AEDES (FINLAYA) AXITIOSUS, A NEW SPECIES OF THE NIVEUS SUBGROUP (DIPTERA: CULICIDAE) FROM EAST MALAYSIA[1]

VARUNI KULASEKERA[2], KENNETH L. KNIGHT[3] AND RALPH E. HARBACH[4]

ABSTRACT. The adult, larval, and pupal stages of *Aedes (Finlaya) axitiosus,* a new species from East Malaysia, are described and illustrated. The species is contrasted to other members of the Niveus Subgroup.

The Niveus Subgroup of the subgenus *Finlaya* Theobald of *Aedes* Meigen includes 25 species which occur in the Oriental Region and adjoining areas of the Palaearctic and Australian regions. The new species described below brings the total to 26 species. These species are generally poorly known and difficult to identify with existing keys and descriptions, yet they are potential vectors of infectious pathogens, particularly filarial parasites. This assertion is based on the incrimination of *Ae. niveus* (Ludlow) as a vector of nocturnally periodic *Wuchereria bancrofti* (Cobbold) in the Philippines (Rozeboom and Cabrera, 1964) and *Ae. harinasutai* Knight as the primary vector of subperiodic *W. bancrofti* filariasis in western Thailand (Gould et al., 1982). In addition, Rudnick (1986) reported data which clearly shows that mosquitoes of the Niveus Subgroup are important canopy vectors of dengue virus in Malaysia.

Colless (1958, 1959) provided the last taxonomic review of the Niveus Subgroup, which included limited, unequal treatments of only 19 species. This review is now out of date. The present paper does not resolve this problem, but it does increase our knowledge of the group and should improve our ability to identify the included species.

The morphological terminology and abbreviations used in this report are taken from Harbach and Knight (1980, 1982) and Knight and Harrison (1987).

Aedes (Finlaya) axitiosus, new species

Adult. Integument brownish black to black; setae dark, numbers in Table 1; scales narrow on palpus, proboscis, wing, halter, scutum, femora, tibiae and tarsi, broad and decumbent on vertex, gena, antepronotum, scutellum, thoracic pleura, coxae, trochanters, abdomen and genitalia; areas of white scales on vertex, gena, lower part of antepronotum, scutum, prescutellar area, scutellum, proepisternum, prealar area, upper and lower posterior area of mesokatepisternum, mesepimeron, coxae, trochanters, femora and abdomen, presence and extent of pale scales on vertex, scutum and scutellum different in male and female, vertex with dark erect forked scales posteriorly. *Head:* Antennal pedicel with small hairlike dark scales anteromesally; forefemur/proboscis ratio 0.60-0.87 (mean 0.72); clypeus bare. *Thorax:* Acrostichal and dorsocentral setae absent; scutellum trilobed. *Wing:* Length 2.55-3.00 mm (mean 2.65 mm); no remigial setae; upper calypter with elongate hairlike scales; veins completely dark-scaled. *Halter:* Scabellum and pedicel pale; capitellum dark. *Legs:* Midfemur/forefemur ratio 1.03-1.25 (mean 1.12); fore- and midfemora mainly black-scaled, forefemur with narrow area of pale scales ventrobasally, midfemur with variable line of pale scales posteroventrally on proximal 0.5; hindfemur mainly white-scaled, with dark scales forming complete narrow band at base, extending along entire dorsal surface and distally spreading over anterior, posterior and ventral surfaces, covering 0.30-0.40 of anterior surface and 0.45-0.50 of posterior and ventral surfaces (dorsal dark scaling faint proximally in one specimen); tibiae and tarsi black-scaled. *Abdomen:* Terga IV-VII with medially interrupted or complete basal white bands. Sternum I with median white scale-patch; sterna II-VII each with basal white band.

Female. *Head:* Palpus/proboscis ratio 0.18-0.20 (mean 0.19). Antennal flagellar whorls with 5 or 6 short setae; antenna/proboscis ratio 0.88-0.93 (mean 0.91). Dorsal scales of vertex black, anteromedial area near eyes with silvery-white scales that continue laterally along ocular margin; lateral scaling pale, without anterior cluster of dark scales. *Thorax:* Anterior 0.5 of scutum white-scaled except in middle; posterior 0.5 with black scales, black scaling extends forward to anterior promontory as median longitudinal stripe that completely divides anterior white scaling; white scaling tapers posteriorly to level of midregion of paratergite. Scutellum black-scaled. *Legs:* Midfemur/forefemur ratio 0.91 (lengths measurable in only 1 specimen). *Abdomen:* Terga VI-VIII with basal white bands.

Male. *Head:* Antennal flagellar whorls with 20+ setae; antenna/proboscis ratio 0.58-0.82 (mean 0.66); palpus/

[1] The views of the authors do not purport to reflect the views of the Department of the Army or the Department of Defense.

[2] Department of Entomology, University of Maryland, College Park, MD 20742. Address for reprints: Walter Reed Biosystematics Unit, Museum Support Center, Smithsonian Institution, Washington, DC 20560.

[3] Professor Emeritus, Department of Entomology, North Carolina State University, Raleigh, NC 27650.

[4] Walter Reed Biosystematics Unit, Department of Entomology, Walter Reed Army Institute of Research, Washington, DC 20307-5100.

