

Undescribed Setae in Larvae of Culicidae (Diptera)¹

by

Robert H. Hochman² and John F. Reinert³

ABSTRACT. An unnamed pair of setae (two pairs in some species groups) on the larval cervical membrane in all genera of Culicidae examined is described and illustrated, and names are proposed (18, 19-C). Homology in Dixinae with 16, 17-C is revised. Their apparent function is suggested. Their taxonomic importance and possible phylogenetic significance are discussed, with special reference to *Aedes* subgenera *Ochlerotatus* and *Finlaya*.

In mosquito studies, the earliest supraspecific classifications were based entirely on characters of the adult. When the immature stages were later studied, only the head and terminal segments of the larva and the most prominent setae of the abdomen (where the homologies were clear) were considered. Raising the study of immatures to the same level as that of adults required the development of a complete system of setal nomenclature that assigned to phylogenetically homologous setae, regardless of shifts of position in different taxa, an identical name. This work was begun by Martini (1923), but he failed to take proper account of the ventral transitory setae. It crystallized in the authoritative and virtually exhaustive researches of Belkin (1950, 1952, 1953, 1954), who based his nomenclature on the ontogenetic homology of the abdominal setae of the fourth stage larva and the pupa. Belkin (1962), in treating the South Pacific fauna, revised his system and illustrated its application to most Oriental genera and subgenera, thus providing taxonomists with an important tool with which to study phylogenetic affinities of species groups. The apparently complete acceptance of this tool as paradigm, however, has left at least one setiferous region unstudied.

During larval chaetotaxy studies of *Aedes* Meigen, an unnamed ventrolateral seta was noted on the cervical membrane by the senior author. Further research confirmed its presence in all culicid genera for which adequate material was available (30 genera, 74 subgenera, 333 species; see Table I). It was subsequently learned that these setae were originally observed by

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²Southeast Asia Mosquito Project, Smithsonian Institution, United States National Museum, Washington, D. C. 20560.

³Department of Entomology, Walter Reed Army Institute of Research, Walter Reed Army Medical Center, Washington, D. C. 20012.

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MacKenzie 1971 (1972). He referred to them as cervical hairs and recorded their length and branching in third and fourth stage larvae of the four *Aedes* species he studied (*abserratus* Felt and Young, *atropalpus* (Coquillett), *vexans* (Meigen), and *cinereus* Meigen). However, he made no attempt to determine their general occurrence in the Culicidae, nor was any speculation made about this.

Belkin (1962) noted and illustrated two paired setae on the cervical area in larvae of Dixinae, which he tentatively homologized with 16, 17-C of the Culicinae. Belkin (1968) and Belkin, Heinemann and Page (1970) illustrated these setae in Dixinae of New Zealand and Jamaica, and retained the homology of the 1962 study. These setae are homologous with the similarly located setae here reported in the Culicinae (Figs. 1, 2) and Chaoborinae. Species of *Culex* (*Lophoceraomyia*) Theobald and *Culex* (*Culiciomyia*) Theobald, in which 16, 17-C are present on the ocular lobes of the head capsule, have, in addition, two paired setae on the cervical membrane (Fig. 2). Species of *Malaya* Leicester have 16, 17-C and one paired cervical seta. Therefore, new names are necessary to correct the homology.

The undescribed setae arise in a region neglected in most studies of external larval morphology. They are obscured in many mounted whole larvae by the retraction of the head capsule and folding of the cervical membrane; in skins, by the rupturing and displacement of the membrane by the emerging pupa. Anteriorly the cervical membrane is fused with the head capsule at the collar, and posteriorly with the thicker cuticle of the thorax at the prosteronum. Study of first instars of *Aedes melanimon* Dyar suggests that, embryologically, the membrane originated in the procephalic lobes. The cervical area, it seems, is best considered as an unsclerotized, differentiated area of the head.

In order to require little change in the accepted system of nomenclature, it is proposed that the cervical seta be designated 18-C. Where two setae are present, it is proposed the more lateral be designated 18-C, the more ventral or anterior 19-C.

