

**Studies on the pupal mosquitoes of Japan (11)
Subgenera *Oculeomyia* (stat. nov.) and *Sirivanakarnius* (nov.) of
the genus *Culex*, with a key of pupal mosquitoes from
Ogasawara-guntô (Diptera: Culicidae)**

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Abstract: The pupae of *Culex* (*Oculeomyia*) *bitaeniorhynchus* and *Cx.* (*Sirivanakarnius*) *boninensis* are described and their taxonomic characters are discussed. Chaetotaxy tables and full illustrations for these two species are prepared. *Oculeomyia* is resurrected from synonymy with the subgenus *Culex* and given subgeneric status to include *Culex bitaeniorhynchus* and *Cx. sinensis*. A new subgenus *Sirivanakarnius* is established for *Culex boninensis*. A key to species of the pupa of mosquitoes from Ogasawara-guntô is presented.

Key words: mosquito pupa, morphotaxonomy, *Culex*, *Oculeomyia*, *Sirivanakarnius*, Japan

This paper is a revision of the pupae of *Culex bitaeniorhynchus*, *Cx. sinensis* and *Cx. boninensis*, which previously have been included in the subgenus *Culex*. In this occasion, I transfer the former two species to the subgenus *Oculeomyia* previously treated as a synonym of the subgenus *Culex*, and establish a new subgenus *Sirivanakarnius* for the lattermost species.

Principles and methods of this study concerning the pupae follow Tanaka (1999, 2001); terminology of the adults and larvae follows Tanaka et al., 1979.

I am greatly indebted to Mr. Edward S. Saugstad for reviewing the manuscript.

Resurrection of *Oculeomyia* to subgeneric status

Culex bitaeniorhynchus and its congeners have conventionally been treated as a species subgroup in the subgenus *Culex*. Edwards (1932) established the *bitaeniorhynchus* series in group A (*Lasioconops* or *sitiens*-group) of the subgenus *Culex*, and assigned 12 species of the world to it; among them, *Culex poicilipes* Theobald may belong to a different group. Belkin's (1962) *bitaeniorhynchus* subgroup of the *sitiens* group consists of five South Pacific species. Bram (1967) treated three Thailand species of *Bitaeiorhynchus* Subgroup in *Sitiens* Group. Sirivanakarn (1976) recognized 11 oriental species of *Bitaeiorhynchus* Subgroup in *Sitiens* Group, and gave precise morphological basis for the subgroup in the adult, pupal and larval stages. Sirivanakarn (*l.c.*) also stated that his *Bitaeiorhynchus* Subgroup corresponded to the *bitaeiorhynchus* series of Edwards (1932) and to the *bitaeniorhynchus* subgroup of Belkin (1962) and Bram (1977).

Tanaka et al. (1979) studied and described the larval mandible and maxilla of most Japanese species of mosquitoes. According to them, the mandible and maxilla of *Cx. bitaeniorhynchus* are greatly different from not only other species of the subgenus *Culex*

but also from species of all the other subgenera of the genus *Culex* studied. *Culex sinensis* was studied on a single whole mounted specimen, and as far as observed in this specimen, its mandible and maxilla were found to be essentially identical with those of *Cx. bitaeniorhynchus*. Japanese species of the subgenera *Culex*, *Neoculex*, *Eumelanomyia*, *Lophoceraomyia*, *Culiciomyia* and *Barraudius* are fairly homogenous and markedly different from those of *Cx. bitaeniorhynchus* and *Cx. sinensis* in the characteristics of the mandible and maxilla. Therefore, it will be reasonable to place these two species in a separate subgenus. Theobald (1907) established the genus *Oculeomyia* for *Culex sarawaki* Theobald, 1907, which was synonymized with *Cx. bitaeniorhynchus* by Edwards (1913). Then, *Oculeomyia* can be used as the subgeneric name for *Cx. bitaeniorhynchus* and *Cx. sinensis*.

The subgenus *Oculeomyia* is best characterized in the larval stage as follows. The setae in general are short. The size of the head relative to the thorax and abdomen is smaller than in species of other subgenera. The oral opening is narrow, and the ventral aspect of the head capsule behind the oral cavity is long. The labrum (median labral plate)¹ is completely fused with the frontoclypeus (dorsal apotome) and the suture between them is entirely effaced. The mandible (Fig. 1, a and b) is rounded; the cutting organ including the dorsal teeth, ventral tooth and ventral blade is very strongly developed; the mandibular spurs are stout, lacking MdS₂ (seta 2b-Mn); the mandibular brush is reduced to a short dorsoapical row of a number of rather short hairs; the mandibular comb is reduced to a very short ventroapical row of only a few apically furcate teeth; the piliferous process of the mandible (mandibular lobe) is scarcely protrudent but very wide, and bears several groups of dense short hairs; the mandibular hairs (mandibular sweeper) are arranged in a single continuous row. The maxilla (Fig. 1, c and d) is rounded; the cardo is fused with the cranium along its entire basal margin, though the suture is distinct; the hairs of the maxillary brush are short; the proximal lacinial seta 5-Mx (seta 2-Mx) is distad of the stipital sensoria (seta 1-Mx), which are located distad of the middle of the mesostipes (galeastipes+laciniastipes); the distal lacinial seta 6-Mx is apparently absent; the palpostipes (maxillary palpus) is large, more than half as long as the mesostipes, and fused with it basally; there are only three palpal sensoria (setae 8-, 9- and 13-Mx). The mentum plate (dorsomentum) is straight-sided triangular, and the flanking teeth are often extremely small. The antennal seta 1-A is inserted at about middle of the shaft. The pecten reaches at most basal 1/10 of the siphon, and consists of usually less than 10 teeth.

A more common type of the larval mandible of the genus *Culex* (typical of the filter-feeders; cf. Tanaka et al., 1979, Fig. 6, and Harbach and Knight, 1980, Fig. 47) is triangular with the strongly protrudent piliferous process; the cutting organ is not very large; the mandibular spurs are long and slender, usually with short apically furcate MdS₂; the mandibular brush is a much longer row of numerous hairs; the mandibular comb consists of many more teeth forming also a much longer row; the piliferous process hairs are long; the mandibular hairs are divided into two groups. In a more common type of the larval maxilla of the genus *Culex* (cf. Shalaby, 1957, Fig 18), the cardo is separated from the cranium along almost whole length of its basal margin; the mesostipes is peach-shaped, longer than wide; the hairs of the maxillary brush are very long; proximal lacinial seta 5-Mx is about level of the stipital sensoria, which are usually located proximad of the middle; distal lacinial seta 6-Mx is usually present; the palpostipes is small, usually distinctly less than half as long as and separated from the mesostipes, and usually has 5 palpal sensoria.

¹ Harbach and Knight's (1980) terminology in parenthesis.

