas 1974). Elsewhere in Micronesia (Bohart 1956), New Guinea (Assem and Bonne-Wepster 1964) and the South Pacific (Belkin 1962), *annulirostris* has been considered as a nuisance or serious pest of man. Females

from these areas readily attack man and are vicious biters in the evening.

The medical importance of *annulirostris* in the Philippines is not known. In New Guinea, it has been considered to be one of the important vectors of *Wuchereria bancrofti* (de Rook 1957a; de Rook and van Dijk 1959). In Australia, it has been reported to be naturally infected with 44 strains of Sindbis, Murray Valley encephalitis, Koongol and other unidentified agents and one strain of Belmont virus (Doherty et al. 1963, 1968, 1972) and has been considered to be a probable vector of arboviruses in cattle and buffalo (Standfast and Dyce 1972).

VISHNUI SUBGROUP

The *Vishnui* Subgroup essentially conforms to the *Sitiens* Subgroup characters and is chiefly characterized in the male genitalia by (1) inner division of phallosome not expanded to form a prominent lobe sternad; (2) outer division of phallosome broad, lobelike and usually with 1, 2 strong mesal spines and 1 sternal spine, sometimes with several spines or denticles on lateral margin; in the pupa by pinna of trumpet lightly oblique; in the larva by (1) seta 4-P usually double, sometimes single or multibranched; (2) siphon usually slender, thin, moderately to very long; (3) median caudal filament of spiracular apparatus usually well developed and (4) anal gills long, slender, tubular or fusiform, varied from 1.5 to 4.0 times as long as saddle.

DISCUSSION. The *Vishnui* Subgroup is largely restricted to Southeast Asia and adjacent tropical areas with a small extension into the west as far as the Mediterranean and the Ethiopian areas; into the north as far as the eastern Palearctic, including China, Manchuria, maritime provinces of USSR, Korea and Japan and into the east as far as the Solomons in the South Pacific and northern Australia. In Southeast Asia and adjacent areas, the *Vishnui* Subgroup is highly complex and taxonomically difficult, comprising various nominal taxa which are extremely similar in the adults and the male genitalia, but are strongly differentiated from one another in the larva and sometimes also in the pupa. The identity and the taxonomic status of the species involved can only be definitely determined by an examination of all stages associated through individual rearing. In this study 8 species are recognized in the *Vishnui* Subgroup. Most of these species are based on the study of material from Southeast Asia, India, Sri Lanka, China, Japan, Korea and New Guinea. These 8 species can be roughly classified into 3 complexes: *vishnui, tritaeniorhynchus* and *whitei* on the basis of the male sexual characters, the color of scales on the mesonotum, the male genitalia and the pupal and larval stages.

The *vishnui* complex as interpreted here is restricted to *vishnui* Theobald 1901; *pseudovishnui* Colless 1957; *perplexus* Leicester 1908; *alienus* Colless 1957; *philippinensis* n. sp. and *incognitus* Baisas 1938. In addition, there are 3 other extralimital forms which apparently belong to this complex on the basis of the male genitalia and larval stages: *permixtus* Hsieh and Liao 1956, *cheni* Ho 1963 from China and *omani* Belkin 1962 from the South Pacific. This complex is characterized in the male by ventral surface of palpal segment 3 with transparent scalelike setae; in the adults of both sexes by anterior 0.7 of the mesonotum usually predominantly covered with pale beige, yellow or golden scales or with partially dark and pale scales; in the male genitalia by apical tergal crown of inner division of the phallosome with 4-6 relatively strong and long fingerlike or toothlike processes and by the presence of 1, 2 strong mesal and 1 sternal spine in the outer division; in the pupa by pale yellow or slightly darkened and relatively long trumpet (0.6-0.9 mm) and by seta 1-II

usually less than 10 branched; in the larva by seta 7-I single; comb scales varied; usually small, numerous, with apical fringe terminating into a strong median spine or sometimes fewer (6, 7 in number), large, spinelike or numerous, with a mixture of large and small ones and by the presence of 6-8 pairs (total 12-16) of siphonal tufts.

The *tritaeniorhynchus* complex as recognized here includes only *tritaeniorhynchus* which is the most common and widespread of all members of the *Vishnui* Subgroup. It is chiefly characterized in the male by the ventral surface of palpal segment 3 with dark, fine, hairlike setae; in the adults by anterior 0.7 of the mesonotum predominantly covered with dark brown or golden brown scales; in the male genitalia by apical tergal crown of inner division of phallosome with relatively weaker and shorter fingerlike processes; in the pupa by brownish and shorter trumpet (0.50-0.65 mm) and seta 1-II more than 10 branched; in the larva by seta 7-I double; comb scales small, numerous, subequal, with normal, rounded apical fringe of evenly fine spicules and by the presence of 5, 6 pairs (total 10-12) of siphonal tufts.

The *whitei* complex is represented only by *whitei* which essentially conforms to the *vishnui* complex in the general adult characters, including male palpus but is strongly differentiated from all members of that complex in the male phallosome by the presence of several lateral and mesal spines or denticles in the outer division; in the larva by seta 7-I double, or sometimes triple; comb scales small, numerous, with apical fringe terminating into a weak median spine and by the presence of 5 pairs (total 10) of siphonal tufts.

23. *CULEX (CULEX) VISHNUI* THEOBALD
(Figs. 16, 45, 46, 47)

Culex vishnui Theobald 1901a: 355 (♀*); Edwards 1913b: 233 (♀, in part); Barraud 1924a: 996 (♂*, ♀, in part).

Culex annulus Theobald 1901a: 358 (♀); Giles 1902: 405 (♀); Blanchard 1905: 293 (♀); Leicester 1908: 144 (♀); Edwards 1913b: 233 (synonymy with *tritaeniorhynchus* Giles).

Culex pseudoinfula Theobald 1911b: 237 (♀); Edwards 1913b: 233 (synonymy); Colless 1957a: 93 (synonymy with *annulus* Theobald).

Culex (Culex) tritaeniorhynchus Giles, Edwards 1932: 204 (taxonomy, in part).

Culex (Culex) vishnui Theobald, Edwards 1932: 205 (taxonomy, in part); Barraud 1934: 400 (♂*, ♀, in part); Reuben 1969: 643 (♂*, ♀*, L*, taxonomy).

Culex (Culex) adelae Baisas 1938: 200 (♂*, ♀, P*, L*); Colless 1957a: 93 (synonymy with *annulus* Theobald).

Culex (Culex) annulus Theobald, Colless 1957a: 93 (♂, ♀, L*, revalidated) Delfinado 1966: 138 (♂*, ♀, L*); Bram 1967a: 205 (♂*, ♀*, P*, L*); Reuben 1969: 643 (synonymy with *vishnui* Theobald); Baisas 1974: 86 (♂*, ♀, P, L*).

FEMALE (Fig. 16, 45). Wing: 2.7-3.6 mm (average 3.2 mm). Forefemur: 1.3-1.7 mm (average 1.6 mm). Proboscis: 1.5-2.0 mm (average 1.8 mm). Abdomen: 2.2-2.7 mm (average 2.5 mm). Medium sized species; coloration variable. *Head.* Narrow decumbent scales of vertex yellowish white; erect scales varying from partially pale golden brown or dull yellow in center, dark brown on posterolateral areas to entirely brownish; lateral patch of broad scales pale beige to whitish, very distinct. Palpus about 0.2 of pro-

boscis; apex of segment 4 tipped with white scales; segment 3 and basal portion of segment 4 with or without some scattered pale scales on inner dorsal surface. Proboscis slightly longer than forefemur; median pale ring broad, 0.20-0.25 of proboscis length; portions distad and proximad of median ring usually entirely dark, sometimes sprinkled with a few pale scales. *Cibarial Armature.* Cibarial teeth 26-28 in number, in concave row which is slightly produced at middle; median 4-6 teeth narrow, elongate and tapered into a fine point apically; lateral teeth coarser, shorter, with abruptly pointed or truncate apices. *Thorax.* Mesonotal integument reddish to dark brown, sometimes pale brown; mesonotal scales narrow, moderately dense, color variable, from predominantly pale yellowish to brownish with mottling of brownish or yellowish scales not forming definite patterns on anterior 0.70-0.75; scales on antealar and supraalar areas rather coarse and largely whitish or yellowish; scales on prescutellar space and scutellar lobes pale beige to whitish. *Apn* and *ppn* with several narrow scales which are largely pale yellowish or concolorous with scales on mesonotum. Pleural integument paler or same color as mesonotum; *ppl,* upper corner and lower posterior border of *stp* and upper anterior *mep* with distinct pale scale patches; a few pale scales among upper *mep* bristles always present. *Legs.* Color of anterior surface of femora variable; anterior surface of fore- and midfemora entirely dark or lightly to strongly speckled with pale scales not contrasting sharply with dark scaled background, sometimes largely pale with sprinkling of dark scales; anterior surface of hindfemur with longitudinal pale stripe extending from base to near apex, dorsal area laterad of stripe usually entirely dark or sometimes speckled with pale scales; all tibiae and tarsomere 1 entirely dark, lightly speckled or with poorly defined pale stripe on anterior surface; tarsomeres 2-4 of all legs with or without scattered pale scales proximad and distad of apical and basal pale bands. *Wing.* Scales on all veins usually entirely dark except for short pale streak on posterior surface at extreme base of vein C; sometimes with a few pale scales scattered among dark ones on veins C, Sc, R and Cu; plume scales on veins R_2, R_3 and R_{4+5} narrow. *Abdomen.* Tergum I with median caudal scale patch which is partially pale in middle and dark laterally; terga II-VII with relatively broad, even basal transverse pale bands connected with elongate basolateral pale spots; tergum VIII with basal and apical pale bands or largely pale; sterna largely pale or with pattern of basal pale bands and apical dark bands as on terga. *Genitalia.* Essentially similar to most members of the *Sitiens* Group; tergum IX with lateral row of 4-6 setae; postgenital plate truncate or lightly emarginate on caudal margin; vaginal sclerite well sclerotized and pigmented, U or V-shaped; insula with a dense tuft of 8-10 setae.

MALE (Fig. 45). Essentially similar to female except for sexual characters. *Head.* Palpus exceeding proboscis by full length of segment 5; segment 2 with distinct apical pale band on dorsal surface; segment 3 with dorsal median pale band, apical 0.25 with ventrolateral tuft of 15-20 dark bristles, ventral surface with a row of short and pale translucent scale like setae which are progressively longer in apical 0.5; segments 4 and 5 moderately to strongly plumose, each with narrow basal pale band on dorsal surface; apex of segment 5 usually tipped with some pale scales. Proboscis with distinct ventral tuft of 5-10 long hairs at base of median pale ring.

MALE GENITALIA (Fig. 46). *Segment IX.* Tergal lobe with a row of 4-7 moderately long setae. *Basimere.* Conical, rather slender, about 0.27 mm in length. *Subapical lobe.* Setae *a-c* of proximal division subequally long, rodlike; setae *d-f* of distal division consists of 3, 4 narrow, bladelike or rodlike setae, the distalmost of which is longest, the other 2, 3 shorter, subequal, all

with hooked apex; leaf *g* broad, acuminate or rounded apically; seta *h* moderately strong, but not distinctly flattened. *Distimere.* Sickle-shaped; subapical dorsal surface lightly annulate and with a very weakly developed crest of fine spicules (visible under 43X objective); subapical claw short, distally flat and somewhat bilobed. *Phallosome.* Inner division of lateral plate with prominent apical tergal crown of 4, 5 strong, fingerlike processes, all curved, porrect or projecting caudad, the most mesal longest, lateral ones gradually shorter, with apices reaching beyond apical margin of sternal spiculate portion; the latter irregular, not produced into an angle laterally; outer division with a strong, divergent mesal spine and a strong sternal spine which is strongly curved or angled with apex pointing basad; lateral basal process moderately broad and long. *Proctiger.* Apical crown medium sized; basal sternal process dark, stout, long, curved sternad; subbasal process well developed, 0.1-0.2 of the length of basal sternal process; cercal setae 2, 3.

PUPA (Fig. 46). Abdomen: 2.5-3.0 mm (average 2.7 mm). Paddle. 0.7-0.8 mm (average 0.74 mm). *Trumpet.* 0.60-0.78 mm (average 0.7 mm); index usually more than 6 (5-9). Cephalothorax and abdomen cream-colored or yellowish white, without characteristic darkened areas. Complete chaetotaxy as figured, the following are diagnostic. *Trumpet.* Yellowish, more or less uniformly cylindrical from base to apex and moderately long; pinna slightly oblique, apical margin truncate of slightly emarginate. *Cephalothorax.* Seta 1-C triple; 8-C usually double (2, 3); 9-C double. *Metanotum.* Seta 10-C usually 4, 5 branched (3-7); 11-C double; 12-C usually 4 branched (2-4), rather weak and short, about 0.5 of 11-C. *Abdomen.* Seta 1-II usually 7, 8 branched (6-9); 1-III usually 7, 8 branched (6-12); 1-IV usually 6, 7 branched (4-7); 1-V, VI 4, 5 branched; 1-VII usually 3, 4 branched (2-4); 5-IV usually triple (2, 3); 5-V, VI usually double (1, 2), longer than segment following; 6-III, IV usually triple (2, 3); 6-V, VI usually 4 branched (3, 4); 4, 5-VII usually double (1, 2); 9-VII usually 4 branched (3, 4); 4-VIII double; 9-VIII 6-10 branched. *Paddle.* Broad and largely pale to almost transparent; midrib weak and pale; apical setae 1, 2-P present, minute.

LARVA (Fig. 47). Head: 0.70-0.78 mm (average 0.74 mm). Siphon: 1.3-1.8 mm (average 1.5 mm); index usually 7(6-8). Saddle: 0.32 mm; siphon/saddle ratio about 4.5. This species is distinguished from the rest of the *vishnui* complex and other members of the *Sitiens* Group by the presence of a distinct patch of numerous minute spicules on the thorax and by the following additional characters. *Head.* Yellowish white; seta 1-C dark, slender, simple, spiniform; 5, 6-C double; 7-C pale, moderately flattened and usually 8, 9 branched (7-11) 13-C double or triple. Antenna as long as head and very pale in middle portion; spicules strong and numerous; seta 1-A large, fan-shaped, about 25 branched; 2, 3-A dark, bristlelike and subapical. Mental plate with 6 lateral teeth on each side of median tooth. *Thorax.* Broad patch of minute spicules visible under 10X objective; usually largely restricted to dorsal pleural area; seta 4-P strong, double, its length nearly as long as setae 1-3-P. *Abdomen.* Setae 6-III-VI double; 7-I single; 1-III-VI 0.25-0.50 of 6-III-VI; 1-III, IV 3, 4 branched; 1-V, VI 4, 5 branched; seta 1-VII 5-7 branched; 4, 7, 10 and 12-VII single. Comb scales numerous, about 22, arranged in a broad oval patch; all scales similar in size and length, with apical fringe terminating to a moderately strong median spine. Saddle complete; posterior caudal margin lightly infuscate and spiculate; seta 1-X weak, usually triple (2, 3); 2-X usually triple (2-4); anal gills slender, tubular or fusiform, as long as or slightly longer than saddle. *Siphon.* Slender, straight or slightly curved dorsad in distal portion; color same as head capsule; length very vari-

able, usually 1.4-1.5 mm; pecten with 12-15 teeth; 3-4 distal teeth usually with 5-7 basal denticles and a long and very strong apical denticle, the latter straight or strongly curved; siphonal tufts strong, distinct, usually 7 pairs (or total 14), sometimes 6 pairs (or total 12); placed distad of pecten; 4, 5 proximal pairs closely spaced, forming a prominent irregular row on ventral surface, each 8-10 branched, the most proximal longest, slightly exceeding siphonal width at point of attachment, the rest gradually shorter; the most distal pair short, subventral; 1 lateral pair as long as most distal, placed slightly beyond midpoint of siphon; seta 2-S very weak, pale and short; median caudal filament of spiracular apparatus well developed.

TYPE-DATA. (1) *Culex vishnui* Theobald, Holotype ♀*, *Madras*, INDIA, Cornwall (BM); (2) *Culex annulus* Theobald, Holotype ♀*, Tai Po, Pokfulam, HONG KONG, C. Thomson (BM); (3) *Culex pseudoinfula* Theobald, Holotype ♀, Pasuruan and Samarang, *Java*, INDONESIA (AM); (4) *Culex (Culex) adelae* Baisas, Holotype ♂ with associated pupal and larval skins, Tungkong Manga, *(Luzon)*, PHILIPPINES, March 1937 (PHB; lost or destroyed).

DISTRIBUTION. Widespread throughout Southeast Asia with extension into the north and northeast as far as South China, Hong Kong, Taiwan and the Ryukyus, east as far as the Philippines, south as far as Java, Indonesia and west as far as India and Sri Lanka. Material examined: 1,548 specimens: 505♂, 649♀, 394 L; 508 individual rearings (133 pupal, 375 larval).

INDIA. *Madras:* Cornwall (type-locality); North Arcot, Virus Research Center (Poona); Chinglepet, Thandalam Village; *Assam:* N. Tinsukia; Dibrugarh; Dooma Dooma; Rupsi; Chabua; Lalmanirhat; *Bengal:* Calcutta, N. Salt Lake, Dum Dum; 56♂, 57♀, 21 L, 8 lp.

BANGLADESH. Sylhet; 7♂, 16♀, 1 L, 8 p, 5 lp.

BURMA. Rangoon: 4♂, 5♀, 5 p.

SRI LANKA. Peradeniya, Kandy District; 1♂, 1♀, 2 lp (associated adults missing).

THAILAND. Chiang Mai; Lampang; Phrae; Nan; Khon Kaen; Kalasin; Sakhon Nakhon; Nakhon Phanom; Udon Thani; Nakhon Ratchasima; Nakhon Nayok; Sara Buri; Phet Buri; Pathum Thani; Nonthaburi; Kanchanaburi; Chon Buri; Prachuap Khiri Khan; Ranong; Nakhon Si Thammarat; Surat Thani; Satum; 80♂, 165♀, 188 L, 72 p, 18 lp.

VIETNAM. Duc My; Can Tho; Phu Bei; Bien Hoa; Van Gia; Ban Me Thuot; Quang Nam; Saigon; An-Khe; Phu Ioi; Qui Nhon; Di An; Nha Trang; Antuc; Long Binh; Pleiku; 10♂, 10♀, 35 L.

CAMBODIA. Phnom Penh; Ari Gsatr; 24♂, 9♀.

MALAYSIA. *Peninsular Malaysia: -Selangor:* Subang Forest Reserve, Rantau Panjang; Puchong; Kuala Lumpur; Ulu Langat; Univ. Malaysia; *Pahang:* Kuala Lipis; Merapoh; C. Highlands; Kuantan; Pdg. Tungku, Merapoh; *Trengganu:* Kuala Brang; *Johore:* Kg. Kahang; Labis; *Kelantan:* Gua Musang; *Perak:* Lahat; Chiore Forest Reserve; Kuala Dipang; Senlu; Kuala Kangsar; Sungei Siput; Trong; *Perlis:* Pedang Besar; *Kedah:* Changlun; Sintok Forest Reserve; 160♂, 201♀, 60 L, 37 p, 116 lp. *Malaysia:-Sabah:* Beaufort; Tenom; Papar; Kota Kinabalu (Jesselton); Mankubau; 4♂, 9♀, 1 p.

SINGAPORE. Localities not specified; 11♂, 15♀, 3 L, 1 p, 21 lp.

INDONESIA. *Java:* Djakarta; Bogor; *Sumatra:* Bengkulu; *Sulawesi:* Minahassa; 2♂, 4♀, 1 L.

PHILIPPINES. *Luzon:* Rizal, Wack Wack; Batangas; Subic Bay; Agoo La Union; Bataon; Camp Stotsenberg; Subic Naval Base, Clark Air Base; N. Vizcaya; *Mindoro:* San Jose; *Samar:* Osmena, Combayen; *Leyte:* Abuyog; Palo; Gulf; *Palawan:* Iwahig; *Calicoan Is.; Culion Is.; Mindanao:* Zamboanga;

Kolambugan; Lanao; Ori Missamis; Kabakan; 117♂, 118♀, 80 L, 7 p, 165 lp.

HONG KONG. 4♂, 19♀, 5 L, 2 p, 3 lp.

CHINA. Canton; Nanking; Chekiang; 2♂, 2♀.

TAIWAN. Chow Chow; Ping Tung; Sze-Chun; Sun-Moon Lake; Taipei; Lung Tan; Hsin Chu Hsien; 21♂, 17♀, 36 lp.

JAPAN. *Ryukyus: Okinawa-Yaeyama,* Chizuka; 2♂, 1♀, 1 lp.

TAXONOMIC DISCUSSION. The identity and the taxonomic status of *vishnui* was confused and highly controversial until Reuben (1969) redescribed all stages from reared specimens collected in the type locality in Madras, South India. I am following Reuben (loc. cit.) in synonymizing *annulus* Theobald 1901 with *vishnui* Theobald 1901 and consider all Southeast Asian forms previously attributed to *annulus* by Colless (1957a), Delfinado (1966) and Bram (1967a) as this species. In addition, *pseudoinfula* Theobald 1911 from Indonesia and *adelae* Baisas from the Philippines, previously synonymized with *annulus* by Colless (1957a), are transferred to the synonymy of this species. It is also quite possible that *permixtus* Hsieh and Liao (1956) from Amoy and *cheni* Ho (1963) from Canton, China are synonyms of *vishnui* judging from the figures and the descriptions by these authors.

Culex vishnui as interpreted here is an extremely variable species. The type and topotypic adults from Madras which have been re-examined differ strikingly from those in Southeast Asia and other parts of India, including Bengal and Assam in the presence of speckling of pale scales on the femora of the legs but are identical to the latter populations in all other stages. The speckling of the legs of typical *vishnui* adults is usually better developed in the females than in the males, and as pointed out by Reuben (1969), it is also subject to considerable individual variation. The typical adult forms also exhibit a striking difference in having the scales on the anterior 0.7 of the mesonotum predominantly pale beige in contrast to usually predominantly brownish among the majority of the Southeast Asian populations. It appears most probable that the type form of *vishnui* is nothing more than a local ecotypic modification of a single widespread species and that the Southeast Asian species (previously known as *annulus*) is probably at most subspecifically distinct. When the results of experimental crosses among the 2 populations are available, it should be possible to determine the specific or subspecific status of these forms.

Culex vishnui is clearly differentiated from other members of the *vishnui* complex in the larva and sometimes also in the pupa as indicated in the keys and as described above. In Southeast Asia, separation of *vishnui* adults, especially the female, from *pseudovishnui* and *tritaeniorhynchus* has been rather tenuous. In sorting out adults from light trap or general field collections, the *vishnui* females are more likely to be confused with *pseudovishnui* than with *tritaeniorhynchus*. Caution should be taken in using the key and other characters as given in the above diagnosis.

BIONOMICS. The typical breeding sites of *vishnui* are general ground pools, including puddles, ditches, ponds, animal or wheel tracks and swampy ground containing numerous grasses and other aquatic vegetation in open or cleared land such as rice fields. It has also been found breeding in pools at the edge of small streams and in rock pools. The larvae and pupae have been frequently collected in association with those of *C. pseudovishnui, C. tritaeniorhynchus* and *Anopheles* species. In extensive field studies by Reuben (1971a, 1971d, 1971e) in Madras, adult density of *vishnui* was reported to be lowest from March to May, rose with the onset of the southwest monsoon during October to November and began to decline from January to May. The *vishnui* larvae were found to be most common in fallow rice fields where they were largely con-

centrated near the edge of paddy blocks during the early rice growing season. Their occurrence apparently precedes that of *pseudovishnui* and *tritaeniorhynchus* which utilize similar breeding habitats. The *vishnui* adults were collected both indoors and outdoors, in animal bait-traps, hand catches from resting and in Thailand several specimens were also collected in light traps. The preferred or natural hosts of *vishnui* females are pigs and birds (Colless 1959; Reuben 1971c, 1971d), but other animals, including cow and man are also readily attacked in the absence of the preferred host. In Taiwan, *vishnui* (as *annulus*) was reported to feed mainly on pigs (Mitchell et al. 1973) and in Thailand on buffalo and cattle (Gould et al. 1974).

MEDICAL IMPORTANCE. *Culex vishnui* is possibly one of the important vectors of Japanese encephalitis virus (JE) in Southeast Asia but because of the difficulty in separating the adults from other common species, particularly *tritaeniorhynchus* and *pseudovishnui*, its significance in the natural transmission of the disease has not yet been clearly established. In Taiwan, Cates and Detels (1969) found *vishnui* (as *annulus*) to be the only JE virus-positive mosquito and concluded that it was the important vector of this disease. Earlier, Wang et al. (1962) isolated JE virus from both *tritaeniorhynchus* and *fuscocephala* in Taiwan. In a virus isolation study by Carey, Reuben and Myers (1968) in Madras, India, one strain of JE virus, one strain of Sindbis and 2 strains of Umbre were isolated from *vishnui* (as *Culex* sp. 3) and one strain of Umbre was isolated from a mixed pool of *pseudovishnui* and *vishnui* (as *Culex* sp. 3). No attempt has yet been made to determine the efficiency of *vishnui* as a vector of JE virus through experimental transmission in the laboratory. In Chiang Mai, Thailand, Ingwavuma virus and one strain of Tembusu virus were reportedly isolated from pools of the *vishnui* complex (Top et al. 1974; Gould et al. 1974).

24. *CULEX (CULEX) PSEUDOVISHNUI* COLLESS
(Figs. 48, 49)

Culex (Culex) pseudovishnui Colless 1957a: 88 (♂*, ♀, L*); Delfinado 1966: 147 (♂, ♀, P, L*); Bram 1967a: 222 (♂*, ♀, L*); Reuben 1969: 648 (♂*, ♀*, L*); Matsuo and Ramalingam 1972: 55 (L, morphology).

Culex (Culex) neovishnui Lien 1968: 230 (♂*, ♀, P*, L*); Miyagi and Iha 1970: 71 (taxonomy). NEW SYNONYMY.

Culex vishnui of Barraud 1923a: 938 (L*); Barraud 1924a: 996 (♂*, ♀, in part); Borel 1930: 333 (♂*, ♀, L*).

Culex (Culex) vishnui of Edwards 1932: 205 (taxonomy, in part); Barraud 1934: 400 (♂*, ♀, L*, in part); Bohart and Ingram 1946: 83 (♂*, ♀, L*); LaCasse and Yamaguti 1950: 236 (♂, ♀, P, L); Bonne-Wepster 1954: 126 (♂, ♀, L*).

FEMALE. Wing: 3.06 mm. Forefemur; 1.5 mm. Proboscis: 1.7 mm. Abdomen: 2.3 mm. Small to medium sized species; in general extremely similar to *vishnui*, differing slightly in the following characters. *Head.* Erect scales of vertex pale beige or yellowish white in center, contrasting rather sharply with dark ones on posterolateral area. Palpus usually entirely dark except for apex of segment 4 which is sometimes tipped with pale scales. *Cibarial Armature.* As described and figured for *vishnui* from which it is virtually indistinguishable. *Thorax.* Mesonotal scales usually predominantly pale beige, yellow or golden, with or without mottling of several dark ones

along acrostichal and dorsocentral lines and fossae; scales around prescutellar space dark; scales on prescutellar space and scutellar lobes entirely pale. *Legs*. Anterior surface of fore- and midfemora dark scaled, speckling absent; anterior surface of hindfemur with longitudinal pale stripe extending from base to near apex, area dorsad and laterad of stripe dark scaled; anterior surface of tibiae and tarsomere 1 entirely dark, pale streak or stripe absent. *Wing*. Scales on all veins entirely dark except for a short pale streak on posterior surface at extreme base of vein C. *Abdomen*. Terga II-VII with basal pale bands which are very variable in width, usually broad and distinct on terga II-VI, narrow and indistinct on terga VII-VIII, sometimes extremely narrow and not visible from above on all segments; basolateral pale spots well developed on all terga. *Genitalia*. Essentially similar to *vishnui*, differing slightly as follows: Tergum IX with lateral row of 3-5 setae which are more widely spread; postgenital plate evenly rounded on caudal margin.

MALE. Essentially as described for female, differing from *vishnui* in the following features. *Head*. Palpal segment 3 with or without median pale band on dorsal surface, apical 0.25 with ventrolateral rows of about 14 bristles. Proboscis usually without ventral tuft of long hairs proximad of median pale ring.

MALE GENITALIA (Fig. 48). Exceedingly similar to *vishnui* in all details except for more slender lateral basal process of outer division of phallosome.

PUPA (Fig. 48). Abdomen: 2.3 mm. Paddle: 0.65 mm. Trumpet: 0.6 mm, index 9. Cephalothorax and abdomen cream-colored. Complete chaetotaxy as figured; distinguished from *vishnui* and other members of the *vishnui* complex by the following. *Trumpet*. Moderately long and more or less uniformly cylindrical. *Cephalothorax*. Seta 8-C usually 4, 5 branched (3-6). *Metanotum*. Seta 12-C strong, subequal to 11-C, usually triple (2-4). *Abdomen*. Seta 5-IV usually 7 branched (6, 7); 5-V, VI double, strong, 1.5 times as long as segment following; 6-III, IV usually 4, 5 branched (3-6); 6-V, VI usually 5, 6 branched (4-7). *Paddle*. Outer and inner part very pale; midrib variable from lightly to strongly pigmented.

LARVA (Fig. 49). Head: 0.65 mm. Siphon: 1.0-1.9 mm; index 6-10. Saddle: 0.32 mm; siphon/saddle ratio 3.5-5.0. As figured; differing from *vishnui* and other members of the *vishnui* complex in the following combination of characters. *Head*. Seta 5-C usually triple (2-5); 6-C usually double, rarely triple; 7-C dark, moderately flattened and strongly pectinate, 8-11 branched; 13-C single or double. *Thorax*. Spiculation absent; seta 4-P variable from weak and short, 6-15 branched to strong, long and double. *Abdomen*. Setae 1-III, IV usually 6, 7 branched (5-9); 1-V, VI stronger than 1-III, IV, usually 7, 8 branched (6-9); 6-III-VI usually triple (3, 4); seta 1-VII 6-11 branched; 4, 10 and 12-VII single; 7-VII double. Comb scales very large, subequal, usually 5-7, sometimes more, but not exceeding 12, in single or sometimes double rows; individual scale with strong and long apical spine and basal fringe of fine spicules. Saddle seta 1-X usually 4 branched (4, 5); 2-X 3, 4 branched; anal gills slender, 1.5-2.0 times as long as saddle length. *Siphon*. Variable in length; distally tapered, lightly to strongly curved dorsad; siphonal tufts 7, 8 pairs (total 14-16), 6 proximal pairs strong, 5, 6 branched each, inserted subventrally, pairing more or less regular; most proximal pair longest, about 1.5 times as long as siphonal width at point of attachment; rest gradually shorter; 1, 2 distal pairs weak, inserted laterally or dorsolaterally beyond midpoint of siphon; seta 2-S dark, slender, spiniform.

TYPE-DATA. (1) *Culex (C.) pseudovishnui* Colless, Holotype ♀*(57/11/7) with associated pupal and larval skins, SINGAPORE, 9 May 1957. D. H. Col-

less (BM); (2) *Culex (C.) neovishnui* Lien, Holotype ♂ (CU 30.6) with associated pupal and larval skins, Peiyuan, Tungho, *Taitung,* TAIWAN, reared from egg-raft laid by a female caught when biting a man at night in the woods, 8-9 June 1967, J. C. Lien, W. L. Cheng and R. S. Lin (Taiwan Provincial Institute of Infectious Diseases, Taipei, Republic of China).

DISTRIBUTION. Widespread over most parts of the Oriental region, extending north and northeast into China and Japan, east and south into New Guinea (West Irian, Indonesia) and west into Pakistan, India and Sri Lanka. Material examined. 1,268 specimens: 319♂, 502♀, 447 L; 295 individual rearings (129 pupal, 166 larval).

INDIA. *Madras:* North Arcot, Poona; Bihar, Purnea; *Bengal:* Sukna; Darjeeling District; Calcutta, Salt Lake; *Assam:* Lalmanirhat; Jorhat; Rupsi; Dibrugarh; Dooma Dooma; Chabua; Tezpur; 6 mi. N. Tinsukia; 11♂, 17♀, 30 L, 4 p, 7 lp.

BANGLADESH. Sylhet; 2♂, 8♀, 2 p, 3 lp.

SRI LANKA. *Central Province:* Peradeniya; Kandy District; Hasalaka; Mahiyangane; Nuwara Eliya; Monaragala District, Padiyatalawa; *North Central Province:* Anuradhapura District; Padaviya; *Northern Province:* Vavuniya District; *Sabaragamuwa Province:* Ratnapura District; Panamure; 25♂, 59♀, 26 L, 3 lp.

PAKISTAN. Lahore; 2 lp (adults missing).

THAILAND. Chiang Mai; Lampang; Udon Thani; Tak; Khon Kaen; Mae Hong Son; Nan; Nakhon Ratchasima; Nakhon Nayok; Phet Buri; Chon Buri; Rayong; Trat; Prachuap Khiri Khan; Ranong; Surat Thani; Krabi; Phuket; Yala; Narathiwat; 94♂, 126♀, 208 L, 107 p, 15 lp.

CAMBODIA. Phnom Penh; Ari Gsartr; 2♂, 8♀.

VIETNAM. Cantho; Cu Chi; Phu Bei; Bien Hoa; 1♂, 8♀, 11 L, 2 p.

MALAYSIA. *Peninsular Malaysia: Selangor*-Kuala Lumpur; Sungei Besi; Kepong; Ulu Langat; Rantau Panjang; Ulu Klang; *Trengganu*-Dungun; *Pahang*-Pdg. Tungku; Pekan Rd.; Kuantan; *Perak*-Leng Gong; Sungei Siput; C. Highland Rd.; Chiore F. R.; Maxwell's Hill; Lasah; Kuala Kangsar; *Perlis*-Padang Besar; *Kedah*-Kg. Peng Besar; 47♂, 78♀, 47 L, 3 p, 35 lp; *Malaysia: Sabah*-Tambunan; Apin; Tuaran; Kota Kinabalu (Jesselton); Kinarut; Labuan; Mt. Kinabalu; Kuala Penya; Stipitang; Tenom; 13♂, 23♀, 2 p, 7 lp.

SINGAPORE. Pulau Ubin; Henderson Rd.; 8♂, 7♀, 10 L, 1 p, 10 lp.

INDONESIA. *Kalimantan:* Tarakan; *Java:* Djakarta; Bogor; Pelabuhan Ratu; *Sumatra*: Bengkulu; *Morotai* (Mollucas); *New Guinea* (West Irian): Li Sentani; Cyclops Mtn.; Tenah, Merah Bay; 27♂, 45♀, 7 L.

PHILIPPINES. *Luzon:* Subic Bay; Pangasinan; Tayug; San Fernando; *Mindoro:* San Jose; *Palawan:* Iwahig; Balcahan; *Culion Is.; Sanga Sanga Is.:* Lapit Lapit; *Leyte; Mindanao:* Kalabakan; 50♂, 71♀, 52 L, 2 p, 12 lp.

HONG KONG. 3♂, 10♀, 7 L, 6 p, 6 lp.

TAIWAN. 1♂, 2♀, 5 L, 2 lp.

JAPAN. Kyoto; Nagasaki; *Honshu* (Otsu); 30 L; *Ryukyus: Okinawa*-Chizuka; Tancha Onna; Chibana Misato; Shimabuku; Yaka Kin; Yaeyama; *Iriomote;* 35♂, 40♀, 6 L, 64 lp.

CHINA. Shanghai; 8 L.

TAXONOMIC DISCUSSION. *Culex pseudovishnui* is the most common and widespread species of the *vishnui* complex in Southeast Asia and other parts of the Oriental region. Until it was described and recognized by Colless (1957a: 88-93), *pseudovishnui* had been partially or entirely referred to as *vishnui* Theobald in all previous regional and local studies (Barraud 1923a, 1924a; Borel 1930, Bonne-Wepster and Brug 1939, Lee 1944, Bohart and

Ingram 1946, LaCasse and Yamaguti 1950 and Bonne-Wepster 1954). As pointed out by Colless (1957a), the larvae figured and described by these authors as *vishnui* were erroneous, due to misidentification.

Culex pseudovishnui can be clearly separated from the rest of the *vishnui* complex and subgroup by the larval and pupal characters as indicated in the keys and as described above. Most diagnostic of the *pseudovishnui* larva are the presence of a row of 5-7 very large, spinelike comb scales; the characteristic siphon and the number and arrangement of siphonal tufts. The pupa can be readily recognized by seta 8-C which is usually 4, 5 branched; the pale trumpet and by the branching of seta 1-II (see key). The adults of *pseudovishnui* cannot be separated from those of *perplexus, alienus, incognitus* and *philippinensis* with certainty but are, with practice, readily distinguished from those of *vishnui* and *tritaeniorhynchus* by the paler color of the erect scales of the head and the mesonotal scales of the thorax and by the whitish longitudinal stripe on the anterior surface of the hindfemur. The *pseudovishnui* males also differ from the latter 2 species in the absence of a ventral tuft of long hairs proximad of the median pale ring of the proboscis. The male genitalia are virtually indistinguishable from *alienus* and *incognitus* but can be differentiated from those of *vishnui, perplexus, philippinensis* and *tritaeniorhynchus* by the slight differences in the phallosome and the proctiger.

Of all stages of *pseudovishnui,* the larvae apparently exhibit a striking, discontinuous variation in the length and branching of seta 4-P and the number of lateral hair tufts of the siphon. Based on these 2 larval characters, Lien (1968: 230-4) described *neovishnui* from Taiwan as distinct from typical *pseudovishnui* by having seta 4-P double and strong (weak and multiple in the type form) and presence of 1 pair of lateral tufts (usually 2 in the type form) on the apical half of the siphon. My study and the comparative analysis of these larval characters by Matsuo and Ramalingam (1972: 55-61) of the material from several parts of Southeast Asia and other adjacent areas, including Taiwan, the Ryukyus and Japan reveal considerable overlap in these characters. The larval material from Malaysia, Singapore, Thailand, etc., all exhibit the characters typical of *pseudovishnui* and *neovishnui* without any indication of correlated differences in other stages. Both larval forms have been found together in the majority of collections from Thailand and Malaysia. Although larvae of the typical *pseudovishnui* have not yet been found in Taiwan, the Ryukyus and Japan I am rather convinced that they are only a variation within a single species. The tentative synonymy of *neovishnui* Lien with *pseudovishnui* as discussion by Matsuo and Ramalingam (1972) is warranted on the basis of the present review.

BIONOMICS. The larvae and pupae of *pseudovishnui* came largely from collections in various types of fresh water ground pools in rural, open country such as rice fields at the elevation ranging from near sea level to about 46 m. They have also been collected from pools at stream margins. Frequently they were found in association with *tritaeniorhynchus* and *vishnui* and occasionally with *bitaeniorhynchus, mimulus* and *fuscocephala* in the collections from Thailand and Malaysia. In Madras, India, Reuben (1971e) reported that the larvae were abundant and began to replace *vishnui* by the time rice reaches 0.3 m in height; they appeared to be spread along the edge as well as the interior of a paddy block. Adult density follows a similar pattern to the rainfall as in *vishnui* (Reuben 1971a). They were collected both indoors and outdoors in animal bait traps and light traps. The females occasionally bite man, but birds, pigs and cattle are most frequently attacked and are the principal source of blood (Colless 1959; Reuben 1971c, 1971d).

MEDICAL IMPORTANCE. *Culex pseudovishnui* may be a vector of Japanese encephalitis virus in the Oriental region, but because of the difficulty in separating the adults, especially from *vishnui* and other dominant sympatric forms, including *tritaeniorhynchus*, its role as a reservoir or carrier of this disease or other related viruses has not yet been definitely established. Carey, Reuben and Myers (1968) reportedly isolated one strain of Umbre virus from a mixed pool which contained specimens of *pseudovishnui* and *vishnui* (as sp. 3) in Madras, India. In Thailand, a strain of Tembusu virus was isolated from a pool of *Culex vishnui* complex which apparently included *vishnui* and *pseudovishnui* (Gould et al. 1974). Nothing more is known about its medical importance. Further virus isolation from positively identified specimens and experimental transmission in the laboratory are required.

25. *CULEX (CULEX) PERPLEXUS* LEICESTER
(Figs. 50, 51)

Culex perplexus Leicester 1908: 150 (♂, ♀).
Culex (Culex) vishnui of Edwards 1932: 205 (taxonomy); Barraud 1934: 400 (♂*, ♀, L*, in part).
Culex (Culex) perplexus Leicester, Colless 1957a: 95 (♂, ♀, L*, revalidated); Bram 1967a: 221 (♂*, ♀, L*).

FEMALE. Wing: 3.4 mm. Forefemur: 1.6 mm. Proboscis 1.6 mm. Abdomen: 2.3 mm. As described by Colless (1957: 95-7); very similar to *pseudovishnui* and other members of the *vishnui* complex; differing in larger size, generally darker in coloration and in the following additional characters. *Head.* Erect scales of vertex predominantly yellowish to golden except for a few dark ones on posterolateral area. Palpus usually completely dark scaled; apex of segment 4 entirely dark or sometimes tipped with pale scales. Proboscis thicker, as long as or sometimes shorter than forefemur; median pale ring narrower, varying from 0.10 to 0.13 of proboscis length. *Thorax.* Mesonotal integument darker to almost blackish; scales on anterior 0.7 of mesonotum usually entirely cream-colored or yellow, sometimes largely dark in middle, pale on marginal areas; scales on posterior 0.3 cephalad and laterad of prescutellar space usually entirely dark, sometimes with variable amount of pale scales forming streaks; scales in prescutellar space entirely dark or partially pale; scales in scutellar lobes pale. *Legs.* Tarsomeres 1-4 of all legs with very narrow apical and basal pale bands. *Wing.* All scales dark; base of vein C without a distinct pale line on posterior surface; plume scales on veins R_{4+5} and branches of M and Cu relatively broad clavate. *Abdomen.* Terga II-VII entirely dark or with narrow basal pale bands; basolateral pale spots present on at least terga III-VII.

MALE. Differing from other members of the *vishnui* complex as described for female and in the following. *Head.* Palpal segment 2 without apical pale band; segment 3 entirely dark or with median pale band, apical 0.2 with ventral lateral tuft of 10 bristles. Proboscis with a distinct ventral tuft of 5, 6 long hairs at base of median pale ring.

MALE GENITALIA (Fig. 50). Exceedingly similar to other members of the *vishnui* complex, differing in having lateral basal process of outer division of phallosome larger, more or less rounded and in having weaker and shorter fingerlike processes of apical tergal crown of inner division.

PUPA (Fig. 50). Abdomen: 2.5-3.0 mm (average: 2.8 mm). Paddle:

0.65-0.78 mm (average 0.72 mm). Trumpet 0.70-0.83 mm (average 0.72 mm); index 8-11. Coloration very variable from yellowish, with or without striking pattern of dark and light areas on cephalothorax and abdomen. Complete chaetotaxy as figured; distinctive in the following combination. *Trumpet.* Dark brown, relatively slender, long and uniformly cylindrical or slightly swollen in middle, narrowed towards apex; pinna short, lightly oblique, apical margin truncate. *Cephalothorax.* Seta 1-C usually triple (3,4); 8-C usually double (2,3); 9-C usually double (1,2). *Abdomen.* Seta 5-IV 6,7 branched (6-9); 5-V usually triple (2-5); 5-VI double; 6-III, IV weak, usually triple (3-6); 6-V, VI stronger, usually 4 branched (3-6). *Paddle.* Midrib moderately to strongly pigmented; areas along midrib lightly to strongly pigmented, other parts of paddle pale.

LARVA (Fig. 51). Head: 0.65 mm. Siphon: 1.1-2.3 mm (average 1.8 mm); index 6-11. Saddle: 0.34 mm; siphon/saddle 4.0-4.5. Coloration of head capsule, siphon and saddle variable as in the pupa; differing from other members of the *vishnui* complex particularly in the following combination of characters. *Head.* Seta 1-C, dark, stout, spiniform, with or without accessory lateral spicules; 5-C 3,4 branched (2-5); 6-C usually double (2,3); 7-C very dark, strongly flattened, 10-15 branched and strongly pectinate; 13-C usually double (2,3). *Thorax.* Spiculation absent; seta 4-P strong, double; 7-P usually triple (3,4); 8-P usually double (2,3). *Abdomen.* Setae 6-III, IV usually triple (3,4); 6-V, VI usually double (2,3); 1-III-VI 8-10 branched; seta 1-VII 8-10 branched; 4-VII usually single; 7-VII double or triple; 10-VII double; 12-VII single. Comb scales 12-20 in a small oval patch; size of scales intermediate between *pseudovishnui* and *vishnui,* all subequal, with strong apical spine and lateral fringe of several fine spicules; seta 1-VIII dark, flattened, 4,5 branched and strongly barbed; 2-VIII usually single, sometimes double; 3-VIII 6,7 branched and strongly barbed; 5-VIII 4-6 branched. Saddle complete, darker or concolorous with siphon; seta 1-X 4,5 branched; 2-X triple; 4-X usually with 6 pairs of setae, sometimes 5.5 pairs; anal gills pale, slender, 1.0-1.5 times as long as saddle. *Siphon.* Yellowish to dark brownish; slender, straight and distally tapered; length variable; pecten teeth 9-12 in number; siphonal tufts 6,7 pairs (total 12,14) widely spaced, 5-6 proximal pairs inserted subventrally beyond pecten, 4,5 branched each; 1 pair lateral in apical 0.5 of siphon, 2-4 branched; most proximal 1.0-1.5 times as long as siphonal width at point of attachment, rest gradually shorter, lateral pair about as long as siphonal width at point of insertion; seta 2-S slender, spiniform; median caudal filament very well developed.

TYPE-DATA. Lectotype ♀*, Kuala Lumpur, *(Selangor),* MALAYA (PENINSULAR MALAYSIA), pupa from large stagnant pool filled with floating water weeds near houses, 2 December 1903, G. F. Leicester (BM; selection of Bram 1967a: 222).

DISTRIBUTION. Known only from Thailand, Malaysia, Singapore, Indonesia and India. Material examined. 102 specimens: 23♂, 29♀, 50 L; 29 individual rearings (16 pupal, 13 larval).

INDIA. Andaman Is.; 2♂, 3♀.

THAILAND. *Prachin Buri:* Ban Bu Phram; *Trat:* Ban Salak Phet; *Phet Buri; Prachuap Khiri Khan:* Khlong Hin Chaung; 10♂, 16♀, 37 L, 16 p, 7 lp.

MALAYSIA. *Peninsular Malaysia: Selangor*-Kuala Lumpur; *Trengganu:* Kg. Tapah, Kuala Brang; *Perak:* Sungei Siput; 1♂, 1♀, 4 L. *Malaysia: Sabah*-Tenom; 6♂, 5♀, 7 L.

INDONESIA. *Kalimantan:* Sotek; 2 L.

SINGAPORE. 4♂, 4♀, 6 lp.

TAXONOMIC DISCUSSION. *Culex perplexus* can be readily separated from other members of the *vishnui* complex in the larva and pupa as indicated in the keys and as described above. The most distinctive features of the larva of *perplexus* are the number and type of the comb scales, the siphon shape, the number, relative length and the arrangement of the siphonal tufts and those of the pupa are the shape, length and color of the trumpet, the branching of abdominal setae 5-IV, V and the color of paddle midrib. Except for the diagnostic chaetotaxy and other distinctive features, the larva and pupa of *perplexus* exhibit considerable variation in pigmentation of the integument, particularly in the material from Prachin Buri, Thailand. The specimens from stream pools which contain numerous dead leaves under heavy forest shade are the darkest and exhibit a striking color pattern, whereas those which came from swamp pools containing living aquatic vegetation under partial shade are much paler and exhibit no color pattern. The dark and pale larval and pupal forms do not appear to be correlated with any differences in the adults and it seems most likely that these variations are environmentally induced.

The adults of *perplexus* are also very variable, particularly in the presence or absence of basal pale bands on the abdominal terga. The adults which exhibit completely dark abdominal terga can be readily separated from *pseudovishnui* and *alienus* whereas those which exhibit basal pale bands are usually distinguished from the latter 2 species by (1) darker integument of the mesonotum, (2) relatively narrower median pale ring of the proboscis, (3) relatively shorter proboscis, (4) broader plume scales on veins R_{4+5} and branches of M and Cu, (5) narrower apical and basal pale bands of tarsomeres 1-4 of the legs, (6) male palpal segment 2 completely dark or without distinct apical band on dorsal surface and (7) male proboscis with a distinct ventral tuft of long hairs at the base of median pale ring.

Among the members of the *vishnui* complex, *perplexus* is apparently most closely related to *pseudovishnui*. Both species exhibit only a slight overlap in the breeding site, but appear to be ecologically distinct; *perplexus* usually breeds in pools under forest shade while *pseudovishnui* usually breeds in the open in rice fields.

BIONOMICS. *Culex perplexus* appears to be an uncommon forest form whose breeding habitats are restricted to fresh water ground pools such as pools in dried up stream beds or at stream margins, swamps and ponds. All collections from stream pools usually contain numerous decayed leaves and those from swamps and ponds usually contain some green algae. These habitats are under heavy or partial shade of primary or secondary rain forest at elevations ranging from 200 to 300 m. The immatures were collected in association with specimens of *C. (Eumelanomyia) malayi* (Leicester), *C. (Lophoceraomyia) infantulus*, *C. (Lophoceraomyia) quadripalpis* (Edwards), *C. (Culiciomyia) pallidothorax* Theobald; *C. (Culiciomyia) scanloni* Bram; *C. (Culex) bitaeniorhynchus*, *C. (Culex) pseudovishnui*, *Uranotaenia annandalei* Barraud and *Anopheles barbirostris*. Most of the adults were obtained from rearing the larvae or pupae. The feeding habits of the females and their role in transmission disease are unknown.

26. *CULEX (CULEX) ALIENUS* COLLESS
(Figs. 52, 53)

Culex (Culex) alienus Colless 1957a: 97 (♂, ♀, L*); Bram 1967a: 202 (♂*, ♀, L*).

FEMALE. Wing: 3.1 mm. Forefemur: 1.4 mm. Proboscis: 1.7 mm. Abdomen: 2.5 mm. Extremely similar to *pseudovishnui* and other members of the *vishnui* complex, differing slightly in the following. *Head.* Erect scales of vertex predominantly pale yellowish or bronzy except for a few dark ones on posterolateral areas. Palpus segment 4 always tipped with pale scales on its apex. Proboscis distinctly longer than forefemur; median pale ring moderately broad. *Thorax.* Mesonotal integument brownish; scales on anterior 0.7 of mesonotum always pale beige or pale yellowish; posterior 0.3 of mesonotum largely dark brown scaled cephalad and laterad of prescutellar space; scales on prescutellar space largely dark except for a few pale ones on posterior caudal margin. *Legs* and *Wing.* Essentially as described for *pseudovishnui.* *Abdomen.* Terga II-VII always with basal pale bands.

MALE. Essentially as described for female, differing from *pseudovishnui* particularly in having a ventral tuft of about 6 long hairs at base of median pale ring of proboscis, these hairs are 2 to 3 times as long as labial width.

MALE GENITALIA (Fig. 52). Exceedingly similar to *pseudovishnui* from which it can not be separated with certainty; differing from *vishnui* and *perplexus* slightly in having smaller lateral basal process of the outer division of the phallosome.

PUPA (Fig. 52). Abdomen: 2.5-3.2 mm (average 2.9 mm). Paddle: 0.71-0.78 mm (average 0.75 mm). Trumpet: 0.60-0.72 mm (average 0.65 mm); index 9-10. Very similar to *vishnui* and *pseudovishnui.* Cephalothorax and abdomen cream-colored. Complete chaetotaxy as figured; the following are diagnostic. *Trumpet.* Slightly darker than underlying integument and more or less uniformly cylindrical from base to apex. *Cephalothorax.* Seta 8-C usually triple (2-5); 9-C double. *Abdomen.* Seta 5-IV usually 4, 5 branched (4-6); 5-V, VI double; 6-III, IV usually triple (2-4); 6-V usually 4 branched (3, 4); 6-VI usually 5 branched (3-6). Paddle. Inner and outer parts very pale, without infuscate areas; midrib weak and pale.

LARVA (Fig. 53). Head: 0.74 mm. Siphon: 1.4-1.6 mm (average 1.5 mm); index 9. Saddle: 0.36 mm; siphon/saddle ratio 4-5. Differing from other members of the *vishnui* complex in the shape and the strong subventral tufts of siphon and in the following. *Head.* Yellowish with indefinite darkened area; seta 1-C relatively long; 4-C shorter than the distance between bases of the pair; 5-C usually double (2, 3); 6-C double; 7-C weak and pale, 8-12 branched; 13-C usually 4 branched (4, 5). *Thorax.* Spiculation absent; 4-P strong, usually double (1, 2); 7-P double or triple; 8-P usually double, sometimes single. *Abdomen.* Setae 1-III-VI usually double (2-4); 6-III-VI all double, seta 1-VII 4, 5 branched; 4, 7, 10 and 12-VII single. Comb scales small, 13-20 in a small oval patch, scales in posterior row slightly longer than those in anterior row, all terminating in an acute apical spine. Saddle concolorous with siphon; seta 1-X double or triple; 2-X triple; anal gills slender, tubular, about 3 times as long as saddle length. *Siphon.* Yellowish or brownish; slender and distally strongly tapered; siphonal tufts 5.5-6 pairs (total 11-12) in number, one of which is lateral, the rest subventral; pairing regular; 3 proximal subventral pairs very strong, long, double or triple, 4-5 times as long as siphonal width at point of attachment; distal subventral pairs shorter, 3, 4 branched; lateral pair inserted in apical 0.5 of siphon, 3, 4 branched, about 3 times as long as siphon width at point of insertion; seta 2-S dark, relatively strong and long; median caudal filament developed.

TYPE-DATA. Holotype ♀* (LT31) and whole larva morphotype, Long Tebangan, Fourth Division, *Sarawak* (BORNEO), August 1953, D. H. Colless (BM).

DISTRIBUTION. Presently known only from Thailand, Vietnam, Malaysia

and Singapore. Material examined. 58 specimens: 16♂, 16♀, 26 L; 19 individual rearings (5 pupal, 14 larval).

THAILAND. Trat; 5 L.

VIETNAM. Saigon; Cu-Chi; 8 L.

MALAYSIA. *Peninsular Malaysia: Kelantan*-Tumpat; *Kedah:* Kg. Bagan; *Perak:* Chenderiang; 11♂, 7♀, 1 L, 8 lp. *Malaysia: Sarawak* (type-locality); 3♂, 3♀, 3 L (skins), 2 p; *Sabah:* Sipitang; Tarakan; 2♂, 6♀, 7 L, 3 p, 6 lp.

SINGAPORE. 2 L.

TAXONOMIC DISCUSSION. *Culex alienus* is apparently one of the uncommon members of the *vishnui* complex and like *perplexus,* appears to be restricted to certain areas connected with or adjacent to the Malaya Peninsula. It is possible that it may also be discovered among the neighboring islands of Indonesia when more extensive larval surveys are made. Of all stages, the larva of *alienus* is most distinctive and can be readily separated from all members of the *vishnui* complex by the features of the siphon, number and type of the comb scales and branching of certain setae. The adults of *alienus* are difficult to separate from *pseudovishnui* and *perplexus* except through a close comparison using slight differences in the color of scales on the mesonotum as indicated above. It can usually be distinguished from *pseudovishnui* by scales on the anterior 0.7 of the mesonotum entirely pale and the scales on the prescutellar space mostly dark and from *perplexus* by the generally paler coloration of the thorax and broader median pale ring of the proboscis. The male genitalia are virtually indistinguishable from *pseudovishnui* but differ slightly from *perplexus* and *vishnui* in having a more slender lateral basal process of the outer division of the phallosome. The pupa, although showing some overlap with all of these species, can be separated by the combination of the chaetotaxy and other general features as described above and as indicated in the key.

BIONOMICS. *Culex alienus* is typically a fresh water ground pool breeder in open country such as in rice fields or in hills fully or partially exposed to the sun. The immatures have been collected in wells, ditches, sandy or gravel pools, marshy depression and ponds in association with *C. pseudovishnui, C. tritaeniorhynchus, C. gelidus, C. fuscocephala* and *Anopheles sp.* The water was fresh and clear, containing little or no aquatic vegetation. The elevations ranged from sea level to about 70 m. All adults have been obtained from rearing larvae and pupae. Nothing is known about the feeding habits of the females and their disease relationships.

27. *CULEX (CULEX) PHILIPPINENSIS* NEW SPECIES
(Figs. 54, 55)

FEMALE. Wing: 3.4 mm. Forefemur: 1.7 mm. Proboscis: 1.7 mm. Abdomen: 2.5 mm. In general extremely similar to *pseudovishnui* and its closely related forms, differing slightly in the following combination of characters. *Head.* Proboscis relatively short, equal to or slightly longer than forefemur; median pale ring about 0.2 of total length of proboscis. *Cibarial Armature.* Essentially similar to *pseudovishnui;* cibarial bar with about 20 teeth in a concave row; median 4-6 teeth narrow, elongate and fine, closely spaced; lateral teeth coarser, shorter and widely spaced. *Thorax.* Mesonotal integument pale brown; scales on anterior 0.7 mesonotal disc entirely pale beige or with dark scales forming a distinct longitudinal streak on acrostichal line and a spot in middle of fossae; scales cephalad and laterad of prescutellar space dark brown; scales on prescutellar space entirely pale. *Legs.* As

described for *pseudovishnui*; apical and basal pale bands of tarsomeres 1-4 of all legs moderately broad and distinct. *Wing.* All scales dark, narrow and dense; base of vein C without pale scaled streak or spot on posterior surface. *Abdomen.* Terga II-VII with narrow basal pale bands and elongate basolateral pale spot; sterna largely pale or with pattern of basal pale bands as terga. *Genitalia.* Essentially as described and figured for *vishnui* and *pseudovishnui;* tergum IX with a lateral row of 6, 7 setae on each side; postgenital plate with truncate caudal margin; vaginal sclerite U-shaped and well sclerotized; insula with a tuft of 8-11 strong setae.

MALE. In general as described for female except for broader basal bands on abdominal terga; differing from other members of the *vishnui* complex particularly in the following features. *Head.* Palpus rather short, exceeding proboscis by about 0.5 of length of segment 5; segment 2 and 3 without pale scales forming bands on dorsal surface; short scalelike setae on ventral surface of segment 3 apparently fewer, apical 0.1 of segment 3 with weak tuft of 6, 7 bristles; segment 4 and 5 reduced in length, weakly to moderately plumose and entirely dark or with poorly defined basal bands on dorsal surface. Proboscis without ventral tuft of hairs at base of median pale ring.

MALE GENITALIA (Fig. 54). Very similar to other members of the *vishnui* complex in the basimere, subapical lobe, distimere and type of phallosome, differing strikingly in the almost complete absence of basal sternal process of the proctiger and in the following additional detail. *Subapical lobe.* Leaf *g* of distal division relatively narrower and shorter. *Phallosome.* Inner division with apical tergal crown of 4, 5 weaker and shorter fingerlike processes; sternal spine of outer division very large, somewhat resembling *sitiens;* lateral basal process of outer division relatively large, broad and rounded. *Proctiger.* Apical crown of spicules dark, medium sized; basal sternal process of paraproct very short, rudimentary to almost completely absent; subbasal process absent; cercal setae 2-3.

PUPA (Fig. 54). Abdomen: 2.5 mm. Paddle: 0.74 mm. Trumpet 0.65 mm; index 5-7. Cephalothorax and abdomen pale, cream-colored, without definite pattern of darkened areas. All setae developed, the following diagnostic. *Trumpet.* Moderately long and more or less uniformly cylindrical; basal half of meatus dark, apical half pale. *Cephalothorax.* Setae 1-3-C usually triple (2-4); 8-C usually triple (2-5). *Abdomen.* Seta 5-IV usually triple (2-4), 5-V, VI double, long, about 1.5 of segment following; 6-III-VI usually triple (2-4); 2-VII always mesad of 1-VII; 4, 5-VII always single; 4-VIII usually single, rarely double. *Paddle.* Broad and entirely pale; midrib pale or lightly pigmented.

LARVA (Fig. 55). Head: 0.78 mm. Siphon: 1.5-2.0 mm; index 8-11. Saddle: 0.36 mm; siphon/saddle ratio 4.5-5.5. Complete chaetotaxy as figured, distinguished from other members of the *vishnui* complex by the following features. *Head.* Yellowish white; seta 4-C single, as long as or slightly longer than distance between bases of the pair; 5-C usually triple, sometimes double; 6-C double; 7-C pale, 6-8 branched, weakly barbed; 14-C single or double. *Thorax.* Spiculation absent; seta 1-M relatively long, about 0.5 of 3-M. *Abdomen.* Setae 1-III-VI usually triple (2-4); 6-III-VI double. Comb scales numerous, 30-40, all small, subequal, with weak apical spine and lateral fringe of evenly fine spicules. Saddle complete, same color as siphon; seta 1-X double; 2-X double or triple. *Siphon.* Slender, pale, moderately to very long, distal portion moderately to strongly tapered, somewhat resembling *alienus;* pecten teeth 9-12; siphonal tufts usually 6 pairs (total 12), sometimes 5.5 or 7 pairs; 4 proximal pairs strong, subventral, usually triple (2-4), about

3, 4 times as long as siphonal width at point of attachment; 2 distal pairs weak and short, double or triple, the proximal pair inserted laterally, the distal subventrally, about 1.5 times as long as siphonal width at point of insertion; seta 2-S weak and short; median caudal filament poorly developed.

TYPE-DATA. Holotype ♂ (C1 314-3) with associated pupal and larval skins and genitalia slide, Tay-Tay, Rizal, *Luzon*, PHILIPPINES, November - December 1966, F. E. Baisas (USNM); Allotype ♀ (C1 329-5) with associated pupal and larval skins, same locality as holotype (USNM); Paratypes: 8 ♂ (C1 329: C1 330; C1 338), 3 with associated pupal and larval skins, 28 ♀ (C1 301; C1 303; C1 306; C1 328; C1 329; C1 330; C1 338) with associated pupal and larval skins, same data as holotype and allotype (USNM, BM, BBM).

DISTRIBUTION. Known only from the Philippines. Material examined. 60 specimens: 15♂, 40♀, 5 L; 56 individual larval rearings.

PHILIPPINES. *Luzon:* Rizal, Tay-Tay; 9♂, 29♀, 5 L, 37 lp; *Samar:* Osmena; 1♂; *Mindanao:* San Ramon; 5♂, 11♀, 19 lp.

TAXONOMIC DISCUSSION. The above description of all stages of *philippinensis* is based on several reared specimens collected by the late F. E. Baisas in Luzon and by Rozeboom, Knight and Laffoon in Samar and Mindanao. This species was fairly abundant in the localities where it was found and is probably widespread among the Philippine islands.

Culex philippinensis is strongly differentiated from the rest of the *vishnui* complex in the male genitalia by the considerable reduction to almost complete absence of the basal sternal process of the proctiger. In the adults, the males are also quite distinct in the reduction of the length and number of bristles of palpal segments 4 and 5 but the females are virtually indistinguishable from *pseudovishnui*. The pupa and larva can be readily separated by the characters given in the keys and as described above. The larva of *philippinensis* is very similar to *alienus* in most features, including the siphon and its hair tufts, but can be separated from the latter by the presence of more numerous and finer comb scales and by having shorter and weaker siphonal tufts.

BIONOMICS. *Culex philippinensis* is a typical ground pool breeder. In Rizal, Luzon, larvae were reported to have been collected from rock pools and in Mindanao in wheel tracks, road ruts and puddles. No further field data were available as to the condition of the breeding sites. All adults were obtained from individual rearings.