A cervical sclerite (sometimes weakly developed or absent) buttresses the neck midventrally at the median fold or line of flexion. Setae 18, 19-C are positioned at the level of this sclerite, perhaps associated with the muscles (identified as numbers 25 and 26 by Christophers, 1960: 310) arising in the collar and inserted into the cervical membrane laterally and ventrolaterally. This condition may indicate they function as proprioceptors monitoring tensions in the muscles and cuticle controlling the angle of the head to thorax and the degree of retraction of the head. A similar function with respect to the abdominal segments seems to be performed by 14-III-VII.

The development of 18, 19-C in Culicinae varies in length from minute to rather long (in relation to the diameter of its alveolus), from unpigmented to moderately or darkly pigmented, from single or double to multiple branched. It may be slender or stout. Its alveolus ranges from inapparent (some *Culex*) to conspicuously larger than the setal diameter. When both setae are present, they are approximated to each other and almost always unbranched (in *Aedes notoscriptus* (Skuse) both 18, 19-C are 2 or 3 branched). In Dixinae, 18-C is greatly elongated and strongly developed, and 19-C is relatively minute. In

Culicinae and Chaoborinae, both setae are usually similarly developed (18-C stouter in *C. theileri* Theobald).

On the grounds of prior classification, the presence of two paired setae is very likely a conservative attribute state (in the sense of Jardine and Sibson, 1971) in recent phylads. Setae 18, 19-C are similarly developed in *Culex* Linnaeus and *Deinocerites* Theobald, which genera are considered to be closely related (Belkin, 1962; Adames, 1971). Two paired cervical setae occur in *Opifex fuscus* Hutton, *Aedes* (*Nothoskusea*) *chathamicus* Dumbleton, and *Aedes* (*Halaedes*) *australis* (Erickson) which, Belkin (1968) submits, are successive segregates of the same phyletic line.

In the large and heterogeneous subgenus *Ochlerotatus* Lynch Arribálzaga, both states (presence and absence of 19-C) occur. Apparently all species in Groups C (both species whose larvae are known, seen) and F (15 of the 24 valid included species, seen) of Edwards (1932) lack 19-C. All these *Ochlerotatus* species with one paired seta are further related zoogeographically in that they are evidently either of Neotropical origin (some with Nearctic extensions of their ranges), or they are Nearctic representatives of originally Neotropical species groups. One of these groups, the *serratus* group, it has been recommended (Belkin, Heinemann and Page, 1970: 160), should be separated from other New World *Ochlerotatus*. All species examined in Edwards' Groups A (6 of the 13 included species, seen), B (9 of the 17 included species, seen), D (1 of the 2 included species, seen), E (5 of the 9 included species, seen), G (20 of the 33 included species, seen) and H (2 of the 6 included species, seen) have two paired cervical setae.

The known exceptions to the above observations more strongly suggest the conservative nature of the one paired and two paired states. The *Ochlerotatus* species not in Groups C or F having a single paired seta----*atropalpus*, *epactius* Dyar and Knab, and *fluviatilis* (Lutz)----are recent transfers (tentatively proposed; Zavortink, 1972) from *Finlaya* Theobald, in which one pair is typical. The atypical species noted in *Finlaya* comprise two groups----the *aureostriatus* group (*aureostriatus* (Doleschall), subspecies *okinawanus* Bohart and *taiwanus* Lien, variety *greenii* (Theobald), *christophersi* Edwards and probably *gilli* (Barraud), but no material of the latter species seen) and the *notoscriptus* group (*notoscriptus* (Skuse) and *albilabris* Edwards). In addition to the presence of two paired setae, these species show other striking divergences in the larva and adult from the rest of *Finlaya*. The *notoscriptus* group and a South Pacific species of the *aureostriatus* group for which the larva is not known, it was asserted by Belkin (1962: 347), are more closely related to each other than to other species with which they were grouped in Knight and Marks (1952), and show many affinities with *scutellabum* Boshell-Manrique. This last named species was recently transferred from *Finlaya* to *Ochlerotatus* (Zavortink, 1972) and, together with the closely related *milleri* Dyar (removed from *Finlaya* by Knight and Marks, 1952; included in *Ochlerotatus* by Stone, Knight and Starcke, 1959), belongs to Group E of Edwards. These two species of *Ochlerotatus* and the atypical species of *Finlaya* to which they are supposed similar, are also alike in having two paired cervical setae.