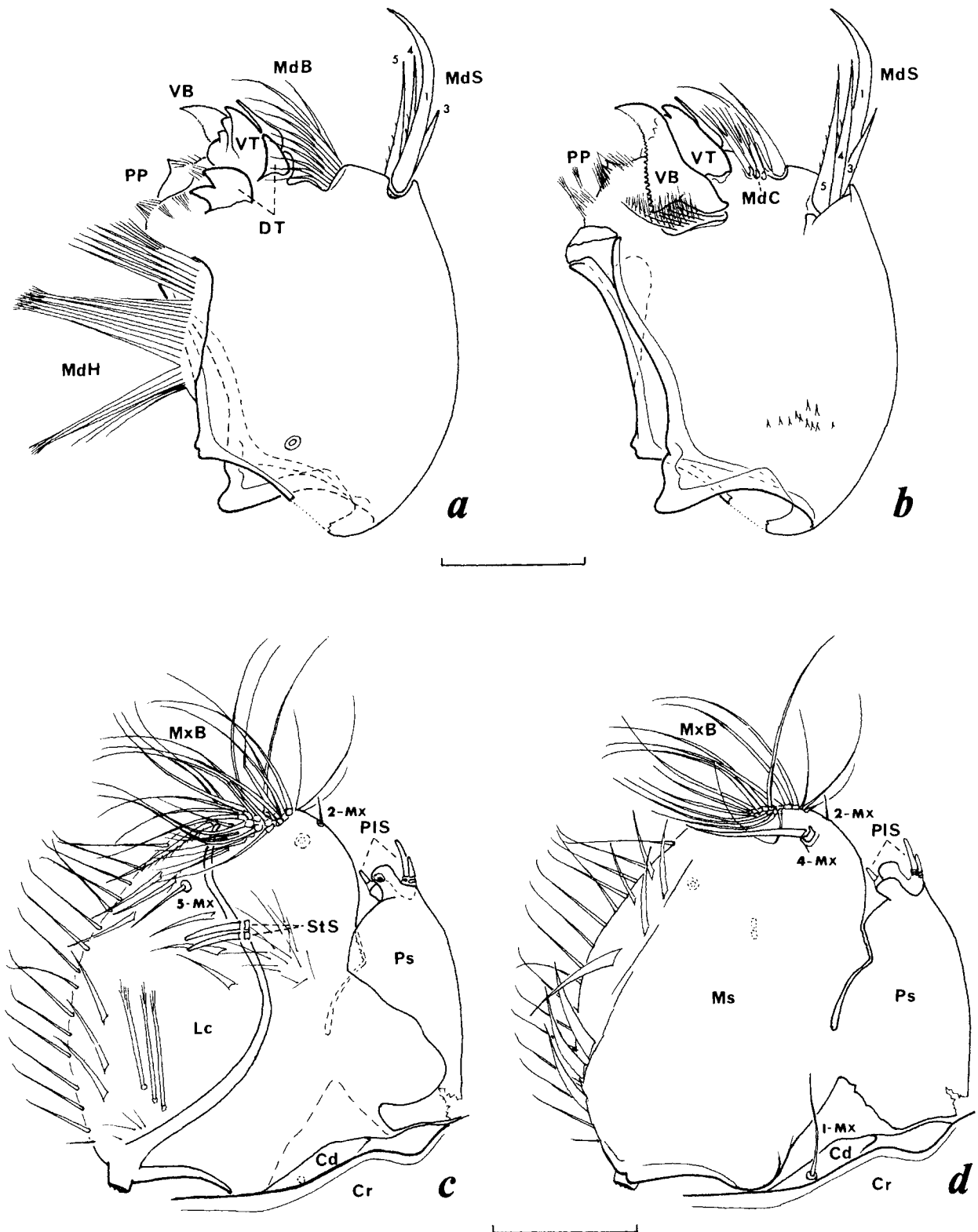


Fig. 1. Larval mandible and maxilla of *Culex (Oculeomyia) bitaeniorhynchus*. **a** and **b**, mandible; **c** and **d**, maxilla (Most lacinial spicules are not illustrated.); **a** and **c**, dorsal aspect; **b** and **d**, ventral aspect. Cd, cardo; Cr, cranium; DT, dorsal tooth; Lc, lacinia; MdB, mandibular brush; MdC, mandibular comb; MdH, mandibular hair; MdS, mandibular spur; Ms, mesostipes; MxB, maxillary brush; PIS, palpal sensorium; PP, piliferous process; Ps, palpostipes; StS, stipital sensorium; VB, ventral blade; VT, ventral tooth; 1-Mx, cardinal seta; 2-Mx, dorsal stipital seta; 4-Mx, ventral stipital seta; 5-Mx, proximal lacinial seta. (Scales represent 0.1 mm.)

Fusion of the palpostipes to the mesostipes (this may be a secondary fusion but not a primitive condition as in *Dixa*) and the cardo to the cranium, the shortened piliferous process and maxillary brush and reduction of madibular spur, brush and comb are the most pronounced characteristics of *Cx. bitaeniorhynchus*. Sclerite fusion in these organs often is seen in predatory species such as those in *Lutzia* and *Toxorhynchites*. *Cx. bitaeniorhynchus*, however, is a representative *Spirogyra*-eater, and the generally stronger structures of the mandible and maxilla of this species may be related to this feeding habit.

Only Tanaka et al. (1979) has done a precise study on the larval mandible and maxilla of species of the *bitaeniorhynchus* subgroup. However, as to the size of the head, fused labrum, peculiar mentum plate and pecten, the following species in addition to *Cx. bitaeniorhynchus* and *Cx. sinensis* have these characters in common according to the descriptions and figures given by Hopkins (1952), Belkin (1962), Bram (1967) and Sirivanakarn (1976): *Cx. annulioris* Theobald and *Cx. ethiopicus* Edwards from Africa; *Cx. albinervis* Edwards, *Cx. squamosus* (Taylor) and *Cx. starckeae* Stone and Knight from the South Pacific; and *Cx. infula* Theobald, *Cx. luzonensis* Sirivanakarn, *Cx. selangorensis* Sirivanakarn, *Cx. pseudosinensis* Colless, *Cx. cornutus* Edwards, *Cx. geminus* Colless and *Cx. kinabaluensis* Sirivanakarn from the Oriental Region. These species also will belong to *Oculeomyia*, and if the mandible and maxilla of all these species have the same characters as those of *Cx. bitaeniorhynchus*, *Oculeomyia* could be ranked as a full genus.

The adult characters of this group were satisfactorily described and discussed by Sirivanakarn (1976), and I have nothing to add to them. The pupal characters are described and discussed in this paper.