28. *CULEX (CULEX) INCOGNITUS* BAISAS
(Figs. 16, 56, 57)

Culex (Culex) incognitus Baisas 1938: 203 (♂*, ♀*, P*, L*); Delfinado 1966: 145 (♂*, ♀, P, L*); Baisas 1974: 94 (♂*, ♀*, P, L*).

FEMALE (Fig. 16). Wing: 3.2 mm. Forefemur: 1.5 mm. Proboscis: 1.7 mm. Abdomen: 2.5 mm. In general very similar to other members of the *vishnui* complex, differing slightly in darker coloration (somewhat resembling *perplexus*) and in the following characters. *Head.* Erect scales of vertex whitish, yellowish brown, golden or bronzy in center, blackish posterolaterally. Proboscis with clearly marked median pale ring which occupies about 0.2 of total length. *Cibarial Armature.* Very distinctive; cibarial bar with a concave row of about 26 subequal teeth which are narrow, fine, all distally tapered to a sharp point apically. *Thorax.* Mesonotal integument dark brown to black; scales on mesonotum largely golden brown or dark in middle, forming a broad

dark streak or patch on acrostichal and dorsocentral lines and fossal areas, continued as dark streak cephalad and laterad of prescutellar space; scales on anterior promontory, humeral, scutal angles, lateral and posterior fossal and antealar areas and areas mesad of supraalar pale beige to golden; scales on prescutellar space and scutellar lobe yellowish to whitish. Pleural integument dark or same color as mesonotum; pleural scale patches very distinct. *Legs*. Anterior surface of fore- and midfemora entirely dark scaled, speckling of pale scales absent; anterior surface of hindfemur with a narrow pale longitudinal stripe extending from base to about 0.75 of total length; tibiae of all legs dark scaled except for light apical ring; all tarsomeres 1-4 with narrow, but very distinct apical and basal pale bands. *Wing*. All scales dark and very dense on all veins; plume scales on veins R_2, R_3, R_{4+5} and branches of M and Cu narrow; base of vein C without pale scale streak. *Abdomen*. Basal pale bands on terga II-VII present or absent; basolateral pale spots always present, extending to 0.5 or more of segment length; sterna with broad basal pale band and broad apical dark bands. *Genitalia*. Essentially similar to *vishnui* and *pseudovishnui*, differing in having all sclerites more strongly pigmented; vaginal sclerite V-shaped and insula with stronger tuft of 9-12 setae.

MALE. In general as described for female except for the following. *Head*. Palpus exceeding proboscis by about full length of segment 5; segment 2 entirely dark scaled; segment 3 with or without median pale band or scattered pale scales on dorsal surface, apical 0.25 with 10-15 strong bristles; segments 4 and 5 strongly plumose and with distinct basal pale bands on dorsal surface, apical 0.1-0.2 of segment 5 pale to tip. Proboscis with a small ventral tuft of 2-4 hairs at base of median pale ring, hairs 2, 3 times as long as labial width at point of insertion. *Abdomen*. Terga II-VII always with basal pale bands.

MALE GENITALIA (Fig. 56). Exceedingly similar to *vishnui* and other members of that complex, differing slightly in the following combination of characters. *Subapical lobe*. Leaf *g* of distal division relatively broader, apically rounded or acuminate; setae *d-f* relatively strong, all apparently rodlike. *Phallosome*. Outer division with moderately large, rounded lateral basal process.

PUPA (Fig. 56). Abdomen: 2.52 mm. Paddle: 0.7 mm. Trumpet: 0.8-0.9 mm; index 10-15. Generally distinguished from other members of the *vishnui* complex by very long trumpet. Yellowish white without definite pattern of dark and light areas. Chaetotaxy as figured, the following combination diagnostic. *Trumpet*. Slender, very long and uniformly cylindrical; pinna narrow and slightly oblique. *Cephalothorax*. Seta 1-C 4, 5 branched; 8-C usually 4, 5 branched (4-6). *Abdomen*. Seta 5-IV 5-8 branched; 5-V usually double (2, 3); 5-VI double; 6-III-VI subequally long, usually 6, 7 branched (5-8). *Paddle*. Broad and pale to almost transparent; midrib weak and pale.

LARVA (Fig. 57). Head: 0.78 mm. Siphon: 2.2-3.0 mm; index 10-14. Saddle: 0.4 mm; siphon/saddle 6-7. Distinguished from other members of the *vishnui* complex by the thin and very long siphon and in the following. *Head*. Integument varying from pale, cream-colored to dark brown; seta 4-C short, single, less than 0.5 of distance between bases of the pair; 5-C usually double (2, 3); 6-C double; 7-C dark, flattened, 8-10 branched. *Thorax*. Spiculation absent; most prothoracic setae and lateral pleural setae of meso- and metathorax very strong and dark; seta 4-P usually single (1, 2). *Abdomen*. Setae 1-III-VI usually 4, 5 branched (4-6); 6-III-VI double. Comb scales numerous, 27-32, strongly differentiated into 2 different types; scales in posterior row and on ventral surface large with stout apical spine, rest of scales in anterior

rows and in center of patch small, with rounded apical fringe of even fine spicules. Saddle usually same color as siphon, sometimes dark brown; seta 1-X usually triple (3, 4); 2-X triple; anal gills 1.5-2.0 times as long as saddle. *Siphon.* Very long, thin with high index and siphon/saddle ratio; pigmentation yellowish white except for basal dark ring; pecten teeth 10-14 in number, median teeth barbed with 6, 7 graded denticles; distal teeth with several fine denticles in basal 0.5, apical 0.5 simple or represented by strong heavy spine; siphonal tufts 7 or 8 pairs (total 14-16), all weak, short, subequal and widely spaced, inserted subventrally or laterally; each tuft usually double or triple (1-3), their length as long as or slightly longer than siphonal width at point of attachment; median caudal filament very well developed.

TYPE-DATA. Holotype ♂ (No. F 159-253) with associated pupal and larval skins, Tanque at Calauan, Laguna Province, *(Luzon)*, PHILIPPINES, 11 May 1935, F. E. Baisas (PBH; destroyed).

DISTRIBUTION. Widely distributed in the Philippines; also known from the Moluccas, Sulawesi, Indonesia. Material examined. 253 specimens: 99♂, 77♀, 77 L; 55 individual rearings (3 pupal, 52 larval).

PHILIPPINES. *Luzon:* La Union; Subic Naval Base; San Fernando; Clark Air Base; Olongapo; *Mindoro:* San Jose; *Samar:* Osmena; *Leyte:* Palo; Tacloban; Lago Lago; Bay Bay; *Mindanao:* Lanao; Parang; Pasanonco; San Ramon; *Jinamoc Is.; Dinagut Is.; Nueva Is.;* 99♂, 77♀, 69 L, 3 p, 52 lp.

INDONESIA. *Moluccas:* Halmahera, Morotai; *Sulawesi:* Pomalaa; 8 L.

TAXONOMIC DISCUSSION. Although the type and other specimens in the type series of *incognitus,* originally designated by Baisas (1938) were destroyed, the description and the figures of the larval siphon, the female cibarial armature and the male genitalia by this author agree well with all specimens examined by me. The descriptions of all stages by Delfinado (1966: 145-7) are also applicable to this species except for the presence of speckling on the anterior surface of the forefemur and the extensively pale midfemur of the adults which are erroneous.

Culex incognitus is strongly differentiated from the rest of the *vishnui* complex in the larva and pupa and can readily be recognized in these stages. The adults are apparently more similar to *perplexus* than to any other species, particularly in being generally dark or blackish in coloration and in the presence or absence of basal pale bands on the female abdominal terga. The pattern of coloration of the mesonotal scales is variable, but appears to be more striking than in *pseudovishnui* and *philippinensis*. For positive identification of the *incognitus* females, the cibarial armature, the associated larval and pupal stages of this species should also be examined.

The Philippine *incognitus* is evidently most closely related to *omani* Belkin (1962: 210) from Guadalcanal, Solomon Islands, in the South Pacific. In comparing the specimens with the type of the latter species, I found only slight differences in the detailed characters of all stages between the 2 forms. Both are almost identical in the larva except for seta 4-P which is usually single in *incognitus* (double in *omani*) and the length of setae 1-III-VI which are relatively shorter in *incognitus*. The adults of *incognitus* are darker than *omani* and the apical tergal crown of the inner division of the male phallosome of *incognitus* is composed of 4, 5 fingerlike processes (3 in *omani*). This evidence suggests that these forms are only subspecifically distinct and that they were probably represented by a single widespread species which was subsequently differentiated into distinct segregates through geographical isolation.

BIONOMICS. The Philippine *incognitus* is apparently common but not as abundant or frequently encountered as *vishnui, pseudovishnui* or *tritaenior-*

hynchus. The most frequent breeding sites of *incognitus* are rock pools containing decayed leaves, stream pools, forest swamps and pools at margins of creeks under heavy shade. Immatures have been collected also in grassy pools, open swamps, pools in rice fields and according to Delfinado (1966), in water tanks and slow streams containing green algae. Very little is known about adult biology. Delfinado (1966) noted that females are common inside houses and in carabao (water buffalo) bait traps, but no definite data are available on whether they bite and feed on man or other animals. Baisas (1974) noted that it is evidently zoophilic but because of low adult density, it seems to be of no medical importance.

29. *CULEX (CULEX) TRITAENIORHYNCHUS* GILES
(Figs. 16, 58, 59, 60)

Culex tritaeniorhynchus Giles 1901a: 606 (adult); Theobald 1901a: 364 (♂*, ♀*); Giles 1902: 401 (♂, ♀); Edwards 1913b: 233 (taxonomy); Edwards 1917: 224 (♂, ♀); Edwards 1921: 339 (L), Macfie and Ingram 1922: 180 (♀*); Barraud 1923a: 940 (L*); Barraud 1924a: 995 (♂*, ♀); Borel 1930: 336 (♂*, ♀, L*); Ho 1931: 158 (♂*, ♀).

Culex biroi Theobald 1905a: 82 (♂*, ♀); Edwards 1913b: 233 (synonymy).

Culex summorosus Dyar 1920: 180 (♂); Bram 1967a: 225 (synonymy).

Culex tritaeniorhynchus var. *siamensis* Barraud and Christophers 1931: 283 (♂); Colless 1957a: 98 (synonymy with *C. tritaeniorhynchus summorosus* Dyar).

Culex (Culex) tritaeniorhynchus Giles, Edwards 1932: 204 (taxonomy, in part): Barraud 1934: 404 (♂*, ♀, L*); Li and Wu 1935: 101 (L*); Stackelberg 1937: 235 (♂*); Edwards 1941: 299 (♂, ♀); Bohart 1945: 80 (♂*, L); Bohart and Ingram 1946: 81 (♂*, ♀, L*); LaCasse and Yamaguti 1950: 230 (♂*, ♀*, P*, L*); Monchadskii 1951: 277 (L*); Iyengar and Menon 1955: 6 (L*); Khattat 1955: 165 (L*); Bohart 1956: 83 (♂*, ♀, L*); Ovazza, Hamon and Neri 1956: 165 (♂*); Hara 1957: 56 (♀ genitalia*); Bram 1967a: 225 (♂*, ♀*, P*, L*).

Culex (Culex) summorosus Dyar, Baisas 1938: 196 (♂*, ♀*, P*, L*).

Culex (Culex) tritaeniorhynchus summorosus Dyar, Colless 1957a: 98 (♂*, ♀, L*); Delfinado 1966: 153 (♂*, ♀, P, L*); Baisas 1974: 104 (♂, ♀, P, L*).

Culex (Culex) tritaeniorhynchus var. *siamensis* Barraud and Christophers, Brug 1934: 515 (♂); Brug 1939: 112 (L*); Bonne-Wepster and Brug 1937: 72 (♂, ♀*); Bonne-Wepster and Brug 1939: 1270 (L*); Bonne-Wepster 1954: 125 (♂, ♀*, L*); Mattingly 1956: 37 (lectotype designation).

FEMALE (Fig. 16, 58). Wing: 2.5-3.6 mm (average 3.2 mm). Forefemur: 1.1-1.5 mm (average 1.4 mm). Proboscis: 1.4-1.8 mm (average 1.6 mm). Abdomen: 1.8-2.5 mm (average 2.2 mm). Relatively small, slender, reddish brown species; differing from the members of the *vishnui* complex in the entirely dark brown erect scales of vertex; mesonotal and pleural integument reddish brown; mesonotal scales narrower, finer and predominantly dark or golden brown and in the following. *Head*. Narrow decumbent scales of vertex finer and predominantly golden except for a few pale ones drooping over frons; erect scales relatively shorter, narrower and entirely dark brown; lateral patch of broad scales dull yellowish. Palpus entirely dark or sometimes with pale scales on apex of segment 4. Proboscis with a very narrow median pale ring which occupies 0.10-0.15 of total length and with or without pale

scales scattering or forming streak proximad of median ring on lateral and ventral surfaces. *Cibarial Armature.* Very distinctive; cibarial bar with a concave row of about 30 long, narrow and fine teeth, all of which are subequal in length and distally filamentous. *Thorax.* Mesonotal integument reddish brown or sometimes deep chestnut brown; mesonotal scales very narrow, fine, entirely or predominantly dark brown or golden brown on anterior 0.7 of disc except for a few paler ones on extreme anterior promontory and lateral marginal areas; scales cephalad and laterad of prescutellar space dark brown; scales in middle of prescutellar space and scutellar lobes pale yellowish or whitish. *Apn* and *ppn* with narrow dark brown scales as on anterior 0.7 of mesonotum. Pleuron same color as mesonotum; pale scale patches on *ppl,* upper corner and lower posterior border of *stp* and anterior upper *mep* small or poorly developed; a few pale scales among upper *mep* bristles present or absent. *Legs.* Anterior surface of fore- and midfemora dark brown to black; anterior surface of hindfemur with longitudinal pale stripe poorly contrasted with dark scaled areas on lateral dorsal surface; all tibiae dark scaled on anterior surface; tarsomeres 1-4 of all legs with narrow, poorly defined apical and basal pale bands. *Wing.* Scales on all veins dark except for a short pale scale line at extreme base of vein C; plume scales on veins R_2, R_3, R_{4+5} narrow and very dense; cell R_2 4, 5 times as long as R_{2+3}. *Abdomen.* Terga II-VII with narrow basal pale bands and elongate basolateral pale spots; sterna usually entirely pale yellowish, sometimes with small dark apicolateral patches or spots. *Genitalia.* Essentially similar to members of *vishnui* complex from which it can not be distinguished with certainty. Tergum IX with a lateral row of 5, 6 setae; postgenital plate truncate or lightly emarginate on caudal margin; vaginal sclerite well sclerotized, V- or U-shaped; insula with a tuft of 10 setae.

MALE (Fig. 58). In general as described for female except for broader basal bands on abdominal terga; differing from all members of the *vishnui* complex in having short setae on ventral surface of palpal segment 3 finer, hairlike, dark and in the following characters. *Head.* Palpus very thin, exceeding proboscis by 1.0-1.5 of length of segment 5; segment 2 with or without apical pale band on dorsal surface; segment 3 with or without dorsal median pale ring, apical 0.4-0.5 with ventrolateral tuft of 20-30 strong bristles; segments 4 and 5 strongly plumose and with narrow basal pale bands on dorsal surface; apex of segment 5 entirely dark or sometimes tipped with pale scales. Proboscis with a prominent ventral tuft of 10 or more very long hairs at base of median pale ring.

MALE GENITALIA (Fig. 59). Exceedingly similar to the members of the *vishnui* complex, differing particularly in the following features. *Subapical lobe.* Most distal seta in group *d-f* of distal division usually more strongly flattened and apically blunt, club-shaped leaf *g* moderately to very broad. *Phallosome.* Apical spiculate portion of inner division of lateral plate distally expanded, forming a triangular lobe which tapers into a sharp point laterad; 4-6 fingerlike processes of inner division variable in size and length; usually shorter and smaller than in all forms of *vishnui* complex, their apices barely reaching beyond apical margin of sternal spiculate portion; lateral basal process of outer division small; sternal spine more slender and gently curved basad. *Proctiger.* As in *vishnui* and *pseudovishnui;* basal sternal process of paraproct long, heavy, curved sternad; subbasal process distinct, about 0.3 of basal sternal process; cercal setae 2 or 3.

PUPA (Fig. 59). Abdomen: 2.9 mm. Paddle: 0.65 mm. Trumpet: 0.5-0.6 mm; index 6-7. Cephalothorax and abdomen cream-colored or yellowish

without definite pattern of dark and pale areas. Chaetotaxy as figured; the following characteristic. *Trumpet.* Relatively short, dark brown, strongly contrasting with underlying integument; meatus uniform in width, apical margin truncate or lightly emarginate; pinna slightly oblique. *Cephalothorax.* Seta 8-C usually 5, 6 branched (4-7); 9-C as long as 8-C, usually double (2, 3). *Metanotum.* Seta 12-C as long as 11-C. *Abdomen.* Seta 1-II multiple, more than 10 branched; 5-IV 4-6 branched, as long as segment following; 5-V usually double (2, 3), 5-VI double, both setae as long as 5-IV; 6-III, IV usually 4 branched (4, 5); 6-V, VI longer than 6-III, IV, usually 5 branched (4-7); 4, 5-VII double; 4-VIII double or triple. *Paddle.* Inner and outer part pale; basal external margin of outer part distinct; midrib moderately pigmented.

LARVA (Fig. 60). Head: 0.7 mm. Siphon: 1.4-2.0 mm; index 7-10 Saddle: 0.36 mm; siphon/saddle 4.0-5.5. Similar to members of the *vishnui* complex in general and in several details of chaetotaxy, differing particularly in the following combination of characters. *Head.* Seta 1-C relatively short; 4-C single, about as long as distance between bases of the pair; 5-C usually triple (3, 4); 7-C pale, 6-8 branched and weakly barbed. *Thorax.* Spiculation absent; seta 4-P strong and double. *Abdomen.* Seta 7-I double; 1-III, IV weak, usually triple (3, 4); 1-V, VI longer than 1-III, IV, usually 4 branched (4, 5); 6-III usually double (2, 3); 6-IV usually triple (2, 3); 6-V, VI double. Comb scales small, numerous, about 40, in a broad oval patch; all scales apically rounded, with even fringe of fine spicules. Saddle same color as siphon; seta 1-X usually triple (2-4); 2-X double or triple; anal gills as long as or slightly longer than saddle. *Siphon.* Slender, straight, slightly tapered distally; variable in length, usually 1.4-1.5 mm, rarely exceeding 1.8 mm; yellowish to brownish; pecten teeth 10-14; 4, 5 distal teeth with lateral barb of 5, 6 graded denticles, apical denticle weak, tapered to a sharp point; siphonal tufts weak, widely spaced, 5 or 6 pairs (total 10-12); pairing irregular; 4, 5 pairs inserted subventrally in proximal 0.30-0.75 of total length; 1, 2 pairs inserted laterally beyond middle; subventral pairs usually 4 branched (3-5), subequal in length, as long as or slightly longer than siphonal width at point of attachment; lateral and most distal pairs double or triple and slightly shorter than subventral pairs; median caudal filament very well developed.

TYPE-DATA. (1) *Culex tritaeniorhynchus* Giles, Holotype ♀*, Travancore, (*Madras* State). INDIA, 29 June 1900, S. P. James (BM); (2) *Culex biroi* Theobald, Syntypes ♂ and ♀, *Bombay*, INDIA (HNM); (3) *Culex summorosus* Dyar, Holotype ♂* with slide of genitalia, Los Banos, *Luzon*, PHILIPPINES (USNM); (4) *Culex tritaeniorhynchus* var. *siamensis* Barraud and Christophers, Lectotype ♂* (Y454) with slide of genitalia, *Chiang Mai*, SIAM (THAILAND), J. A. Sinton (BM; selection of Mattingly 1956: 37).

DISTRIBUTION. Widely distributed throughout the Oriental region extending west into the Middle East, the Mediterranean and the Ethiopian region; north into China, Manchuria, Maritime provinces of USSR, Japan and Korea; east into Micronesia (Bonin Island); southeast and south as far as Sulawesi, Kabaena, Lombok, Alor, Amboina and Java, Indonesia. Material examined. 3,904 specimens: 1,003♂, 1,975♀, 926 L; 594 individual rearings (267 pupal, 327 larval).

PAKISTAN. *Lahore:* Ravi Bank; 33♂, 50♀, 1 p, 12 lp.

INDIA. *Bombay:* Kawar; *Madras:* N. Arcot (Poona); *Bengal:* Calcutta; Old Jalpaiguri; Lalmanirhat; *Bihar:* Purnea; *Assam:* Dibrugarh; Chabua; Dooma Dooma; Jorhat; Rupsi; Tezpur; 62♂, 114♀, 42 L, 25 p, 12 lp.

BANGLADESH. Decca; Khulna; 13♂, 13♀.

SRI LANKA. *Central Province:* Kandy District; Peradeniya; *North Central Province:* Anuradhapura District; Padaviya; Irrigation bungalow; *Sabaragamuwa*

Province: Ratnapura District; Uggalkaltata; Panamure; *Southern Province:* Hambantota District, Palatupana; *Uva Province:* Monaragala; 5 mi. SE. Padiyatalawa; SE. Mahiyangane; 7♂, 41♀, 2 L, 4 lp.

BURMA. *Rangoon;* 6♂, 18♀, 7 p, 2 lp.

THAILAND. *Chiang Mai:* Muang; Doi Sutep; Hang Dong; Chang Puak; *Lampang:* Ban Rong Na; Mae Ngao River; *Lamphun:* Lee District; *Nakhon Ratchasima:* Pak Chong; *Phet Buri; Sara Buri:* Prabudha Bath; *Thon Buri; Bangkok; Nonthaburi; Samut Prakan; Chon Buri:* Siracha; Bang La Mung; Bang Phra; *Rayong:* Ben Takat Ngao; *Chanthaburi:* Ban Bang Kachai; Ban Laem Sing; *Ayutthaya; Pathum Thani; Prachuap Khiri Khan; Phrae:* Ban Ta Loe; *Khon Kaen:* Phuwiang; *Surat Thani:* Koh Samui; Bang Makham; *Trat:* Koh Chang; Koh Khlum; *Krabi;* Ban Sai Thai; *Phuket:* Bang Khian; Ban Huai Luk; Ban Borae; Ban Pa Thong; *Nakhon Si Thammarat:* Chang Khao; Ban Rim Thanon; *Narathiwat:* Waeng; 219♂, 728♀, 485 L, 165 p, 43 lp.

CAMBODIA. Phnom Penh; Ari-Satr; 13♂, 65♀.

VIETNAM. Phu Bei; Cu Chi; Phu Tho; Binh Duong; Go Vap; Soc Trang; Con Son, Cam Ranh Bay; Saigon; Can Tho; Bien Hoa; Phu Loi; Gia Dinh; 26♂, 78♀, 34 L, 4 p, 13 lp.

MALAYSIA. *Peninsular Malaysia: Selangor*-Kuala Lumpur; Kepong, Salak; Puchong, Rantau Panjang; Bt. Kutu; *Pahang:* Pdg. Tungku, K. Lipis; Kuantau; Chenderiang; Pekan Rd.; *Perak:* Tanjong Tualong F. R., Pusing; Senlu; Tg. Rambutan; Kuala Kangsar; *Perlis:* Kg. Sg. Bahru; Kg. Gunong; Kg. Sg. Padang; Simpang Ampat; Kg. To´ Kayaman; Kg. Baru; *Kedah:* Changlun; Sintok; *Trengganu:* Kemaman, Dungun; *Kelantan:* Tumpat; 185♂, 199♀, 119 L, 39 p, 118 lp. *Malaysia: Sabah*-Papar; Kuala Penyu; Beaufort; Kota Kinabalu (Jesselton); Kudat; Tarakan; Ranau (British Borneo); 38♂, 45♀, 3 p, 12 lp.

SINGAPORE. 11♂, 21♀, 14 L, 3 p, 22 lp.

INDONESIA. *Kalimantan* (Borneo); *Sumatra:* Bengkulu; *Java:* Djakarta; Pelabaean; *Sulawesi:* Makasar; 36♂, 49♀.

PHILIPPINES. *Luzon:* Agoo La Union; Camp Stotsenberg; Camp Gregg; Camp Wilhelm; Rizal; Camp Nichol; Subic Naval Base; Clark Air Base; *Mindoro:* San Jose; Caminawit; *Samar:* Osmena; Calotans, San Antonio; *Leyte:* Tacloban; Gulf; Abuyag; Palo; Carigara; Santa Rosa; Dulag; Samar Giurang; *Palawan:* Princesa, Iwahig; Panitan, Quezon; *Mindanao:* Parang; Kabakan; Zamboanga; Pasanonga; Pettit Barrack; Torray Barrack; *Tawi Tawi:* Kamagon, Tarawakan; Batu Batu; *Basbas Is.: Calaccad Is.;* 288♂, 474♀, 142 L, 146 lp.

HONG KONG. Ho Chung, N. T.; S. Sai Kung; Tai-wan; 23♂, 12♀, 10 L, 20 p, 9 lp.

TAIWAN. *Taipei:* Shihlin, Hsin Chu; *Ping Tung:* Chow-Chow; Taichung; 6♂, 12♀, 4 L, 12 lp.

JAPAN. *Honshu:* Chiba Pref; Shinhama; Kyoto; 3♂, 4♀, 20 L; *Ryukyus: Okinawa*-Chizuka; Chiwa; Naha; Taucha Onna; *Oyama;* 33♂, 32♀, 54 L, 40 lp.

KOREA. Seoul; 1♂, 20♀.

Additional records from the literature. ETHIOPIAN REGION: Gold Coast; Nigeria; Zanzibar; Mauritius (Edwards 1941: 299); MEDITERRANEAN and MIDDLE EAST: Palestine; Syria; Iraq; Iran; Egypt; Arabia (Barraud 1934; 406; Monchadskii 1951: 277; Mattingly and Knight 1956: 121; Lofti 1970: 402); INDIA: Maldive Islands (Carter and Wijesundara 1948: 150); CHINA: Anhwei; Chekiang; Fukien; Hopei; Hupeh; Kiangsi, Kiangsu; Kirin; Lianoning; Kwangtung; Shantung; Hainan; Amoy (Feng 1938: Hsieh and Liao 1956; Chu 1958); INDONESIA: Nias; Siberoet; Krakatau; Celebes (Sulawesi); Kabaena, Lombok; Alor; Amboina (Brug and Bonne-Wepster 1947: 187); MICRONESIA: Bonin Islands (Bohart 1956: 84); USSR: Transcaucasia; Turkmenia; Far East; Man-

churia (Mondchadskii 1951: 277).

TAXONOMIC DISCUSSION. I am treating *tritaeniorhynchus* as a single variable species as done by Bram (1967a). The form *summorosus* which has been treated as a subspecies of *tritaeniorhynchus* for the Southeast Asian populations by Colless (1957a: 98) and has been attributed to the Philippine populations in a specific (Baisas 1938) or subspecific sense (Delfinado 1966, Baisas 1974), is not recognized in this study. Although the *summorosus* form differs slightly from the typical Indian *tritaeniorhynchus* in having longer fingerlike processes of the male phallosome as pointed out by Colless (1957a), I have found no significant correlated differences in any other stage to justify recognizing the 2 forms as separate subspecies. The results of experimental crosses between typical *tritaeniorhynchus* in Pakistan and the *summorosus* form in Japan as discussed by Barnett (1967) also show no reproductive incompatibility between the 2 forms. Based on this evidence and the pattern of distribution, it appears most likely that the 2 forms are variations of a single widespread species.

Culex tritaeniorhynchus can be readily separated from other members of the *Vishnui* Subgroup as well as the *Sitiens* Group. In Southeast Asia, adults have been confused with *vishnui* (previously referred to *annulus*) apparently because they were only superficially examined and most of the previous descriptions lacked emphasizing correlated significant features for separating the 2 species. As discussed by Colless (1957a) and as indicated here, the *tritaeniorhynchus* females can be generally distinguished from those of *vishnui* by: (1) proboscis with narrower median pale ring; (2) lateral and ventral surfaces of the proboscis usually with some pale scales scattering or forming a streak in basal 0.5 proximad of the median pale ring; (3) erect scales of vertex of the head more slender, shorter and entirely dark brown; (4) anterior 0.7 of the mesonotum predominantly covered with narrower, finer and dark brown or golden brown scales; (5) abdominal terga with narrower basal pale bands and (6) usually smaller size. The female cibarial armature, the male palpus and proboscis and the shape of the sternal apical portion of inner division of the male phallosome of *tritaeniorhynchus* are also very diagnostic, providing a clear cut separation from all members of the *vishnui* complex. The pupa resembles *pseudovishnui* in most features of the chaetotaxy, but differs from it in having a shorter brownish trumpet and seta 1-II multiple, with more than 10 branches. The larva is very distinctive, particularly in having seta 7-I double; numerous small comb scales which are apically rounded with fringe of evenly fine spicules and short and widely spaced siphonal tufts, not forming prominent rows.

Culex tritaeniorhynchus has been previously considered by all authors as a member of the *vishnui* complex, subgroup or group in a general or broad sense. Present evidence shows that it is somewhat intermediate between the *vishnui* complex and *Barraudi* Subgroup. It exhibits similarity to the members of the *vishnui* complex in the male genitalia, general adult characters and the pupal stage but is similar to the members of the *Barraudi* Subgroup in the larval characters and in the male palpus. On this basis, I am placing *tritaeniorhynchus* in a distinct complex of the *Vishnui* Subgroup.

BIONOMICS. *Culex tritaeniorhynchus* is a common rural species and is most frequently encountered in the open such as rice fields, native plantations and shallow marshes. The most common breeding sites include general ground pools, ponds, wells, ditches and puddles containing fresh or polluted water with numerous grasses, rice or other aquatic vegetation. These habitats are partially shaded or fully exposed to sunlight. On occasion the immatures have

have also been collected in pools near stream margins or along margins of slow moving streams. In most localities, all stages of *tritaeniorhynchus* are very abundant, exceeding those of *vishnui* and *pseudovishnui* in number and density throughout the year. The relative abundance and population fluctuation of *tritaeniorhynchus* follows essentially a similar pattern of rainfall as in *vishnui* and *pseudovishnui* (Reuben 1971a, 1971d, 1971e). As in the case of *pseudovishnui,* Reuben (1971d) reported that the *tritaeniorhynchus* larva becomes dominant when the rice reaches about 0.3 m in height, replacing that of *vishnui.* The overall occurrence of *tritaeniorhynchus* is fairly uniform throughout the year but, in Madras adults were reported to be most abundant in August (Reuben 1971e). Adults were usually collected in large number at night outdoors in cowsheds, in biting collections on cows, pigs and occasionally man and in light traps or animal bait traps. In Madras, India, Reuben (1971e) reported that adults were rarely taken resting in cowsheds, relatively infrequently in outdoor shelters and showed a preference for sugar cane fields as a daytime resting place. In the studies by Colless (1959) in Singapore, Reuben (1971c) and Christopher and Reuben (1971) in Madras, India, females of *tritaeniorhynchus* obtained blood meals largely from pigs and cows. In Sarawak, Hill et al. (1969) reported it to feed mainly on pigs and fowl. The genetics of *tritaeniorhynchus* are reviewed in Baker and Sakai (1974). For additional details on bionomics, consult Bram (1967a) and other references catalogued by Travis and Labadan (1967).

MEDICAL IMPORTANCE. *Culex tritaeniorhynchus* has generally been implicated as a potential or natural vector of Japanese encephalitis virus from various parts of the Oriental region since it was experimentally shown to be capable of transmitting this disease in Japan by Hammon et al. (1949). In the vicinity of Tokyo it has been reported to be the primary and perhaps only vector of this disease (Buescher et al. 1959). In Southeast Asia, it is undoubtedly one of the most important vectors of this disease due to its great abundance and feeding behavior on infected host animals. However, the epidemiology of the disease is complicated by possible secondary vectors such as *Culex (Culex) vishnui* (Cates and Detels 1969, as *annulus*) and other species which have been found naturally infected with and capable of transmitting JE virus in the laboratory, i.e., *fuscocephala* (Muangman et al. 1972) and *gelidus* (Gould et al. 1962). In the studies on virus isolation, *tritaeniorhynchus* was found to be naturally infected with 6 strains of JE virus in India (Carey et al. 1968), 13 strains of JE virus in Thailand (Simasathien et al. 1972), one strain of JE virus and 2 strains of Tembusu virus in Sarawak, Borneo (Macdonald et al. 1965), 5 strains of JE virus in Vietnam (Nguyen et al. 1974) and 8 strains of JE virus in Chiang Mai, Thailand (Gould et al. 1974). In Japan, it was found to be infected with Aino virus (Takahashi et al. 1968). In addition, *tritaeniorhynchus* were also reported to be naturally or experimentally infected with *Brugia malayi* (Carter 1948, Hu 1940), *Wuchereria bancrofti* (Bohart 1946, Hsiao and Bohart 1946, Bohart and Ingram 1946, Yamada and Komori 1927, Hsiao 1948) and with dengue virus (Rudnick and Hamon 1961). The roles of *tritaeniorhynchus* as vectors of filariasis and dengue virus have not yet been evaluated, but there is no epidemiological evidence implicating the species in dengue transmission.

30. *CULEX (CULEX) WHITEI* BARRAUD
(Figs. 61, 62)

Culex whitei Barraud 1923b: 508 (♂, ♀); Barraud 1924a: 998 (♂*).
Culex (Culex) whitei Barraud, Edwards 1932: 205 (taxonomy); Barraud 1934: 402 (♂*, ♀, L); Peters and Dewar 1956: 46 (L*); Bram 1967a: 233 (♂*, ♀, L*).

FEMALE. Wing: 3.2-4.0 mm (average 3.5 mm). Forefemur: 1.4-1.8 mm (average 1.6 mm). Proboscis: 1.6-2.0 mm (average 1.8 mm). Abdomen: 2.5 mm. Medium sized species; in general very similar to members of the *vishnui* complex, differing slightly in the following combination of characters. *Head.* Erect scales of vertex yellowish to golden brown in center, dark on posterolateral area; lateral patch of broad appressed scales very distinct. Palpus 0.25 of proboscis length; apex of segment 4 tipped with several whitish scales, rest dark or black. Proboscis distinctly longer than forefemur, median pale ring clearly marked, occupying about 0.2 of total labial length, rest uniformly dark or blackish, no scattered pale scales distad or proximad of median pale ring. *Cibarial Armature.* As described and figured for *vishnui* from which it is virtually indistinguishable. *Thorax.* Anterior 0.70 of mesonotum largely covered with pale yellowish to golden scales, with indefinite mottling of dark brownish scales in middle, usually dark scaled cephalad and laterad of prescutellar space; marginal areas with lighter scales; posterior 0.3 of mesonotum largely pale yellowish or golden scaled, not contrasting with those on anterior 0.7; scales in middle of prescutellar space and scutellar lobes entirely pale. Pleural scale patches relatively broad and very distinct. *Legs.* Anterior surface of fore- and midfemora usually lightly sprinkled with some pale scales, more or less resembling *sitiens*, sometimes completely dark; anterior surface of hindfemur with a broad whitish longitudinal stripe extending from base to near apex; foretibia entirely dark on anterior surface; mid- and hindtibiae entirely dark or with indistinct longitudinal pale stripe in middle. *Wing.* All scales dark; base of vein C without pale scale streak on posterior surface; plume scales on veins R_2, R_3, R_{4+5} narrow, linear and dense; cell R_2 2.0 of the length of vein R_{2+3}. *Abdomen.* Terga II-VIII usually with narrow basal pale bands, these sometimes completely absent or represented by small median basal pale patches or streaks; sterna largely pale with apicolateral dark scale patches. *Genitalia.* As described and figured for *vishnui*, differing slightly in the following. Tergum IX with a lateral row of 7, 8 stronger and longer setae; vaginal sclerite always V-shaped and darkly pigmented; insula with a stronger tuft of 10-14 setae; posterior cowl more strongly sclerotized.

MALE. In general as described for female except for abdominal basal bands which are always present and broader. *Head.* Palpus exceeding proboscis by 1.5 of length of segment 5; segment 3 with median pale band on dorsal surface; ventral surface with a row of scalelike setae along whole length; apical 0.25 with ventrolateral tuft of 17-18 bristles; segments 4 and 5 strongly plumose and with distinct basal pale band on dorsal surface; apex of segment 5 tipped with pale scales or sometimes entirely dark. Proboscis with a weak ventral tuft of 6-8 long hairs at base of median pale ring.

MALE GENITALIA (Fig. 61). Essentially similar to most members of the *vishnui* complex in basimere, distimere and proctiger; differing particularly in the following characters. *Subapical lobe.* Most distal seta in group *d-f* of distal division broad, club-shaped; leaf *g* very broad, apex rounded or acu-

minate; seta *h* relatively stronger and longer. *Phallosome.* Apical tergal crown of inner division with 3,4 rather short fingerlike processes; outer division with 2,3 strong mesal spines, 4,5 strong lateral spines and several weak lateral denticles, the latter densely packed; sternal spine slender, long, divergent laterad; lateral basal process slender and distally produced into a rounded knob. *Proctiger.* Apical crown relatively large and with numerous coarse spicules; basal sternal process of paraproct present, long, strong, curved sternad; cercal setae 2.

PUPA (Fig. 61). Abdomen: 2.7-3.0 mm (average 2.9 mm). Paddle: 0.8 mm. Trumpet: 0.62-0.65 mm (average 0.63 mm); index 5.8. Cephalothorax and metanotum cream-colored or pale yellowish. Complete chaetotaxy as figured; the following diagnostic. *Trumpet.* Meatus dark in basal half, yellowish in apical half; pinna oblique and lightly to strongly flared; apical margin truncate or lightly emarginate. *Cephalothorax.* Setae 1-3-C short and usually double (1-3); 6-C about 0.5 of the length of 7-C; 8-C usually double (2-4). *Metanotum.* Seta 10-C usually double or triple (2-5). *Abdomen.* Seta 1-III 3-9 branched; 1-IV 2-7 branched; 1-V 1-4 branched; 1-VI 2-6 branched; 1-VII 2-5 branched; 5-IV-VI slightly shorter than or as long as segment following; 5-IV usually 4 branched (3-5); 5-V, VI double; 6-III-VI 1-4 branched; 4, 5-VII usually double (1,2); 9-VII weak, short, 2-5 branched; 4-VIII single or double; 9-VIII weak and short, subequal to 9-VII, 5-9 branched. *Paddle.* Inner and outer parts very pale; midrib lightly pigmented.

LARVA (Fig. 62). Head: 0.78-0.90 mm (average 0.8 mm). Siphon: 1.6-2.4 mm (average 2.0 mm); index 8-9. Saddle: 0.38 mm; siphon/saddle ratio 5-6. Generally similar to other members of the *Vishnui* Subgroup; differing particularly in the following features. *Head.* Creamy white; seta 4-C single and long, about 1.5 of the distance between bases of the pair; 5-C 3-6 branched; 6-C 3,4 branched; 14-C minute, filiform and usually single (1,2). *Thorax.* Spiculation absent; seta 4-P usually double (2,3), strong; 7-P triple; 8-P double. *Abdomen.* Setae 6-I, II 3,4 branched, sometimes 5 branched; 7-I usually double, sometimes triple; 1-III 1-3 branched, variable in length, usually shorter than 6-III; 1-IV, V single, strong, of the same magnitude as setae 6 and placed on distinct tubercles; 1-VI usually 3,4 branched (2-4), of the same magnitude as 1-III; 6-III-VI all double. Comb scales numerous, about 40, all small and subequal in size, in a broad oval patch; individual scales pointed or terminating in a weak apical spine and with lateral fringe of finer spicules. Saddle same color as siphon; seta 1-X strong, single or weak, double or triple; 2-X double; anal gills 1-4 times as long as saddle. *Siphon.* Relatively thick and long; pigmentation bright yellow to brown; pecten teeth 8-13; 3,4 distal teeth with lateral barb of 6-8 delicate denticles and a fine apical denticle; siphonal tufts, weak, short and widely spaced; usually 5 pairs (total 10), sometimes 4.5 or 6 pairs; 4 proximal pairs subventral, double or triple, most proximal as long as siphonal width at point of attachment, rest gradually shorter; 1 distal pair double or triple, short, inserted laterally beyond midpoint of siphon; median caudal filament well developed; ventral valve of spiracular apparatus relatively broad and black.

TYPE-DATA. Lectotype ♀*, Haflong, Cachar Hills, *Assam,* INDIA, August 1922, larvae from pools, P. J. Barraud (BM; selection of Bram 1967a: 235).

DISTRIBUTION. Presently known only from India, Bangladesh, Thailand, Vietnam, Peninsular Malaysia (Malaysia), the Philippines and Indonesia.

Material examined. 280 specimens: 67♂, 75♀, 138 L; 104 individual rearings (51 pupal, 53 larval).

INDIA. *Assam:* Haflong, Cachar Hills (type-locality); 9♂, 4♀.

BANGLADESH. Sylhet; 9♂, 7♀, 15 p.

THAILAND. *Chiang Mai:* Payao; Chiang Dao; Fang; *Lampang:* Ngao; Ban Pha Khoi; Ban Pha Daeng; Ban Rong; *Mae Hong Son:* Doi Chang; *Nan:* Pha Daeng Khawi; *Nakhon Ratchasima:* Pak Chong; *Phet Buri:* Tha Yang; *Chon Buri:* Ban Huai Luk; *Ranong:* Muang, Huey Pluching; *Nakhon Si Thammarat:* Chaung Khao; 34♂, 51♀, 115 L, 36 p, 36 lp.

VIETNAM. Saigon; Ankhe; Antuc; Quang Tri; 2♂, 14 L.

MALAYSIA. *Peninsular Malaysia: Kedah*-Sintok F. R.; *Johore:* Kota Tinggi; N. S.: Kg. Inas; 6♂, 7♀, 7 L, 3 lp.

INDONESIA. *Ceram:* Piroe, 1♂; *Lombok;* 2 L.

PHILIPPINES. *Luzon:* Subic Naval Base; San Fabian; Pangasinan; Laguna; *Leyte:* Mt. Lobi; 6♂, 6♀, 14 lp.

Additional records from the literature. NEPAL (Peters and Dewar 1956).

TAXONOMIC DISCUSSION. *Culex whitei* is apparently an uncommon species but exhibits a broad range of distribution from Nepal to the east as far as the Philippines and Ceram, Indonesia. The occurrence of this species in Peninsular Malaysia, the Philippines and Ceram, Indonesia constitute additional new records. Its presence in the Philippines, noted by Baisas (1938: 196) under the discussion of his *summorosus* subgroup, was stated to be uncertain until I examined specimens from this area and confirmed their identity.

Culex whitei is very distinctive in the male phallosome and larval stages. The adults of *whitei* are very variable, particularly in the presence of absence of light speckling on the anterior surface of the fore- and midfemur, overlapping with specimens of *sitiens* and members of the *vishnui* complex. The speckled form of *whitei* can be distinguished from *sitiens* and the members of the *vishnui* complex as indicated in the key whereas those which exhibit no speckling on the femora are indistinguishable from members of the *vishnui* complex except through association of the male genitalia and the larval stage. The pupa of *whitei* is also distinct, particularly in the shape of the trumpet but is very variable in the branching of the setae noted above. The pupae from Thailand and Peninsular Malaysia exhibit fewer branches of seta 8-C, setae 6-III-VI and 1-III-VII than those from the Philippines, but show no difference from the latter in all other stages. With additional material from each of these areas, it will be possible to determine whether more than one form is involved.

Because of the distinctive male phallosome and larva, *whitei* is assigned to its own complex. The affinity of *whitei* is intermediate between the *vishnui* complex and *Barraudi* Subgroup; the adults are similar to the former but the pupa and larvae resemble the latter.

BIONOMICS. The typical breeding sites of *whitei* are fresh water ground pools in dried up stream beds or near the margins of streams and creeks in the hills or mountain areas at an elevation ranging from 400 to 500 meters. These habitats usually contain numerous decayed leaves and branches of trees and are under partial or heavy shade of tropical forest. The immatures were also collected from marshy ground in the open at 30 m in Peninsular Malaysia and from a rice field in the Philippines. They were usually found in association with specimens of *C. (Lophoceraomyia) mammilifer* (Leicester); *C. (Culiciomyia) pallidothorax* Theobald and *nigropunctatus* Edwards, *Uranotaenia macfarlanei* Edwards and *Aedes (Finlaya) luzonensis* Rozeboom in the collections from shaded stream pools and with *C. (Lutzia) halifaxii* Theobald, *C. (Culex) gelidus* and *tritaeniorhynchus; C. (Eumelanomyia) malayi; C. (Culiciomyia) fragilis* Ludlow and *nigropunctatus; C. (Lophoceraomyia) variatus* Leicester and *Anopheles barbirostris* in the collection from open swampy ground. The adults have

been seldom collected in the field. Nothing is known about the feeding habits of the females and their disease relationships.

BARRAUDI SUBGROUP

The *Barraudi* Subgroup exhibits considerable overlap with the *Vishnui* Subgroup in all stages and might be considered as a complex of the latter subgroup. However, because of the distinctive adults, it is recognized as a separate subgroup. The *Barraudi* Subgroup is characterized in the adults of both sexes by the presence of a small, semi-erect silvery white scale patch on the anterior lower surface of postspiracular area (absent in all other members of the *Sitiens* Group and *Vishnui* Subgroup) and by the presence of a distinct longitudinal pale stripe, particularly on the anterior surface of femora and tibiae of mid- and hindlegs; in the male genitalia by outer division of the phallosome with a strong, prominent, laterally divergent sternal spine (heavily curved and pointing basad in all members of the *Vishnui* Subgroup) and in the larva by seta 7-I double; comb scales small, numerous with more or less normal apical fringe of evenly fine spicules and by the presence of 4. 5-6 pairs (total 9-12) of siphonal tufts.

DISCUSSION. The *Barraudi* Subgroup is represented by 2 rare and closely related species, *barraudi* Edwards and *edwardsi* Barraud, both of which were originally described from India. Their detailed affinities are not clear. The larva and pupa resemble those of *whitei* more than any other form; the male phallosome resembles that of members of the *mimeticus* complex in the development of the sternal spine of the outer division and the adults are generally similar to *tritaeniorhynchus* in having the scales of mesonotum predominantly dark brown and in having dark fine hairlike setae on the ventral surface of segment 3 of the male palpus.

31. *CULEX (CULEX) BARRAUDI* EDWARDS
(Figs. 63, 64)

Culex barraudi Edwards 1922a: 284 (♂*); Barraud 1923a: 939 (L*); Barraud 1924a: 997 (♂*, ♀); Senior-White 1927: 71 (L*).

Culex (Culex) barraudi Edwards, Edwards 1932: 204 (taxonomy); Barraud 1934: 403 (♂*, ♀, L*); Peters and Dewar 1956: 46 (♂*, L*); Bram 1967a: 209 (♂*, ♀, L*).

FEMALE. Wing: 3.2 mm. Forefemur: 1.6 mm. Proboscis: 1.75 mm. Resembling other members of the *Vishnui* Subgroup in general external characters, differing as follows. *Head.* Erect scales of vertex largely brownish or blackish except for a few pale ones in center; lateral patch of broad appressed scales whitish, very distinct. Palpus tipped with pale scales on apex of segment 4; rest dark. Proboscis with median pale ring occupying about 0.2 of total length. *Cibarial Armature.* Rather similar to *sitiens;* cibarial bar with a concave row of about 25 very short, coarse and abruptly pointed teeth, all subequal in length and size. *Thorax* (Fig. 63). Mesonotal integument tan to dark brown; scales on anterior 0.7 narrow, rather fine, predominantly golden or dark brown in middle, pale yellowish on extreme anterior promontory and on marginal areas; sometimes also with pale yellow scales forming spots or streaks behind fossae, posterior acrostichal and dorsocentral areas at level of

anterior wing base; scales on posterior 0.3 laterad of prescutellar space golden to dark brown, not contrasting with scales on anterior 0.7; scales on prescutellar space and scutellar lobe entirely pale beige, whitish or yellowish. Pleural integument same color as mesonotum; *psp* with characteristic minute silvery white scale patch on lower anterior surface in addition to pale scale patches on *ppl*, *stp* and *mep*. *Legs*. Anterior surface of forefemur completely dark; that of midfemur with a narrow, rather poorly defined longitudinal pale stripe along whole length and with or without light sprinkling of pale scales on lower surface at middle; anterior surface of hindfemur with distinct longitudinal pale stripe from base to near apex, bordered above and below by dark scaled stripes; fore- and midtibia entirely dark anteriorly; midtibia with poorly defined pale stripe in middle; anterior surface of hindtibia with a longitudinal pale stripe from basal 0.25 to apical 0.75 of the length. *Wing*. All scales dark, narrow and dense; no pale scaled line or streak at base or in basal 0.5 of veins C. *Abdomen*. Terga II-VII with basal pale bands, narrower on posterior segments.

MALE. As described for female, differing in largely pale mesonotal scales, absence of scattered pale scales on anterior surface of forefemur, absence of longitudinal pale stripe on anterior surface of midfemur and in broader basal bands on abdominal terga II-VII. *Head*. Palpus exceeding proboscis by full length of segment 5; segment 3 with row of short, dark, hairlike setae on ventral surface, apical 0.25 with about 8 strong bristles; segments 4 and 5 weakly to moderately plumose, with narrow basal pale bands on dorsal surface; apex of segment 5 without apical pale band. Proboscis with very poorly developed ventral tuft of a few rather short hairs at base of median pale ring.

MALE GENITALIA (Fig. 63). Essentially similar to other members of the *Vishnui* Subgroup, differing particularly in the following features. *Basimere*. Setae on inner tergal surface laterad of subapical lobe less numerous and apparently shorter and weaker. *Subapical lobe*. Leaf *g* of distal division relatively broad, heart-shaped, with acuminate apex. *Phallosome*. Apical tergal crown of inner division with 4, 5 stout fingerlike processes, all apparently subequal in length, straight, divergent laterad or dorsolaterad; outer division with 1 large and 1 small mesal spine; sternal spine poorly developed, rather short and indistinct; lateral basal process slender. *Proctiger*. Apical crown relatively large; basal sternal process of paraproct present, very strong, thick, curved sternad.

PUPA. Abdomen: 2.5 mm. Paddle: 0.78 mm. Trumpet: 0.70 mm; index 8. In general as described and figured for *whitei* (Fig. 61). *Trumpet*. Brown or yellowish brown, more or less uniform in width except for slightly expanded pinna. *Cephalothorax*. Seta 8-C 4 branched; 9-C double or triple. *Abdomen:* Seta 1-II 10 branched; 1-III 9 branched; 1-IV 5-7 branched; 1-V, VI 5, 6 branched; 1-VII 4 branched; 5-IV triple, 5-V, VI double, as long as or slightly longer than segment following, 6-III-VI usually triple, rarely double. *Paddle*. Entirely pale; midrib weak, pale or lightly pigmented.

LARVA (Fig. 64). Head: 0.78 mm. Siphon: 1.8-2.0 mm; index 8. Saddle: 0.36 mm; siphon/saddle ratio 5. Extremely similar to *whitei* in shape and size of siphon and in chaetotaxy, differing particularly in the following. *Abdomen*. Setae 6-I, II triple; 1-III-VI about 0.5 of setae 6-III-VI, all subequal in length; 1-III, IV double or triple (1-3); 1-V, VI 3-5 branched. Apical fringe of comb scales more or less rounded, composed of 3, 4 equally strong apical spicules and several fine lateral spicules. Seta 1-X of saddle usually single (1, 2). *Siphon*. Bright yellow except for basal dark ring; siphonal tufts longer

and stronger, 4.5-5 pairs (total 9-10); 2.5-3 pairs inserted subventrally; other 2 pairs inserted laterally, each usually triple (2-4); most proximal pair longest, about 1.5 times as long as siphonal width at point of attachment, rest gradually shorter; ventral valve of spiracular apparatus broader, longer and very dark; median caudal filament poorly developed.

TYPE-DATA. Holotype ♂* (E 267) with slide of genitalia, Mahdopur, *Punjab:* INDIA, April 1921, P. J. Barraud (BM).

DISTRIBUTION. Known only from India, China and Thailand. Material examined. 21 specimens: 12♂, 7♀, 2 L; 2 individual larval rearings.

INDIA. *Punjab:* Mahdopur (type-locality); 6♂, 1♀, 2 lp (all in type-series); *Western Himalayas:* Kasauli; 5♂, 4♀.

CHINA. *Yunnan:* Poashan Valley; 2 L (S. C. Billings, 1944).

THAILAND. *Chinag Mai:* Huey Mae Sanarn; Ban Bo Rae Hod; 1♂, 2♀.

Additional records from the literature. INDIA. *Punjab,* Pathankote; Amritsar; Kalka; *Western Himalayas:* Murree; *South India:* Karikal, Tanjore (Barraud 1924a, 1934); SRI LANKA (Senior-White 1927); NEPAL (Peters and Dewar 1956); PAKISTAN (Aslamkhan 1971).

TAXONOMIC DISCUSSION. *Culex barraudi* is a very poorly known species. This is because the original description of the holotype male by Edwards (1922a: 284-5) and the subsequent descriptions of both sexes and the larva by Barraud (1923a: 939, 1924a: 997, 1934: 403) were inadequate, lacking certain significant features which are diagnostic of this species. In this study, I re-examined the type, additional specimens in the type-series and other previously identified by Barraud. A comparison of the Indian material of *barraudi* with the few adults described by Bram (1967a: 209-13) from Thailand indicates that specimens from these 2 countries are conspecific. Except for some corrections and additions as indicated above, descriptions of the adults, male genitalia and larva by Bram (loc. cit.) are generally applicable to *barraudi.*

Culex barraudi is extremely similar to *edwardsi* Barraud in all stages and with the latter evidently falls into a distinct complex or subgroup. The synonymy of *edwardsi* with *barraudi* proposed by Bram (1967a) was premature and does not appear to be justified, as discussed by Marks (1971: 195-6). In comparing the type adults and others in the type series of both species, I found that they differ from one another rather strikingly in the relative size, details of the male palpus and proboscis and slightly in other external features and in the male phallosome. This evidence suggests that *barraudi* and *edwardsi* are in fact not conspecific, but most probably represent 2 distinct forms of a complex. However, with additional material, especially adults with associated immature stages from the type localities in India for a detailed analysis, it should be possible to determine their precise status.

Culex barraudi adults can be readily separated from members of the *Vishnui* Subgroup by the presence of a minute, semi-erect, silvery white scale patch on the lower anterior surface of the postspiracular area and by the presence of a narrow longitudinal pale stripe on the anterior surface of mid-femur, mid- and hindtibiae; in the male by the fine, hairlike setae on ventral surface of palpal segment 3 and by the poorly developed ventral tuft of hairs at the base of median pale ring of the proboscis; in the male genitalia by the details of the inner and outer division of the phallosome. The pupa and larva of *barraudi* are extremely similar to *whitei* in general features and chaetotaxy, but can be separated from the latter as indicated in the above diagnosis and in the keys. For separating *barraudi* from *edwardsi,* see the keys and the discussion under the latter species.

The additional new record of *barraudi* from China is based on 2 whole lar-

vae. In the absence of associated adults, this record is only provisional and requires confirmation. All additional records from India by Barraud (1924a, 1934) and Peters and Dewar (1956) are presumably valid but the record from Sri Lanka by Senior-White (1927) is doubtful.

BIONOMICS. *Culex barraudi* appears to be restricted to a high elevation in mountainous areas in the northern parts of the Oriental regions. In Punjab, India, it was reported to breed in ground pools, marsh, etc. (Barraud 1934: 403). In Chiang Mai, northern Thailand, it was collected once in sandy pools without further notes on the environment. The adults from Kasauli and Murree in the Western Himalayas were reported to come from an elevation of 1,540-2,140 meters (Barraud 1934: 403). Adult biology, feeding habits and disease relationships are practically unknown.

32. *CULEX (CULEX) EDWARDSI* BARRAUD
(Fig. 63)

Culex edwardsi Barraud 1923b: 507 (♀); Barraud 1924a: 995 (♀).
Culex (Culex) edwardsi Barraud, Edwards 1932: 204 (taxonomy); Barraud 1934: 403 (♂*, ♀); Carter and Wijesundara 1948: 148 (L*); Peters and Christian 1963: 35 (distribution); Marks 1971: 195 (taxonomy).
Culex (Culex) barraudi of Bram 1967a: 211, (in part).

FEMALE. Wing: 4.3 mm. Forefemur: 2.0 mm. Proboscis: 2.0 mm. Abdomen: 2.9 mm. In general, extremely similar to *barraudi* in the presence of a distinct, minute, silvery white scale patch on lower anterior surface of postspiracular area, differing in the presence of well defined longitudinal pale stripes on anterior surface of femora and tibiae of mid- and hindlegs, larger size and in the following features. *Thorax*. Scales on anterior 0.7 of mesonotum coarser and predominantly dark brown. *Legs*. Anterior surface of forefemur with or without distinct longitudinal pale stripe or chain of pale spots extending from base to apical 0.75 on lower margin; foretibia with or without scattered pale scales which may form a complete stripe or a chain of pale spots anteriorly; anterior surface of femora and tibiae of mid- and hindlegs with well defined longitudinal pale stripes along the whole length; pale stripe on hindfemur broad, covering entire surface in basal 0.5 and tapering in apical 0.5; tarsomeres of all legs with broader and more conspicuous basal and apical pale bands. *Wing*. Posterior dorsal surface of vein C with pale scale line or streak at least at base near humeral vein or sometimes extending to 0.5 or more of the whole length; dorsal scales of vein Sc usually largely pale, sometimes dark. *Abdomen*. Basal pale bands of terga II-VI relatively broader; terga V-VII with distinct narrow apical pale bands, largely restricted to middle.

MALE. Essentially similar to female in general and in the striping of the legs; differing from *barraudi* as described for female and in the following. *Head*. Palpus longer and thicker, exceeding proboscis by 1.5 of segment 5; segment 3 with prominent ventrolateral tufts of about 30 bristles from basal 0.4 or 0.5 to apex; segments 4 and 5 very strongly plumose; apical 0.25 of segment 5 pale scaled to tip. Proboscis with a strong and very conspicuous ventral tuft of at least 10 long hairs at base of median pale ring, these hairs about 5 times as long as labial width at point of insertion.

MALE GENITALIA (Fig. 63). Exceedingly similar to *barraudi*, differing slightly in the following details. *Subapical lobe*. Setae *d-f* of distal division apparently stronger and more flattened; leaf *g* relatively broader. *Phallosome*.

Sternal spine of outer division very well developed, relatively large, strongly divergent laterad; lateral basal process larger, with variable number of distinct denticles near base of mesal spine.

PUPA. Abdomen: 4.0 mm. Paddle: 1.0 mm. Trumpet: 0.75-0.90 mm; index 8-9. Extremely similar to *barraudi* and *whitei;* and as figured for *whitei* (Fig. 61), differing in larger size, longer and more uniformly cylindrical trumpet and in the following. *Cephalothorax.* Seta 8-C usually double (2, 3). *Abdomen.* Seta 1-II forked into 4 branches; 6-III, IV double; 6-V, VI 3, 4 branched; 5-VII very strong, longer than seta 1-VIII, double; 4-VIII single.

LARVA. Head: 0.90 mm. Siphon: 2.0 mm; index 7. Saddle: 0.36 mm; siphon/saddle ratio 6. Extremely similar to *barraudi,* differing from it particularly in the following features. *Abdomen.* Setae 6-III, IV usually triple (2, 3); 1-III-VI usually double or triple (2-4). Comb scales more or less pointed apically; median apical spicule apparently stronger than lateral spicules. Posterior margin of saddle with stronger spicules; seta 1-X strong and single. *Siphon.* Pecten teeth slightly shorter and larger; most distal teeth with 4, 5 lateral denticles and a weak apical denticle; siphonal tufts 5.5-6 pairs (total 11-12); 3.5-4 pairs inserted subventrally, 1.5-2 pairs inserted laterally; median caudal filament of spiracular apparatus well developed.

TYPE-DATA. Holotype ♀*, Shillong, Khasi Hills, *Assam,* INDIA, June 1922, P. J. Barraud (BM).

DISTRIBUTION. Definitely known only from India, Papua-New Guinea and Queensland, Australia. Material examined. 12 specimens: 7♂, 5♀; 4 individual rearings (1 pupal, 3 larval).

INDIA. *Assam:* Shillong, Khasi Hills (type-locality); 1♀ (holotype), 1♂; *Central India:* Rewa State, Amol Nullah; 2♂, 1♀ (Senior-White); *South India:* Coorg, Mercara and Virajpet; 1♂, 2♀ (Baily); *Madras:* Nilgiri Hills, 1♂, 1♀, 1 p, 1 lp (B. N. Mohan, 1974).

PAPUA-NEW GUINEA. *S. Highlands: Minj;* 2♂, 1♀, 2 lp (Peters and Christian).

Additional records from the literature: SRI LANKA. Nuwara, Eliya (Carter and Wijesundara 1948). AUSTRALIA. *Queensland:* Fraser Is. (Marks 1968).

TAXONOMIC DISCUSSION. *Culex edwardsi* is very closely related to *barraudi* on the basis of similarity in all stages and as discussed under the latter; the 2 species evidently fall into a distinct complex or subgroup. Although both species have long been known only from the types and from the limited number of identified specimens originally described and figured by Barraud (1923b; 1924a; 1934), present comparison has shown that they are distinct and probably not conspecific as interpreted by Bram (1967a: 209-213). In this study, *edwardsi* is resurrected from synonymy with *barraudi.*

This species is still very poorly known from every locality within its reported range. The above descriptions of the adults have been based on the study of the type female and specimens listed in the distribution section. In comparing the Indian specimens with those from New Guinea, I found that they are essentially similar in all stages, indicating that they are conspecific.

Culex edwardsi can be distinguished from *barraudi* in the adults by: (1) larger size; (2) mesonotal scales coarser and more predominantly brownish on anterior 0.7; (3) longitudinal pale stripes of the femora and tibiae of mid- and hindlegs well developed in both sexes and apparently more conspicuous; (4) posterior surface of vein C with distinct pale scale line extending from base to about 0.5 or more of the total length; (5) abdominal terga V-VII of the female with narrow median apical pale bands in addition to basal bands; in the

male by (1) longer palpus; (2) ventral lateral tuft of palpal segment 3 larger, with more numerous bristles, extending from basal 0.4-0.5 to the apex; (3) palpal segments 4 and 5 densely long plumose, with more numerous bristles on lateral and mesal surfaces and (4) proboscis with a strong ventral tuft of long hairs at the base of median pale ring. In the male genitalia, *edwardsi* differs from *barraudi* particularly in having a stronger, longer and more prominent sternal spine in the outer division of the phallosome. The pupa and larva of *edwardsi* are very similar to *barraudi* and both apparently exhibit much overlap with *whitei*. The *edwardsi* pupa differs from those of *barraudi* and *whitei* in having abdominal seta 5-VII stronger and longer. The larva can be separated from *whitei* by weaker and shorter setae 1-IV and V and from *barraudi* by the presence of 5.5-6 pairs of siphonal tufts (4.5-5 pairs in *barraudi*) and by a few other features as indicated in the above description.

BIONOMICS. Very little is known about the larval breeding sites and the adult biology of *edwardsi*. It appears to be uncommon and restricted to a very high elevation as *barraudi*. In the Nilgiri Hills, Madras, the immatures were collected twice, once in a stream pool and once in a spring pool. In Sri Lanka, the larvae were collected from a grassy pond and a swamp at the elevation of about 1,232-1,846 m (Carter and Wijesundara 1948: 148). Peters and Christian (1963) described it as a fresh water breeder in New Guinea, but no information about the breeding site was given. The adults, including the type of *edwardsi* from India reported by Barraud (1924a, 1934) all apparently came from general field catches and those recently collected from the Nilgiri Hills all came from field rearing. At Minj, Papua-New Guinea, Peters and Christian (loc. cit.) collected adults in a light trap and in Australia, Marks (1968, 1971) noted that it has been taken in chicken-baited, light and truck traps. It is not known to bite man.