Further study of these setae in other taxa of the same rank should help to determine their precise value (when combined with other morphological evidence) as phylogenetic indicators.

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Table I. Species in which cervical setae were seen*

<i>Aedeomyia</i> (<i>Aedeomyia</i>) <i>catasticta</i> (1)	<i>Aedes</i> (<i>Finlaya</i>) <i>chrysolineatus</i> (1)
<i>Aedes</i> (<i>Abraedes</i>) <i>papago</i> (1)	<i>croceus</i> (1)
(<i>Aedes</i>) <i>esoensis</i> (1)	<i>crossi</i> (1)
(<i>Aedimorphus</i>) <i>albocephalus</i> (1)	<i>dobodurus</i> (1)
<i>alboscuteclatus</i> (1)	<i>embuensis</i> (1)
<i>caecus</i> (1)	<i>formosensis</i> (1)
<i>capensis</i> (1)	<i>ganapathi</i> (1)
<i>hirsutus</i> (1)	<i>gubernatoris</i> (1)
<i>lamborni</i> (1)	<i>harperi</i> (1)
<i>mediolineatus</i> (1)	<i>harveyi</i> (1)
<i>minutus</i> (1)	<i>hatorii</i> (1)
<i>natronius</i> (1)	<i>hollandius</i> (1)
<i>oakleyi</i> (1)	<i>inermis</i> (1)
<i>orbitae</i> (1)	<i>japonicus</i> (1)
<i>pallidostriatus</i> (1)	<i>jugraensis</i> (1)
<i>pampangensis</i> (1)	<i>kochi</i> (1)
<i>senyavinensis</i> (1)	<i>koreicus</i> (1)
<i>syntheticus</i> (1)	<i>leucopleurus</i> (1)
<i>vexans</i> (1)	<i>longipalpis</i> (1)
(<i>Alanstonea</i>) <i>brevitibia</i> (1)	<i>macfarlanei</i> (1)
(<i>Ayurakitia</i>) <i>griffithi</i> (1)	<i>mohani</i> (1)
(<i>Aztecaedes</i>) <i>ramirezi</i> (2)	<i>niveoides</i> (1)
(<i>Bothaella</i>) <i>eldridgei</i> (1)	<i>notoscriptus</i> (2)
<i>helenae</i> (1)	<i>novalbitarsis</i> (1)
(<i>Cancraedes</i>) <i>masculinus</i> (1)	<i>oreophilus</i> (1)
<i>penghuensis</i> (1)	<i>pexus</i> (1)
(<i>Christophersomyia</i>) <i>ibis</i> (1)	<i>prominens</i> (1)
<i>thomsoni</i> (1)	<i>pseudotaeniatatus</i> (1)
(<i>Diceromyia</i>) <i>adersi</i> (1)	<i>pulchriventer</i> (1)
<i>franciscoi</i> (1)	<i>rizali</i> (1)
<i>iyengari</i> (1)	<i>saxicola</i> (1)
<i>nummatus</i> (1)	<i>schlosseri</i> (1)
<i>taylori</i> (1)	<i>sherki</i> (1)
<i>whartoni</i> (1)	<i>shortti</i> (1)
(<i>Edwardsaedes</i>) <i>imprimens</i> (1)	<i>stonei</i> (1)
(<i>Finlaya</i>) <i>albilabris</i> (2)	<i>subalbitarsis</i> (1)
<i>alboannulatus</i> (1)	<i>togoi</i> (1)
<i>albolateralis</i> (1)	(<i>Geoskusea</i>) <i>daggyi</i> (2)
<i>albotaeniatatus</i> (1)	<i>kabaenensis</i> (2)
<i>ananae</i> (1)	<i>longiforceps</i> (2)
<i>argenteitarsis</i> (1)	(<i>Gymnometopa</i>) <i>mediovittatus</i> (1)
<i>argyronotum</i> (1)	(<i>Halaedes</i>) <i>australis</i> (2)
<i>aureostriatus aureostriatus</i> (2)	(<i>Howardina</i>) <i>allotecnon</i> (1)
<i>aureostriatus okinawanus</i> (2)	<i>serlineatus</i> (1)
<i>aureostriatus taiwanus</i> (2)	<i>walkeri</i> (1)
<i>aureostriatus var. greenii</i> (2)	(<i>Kompia</i>) <i>purpureipes</i> (1)
<i>christophersi</i> (2)	(<i>Leptosomatomyia</i>) <i>aurimargo</i> (1)