The pupa of the subgenus *Oculeomyia*

Dorsal apotome with each lobe roughly elliptical or semicircular; lateralia without traces of facets of compound eye. Trumpet broadened apically, triangular in lateral view, with tracheoid in basal 1/3; pinna very widely open, about 1/3 to nearly half as long as trumpet. All cephalothoracic setae except for 10- and 11-C very short but mostly branched; 2-C close to posterior margin of lateralia; 3-C well separated from 2-C and distant from posterior margin of lateralia; 6-C shortest of cephalothoracic setae; 8-C caudad of trumpet base; 12-C shorter than 10- and 11-C. Middle of metathorax not forming a distinct square median plate. Abdominal terga and sterna with microsculpture similar to that of the subgenus *Culex*; tergum I with reticulation on median sclerotized part. Seta 1-I typical float hair; 1-II ordinary branched seta, sometimes single; 1-III-VI about a half to more than half as long as respective next terga; 1-VII sometimes definitely stronger than others except for 9-VII. Seta 2-II anterolaterad of 3-II; 2-III-VI usually mesad of respective setae 1 and close to posterior margin of respective terga; 2-VII variable in position, but often mesad of 1-VII. Seta 3-I close to 2-I. Seta 4-I closer to 6-I than to 3-I; 4-IV, -VI and -VII anterolaterad of respective setae 5. Seta 5-II longer than and anteromesad of 4-II; 5-III longer than and almost always anteromesad of 4-III; 5-IV-VI often longest of setae of respective segments, sometimes subequal to respective setae 1. Setae 6-I and -II not remarkably long, usually subequal to respective setae 3; 6-III and -IV weak, subequal to each other in strength; 6-V and -VI remarkably stronger than 6-III and -IV, subequal to each other in strength; 6-VII caudad of and slightly mesad of 9-VII. Setae 7-I and -II a little shorter than respective setae 6; 7-III shorter than 8-III; 7-IV as long as 8-IV; 7-V longer than 8-V; 7-VI and -VII single or branched. Seta 8-VII longer than seta 8 of preceding segments. Seta 9-I often branched; 9-II-V usually single and posterolaterad of respective setae 7; 9-VII inserted on tergum close to side margin at about posterior 1/3 of the segment, more or less differentiated; 9-VIII inserted on sternum close to side margin

of the segment, removed a little cephalad of posterolateral corner, more or less differentiated, subequal to 9-VII in length. Setae 11-III-VI with alveolus often weak; 11-VI laterad of 10-VI; 11-VII usually anterolaterad of 10-VII. Seta 14-VIII subequal to 2-VII in size. Segment VIII with posterolateral corner acutely produced posteriorly; posterolateral corner of the preceding segments sometimes acute. Segment IX (median caudal lobe) very short, weakly arched posteriorly, with a short stout seta 1-IX on each side. Paddle rounded, practically smooth on margins, sometimes partially infusate; outer lobe wider than inner one; 2 paddle setae, position relative to each other variable; 1-Pd longer than 2-Pd, with distinct alveolus; 2-Pd with alveolus distinct or indistinct.

Supernumerary setae. Setae 11-I, 10-II and uninterpretable setae on segment VIII were found in *Cx. bitaeniorhynchus*.

The pupa of *Oculeomyia* is not so well characterized as is the larva, but may be distinguished from that of the subgenus *Culex* in the following points. Trumpet strongly broadened towards very widely open pinna. All cephalothoracic setae except for 10- and 11-C very short. Setae 6-I and -II not very long; 6-V and -VI markedly stronger than 6-III and IV; paddle often partially infusate. The pupa of *Oculeomyia* differs from that of the genus *Lutzia* in the following points. Most of cephalothoracic setae branched; setae 2- and 3-C well separated; 6-I and -II longer than respective setae 7; 6-V and -VI markedly stronger than 6-III and -IV; paddle often partially infusate, with midrib almost straight and sclerotized part reaching nearly apex.

Key to Japanese species of the pupa of *Oculeomyia*

1. Most setae with pronounced dark circular alveolar spot. Paddle with inner lobe infusate. Seta 3-I-III almost always single; 7-VI and -VII single; 4-VIII 1-3 (most often 2) branched.
.....*Cx. bitaeniorhynchus*
- Setae without distinct alveolar spot. Paddle whitish to almost transparent. Seta 3-I-III double; 7-VI and -VII double or triple; 4-VIII 3-5 branched. (after Sirivanakarn, 1976).....*Cx. sinensis*

Culex (Oculeomyia) bitaeniorhynchus Giles

[Japanese name: Karatsu-ieka]

(Fig. 2; Table 1)

Giles, 1901, J. Bombay nat. Hist. Soc. 13: 607 (adult). Type-loc.: Travancore, India.

Culex karatsuensis Mochizuki, 1913, Fukuoka Ikadaigaku Zasshi 7: 28 (♂, ♀, egg). Type-loc.: Fukuoka and Karatsu, Kyūshū, Japan.

Trumpet length: 0.89–1.06 mm. Paddle length: 0.94–1.11 mm.

Most of setae (except for very small setae such as 0, 2, 9, 11, 14 of most abdominal segments) and aetose sensilla with a dark circular alveolar spot. Dorsal apotome rather small, with each lobe elliptical. Trumpet with pinna 0.29–0.42 (\bar{x} 0.34) length of trumpet. Seta 3-C > 1-C > 2-C in length; 4-, 5- and 7-C subequal in length; 8-C longer than 9-C; 11-C longest of the cephalothoracic setae, about as long as tergum I, rather strong; 12-C distinctly shorter than 10- and 11-C. Seta 3-I next to 1-I in length, 0.68–1.04 (\bar{x} 0.84) length of tergum I; 6-I subequal to 3-I in length. Setae 3-, 5- and 6-II subequal in length; 3-II 0.55–0.74 (\bar{x} 0.63) length of tergum I, 0.39–0.51 (\bar{x} 0.45) length of tergum III; 5-II anteromesad of 4-II and often even anteromesad of 2-II. Seta 1-III usually longest of setae of the segment, often with one branch much smaller than others, 0.52–0.78 (\bar{x} 0.63) length of tergum IV; 3-III 0.36–0.63 (\bar{x} 0.53) length of tergum IV, rarely longer than 1-III; aetose sensillum caudad of 4-IV and transverse position variable. Seta 1-IV sometimes longest of setae of the segment, 0.58–0.85 (\bar{x} 0.72) length of tergum V; 3-IV most often tandem with (and cephalad of) 5-IV; 5-IV usually