MIMETICUS SUBGROUP

The *Mimeticus* Subgroup generally conforms to the *Sitiens* and *Vishnui* Subgroups in all stages and is chiefly characterized by the following combination of characters: in the adults by (1) presence of a striking pattern of pale spots on the wing; in the males by ventral surface of palpal segment 3 always with short, scalelike setae; in the pupa by seta 1-II usually between 1-9 branched, not exceeding 10 branched; and in the larva by (1) seta 4-P, single (except for *C. mimuloides* which has this seta double); (2) seta 7-I always single; (3) comb scales numerous, all small, subequal in a broad oval patch and (4) median caudal filament of spiracular apparatus absent or poorly developed.

DISCUSSION. The *Mimeticus* Subgroup as recognized here corresponds to the *Mimeticus* series or group as defined by Edwards (1932: 201-5; in Barraud 1934: 450-3). Its members can be easily distinguished from the rest of the *Sitiens* Group in the adults by the spotted wing and in the majority of species by the single seta 4-P of the larva. This subgroup apparently exhibits the strongest affinity with the *Vishnui* Subgroup on the basis of the male phallosome and the morphology of all stages, indicating that it was probably derived from the latter and that the subgroup as a whole presumably originated in the Oriental region.

The *Mimeticus* Subgroup is diverse, highly complex and taxonomically very difficult. Some Oriental members of this subgroup are still poorly known because they are not commonly encountered and appear to be restricted to certain localities at a very high elevation. The identity and the status of some *mimeti-*

cus forms are very difficult to determine because of the considerable overlap and similarity in one or more stages. When additional specimens from progeny and individual rearings become available from several localities for a thorough analysis, it may be necessary to revalidate the status of some of these forms. Based primarily on the differences in the male genitalia, pattern and extent of pale spots of the wing and in certain cases also on the larval and pupal stages, I am recognizing 10 species of the *Mimeticus* Subgroup in the Oriental and Palearctic regions. The majority of these are exclusively Oriental except for *mimeticus* whose range extends into the Middle East, the Mediterranean and the northeastern Palearctic (China, Japan and Korea), *mimulus* which is also known from New Guinea and northern Australia and *orientalis* which is known only from the northeastern Palearctic, particularly Japan, Korea and possibly China and USSR.

The 10 members of the *Mimeticus* Subgroup recognized here can be assembled into 2 complexes: *mimeticus* and *mimulus* on the basis of the differences in the pattern and the extent of the wing spots, certain features of the male genitalia, pupal and larval chaetotaxy. Separation of the adults of the members in each complex are very tenuous and require examination of the male genitalia and associated immature stages.

The *mimeticus* complex is composed of *mimeticus* Noè 1899, *fasyi* Baisas 1938, *jacksoni* Edwards 1934, *tsengi* Lien 1968, *mimuloides* Barraud 1924 and *diengensis* Brug 1931. This complex also includes *solitarius* Bonne-Wepster 1938 from New Guinea. The *mimeticus* complex is characterized in the adults by (1) wing with only 3 costal pale spots in apical 0.5 and (2) first costal spot at about the middle of vein C involving veins C and Sc or sometimes restricted to Sc only; in the male genitalia by (1) distimere without distinct subapical crest of minute spicules; (2) leaf *g* of the subapical lobe relatively narrow; (3) outer division of the phallosome with a strong, prominent sternal spine which is divergent laterad and (4) basal sternal process of the proctiger absent or present; if present, usually very slender, thin and pale; in the pupa by (1) seta 1-II usually single or double, rarely more branched; (2) setae 1-III, IV usually 2-6 branched, rarely more branched; (3) setae 6-III, IV usually single or double rarely 3, 4 branched and (4) seta 4-VIII usually single, rarely double and in the larva by (1) comb scales relatively coarse and usually with apical fringes terminating into a strong median spine; (2) siphon usually 1.4-1.6 mm in length, rarely exceeding 2.0 mm; (3) 4 proximal pairs of siphonal tufts usually strongest, closely spaced, forming a prominent row, 2 distal pairs weaker and shorter and (4) apical half of siphon with or without prominent spines on ventral surface.

The *mimulus* complex includes *mimulus* Edwards 1915, *murrelli* Lien 1968, *propinquus* Colless 1955 and *orientalis* Edwards 1921. It is characterized in the adults by (1) wing with or without basal costal pale spot in addition to 3 other costal spots in apical 0.5; (2) first costal spot at about the middle of vein C involving veins C, Sc, R_1 and R_s, sometimes also extending to veins M and Cu; in the male genitalia by (1) distimere with distinct subapical crest of several minute spicules; (2) leaf *g* of the subapical lobe broad; (3) outer division of the phallosome with a poorly or well developed sternal spine which is usually strongly curved with apex projecting basad; (4) basal sternal process of the proctiger present, very strong, stout and dark; in the pupa by (1) seta 1-II usually more than 3 branched (2-9); (2) setae 1-III, IV 5-10 branched; (3) setae 6-III, IV usually triple, rarely double; (4) seta 4-VIII double and in the larva by (1) comb scales relatively fine and with apical fringe of evenly fine spicules or terminating into a weak medium apical spine; (2) siphon 1.4-2.5 mm in length;

(3) all siphonal tufts relatively weak, short, subequal, widely spaced, not forming a prominent row; (4) apical half of siphon without prominent spines on ventral surface.

33. *CULEX (CULEX) MIMETICUS* NOÈ
(Figs. 16, 65, 67, 68)

Culex mimeticus Noè 1899: 240 (♀); Edwards 1921: 337 (♂, ♀, L); Edwards 1922a: 284 (distribution); Barraud 1923a: 941 (L*); Barraud 1924a: 991 (♂*, ♀, in part); Borel 1930: 318 (♂*, ♀, L*); Ho 1931: 154 (♂*, ♀*).

Culex pseudomimeticus Sergent 1909 (1910): 445 (adult); Edwards 1932: 205 (synonymy).

Culex (Culex) mimeticus Noè, Edwards 1932: 205 (taxonomy, in part); Barraud 1934: 409 (♂*, ♀, L*, in part); Edwards, in Barraud 1934: 451 (♂, ♀, key); Feng 1938: 302 (distribution, biology); Bohart and Ingram 1946: 80 (♂*, ♀, L*); LaCasse and Yamaguti 1950: 241 (♂*, ♀*, P*, L*).

FEMALE (Fig. 16, 65). Wing: 4.5 mm. Forefemur: 2.1 mm. Proboscis: 2.2 mm. Abdomen: 3.0 mm. Medium or large sized species. *Head.* Narrow decumbent scales on vertex entirely pale or partially pale yellowish along dorsal midline, darker on lateral areas; erect scales numerous, very coarse, golden or bronzy in center, dark brown on lateral and posterolateral areas; lateral patch of broad whitish scales, very distinct from above. Palpus tipped with pale scales on apex of segment 4, rest dark. Proboscis with a broad median pale ring; portions distad and proximad of median ring entirely dark scaled. *Cibarial Armature.* Essentially similar to most members of the *Sitiens* Group; cibarial bar with a concave row of about 30 short and coarse teeth all of which are subequal and abruptly pointed apically. *Thorax.* Mesonotal integument dark brown; mesonotal scales on anterior 0.7 coarse and predominantly yellowish to golden with mottling of brown scales forming spots and streaks on fossae, acrostichal and dorsocentral areas; scales on prescutellar space and scutellar lobes largely pale beige or pale yellowish. *Apn* and *ppn* with golden and brownish scales as on mesonotum. Pleuron same color as mesonotum; pale scale patches on upper corner of *stp* and upper *mep* broad and more or less contiguous; several pale scales present among upper *mep* bristles. *Legs.* Anterior surface of fore- and midfemora usually entirely dark, sometimes lightly speckled with pale scales, subapical yellowish spots (knee spots) present; anterior surface of hindfemur with longitudinal pale stripe extending from base to slightly beyond 0.5 of whole length, apical 0.5 dark; dark area dorsad and distad of stripe with or without light sprinkling of pale scales; pale stripe usually lightly freckled with some dark scales; subapical yellowish spot absent; fore- and midtibiae without pale stripe; hindtibia usually with distinct longitudinal stripe on anterior surface; tarsomeres 1-4 of all legs with broad basal and narrow apical pale bands. *Wing.* Characteristic pattern of pale spots as figured; extent of pale spots variable; base of vein C without pale scale line or streak on posterior surface, apical 0.5 or slightly more with 3 costal spots (first costal, 2nd costal and 3rd costal); first costal spot at about middle of vein C involves veins C and Sc; 2nd costal spot at about 0.75 of vein C involves veins C, apex of Sc and middle of R_1; 3rd costal spot near tip of wing usually involves apical portions of veins C, R_1 and R_2; furcation of R_{2+3} proximad of or at same level of furcation of M, both with pale spots largely involves basal portions of veins R_2, R_3, M_{1+2} and M_{3+4}; vein R_{4+5} pale

from basal 0.4 to apical 0.75; vein Cu, pale from basal 0.25 to apical 0.75; Cu_2 with short apical pale streak; fringe scales on apex of Cu_2 pale; vein 1A pale from basal 0.25 to 0.50; plume scales narrow and dense on veins R_2, R_3, R_{4+5}, M_{1+2} and M_{3+4}. *Abdomen.* Terga II-VII with basal pale bands of variable width and large basolateral pale spots; terga VI-VII with narrow median apical pale bands; sterna II-VII with broad basal pale bands and narrow apical dark bands. *Genitalia.* Essentially similar to those of the *Sitiens* Group; tergum IX with a lateral row of 5, 6 strong setae; postgenital plate rounded or slightly emarginate on caudal margin; vaginal sclerite U- or V-shaped; insula with a tuft of about 10 moderately strong setae.

MALE. In general similar to female except for less striking pattern of wing spots and less dense scales on all wing veins. *Head.* Palpus exceeding proboscis by at least full length of segment 5; segment 3 with a broad median pale band on dorsal surface, ventral surface with a dense row of short, scale-like setae along whole length, apical 0.25 with a strong ventral lateral tuft of 10-16 bristles; segments 4 and 5 strongly plumose, each with a broad basal pale band on dorsal surface; apex of segment 5 tipped with pale scales. Proboscis with pale scale line distad and proximad of median pale ring on dorsal surface; ventral tuft of hairs at base of median pale ring very weak, indistinct, composed of a few hairs which are 2, 3 times as long as labial width at point of insertion.

MALE GENITALIA (Fig. 67). Essentially similar to members of the *Sitiens* and *Vishnui* Subgroups, differing particularly in the following features. *Subapical lobe.* Setae *d-f* of distal division 4, all flattened, most distal seta longest and hooked apically; the rest shorter, subequal; leaf *g* relatively narrow, apically rounded or abruptly pointed. *Distimere.* Dorsal subapical crest of minute spicules completely absent. *Phallosome.* Apical tergal crown of inner division of lateral plate with 2-4 fingerlike processes which are variable in length and thickness, all more or less straight and with apices pointing laterad or dorsolaterad; outer division with 1 strong mesal spine and with or without 1 other weaker spine on tergal surface, sternal surface with a prominent sternal spine which is gently or strongly divergent laterad; lateral basal process broadly rounded or slightly elongate, forming a distinct knob. *Proctiger.* Apical crown large, dark, composed of numerous coarse spicules; basal sternal process very slender, thin, pale, about 0.05 mm in length, gently curved sternad; subbasal process very short; cercal sclerite broadly sclerotized; cercal setae usually 2(2-4).

PUPA (Fig. 67). Abdomen: 2.7 mm. Paddle: 0.8 mm. Trumpet: 0.7 mm; index 7-9. Cephalothorax and abdomen yellowish or cream-colored without distinct pattern of darkened areas. Complete chaetotaxy as figured, distinctive in the following. *Trumpet.* Yellowish brown, more or less uniform in width except for slightly expanded pinna; apical margin truncate or broadly rounded. *Cephalothorax.* Seta 8-C double; 9-C usually double. *Metanotum.* Seta 10-C usually 3, 4 branched (3-5). *Abdomen.* Seta 1-II single or forked into 2 branches; 1-III 2-4 branched; 1-IV 3, 4 branched; 1-V-VII usually double (1-3); 5-IV usually double or triple (2-4), as long as or slightly longer than segment following; 5-V, VI double, 1.5 times as long as segment following; 6-III-VI single or double; 2-VII usually mesad of 1-VII; 4, 5-VII usually single; 5-VII nearly as long as the length of segment VIII; 9-VII usually double or triple (2-4); 4-VIII usually single (1, 2); 9-VIII 4-8 branched, as long as 9-VII. *Paddle.* Very broad and entirely pale; midrib lightly pigmented; setae 1, 2-P present; 2-P stronger than 1-P.

LARVA (Fig. 68). Head: 0.78 mm. Siphon: 1.5-1.7 mm; index 6-7.

Saddle: 0.4 mm; siphon/saddle ratio 4. Generally similar to members of the *Vishnui* Subgroup, differing particularly in the following combination of characters. *Head.* Seta 5-C usually 3, 4 branched (3-5); 6-C usually double (2, 3); 7-C 5-7 branched; setae 10, 11 and 13-C usually double (2, 3); 12-C triple; 14-C very distinct and strong, somewhat spiniform. Antenna as long as head. *Thorax.* Spiculation absent; seta 4-P single and as strong as 1-3-P; setae 8, 9-M usually 5, 6 branched; 7-T 7 branched; 13-T usually double (2-4). *Abdomen.* Setae 6-I, II triple; 7-I single; 6-III-VI double or triple; all setae 5-I-VI single and very distinct; 1-III-VI usually double, all subequal, about 0.5 of seta 6-III-VI. Comb scales 25-30, all small, subequal in size and with apical fringe terminating in a strong, distinct median spine. Seta 1-X of saddle usually double (2, 3); 2-X double; anal gills slender, 2, 3 times as long as saddle length. *Siphon.* Moderately long, straight and gradually tapered distally; pigmentation yellowish white except for basal dark ring; pecten teeth 13-18, all gently curved dorsad; siphonal tufts 6 pairs (or total 12), inserted beyond pecten; 4 proximal pairs strong, subequal, 4, 5 branched, in a prominent row on ventral surface, their length 2, 3 times of siphonal width at point of attachment; 2 distal pairs weaker and shorter, double or triple, the proximal inserted laterally, the other subventrally, their length as long as siphonal width at point of attachment; seta 2-S dark, strong and moderately long; median caudal filament of spiracular apparatus absent.

TYPE-DATA. (1) *Culex mimeticus* Noè, Type ♀ (non-existent), Grassano, Basilicata, ITALY; deposited in Rome University Museum (Barraud 1924a, 1934); (2) *C. pseudomimeticus* Sergent; Type (non-existent), Chiffa, ALGERIA.

DISTRIBUTION. Presumably widespread in the Oriental region with the range extending west into the Middle East and the Mediterranean; north and northeast into the Palearctic (including Tibet, Kashmir, China, Japan and Korea). Material examined: 178 specimens: 51♂, 65♀, 62 L; 16 individual rearings (1 pupal, 15 larval).

ITALY. *Matera Province:* Grassano, Basilicata (type locality); Savignano (Avelliuo); 4♂, 6♀, 10 lp (M. Coluzzi, 1970).

GREECE. *Macedonia:* N. Salonica; 1♂.

TUNISIA. Mateur; 15♂, 12♀, 1 L (G. T. Riegel, 1943).

ALGERIA. Chanzy; 5♀.

IRAQ. Mirgasur, Shanider; 3 L.

IRAN. Teheran; Arimarabad, E. Chalus, Kheyrud River; Khorramabad; Kambu; 2♂, 4♀, 1 L.

NEPAL. Khatmandu; 1 L (J. Maldonado, 1958).

TIBET. Yatung; 2♂.

INDIA. *Western Himalayas:* Kasauli; Durhampur; *Assam:* Tezpur; Ledo; Dibrugarh; Shillong; *Madras:* Nilgiri Hills, Manjoor; 7♂, 6♀, 3 L; *Kashmir:* Narang; 1♂, 1♀.

BURMA. Salween River Valley; 2 L (S. C. Billings).

MALAYSIA. *Peninsular Malaysia: Pahang*-Cameron Highlands; Mt. Brinchang; 7♂, 7♀, 3 L, 5 lp.

VIETNAM. Dalat, Du Sinh Hamlet; 2♀, 1 p.

HONG KONG. 4♂, 1♀, 6 L (skins).

CHINA. Peking; Hanchow; Foochow; Nanking; Yunnan; Chentu; 1♂, 3♀, 31 L.

JAPAN. Kyoto; Nagasaki; Otsu *(Honshu);* 4♂, 9♀, 3 L. *Ryukyus:* Okinawa; Taera; Nakasoni; 1♂, 4♀, 7 L.

KOREA. Yanggu; Koje-do; Nouak; 2♂, 5♀, 1 L.

Additional records from the literature: SRI LANKA; INDOCHINA (Barraud

1934: 411); PAKISTAN (Aslamkhan 1971); TAIWAN (FORMOSA) (Edwards, in Barraud 1934: 451; Lien 1968); CHINA: Anhwei, Chekiang, Hopei, Kiangsi, Kiangsu, Kwangtung, Shangtung, Tibet (Feng 1938); FRANCE: Corsica; ITALY: Sardinia; SPAIN (Aitken 1954: 486; Nicoli and Nicoli 1964: 38); USSR (Monchadskii 1951).

TAXONOMIC DISCUSSION. *Culex mimeticus* was originally described from Italy by Noè (1899) and the name has since been widely used by European workers for all spotted wing *Culex* from several parts of the Mediterranean, Middle East and the Oriental region. The type of *mimeticus* is apparently lost. However, through the courtesy of Dr. M. Coluzzi in Italy, I have obtained a good number of topotypic specimens with associated immature stages for detailed study and comparison with the Oriental forms. In addition, I have also examined specimens from several other areas in the collections of the USNM and the British Museum (Natural History).

This is the most widespread species of the *Mimeticus* Subgroup. It is still poorly known from most parts of the Oriental region. The earlier Oriental records of this species are not always reliable because of the considerable overlap in the pattern of wing spots with other members of the complex. The only feature which is diagnostic of *mimeticus* and has been used here in separating it from other members of this complex is the presence of a long, slender basal sternal process of the proctiger of the male genitalia. This particular feature shows an overlap only with *mimuloides* which differs from *mimeticus* in several characters of the larva and other stages. Within Southeast Asia, *mimeticus* is definitely known only from Pahang, Peninsular Malaysia, Vietnam, Hong Kong and Okinawa. The records in the literature from Sri Lanka (Barraud 1934) and Taiwan (Edwards 1934, Lien 1968) are uncertain. They require further confirmation since these were based entirely on the pattern of wing spots. The male genitalia as figured by Lien (1968: 251) from Taiwan do not appear to agree with the typical form of this species.

Except for the diagnostic male genitalia, *mimeticus* exhibits much similarity to and overlaps with *fasyi* Baisas, *jacksoni* Edwards and *tsengi* Lien in the pattern of wing spots and in most features of the pupal and larval stages. For the separation of these taxa from *mimeticus*, see the keys and the discussions under each individual taxon. It appears probable that all of these forms are only subspecifically distinct. Additional material from individual and progeny rearings from several localities is needed to determine the definite status of each of these forms.

BIONOMICS. *Culex mimeticus* is a common Mediterranean species of *Culex (Culex)* (Aitken 1954, Nicoli and Nicoli 1964) but is not frequently encountered in the Oriental region. It appears to be restricted to high elevations in the mountains or hill areas in India, Burma (Barraud 1934), Southeast Asia and other adjacent areas. In Tibet, it was reported from an elevation of 3,050 m (Feng 1938). The usual breeding sites of *mimeticus* include general ground pools in dried up stream beds and in the vicinity of mountain streams or brooks, running streams and rock pools. In Japan, it has been collected from drainage ditches and rice fields (LaCasse and Yamaguti 1950, Hsiao and Bohart 1946). The single collection from Pahang, Peninsular Malaysia came from a rock pool at an elevation of 1,540 m. The water of the breeding sites is fresh and usually contains green algae. In Japan, Hsiao and Bohart (1946) reported that adults occasionally entered houses. The adult biology and medical importance of *mimeticus* from all areas are unknown.

34. *CULEX (CULEX) FASYI* BAISAS
(Fig. 69)

Culex (Culex) fasyi Baisas 1938: 215 (♂*, ♀); Delfinado 1966: 142 (♂*, ♀).

FEMALE. Wing: 4.0-5.0 mm (average 4.5 mm). Forefemur: 2.2 mm. Proboscis: 2.3 mm. Abdomen: 3.2 mm. As described by Baisas (1938: 215-6) and Delfinado (1966: 142-3); extremely similar to *mimeticus* in the pattern of wing spots and in general facies, differing slightly as follows. *Thorax.* Scales on anterior 0.7 of mesonotum more extensively brownish. *Wing.* Furcation of vein M usually dark; basal portion of vein M proximad of crossvein M-Cu usually with a short pale scale line on ventral surface (absent in *mimeticus*). *Abdomen.* Terga III-VI usually with a row of pale scales forming narrow apical bands and with a few light scales forming a pair of minute spots adjacent to apical band; basal pale bands on all terga progressively narrower towards posterior segments.

MALE. In general similar to female with sexual characters as described for *mimeticus,* differing from the latter in having 20 or more ventrolateral bristles in apical 0.5 of palpal segment 3.

MALE GENITALIA (Fig. 69). Extremely similar to *mimeticus* in details of basimere, subapical lobe, distimere and phallosome, differing from it particularly in having a shorter basal sternal process of the proctiger which is about 0.01-0.03 mm in length and in the following. *Subapical lobe.* Leaf *g* of distal division apparently shorter. *Phallosome.* Fingerlike processes of inner division stronger, slightly swollen in middle, somewhat lanceolate in shape. *Proctiger.* Paraproct usually with some minute spicules distad of subbasal process; the latter as long as or shorter than basal sternal process.

PUPA. As figured and as described for *mimeticus,* differing particularly in having seta 9-C always single and seta 1-III 5-8 branched.

LARVA. As figured and as described for *mimeticus* to which it is extremely similar in features of the siphon and in chaetotaxy, differing particularly in having seta 5-C usually 5 branched (4-6) and 6-C usually triple (3, 4).

TYPE-DATA. Holotype ♂ (No. R50-a) and 7 cotypes (4♂, 3♀), Highlands of Baguio, *Luzon:* PHILIPPINES, May 7, 1934, F. E. Baisas (PBH). The holotype and all cotypes are no longer in existence.

DISTRIBUTION. Known only from Luzon in the Philippines. Material examined. 86 specimens: 37♂, 37♀, 12 L; 3 individual larval rearings.

PHILIPPINES. *Luzon,* Bonquet Otok; Bontok, Chico River; Calawan; Mountain Province, Baguio; 37♂, 37♀, 12 L, 3 lp.

TAXONOMIC DISCUSSION. The holotype and cotype adults of *fasyi* originally designated by Baisas (1938: 215-6) were destroyed by termites after World War II (F. E. Baisas personal communication). I have examined several topotypic adults and whole larvae and several others with associated immature stages in the collection of the USNM. The adult of *fasyi* apparently agrees well with the original description of Baisas (1938) and the subsequent description by Delfinado (1966). The pupa and larva of *fasyi* have not been known before and are described here.

Culex fasyi is probably the only representative of the *mimeticus* complex in the Philippines where it appears to be restricted to Luzon. All stages of *fasyi* are exceedingly similar to those of *mimeticus* but can be distinguished from the latter with certainty in the male genitalia by the shorter basal sternal process of the proctiger. There is also much similarity in all stages, including

the male genitalia, between the Philippine *fasyi* and *solitarius* Bonne-Wepster (1938) from New Guinea (Bonne-Wepster 1954: 129-31), suggesting that these forms may be conspecific. However, as I have examined only a few reared specimens of the latter and since the distribution of both forms is still very poorly known, it is premature to synonymize them at this time.

BIONOMICS. *Culex fasyi* is an uncommon Philippine form of *Culex (Culex)* and like *mimeticus*, appears to be restricted to a high elevation. The larvae have been collected in stream pools containing a dense algal mat in association with specimens of *Anopheles* sp. (Baisas 1938). Nothing is known about the adult biology and the medical importance of *fasyi*.

35. *CULEX (CULEX) JACKSONI* EDWARDS
(Figs. 65, 70, 71)

Culex (Culex) jacksoni Edwards (in Barraud) 1934: 452 (♂, ♀, L).
Culex (Culex) fuscifurcatus Edwards, in Barraud 1934: 452 (♂, ♀); Carter and Wijesundara 1948: 149 (L*); Harrison et al. 1974: 143 (distribution). NEW SYNONYMY.
Culex (Culex) kangi Lien 1968: 235 (♂*, ♀*, P*, L*). NEW SYNONYMY.

FEMALE (Fig. 65). Wing: 4.8 mm. Forefemur: 2.2 mm. Proboscis: 2.2 mm. Abdomen: 3.4 mm. Extremely similar to *mimeticus* in the pattern of wing spots, differing slightly in the following features. *Thorax.* Mesonotal scales on anterior 0.7 entirely dark brownish in middle of disc; pale scales restricted to anterior promontory and other marginal areas cephalad of anterior wing base. *Legs.* Anterior surface of forefemur usually speckled with several pale scales in apical 0.5; midtibia usually with distinct longitudinal pale stripe extending from base to apex on anterior surface, continued as narrow stripe on midtarsomere 1. *Wing.* Pattern of pale spots as figured; 3rd costal spot near apex of wing sometimes involves only apical portion of vein R_1; furcation of vein M usually pale, sometimes dark.

MALE. As described for female, differing from *mimeticus* particularly in the following. *Head.* Proboscis with a strong ventral tuft of several long hairs at base of median pale ring; these hairs about 5 times as long as labial width at point of attachment; basal and distal portions of labium without pale scales forming streak proximad or distad of median pale ring on dorsal surface.

MALE GENITALIA (Fig. 70). Exceedingly similar to *mimeticus, fasyi* and *tsengi* in the details of basimere, subapical lobe, distimere and in the type of phallosome, differing from these species in the complete absence of basal sternal process of the proctiger and in having apical tergal crown of inner division usually with 4, 5 fingerlike processes.

PUPA (Fig. 70). Abdomen: 3.5 mm. Paddle: 1.02 mm. Trumpet: 0.85-0.90 mm; index about 7. Apparently very similar to *mimeticus*, differing in the following combination of characters. *Cephalothorax.* Setae 8, 9-C usually double, sometimes triple. *Abdomen.* Seta 1-III usually 5 branched (4-6); 1-IV 4-6 branched; 1-V 2-4 branched; all setae 6-III-VI usually single, rarely double.

LARVA (Fig. 71). Head: 0.85 mm. Siphon: 1.4-1.6 mm; index 5. Saddle: 0.44 mm; siphon/saddle ratio 3.5. Distinguished from *mimeticus* and *fasyi* by the presence of 2-11 prominent ventrolateral spines in apical 0.5 of siphon and by the following features. *Head.* Seta 5-C usually 5 branched (4-7);

6-C usually triple, sometimes 4 branched. Antenna relatively short, its length varying from 0.5 to 0.75 of head length. *Thorax.* Seta 7-P usually triple, sometimes 4 branched; 8-P usually double, sometimes triple. *Abdomen.* Seta 6-I usually 4, 5 branched, rarely triple; 6-II 4, 5 branched; 6-III, IV usually 3, 4 branched, rarely double; 6-V, VI double or triple; 1-III-VI usually double (1-3); 5-I-VI bifid or trifid, rarely single. Comb scales 36-38, all apparently finer and with relatively weaker apical spines. Anal gills slender, usually blue in live specimens, their length slightly exceeding saddle. *Siphon.* Rather thick, moderately long and with variable number of prominent spines on ventrolateral surface within 2, 3 distal pairs of siphonal tufts; 11-19 pecten teeth in basal 0.5 of siphon, sometimes extending to 0.75; siphonal tufts variously developed; 5, 6 pairs (total 10-12) in number, 3, 4 proximal pairs inserted ventrally, but not forming a prominent row, 4, 5 branched, their length varying from slightly shorter to slightly longer than siphonal width at point of attachment; 2 distal pair double, very short and weak.

TYPE-DATA. (1) *Culex (C.) jacksoni* Edwards, Lectotype ♂* with attached genitalia mount; Shonson Hill, HONG KONG, 18 March 1933, R. B. Jackson (BM; present selection); (2) *Culex (C.) fuscifurcatus* Edwards, Lectotype ♂* with attached genitalia mount, Ootacamund, Nilgiri Hills, *Madras,* INDIA, 7, 500 ft., July 1913, T. B. Fletcher (BM; present selection); (3) *Culex (C.) kangi* Lien, Holotype ♂ (76343-1) with associated pupal and larval skins, Chienchi, Hsinchu, Hsien, TAIWAN, ground pool, March 1965, C. C. Kang; deposited in Taiwan Provincial Institute of Infectious Diseases, Taipei, Republic of China.

DISTRIBUTION. Known only from India, Sri Lanka, China (mainland), Hong Kong, and Taiwan. Material examined. 78 specimens: 40♂, 23♀, 15 L; 34 individual rearings (1 pupal, 33 larval).

INDIA. *Madras:* Nilgiri Hills, Ootacamund, Wellington; 23♂, 15♀, 22 lp.

SRI LANKA. Kandy District, Rangala; 1♂, 1♀, 1 lp.

CHINA. W. Peking; Tsichou; 1♂, 5 L (S. Billings 1945).

HONG KONG. Shonson Hill; 4♂, 3♀, 6 L.

TAIWAN. *San Is.:* Miaoli; Hsinchu Hsien, Hsinchu, Chienchi; 11♂, 4♀, 4 lp.

Additional records from the literature: CHINA: Kwangtung, Amoy (Feng 1938; Hsieh and Liao 1956).

TAXONOMIC DISCUSSION. Prior to this study *jacksoni* was poorly known and its identity obscure. This is due to the original description of Edwards (in Barraud 1934: 452) in which the male genitalia was described as resembling *mimeticus* with a further statement that no differences were found between the 2 species. In studying the attached genitalia mount of the type, I have discovered that it differs strikingly from *mimeticus* in the complete absence of the basal sternal process of the proctiger. The larval skin associated with the type is also unique, particularly in the presence of a few peculiar heavy spines in the distal portion of the siphon, agreeing well with the original description of Edwards.

The synonymy of *fuscifurcatus* Edwards 1934 from Nilgiri Hills, India, and *kangi* Lien 1968 from Taiwan with *jacksoni* as proposed has been based primarily on the similarity in the male genitalia and on the detailed comparison of adult types, paratypes (especially *kangi*) and other topotypic reared material. Apart from considerable variation in the number and size of the peculiar spines on the larval siphons, all of these forms are virtually similar, indicating that they are probably conspecific. The larva of the typical Hong Kong form *(jacksoni)* has the spines on the siphon varying from 2 to 5, all of which are rather

short and weak; the Taiwan form *(kangi)* has 4-7 spines all of which are very strong and long and those from India *(fuscifurcatus)* usually have 9-11 spines similarly developed as in the Taiwan form but longer and forming a prominent double row. In spite of these differences, these larval forms are essentially similar in the detailed chaetotaxy and there are no obvious differences in any other associated stage.

Culex jacksoni appears to be as widespread as *mimeticus* in the Oriental region but whether it may be found with the latter in the same breeding site is not known. The Hong Kong material which I examined at the British Museum (Natural History) was a mixture of these 2 species, both of which were probably collected from the same breeding site, judging from the field notes taken by R. B. Jackson during 1933. In separating the adults of jacksoni from *mimeticus*, caution should be taken in using the characters noted above. For positive identification, the associated male genitalia and larvae should also be examined.

BIONOMICS. The larvae and pupae of *jacksoni* have been collected in general ground pools, irrigation ditches and seepage pools in hills or mountainous country at a high elevation. Lien (1968) noted that the larvae (as *kangi*) were found in association with specimens of *vagans*. In the Nilgiri Hills, Madras, India, Edwards (1934) noted that the adults (as *fuscifurcatus*) were collected at 2,200 m. Adult biology and the medical importance of this species are unknown.

36. *CULEX (CULEX) TSENGI* LIEN
(Figs. 65, 72)

Culex (Culex) tsengi Lien 1968: 237 (♂*, ♀*, P*, L*).

FEMALE (Fig. 65). Wing: 3.4 mm. Forefemur: 1.6 mm. Proboscis: 1.8 mm. Abdomen: 2.2 mm. As described by Lien (1968: 237-40); very similar to other members of the *mimeticus* complex in the pattern of wing spots and in nearly all characters as described for *mimeticus*, differing in smaller size and in the following characters. *Head.* Narrow decumbent scales of vertex fine, pale yellowish to whitish; erect scales pale beige or whitish in center, dark on posterolateral areas. *Thorax.* Mesonotal scales relatively narrow, fine and predominately whitish or yellowish on anterior 0.7 of disc except for some dark scales forming spots in middle of fossae and streaks or blotches on posterior acrostichal and dorsocentral lines cephalad of prescutellar space; scales on prescutellar space and scutellar lobes almost whitish. *Legs.* Midtibia with distinct longitudinal pale stripe as in *jacksoni*. *Wing.* Pattern of wing spots as figured; first costal spot in middle of vein C usually involving vein Sc only or sometimes also posterior surface of C; 3rd costal spot near apex of wing absent or with pale scales restricted to apical portion of vein R_1 only; rest of pale spots essentially similar to *mimeticus*. *Abdomen.* Basal pale bands on all terga rather narrow; terga V-VII without median apical pale bands.

MALE. Essentially similar to female, differing slightly from *mimeticus*, *fasyi* and *jacksoni* particularly in the following combination of features. *Head.* Palpal segments 4 and 5 weakly plumose. Proboscis with a weak ventral tuft of about 6 hairs at base of median pale ring; these hairs about 3 times as long as labial width at point of insertion; dorsal surface of labium with pale scale line proximad of median pale ring.

MALE GENITALIA (Fig. 72). As figured; differing from *mimeticus* and

jacksoni in the presence of a short and slender basal sternal process of the proctiger which is similarly developed as in *fasyi*. *Phallosome*. Apical tergal crown of inner division with 2 stout fingerlike processes. *Proctiger*. Basal sternal process rudimentary, its length about 0.01 mm; paraproct without any minute spicules distad of subbasal process.

PUPA. As figured for *mimeticus* and *jacksoni* (Figs. 67, 70); differing slightly in the following. *Trumpet*. Shorter, about 0.6 mm in length. *Cephalothorax*. Setae 8, 9-C double or triple. *Abdomen*. Setae 6-III, IV double or triple; 6-V, VI double.

LARVA (Fig. 72). As figured and described for *mimeticus* (Fig. 67) and *fasyi* to which it is essentially similar in the detailed chaetotaxy, differing from both and from *jacksoni* as follows. *Siphon*. More or less strongly tapered distally; apical 0.5 with 1-3 strong, long spines ventrally or subventrally; pecten teeth 15-22, in row extending from extreme base to 0.5 or more of total length; 4 proximal pairs of siphonal tufts strong, most proximal one strongest, 2-3 times as long as siphonal width at point of attachment, the rest gradually shorter; seta 2-S relatively long, stout and very dark.

TYPE-DATA. Holotype ♂ (62038.9) with associated pupal and larval skins, Chihtuan, Loshui, Tatung, Ilan Hsien, TAIWAN, 1,200 m, seepage, 9 September 1961, C. L. Chung and L. C. Lu; (deposited in Taiwan Provincial Institute of Infectious Diseases, Taipei, Republic of China).

DISTRIBUTION. Known only from Taiwan. Material examined. 10 specimens: 5♂, 5♀, 10 individual larval rearings.

TAIWAN. Tatung (type-locality); Pingtung, Lai-I; Taipei, Wulai; Chia I.

TAXONOMIC DISCUSSION. The taxonomic status of *tsengi* and the problem as to whether or not it may be conspecific with or only subspecifically distinct from *mimeticus*, *fasyi* and *jacksoni* can not be definitely determined. In this study, I tentatively recognize *tsengi* as distinct on the basis of the extent of certain wing spots, male palpus and proboscis, pupal and larval stages as described above.

The adults of *tsengi* can be distinguished from *mimeticus*, *fasyi* and *jacksoni* by the first costal spot of the wing usually involving only vein Sc and by having the 3rd costal spot near the apex of wing usually involving only the apical portion of vein R_1 or completely absent. The male genitalia differ from *mimeticus* in a shorter basal sternal process of the proctiger, but are extremely similar to and virtually indistinguishable from *fasyi*. The larva resembles *mimeticus* and *fasyi* very closely except for the presence of a few strong spines on the siphon. Further study of specimens from progeny rearing is critically needed to establish the affinities of this form.

BIONOMICS. According to Lien (1968), *tsengi* is widely distributed in mountainous regions throughout Taiwan. The type and other specimens in the type-series were obtained from rearing the larvae in ground pools containing green algae in a dried up stream bed at an elevation of 1,200 m. They were frequently found in association with *bitaeniorhynchus*. Nothing is known about the adult biology and the disease relationships of this species.

37. *CULEX (CULEX) MIMULOIDES* BARRAUD
(Figs. 65, 73, 74)

Culex mimeticus Noè var. *mimuloides* Barraud 1924a: 991 (♂* ♀).
Culex (Culex) mimeticus Noè (in part), Edwards 1932: 205 (taxonomy); Barraud 1934: 409 (♂*, ♀, L).

Culex (Culex) mimuloides Barraud, Edwards, in Barraud 1934: 451 (♂, ♀, key).

FEMALE (Fig. 65). Wing: 4.0-5.4 mm (average 4.7 mm). Forefemur: 1.6-2.5 mm (average 2.0 mm). Proboscis: 1.8-2.6 mm (average 2.2 mm). Abdomen. 3.0 mm. Medium or large sized; essentially conforming to the *mimeticus* complex in having first costal pale spot in middle of vein C involving only veins C and Sc. *Head.* Erect scales of vertex usually pale yellowish in center, dark or black on posterolateral areas, sometimes entirely dark. Proboscis with median pale ring occupying 0.15-0.20 of total length. *Cibarial Armature.* Essentially similar to *mimeticus*. *Thorax.* Mesonotal scales coarse, largely dark brown in middle, or partially pale, golden or yellowish on anterior 0.7 of disc, not producing a distinct pattern; scales on posterior margin of fossae and on marginal areas golden or yellowish; scales in middle of prescutellar space and scutellar lobes dense and entirely pale. *Legs.* Anterior surface of fore- and midfemora without light speckling of pale scales; hindfemur without light speckling of pale scales dorsad or distad of longitudinal pale stripe on anterior surface; mid- and hindtibiae with longitudinal pale stripe extending from basal 0.15 to about 0.75 of whole length; tarsomeres 1-4 of all legs with very broad basal and narrow apical pale bands. *Wing.* Pattern of pale spots and venation as figured; vein R_{4+5} usually completely dark or sometimes with a short pale scale line restricted to apical 0.5; furcation of veins R_{2+3} and M usually pale, sometimes dark; Cu_1 completely dark or with a short pale scale line in middle; cell M_2 longer than cell R_2. *Abdomen.* Basal pale bands on all terga narrow or broad. *Genitalia.* As figured for *mimeticus;* tergum IX with a lateral row of 6-8 setae on each side; postgenital plate truncate or lightly emarginate on caudal margin; vaginal sclerite strongly sclerotized, U- or V-shaped; insula with a strong tuft of about 10 setae.

MALE. Essentially as described for female; palpus and proboscis similar to other members of the *mimeticus* complex, differing slightly in the following. *Head.* Ventral scalelike setae of palpal segment 3 widely spaced and apparently less dense; palpal segments 4 and 5 moderately plumose. Proboscis with narrow median pale ring; ventral tuft of hairs at base of median pale ring very weak or not distinct; no scattered pale scales proximad or distad of median pale ring.

MALE GENITALIA (Fig. 73). Similar to *mimeticus* and other related forms, differing particularly in the following details. *Subapical lobe.* Setae *d-f* of distal division strong, most distal longest, nearly as long as setae *a-c* of proximal division; leaf *g* very narrow, short and lanceolate. *Phallosome.* Apical tergal crown of inner division with 3,4 rather short fingerlike processes, all curved, porrect, with apices projecting caudad; sternal spine of outer division strong and sharply angulate at base with apex projecting laterad; mesal spine strong and long; basal lateral process broad, not produced into a distinct knob. *Proctiger.* Basal sternal process moderately thick and relatively long, about 0.06 mm or slightly more; cercal setae 2.

PUPA (Fig. 73). Abdomen: 3.4 mm. Paddle: 0.97 mm. Trumpet: 0.78 mm; index 8. Exceedingly similar to *mimeticus, fasyi* and *jacksoni,* differing particularly in the following combination of chaetotaxy. *Cephalothorax.* Setae 8, 9-C double, rarely single or triple. *Abdomen.* Seta 1-III usually 6, 7 branched (5-8); 1-IV usually 5 branched (4, 5); 1-V 3, 4 branched; 6-III, IV usually double or triple (2-4), 6-V, VI usually triple or 4 branched, rarely double; 5-V, VI double, 1.5 times as long as segment following; 4, 5-VII usually single (1, 2); 4-VIII usually single (1, 2).

LARVA (Fig. 74). Head: 0.80 mm. Siphon: 1.8-2.2 mm; index 8-9. Saddle: 0.44 mm; siphon/saddle ratio 4-5. As figured; distinguished from other members of *mimeticus* complex particularly by following characters. *Head.* Antenna about as long as head; spicules in basal 0.5 of antennal shaft very strong; seta 5-C usually 5 branched (4-6); 6-C triple; 7-C 7, 8 branched. *Thorax.* Seta 4-P double. *Abdomen.* Seta 6-I usually triple, sometimes 4 branched; 6-II always triple; 6-III-VI double; 1-III-VI double, about 0.5 of length of setae 6-III-VI. Comb scales small, 40 or more, all with more or less rounded apical fringes of evenly fine spicules. Saddle lightly or strongly infuscated along caudal and basal margin; spicules weak and few; seta 1-X double; 2-X usually triple (2-3); anal gills slender, pale, 1, 2 times as long as saddle. *Siphon.* Rather thick, straight, distally slightly tapering and relatively long; apical portion without spines on ventral surface; pecten teeth 11-15, 8-14 teeth in basal 0.3 of siphon short, small, barbed with fine denticles; 2-5 distal teeth very strong, heavily pigmented, entirely simple or with a few weak denticles restricted to base; siphonal tufts 6 pairs (or total 12), widely spaced and short; pairing regular; 5 proximal pairs inserted subventrally, 4, 5 branched each, as long as or shorter than siphonal width at point of attachment; 1 distal pair lateral, weak, short and double.

TYPE-DATA. Lectotype ♂* (one of the 2 specimens, No. 1484, marked as type by Barraud) with genitalia slide, Nilgiri Hills, *Madras,* INDIA, October 1915, Khazan Chan (BM; selection of Mattingly 1956: 37).

DISTRIBUTION. India and China (mainland). Material examined. 122 specimens: 36♂, 56♀, 30 L; 71 individual rearings (4 pupal, 67 larval).

INDIA. *Madras:* Nilgiri Hills (type-locality), Ootacamund, Coonoor, Ban Dishola, Lovedale, Kurkuthi, Burliar, Toll Gate, Selas, Aruwam Kadu, Yeddapalli; 36♂, 56♀, 20 L, 4 p, 67 lp.

CHINA. *Yunnan:* Poashan Valley; 10 L (APO 927, S. Billings, 1944).

TAXONOMIC DISCUSSION. The above description of *mimuloides* has been based on the type and several other topotypic reared specimens recently collected by B. N. Mohan from the Nilgiri Hills area. The new record of *mimuloides* from China is based on the larvae which were collected by S. Billings in 1944.

Culex mimuloides was originally recognized as a variety of *mimeticus* by Barraud (1924a: 991-3, 1934: 409-12) but later, Edwards (in Barraud 1934: 451) elevated it to specific rank among the members of his *mimeticus* group. The wing venation of adults of *mimuloides* is very distinctive, as described by Edwards (1934: 451-2), in having the furcation of vein M proximad of that of vein R_{2+3} or cell M_2 distinctly longer than cell R_2. This character is constant and provides a clear cut separation of *mimuloides* adults from the rest of the *mimeticus* complex which exhibit furcations of R_{2+3} and M approximately at same level, with cell R_2 as long as or slightly longer than cell M_2. The pattern of wing spots of *mimuloides* is very variable and is difficult to be used in differentiating it from *mimeticus* and related species. Other stages of *mimuloides* are distinct and can be readily separated from the rest of the *mimeticus* complex.

Culex mimuloides is somewhat intermediate between members of the *mimeticus* and *mimulus* complexes, but apparently resembles *mimeticus* more than *mimulus* in the pattern of wing spots, male genitalia, pupal and larval stages. The male phallosome and the development of the basal sternal process of the proctiger of *mimuloides* are, however, rather similar to or nearly approaching those of the *mimulus* complex and the members of the *Vishnui* Subgroup.

In the Nilgiri Hills, Madras, *mimuloides* has been found to be sympatric with *jacksoni* and *mimeticus* without apparent intergradation in their diagnostic characters.

BIONOMICS. *Culex mimuloides* has been encountered on many occasions, particularly in the type-locality at Nilgiri Hills, Madras, in southern India. The larvae have been collected in ground pools, stone tanks and borrow pits in marshy areas. These breeding sites are at very high elevations. No further data are available on the conditions of the breeding sites. Most of the adults were obtained from rearing the larvae and only a few were caught in the field. Nothing is known about the adult biology and the medical importance of this species.

38. *CULEX (CULEX) DIENGENSIS* BRUG
(Figs. 66, 69)

Culex (Culex) diengensis Brug 1931: 35 (♂*, ♀); Edwards, in Barraud 1934:450 (adult key).

FEMALE (Fig. 66). Wing: 4.8 mm. Forefemur: 2.1 mm. Proboscis: 2.3 mm. Description based on 2 specimens (marked as cotypes by Brug) from Dieng, Java, Indonesia. Essentially conforms to other members of the *mimeticus* complex, distinctive in the following combination of characters. *Thorax*. Anterior 0.7 of mesonotum predominantly golden brown scaled except for dark scale spots in middle of fossae. *Legs*. Anterior surface of fore- and midfemora without speckling of pale scales, subapical yellowish spots very distinct; anterior surface of hindfemur uniformly pale in basal 0.5; apical 0.5 largely dark, with light speckling of pale scales on dorsal lateral surface; all tibiae without longitudinal pale stripe on anterior surface. *Wing*. Pattern of pale spots as figured; differing from *mimeticus* and other related forms particularly in vein R_{4+5} pale from basal 0.1 to almost at apex; vein Cu_1 pale from level of crossvein m-cu to about 0.75 of total length. *Abdomen*. Basal pale bands on all terga moderately broad.

MALE. Based on the holotype which is essentially similar to female in the pattern and extent of wing spots and in general characters; palpus and proboscis broken off and lost.

MALE GENITALIA (Fig. 69). Description based on the holotype slide. Very distinctive; differing from all members of the *mimeticus* complex and Subgroup in the following. *Basimere*. Very large, basal and middle portions strongly swollen, distal portion narrow. *Subapical lobe*. Setae on proximal and distal divisions poorly developed; setae *a-c* very thin and short; setae *d-f* consisting of 4 narrow pointed blades and 3 other rodlike setae; leaf *g* absent; seta *h* inconspicuous. *Distimere*. Strongly modified; shape irregular; basal portion thick, middle portion strongly swollen, distal portion markedly reduced to a long and thin rod which is curved and strongly bent downward; subapical claw short and small; dorsal and ventral setae absent or inconspicuous. *Phallosome*. Apical portion of inner division with 4, 5 strong, long fingerlike processes, all diverging laterad; outer division without mesal and sternal spines. *Proctiger*. Basal sternal process well developed, rather thick, long, strongly bent sternad; cercal setae 3.

PUPA. Description based on one specimen associated with one of the above cotype females. In general as figured and described for *mimeticus* (Fig. 67) and other related species, differing particularly in the following features.

Trumpet. Longer, about 0.85 mm in length; index 6.5. *Cephalothorax.* Seta 8-C 3,4 branched. *Abdomen.* Setae 5-IV, V double; 5-VI single; 6-III triple; 6-IV-VI 3,4 branched; 4, 5-VII double; 9-VII double or triple; 4-VIII double; 9-VIII 3-6 branched. *Paddle.* Very broad; about 1.0 mm in length; inner and outer parts entirely pale, without infuscate area.

LARVA. Unknown.

TYPE-DATA. Holotype ♂* (17.267), with attached genitalia mount, Merdodo Lake, Telaga Warna (Diënghochebene), *Java*, INDONESIA; Peat moss ground pool, 2,000 meters, 2-3 June 1929, A. Thienemann (BM).

DISTRIBUTION. Known only from the type-locality in Java, Indonesia. Material examined. 3 specimens: 1♂ (holotype), 2♀ (marked as cotypes by Brug); 1 individual pupal rearing.

TAXONOMIC DISCUSSION. *Culex diengensis* is the most distinctive form of the *mimeticus* complex and is strongly characterized by several peculiar modifications in the male genitalia. It is assigned to the *mimeticus* complex on the basis of the pattern of wing spots and general external characters of the adults. As in *mimuloides*, the male phallosome and proctiger of *diengensis* are apparently more similar to the members of the *mimulus* complex than to other members of the *mimeticus* complex.

The previous descriptions of the adult wing spots by Brug (1931) and the key to adults, using the extent of pale scaling of vein R_{4+5} and Cu_1 by Edwards (in Barraud 1934: 450) are applicable to this species. The pupa of *diengensis*, which is described here from a single skin associated with one of the 2 cotype females, can be readily separated from other members of the *mimeticus* complex by the branching of setae 8-C, 5-IV-VI and 6-III-VI.

BIONOMICS. The type specimens of *diengensis* came from a single collection in peat moss ground pools in a mountainous region at an elevation of 2,000 m. The adults were apparently obtained from rearing the larvae and pupae. Adult biology and the medical importance of this species are unknown.

39. *CULEX (CULEX) MIMULUS* EDWARDS
(Figs. 16, 75, 76, 77)

Culex mimulus Edwards 1915: 284 (♂, ♀); Barraud 1923a: 942 (L*, in part); Barraud 1924a: 993 (♂*, ♀); Borel 1930: 324 (♂*, ♀*, L*, in part).
Culex mossmani Taylor 1915: 181 (♂*, ♀); Edwards 1924: 394 (synonymy).
Culex (Culex) mimulus Edwards, Edwards 1932: 205 (taxonomy); Barraud 1934: 412 (♂*, ♀, L*, in part); Edwards, in Barraud 1934: 450 (adult, key); Bonne-Wepster and Brug 1937: 66 (♂, ♀*); Baisas 1938: 214 (♂*); Feng 1938: 302 (distribution); Bonne-Wepster and Brug 1939: 1275 (L*); Lee 1944: 104 (L*); Brug and Bonne-Wepster 1947: 187 (distribution); Bonne-Wepster 1954: 127 (♂, ♀*, L*); Safyanova et al 1964: 1178 (distribution); Delfinado 1966: 150 (♂*, ♀); Bram 1967a: 213 (♂*, ♀*, P*, L*).
Culex (Culex) confusus Baisas 1938: 216 (♂*, ♀); Delfinado 1966: 150 (synonymy).
Culex (Culex) neomimulus Lien 1968: 240 (♂*, ♀*, P*, L*). NEW SYNONYMY.

FEMALE (Fig. 16, 75). Wing: 3.2-4.1 mm (average 3.6 mm). Fore-femur: 1.4-2.0 mm (average 1.6 mm). Proboscis: 1.5-2.0 mm (average 1.75 mm). Abdomen: 2.2-2.8 mm (average 2.5 mm). Small or medium sized species; wing length rarely exceeding 4.0 mm; distinguished from the members of the *mimeticus* complex by having first costal pale spot at about middle of vein C, involving veins C, Sc and R_1 or sometimes R_S, M and Cu. *Head.* Narrow

decumbent scales of vertex rather fine, whitish or yellowish, forming a distinct ocular line; erect scales largely pale, yellow or golden in broad median area, dark brown to black posterolaterally; lateral patch of broad appressed scales whitish, very distinct. Palpus completely dark scaled or sometimes apex of segment 4 tipped with a few pale scales. Proboscis with very distinct median pale ring which occupies at least 0.2 of total length. *Cibarial Armature.* Cibarial bar with a concave row of about 30 teeth; median 4-6 teeth narrow and apically pointed; lateral teeth coarser, flattened and apically pointed or blunt, all subequal in length. *Thorax.* Mesonotal integument reddish brown to black; scales on anterior 0.7 of mesonotum usually predominantly pale beige, yellow or golden with mixture of some dark scales forming distinct longitudinal streaks in middle of acrostichal and posterior dorsocentral areas laterad and cephalad of prescutellar space; scales on prescutellar space sparse and entirely pale; scutellar scales pale. *Apn* and *ppn* with narrow, yellow or golden scales. Pleural integument darker above, paler below; pale scale patches on *stp* and *mep* reduced or relatively small. *Legs.* Anterior surface of fore- and midfemora dark and without subapical pale spot; anterior surface of hindfemur entirely dark or with well defined pale stripe from base to near apex, no scattered pale scales among dark scaled areas on dorsal lateral surface; all tibiae without longitudinal pale stripe on anterior surface; tarsomeres 1-4 of all legs with broad basal and narrow apical pale bands. *Wing.* Pattern of pale spots as figured; extent of pale spots variable; base of C usually without pale scaled streak or spot, sometimes with distinct pale scale line from base to 0.5 of total length; first costal spot usually involves veins C, Sc and R_1, sometimes extending to veins R_S, M and Cu; 2nd costal spot involves veins C, apical portion of Sc and R_1; 3rd costal spot near apex of wing usually involves apical portions of veins C, R_1 and R_2, sometimes restricted to R_1 and R_2 or R_1 only; furcations of veins R_{2+3} and M approximately at same level and usually pale, sometimes dark; R_{4+5} usually entirely dark or with pale scale line of variable length in middle; Cu_1 with pale scaled line in basal 0.5, apical 0.5 dark; Cu_2 with pale scales restricted to apical 0.1 or less, fringe scales on apex of Cu_2 pale, rest dark; 1A usually with pale scale line extending from basal 0.1-0.5, apical 0.5 dark; scales on R_2, R_3 and R_{4+5} narrow and dense. *Abdomen.* Basal pale bands on terga II-VII narrow or broad; basolateral pale spots extending to 0.5 of segment length; sterna with broad basal pale bands and narrow apical dark bands. *Genitalia.* Essentially similar to *mimeticus* from which they are indistinguishable.

MALE (Fig. 75). In general similar to female, differing in less dense wing scales and poorly defined wing spots, particularly on veins R_2, R_3, Cu_1 and 1A. *Head.* Palpus exceeding proboscis by 1.0-1.5 of length of segment 5; segment 3 with a broad median pale band on dorsal surface, ventral surface with short scalelike setae along whole length, apical 0.25 with ventral lateral tuft of 10-12 bristles; segments 4 and 5 moderately to strongly plumose and each with distinct basal pale band dorsally; apical 0.25-0.30 of segment 5 pale to tip. Proboscis with a weak ventral tuft of 4-6 short hairs at base of median pale ring, these hairs 2-3 times as long as labial width.

MALE GENITALIA (Fig. 76). Extremely similar to *vishnui* and other members of the *vishnui* complex. *Segment IX.* Tergal lobe poorly developed, with a row of 5, 6 setae. *Basimere.* Slender, conical, with several setae in 2, 3 rows laterad of subapical lobe. *Subapical lobe.* Setae *d-f* of distal division 3, all apparently flattened and subequal in size and length; leaf *g* short, fairly broad, with blunt or acuminate apex. *Distimere.* Normal; with very weak but distinct subapical crest of minute spicules on dorsal surface; ventral and dor-

sal minute setae present beyond middle; subapical claw short, simple, flattened and apically blunt, about 0.006 mm in length. *Phallosome.* Apical tergal crown of inner division porrect, composed of 5, 6 strong fingerlike processes, all curved and with apices projecting caudad; apical sternal spiculate portion irregular, with a few to several small denticles; outer division with a strong mesal tergal spine and 1 heavy sternal spine, the latter strongly or gently bent at base with apex projecting basad; lateral basal process slightly or strongly produced into a rounded knob. *Proctiger.* Apical crown large, dark, composed of several coarse spicules; basal sternal process well developed, very thick, long, dark and strongly curved sternad; subbasal process distinct and prominent; cercal setae 2.

PUPA (Fig. 76). Abdomen: 3.0 mm. Paddle: 0.74 mm. Trumpet: 0.65-0.84 mm; index 8-13. Cephalothorax and abdomen very pale whitish or lightly yellowish with darkened area not forming a definite pattern. Complete chaetotaxy as figured, distinctive in the following. *Trumpet.* Moderately to very long and uniformly cylindrical; sculpturing weak; basal 0.5 of meatus dark, annulate; apical 0.5 pale yellowish; pinna short; apical margin truncate. *Cephalothorax.* Seta 8-C usually double (2-4); 9-C double. *Metanotum.* Seta 10-C 5-7 branched. *Abdomen.* Seta 1-II forked into 3-6 branches; 1-III 9-10 branched; 1-IV 7-9 branched; 1-V 4, 5 branched, 1-V, VI triple or 4 branched (2-4); 5-IV 3-5 branched, slightly shorter or longer than segment V; 5-V, VI double, 1.5 times as long as segment following; 6-III, IV usually triple (2, 3); 6-V, VI 3, 4 branched; 2-VII laterad or mesad of 1-VII; 4-VII double; 5-VII usually single (1, 2); 9-VII usually 4 branched (3-5); 4-VIII double; 9-VIII 8-10 branched. *Paddle.* Broad, entirely pale, without darkened areas.

LARVA (Fig. 77). Head: 0.71-0.78 mm (average 0.75 mm). Siphon 1.9-2.7 mm (average 2.0 mm); index 9-14. Saddle: 0.36 mm; siphon/saddle ratio 4-7. As figured, distinguished from other members of the *Mimeticus* Subgroup by having a long, thin and pale siphon and by the following additional features. *Head.* Integument of head capsule usually whitish or yellowish white; seta 5-C usually 3, 4 branched (2-4); 6-C usually double (2, 3); 14-C minute, inconspicuous. Antenna about as long as head; spicules strong and numerous. *Thorax.* Seta 4-P single, about as long as 3-P; setae 8, 9-M usually 4 branched (4, 5); seta 7-T usually 5 branched (5, 6); 13-T 5-9 branched. *Abdomen.* Setae 6-I, II triple; 7-I single; all setae 5-I-VI always branched; 1-III-VI usually double or triple (2-5); 6-III-VI double. Comb scales about 30 in number, all small, subequal, apical fringe of spicules terminating into a weak median spine. Saddle same color as siphon; seta 1-X weak, double or triple; 2-X usually double (1, 2); anal gills slender and long, 1.5-4.0 times as long as saddle. *Siphon.* Very long, thin and usually whitish or yellowish, sometimes light brownish; distal portion more or less uniform in width or gradually tapering; pecten teeth 16-24, 4, 5 distal teeth with lateral barb of 5-7 delicate denticles and a sharp straight apical spine; siphonal tufts usually 6 pairs (total 12), sometimes 7, all short and weak, 3, 4 branched, widely spaced and regularly paired; 5 proximal pairs inserted subventrally beyond pecten to about 0.75 of total siphon length, 1 pair lateral, inserted beyond the middle; 3 proximal subventral pairs as long as or slightly longer than siphonal width at point of attachment, rest shorter and weaker; seta 2-S dark, slender and moderately long; median caudal filament of spiracular apparatus absent.

TYPE-DATA. (1) *Culex mimulus* Edwards, Lectotype ♂* (one of 2 syntypes) with genitalia slide, Kuching, *Sarawak,* BORNEO, J. C. Moulton (BM; present selection); (2) *Culex mossmani* Taylor, Type (?), Mossman, *Queensland,* AUSTRALIA (US); (3) *Culex (C.) confusus* Baisas, Holotype

♂ (R79-a), Balabac, *Balabac Island,* PHILIPPINES, 23 June 1934, F. Guinto (PBH; non-existent); (4) *Culex (C.) neomimulus* Lien, Holotype ♂ (78788.32) with associated pupal and larval skins, Pinglin, Shuangchi, Taipei Hsien, TAIWAN; ditch, 17 November 1966, L. C. Lu; (deposited in Taiwan Provincial Institute of Infectious Diseases, Taipei, Republic of China).

DISTRIBUTION. Widespread throughout Southeast Asia, extending west in India and Sri Lanka; north in China, east and south in Papua-New Guinea and northern Australia. Material examined. 974 specimens: 316♂, 364♀, 294 L; 314 individual rearings (113 pupal, 201 larval).

INDIA. *Bombay:* Deccan; Karwa; *Assam:* Dibrugarh; Jorhat; Rupsi; Ledo; *Bengal:* Pusa; 4♂, 8♀, 13 L.

BANGLADESH. Sylhet; 1♂, 3 L, 1 lp.

SRI LANKA. *Central Province:* Kandy District; *North Central Province:* Anuradhapura District; *Northern Province:* Vavuniya District; Suduganga; Kumnegala; 3♂, 4♀, 8 L.

THAILAND. *Chiang Mai:* Doi Huey Som; *Nan:* Ban Sa La; Ban Pha Man; Ban Fang Min; Phuang Chom Phu; Ban Ta Loe; *Lampang:* Ngao; Ban Pha Daeng; Ban Pha Khoi; *Khon Kaen; Mae Hong Son; Nakhon Ratchasima:* Khao Yai; Pachong; Ban Musi; *Kanchanaburi:* Sai Yok; Ban Sai Noi; *Chon Buri:* Bang La Mung; Bang Pain; *Ranong:* Ban Bang Laem Phu; *Surat Thani; Phangnga:* Pathum; Khao Sung; *Nakhon Si Thammarat:* Ban Thuan Lek; *Songkhla; Narathiwat; Stul:* Muang; 57♂, 70♀, 113 L, 76 p; 22 lp.

MALAYSIA. *Peninsular Malaysia-Selangor:* Rantau Pangjang; Ulu Gombak; Ulu Langat; Kuala Lumpur; Kepong F. R.; *Perak:* Chior F. R.; Tg. Rambutan; Kuala Kangsar; Kg. Kuala Dipang; C. Highlands Rd.; Chikus; Seremban, *Pahang:* Chegar Perah; Fraser Hills; Bentong; Gunong Benom; Kuantan; *Trengganu:* Marang; Kemaman; *Johore:* Labis; Senai; *N. S. (Negeri Sembilan):* Seremban; Cape Rachado F. R.; Kg. Inas; 158♂, 163♀, 92 L, 34 p, 115 lp. *Malaysia-Sabah:* Tawau; Kudat; Semporna; Beaufort; Tenom; Sipitang; Mt. Kinabalu; Kota Kinabalu (Jesselton); Keningau; Brunei: Tutong District; *Sarawak:* Kuching (type locality); 63♂, 83♀, 5 L, 3 p, 31 lp.

SINGAPORE. 1♂, 1♀.

INDONESIA. *Sumatra:* Bengkulu; Mt. Tebo; 1♂, 2♀; *Sulawesi;* 2 L.

PAPUA-NEW GUINEA. *Morobe:* Wau; Mt. Missim; *Sepik:* Maprik; 3♂, 2♀, 3 lp.

PHILIPPINES. *Palawan:* Puerto Princesa; Tacburos; Iwahig; Irahnan River; Balsahan River; Bacungan; *Leyte:* Tacloban; *Jolo Jolo Is.;* Muni; *Isabela:* Basilan; *Mindanao:* Agusan, S. Francisco; 14♂, 21♀, 22 L, 27 lp.