*1 in parentheses denotes presence of seta 18-C; 2, the presence of both 18 and 19-C.

Table 1 (continued)

<i>Aedes</i> (Lorrainea) <i>amesii</i> (1)	<i>Aedes</i> (Ochlerotatus) <i>excrucians</i> (2)
<i>fumidus</i> (1)	<i>fitchii</i> (2)
(<i>Macleaya</i>) <i>tremulus</i> (1)	<i>flavescens</i> (2)
(<i>Mucidus</i>) <i>alternans</i> (1)	<i>fluviatilis</i> (1)
<i>aurantius</i> (1)	<i>fulvus pallens</i> (1)
<i>ferinus</i> (1)	<i>grossbecki</i> (2)
<i>laniger</i> (1)	<i>hastatus</i> (1)
<i>quadripunctis</i> (1)	<i>hexodontus</i> (2)
<i>quasiferinus</i> (1)	<i>hortator</i> (1)
<i>scatophagoides</i> (1)	<i>impiger</i> (2)
(<i>Neomacleaya</i>) <i>andamanensis</i> (1)	<i>infirmatus</i> (1)
<i>atrisimilis</i> (1)	<i>intrudens</i> (2)
<i>atrius</i> (1)	<i>mcdonaldi</i> (2)
<i>campylostylus</i> (1)	<i>melanimon</i> (2)
<i>consonensis</i> (1)	<i>milleri</i> cpl. (2)
<i>dux</i> (1)	<i>mitchellae</i> (2)
<i>gibbosus</i> (1)	<i>monticola</i> (2)
<i>indicus</i> (1)	<i>muelleri</i> (2)
<i>johnsoni</i> (1)	<i>nigripes</i> (2)
<i>neomacrodioxoa</i> (1)	<i>nigromaculis</i> (2)
<i>siamensis</i> (1)	<i>niphadopsis</i> (2)
<i>uncus</i> (1)	<i>oligopistus</i> (1)
(<i>Nothoskusea</i>) <i>chathamicus</i> (2)	<i>pertinax</i> (1)
(<i>Ochlerotatus</i>) <i>aboriginis</i> (2)	<i>pionips</i> (2)
<i>abserratus</i> (2)	<i>pullatus</i> (2)
<i>aculeatus</i> (2)	<i>punctodes</i> (2)
<i>albifasciatus</i> (2)	<i>punctor</i> (2)
<i>aloponotum</i> (2)	<i>riparius</i> (2)
<i>angustivittatus</i> (1)	<i>rusticus</i> (2)
<i>atlanticus</i> (1)	<i>scapularis</i> (1)
<i>atropalpus</i> (1)	<i>schizopinax</i> (2)
<i>auratus</i> (1)	<i>scutellalbum</i> (2)
<i>bicristatus</i> (2)	<i>serratus</i> (1)
<i>bimaculatus</i> (1)	<i>sierrensis</i> (2)
<i>calcariae</i> (2)	<i>sollicitans</i> (2)
<i>calumnior</i> (1)	<i>spenceri</i> (2)
<i>camposanus</i> (1)	<i>squamiger</i> (2)
<i>canadensis</i> (2)	<i>sticticus</i> (2)
<i>cantator</i> (2)	<i>stimulans</i> (2)
<i>caspicus</i> (2)	<i>taeniorhynchus</i> (2)
<i>cataphylla</i> (2)	<i>thelcter</i> (1)
<i>communis nevadensis</i> (2)	<i>thibaulti</i> (2)
<i>decticus</i> (2)	<i>tormentor</i> (1)
<i>deserticola</i> (2)	<i>trichurus</i> (2)
<i>detritus</i> (2)	<i>trivittatus</i> (1)
<i>diantaeus</i> (2)	<i>varipalpus</i> (2)
<i>dorsalis</i> (2)	<i>vigilax</i> (2)
<i>dupreei</i> (1)	<i>vittiger</i> (2)
<i>edgari</i> (2)	(<i>Paraedes</i>) <i>bonneae</i> (1)
<i>epactius</i> (1)	<i>ostentatio</i> (1)
<i>eucephalaeus</i> (1)	(<i>Protomacleaya</i>) <i>alboapicus</i> (1)