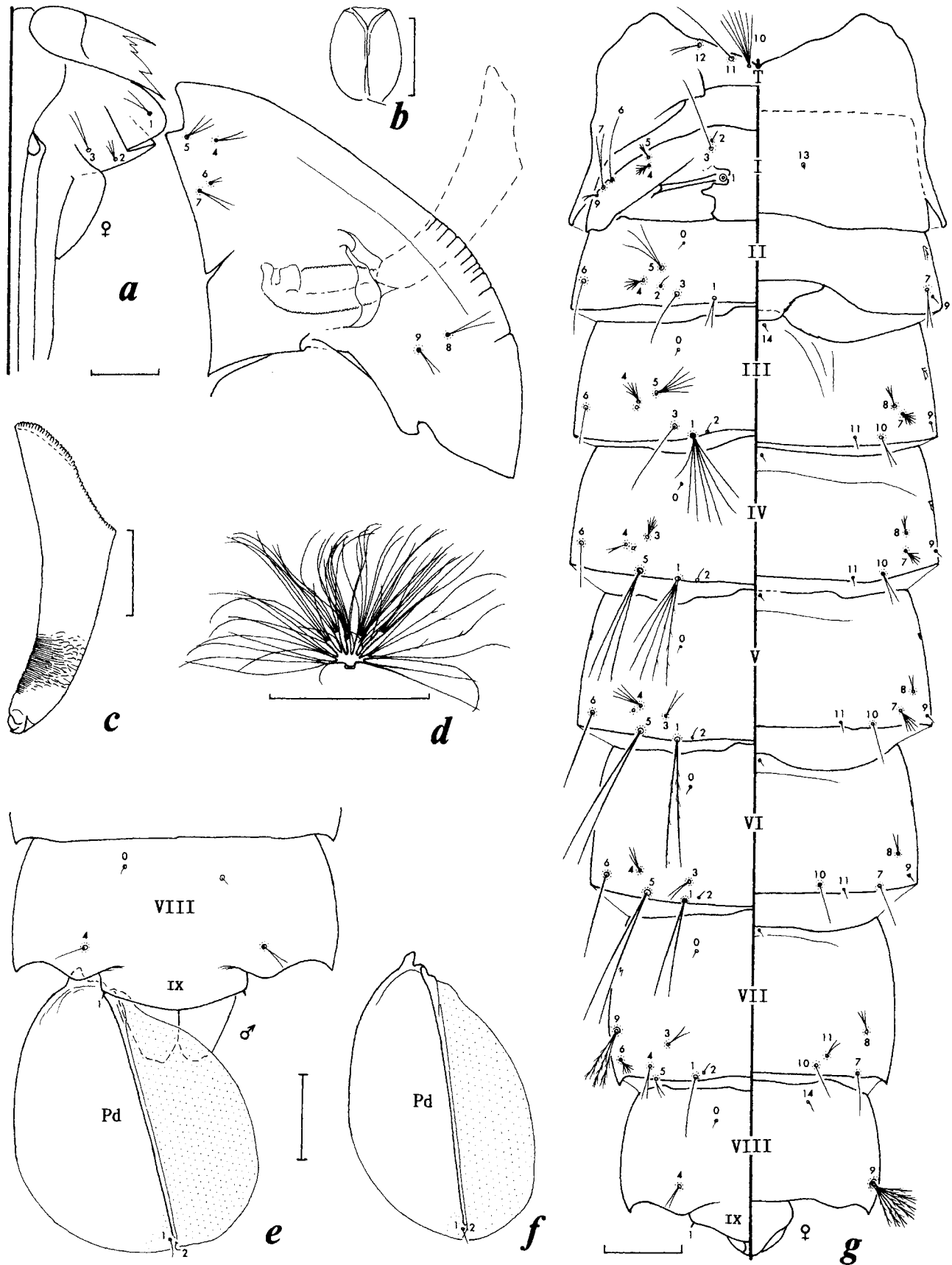


Fig. 2. Pupa of *Culex (Oculeomyia) bitaeniorhynchus*. **a**, Cephalothorax (part); **b**, dorsal apotome; **c**, trumpet; **d**, seta 1-I (float hair); **e**, segment VIII and left paddle (broadest); **f**, left paddle (narrowest); **g**, metathorax and abdomen. (Scales represent 0.3 mm.)

Table 1. Range of the branching of the pupal setae of *Culex (Oculeomyia) bitaeniorhynchus* Giles, 1901.

| Seta No. | Cephalo-thorax | Abdomen | | | | | | | |
|----------|----------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------|-----------|
| | | I | II | III | IV | V | VI | VII | VIII |
| 0 | — | — | 1 | 1 | 1-2(1 [†]) | 1 | 1 | 1 | 1-3(1*) |
| 1 | 1-2(2*) | m | 1-7(2) | 5-13(7) | 3-6(5) | 1-4(2) | 1-3(2) | 1 | — |
| 2 | 2-5(3) | 1-2(1 [†]) | 1 | 1 | 1 | 1 | 1-2(1 [†]) | 1 | — |
| 3 | 2 | 1-2(1*) | 1-2(1 [†]) | 1-2(1 [†]) | 4-8(6) | 1-2(2 [†]) | 1-2(2) | 1-3(2) | — |
| 4 | 2-4(2) | 5-9(6) | 3-7(5) | 4-7(5) | 2-4(2) | 2-5(4) | 2-3(—) | 1-3(2) | 1-3(2) |
| 5 | 2-3(3) | 2-7(3) | 3-5(3) | 3-6(5) | 2-4(3*) | 1-3(2*) | 1-3(2*) | 1-2(2) | — |
| 6 | 2-4(2) | 1-2(1 [†]) | 1-2(1 [†]) | 1 | 1 | 1 | 1 | 3-9(5,6) | 1-Pd |
| 7 | 2 | 2-3(2*) | 1-4(2) | 4-10(7, 8) | 2-6(5) | 3-6(5) | 1 | 1 | 1-2(1*) |
| 8 | 1-3(2) | — | — | 2-6(3) | 1-5(3) | 1-4(2) | 1-4(2) | 1-4(3) | — |
| 9 | 1-3(2) | 1-3(2) | 1 | 1 | 1 | 1 | 1 | 3-6(3) | 4-10(6,7) |
| 10 | 5-11(7) | — | — | 2-3(2) | 1-3(2) | 1-2(1 [†]) | 1 | 1-3(1) | — |
| 11 | 1-2(1) | — | — | 1 | 1-2(1 [†]) | 1-2(1*) | 1-2(1*) | 1-2(2) | 2-Pd |
| 12 | 2-4(2) | — | 1-IX | — | — | — | — | — | 1 |
| 13 | — | 1 | 1 | — | — | — | — | — | — |
| 14 | — | — | — | 1 | 1 | 1 | 1 | 1 | 1 |

m: uncountable numerous branches.

Modes in parenthesis, * the case occurring in 80-89%, † in 90-99%.

Specimens examined: 4♂, 9♀: Honshû; 1♀: Kyûshû.

three branched, often longest of setae of the segment, 0.65-0.96 (\bar{x} 0.79) length of tergum V; aetose sensillum almost always mesad of 4-IV and longitudinal position variable. Seta 1-V 0.68-0.92 (\bar{x} 0.78) length of tergum VI, very rarely longer than 5-V; 3-V occasionally tandem with (and cephalad of) 1-V; 4-V cephalad of 5-V and transverse position variable; 5-V usually two branched, almost always longest of setae of the segment, 0.78-1.02 (\bar{x} 0.90) length of tergum VI; 6-V and -VI remarkably stronger than 6-III and -IV, but distinctly shorter than 1 and 5 of respective segments; aetose sensillum almost always posterolaterad of 4-V. Seta 1-VI 0.51-0.77 (\bar{x} 0.61) length of tergum VII; 3-VI often anteromesad of 1-VI; 5-VI usually two branched, longest of setae of the segment, 0.73-0.91 (\bar{x} 0.82) length of tergum VII. Segment VII with posterolateral corner usually more or less acutely produced posteriorly; seta 1-VII rather strong, subequal to 9-VII in length, 0.38-0.62 (\bar{x} 0.50) length of side of segment VIII, 1-VII > 4-VII > 3-VII > 5-VII in length; 2-VII variable in position, but more often mesad of 1-VII; 6-VII caudad of and slightly mesad of 9-VII; 9-VII strongly barbed, with branches often subdivided and with 3-10 branches at apex, 0.44-0.60 (\bar{x} 0.50) length of side of segment VIII; 11-VII more often anterolaterad of 10-VII. Segment VIII with posterolateral corner acutely produced posteriorly; seta 9-VIII inserted on posterior 0.18-0.25 (\bar{x} 0.22) of the segment, strongly barbed, with branches very often subdivided and with six to more than 10 branches at apex, 0.37-0.58 (\bar{x} 0.47) length of side of the segment, 0.16-0.29 (\bar{x} 0.22) length of paddle, 0.78-1.04 (\bar{x} 0.92) length of 9-VII. Segment IX 0.45-0.49 (\bar{x} 0.47) width of segment VIII; ♂ genital lobe 0.28-0.32 (\bar{x} 0.30) length of paddle. Paddle index 1.18-1.57 (\bar{x} 1.35); inner lobe and apex of outer lobe infuscate; seta 1-Pd 0.03-0.06 (\bar{x} 0.05) length of paddle, with distinct alveolus; 2-Pd 0.01-0.03 (\bar{x} 0.02) length of paddle, often with more or less distinct alveolus.