HONG KONG. 1♂, 1♀.

TAIWAN. Wan Luan, Pintung; Sun Moon Lake, Keelung; Pinglin, Shuangchi, Tapei Hsien; 7♂, 7♀, 36 L, 2 lp.

CHINA. Hanchow; Checkiang; 3♂, 2♀.

Additional records from the literature: PAKISTAN (Aslamkhan 1971); BURMA (Barraud 1934). CHINA: Hunan, Kwangtung, Hainan, Amoy (Feng 1938; Chu 1958; Hsieh and Liao 1956). INDONESIA: Banka; Java; Edam; Borneo (Kalimantan); Kabaena (Brug and Bonne-Wepster 1947; Bonne-Wepster 1954); West Irian: Hollandia (Kota Baru) (Assem and Bonne-Wepster 1964). VIETNAM: Cao Bang; Than Hoa (Safyanava et al 1964). AUSTRALIA: Queensland (Edwards 1924; Lee 1944).

TAXONOMIC DISCUSSION. *Culex mimulus* is the most dominant and widespread form of the spotted wing *Culex* in Southeast Asia and adjacent areas where it probably originated and subsequently dispersed eastward into New Guinea and northern Australia. As discussed by Bram (1967a) and as evident

here, all stages of *mimulus* are very variable. Recently, 2 new additional taxa, *neomimulus* and *murrelli*, have been recognized by Lien (1968) from Taiwan. The present study of the *mimulus* material from several parts of Southeast Asia, including also some paratypes of Lien's species from Taiwan indicates that a complex of forms is involved which exhibits extremely similar adults but with strongly differentiated larvae, somewhat resembling the situation in the *vishnui* complex. Unfortunately, Lien (loc. cit.) in describing his new species did not attempt to revise the entire complex or to describe all stages of the typical *mimulus* for comparison. It is evident, however, that the typical *mimulus* and the 2 new species described by Lien are widespread and apparently exhibit general overlap throughout Southeast Asia and India. Since the typical *mimulus* was originally described only from adults (Edwards 1915), it is not possible to determine exactly as to which adult form the larva and pupa should belong. However, it appears most probable that only 2 taxa are involved in the complex and that these should be recognized as distinct species. One of these is *mimulus* of most authors and the other is *murrelli* described by Lien (1968) from Taiwan. In comparing the paratypes of *neomimulus* Lien with the type and topotypic specimens of the typical *mimulus*, I found them extremely similar in all stages. The adults of *neomimulus* which were described by Lien as distinct from *mimulus* in having the first costal spot involving veins C, Sc, R_1, R_S and sometimes also M and Cu exhibit apparently nothing more than the normal variation of *mimulus* populations from the rest of Southeast Asia. On this basis, I am convinced that they are conspecific and am synonymizing *neomimulus* with *mimulus*.

Culex mimulus is very variable but can be readily separated from the rest of the *Mimeticus* Subgroup except *murrelli* by the pattern and extent of the wing spots as described above. It differs from *murrelli* slightly in having the first costal spot usually extended to veins R_S, M and Cu. In the breeding habitat, typical *mimulus* is more or less restricted to general ground pools with living vegetation whereas *murrelli* is usually restricted to rock pools containing decayed leaves.

The affinities of *mimulus* and its closely related forms, *murrelli* and *propinquus* are not clear, but they appear to be somewhat intermediate between members of the *mimeticus* and *vishnui* complexes. They are similar to the *mimeticus* complex in the development of the wing spots in the adults and in several pupal and larval characters but are more similar to the members of the *vishnui* complex than to the *mimeticus* complex in the type of the male phallosome and in the development of the basal sternal process of the proctiger.

BIONOMICS. *Culex mimulus* is locally fairly common and has been frequently encountered in hills and mountains toward inland areas. The larvae and pupae have been collected in a variety of ground pools, including ponds, wells, ditches, stream pools and marshy depressions but not in rock pools. These breeding sites usually contain green algae, mosses, grasses and other aquatic vegetation. The habitats are fully exposed to sunlight, under partial or heavy shade of forest bushes at an elevation ranging from above sea level to 1,400 m or more. The immatures have also been found in artificial containers such as concrete, stone or cement tanks, coconut shells, snail shells (Delfinado 1966), bamboo stumps and treeholes. The majority of the adults have been reared from pupae or larvae and only a small number were from general field catches and light traps. Bram (1967a) noted that in Thailand adults were collected in houses. Colless (1959) reported that in Singapore females probably feed on birds but are not known to bite man. Nothing is known about the medical importance of *mimulus*.

40. *CULEX (CULEX) MURRELLI* LIEN
(Figs. 66, 78, 79)

Culex (Culex) murrelli Lien 1968: 243 (♂*, ♀*, P*, L*).
Culex mimulus Edwards 1915 (in part), Barraud 1923a: 942 (L*).
Culex (Culex) mimulus Edwards (in part), Barraud 1934: 412 (♂*, ♀, L*); Bram 1967a: 213 (♂*, ♀*, P*, L*).

FEMALE (Fig. 66). As described by Lien (1968: 243-6). Exceedingly similar to *mimulus* in general facies and in the pattern of wing spots, differing slightly in the following characters. *Head.* Palpus usually tipped with pale scales on apex of segment 4. *Cibarial Armature.* As described and figured for *mimulus* from which it is indistinguishable. *Thorax.* Mesonotum largely yellowish or golden scaled and usually with dark scales forming more distinct spots, streaks or patches on fossae, acrostichal line and on posterior dorsocentral areas laterad and cephalad of prescutellar space. *Wing.* Base of vein C without pale scale streak or line on posterior surface; first costal pale spot at middle of vein C restricted to C, S_C and R_1; vein R_{4+5} usually with pale scaled line in middle portion, sometimes entirely dark. *Genitalia.* As described and figured for *mimulus* from which it is indistinguishable.

MALE. As in female, differing from *mimulus* in the following. *Head.* Palpus relatively shorter, exceeding proboscis by at most the length of segment 5; apical 0.25 of segment 3 with ventrolateral tuft of 5-10 dark bristles; segments 4 and 5 apparently with shorter and fewer bristles on mesal and lateral surfaces.

MALE GENITALIA (Fig. 78). Exceedingly similar to *mimulus* in every detail of basimere, subapical lobe, shape of distimere, phallosome and proctiger; differing chiefly in a more slender and longer subapical claw of the distimere which is about 0.01 mm in length.

PUPA (Fig. 78). Abdomen: 2.4 mm. Paddle: 0.72 mm. Trumpet: 0.62 mm; index 7-9. Differing from *mimulus* particularly in the following characters. *Trumpet.* Relatively shorter and with lower index; coloration darker. *Cephalothorax.* Darker, with considerable amount of brownish tinge forming more or less definite darkened areas along middorsal ridge, leg, palpal, proboscis and wing cases; seta 8-C always double. *Metanotum.* Darker, with considerable amount of brownish tinge; seta 11-C usually double, sometimes single. *Abdomen.* Segment I-IV darker, with variable amount of brownish tinge; seta 1-III 5, 6 branched; 1-IV usually 5 branched (4-6); 5-IV double or triple, rarely 4 branched or more.

LARVA (Fig. 79). Head: 0.78 mm. Siphon: 1.4-1.8 mm (average 1.6 mm); index 6-7. Saddle: 0.36 mm; siphon/saddle ratio 4-5. Complete chaetotaxy as figured; differing from *mimulus* as indicated in the key and in the following additional features. *Head.* Head capsule darker, usually with considerable amount of brownish or blackish tinge; seta 6-C always double. *Thorax.* Live specimens usually with considerable amount of dark greenish tinge. *Abdomen.* Color in live specimens same as on thorax; setae 1-III-VI usually double, sometimes single, rarely triple; 1-IV, V usually strong and long, varying from more than 0.5 to 1.0 of seta 6. Comb scales 40-50, apical fringe of spicules normal or rounded and without differentiated median apical spine, sometimes with median apical spine slightly longer than adjacent spicules, but apparently not differentiated as a prominent spine as in *mimulus*. Saddle same color as siphon, posterior caudal margin lightly to strongly infuscate; anal gills 1, 2

times as long as saddle. *Siphon.* Relatively short, thick, straight and distally slightly tapering, with lower index and siphon/saddle ratio; color same as head capsule; pecten teeth 12-13, siphonal tufts stronger, usually 5 pairs (or total 10), sometimes 4 or 6 pairs, more closely spaced; each tuft 3,4 branched; 4 pairs inserted subventrally beyond pecten to about 0.75 of siphon length, 1 pair inserted laterally beyond middle; most proximal tuft about as long as siphonal width at point of attachment, rest gradually shorter; median caudal filament of spiracular apparatus present, rather short or poorly developed.

TYPE-DATA. Holotype ♂ (76324.28) with associated pupal and larval skins, Hsinhsien, Wulai, *Tapei,* Hsien, TAIWAN, rock pool, 23 April 1963, C. L. Chung; (deposited in Taiwan Provincial Institute of Infectious Diseases, Taipei, Republic of China).

DISTRIBUTION. Probably widespread in Southeast Asia and adjacent areas; recorded from Taiwan, China, Thailand, Vietnam and Peninsular Malaysia. Material examined. 737 specimens: 209♂, 220♀, 308 L; 282 individual rearings (142 pupal, 140 larval).

THAILAND. *Chiang Mai:* Doi Sutep; Huey Kaew; *Mae Hong Son:* Ban Mae Hokae; *Lampoon; Khon Kaen; Nakhon Ratchasima:* Pak Chong; Khao Yai; Lam Huey; Tha Khlong; *Nakhon Nayok:* Khao Keow; Sariga water fall; *Kanchanaburi; Chon Buri:* Khao Nga Chang; *Tak:* Huey Lang Saeng; Doi Sam Sao; *Prachin Buri:* Khao Din Ngin; *Trat:* Koh Chang; *Nakhon Sawan; Chanthaburi, Ranong:* Khao Ching Chang; Hard Sampan; Khlong Set Takuat; *Prachuap Khiri Khan; Surat Thani:* Koh Samui; Khao Yai; Khao Phlu; *Trang:* Muang; *Phuket; Songkhla:* Boripat Water Fall; Tone Nga Chang; *Yala;* 164♂, 174♀, 253 L, 124 p, 92 lp.

VIETNAM. Dalat; Saigon; Cam Ranh Bay; 10♂, 14♀, 7 L, 10 p, 4 lp.

MALAYSIA. *Peninsular Malaysia-Pahang:* Frasers' Hills; C. Highlands; Betong; *Perak:* C. Highlands Road; 34♂, 31♀, 46 L, 8 p, 42 lp.

TAIWAN. *Taipei:* Hsinhsien, Wulai (type-locality); 1♂, 1♀, 2 lp (paratypes).

CHINA. Nanking; 2 L.

TAXONOMIC DISCUSSION. *Culex murrelli* is apparently widespread in Southeast Asia but is not as frequently encountered as the typical *mimulus.* In addition to the above records, *murrelli* probably also occurs in India judging from the figures and descriptions of the *mimulus* larva by Barraud (1923a: 942, 1934: 410). As pointed out by Lien (1968: 243-6) the *mimulus* larva as figured and described by Bram (1967a: 217-9) from Thailand was partially referrable to this species. Within Southeast Asia, *murrelli* occurs sympatrically with the typical *mimulus* over a broad range of elevation but has not yet been found in Sarawak which is the type locality of *mimulus.* It appears to be absent in Borneo, the Philippines, islands of Indonesia and New Guinea where *mimulus* is predominant and is the only species of the complex known (Bonne-Wepster and Brug 1939, Bonne-Wepster 1954, Assem and Bonne-Wepster 1964).

Culex murrelli is strongly differentiated from the typical *mimulus* in the larva most conspicuously by (1) the shorter, thicker and darker siphon; (2) the presence of 5 pairs of siphonal tufts (at least 6 in *mimulus*); (3) the normal apical fringe of the comb scales, without a distinct apical median spine and (4) the stronger and longer setae 1-IV-VI which are single or double. The pupa of *murrelli,* although showing a great deal of overlap with *mimulus* in most features of the chaetotaxy, can be separated from the latter by the darker integument of the cephalothorax and abdomen and by the reduction in the number of branches of setae 1-III and IV. The adults of *murrelli* exhibit considerable overlap with those of *mimulus* but differ from the latter slightly in having

the first costal pale spot of the wing restricted to veins C, Sc and R_1. In the male genitalia, *murrelli* differs slightly from *mimulus* in having a longer and more slender subapical claw of the distimere, but show no other differences. As discussed under *mimulus*, *murrelli* apparently exhibits a tendency to breed in rock pools containing dead leaves rather than general ground pools with algae, mosses or other living aquatic vegetation as in the case of the typical *mimulus*. These differences, which are accompanied by a marked divergence in several larval characters indicate that it is ecologically distinct and that it was probably derived from *mimulus* through specialization in the breeding habitat. No evidence has yet been obtained to indicate that there is an overlap in the breeding sites of the 2 species.

BIONOMICS. *Culex murrelli* is fairly common in the localities where it has been collected. At the type-locality in Taiwan, Lien (1968) collected the larvae from rock pools without further detail on the conditions of the breeding sites. Several larval collections have been made in various parts of Thailand, and the majority of these were from rock pools, containing numerous decayed leaves in secondary tropical forest at an elevation ranging from 100 to 150 m. In Peninsular Malaysia, the larvae have been collected both from ground pools with algae and rock pools with decayed leaves at a broad range of elevation from 100 to 1,400 m. All adults were obtained from rearing the pupae or larvae. Nothing is known about adult biology and the medical importance of *murrelli*.

41. *CULEX (CULEX) PROPINQUUS* COLLESS
(Fig. 66)

Culex (Culex) propinquus Colless 1955: 315 (♀*)

FEMALE (Fig. 66). Description based on the holotype. As described by Colless (1955: 315-6) with the following redescription. Generally resembling *mimulus* in the pattern and extent of wing spots, differing from it most conspicuously in having a row or chain of pale spots on veins Cu, Cu_2, and middle of 1A and in the following additional characters. *Head*. Narrow decumbent scales of vertex finer, fewer and largely whitish, forming a distinct ocular line; erect scales more slender, predominantly pale golden in center, dark or blackish on posterolateral areas; lateral patch of broad appressed scales whitish, very distinct. Palpus entirely dark. Proboscis with a broad median pale ring which occupies about 0.3 of total length; basal 0.5 proximad of median pale ring lightly sprinkled with pale scales on lateral and dorsal surfaces. *Thorax*. Mesonotal integument dark brown; scales on anterior 0.7 of mesonotum narrow, rather fine, sparse and predominantly whitish or golden, contrasting sharply with dark integument underneath; no dark scales forming distinct spots, streaks or blotches among pale ones; scales laterad of prescutellar space very sparse and dark, contrasting with pale scales on anterior 0.7 of mesonotal disc; scales on middle of prescutellar space and scutellar lobe whitish or beige. Pleural integument reddish brown; *stp* and *mep* with relatively small scale patches; no scales among upper *mep* bristles. *Legs*. Fore- and midfemora with speckling of pale scales on anterior surface; speckling of midfemur more extensive than that of forefemur; anterior surface of hindfemur with pale stripe and speckling of pale scales among dark scaled area dorsad of stripe; tibiae and tarsomeres 1 of all legs lightly speckled with pale scales anteriorly. *Wing*. Pattern of pale spots as figured; base of vein C without pale scale streak on

posterior surface; first costal pale spot involving only veins C, Sc and R_1; 3rd costal spot involving apical portions of vein C and R_1; furcation of vein R_{2+3} largely pale proximally; vein R_{4+5} with a short pale scale line in basal 0.5; Cu_1 with a long pale scale line from basal 0.25 to almost apex; Cu with a row of a few pale spots proximad of point of furcation; Cu_2 with a row of 2-5 pale spots at 0.2-0.8 of total length; 1A with a row of 5 pale spots in middle. *Abdomen.* Basal bands on all terga poorly developed or indistinct; tergum II with a small basal pale spot at middle; terga III-V with very narrow, indistinct basal pale bands; terga VI, VII without distinct basal bands; tergum VIII with distinct apical pale band; sterna largely dark, with very poorly defined narrow basal pale bands on all segments.

MALE, PUPA and LARVA. Unknown.

TYPE-DATA. Holotype ♀*, Pulau Blakang Mati, SINGAPORE, reared from pupa taken in a well (a sunken 44 gallon drum), 23 February 1955, D. H. Colless (BM).

DISTRIBUTION. Known only from the type-locality in Singapore. Material examined: 1♀ (holotype), as indicated in the type data.

TAXONOMIC DISCUSSION. According to Colless (1955: 315), *propinquus* is known only from 3 females, all of which came from a single collection at the type-locality in Singapore. They are strikingly different from the *mimulus* and *murrelli* in the speckling of the proboscis and legs and in the characteristic rows of pale spots on veins Cu, Cu_2 and 1A of the wing. None of the adults among the numerous material of *mimulus* and *murrelli* I have examined exhibits an overlap in these characters with *propinquus*.

BIONOMICS. The type and 2 other females of *propinquus* were obtained from rearing pupae collected in a well, made of a sunken 44 gallon drum (Colless 1955). No further data are available.

42. *CULEX (CULEX) ORIENTALIS* EDWARDS
(Figs. 66, 80)

Culex orientalis Edwards 1921: 338 (♂, ♀).
Culex (Culex) orientalis Edwards, Edwards 1932: 205 (taxonomy); Edwards, in Barraud 1934: 450 (adult key); LaCasse and Yamaguti 1950: 246 (♂*, ♀*, P*, L*); Hara 1957: 56 (♀* genitalia).

FEMALE (Fig. 66). Description based on specimens from Japan and Korea. Wing: 4.4 mm. Forefemur: 2.0 mm. Proboscis: 2.2 mm. Abdomen: 3.4 mm. Medium or large species; as described and figured by LaCasse and Yamaguti (1950: 246-50); readily distinguished from the rest of *Mimeticus* Subgroup in the wing by the presence of distinct basal costal pale spot which involves posterior surface of vein C, extreme base of vein R and sometimes M and by the following additional features. *Head.* Narrow decumbent scales of vertex very coarse and largely pale yellowish; erect scales coarse, pale golden to whitish in center, dark on posterolateral area. Palpus with several pale scales on apex of segment 4. Proboscis with a broad median pale ring, occupying 0.25-0.35 of total length; no speckling of pale scales distad or proximad of median pale ring. *Cibarial Armature.* Cibarial bar evenly concave, with about 30 delicate teeth, all of which are minute, subequal in size and length and with abruptly pointed or blunt apex. *Thorax.* Mesonotal scales very coarse, color variable from predominantly pale to partially brownish in middle and pale on marginal areas in anterior 0.7 of disc. Pleural scale patches relatively broad,

particularly on *stp* and *mep*. *Legs*. Anterior surface of fore- and midfemora uniformly dark or sometimes with light speckling of pale scales; subapical pale spots very distinct; anterior surface of hindfemur with distinct longitudinal pale stripe and light speckling of pale scales among dark areas dorsad and distad of the stripe; tibiae of all legs with poorly defined longitudinal pale stripes anteriorly; all tarsomeres 1-4 with broad basal and apical pale bands. *Wing*. Pattern of pale spots as figured; extent of spots or streaks variable; basal costal pale spot near humeral vein usually involving posterior surface of vein C, base of R and sometimes also M and Cu; first costal spot at middle of C usually involving C, Sc and R_1, sometimes also M; 2nd costal spot involving C, Sc and R_1; 3rd costal spot usually involving apical portions of C, R_1 and R_2, sometimes restricted to C and R_1 only; furcation of R_{2+3} and M always pale; vein R_{4+5} usually with a broad pale scale line extending from basal 0.1 to apical 0.75 of length; Cu with or without a short pale scale streak proximad point of furcation; Cu_1 with a broad pale scale line from basal 0.25 to apical 0.75 of length; Cu_2 usually with pale scale line from 0.5 to apex; 1A with pale scale line from extreme base to 0.5 or more of total length. *Abdomen*. Basal pale bands on terga II-VII usually very broad, sometimes narrow. *Genitalia*. Apparently indistinguishable from other members of the *Mimeticus* Subgroup. Tergum IX with a lateral row of 6,7 setae; postgenital plate rounded on caudal margin; vaginal sclerite V-shaped and strongly sclerotized; insula with a strong tuft of 10 setae.

MALE. Essentially as described for female; differing in the presence of absence of basal costal pale spot of the wing and from other members of the *Mimeticus* Subgroup in the following. *Head*. Palpus very slender and relatively short, usually exceeding proboscis by at most the full length of segment 5, sometimes shorter; apical 0.1-0.2 of segment 3 with 3-5 weak bristles; segments 4 and 5 reduced in length, weakly to moderately plumose, all bristles rather weak and short. Proboscis with or without ventral weak tuft of hairs at base of median pale ring; apical portion distad of median pale ring largely pale on dorsal surface; basal portion proximad of median pale ring entirely dark or with some scattered pale scales on dorsal surface.

MALE GENITALIA (Fig. 80). Strongly differentiated from the rest of the *Mimeticus* Subgroup in the modification of basimere, subapical lobe and distimere as in the following. *Segment IX*. Tergum narrow; tergal lobe poorly developed, bearing a row of 3,4 setae. *Basimere*. Abnormally large, about 0.42 mm in length; basal portion strongly swollen; apical portion narrow, elongate, with a characteristic subapical tuft of numerous strong bristles on lateral sternal surface; upper lateral tergal surface with numerous long hairlike setae forming a broad patch laterad of subapical lobe; other strong bristles confined to lower lateral surface in basal portion. *Subapical lobe*. Very broad and with numerous long hairlike setae associated with specialized seta of proximal division; proximal and distal divisions widely separated; proximal division very broad, with a close-set row of 3 rodlike setae *(a-c)* and 4,5 strong blades and 1 club-shaped leaf *(d-f)*; distal division with a narrow, short, club-shaped leaflet *(g)* and a very long and strong seta *(h)* distad. *Distimere*. Very large and long; basal portion thick, middle portion enlarged or swollen, distal portion tapered into a blunt point; dorsal margin with distinct crest of several strong spicules extending from basal 0.4 to apex; ventral margin irregular; dorsal and ventral minute setae present; subapical claw very short and slender, placed more or less at apex. *Phallosome*. Generally similar to *mimulus;* apical tergal crown of inner division with 4,5 short slender digitiform processes; outer division with 1,2 strong mesal spines and 1 strong, laterally diver-

gent sternal spine; lateral basal process broadly rounded. *Proctiger.* Apical crown very large, dark, composed of numerous strong spicules; basal sternal process well developed, moderately thick, long and gently curved sternad; cercal setae 3.

PUPA. Specimen not available for description.

LARVA (Fig. 80). Head: 0.78 mm. Siphon: 2.0 mm; index 7. Saddle: 0.43 mm; siphon/saddle ratio 5. As figured and described by LaCasse and Yamaguti (1950: 246-51); strongly resembling typical *mimulus* in most features, differing from it particularly in the following. *Abdomen.* Setae 1-III-VI 4-6 branched, all subequal, about 0.5 or less of the length of setae 6; 6-III, IV double or triple. Comb scales 20-40, all small, subequal and with apical fringe terminating in a strong median spine. Seta 1-X 3, 4 branched; 2-X usually triple (2-4); anal gills 1.5 times as long as saddle. *Siphon.* Shorter and relatively thicker; distally gradually tapered; siphonal tufts 6-8 pairs (or total 12-16); 5-7 pairs subventral, placed beyond pecten to about 0.9 of siphon length; 1 pair lateral, placed beyond the middle; subventral pairs 4, 5 branched, most proximal as long as siphonal width at point of attachment, rest gradually shorter; lateral pairs triple and short; median caudal filament of spiracular apparatus absent.

TYPE-DATA. Holotype ♂*, *Tokyo,* JAPAN, 5 October 1915, S. Yamada; (BM).

DISTRIBUTION. Japan and Korea; also reported from the Philippines, Taiwan, China and USSR. Material examined. 90 specimens: 25♂, 45♀, 20 L.

JAPAN. Tokyo (Type-locality); Yokohama; Kyoto; Yodo; Saitama, Sagiyama; 9♂, 16♀, 8 L.

KOREA. Seoul; Chinhae; other unspecified localities; 16♂, 29♀, 12 L.

Additional records from the literature: PHILIPPINES: Balabac Island; Laguna Province, Luzon (Baisas 1938); TAIWAN: Hwalien Hsien (Lien 1962); USSR: Khaborov; Ussurii; Maritime Province (Monchadskii 1951); CHINA: Chekiang; Kwangtung; Liaoning (Feng 1938).

TAXONOMIC DISCUSSION. *Culex orientalis* exhibits a strong affinity with the members of the *mimulus* complex in the pattern of wing spots, the type of the phallosome and the development of the basal sternal process of the proctiger of the male genitalia and in larval characters. Except for several constant diagnostic features, the *orientalis* adults are very variable, particularly in the extent of the wing spots, color of mesonotal scales and in the length and the plumosity of segments 4 and 5 of the male palpus. This seems to indicate that *orientalis* is probably a complex of forms which at present cannot be correlated in any way with their geographical distribution.

Culex orientalis can be easily recognized in the adults, especially the female by the presence of a distinct basal pale spot which involves veins C, R or also M and Cu of the wing in addition to the other pale costal spots or streaks as described in all other species of the *Mimeticus* Subgroup. The male genitalia of *orientalis* are unique, strongly differentiated from the rest of the *Mimeticus* Subgroup by the modification of the basimere, distimere and by the detail of the subapical lobe. The larvae described above, although not definitely associated with the adults apparently agree well with the description and figure by LaCasse and Yamaguti (1950: 248-9). The *orientalis* larvae apparently resemble those of *mimulus* more than any other members of the *Mimeticus* Subgroup.

Culex orientalis is probably restricted to the northeastern Palearctic, particularly in Japan and Korea and possibly also in north China and USSR. The previous records of this species from Sri Lanka by Carter (1950), Taiwan

by Lien (1962) and from the Philippines by Baisas (1938) are very doubtful and require confirmation. The females recorded as this species from Balabac Island and Laguna Province, Luzon in the Philippines (Baisas 1938: 217) are probably specimens of *mimulus* judging by the description of this author.

BIONOMICS. According to LaCasse and Yamaguti (1950), *orientalis* is moderately abundant in Japan where it has been found to be more common in the north than in the south. The most frequent breeding sites include ground pools, rice fields; natural and artificial ponds, margins of slow moving ditches and streams. The majority of these collections were made in open sunny habitats, containing duckweed, algae or lily pads at a high altitude in mountainous regions. The immatures were frequently collected in association with specimens of *Culex (Eumelanomyia) hayashii* Yamada,* *(Lophoceraomyia) infantulus, C. (Culex) tritaeniorhynchus, C. (Culex) pseudovishnui* and *C. (Culex) bitaeniorhynchus; Anopheles sinensis* Wiedemann and *Aedes dorsalis* (Meigen). Most adults from Japan and Korea are labelled as coming from field catches. In Japan, there is nothing to indicate that this species bites man (LaCasse and Yamaguti 1950). Nothing is known about adult feeding habits and the disease relationships of *orientalis*.

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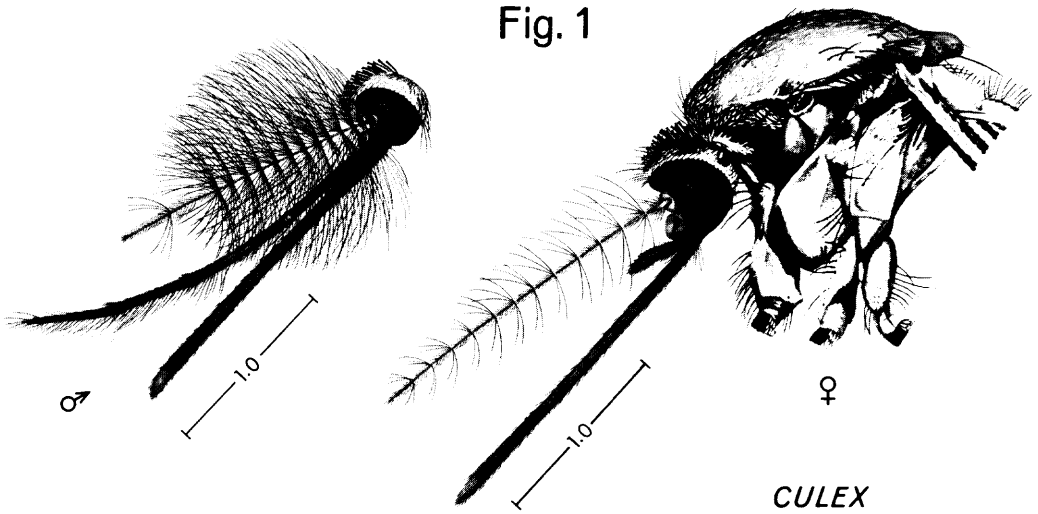
Fig. 1



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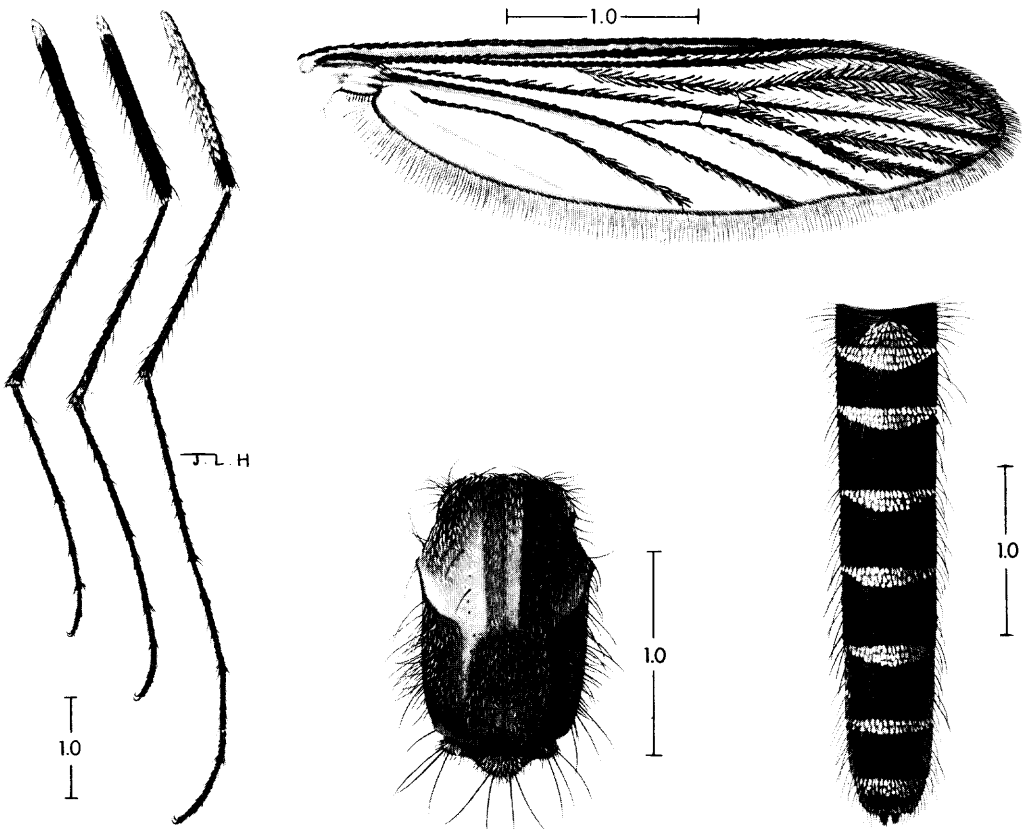
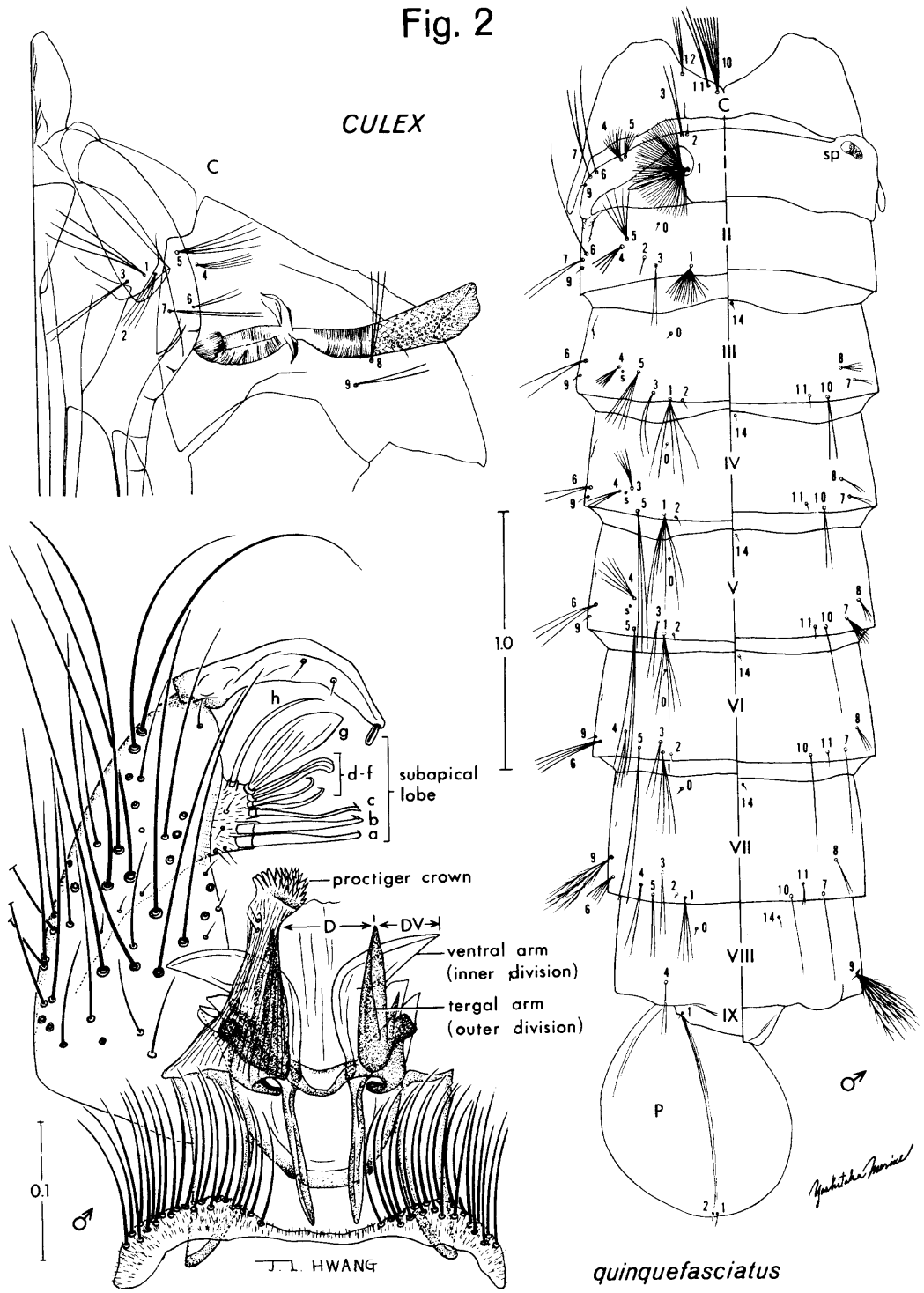


quinquefasciatus

S. ohtawa

Fig. 2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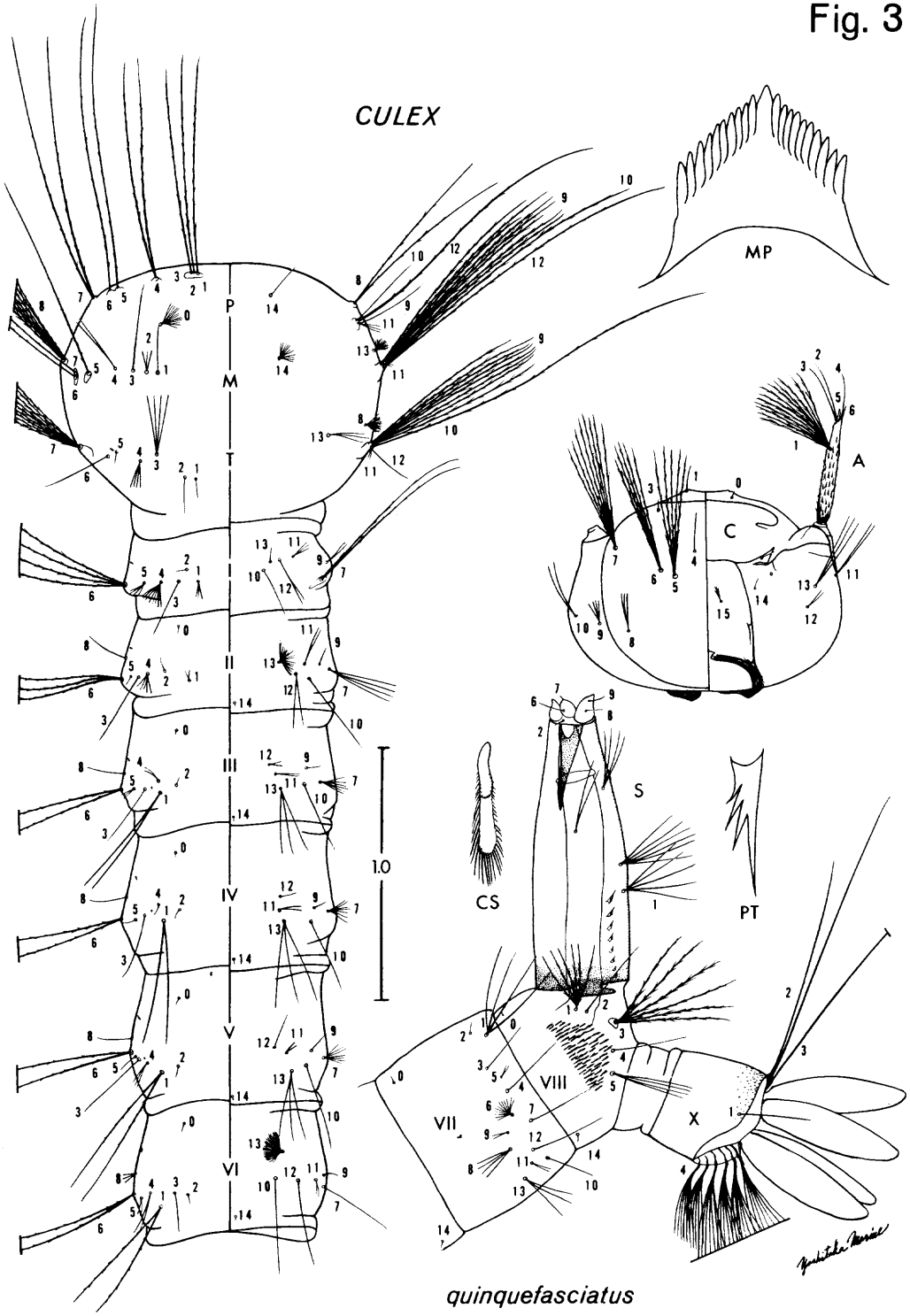
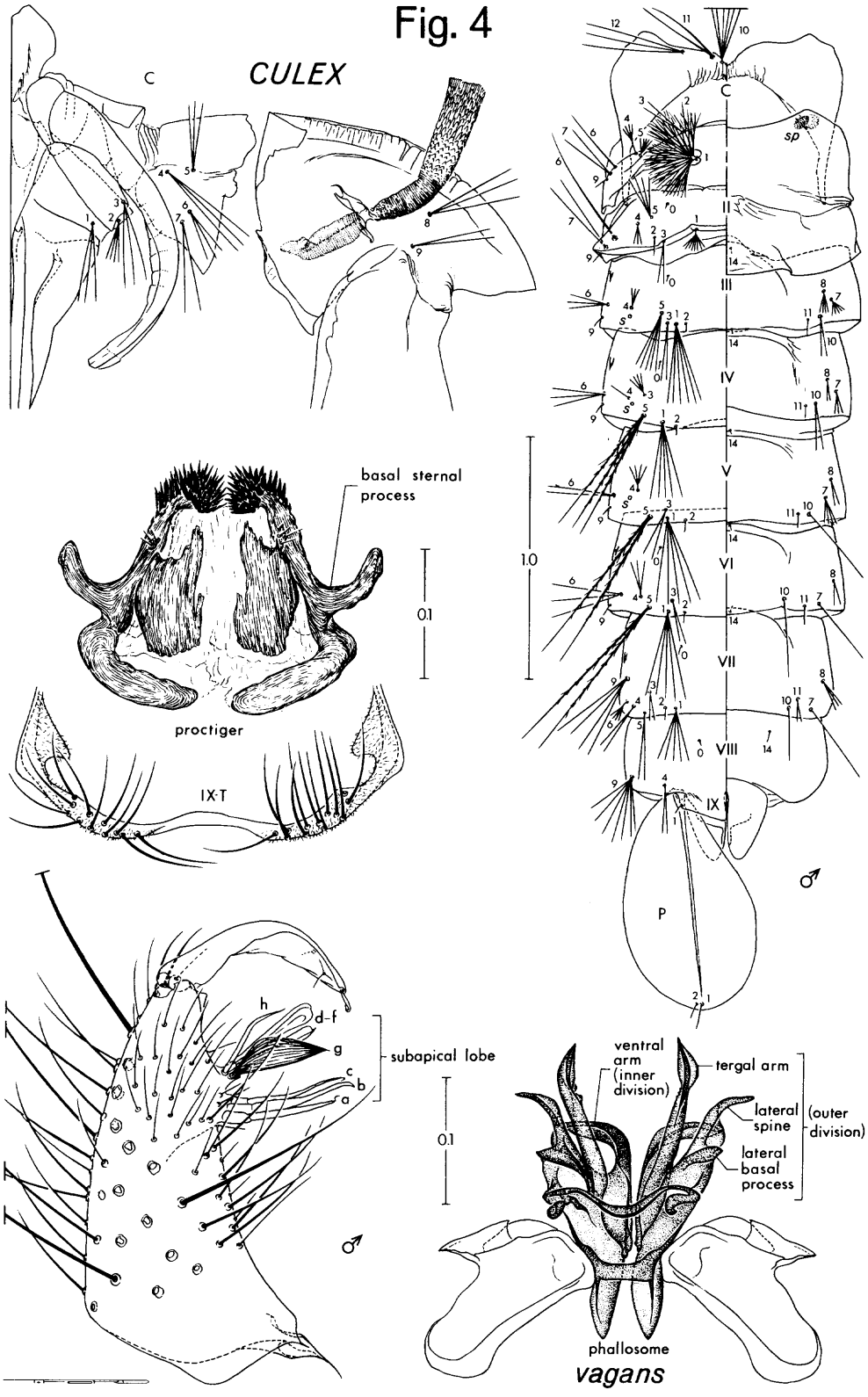
J. L. HWANG
quinquefasciatus

Fig. 3



quinquefasciatus

Fig. 4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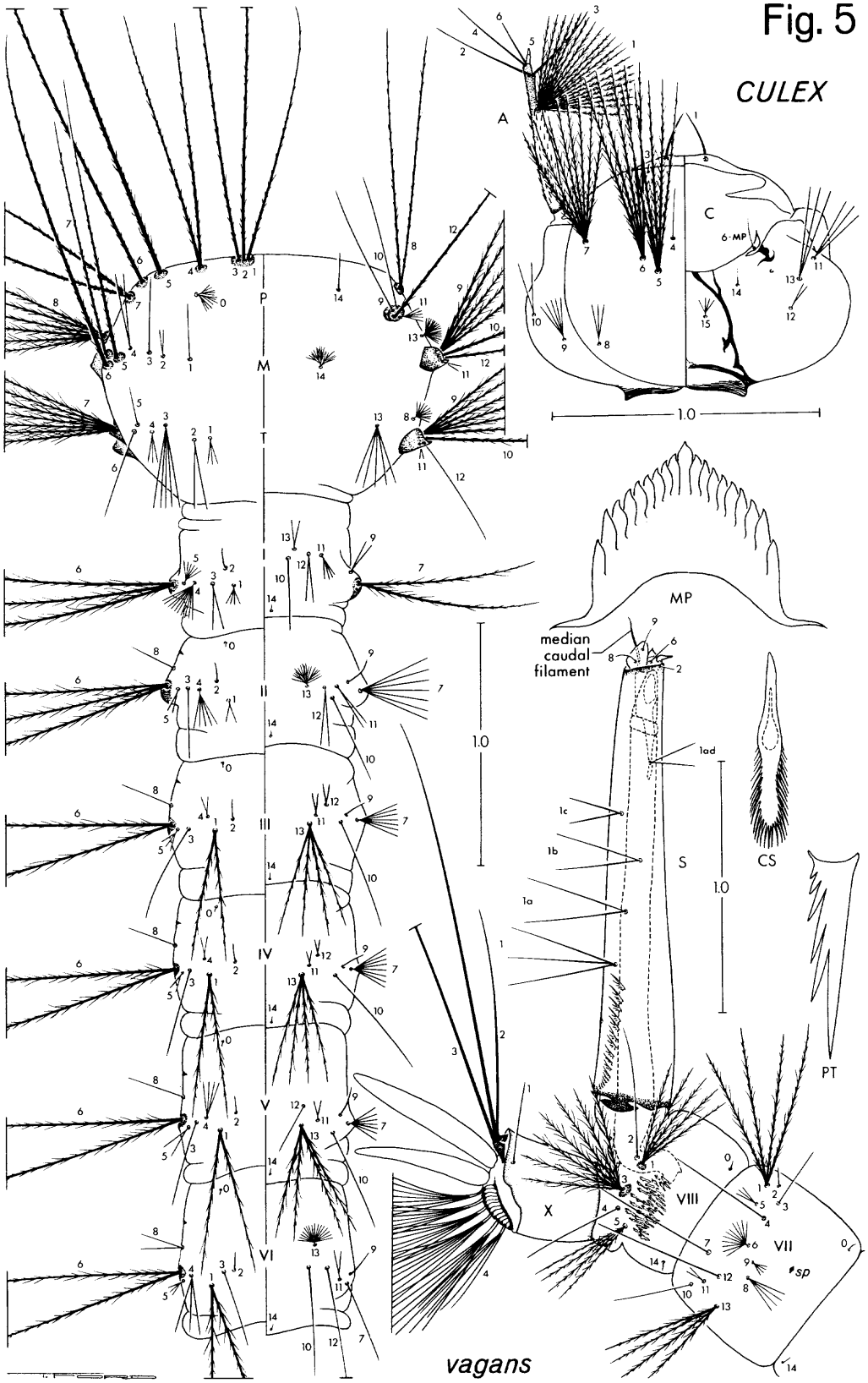
Fig. 5
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Fig. 6

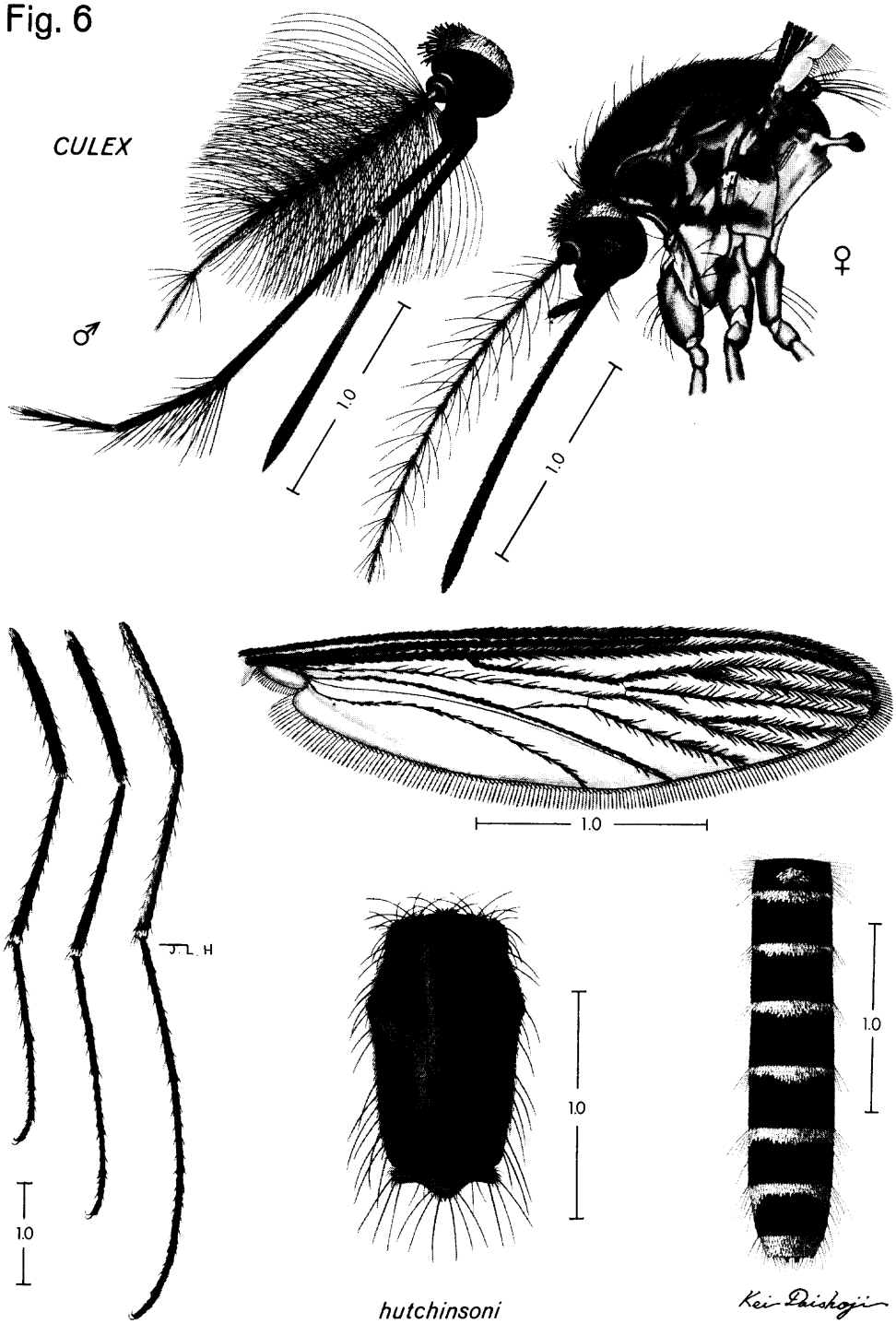

Fig. 7

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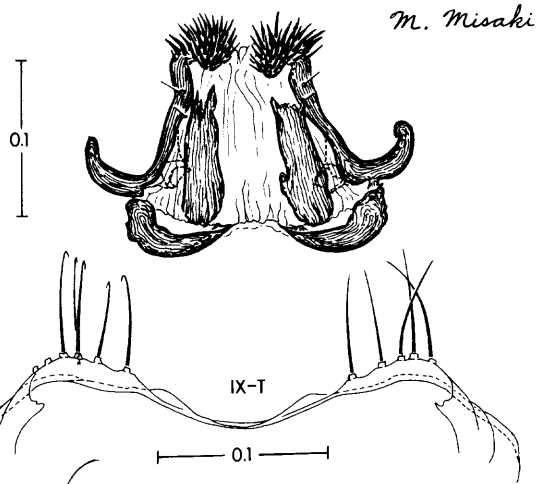
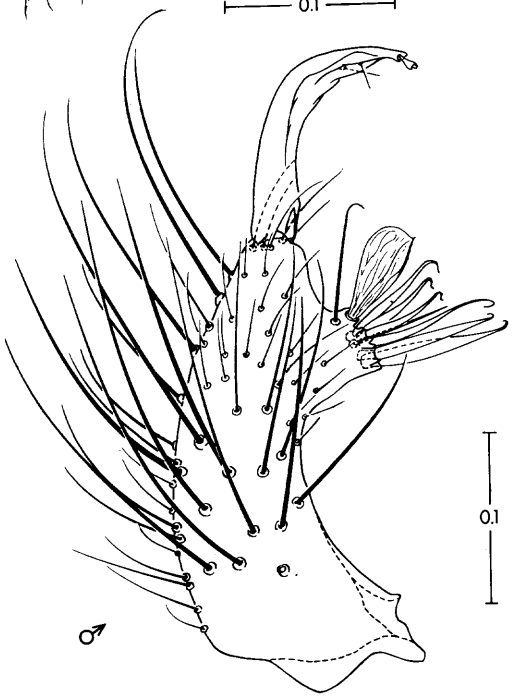
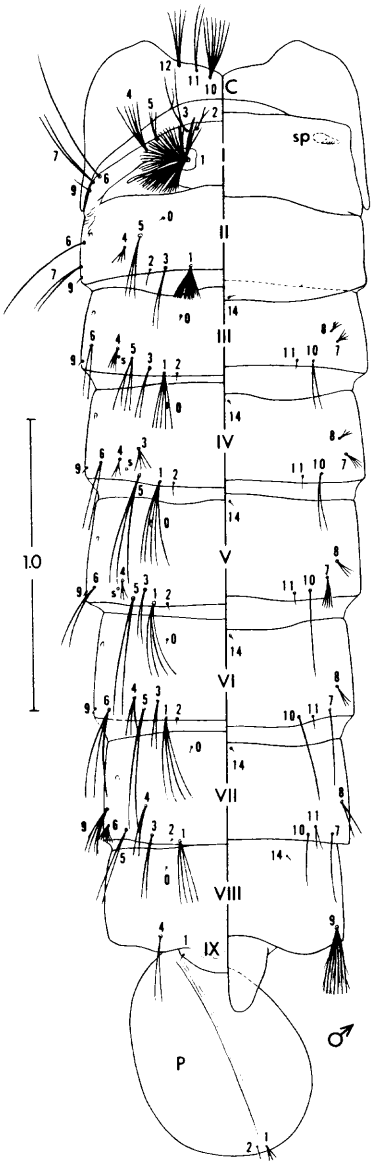
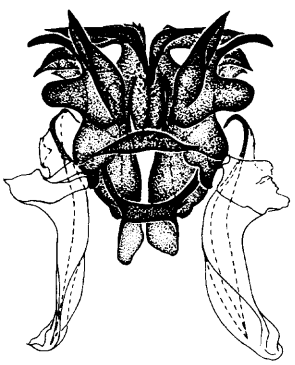
M. Misaki



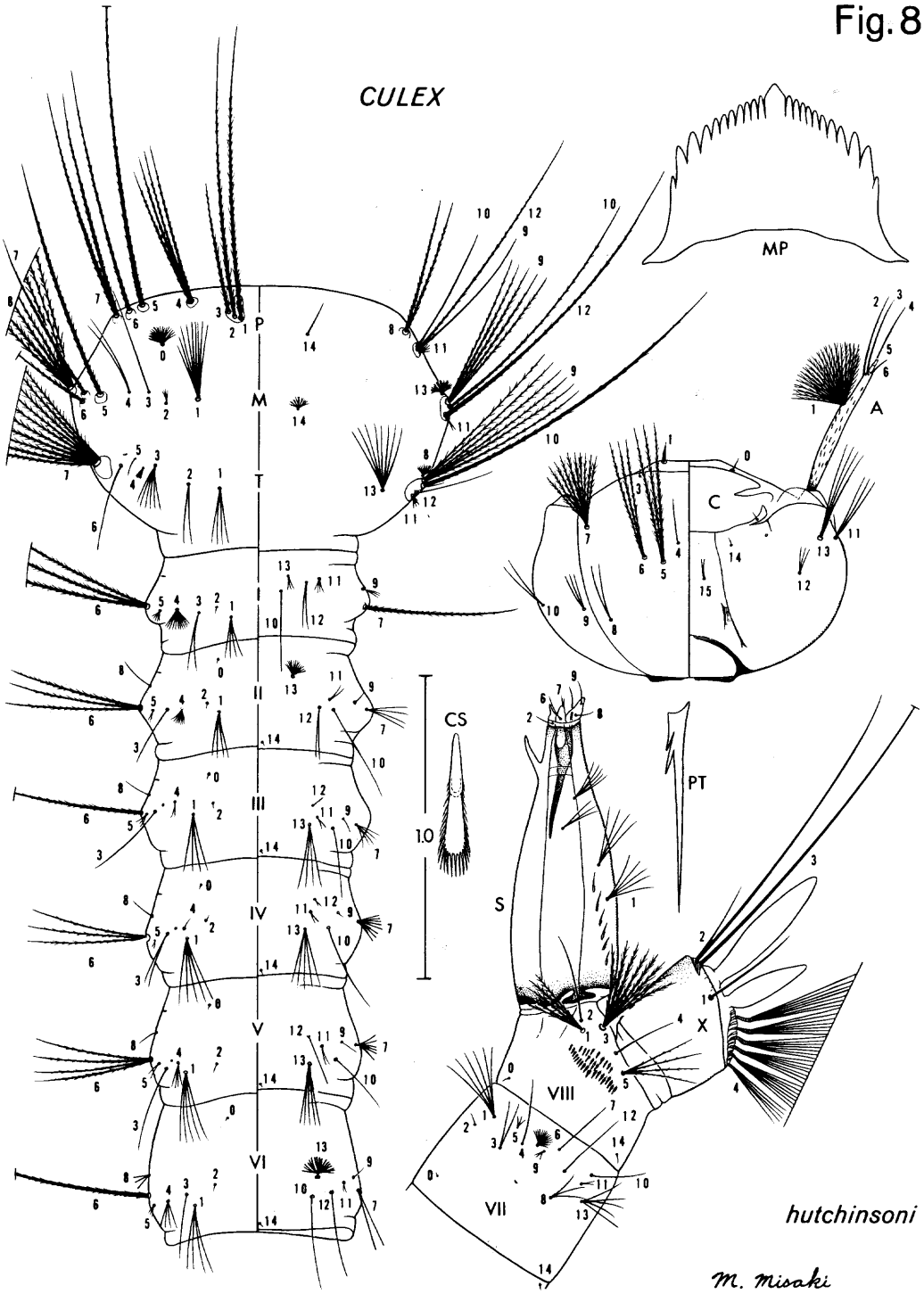






hutchinsoni

Fig. 8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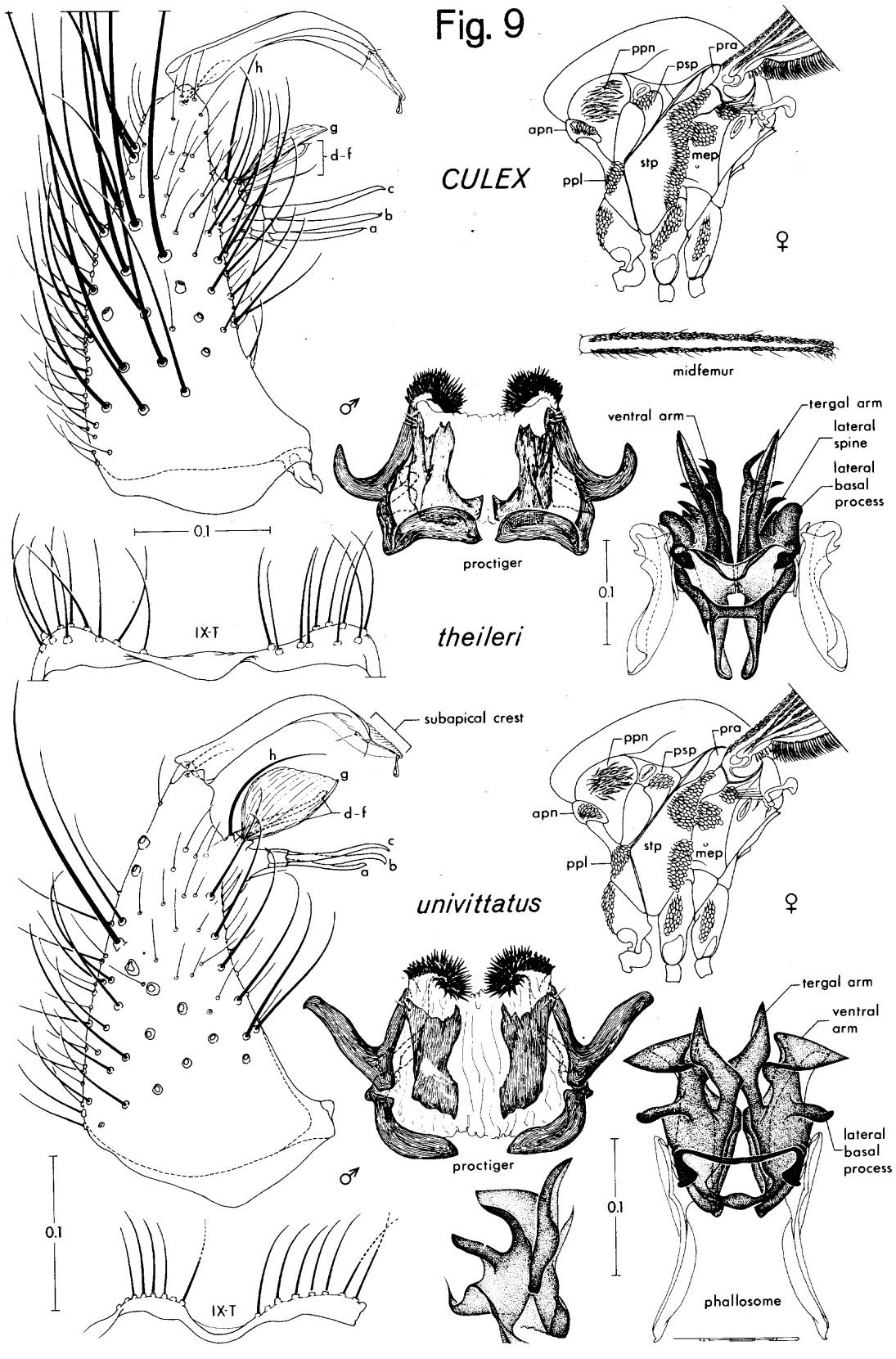
Fig. 9
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Fig.10