Table 1 (continued)

<i>Aedes</i> (<i>Protomacleana</i>) <i>argyrothorax</i> (1)	<i>Culex</i> (<i>Acallyntum</i>) <i>pallidiceps</i> (2)
<i>galindoi</i> (1)	(<i>Culex</i>) <i>bitaeniorhynchus</i> (2)
<i>idanus</i> (1)	<i>pipiens quinquefasciatus</i> (2)
<i>insolitus</i> (1)	<i>pseudovishnui</i> (2)
<i>podographicus</i> (1)	<i>theileri</i> (2)
<i>thorntoni</i> (1)	(<i>Culicomyia</i>) <i>fragilis</i> (2)
<i>triseriatus</i> (1)	<i>nigropunctatus</i> (2)
<i>vargasi</i> (1)	<i>pallidothorax</i> (2)
<i>zavortinki</i> (1)	<i>spathifurca</i> (2)
<i>zoosophs</i> (1)	<i>thurmanorum</i> (2)
(<i>Rhinoskusea</i>) <i>longirostris</i> (1)	(<i>Eumelanomyia</i>) <i>brevipalpis</i> (2)
(<i>Skusea</i>) <i>pembaensis</i> (1)	<i>foliatus</i> (2)
(<i>Stegomyia</i>) <i>aegypti</i> (1)	<i>malayi</i> (2)
<i>agrihanensis</i> (1)	(<i>Lophoceraomyia</i>) <i>minor</i> (2)
<i>albolineatus</i> (1)	<i>peytoni</i> (2)
<i>albopictus</i> (1)	<i>reidi</i> (2)
<i>guamensis</i> (1)	(<i>Lutzia</i>) <i>fuscus</i> (2)
<i>hakanssoni</i> (1)	(<i>Micraedes</i>) <i>schicki</i> (2)
<i>horrescens</i> (1)	(<i>Mochlostyrax</i>) <i>pilosus</i> (2)
<i>luteocephalus</i> (1)	(<i>Neoculex</i>) <i>territans</i> (2)
<i>mediopunctatus</i> (1)	(<i>Thaionomyia</i>) <i>dispectus</i> (2)
<i>patriceae</i> (1)	<i>Culiseta</i> (<i>Climacura</i>) <i>marchettei</i> (2)
<i>polynesiensis</i> (1)	(<i>Culiseta</i>) <i>annulata</i> (2)
<i>upolensis</i> (1)	<i>inornata</i> (2)
<i>vittatus</i> (1)	<i>niveitaeniata</i> (2)
(<i>Verrallina</i>) <i>butleri</i> (1)	<i>particeps</i> (2)
<i>carmenti</i> (1)	<i>Deinocerites</i> <i>belkini</i> (2)
<i>cuccioi</i> (1)	<i>cancer</i> (2)
<i>lineatus</i> (1)	<i>mathesoni</i> (2)
<i>mccormicki</i> (1)	<i>nicoyae</i> (2)
<i>multifolium</i> (1)	<i>pseudus</i> (2)
<i>Anopheles</i> (<i>Anopheles</i>) <i>nigerrimus</i> (1)	<i>Eretmapodites</i> <i>chrysogaster</i> (1)
(<i>Cellia</i>) <i>balabacensis</i> (1)	<i>ferox</i> (1)
<i>kochi</i> (1)	<i>Ficalbia</i> <i>minima</i> (1)
<i>punctulatus</i> (1)	<i>Haemagogus</i> (<i>Conopostegus</i>) <i>clarki</i> (1)
(<i>Nyssorhynchus</i>) <i>albitarsis</i> (1)	<i>leucocelaenus</i> (1)
<i>Armigeres</i> (<i>Armigeres</i>) <i>baisasi</i> (1)	(<i>Haemagogus</i>) <i>boshelli</i> (1)
<i>kinabaluensis</i> (1)	<i>equinus</i> (1)
<i>subalbatus</i> (1)	<i>mesodentatus</i> (1)
(<i>Leicesteria</i>) <i>flavus</i> (1)	<i>Heizmannia</i> (<i>Heizmannia</i>) <i>communis</i> (1)
<i>longipalpis</i> (1)	<i>complex</i> (1)
<i>magnus</i> (1)	<i>macdonaldi</i> (1)
<i>traubi</i> (1)	<i>persimilis</i> (1)
<i>Chagasia</i> <i>batharus</i> (1)	<i>reidi</i> (1)
<i>rozeboomi</i> (1)	<i>scintillans</i> (1)
<i>Chaoborus</i> (<i>Chaoborus</i>) <i>flavicans</i> (2)	<i>taiwanensis</i> (1)
(<i>Schadonophasma</i>) <i>nyblaei</i> (2)	(<i>Mattinglyia</i>) <i>achaetae</i> (1)
<i>Coquillettia</i> (<i>Coquillettia</i>) <i>xanthogaster</i> (1)	<i>thelmae</i> (1)
<i>Culex</i> (<i>Acallemomyia</i>) <i>obscurus</i> (2)	