Supernumerary setae. Seta 11-I was found in nine specimens (15 setae) of 14 examined, about as long as 9-I. Seta 10-II was found in one ♀ specimen (C-1956-6) on both sides; the left one is two branched and the right one is single; they are about as long as 7-II but more slender, extending far beyond the posterior margin of the sternum; both alveolus and remnant of the associated nerve are indistinct. In a ♂ specimen (C-1956-a-17921), on the left side of the middle of the ventral surface of segment IX, there were two single slender setae; they are about the size of 4-VIII, their alveolus and remnant of the associated nerve are indistinct. On the other side of the middle, a bundle of 15 setae of a size similar to those of the left side was observed; they appear to be convergent to a single base but any alveolus-like structure was not confirmed.

Specimens examined: 4♂, 10♀ in total. **Honshu**—Zama, Kanagawa Pref., 4♂, 9♀, IX. 13, 1974, ground pool, col. E. S. Saugstad. **Kyûshû**—Yatsushiro, Kumamoto Pref., 1♀, IX. 22, 1974, rock pool, col. K. Mizusawa and A. Yoshii.

Distribution. Japanese Archipelago (Hokkaidô; Honshû; Shikoku; Kyûshû; Tsushima; Yakushima); Ryukyu Archipelago; Korean Peninsula; Cheju-do; southern Prymorie; continental China; Oriental Region; Micronesia; Australian Region; southern coastal lands of southwestern Asia; Afrotropical Region.

Taxonomic discussion. Asanuma (1948) may be the first to have treated the pupa of this species, and described the presence of alveolar spots, and the characters of seta 9-VIII, posterolateral corner of segment VIII and paddle. La Casse and Yamaguti (1948, 1950) just illustrated the trumpet and paddle. Asanuma and Nakagawa (1953) gave a precise description and an illustration of the metathorax and abdomen. Belkin (1962) presented a key, short description and full illustration on the South Pacific population. Kamimura (1976) treated the pupa briefly. Sirivanakarn (1976) provided a key, description and full illustration on the Oriental population. Harbach (1988) gave a key, description, full illustration and chaetotaxy table on the population of southwestern Asia. The present study added new knowledge of the reticulate tergum I and intersegmental membrane of the abdomen. The latter character is shared with the pupa of *Lutzia*, and should be confirmed in other species of *Oculeomyia* whether or not it could be one of the subgeneric characters.

Three supernumerary setae found on ventral surface of segment IX are quite peculiar. Similar setae have only once been found in *Lutzia (Metalutzia) vorax* Edwards (Tanaka, 2003). Tanaka (2003) thought it might possibly be 13-VIII. In fact, these setae found in *Cx. bitaeniorhynchus* remind some of the larval pentad setae of segment VIII. Further findings will be necessary to interpret the homology of these setae.

Culex (Oculeomyia) sinensis Theobald
(Japanese name: Mitsuhoshi-ieka)

Theobald, 1903, Monogr. Culicid. 3: 180 (as var. of *Culex gelidus*; ♀). Type-loc.: Shaohying, China.

Culex tripunctatus Mochizuki, 1913, Fukuoka Ikadaigaku Zasshi 7: 24 (♂, ♀, egg). Type-loc.: Fukuoka and Karatsu, Kyushu, Japan.

Pupal specimens of this species were not available for the present study.

Distribution. Japanese Archipelago (Honshû; Shikoku; Kyûshû); Ryukyu Archipelago (Amami-, Okinawa- and Yaeyama-guntô); Korean Peninsula; southern Prymorie; middle and southern continental China; Taiwan; Hong Kong; Philippines; Flores; Java; Sumatra; Malay Peninsula; Vietnam; Thailand; Burma; India; Bangladesh; Sri Lanka.

Taxonomic discussion. La Casse and Yamaguti (1948, 1950) just illustrated the trumpet and paddle. Kamimura (1976) treated the pupa briefly. Sirivanakarn (1976) gave a key, description and full illustration. According to Sirivanakarn's description and illustration, *Cx. sinensis* differs from *Cx. bitaeniorhynchus*, in addition to the characters shown in the foregoing key, in that the trumpet is narrower, seta 5-IV is distinctly longer than 1-IV, and the posterolateral corners of abdominal segments III-VI (in addition to VII and VIII) are acute.

Sirivanakarnius*, a new subgenus of the genus *Culex

Type species: *Culex (Culex) boninensis* Bohart, 1957, from Ogasawara-guntô (Bonin Is-

lands.). Monotypic.

Most closely related with the subgenus *Culex*. Best characterized in the adult, especially in the male.

♂ and ♀. Dark mosquito; proboscis, wing and tarsi entirely dark scaled; abdominal terga with neither basal nor apical bands, but with laterobasal patches of white scales, usually not visible in dorsal aspect. Acrostichal bristles present. Pleura with scale patches on sternopleuron and mesepimeron; lower mesepimeral bristle absent.

♂. Flagellomere 12 0.65–0.76 length of flagellomere 13 (0.78–1.45 in 10 Japanese species of subg. *Culex*); flagellomeres 12 + 13 0.94–1.25 length of flagellomeres 1–11 (12 + 13 shorter than 1–11 in nine Japanese species of subg. *Culex*). Palpus not hairy, as long as (0.99–1.08 length of) proboscis [palpus distinctly longer than (1.21–1.48 length of) proboscis in 10 Japanese species of subg. *Culex*]; apical two segments shortened, ratio of segments 2–5 : (1.19–1.31) : (2.22–2.34) : (0.88–0.96) : (1.00) [(0.54–0.95) : (1.26–2.05) : (0.70–1.00) : (1.00) in nine Japanese species of subg. *Culex*]. Subapical lobe of basistyle with three typical rods (α , β , γ), paddle-shaped δ , narrow ϵ (broadly foliate in species of subg. *Culex*), a single μ (multiple in species of subg. *Culex*), and longest bristle-like χ ; a small bristly area just proximad of subapical lobe; dististyle weakly arcuate, with a small claw; paraproct with well developed laterobasal process. Aedeagus unique in form, without spiculate portion; tergoapical division of tergoapical division much shorter than sternomesal subdivision, of a simple conical form in tergal view; sternomesal subdivision of tergoapical division strongly sclerotized, narrow in tergal view, with 5 or 6 stout tergoapical teeth; sternal process or tooth absent.

Larva including characters of mandible and maxilla similar to that of the *mimeticus* subgroup. Labrum separated from frontoclypeus by a distinct suture; seta 1-C dark, stout. Seta 4-P single. Comb scales more than 30, paddle-shaped, evenly fringed with fine spicules. Siphon straight, moderately long; pecten in basal 1/3 of siphon, of 9–14 teeth; seta 1-S almost ventral.

Pupa described below.