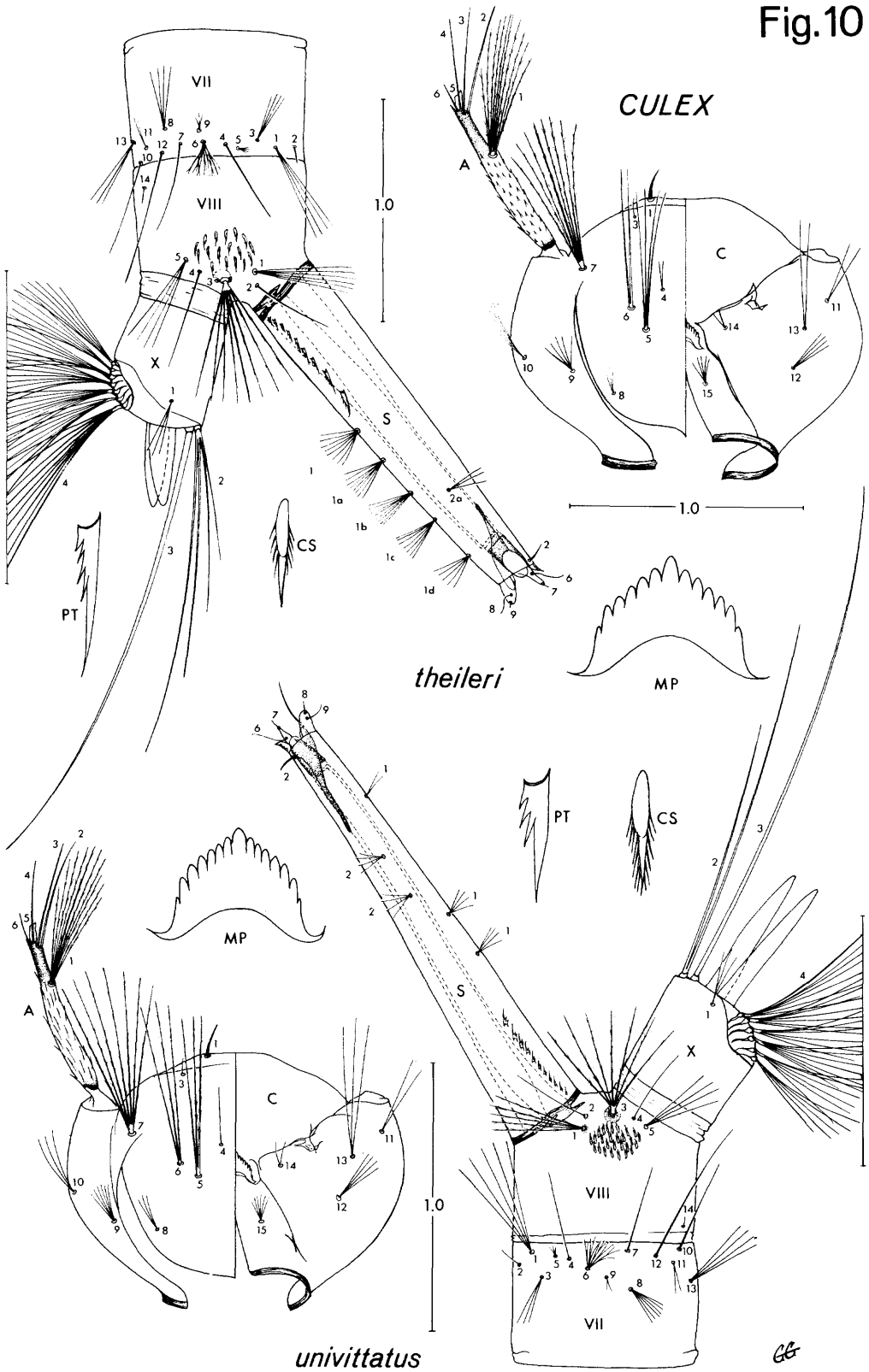
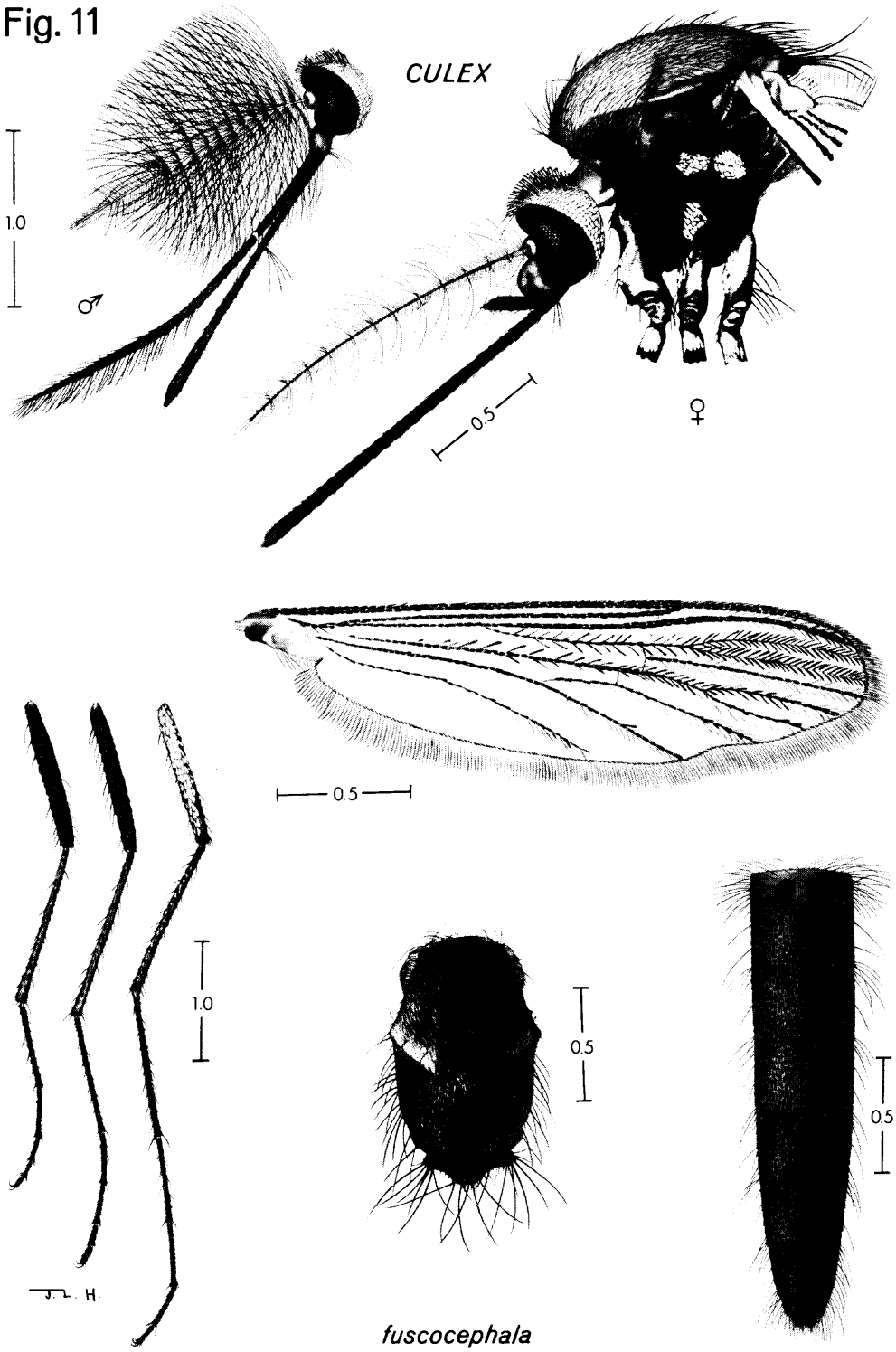


Fig. 11



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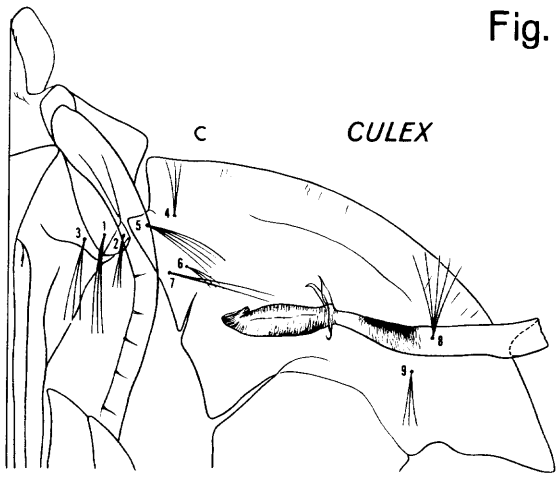

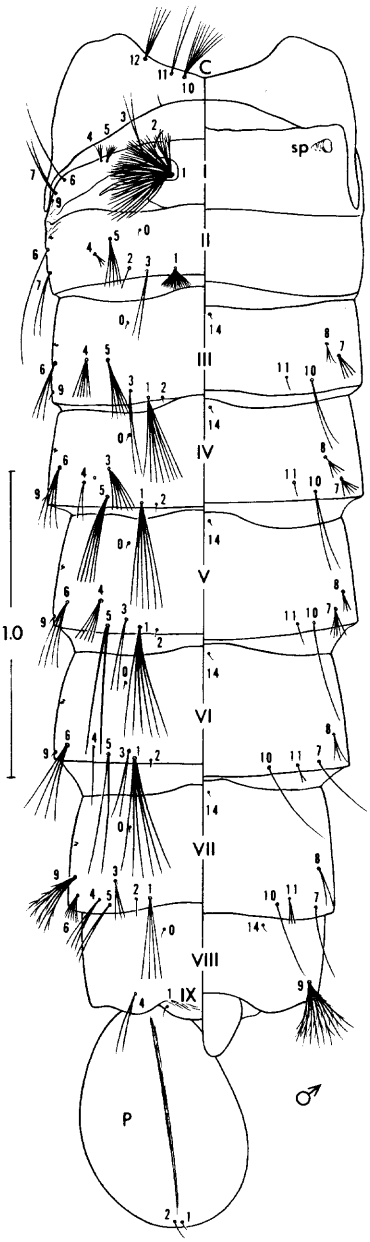

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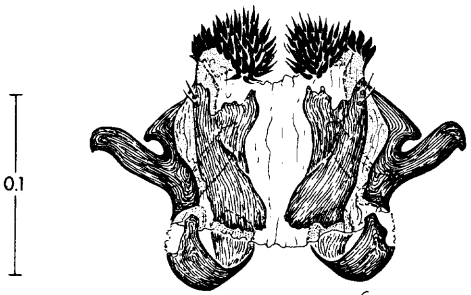

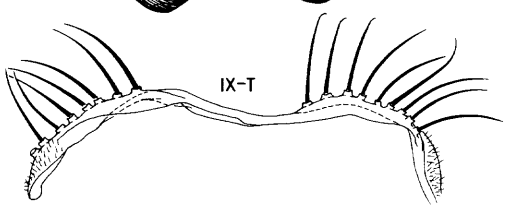

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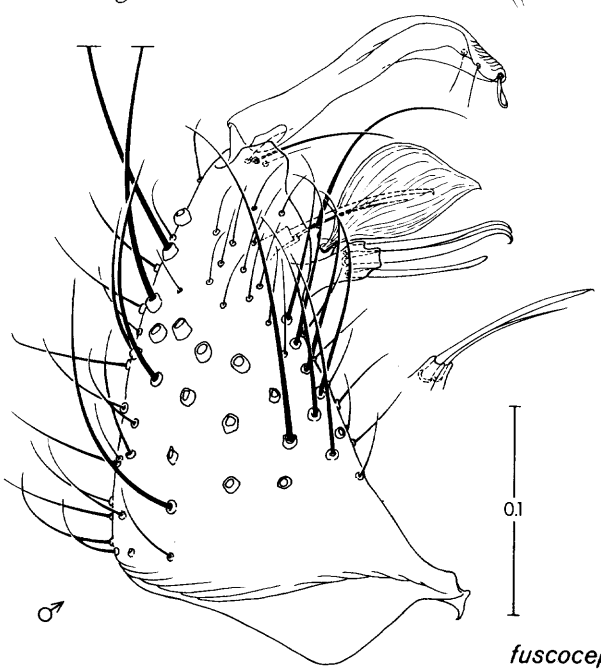

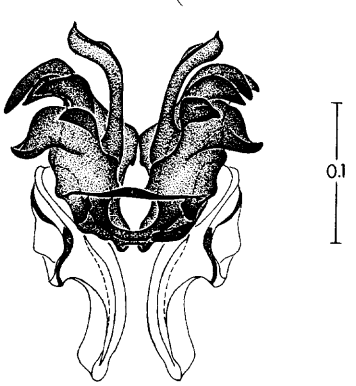

fuscocephala

Fig. 13

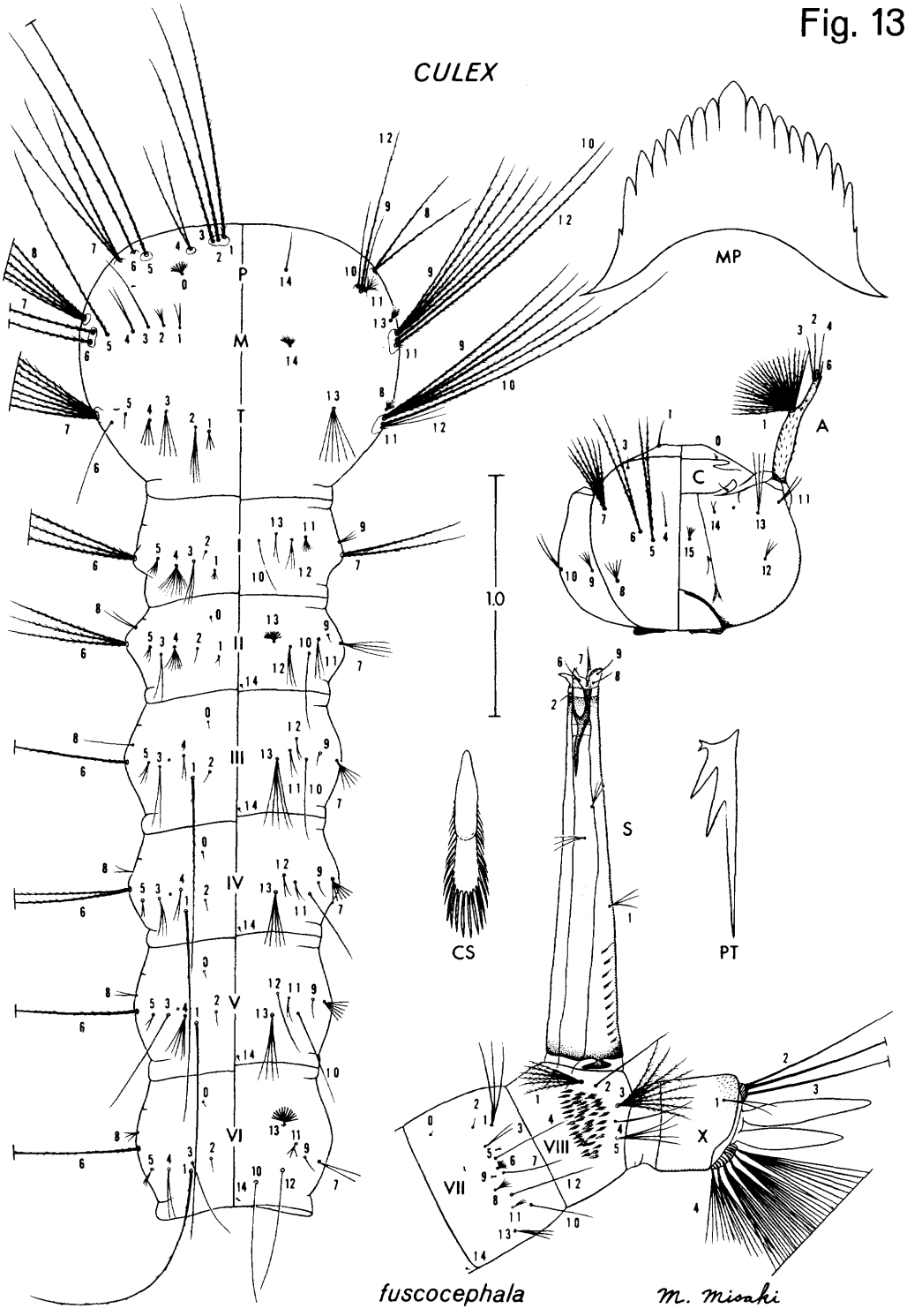
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Fig.14

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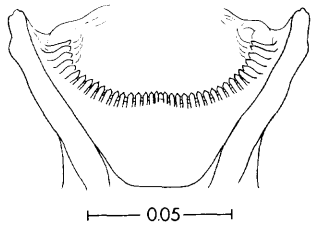
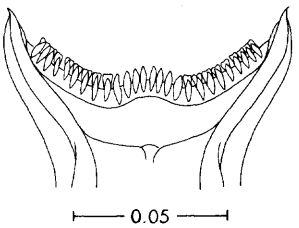
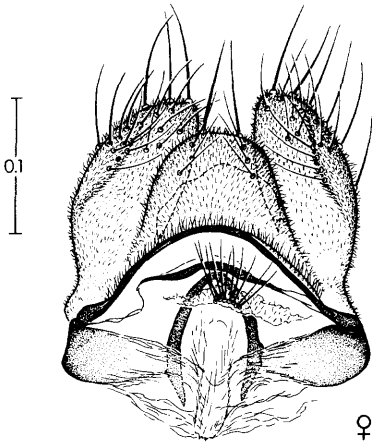
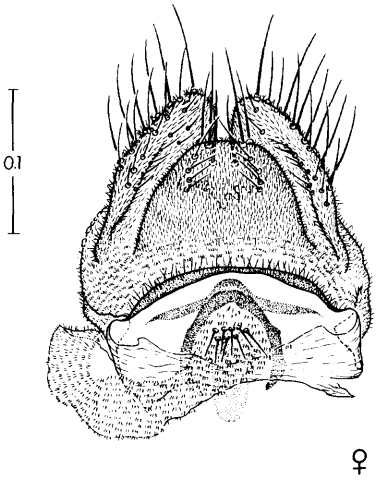






quinquefasciatus



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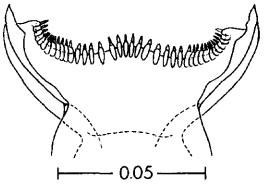
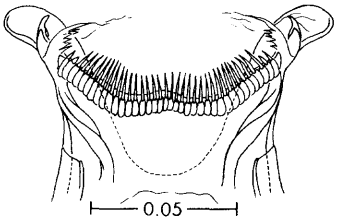
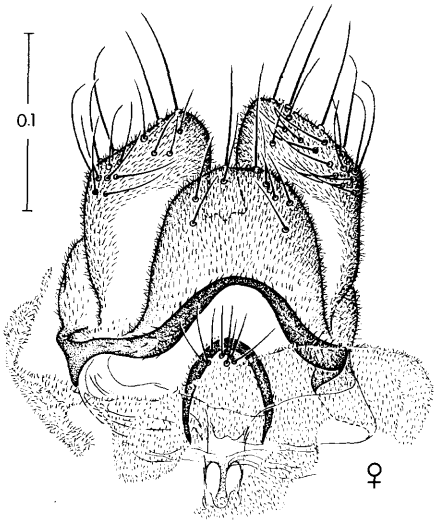
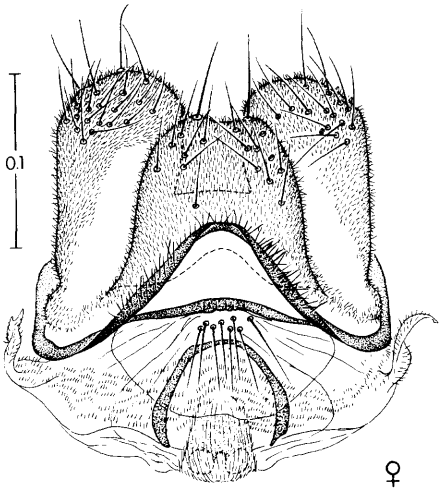






hutchinsoni



fuscocephala

Fig. 15

CULEX

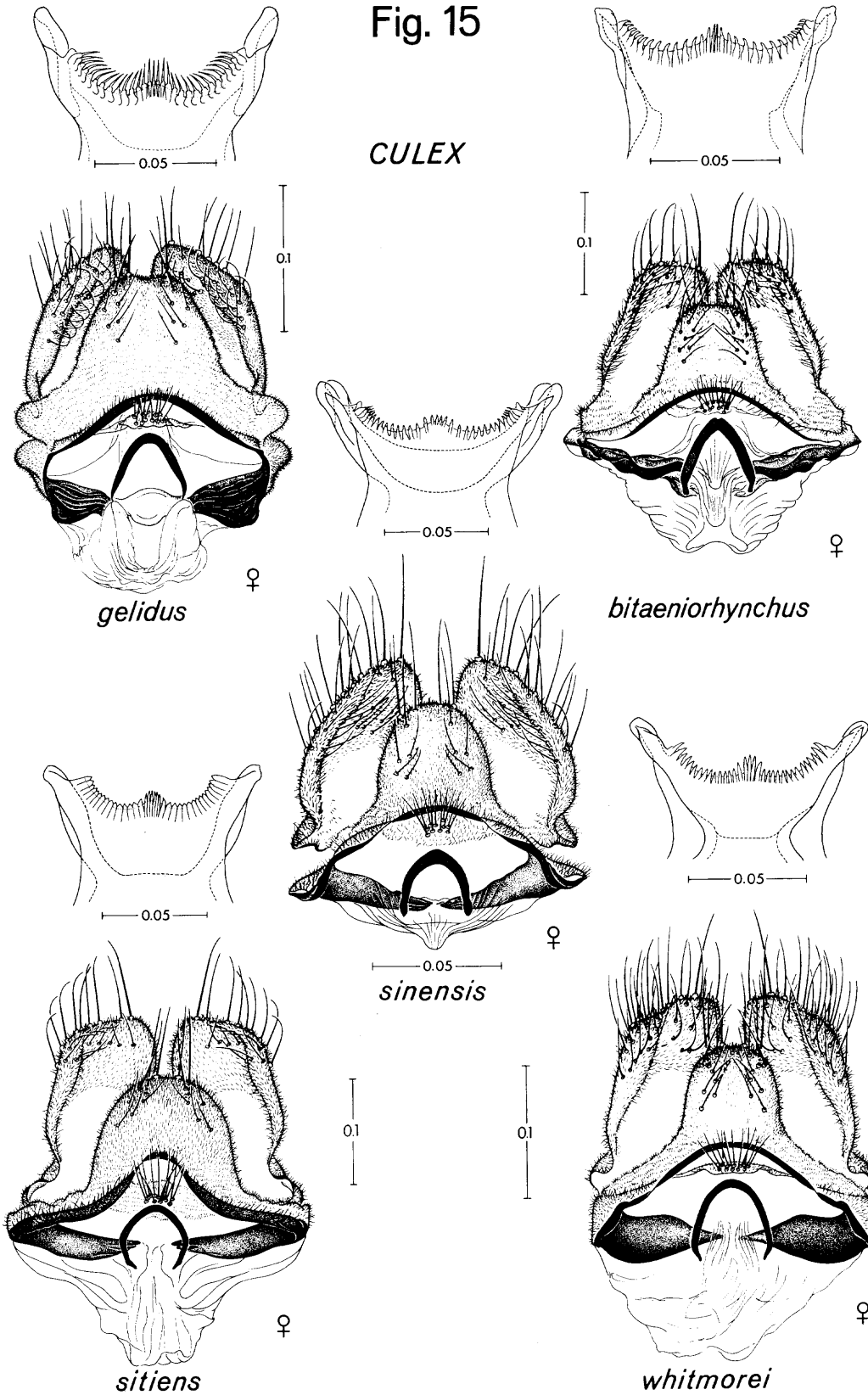

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Fig. 16

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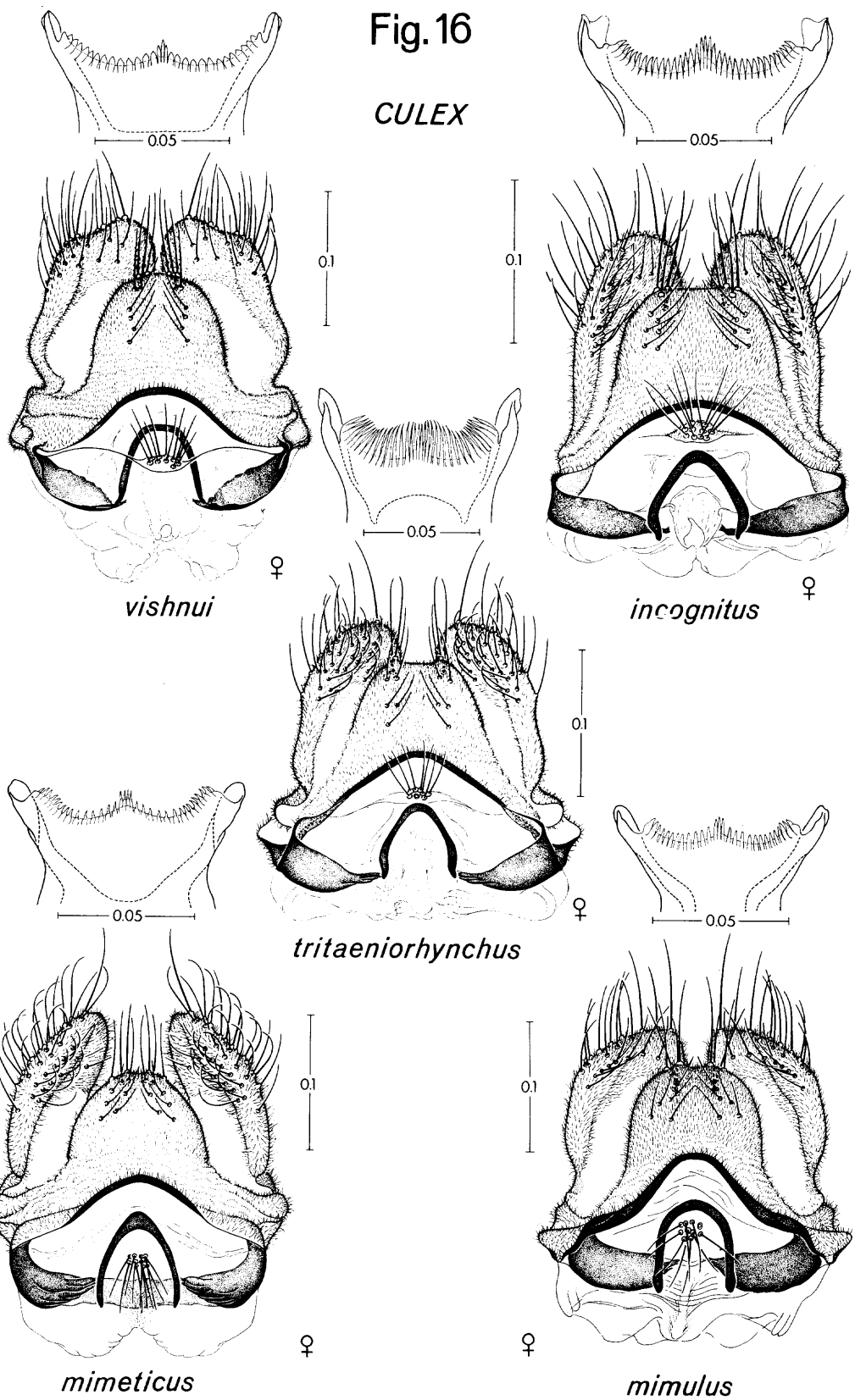
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mimulus

Fig. 17

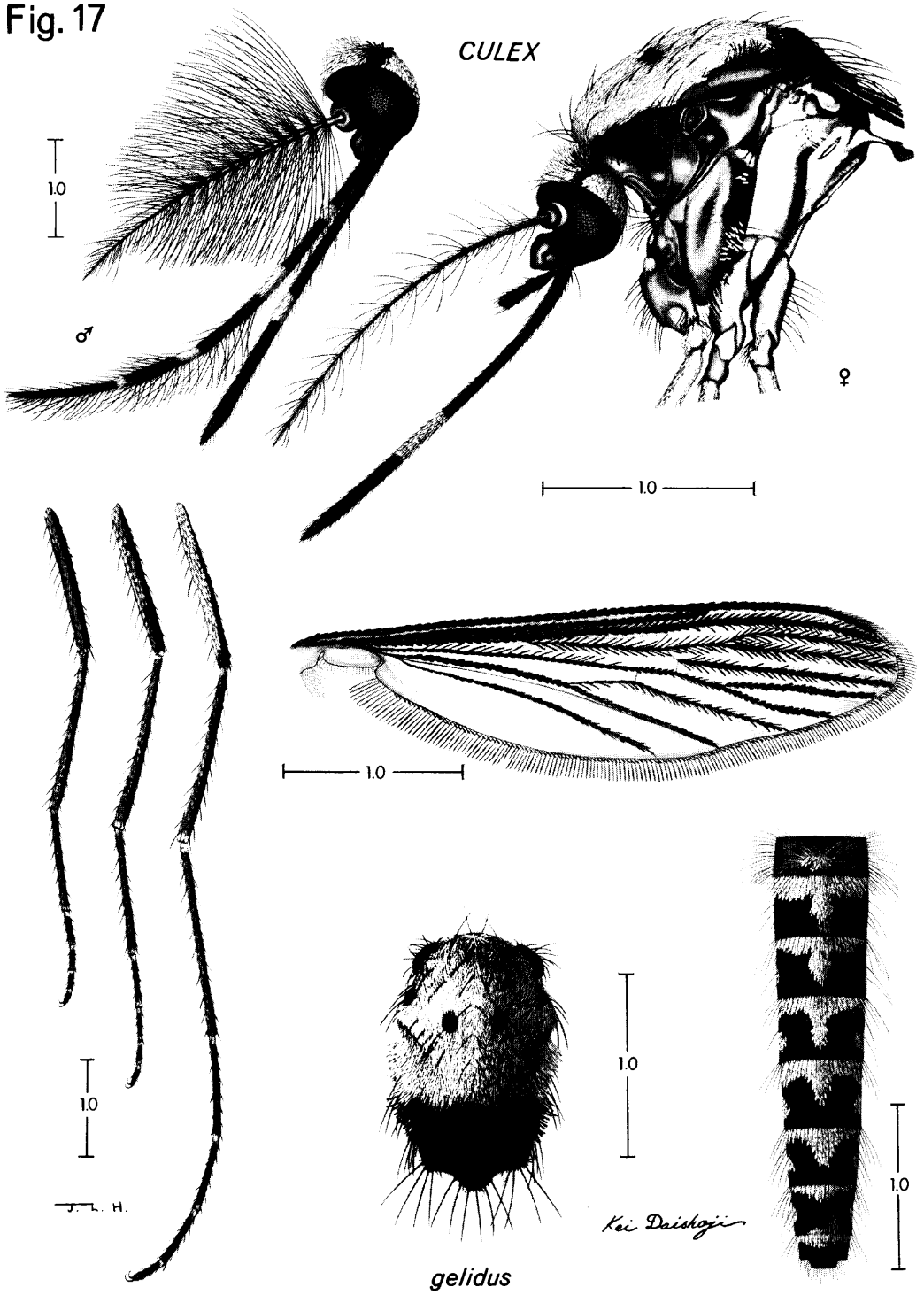


Fig. 18

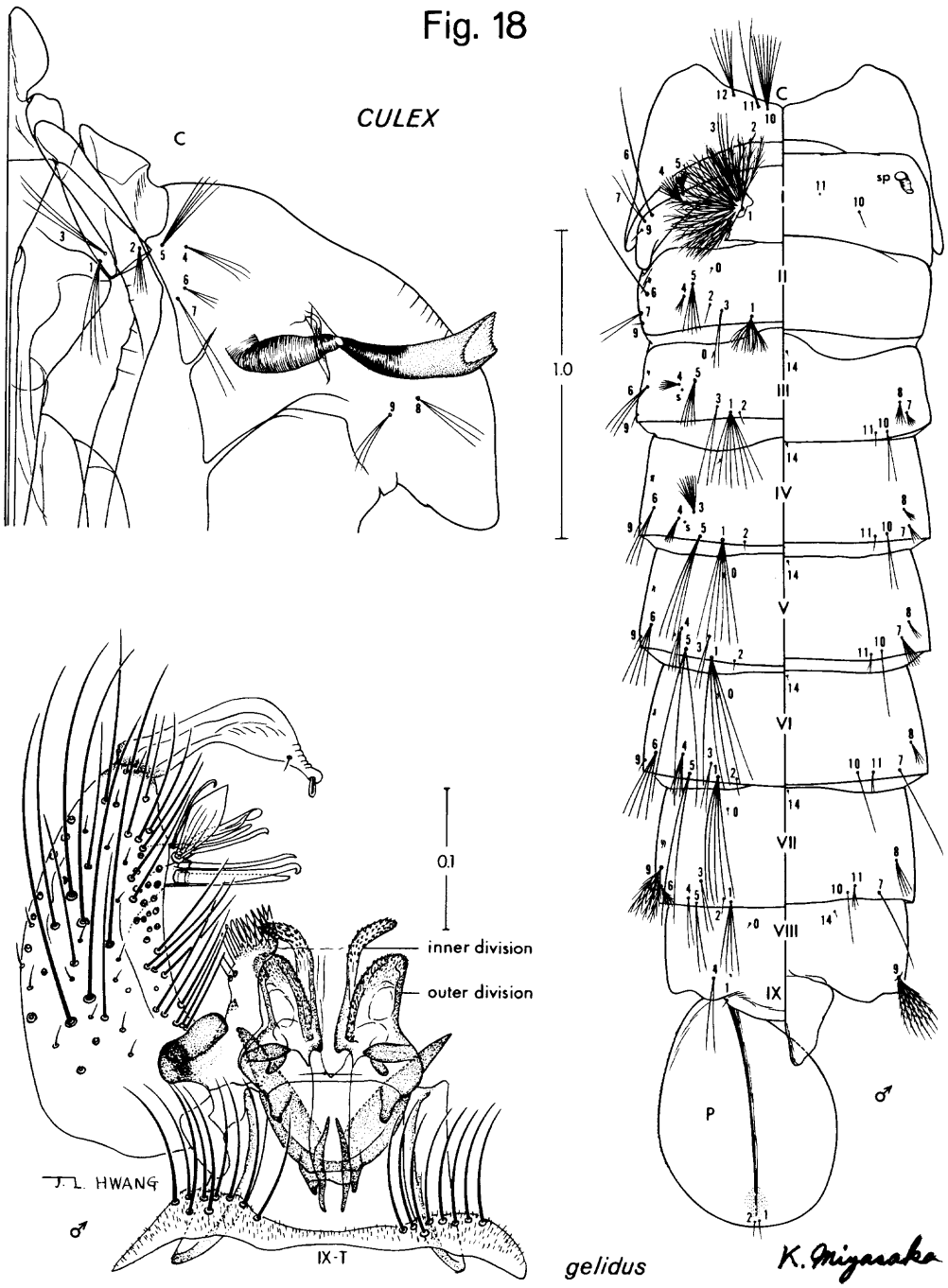
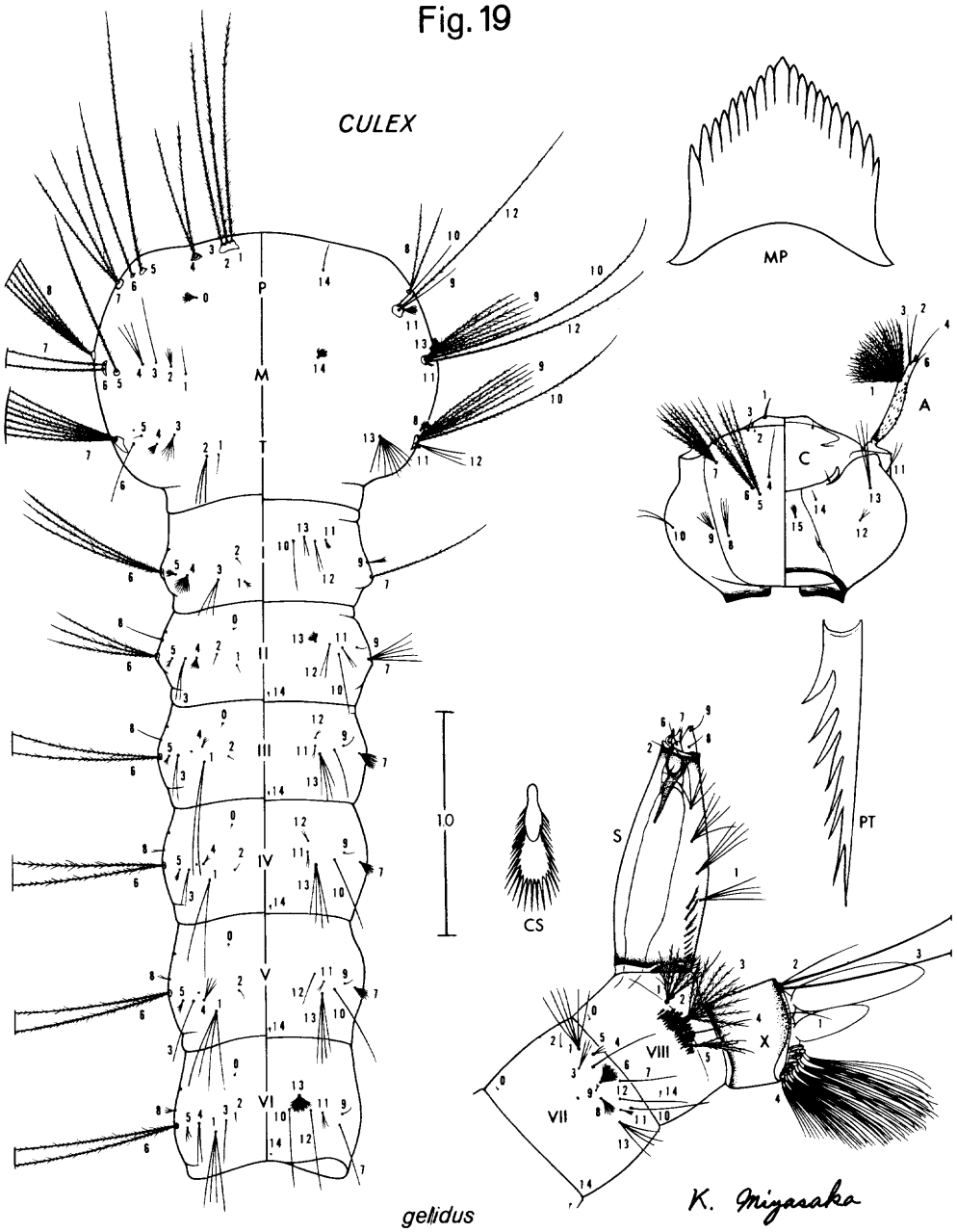
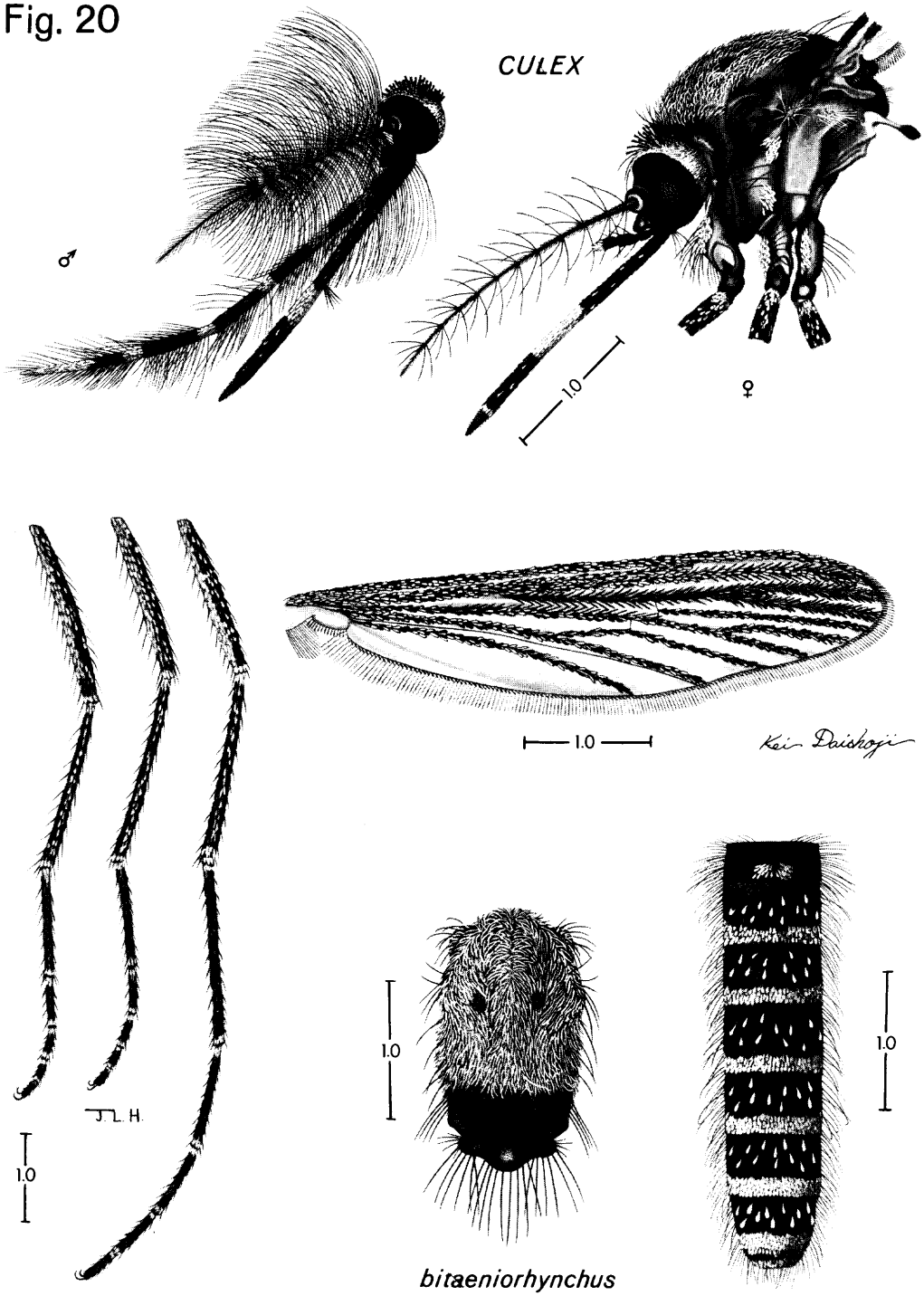

CULEX
C
1.0
0.1
inner division
outer division
J. L. HWANG
♂
IX-T
P
sp
I
II
III
IV
V
VI
VII
VIII
IX
gelidus
K. Mizusaka

Fig. 19



gelidus

Fig. 20



bitaeniorhynchus

Fig. 21

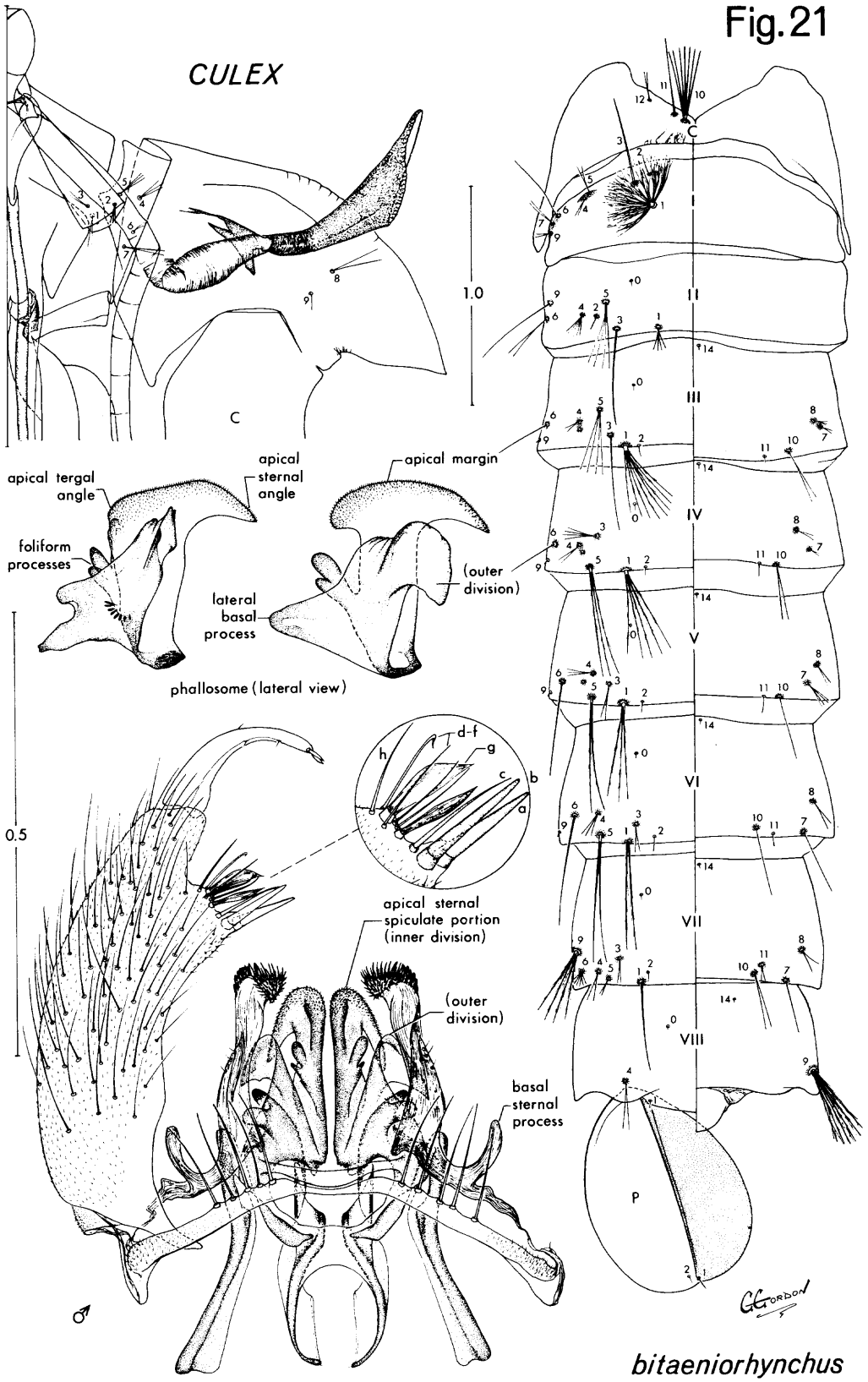

CULEX
C
1.0
apical tergal angle
apical sternal angle
foliform processes
lateral basal process
apical margin
(outer division)
phallosome (lateral view)
0.5
d-f
g
h
c
b
a
apical sternal spiculate portion (inner division)
(outer division)
basal sternal process
♂
I
II
III
IV
V
VI
VII
VIII
P
G Gordon
bitaeniorhynchus

Fig.22

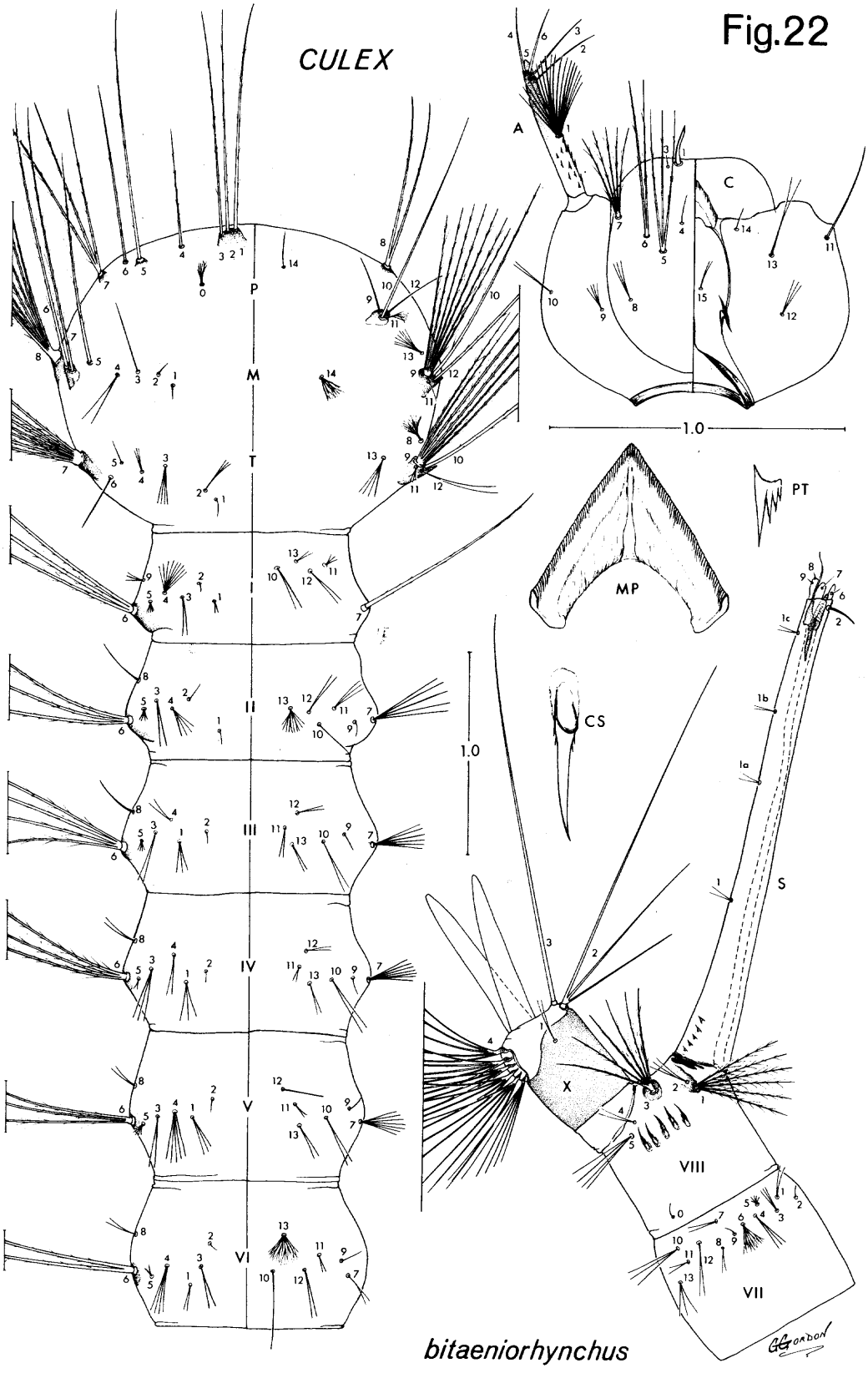
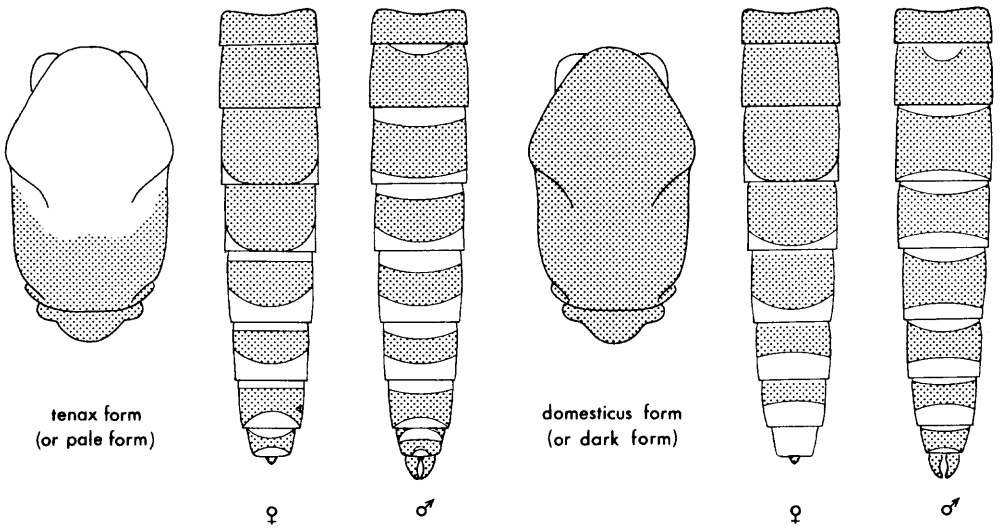
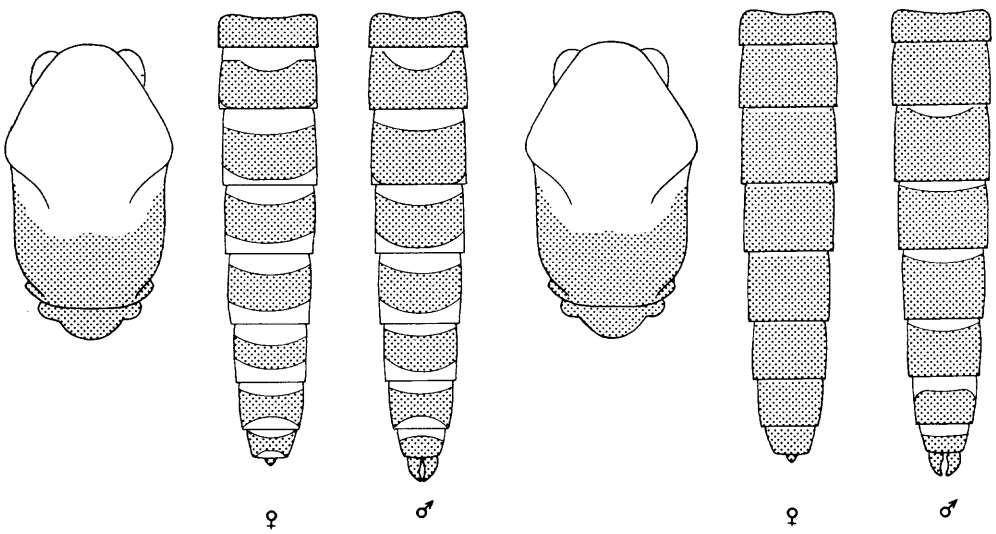

CULEX
A
C
1.0
PT
MP
CS
1.0
P
M
T
I
II
III
IV
V
VI
VII
VIII
X
S
1a
1b
1c
bitaeniorhynchus
GGordon

Fig. 23



infula



luzonensis

selangorensis

Fig. 24

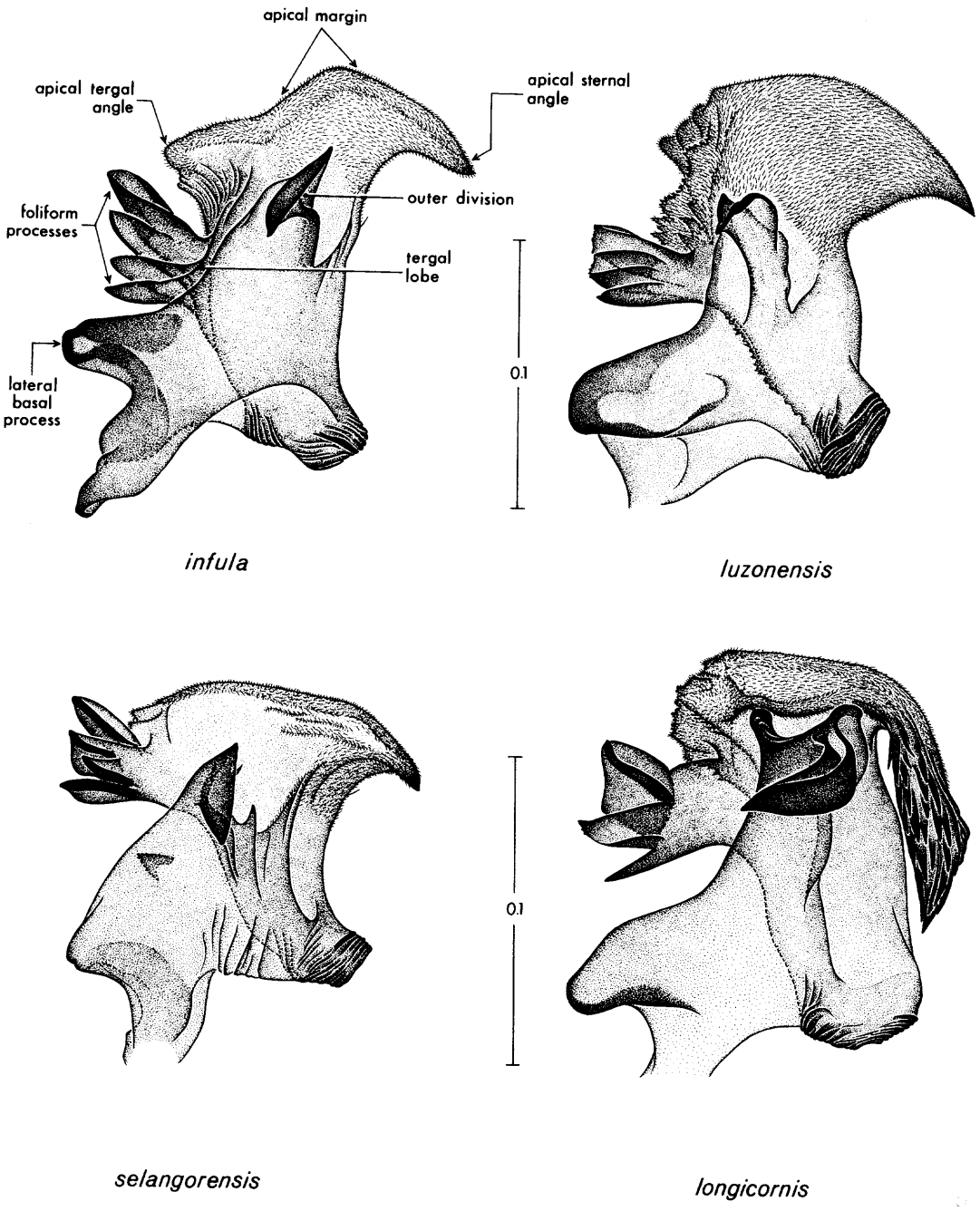
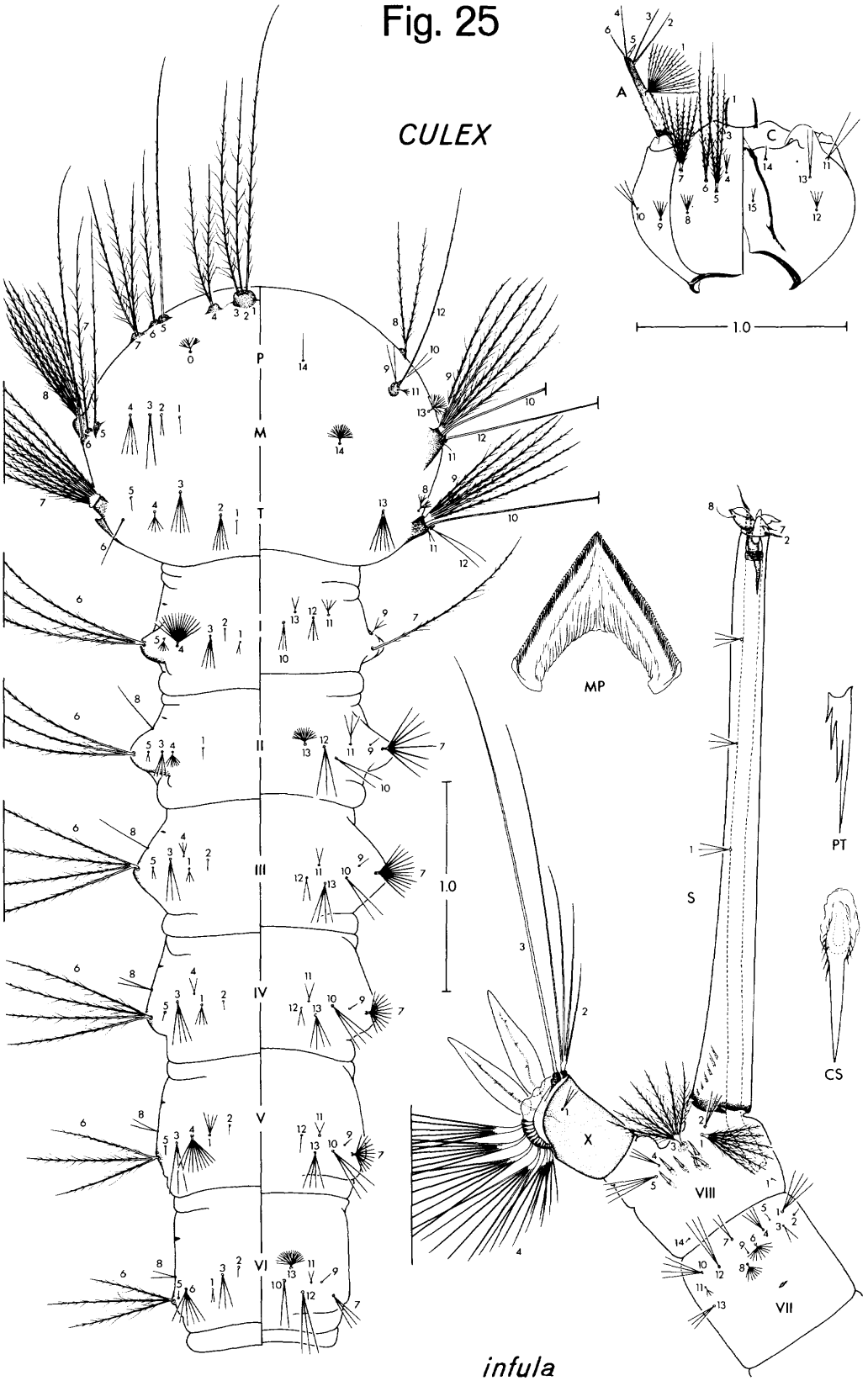

apical margin
apical tergal angle
apical sternal angle
outer division
foliform processes
tergal lobe
lateral basal process
0.1
infula
luzonensis
0.1
selangorensis
longicornis