Table 1 (continued)

<i>Hodgesia bailyi</i> (1)	<i>Topomyia</i> (<i>Topomyia</i>) <i>argyropalpis</i> (1)
<i>malayi</i> (1)	<i>spathulirostris</i> (1)
<i>Malaya genurostris</i> (1)	<i>Toxorhynchites</i> (<i>Lynchiella</i>) <i>utilus</i> (2)
<i>incomptus</i> (1)	(<i>Toxorhynchites</i>) <i>quasiferus</i> (2)
<i>jacobsoni</i> (1)	<i>Tripteroides</i> (<i>Rachionotomyia</i>) <i>aranoides</i> (1)
<i>Mansonia</i> (<i>Mansonia</i>) <i>titillans</i> (1)	(<i>Rachisoura</i>) <i>bisquamata</i> (1)
(<i>Mansonioides</i>) <i>uniformis</i> (1)	(<i>Tripteroides</i>) <i>bimaculipes</i> (1)
<i>Mimomyia</i> (<i>Mimomyia</i>) <i>chamberlaini</i> (1)	<i>Udaya argyrurus</i> (1)
<i>hybrida</i> (1)	<i>Uranotaenia</i> (<i>Pseudoficalbia</i>) <i>maculipleura</i> (1)
(<i>Ravenalites</i>) <i>deguzmanae</i> (1)	<i>maxima</i> (1)
<i>fusca</i> (1)	(<i>Uranotaenia</i>) <i>lowii</i> (1)
<i>Opifex fuscus</i> (2)	<i>macfarlanei</i> (1)
<i>Orthopodomyia signifera</i> (1)	<i>mendiolai</i> (1)
<i>wilsoni</i> (1)	<i>metatarsata</i> (1)
<i>Phoniomyia splendida</i> (1)	<i>sapphirina</i> (1)
<i>Psorophora</i> (<i>Grahamia</i>) <i>columbiae</i> (1)	<i>Wyeomyia</i> (<i>Wyeomyia</i>) <i>juxtahirsuta</i> (1)
<i>signipennis</i> (1)	<i>mittchellii</i> (1)
(<i>Janthinosoma</i>) <i>ferus</i> (1)	<i>smithii</i> (1)
(<i>Psorophora</i>) <i>ciliata</i> (1)	<i>Zeugomyia aguilarii</i> (1)
<i>howardii</i> (1)	<i>gracilis</i> (1)
<i>Sabethes</i> (<i>Sabethoides</i>) <i>chloropterus</i> (1)	<i>lawtoni</i> (1)
<i>Topomyia</i> (<i>Suaymyia</i>) <i>imitata</i> (1)	