Taxonomic discussion. Bohart (1957) and Kamimura (1976) placed *Cx. boninensis* in the subgenus *Culex*, although they explained that some features of this species were unusual for the subgenus. Sirivanakarn (1976) stated “it appears most probable that *boninensis* probably represents a distinct subgenus judging by the male genitalia and adult characters.” However, before describing a new subgenus for it, he appears to have departed from the science field. Tanaka et al. (1979) fully described and illustrated the adult, male genitalia and larva, and expressed “Due to the character of the male palpus and genitalia, *boninensis* appears to have an isolated taxonomic position in the subgenus *Culex*. However, the larvae do not exhibit any peculiar characters.” The pupa of this species was found to be almost identical with that of the subgenus *Culex*, except for distinct imbrication of dermal sculpture. Here, I believe the peculiar adult characteristics enumerated above are sufficient to establish a distinct subgenus, and dedicate its name to Dr. Sunthorn Sirivanakarn.

The pupa of the subgenus *Sirivanakarnius*

Dorsal apotome with each lobe semicircular; lateralia with feeble traces of facets of compound eye. Trumpet cylindrical; index ca 5; pinna about 1/3 as long as trumpet. All cephalothoracic setae shorter than trumpet, branched except sometimes for 11-C; 2-C close to posterior margin of lateralia; 3-C well separated from 2-C; 6-C shortest; 8-C

caudad of trumpet base. Middle of metathorax not forming distinct square median plate. Abdominal terga and sterna covered with pronounced imbrication; tergum I very distinctly reticulate on median sclerotized part; intersegmental membrane partially weakly reticulate. Seta 1-I typical float hair with very numerous secondary branches; 1-II short, penicillate; 1-III-VI more than half as long as respective next terga. Seta 2-II anterolaterad of 3-II; 2-III-VI mesad of respective setae 1 and close to posterior margin of respective terga; 2-VII usually anterolaterad of 1-VII. Seta 3-I close to 2-I; 3-I-III similar to 11-C, almost always 2 branched. Seta 4-I closer to 6-I than to 3-I; 4-IV-VII anterolaterad of respective setae 5. Seta 5-II and -III longer than and mesad of respective setae 4; 5-IV-VI longest of setae of respective segments. Setae 6-I and -II slender, almost always single, longest of setae of respective segments; 6-III-VI almost always branched, 6-V and -VI a little stronger than 6-III and -IV; 6-VII caudad of and slightly mesad of or tandem with 9-VII. Setae 7-I and -II only a little shorter than respective setae 6; 7-III shorter than 8-III; 7-IV as long as 8-IV; 7-V longer than 8-V; 7-VI and -VII almost always single. Seta 8-VII much longer than setae 8 of preceding segments. Seta 9-I often branched; 9-II-V single, caudad of respective setae 7; 9-VII inserted on posterior $1/4-1/3$ of tergum close to side margin, stiff, distinctly barbed, often subdivided apically; 9-VIII similar to 9-VII but with more branches, inserted on sternum close to side margin, removed a little cephalad of posterolateral corner, strongly barbed, often subdivided apically. Seta 11-VI laterad of 10-VI; 11-VII anterolaterad of 10-VII, longer than setae 11 of preceding segments. Seta 14-VIII subequal to 2-VII in size. Segment VIII with posterolateral corner blunt. Segment IX (median caudal lobe) short, moderately arched posteriorly, about half as wide as segment VIII, with a single short stout seta 1-IX on each side. Paddle ovate, with minute spicules along laterobasal bordered margin and on surfaces; outer lobe wider than inner one; averaged index 1.37; two very short paddle setae; 1-Pd longer, with distinct alveolus; 2-Pd sometimes with distinct alveolus.

The pupa of the subgenus *Sirivanakarnius* is not so well characterized as the adult, but can be distinguished from that of the subgenus *Culex* in that the terga and sterna are covered with pronounced imbrication. It differs from that of the *pipiens* group in the very distinctly reticulate tergum I. It differs from that of the genus *Lutzia* in that most of cephalothoracic setae are branched and moderately long, setae 2- and 3-C are well separated, and setae 9-II-V are caudad of respective setae 7.

***Culex (Sirivanakarnius) boninensis* Bohart**

[Japanese name: Ogasawara-ieka]

(Fig. 3; Table 2)

Bohart, (1956) 1957, Ins. Micronesia 12: 75 (♂, ♀, larva, pupa). Type-loc.: Chichi Jima, Bonin Is.

Trumpet length: 0.46–0.67 mm. Paddle length: 0.71–0.90 mm.

Trumpet with tracheoid within basal $2/5$; index 4.0–6.6 (\bar{x} 5.0); pinna 0.19–0.40 (\bar{x} 0.31) length of trumpet. Seta 1-C longer than 2- and 3-C; 7-C usually a little longer than 4- and 5-C; 8-C longer than 9-C; 10–12-C subequal in length. Seta 6-I longest of setae of the segment, 0.97–1.49 (\bar{x} 1.30) length of tergum I, very rarely shorter than it. Seta 5-II anteromesad of 4-II and often even anteromesad of 2-II; 6-II usually slightly shorter than 6-I, longest of setae of the segment, 0.97–1.42 (\bar{x} 1.19) length of tergum I, very rarely shorter than it, 0.73–1.10 (\bar{x} 0.91) length of tergum III. Seta 1-III usually longest of setae of the segment, 0.60–0.86 (\bar{x} 0.70) length of tergum IV; 3- and 5-III subequal to 1-III in length; 5-III always mesad of 4-III but longitudinal position variable; aetose