Fig. 25

CULEX



infula

Fig. 26

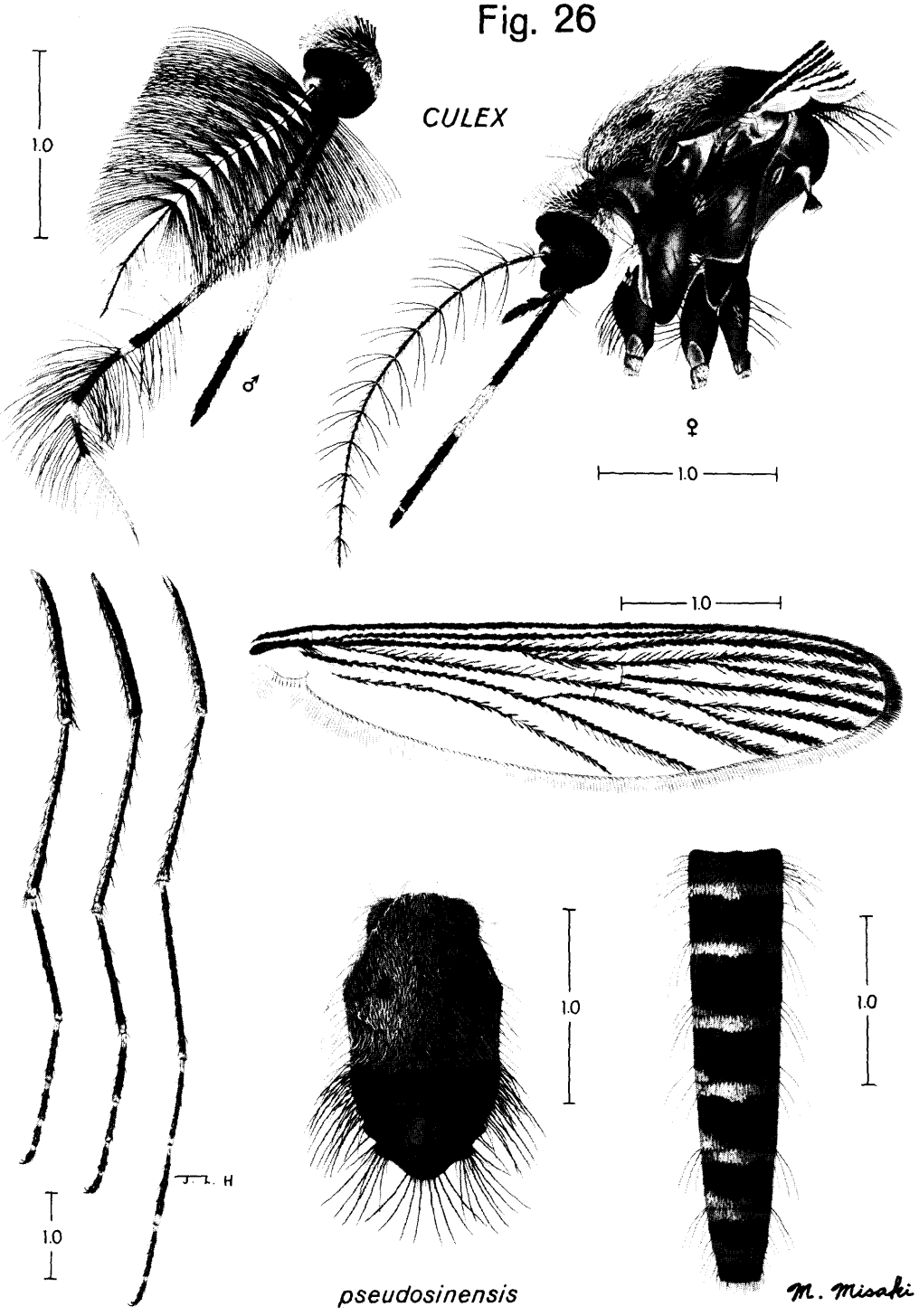


Fig. 27

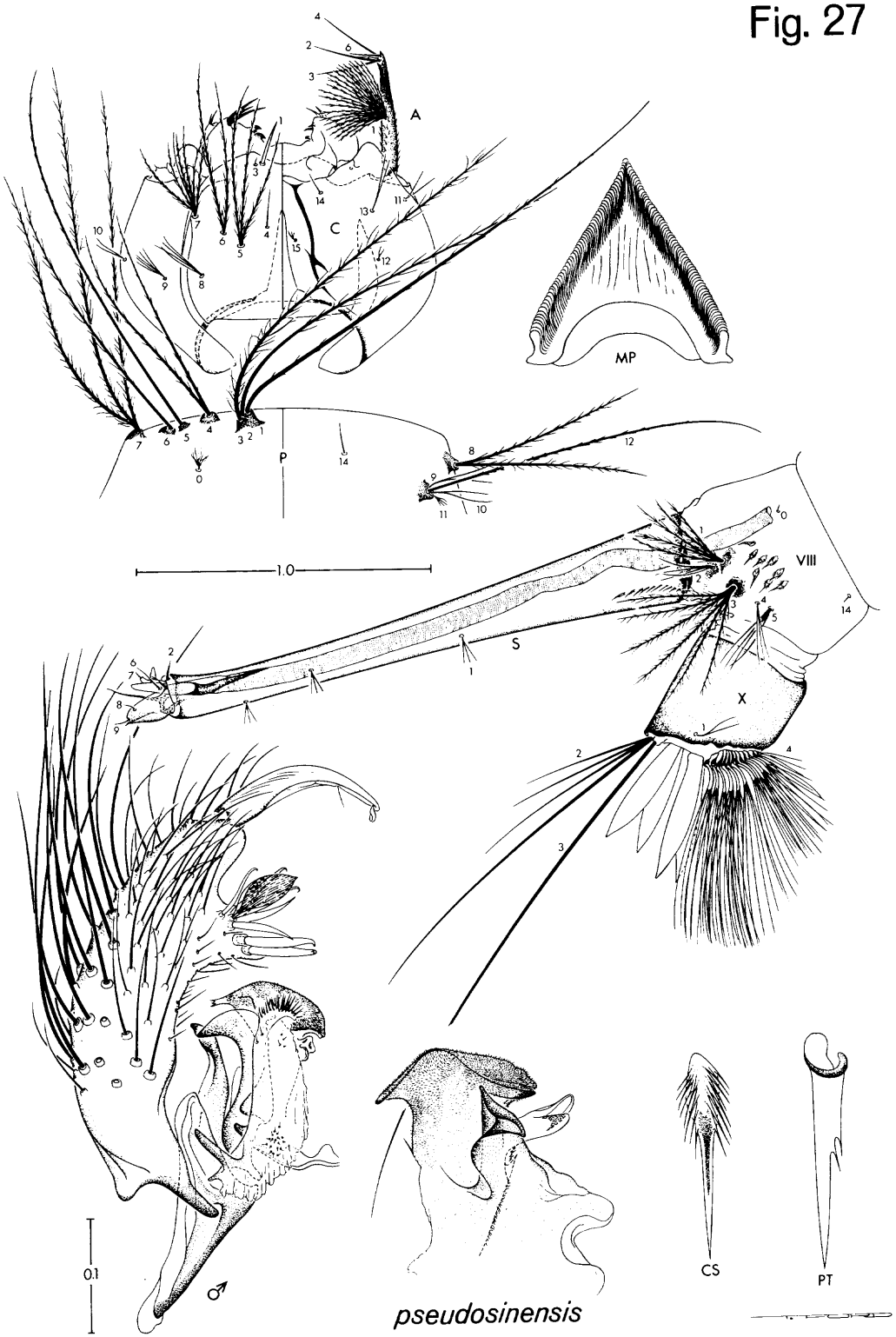


Fig. 28

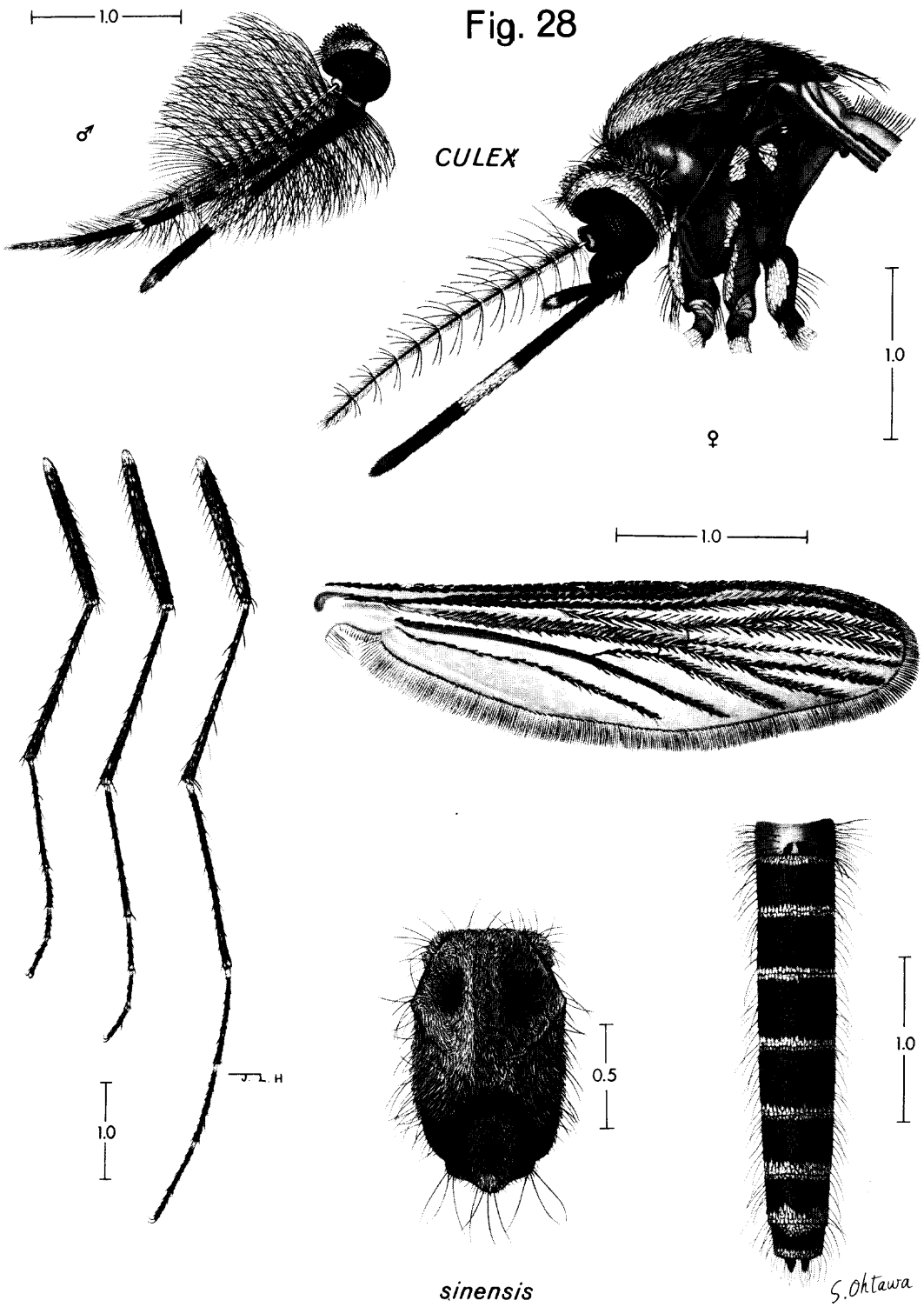
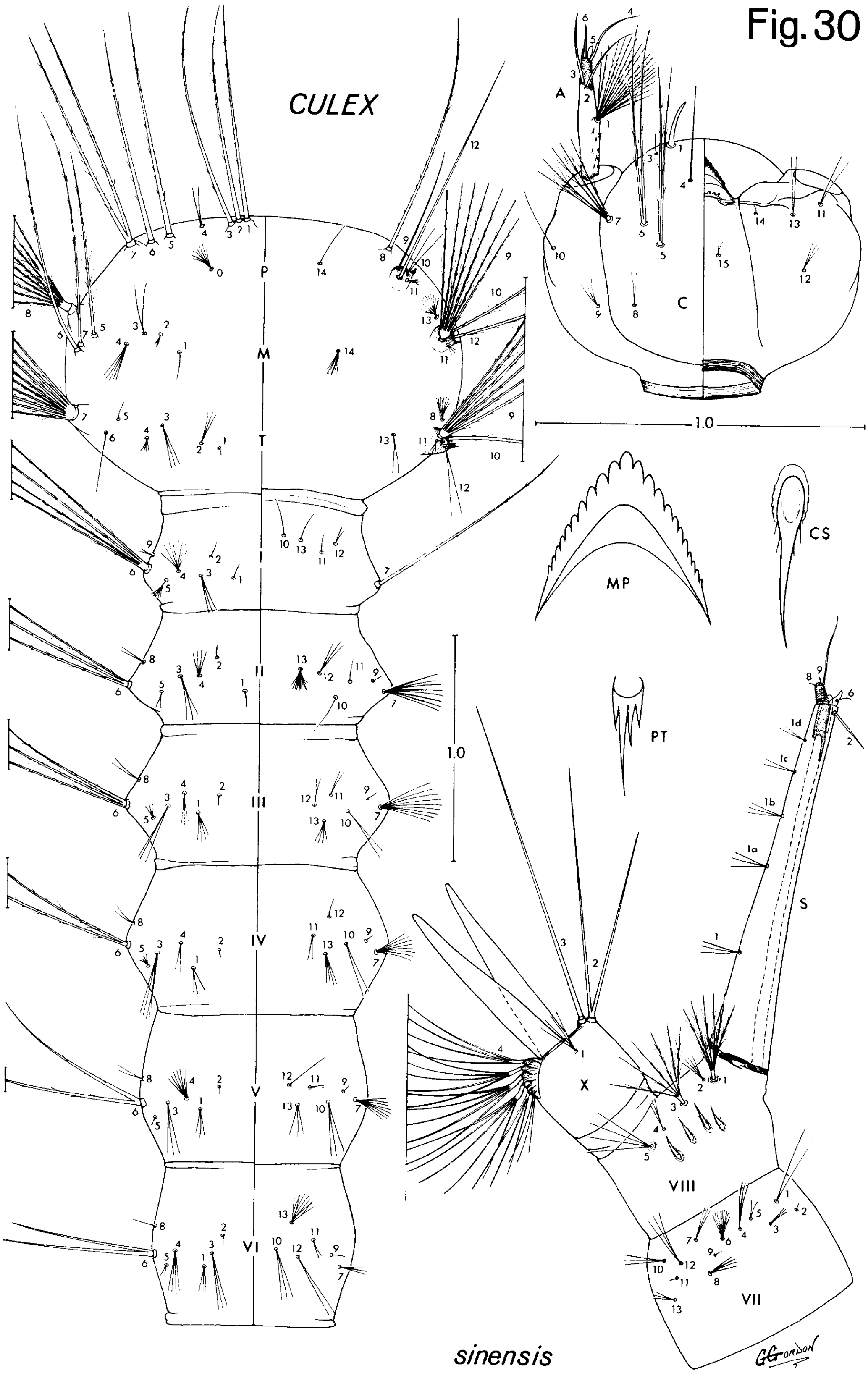


Fig. 29

Fig. 30

CULEX



sinensis

Fig. 31

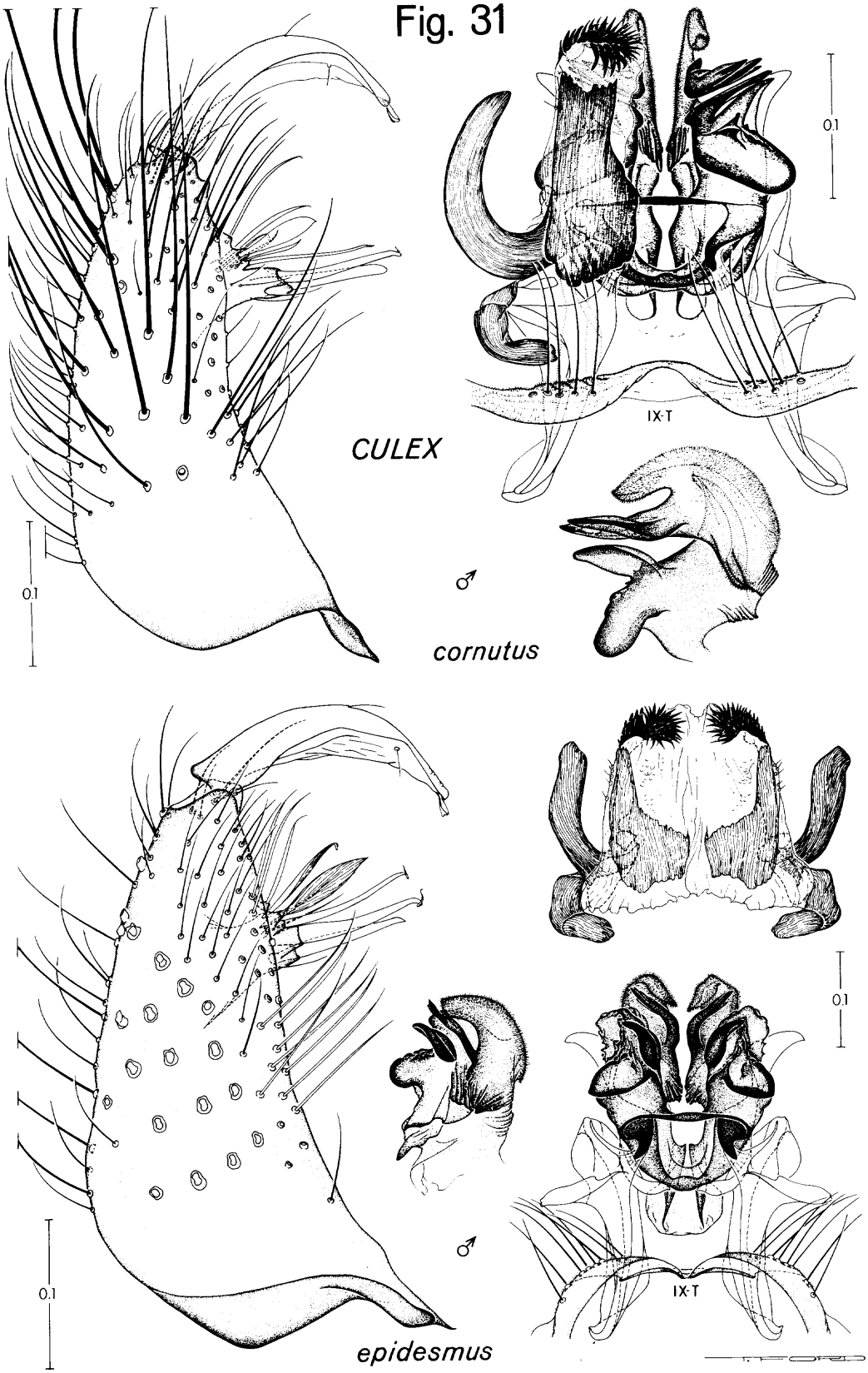


Fig. 32

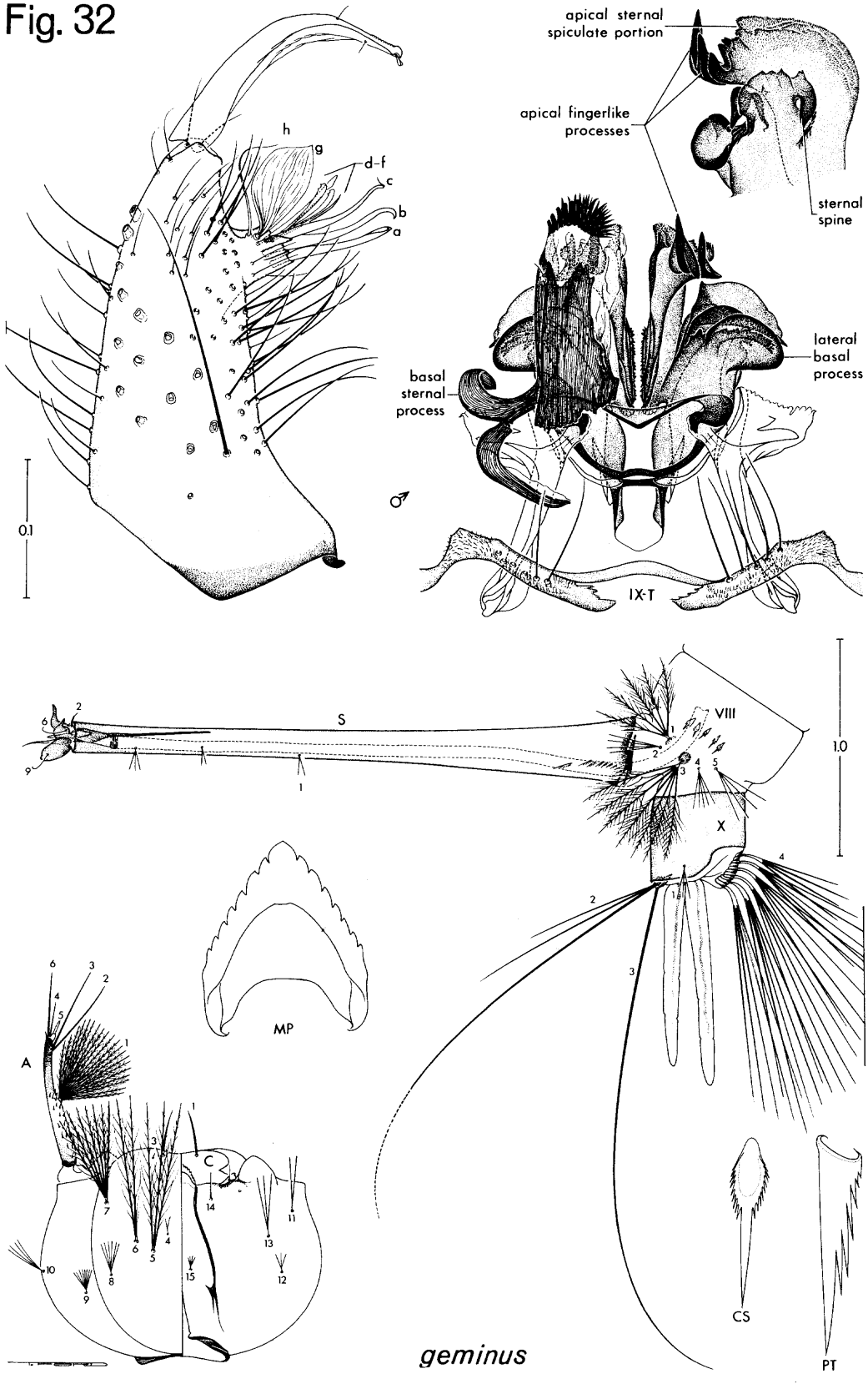

h
g
d-f
c
b
a
0.1
apical sternal spiculate portion
apical fingerlike processes
sternal spine
lateral basal process
basal sternal process
♂
IX-T
S
VIII
X
1.0
MP
A
C
CS
PT
geminus

Fig. 33

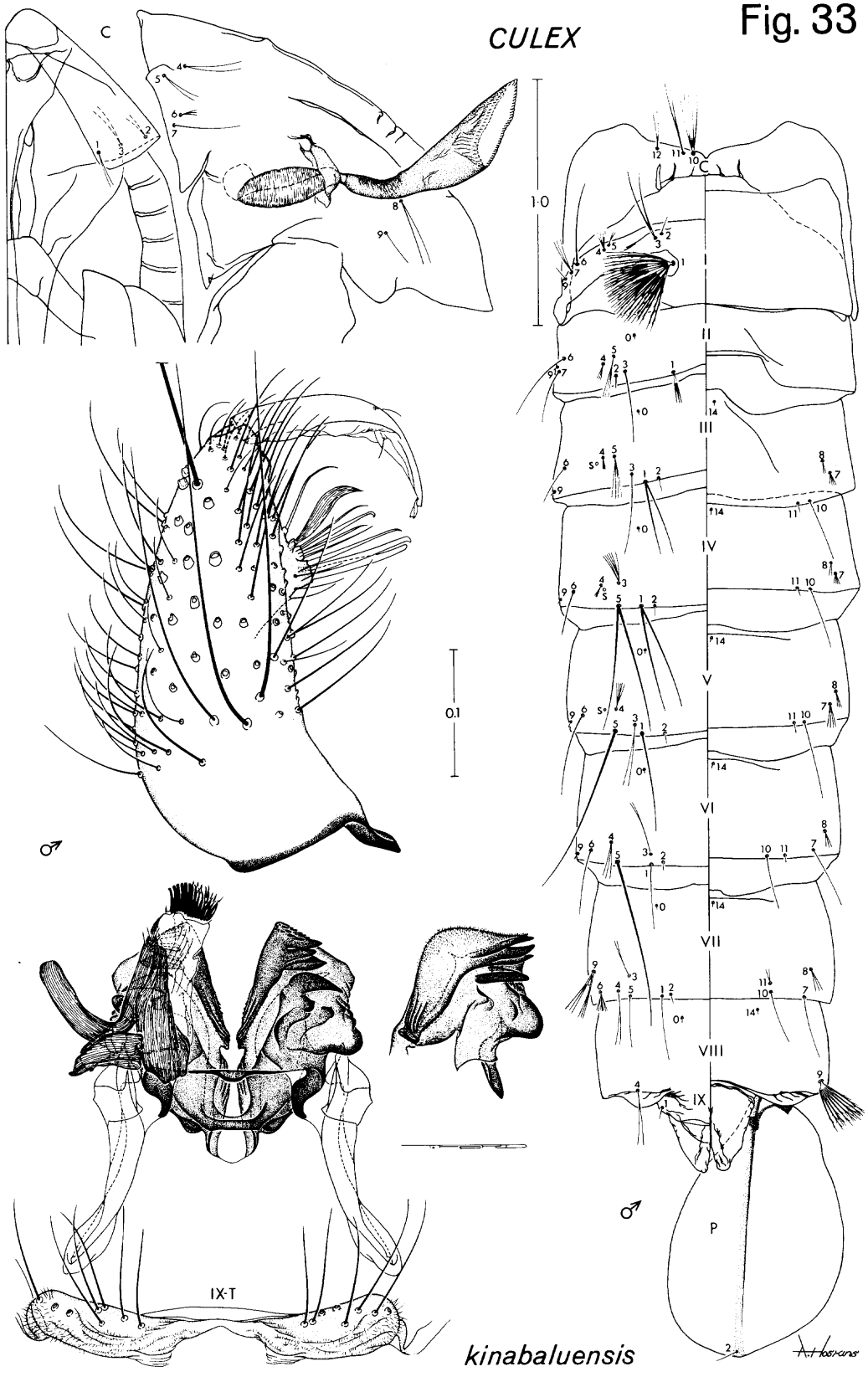
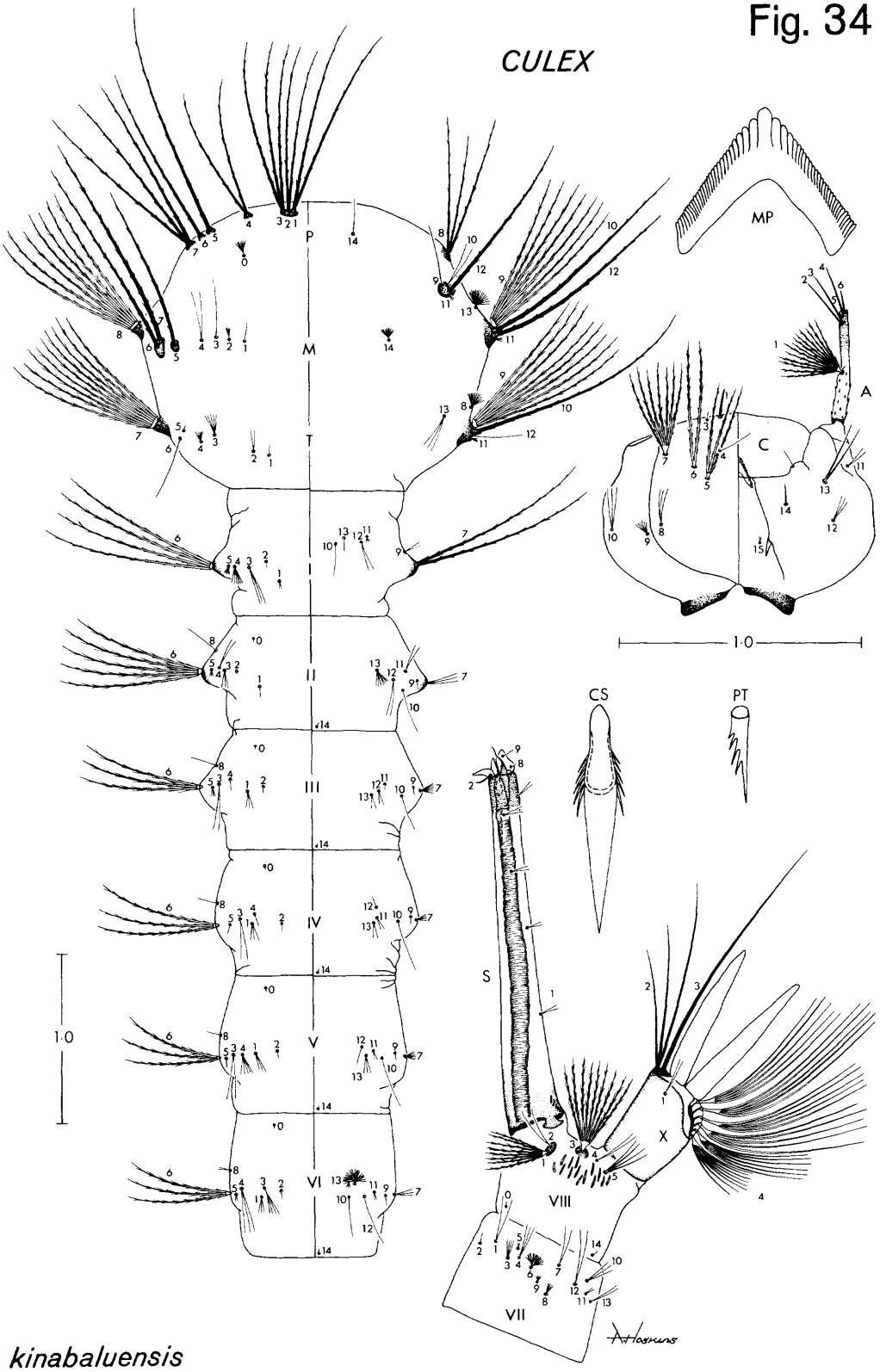


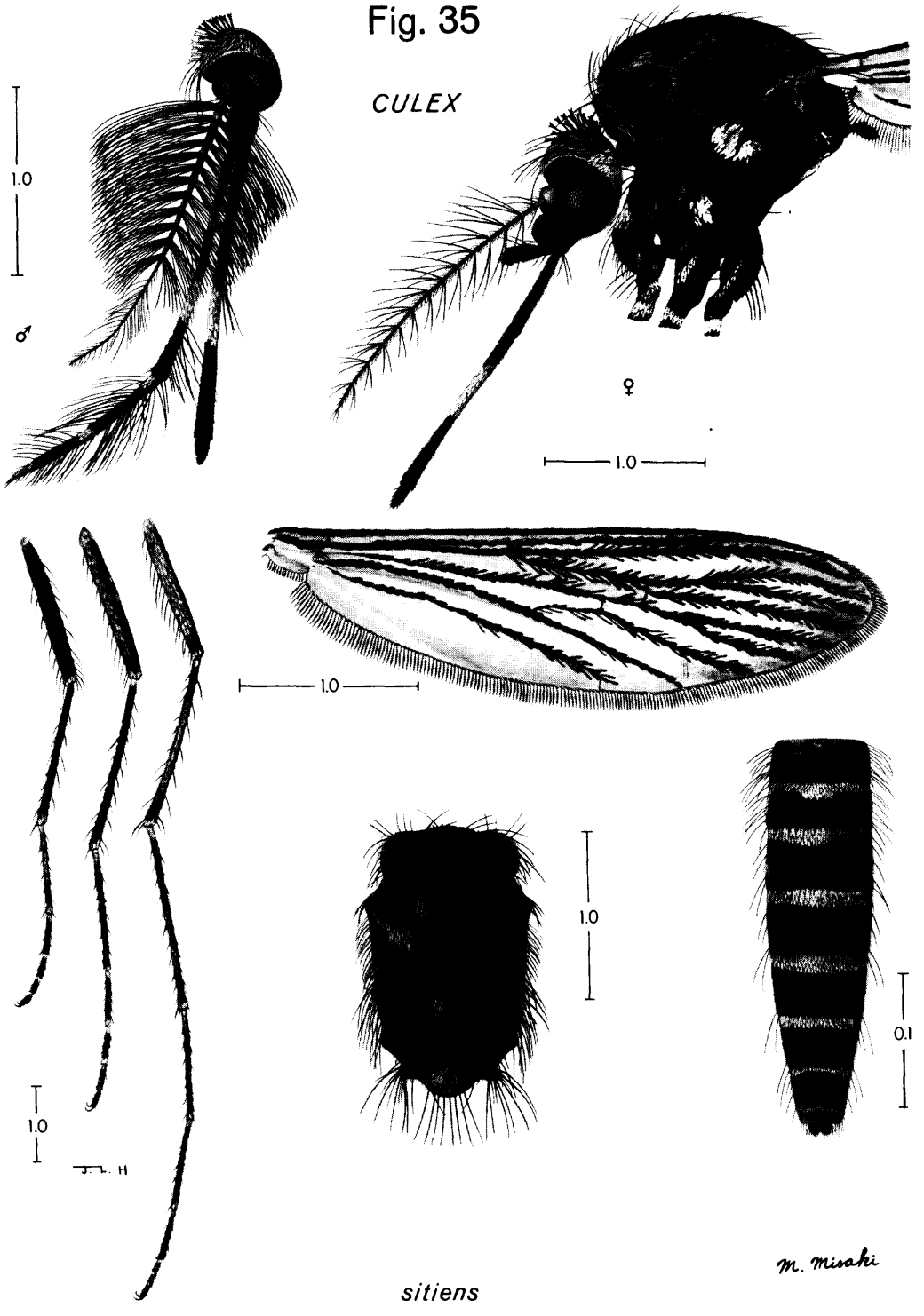
Fig. 34



kinabaluensis

Fig. 35

CULEX



sitiens

Fig. 36

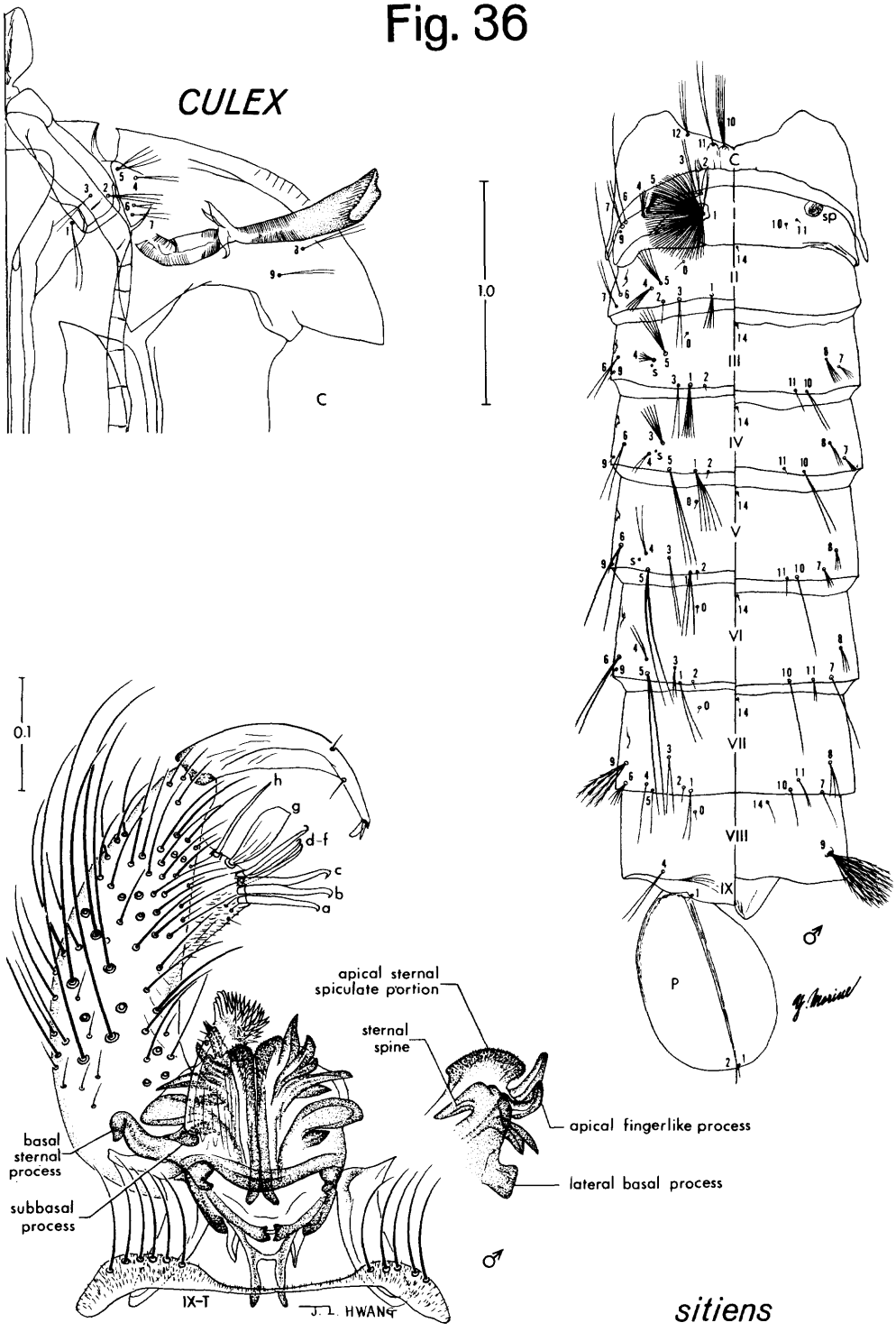
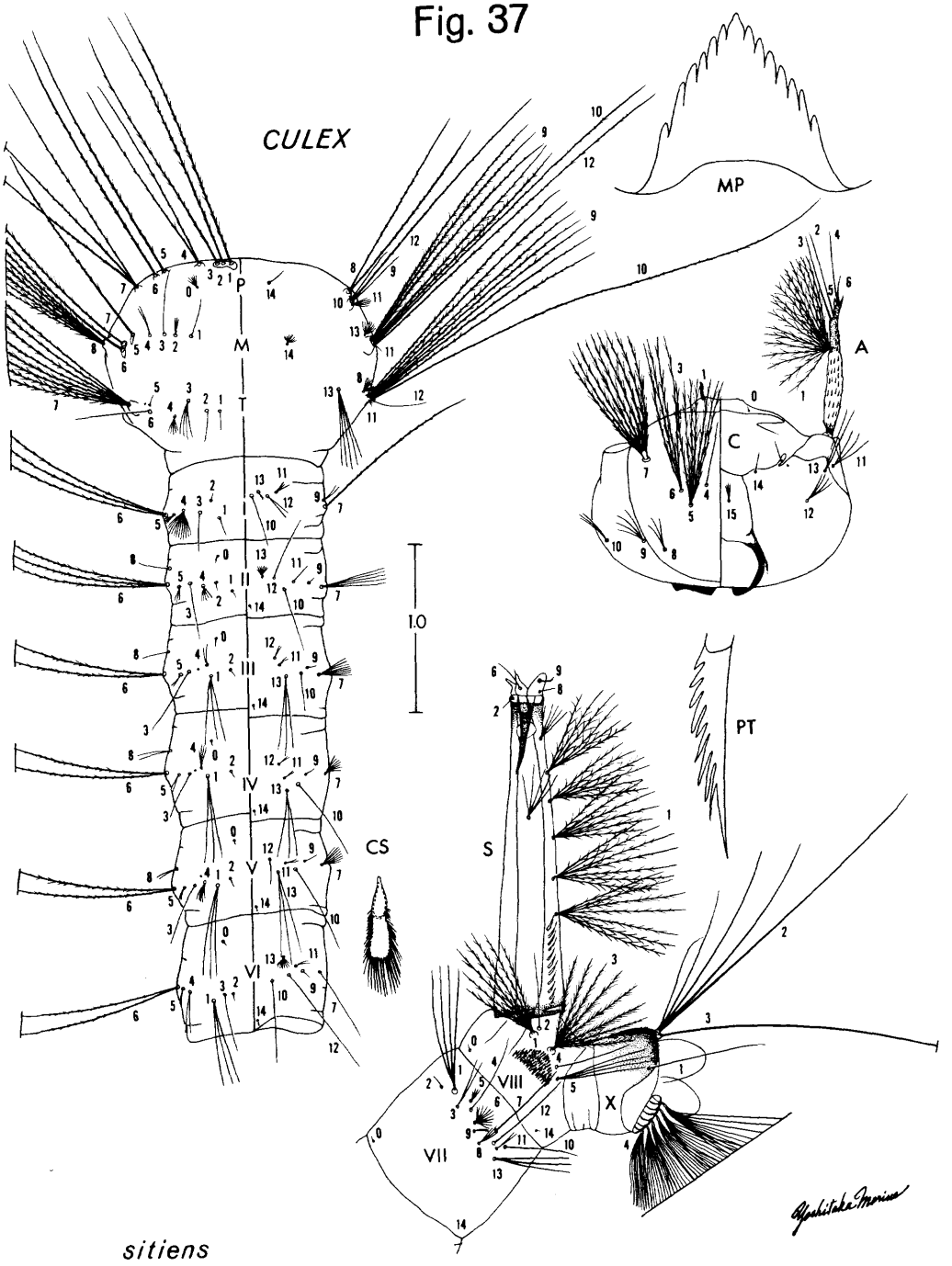

CULEX
C
1.0
sp
C
II
III
IV
V
VI
VII
VIII
IX
P
♂
0.1
h
g
d-f
c
b
a
apical sternal spiculate portion
sternal spine
apical fingerlike process
lateral basal process
basal sternal process
subbasal process
IX-T
J. L. HWANG
♂
sitiens

Fig. 37



sitiens

Fig. 38


CULEX
C
1·0
sp
I
II
III
IV
V
VI
VII
VIII
IX
P
h
d-f
g
c
b
a
0·1
apical fingerlike processes
(inner division)
sternal
spine
(outer
division)
IX-T
♂
alis

Fig. 39

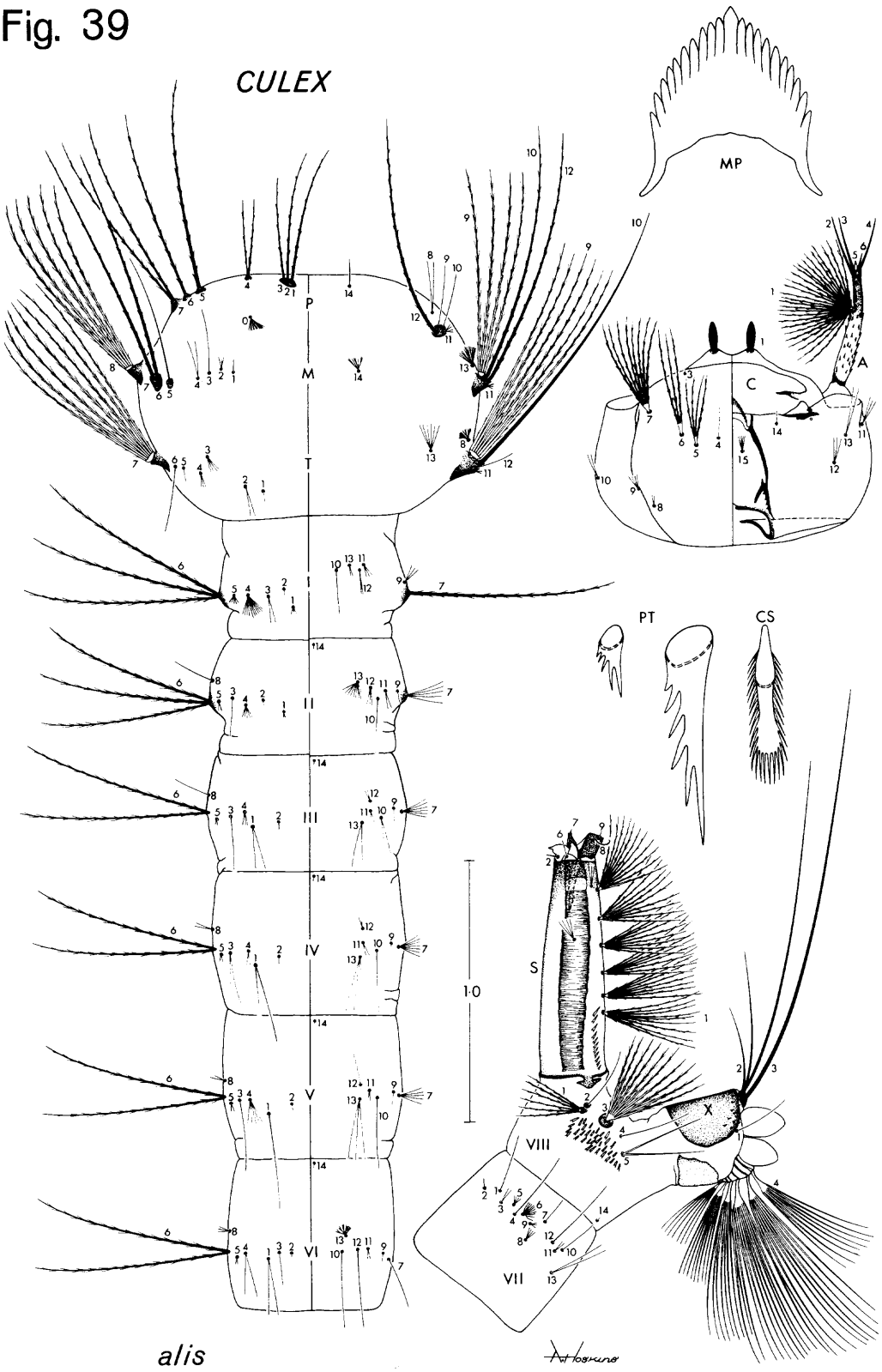
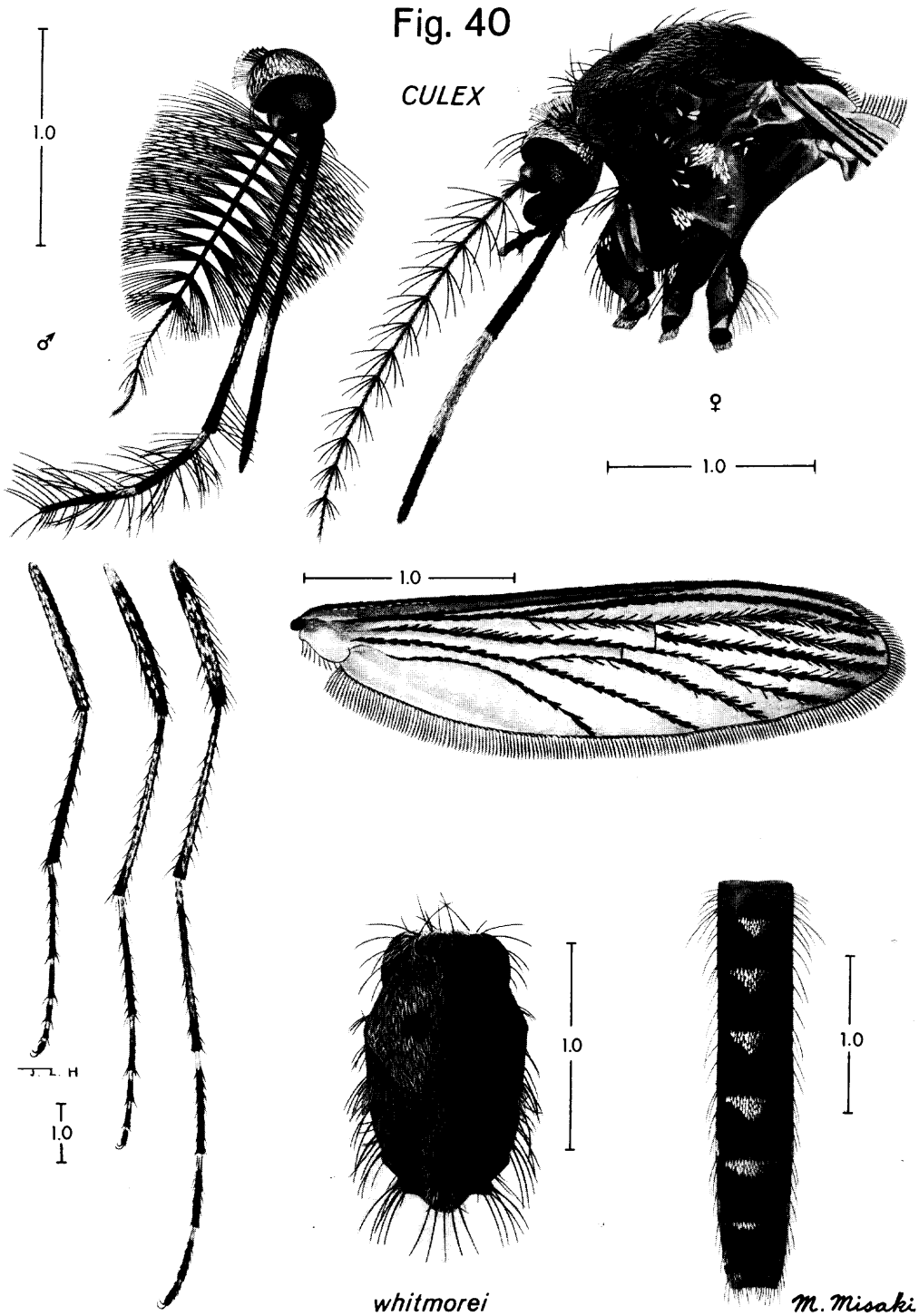


Fig. 40

CULEX



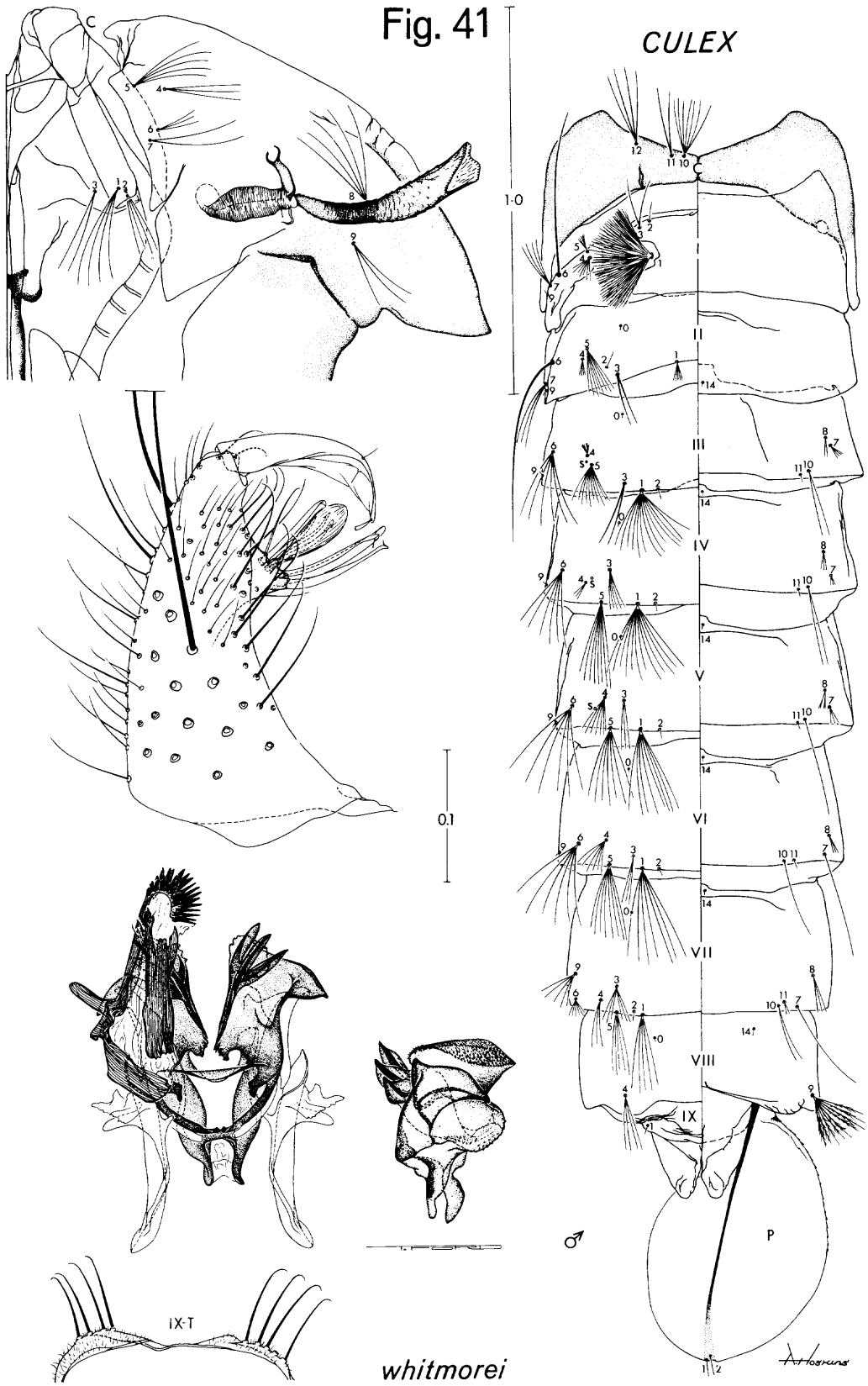
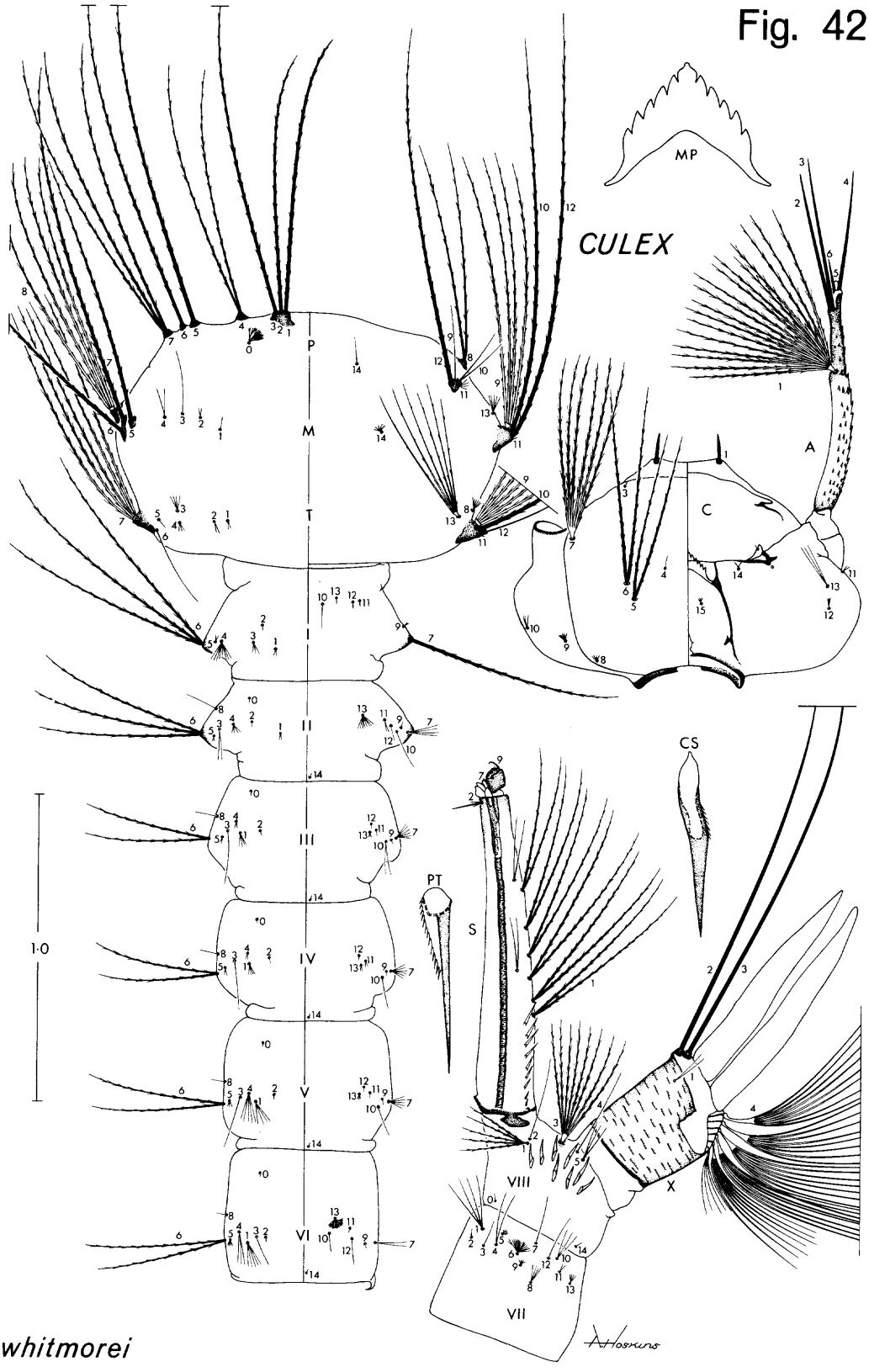