Fig. 1

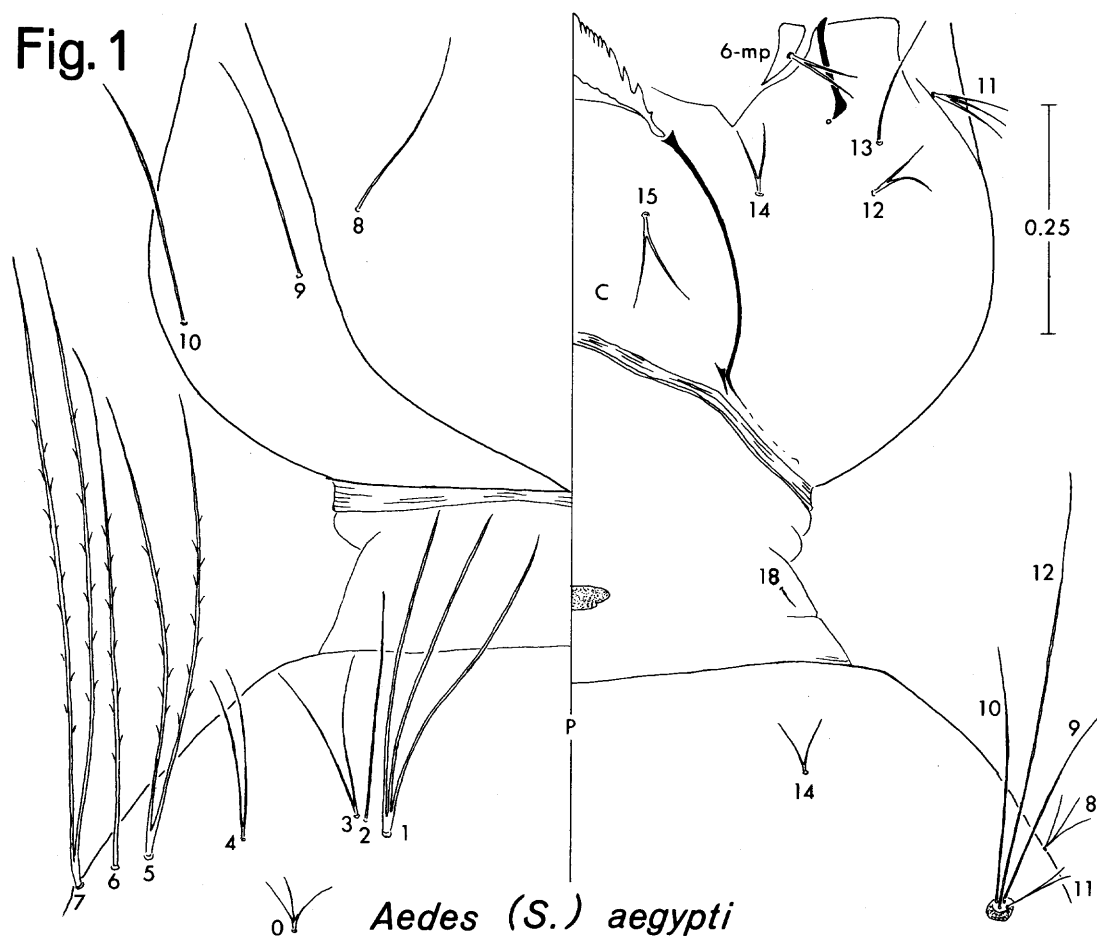


Fig. 2