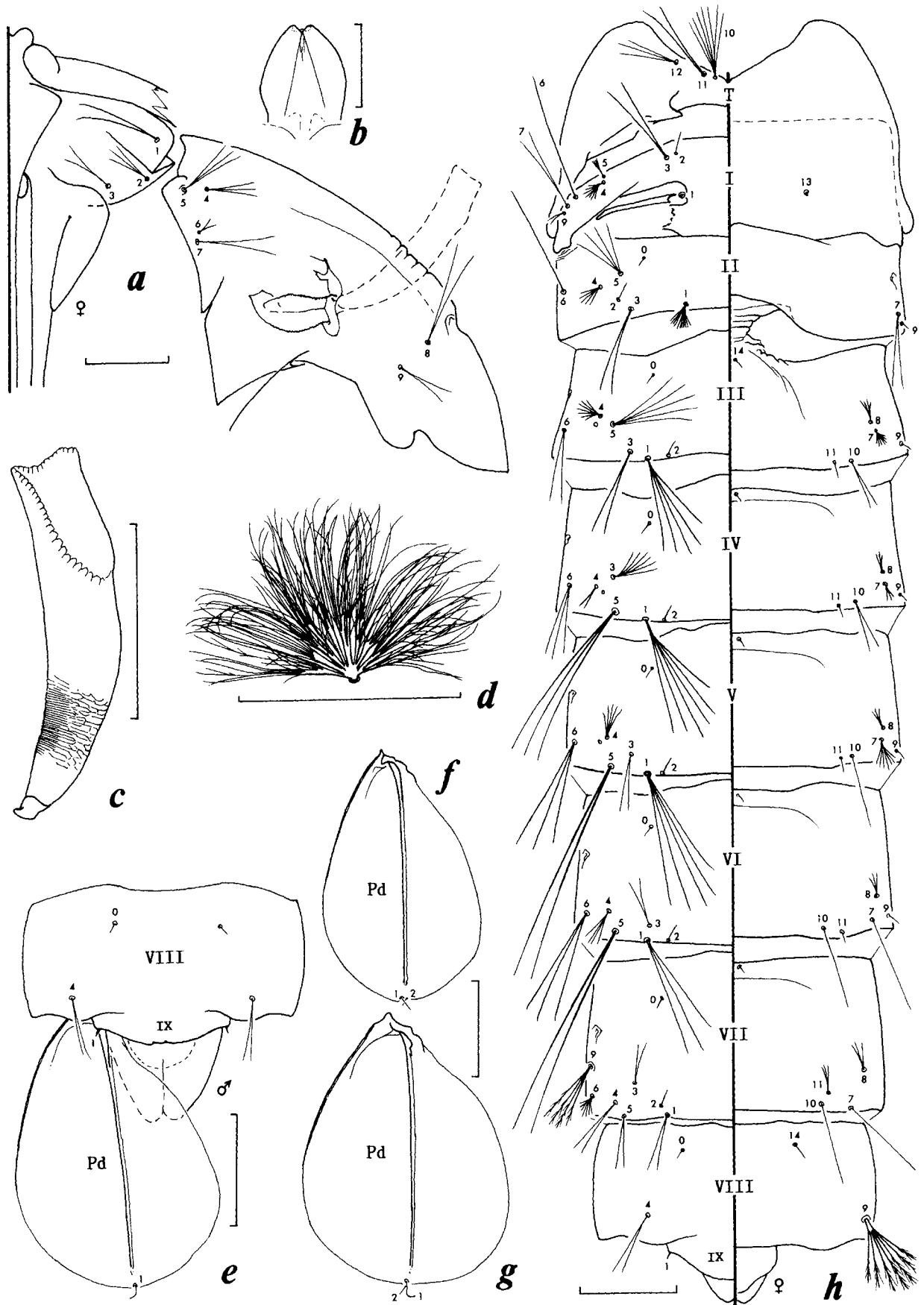


Fig. 3. Pupa of *Culex (Sirivanakarnius) boninensis*. **a**, Cephalothorax (part); **b**, dorsal apotome; **c**, trumpet; **d**, seta 1-I (float hair); **e**, segment VIII and left paddle (typical); **f**, left paddle (narrowest); **g**, left paddle (broadest); **h**, metathorax and abdomen. (Scales represent 0.3 mm.)

Table 2. Range of the branching of the pupal setae of *Culex (Sirivanakarnius) boninensis* Bohart, 1957.

| Seta No. | Cephalo-thorax | Abdomen | | | | | | | |
|----------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | | I | II | III | IV | V | VI | VII | VIII |
| 0 | — | — | 1-2(1 [†]) | 1-2(1 [†]) | 1-2(1*) | 1-2(1 [†]) | 1 | 1 | 1 |
| 1 | 2-4(2) | m | 6-20(11) | 4-10(—) | 2-8(6) | 3-6(5) | 2-5(4) | 3-5(3*) | — |
| 2 | 2-5(3) | 1-4(1 [†]) | 1 | 1 | 1 | 1 | 1 | 1 | — |
| 3 | 1-3(2) | 2 | 2 | 2-3(2 [†]) | 4-9(6) | 2 | 1-2(2 [†]) | 1-5(2) | — |
| 4 | 2-4(3) | 5-10(6, 7) | 3-7(5) | 3-8(7) | 1-4(2) | 3-8(6) | 2-5(4) | 1-2(2 [†]) | 1-2(2 [†]) |
| 5 | 2-5(3) | 2-6(3, 4) | 3-5(4) | 3-7(5) | 2-7(3) | 2-4(2*) | 1-3(2 [†]) | 1-3(2) | — |
| 6 | 2-4(2) | 1-2(1 [†]) | 1 | 1-5(2) | 2-3(3) | 2-3(3) | 2-3(3) | 4-11(7) | 1-Pd |
| 7 | 2-3(2 [†]) | 2-4(2*) | 1-2(2 [†]) | 5-11(6) | 2-5(3) | 5-9(7) | 1-2(1 [†]) | 1-2(1 [†]) | 1-2(1) |
| 8 | 2-3(2*) | — | — | 2-5(4) | 1-4(2, 3) | 1-4(3) | 2-5(3) | 3-5(3) | — |
| 9 | 2-3(2 [†]) | 1-3(2) | 1 | 1 | 1 | 1 | 1 | 3-6(4) | 4-10(7) |
| 10 | 3-14(7) | — | — | 2-3(2 [†]) | 2-3(2 [†]) | 1 | 1 | 1 | — |
| 11 | 1-3(2*) | — | — | 1-2(1 [†]) | 1 | 1-2(1*) | 1-3(1) | 1-6(3) | 2-Pd |
| 12 | 2-4(3) | — | 1-IX | — | — | — | — | — | 1-2(1 [†]) |
| 13 | — | 1 | 1 | — | — | — | — | — | — |
| 14 | — | — | — | 1 | 1 | 1 | 1-2(1 [†]) | 1 | 1-2(1 [†]) |

m: uncountable numerous branches.

Modes in parenthesis, * the case occurring in 80-89%, † in 90-99%.

Specimens examined: 5♂, 7♀: Chichijima, Ogasawara-guntô; 5♂, 3♀: Hahajima, Ogasawara-guntô.

sensillum always caudad of 4-III and more often (67%) laterad of it. Seta 1-IV a little shorter than 5-IV; 3-IV almost always anterolaterad of 5-IV; 5-IV longest of setae of the segment, 0.97-1.31 (\bar{x} 1.12) length of tergum V; aetose sensillum mesad of 4-IV and more often (45%) caudad of it. Seta 5-V longest of setae of the segment, distinctly longer than 1-V, 1.19-1.58 (\bar{x} 1.38) length of tergum VI; 6-V distinctly stronger than 6-IV; aetose sensillum posterolaterad of 4-V. Seta 3-VI often (50%) anteromesad of 1-VI; 5-VI longest of setae of the segment, distinctly longer than 1-VI, usually a little shorter than 5-V, 1.07-1.48 (\bar{x} 1.29) length of tergum VII; 6-VI equal to 6-V in size. Seta 1-, 4- and 5-VII subequal in length and a little longer than 3-VII; 5-VII, when single, longer than 1- and 4-VII; 7-VII slender, longest of setae of the segment; 9-VII stiff, usually strongly barbed or with many short side branches, 3-6 branched at base, sometimes subdivided apically into 4-8 branches, 0.54-0.79 (\bar{x} 0.62) length of side of segment VIII. Seta 9-VIII inserted on posterior 0.13-0.21 (\bar{x} 0.17) of the segment, stiff, strongly barbed or with many short side branches, 4-10 branched at base, often subdivided apically into more than 10 branches, 0.59-0.80 (\bar{x} 0.69) length of side of segment VIII, 0.23-0.32 (\bar{x} 0.28) length of paddle, 0.94-1.27 (\bar{x} 1.09) length of 9-VII. Segment IX 0.46-0.52 (\bar{x} 0.49) width of segment VIII (relatively wider in ♂ than in ♀); male genital lobe 0.33-0.40 (\bar{x} 0.36) length of paddle. Paddle index 1.22-1.49 (\bar{x} 1.37); 1-Pd 0.04-0.08 (\bar{x} 0.06) length of paddle; 2-Pd 0.02-0.06 (\bar{x} 0.04) length of paddle.