Fig. 41
CULEX
C
1·0
0.1
IX-T
P
♂
whitmorei

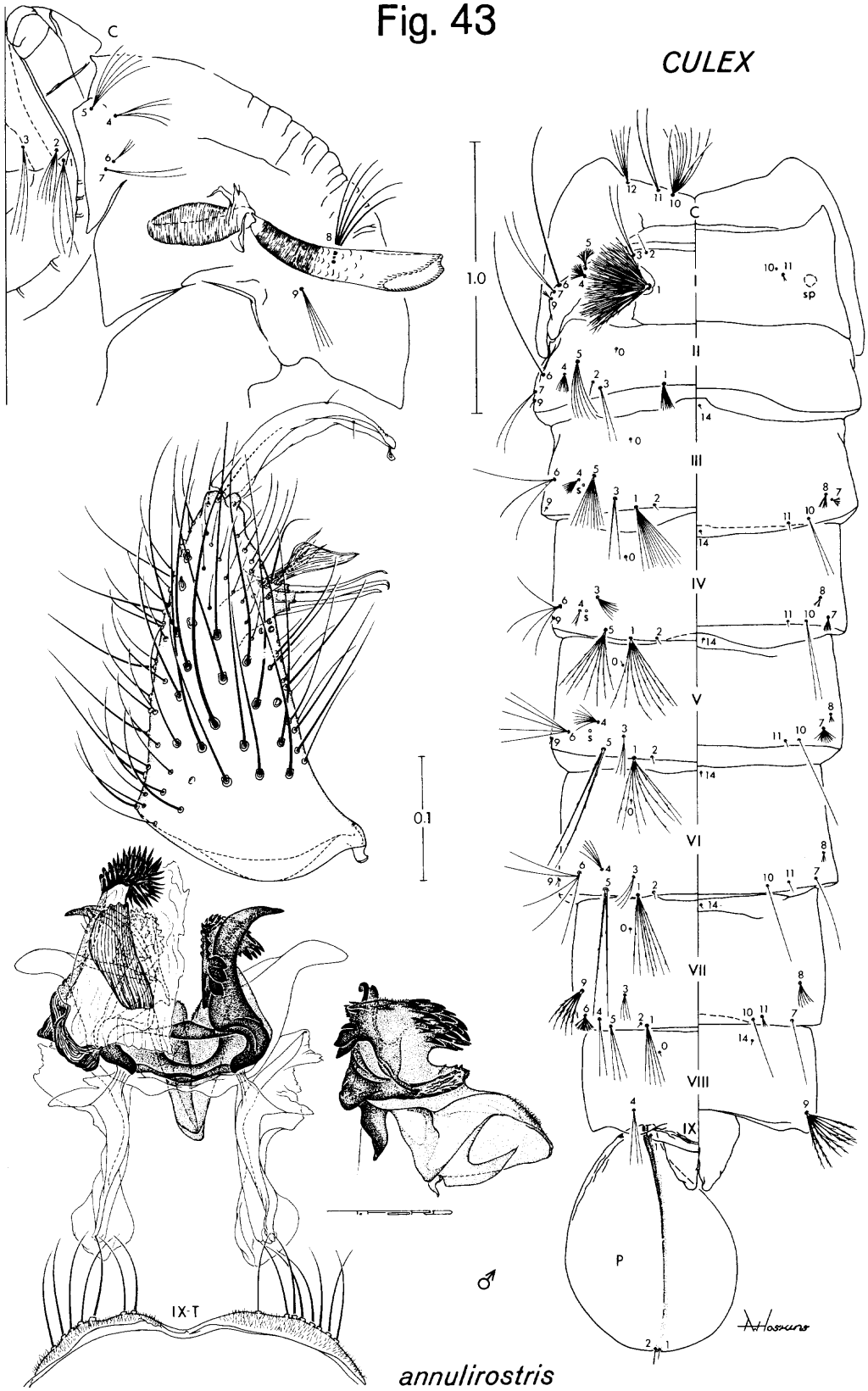
Fig. 42



whitmorei

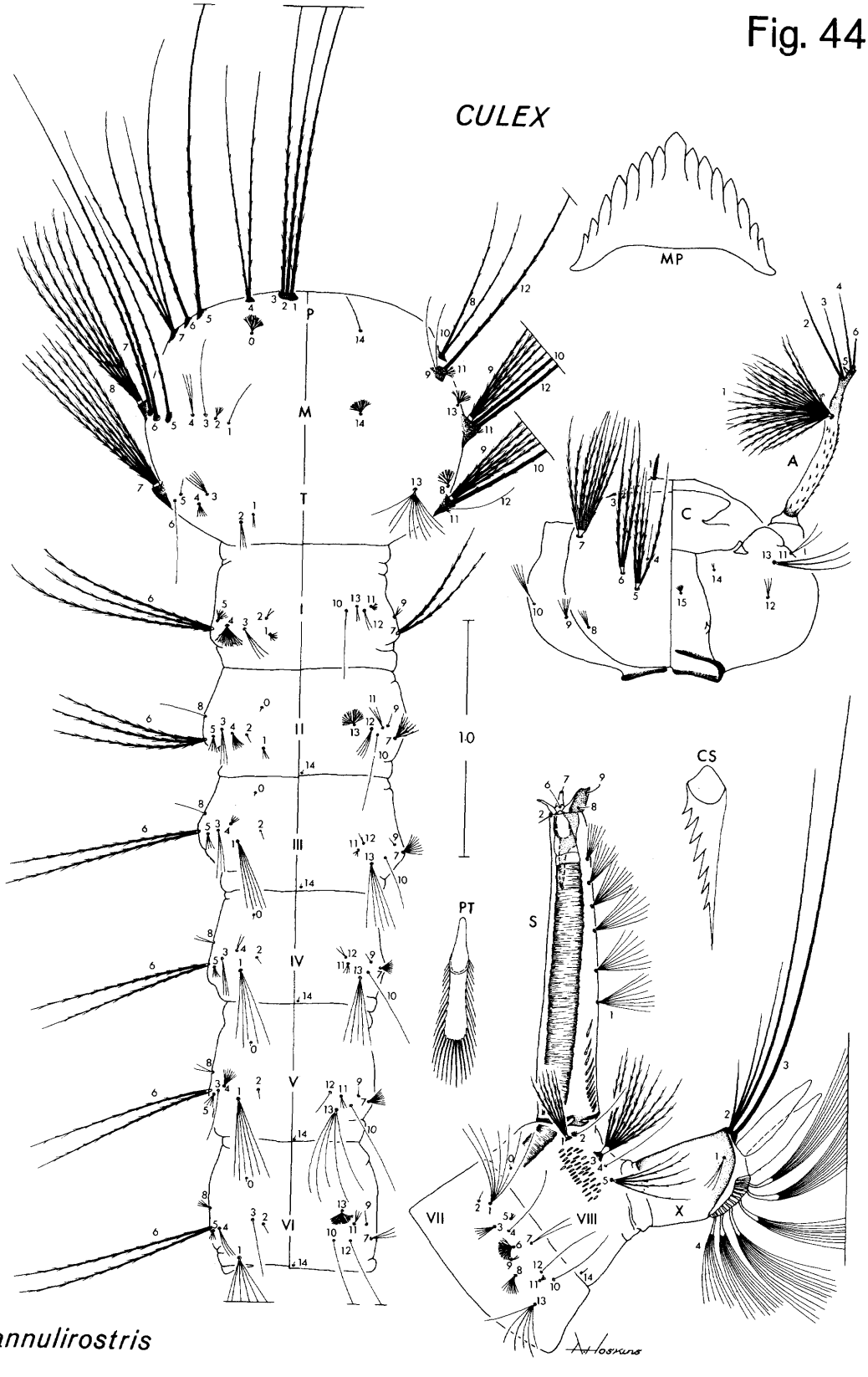
Fig. 43

CULEX



annulirostris

Fig. 44



annulirostris

Fig. 45

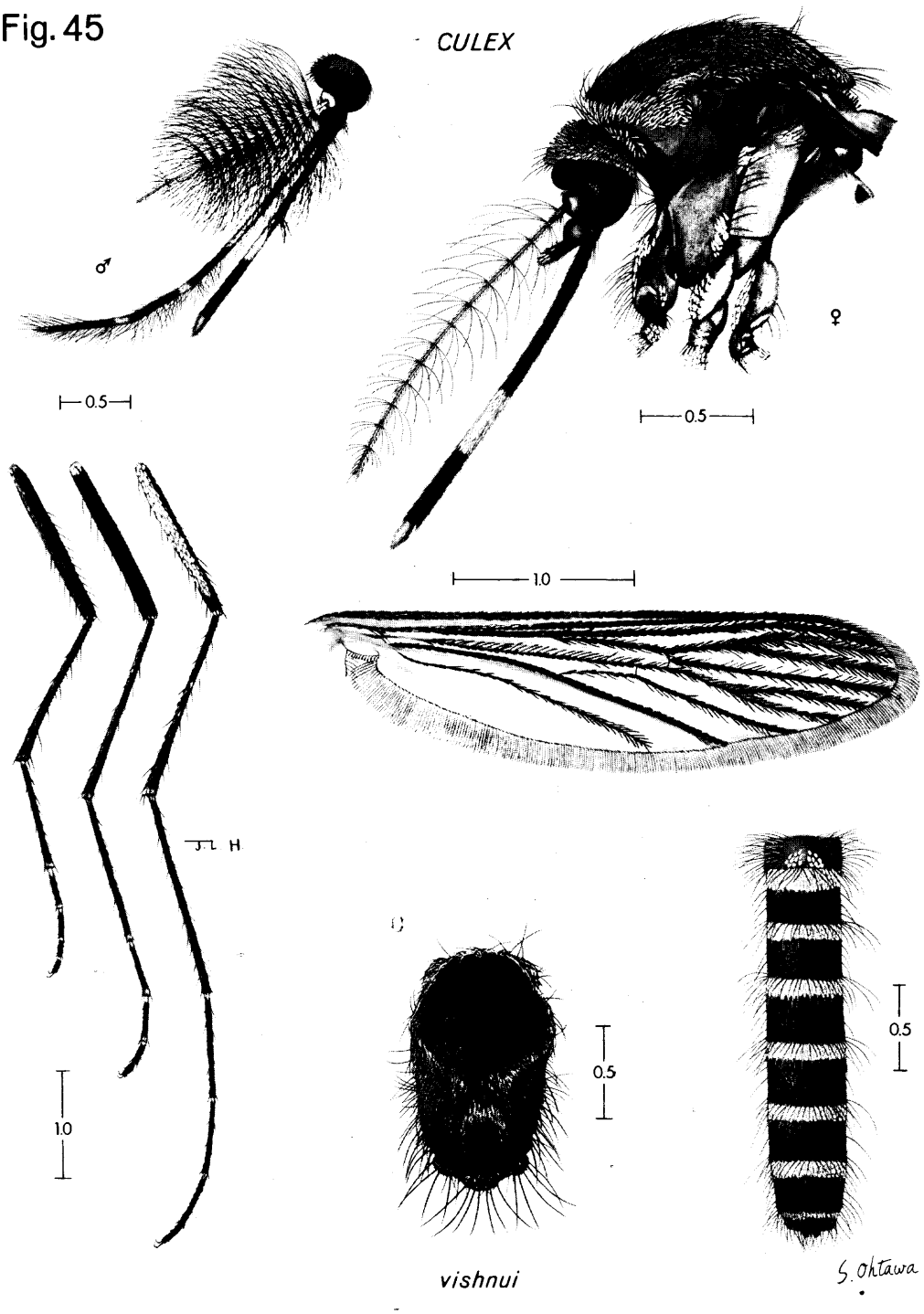


Fig. 46

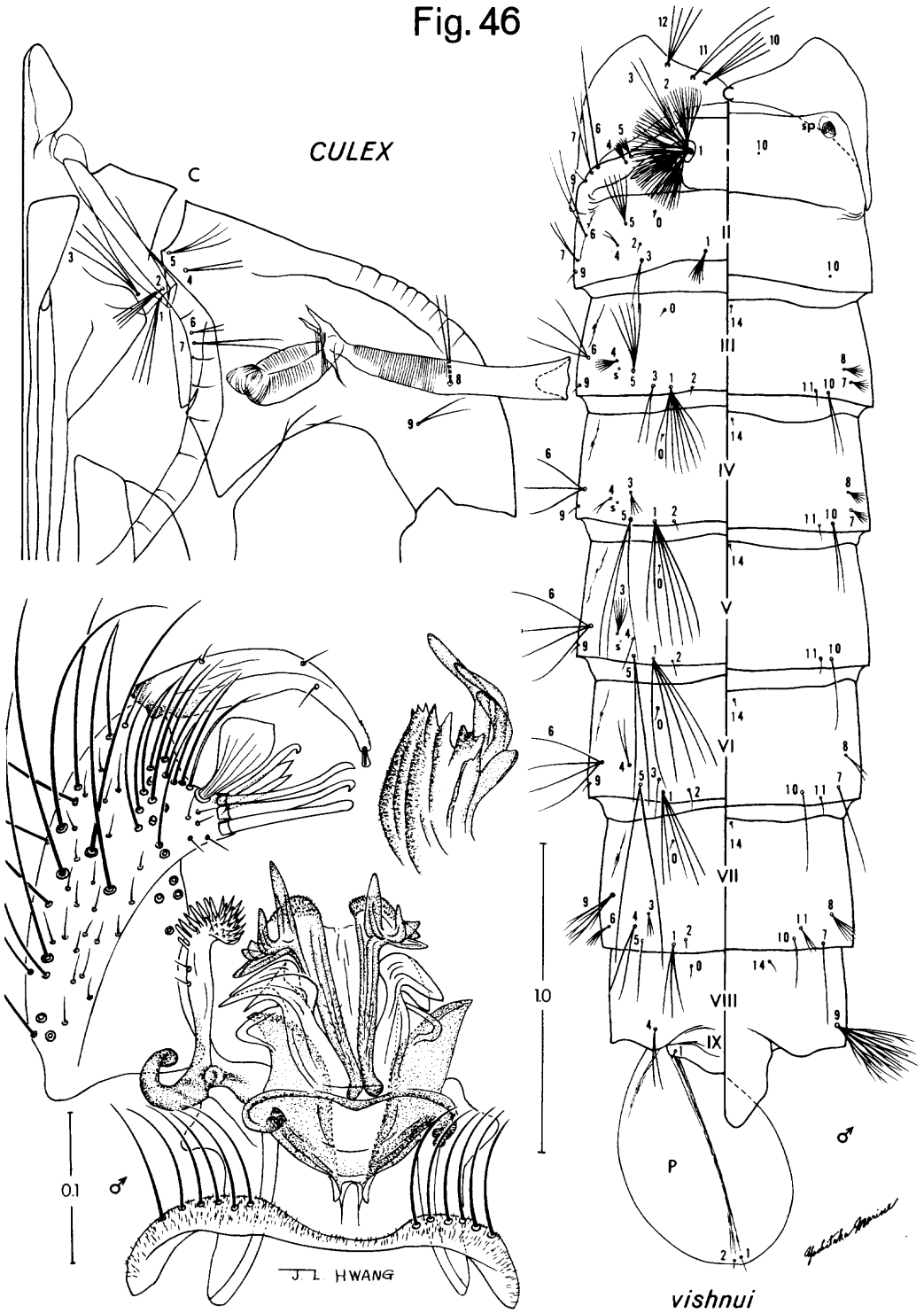


Fig. 47

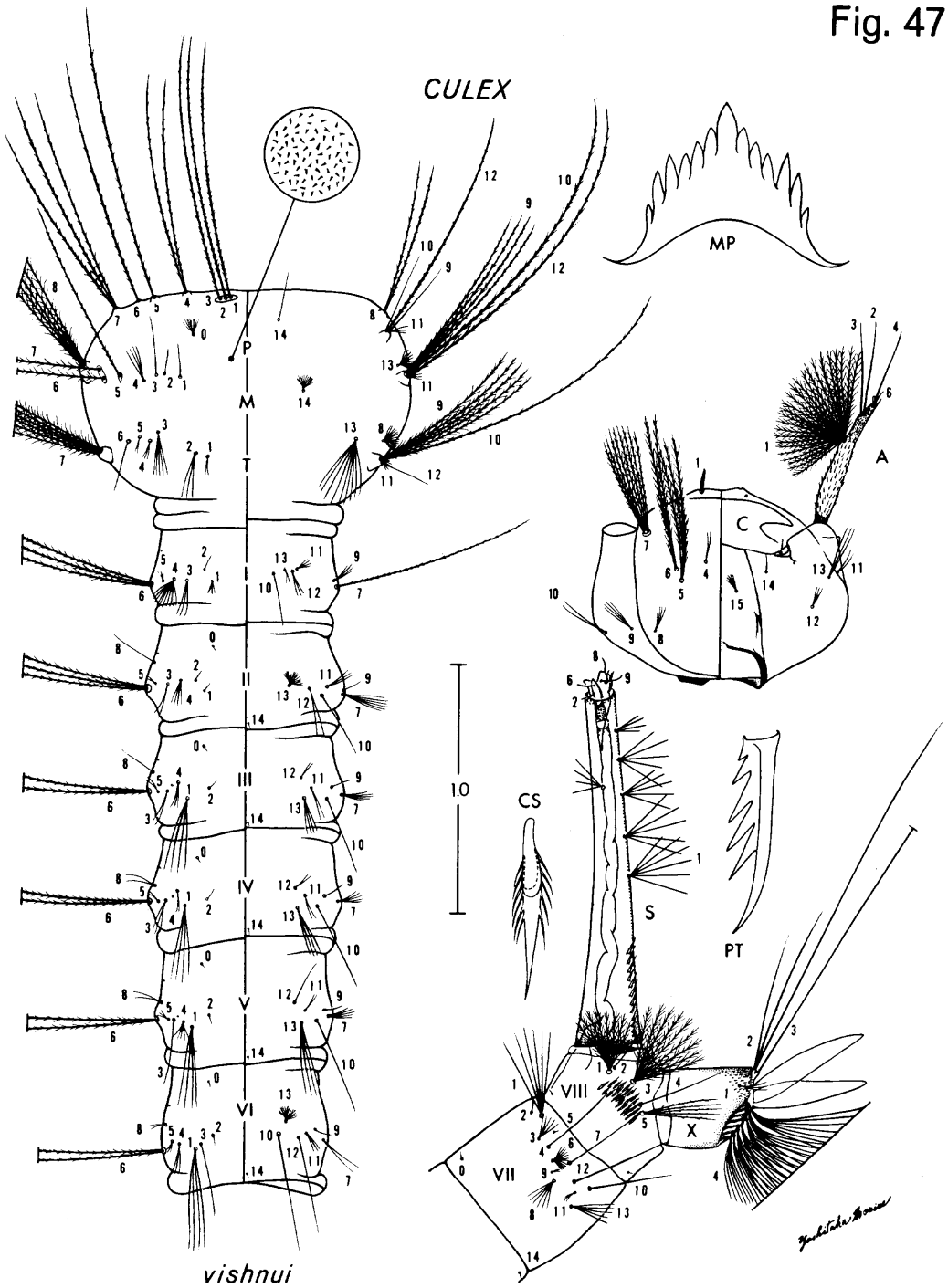


Fig. 48

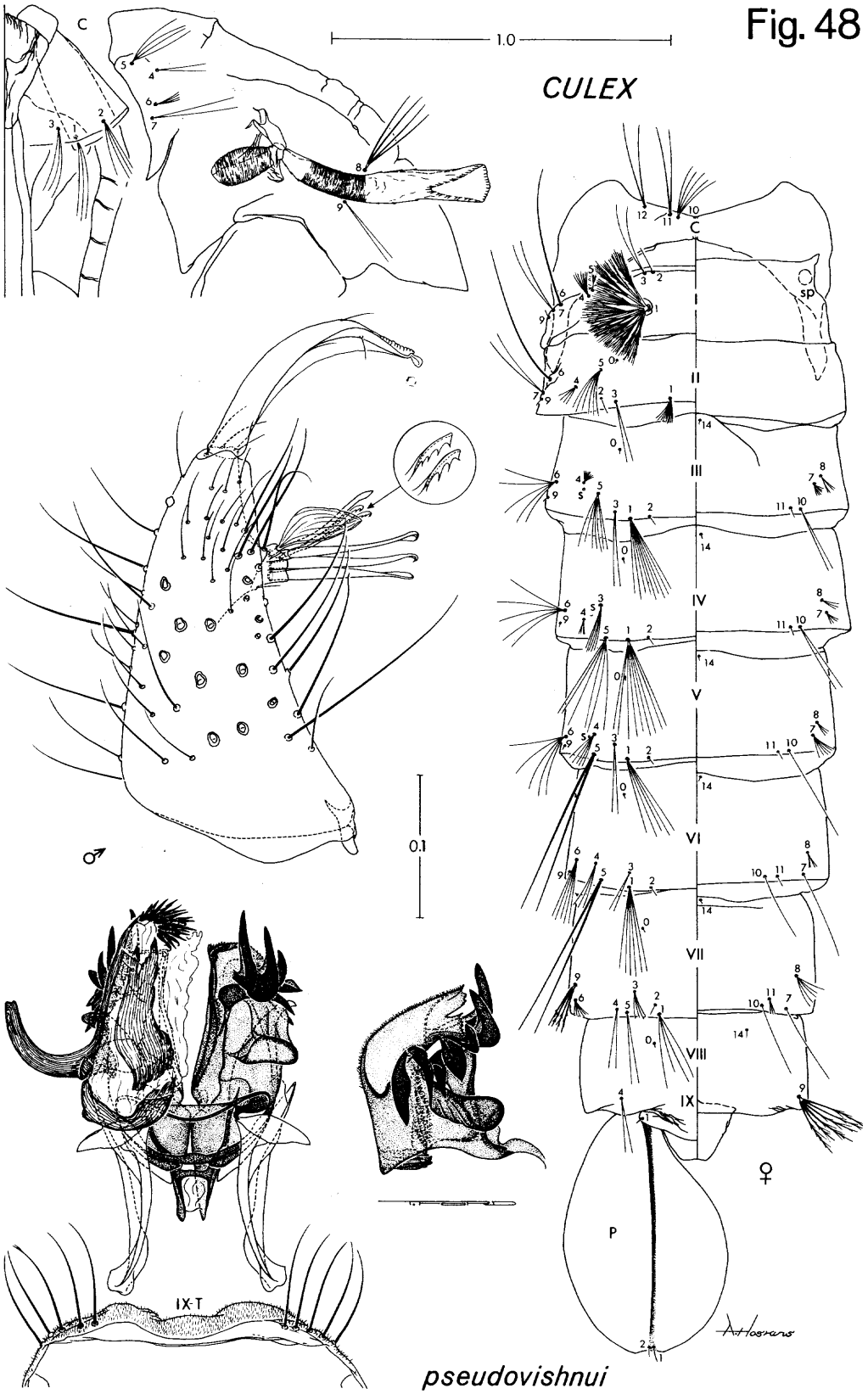
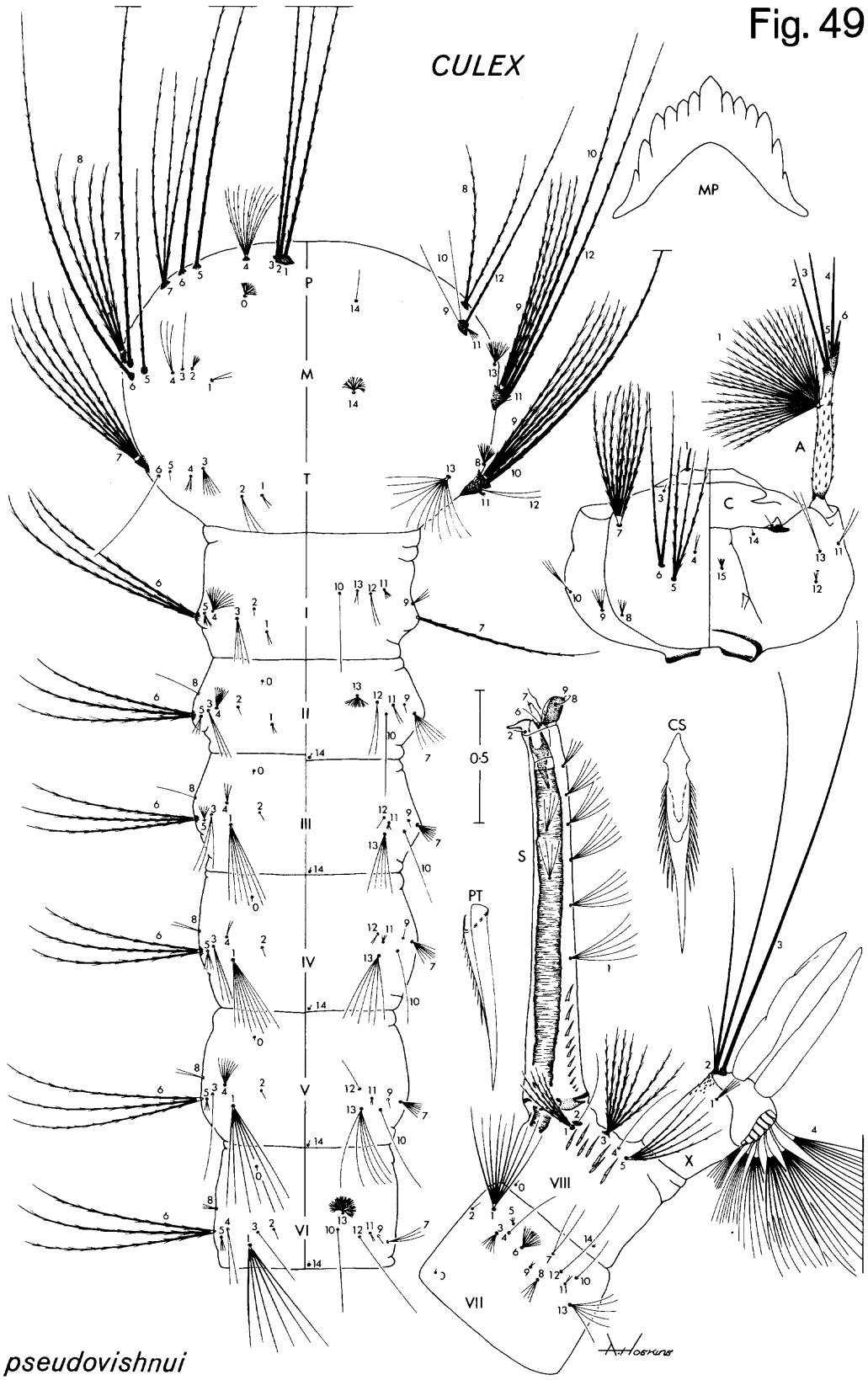


Fig. 49



pseudovishnui

Fig. 50

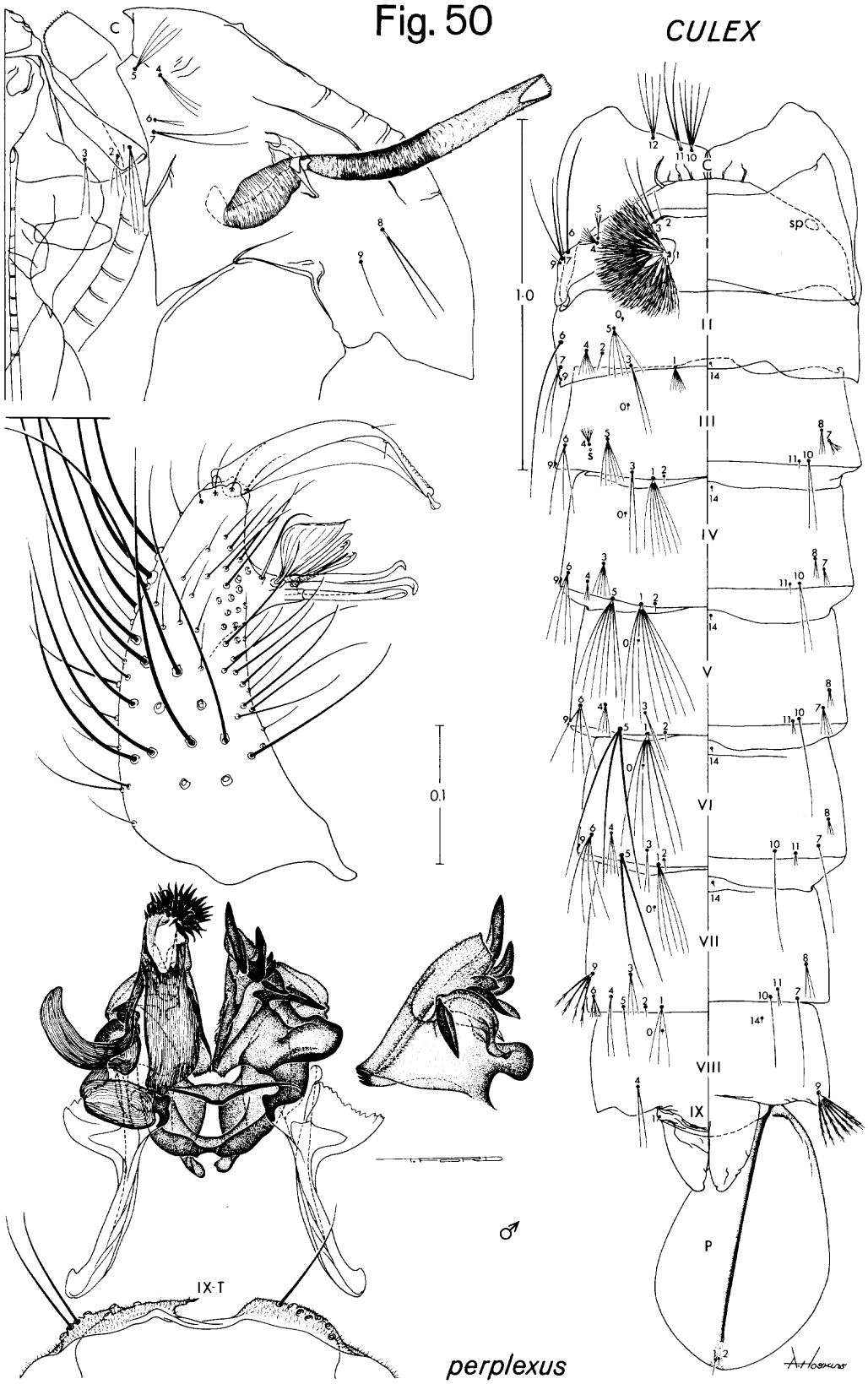
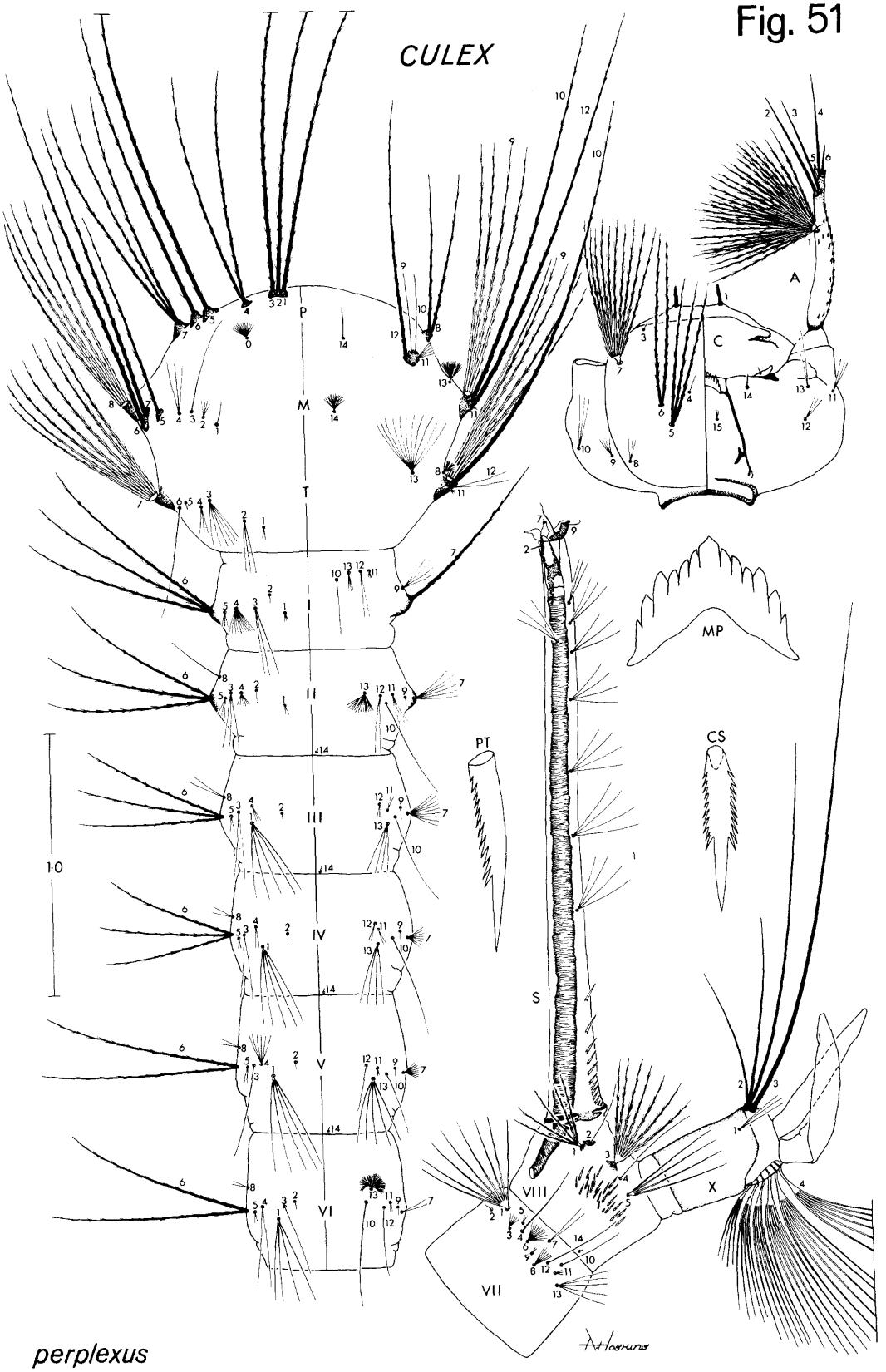


Fig. 51



perplexus

Fig. 52

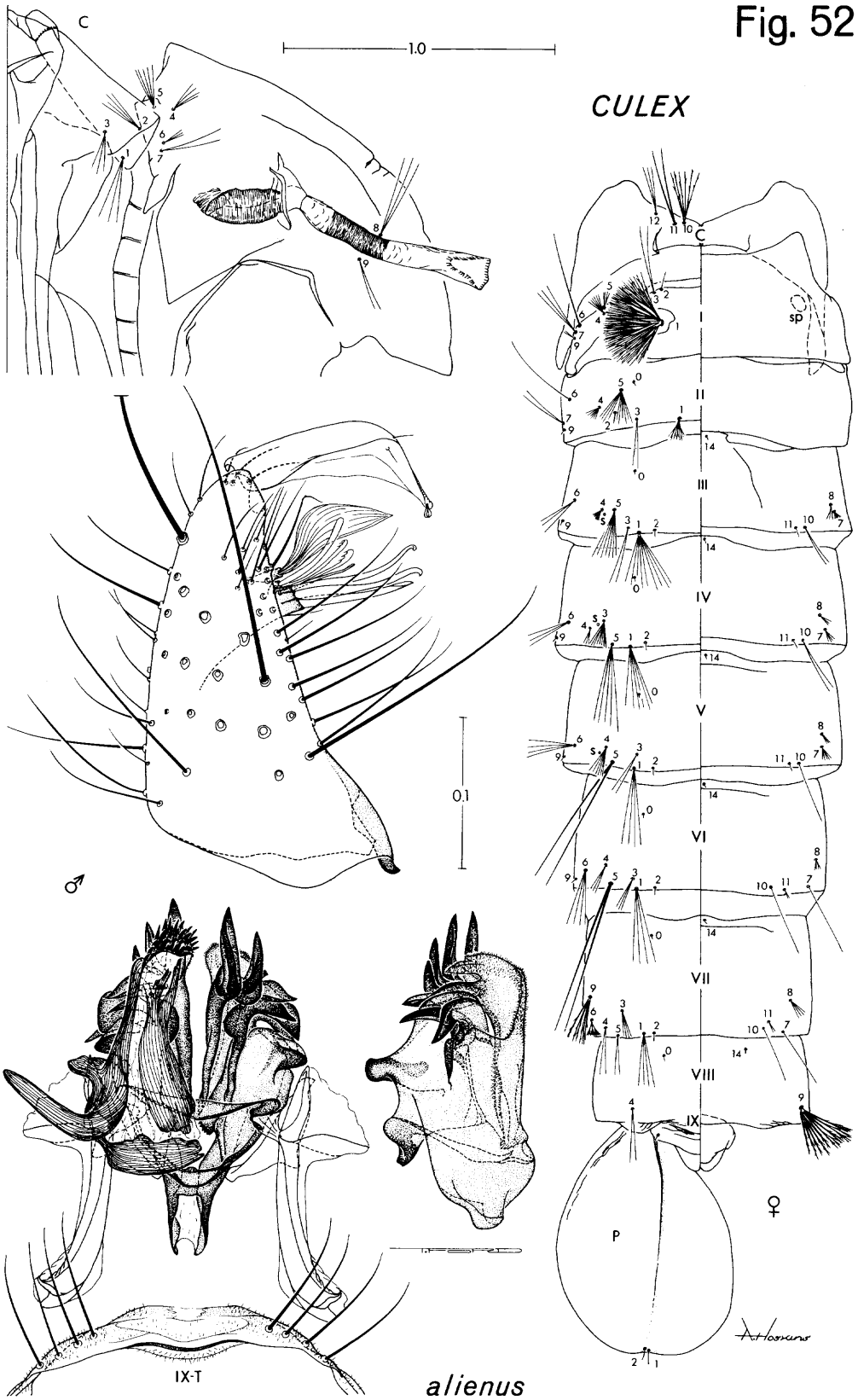


Fig. 53

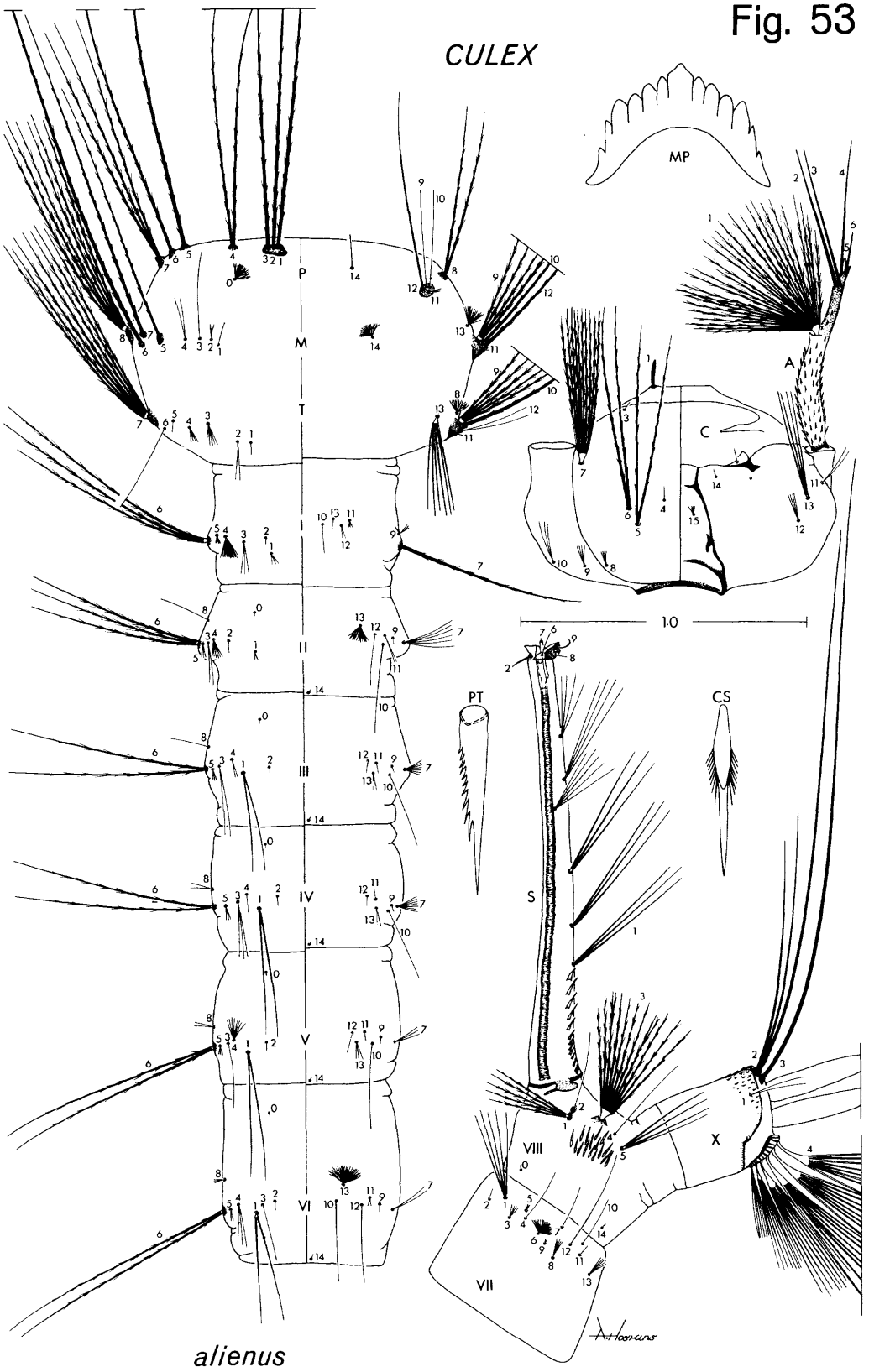


Fig. 54

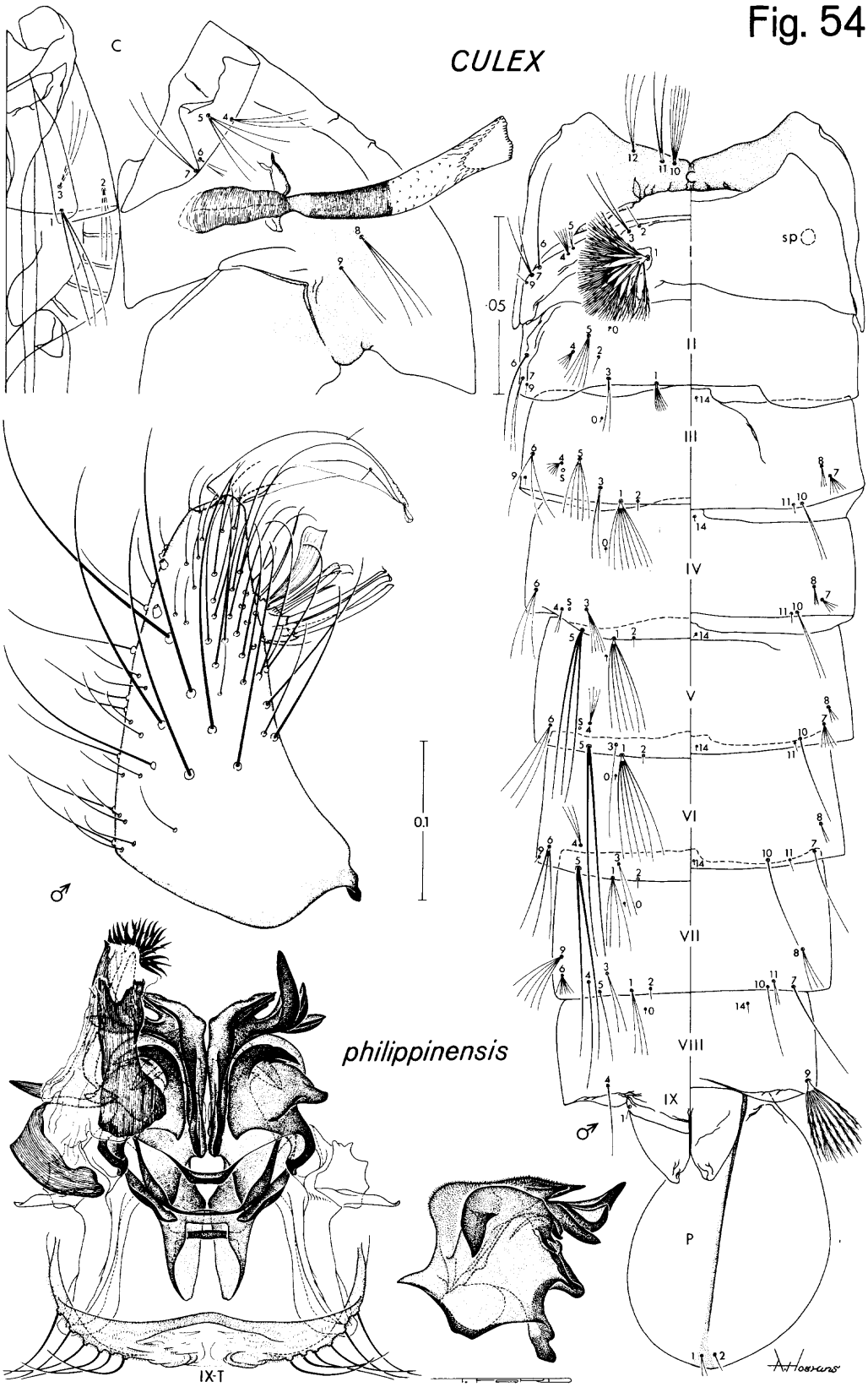
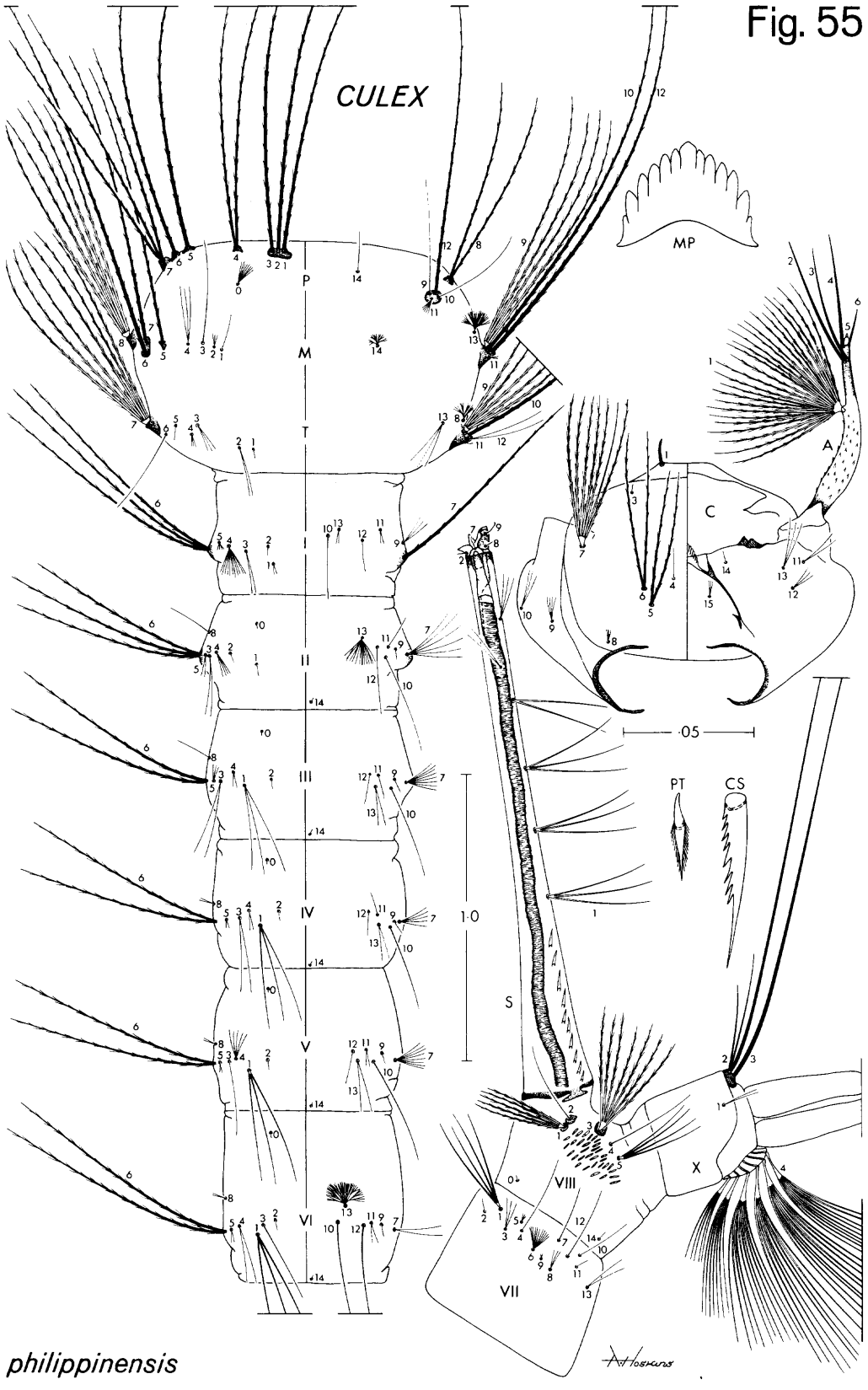

C
CULEX
philippinensis
.05
0.1
sp
I
II
III
IV
V
VI
VII
VIII
IX
P
♂
IX-T

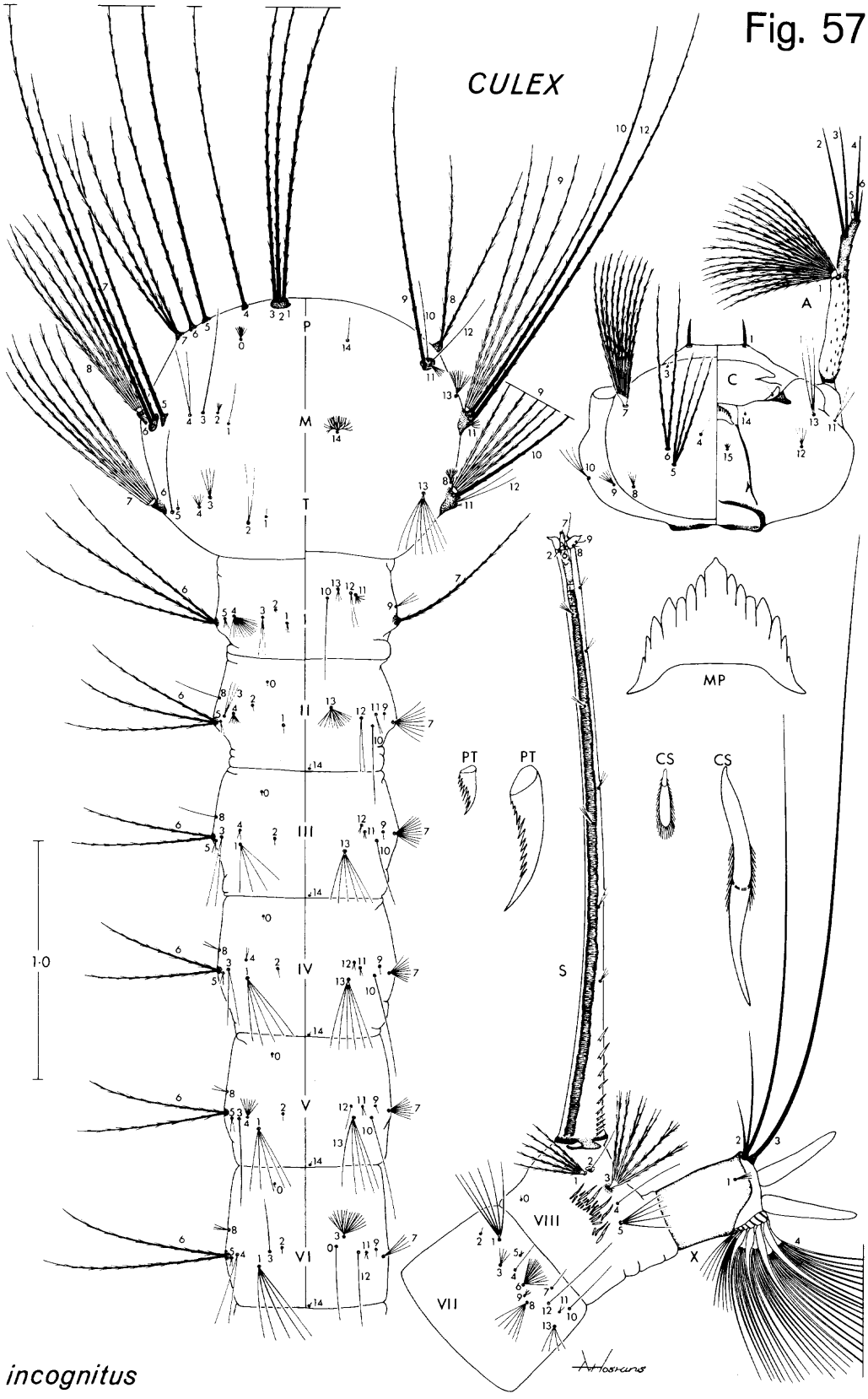
Fig. 55



philippinensis

Fig. 56

Fig. 57



incognitus

Fig. 58

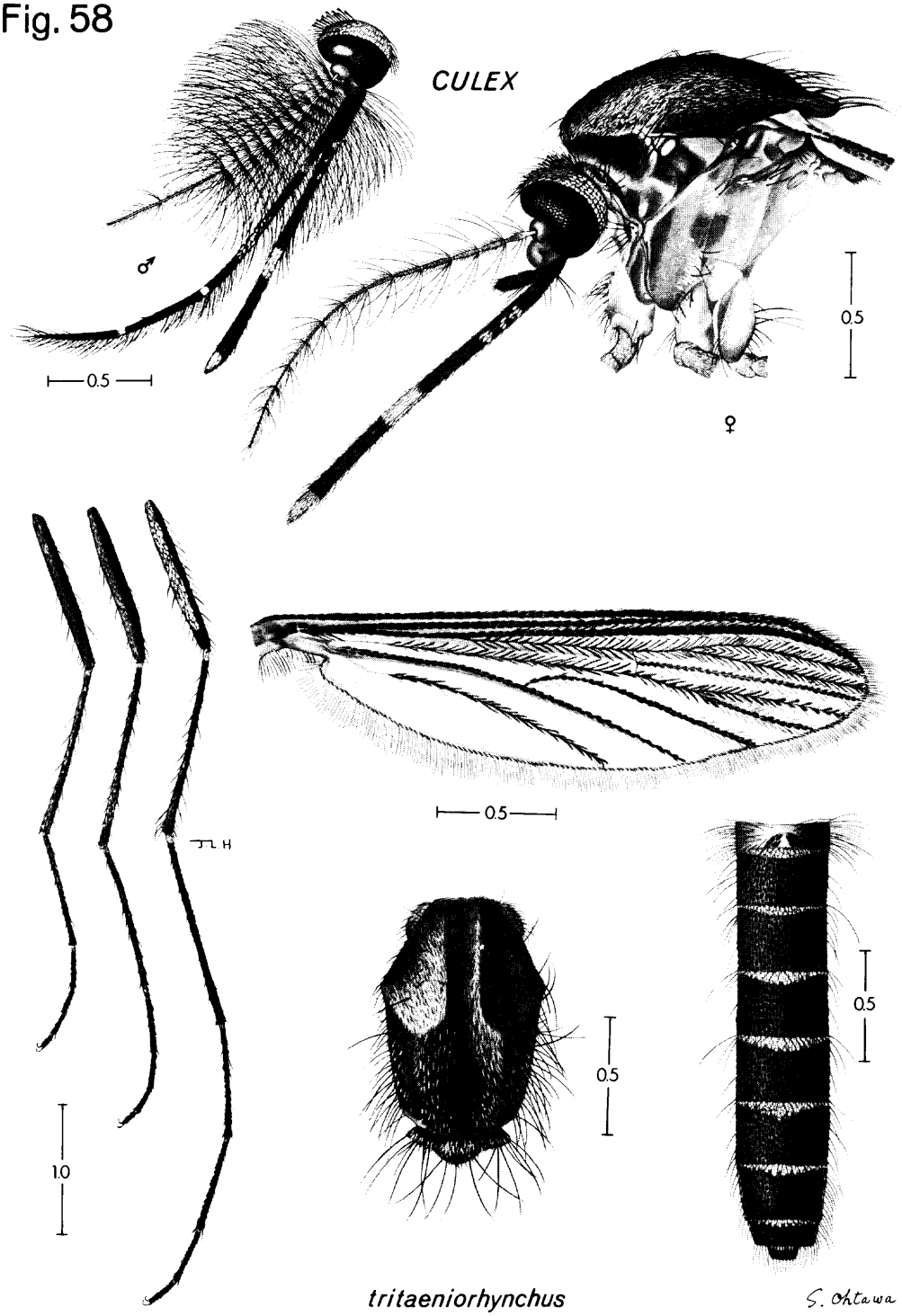
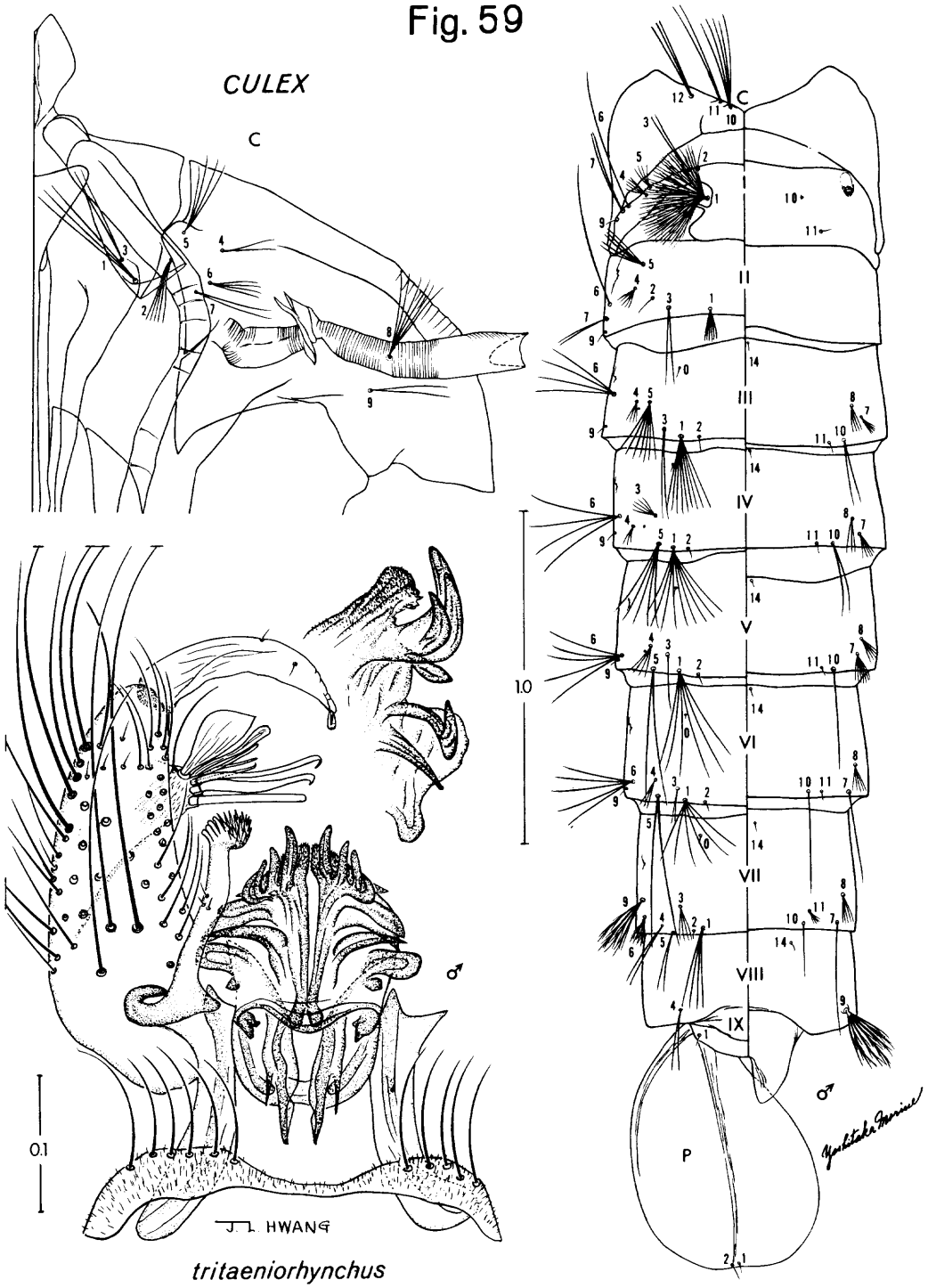


Fig. 59



tritaeniorhynchus

Fig. 60

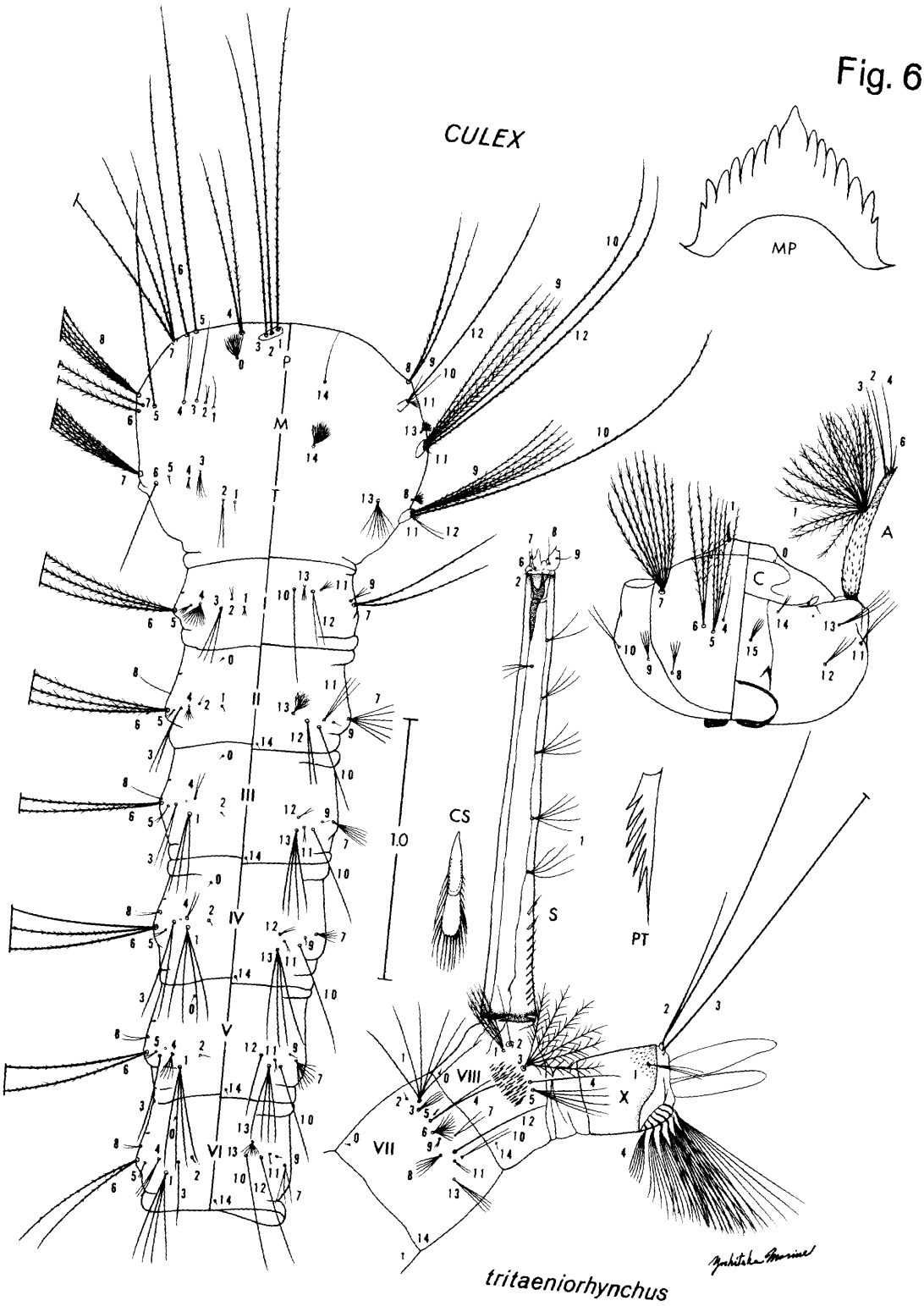
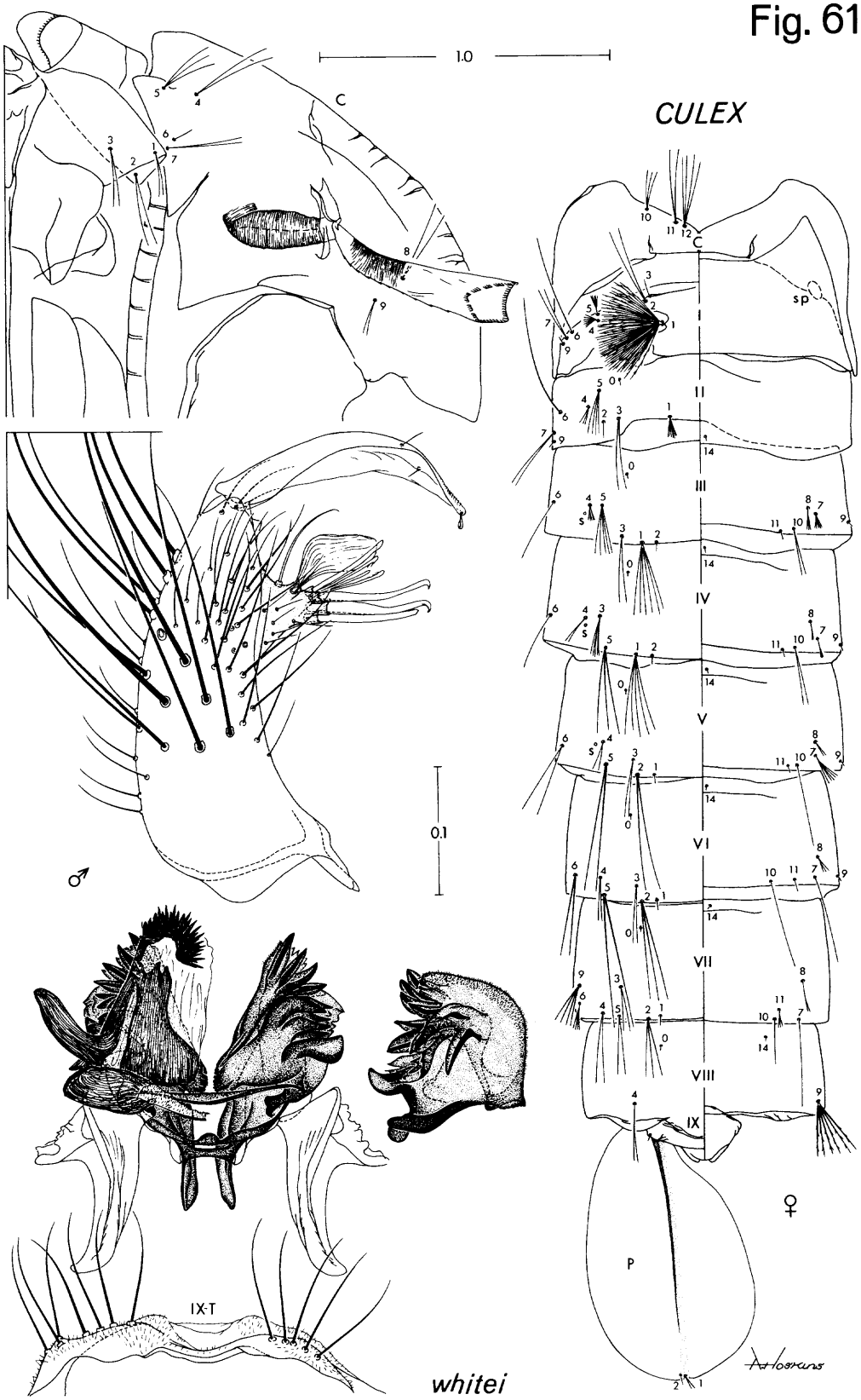

CULEX
MP
P
M
T
A
C
CS
S
PT
1.0
I
II
III
IV
V
VI
VII
VIII
X
tritaeniorhynchus

Fig. 61



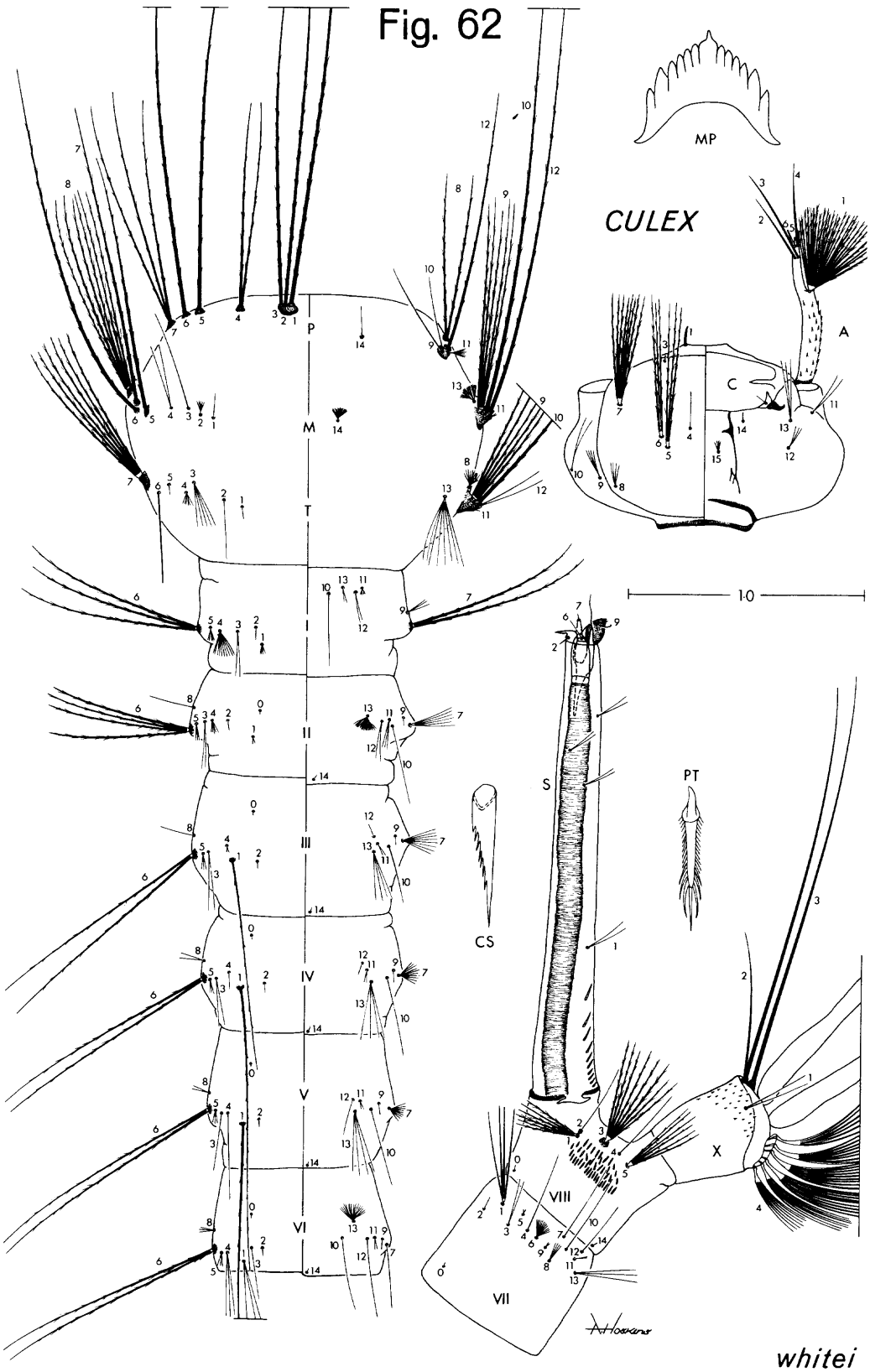


Fig. 62
MP
CULEX
A
C
P
M
T
I
II
III
IV
V
VI
VII
VIII
X
S
PT
CS
1.0
whitei

Fig. 63

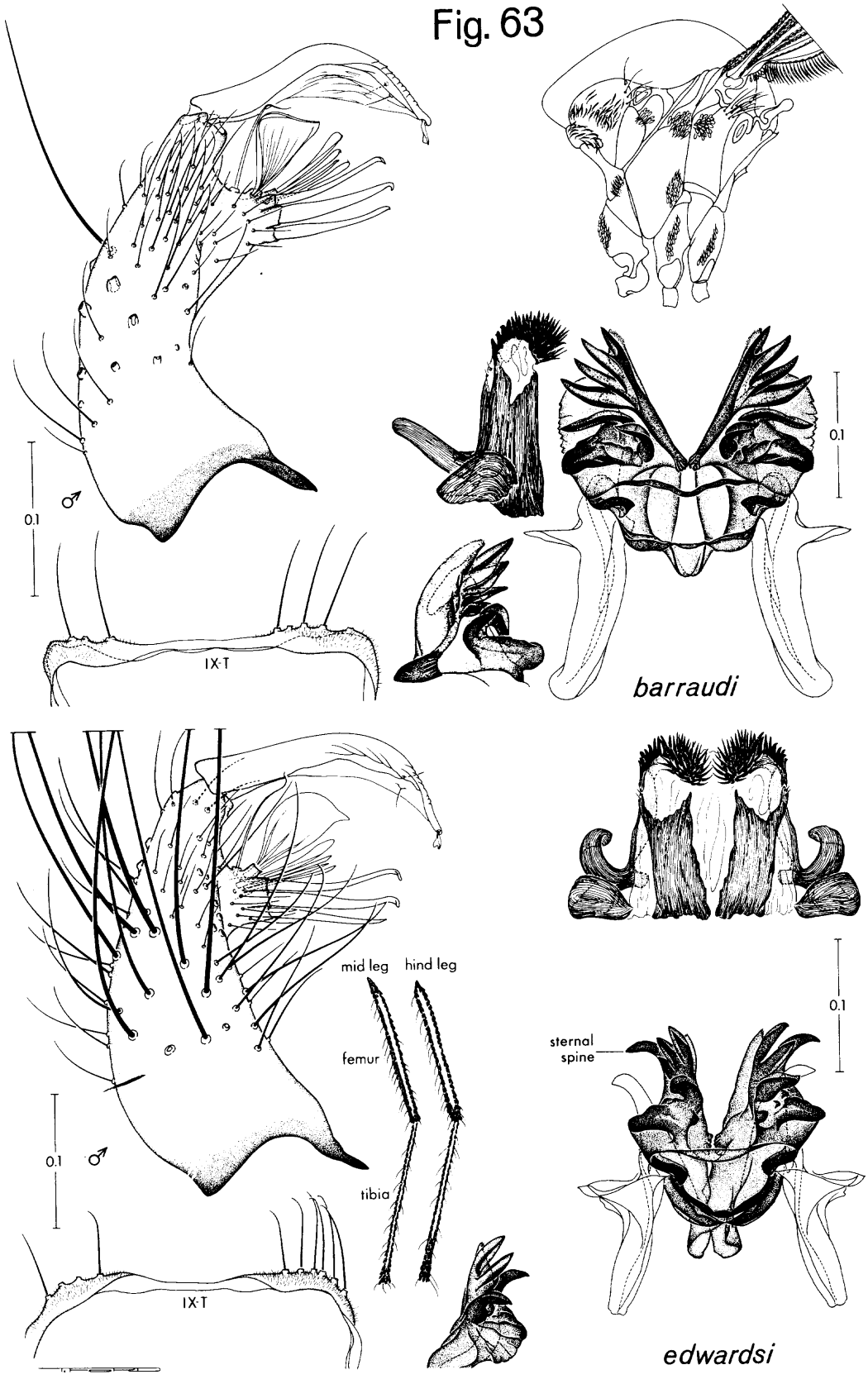

0.1
♂
IX-T
0.1
barraudi
mid leg
hind leg
femur
tibia
0.1
♂
IX-T
0.1
sternal spine
edwardsi