Supernumerary setae. Seta 11-I was found in 10 specimens (16 setae) of 20 examined, 1-3 branched, about size of 9-I. Seta 11-II was found in six specimens (nine setae), single in one, 2-4 branched in others, about length of 4-II, rather stiff, not reaching posterior margin of the sternum; the alveolus and remnant of the associated nerve are absent or indistinct. Seta 13-IV was found in three specimens (five setae), anteromesad of 11-IV, 2-5 branched, about length of 7-IV; the alveolus and remnant of the associated nerve are absent or indistinct. Two 4-C of the same length were found close together on the right side of a ♂ specimen (N-1724-18); one is two branched, another is three branched.

Specimens examined: 24♂, 22♀ in total. **Chichi-jima, Ogasawara-guntô**—Mt. Chûô, 1♂, VI. 25, 1972, col. S. Shinonaga; 1♂, 1♀, V. 19, 1973, ground pool, col. S. Shinonaga; 1♀, IX. 28, 1973, ground pool, col. K. Mizusawa; 12♂, 1♀, IX. 28, 1973, rock hole, col. K. Mizusawa. Fukiagedani, 1♂, 11♀, V. 25, 1973, ground pool, col. S. Shinonaga. Ôgiura, 1♀,

VI. 30, 1972, ground pool, col. S. Shinonaga; 2♀, IX. 28, 1973, stream, col. K. Mizusawa. Okumura, 2♂, 2♀, IX. 29, 1973, ground pool, col. K. Mizusawa. **Haha-jima, Ogasawara-guntō**—7♂, 3♀, VI, 1973, ground pool, col. S. Hayashida.

Distribution. Ogasawara-guntō (the Bonin Islands).

Taxonomic discussion. Bohart (1957) gave only a three-line description of the pupa in his original description of this species. Kamimura (1976) described the branching of a number of setae. The present study is the first detailed one on the pupa of this species.

Ten species of mosquitoes occur in Ogasawara-guntō including this species and (apparently now absent) *Ae. (Stg.) aegypti*. The pupae of these species will be distinguished from each other by the following key.

Key to species of the pupa of mosquitoes from Ogasawara-guntō

1. Trumpet with tracheoid within basal half.2
 - Trumpet without tracheoid.6
2. Cephalothoracic setae mostly branched and moderately long; 2- and 3-C well separated. Intersegmental membrane not or indistinctly reticulate. Setae 9-II-V caudad of respective setae 7.3
 - Cephalothoracic setae mostly single and very short; 2- and 3-C approximated. Intersegmental membrane distinctly reticulate. Setae 9-II-V cephalad of respective setae 7.5
3. Tergum I without reticulation on median sclerotized part.*Culex (Culex) pipiens quinquefasciatus*
 - Tergum I with reticulation on median sclerotized part.4
4. Seta 8-C 4-7 (most often five) branched; 6-I and -II very long, 1.78-2.96 (usually more than twice) length of tergum I; 1-II long, with usually more (17-38; \bar{x} 26) branches; 6-V and -VI 4-8 (most often six) branched. Lateralia without traces of facets of compound eye. Trumpet usually longer, average index 6.5; pinna usually shorter, 0.17-0.26 (\bar{x} 0.22) length of trumpet. Imbrication of terga and sterna limited to lateral areas of each.*Culex (Culex) tritaeniorhynchus*
 - Seta 8-C 2-3 (usually two) branched; 6-I and -II moderately long, 0.97-1.49 length of tergum I; 1-II short, with usually fewer (6-20; \bar{x} 12) branches; 6-V and -VI 2-3 (most often three) branched. Lateralia with feeble traces of facets of compound eye. Trumpet usually shorter, average index 5.0; pinna usually longer, 0.19-0.40 (\bar{x} 0.31) length of trumpet. Abdominal terga and sterna II-VIII entirely covered with pronounced imbrication.*Culex (Sirivanakarnius) boninensis*
5. Seta 1-I with less than 10 primary and about 20 secondary branches; 2- and 3-I separated; 1-II with divergent branches; 1-III and -IV single; 5-II laterad of 4-II; 9-II-VI pointed-tipped as 9-I; 9-VII very weakly and sparsely barbed, single or two branched; 9-VIII with only 2-3 branches; segment VIII with posterolateral corner not produced.*Lutzia (Insulalutzia) shinonagai*
 - Seta 1-I with about 10 primary and numerous secondary branches; 2- and 3-I approximated; 1-II with branches not very divergent; 1-III and -IV multibranched and never single; 5-II mesad of 4-II; 9-II-VI blunt-tipped; 9-VII and -VIII strongly barbed and with more (2-14) branches; segment VIII with posterolateral corner rather sharply produced. ...*Lutzia (Metalutzia) vorax*
6. Paddle fringed with filamentous spicules.*Aedes (Stegomyia) albopictus*
 - Paddle fringed with dentiform spicules.7
7. Seta 6-C longest of 4-7-C and rather strong; 5-II laterad of 4-II; 2-III-V never mesad of respective setae 1, and at middle to posterior 1/3 of respective segments.8

- Seta 6-C shortest of 4-7-C; 5-II mesad of 4-II; 2-III-V usually mesad of respective setae 1, and more or less close to posterior margin of the segment.9
- 8. Trumpet long, cylindrical and broadened at apex; seta 2-III almost always anterolaterad of 3-III; 2-IV-VI usually placed more anterolaterally and often anterolaterad of respective setae 3.
.....*Aedes (Stegomyia) wadai*
- Trumpet short, broadened from base to apex; seta 2-III anteromesad of 3-III; 2-IV-VI usually placed more posteromesally and often mesad of respective setae 3 (after Belkin, 1962, Fig. 313).
.....*Aedes (Stegomyia) aegypti*
- 9. Seta 2-Pd absent; 1-II, 8-VII and 9-VII 10-36 (most often 13-15), 3-11 (most often five) and 4-9 (most often six) branched respectively.*Aedes (Finlaya) togoi*
- Seta 2-Pd present; 1-II, 8-VII and 9-VII 2-8 (most often five), 1-4 (most often two) and 2-5 (most often three) branched respectively.*Aedes (Finlaya) savoryi*

Additional note

Through the series of this study (Tanaka, 1999-2004), I have carelessly overlooked a paper of Mochizuki (1913). This is one of the earlier works of mosquito taxonomy dealing with 12 species of Japanese mosquitoes. The adults and larvae are very well described and illustrated. He also treated the pupae of eight species, giving a two-line description and illustrations of segments VI-VIII, the paddle and seta 9-VIII for each species. These species are *Culex pallens* (*Culex pipiens pallens*), *Culex biroi* (*Culex tritaeniorhynchus*), *Culex tigripes* (*Lutzia vorax*), *Culex* (?) *japonicus* (*Aedes japonicus japonicus*), *Stegomyia scutellaris* (*Aedes albopictus*), *Desvoidya obturbans* = *Culex subalbatus* (*Armigeres subalbatus*), *Myzorrhynchus sinensis* (*Anopheles sinensis*), and *Stegomyia fasciata* (*Aedes aegypti*). The honor to have taxonomically treated the pupae of these species for the first time thus should be given to Mochizuki (1913).

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