Fig. 64

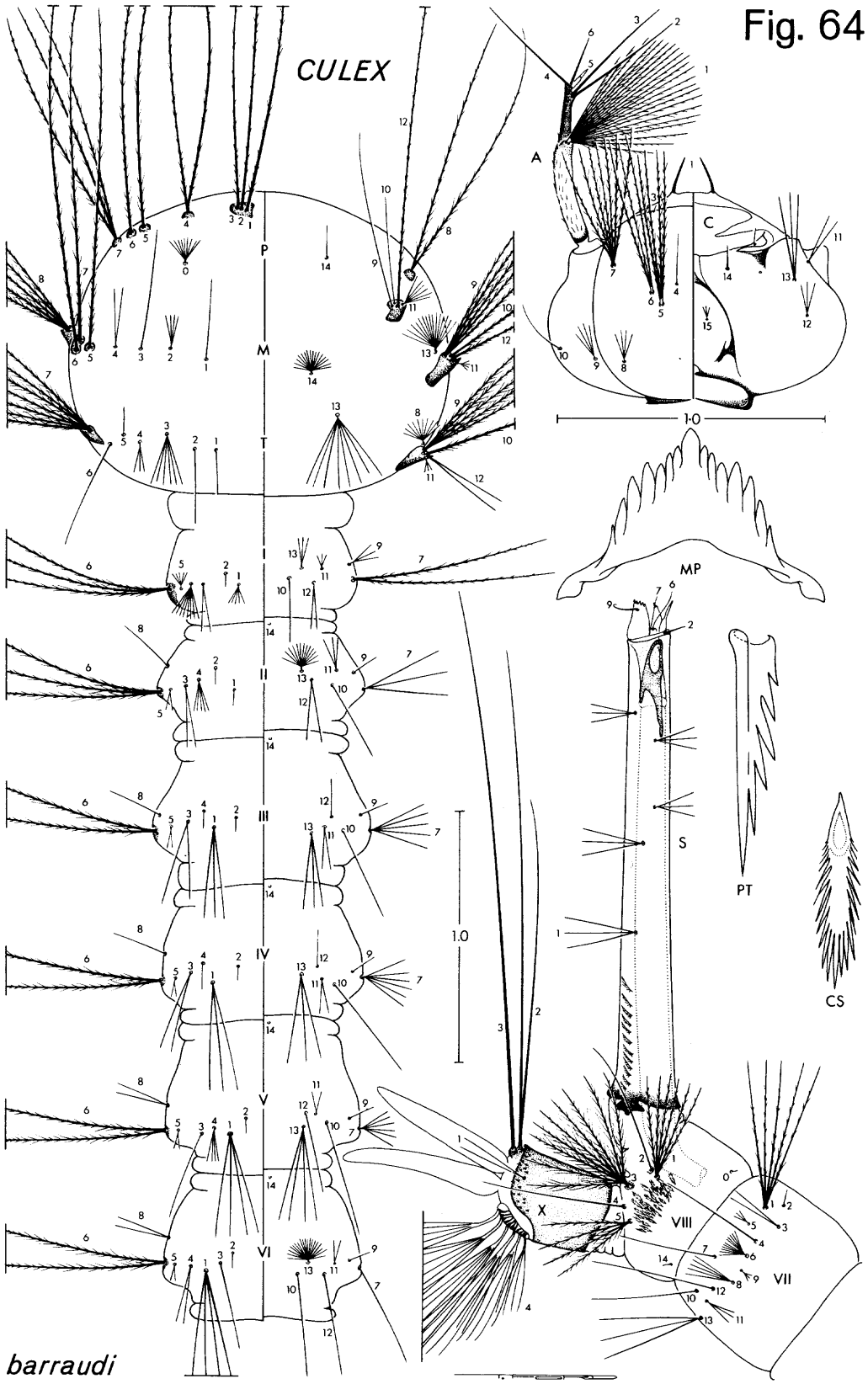


Fig.65

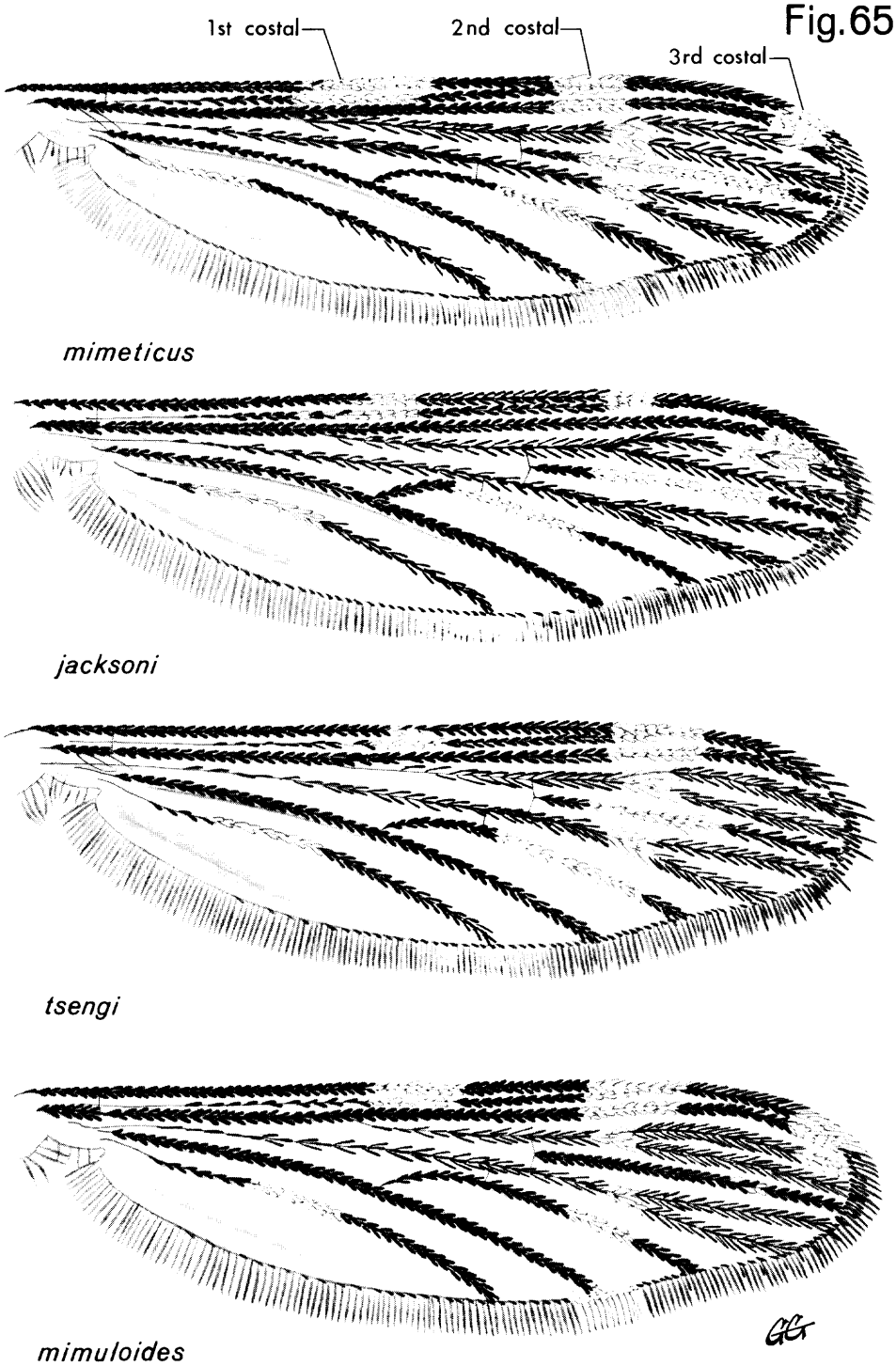

1st costal
2nd costal
3rd costal
mimeticus
jacksoni
tsengi
mimuloides

Fig.66

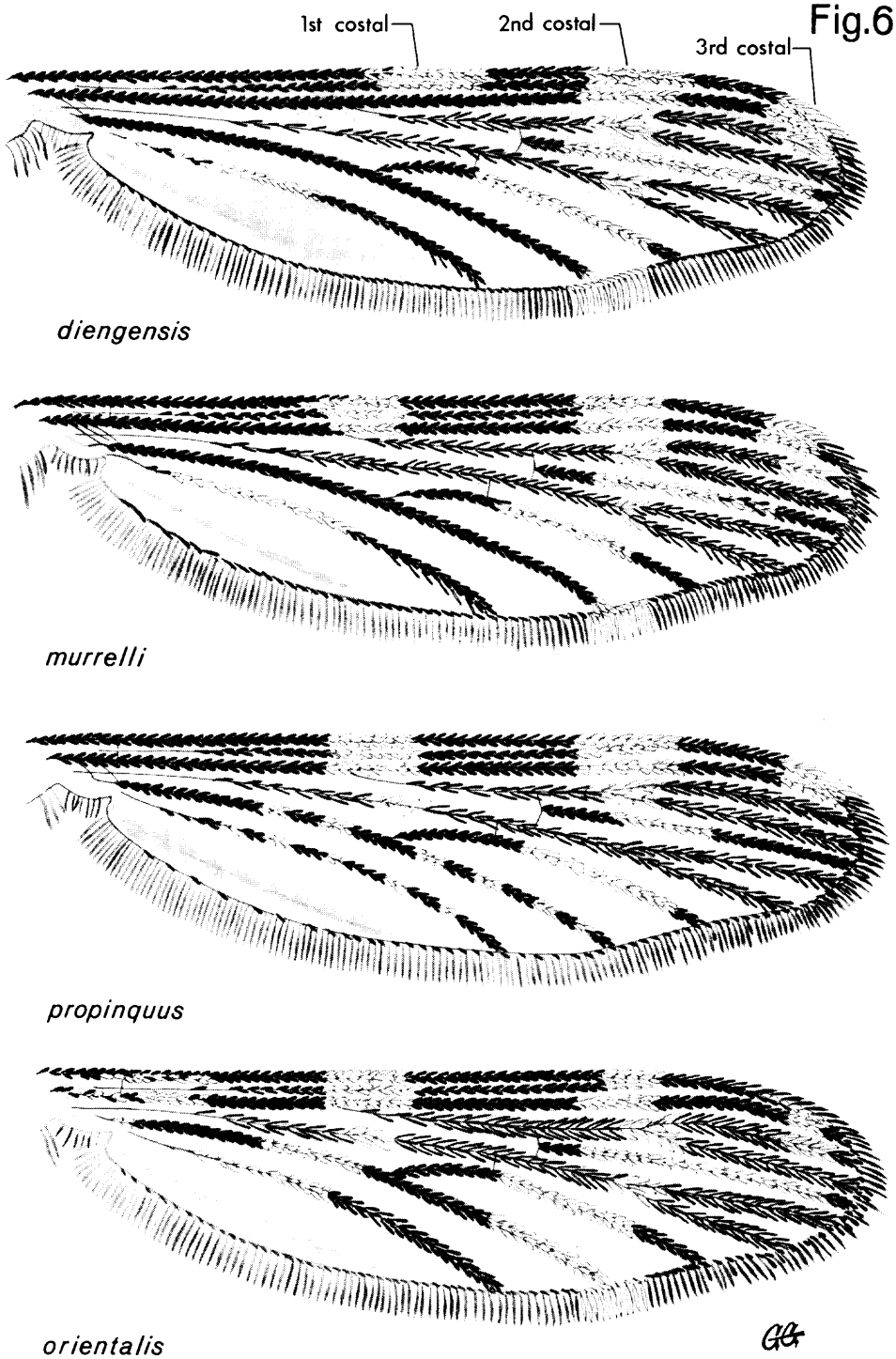
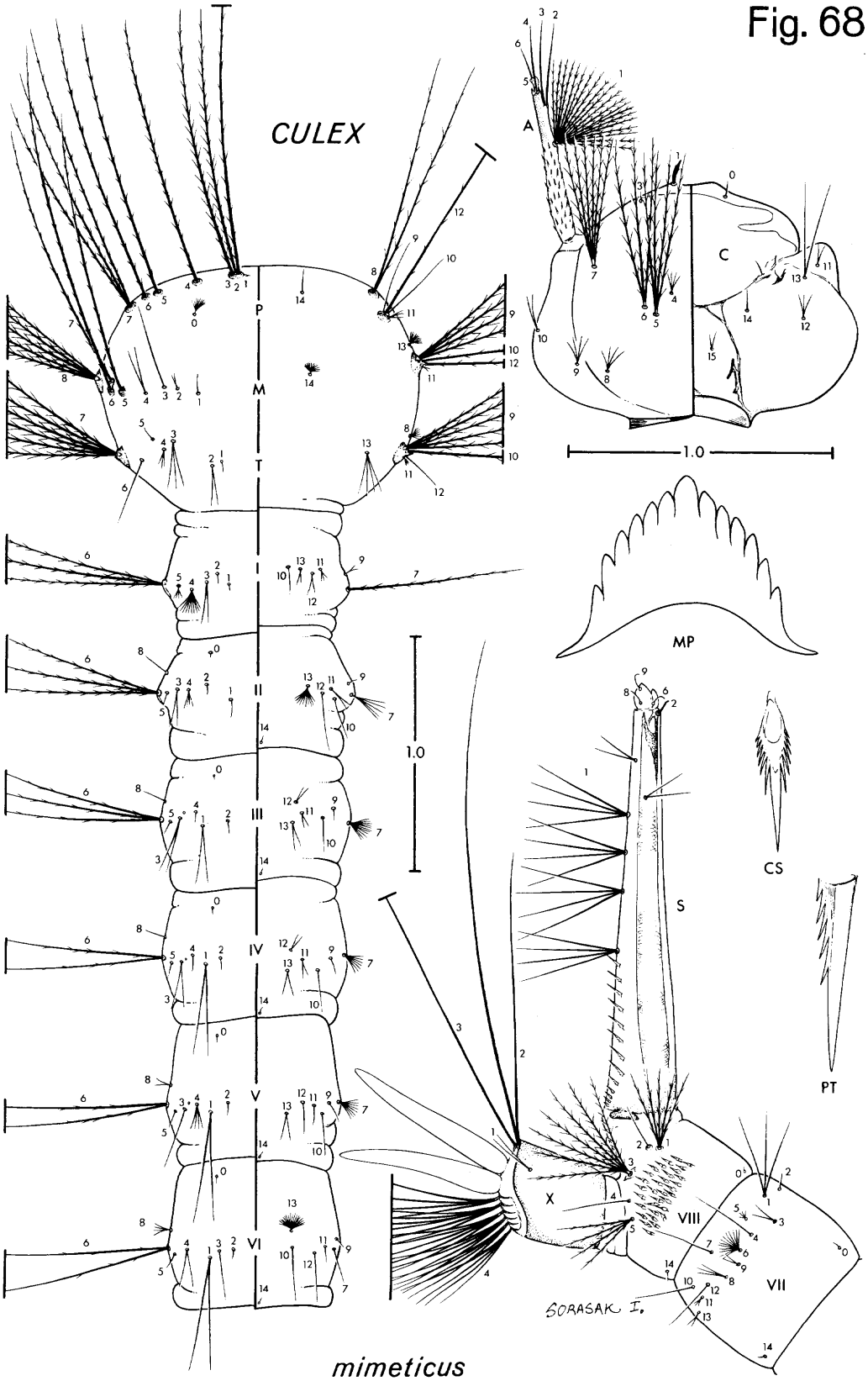

1st costal
2nd costal
3rd costal
diengensis
murrelli
propinquus
orientalis

Fig. 67


1.0
CULEX
C
sp
I
II
III
IV
V
VI
VII
VIII
IX
P
♂
IX-T
0.2
mimeticus
SORASAKI.

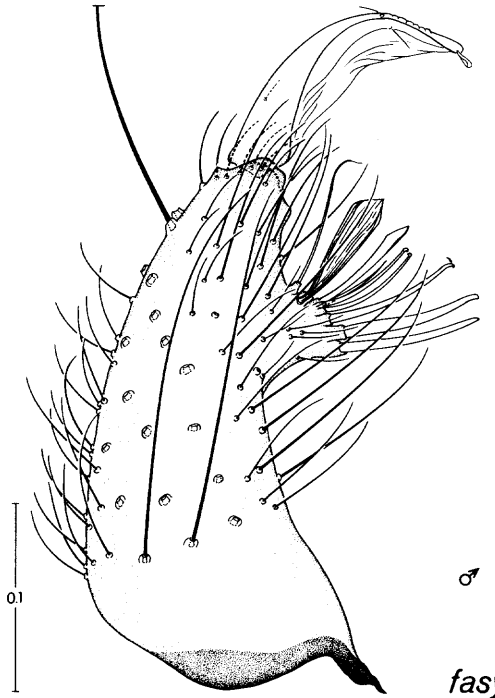
Fig. 68



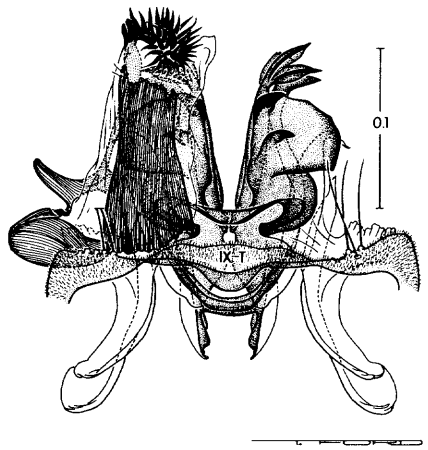
mimeticus

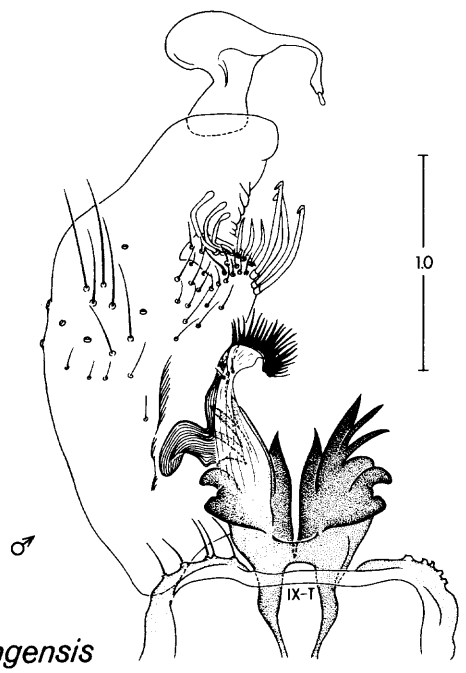
Fig. 69

CULEX



fasyi



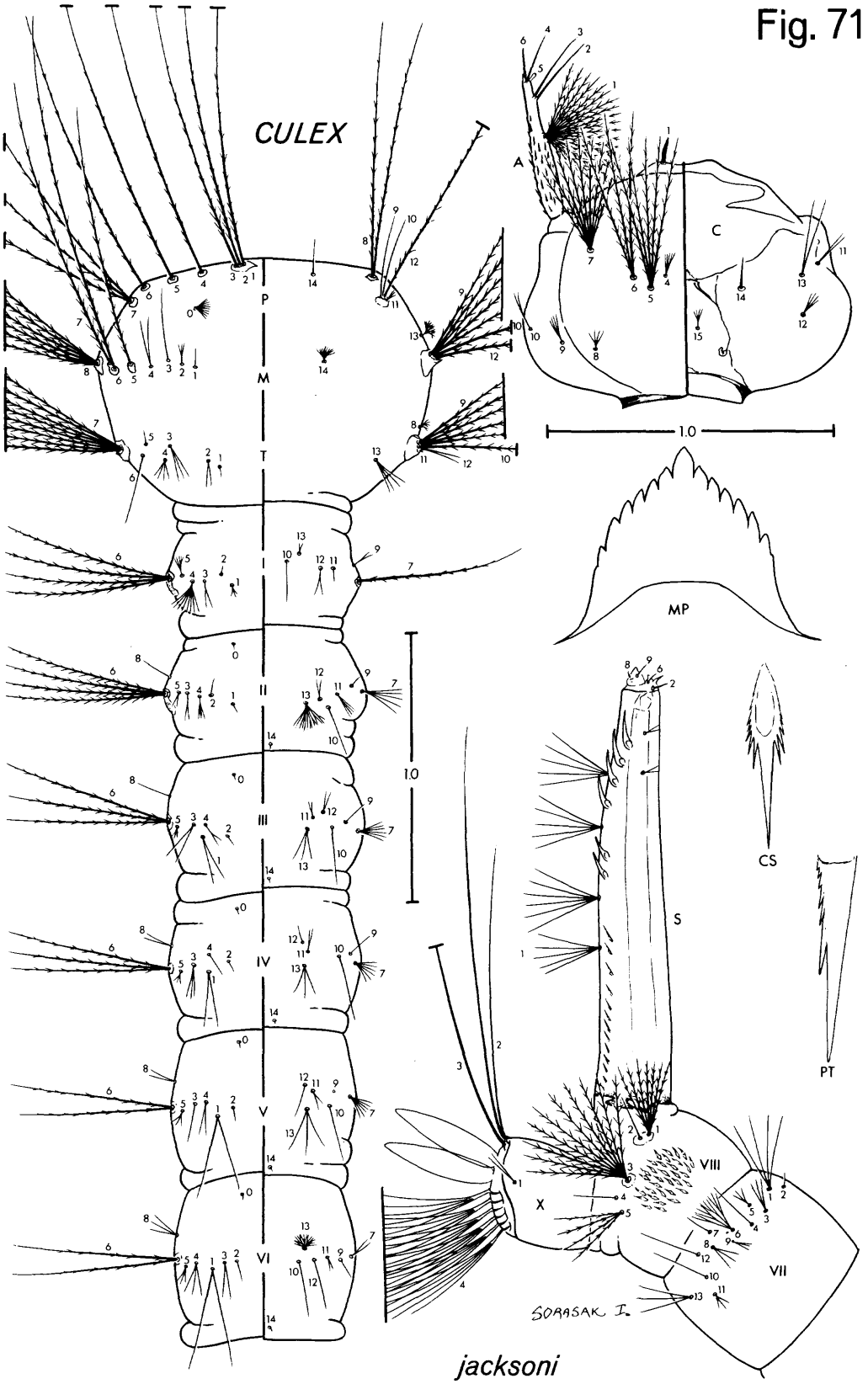


diengensis

Fig. 70

jacksoni

Fig. 71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III
IV
V
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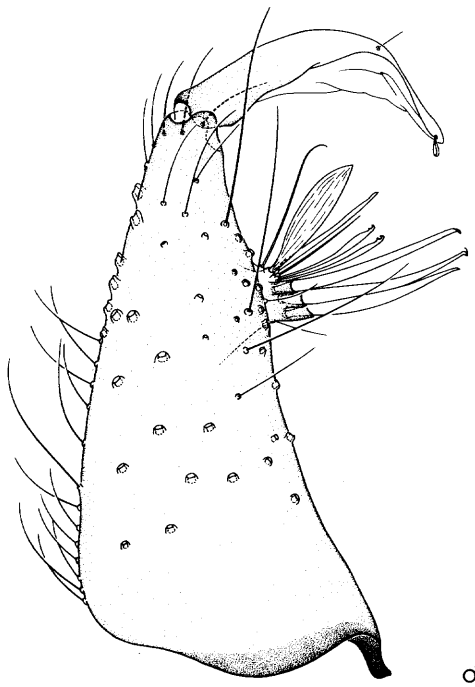
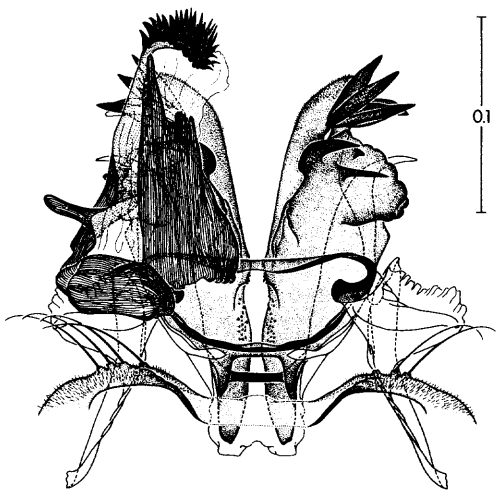
SORASAK I.
jacksoni

Fig. 72

CULEX



♂



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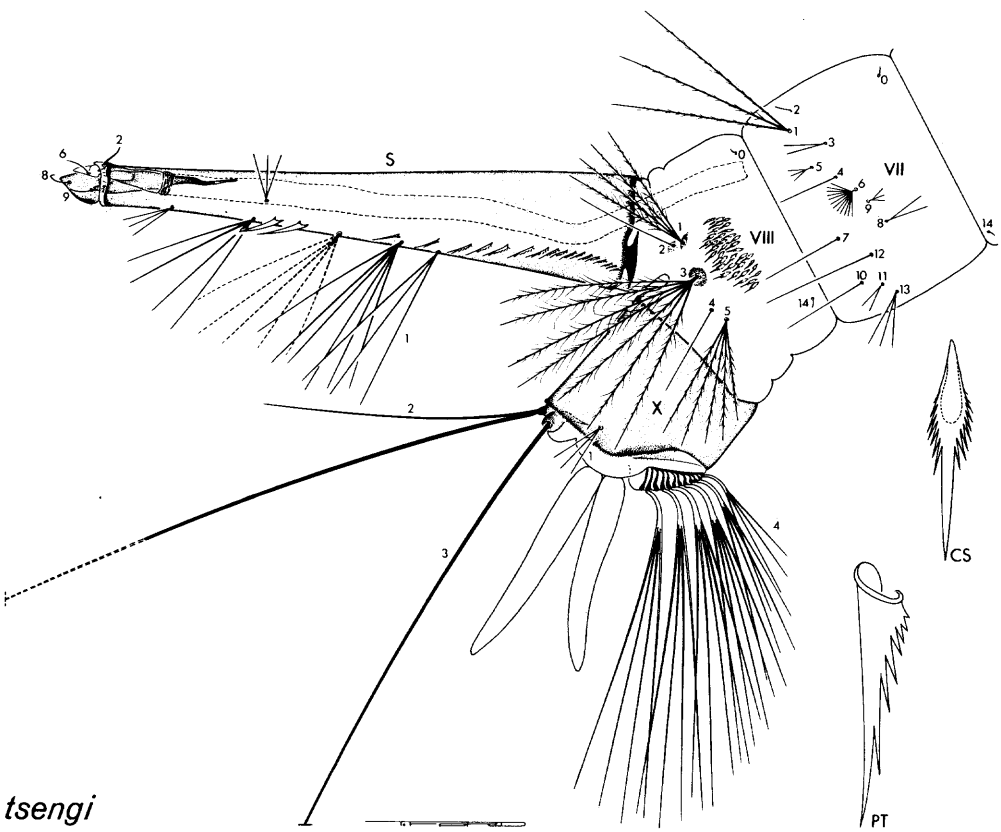
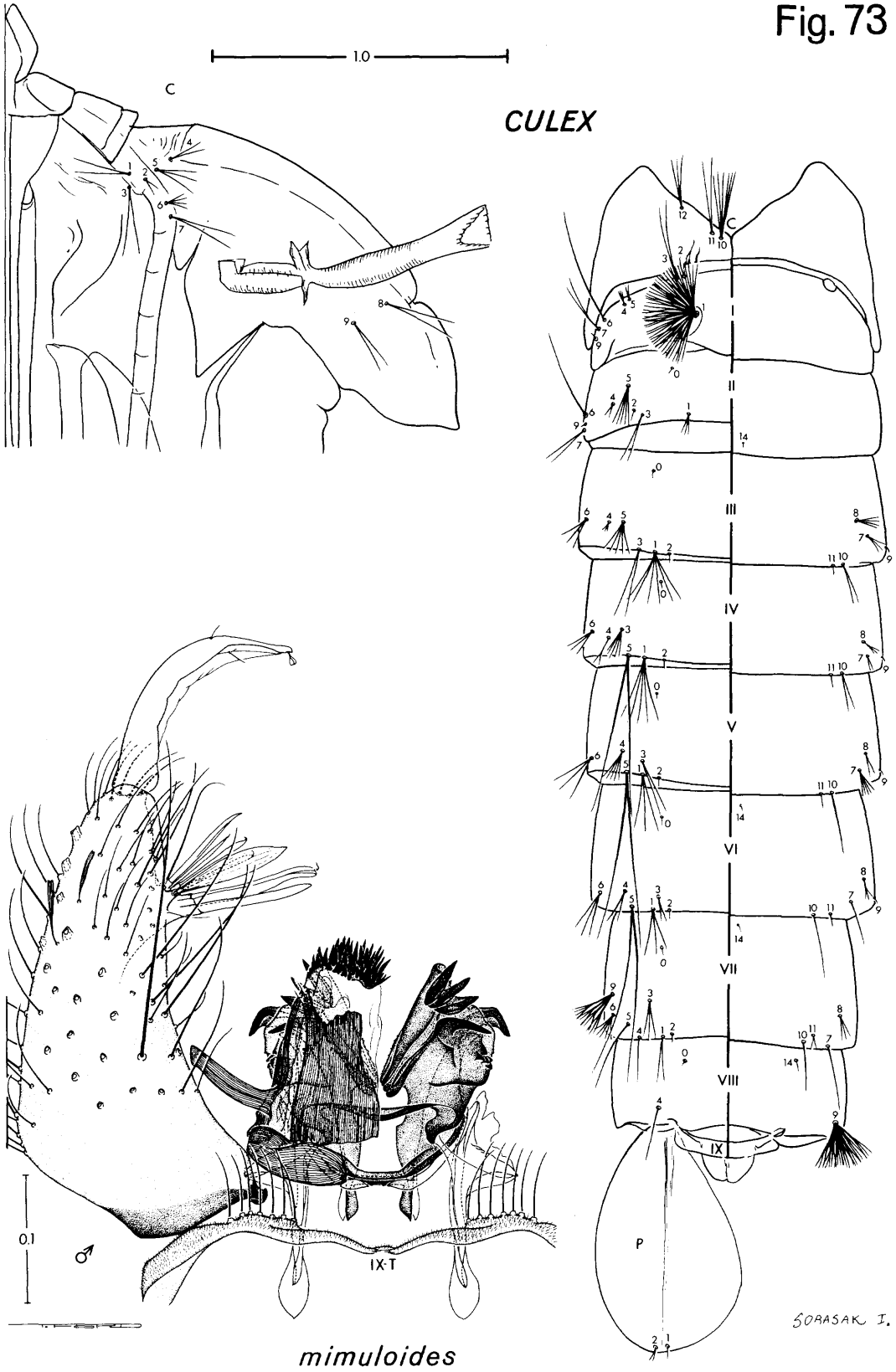


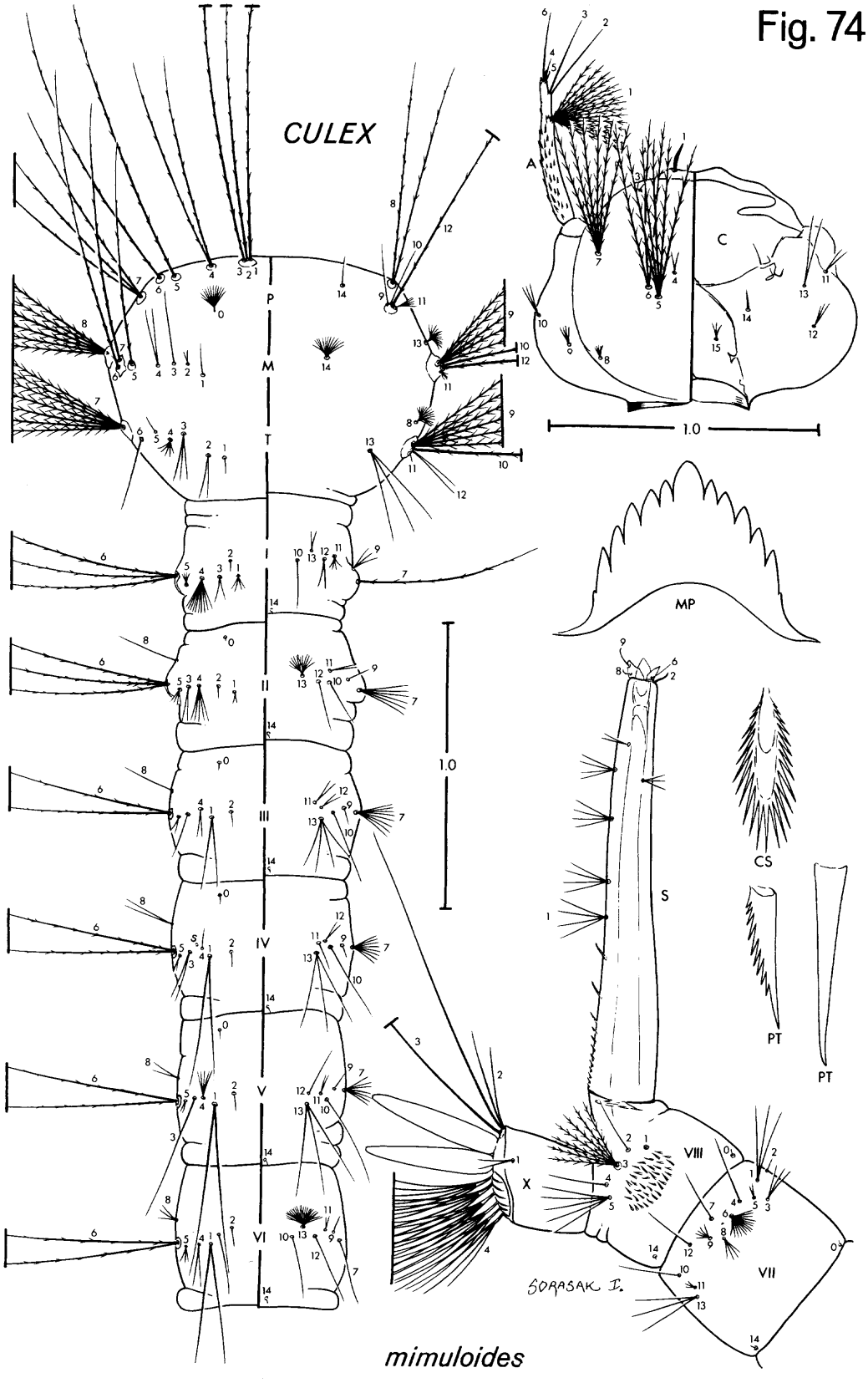
tsengi

Fig. 73



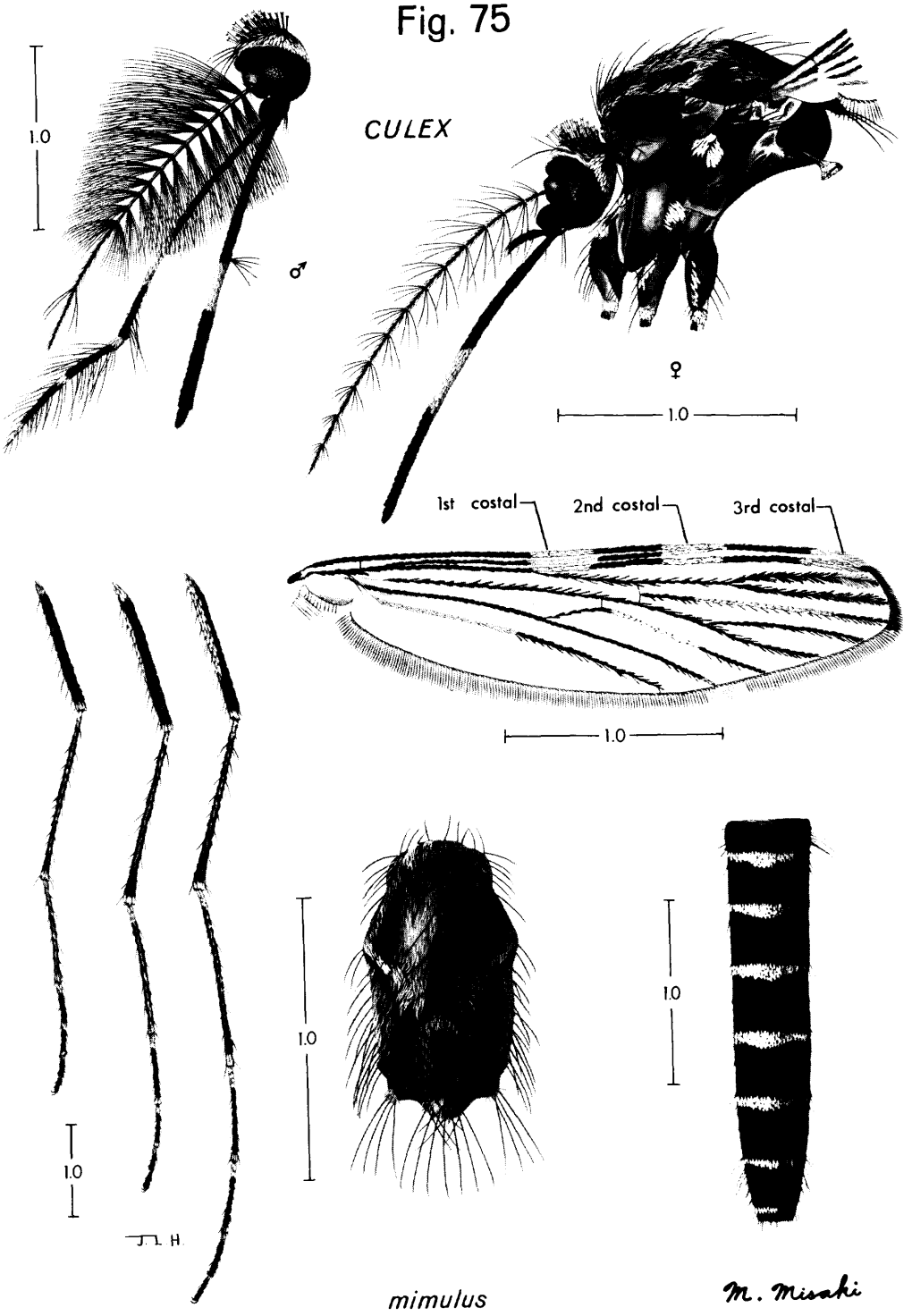
mimuloides

Fig. 74



mimuloides

Fig. 75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2nd costal
3rd costal
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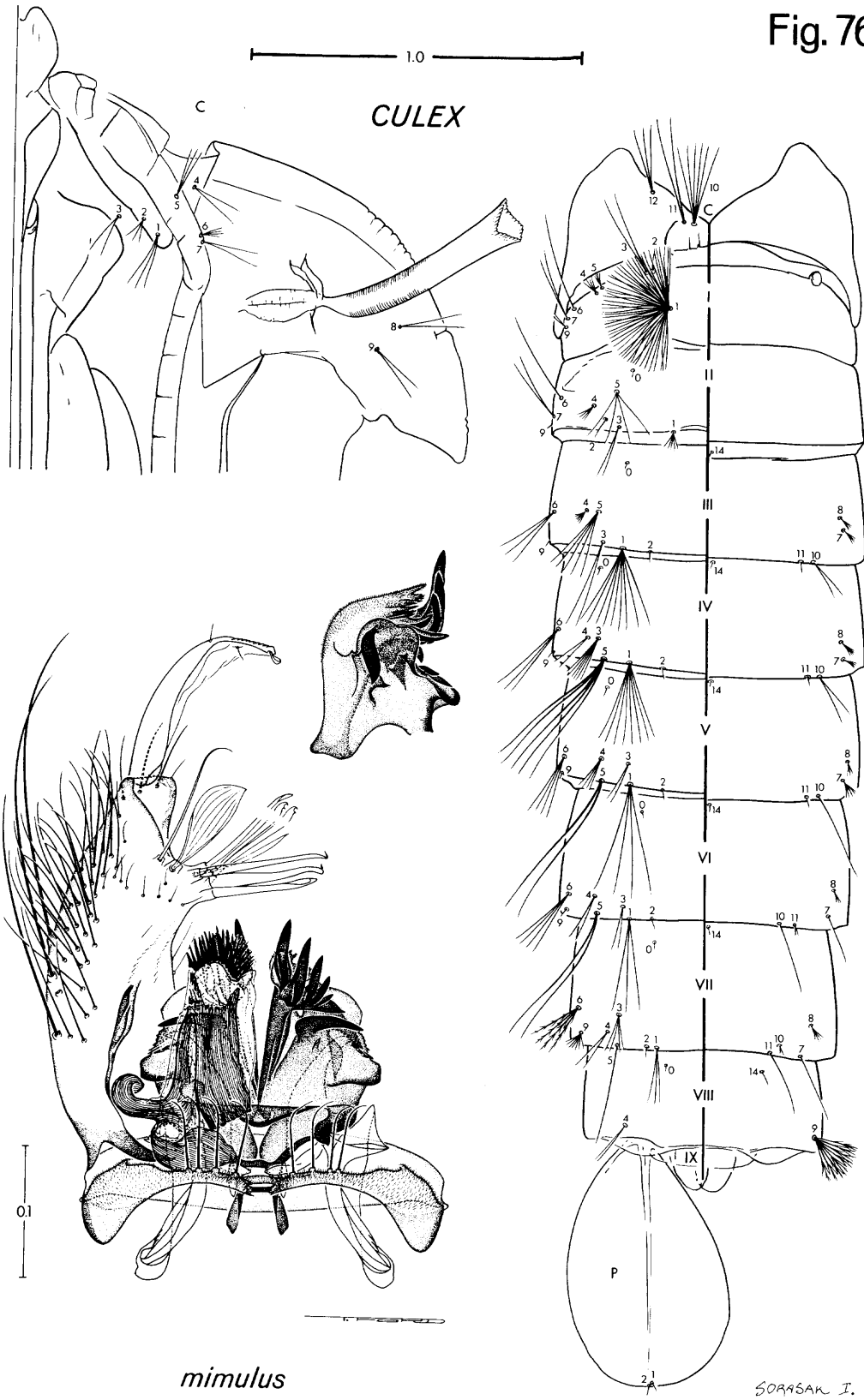
J. L. H.
mimulus
M. Misaki

Fig. 76



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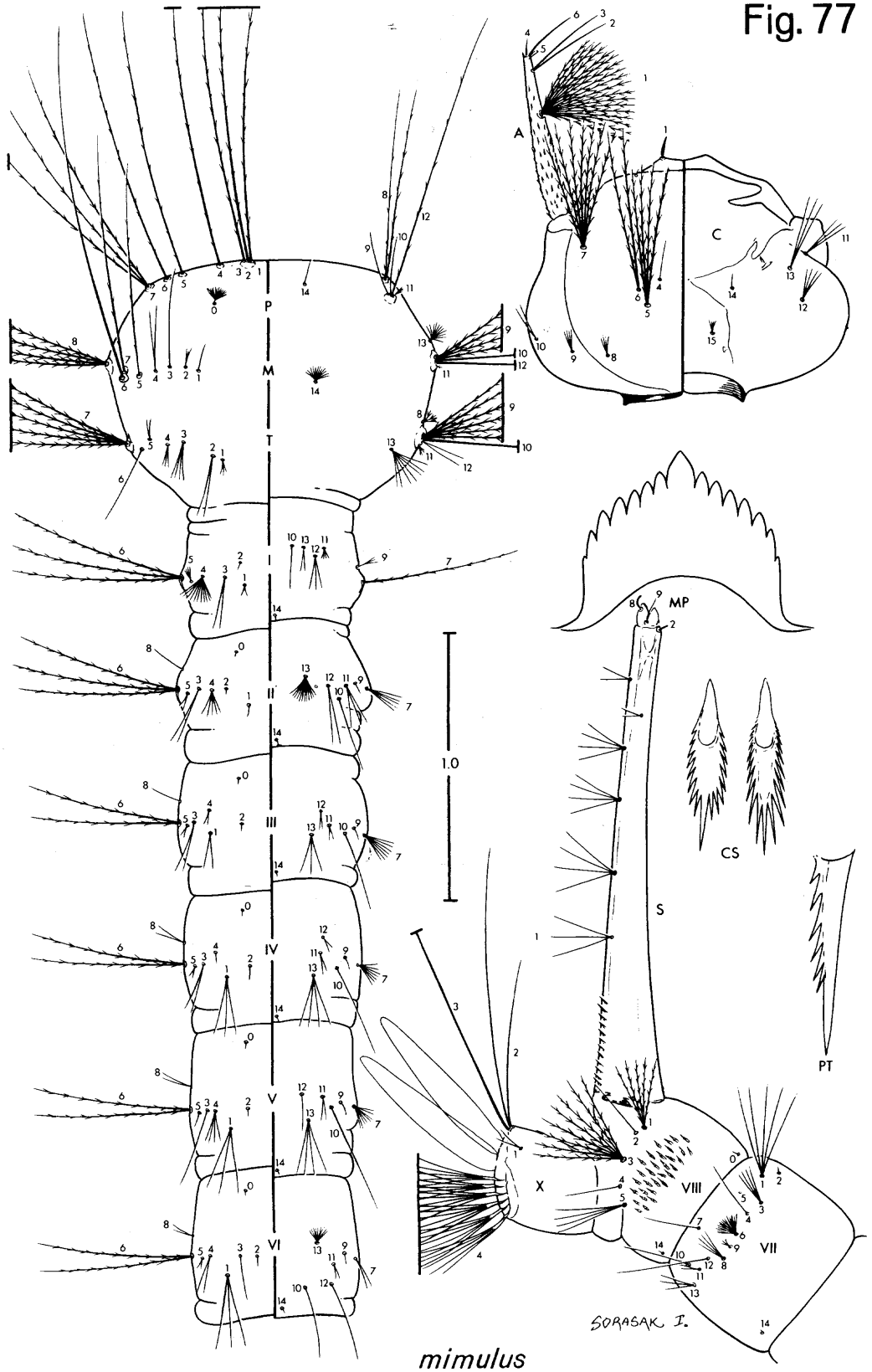


mimulus

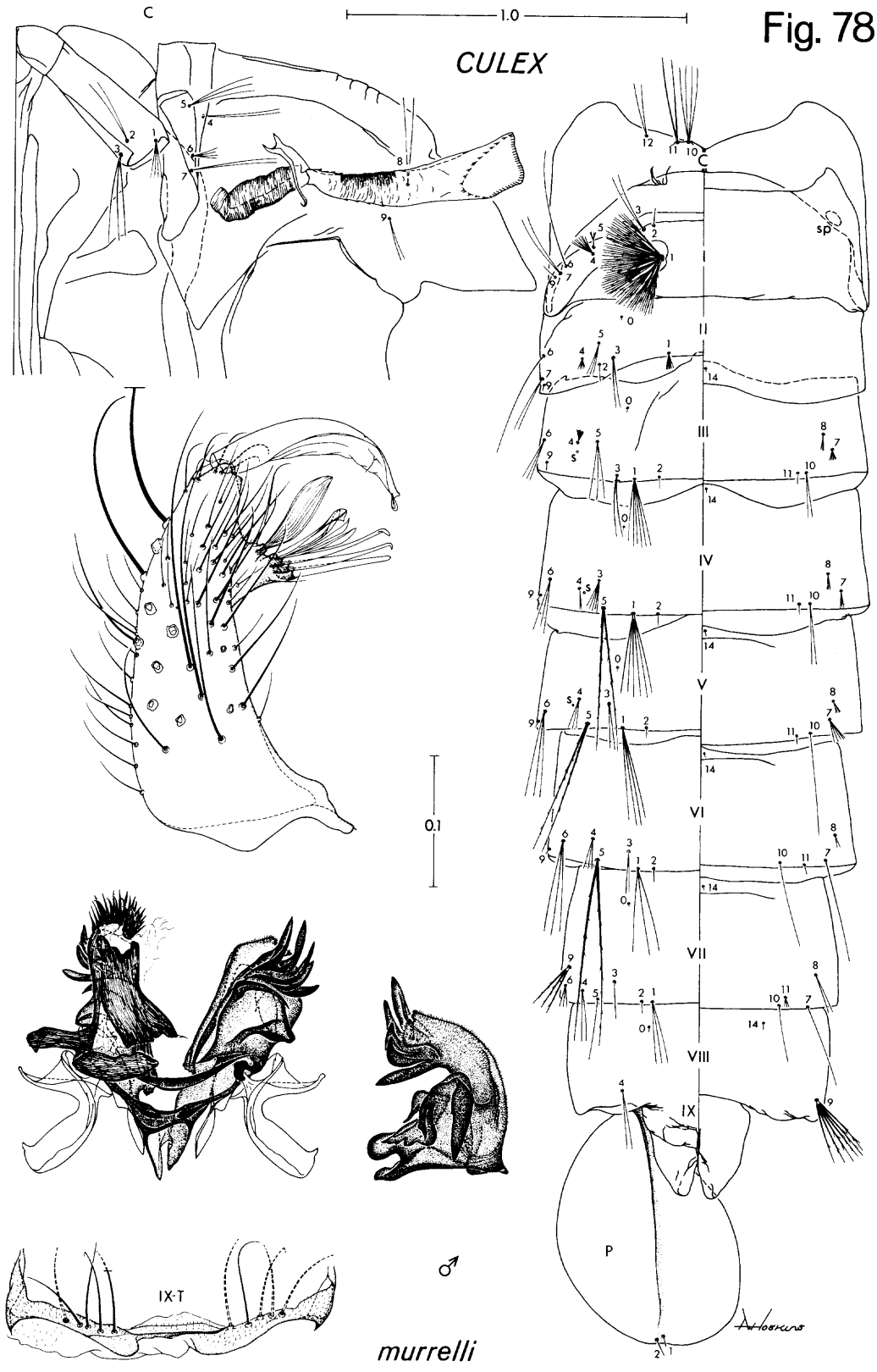


Fig. 78

Fig. 79

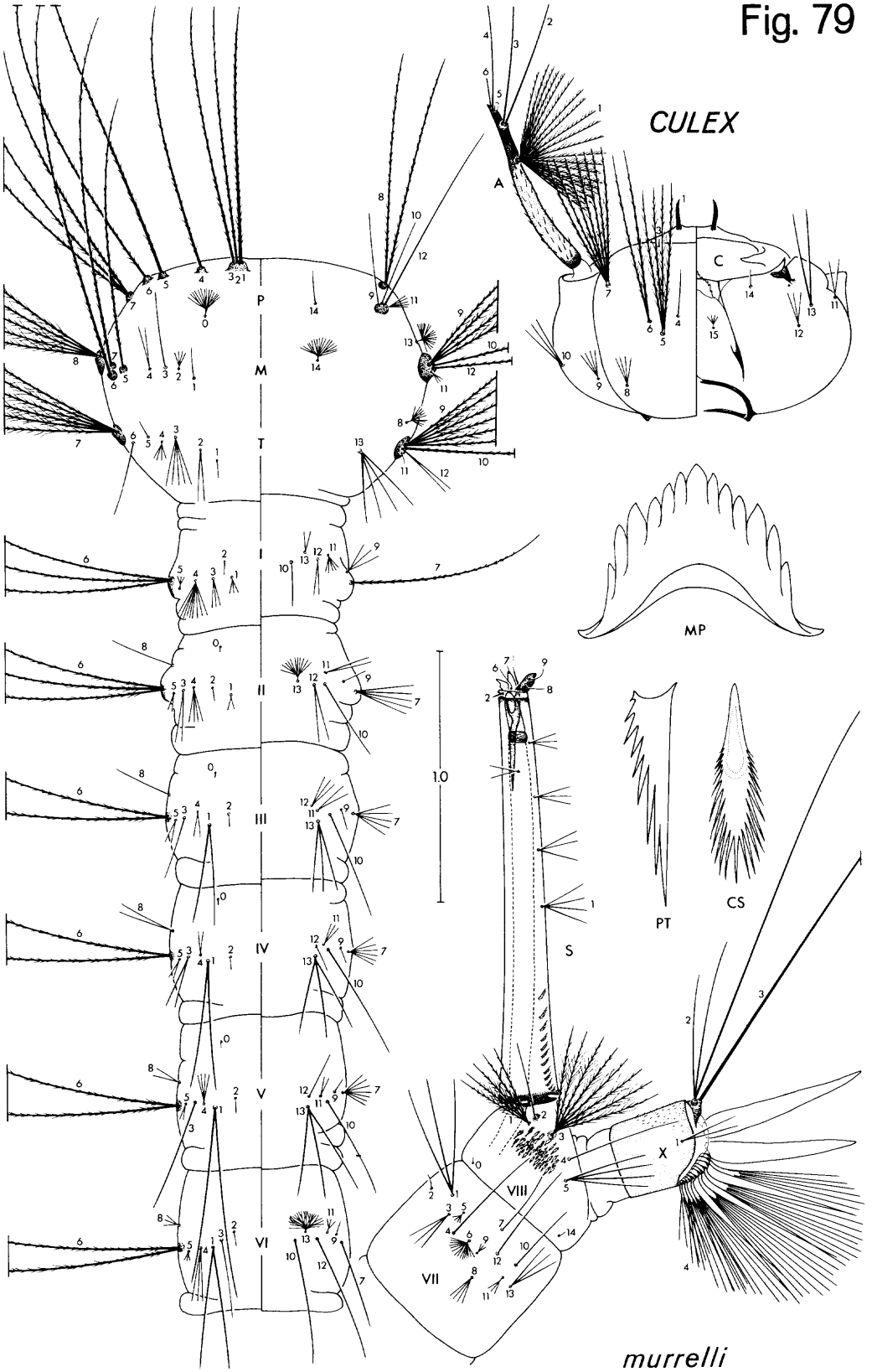
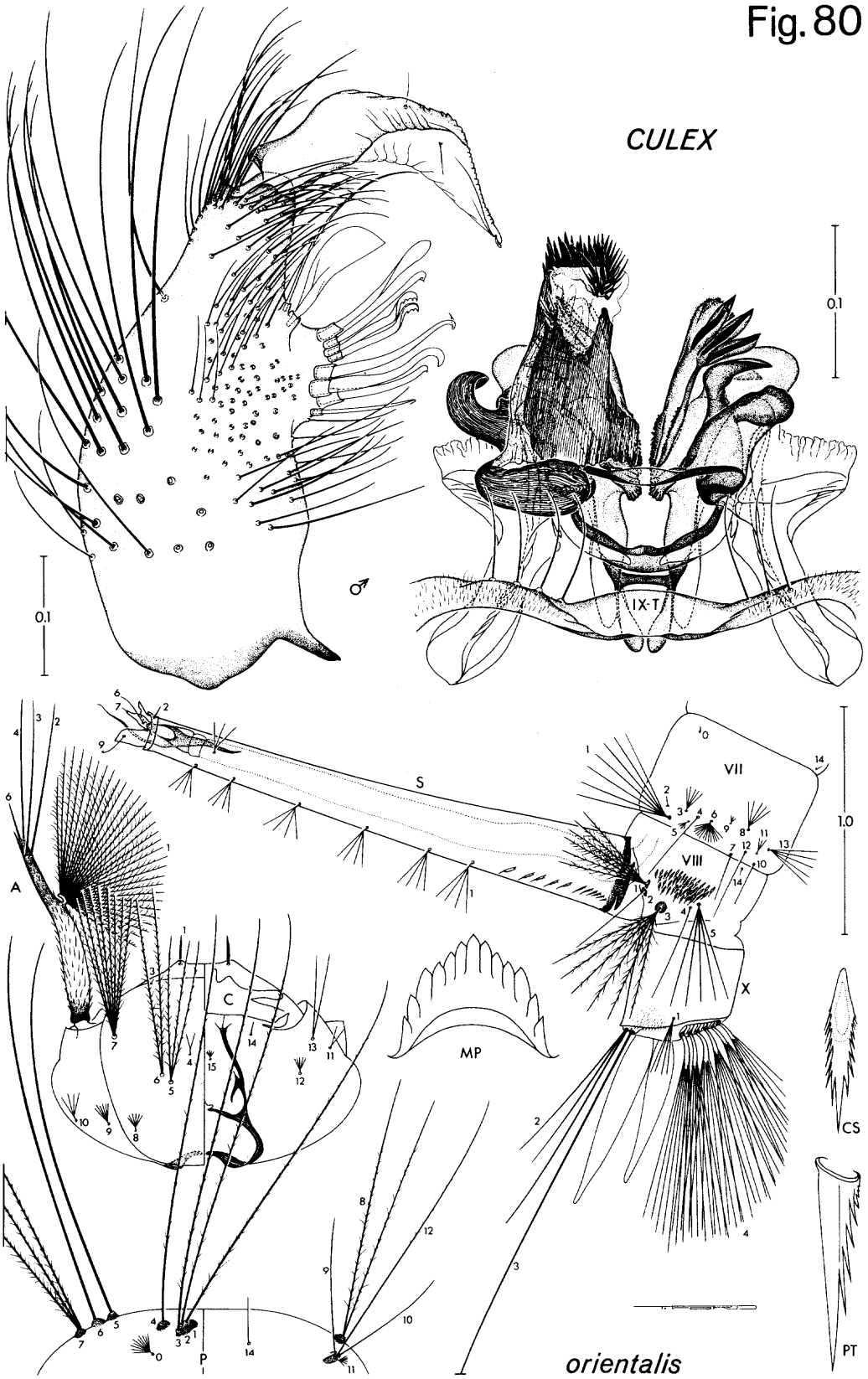
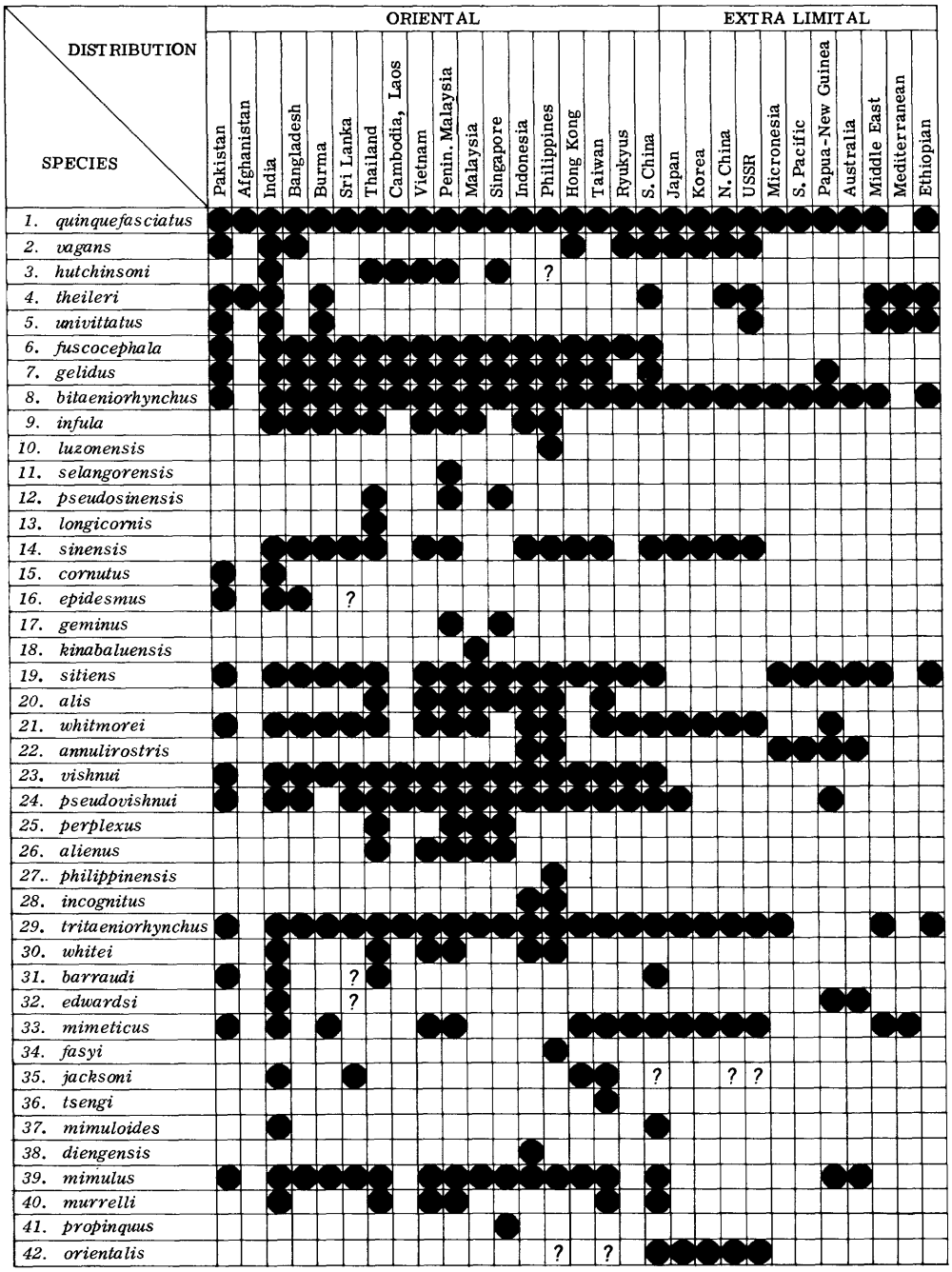


Fig. 80



APPENDIX A. DISTRIBUTION OF ORIENTAL *CULEX (CULEX)* SPECIES



APPENDIX B: CURRENT TAXONOMIC CHANGES

NEW TAXA

CHANGES IN TAXONOMIC STATUS

LECTOTYPE SELECTIONS

INDEX

Valid names are set in roman type, synonyms and nonvalid names are italicized. Italicized pages refer to the primary treatment of the taxon, arabic numerals refer to secondary text references and numbers in parentheses refer to figures.