Table 1. Variation in number of setae in setal groups in adults of *Aedes (Finlaya) axitiosus.*

Setal group	Male	Female
Flagellar whorl	20+	5,6
Labial basal	3-5	4,5
Interocular	2	2
Ocular	6-8	4-8
Antepronotal	7-9	8-16
Postpronotal	4,5	5-7
Lateral anterior promontory	7,8	9,10
Median anterior promontory	none	none
Anterior scutal fossal	4,5	4-7
Lateral scutal fossal	none	none
Median scutal fossal	none	none
Posterior scutal fossal	none	none
Prescutellar	10-12	11-14
Supraparatergal	8-10	9,10
Antealar	10-12	12
Supraalar	7-11	12,13
Median scutellar	6	5,6
Lateral scutellar	5,6	4-6
Mesopostnotal	none	none
Upper proepisternal	5-8	11
Lower proepisternal	none	none
Postspiracular	5,6	4-7
Prealar	8-11	6-13
Upper mesokatepisternal	3	4
Median mesokatepisternal	2	2
Lower mesokatepisternal	2	3
Upper mesepimeral	5,6	7
Lower mesepimeral	none	none
Forecoxal	10,12	11
Midcoxal	6,7	6-8
Hindcoxal	10-12	11,12

proboscis ratio 0.80-0.93 (mean 0.86). Broad decumbent scales on vertex silvery white, erect scales dark. *Thorax:* Scutum silvery white-scaled with few dark scales on posterior 0.1 of dorsocentral and acrostichal areas; prescutellar area bordered with pale scales which in turn are bordered by dark scales along scutal margin; scutellum with silvery-white scales. *Legs:* Proboscis/forefemur ratio 1.16-1.67 (mean 1.35); midfemur/forefemur ratio 1.03-1.25 (mean 1.13). *Abdomen:* Terga IV-VIII with complete basal white bands. *Genitalia* (Fig. 1): Posterior margin of tergum VIII (ventral in position) emarginate in middle, with 19-23 setae, posterior margin of sternum VIII (dorsal in position) with 15-17 setae, both with elongate, spatulate scales; tergum IX lobes not prominent, each with 4-7 setae; sternum IX broad, shieldlike, with 7 or 8 setae. Gonocoxite (mesal aspect) length/width ratio 2.0-3.2 (mean 2.5), upper dorsomesal setae (uds) relatively short except for few at distal end, increasing in number and length from apex to base, forming prominent upper dorsal setal cluster (udsc) proximally; lower dorsomesal setae (lds) short and sparse in middle, much longer and denser distally, clustered proximally to form lower dorsomesal setal cluster (ldsc); mesal membrane (MM) minutely spiculate; upper ventromesal area poorly developed, with sparsely scattered setae on sclerotized margin, lower ventromesal area with prominent scale cluster (lvsc) and setae of various lengths at apex and base; basal ridge (br) nearly fully detached from lower dorsomesal area, elongate and narrow, bearing 2 setae at apex and 4 on proximal 0.5, basal ridge apodeme inconspicuous; apodeme of gonocoxite (AG) (="dorsal attachment of the gonocoxite" of Knight and Harrison, 1987) well developed; gonostylar claw/gonostylus ratio 0.66-0.80 (mean 0.72). Claspette filament/stem ratio 0.80-1.00 (mean 0.91), filament with distinct angular expansion on convex margin, narrowed distally and slightly hooked at tip; stem with 3 setae. Dorsoapical margin of aedeagus produced in middle with 3 or 4 short spicules on each side. Apex of paraproct undivided.

Pupa (Fig. 2). Character and positions of setae as figured; range and modal number of branches in Table 2. *Cephalothorax:* Lightly tanned, posterior area of scutum and metanotum moderately tanned. Seta 1-CT longer than 2,3-CT, 1,2-CT single, 3-CT single or double; 4-6-CT shorter than 7-CT, 4-CT with 2-4 branches, 5,6-CT single or double; 7-CT single to triple; 11-CT longer than 10,12-CT, aciculate, single; 12-CT with 2-4 branches arising from main stem. *Trumpet:* Dark; index 3.45-4.29 (mean 3.93); meatus/trumpet ratio 0.60-0.78 (mean 0.69). *Abdomen:* Lightly tanned, integument around bases of setae 3-6-II-VI (sometimes VII) distinctly darker. Seta 2-II lateral to seta 1, closely associated with seta 3, 2-III-VII mesal to seta 1; 3-III,V,VI closely associated with seta 1, anterior and only slightly lateral or mesal to this seta; 4,5-I of equal length, 4-I with 4-7 branches, 5-I double or triple; 3-II, III as long as following tergum, 3-IV-VII about 0.5 length of following tergum, all single; 5-IV,V long, twice length of following tergum, single, 5-VI,VII shorter than following tergum, 5-VI single, 5-VII single or double. *Paddle:* Lightly tanned; midrib dark, complete to apex; outer margin with minute spicules on distal 0.33-0.66, inner margin with similar spicules on distal 0.25; index 1.32-1.56 (mean 1.43). Seta 1-P single to triple, aciculate.

Larva (Fig. 3). Character and placement of setae as figured; range and modal number of branches in Table 3. *Head*: Wider than long, length 0.75-0.88 mm (mean 0.83 mm); moderately tanned, collar and dorsomentum heavily tanned; dorsomentum with 8-10 lateral teeth on either side of distinctly longer median tooth. Seta 1-C heavily pigmented, slightly bent mesad, bifurcate or trifurcate at tip; 2-C absent; 7-C anterolateral to 6-C. *Antenna:* Slender, gradually bent mesad, with sparse slender spicules on dorsal, lateral and ventral surfaces, mesal surface appar-

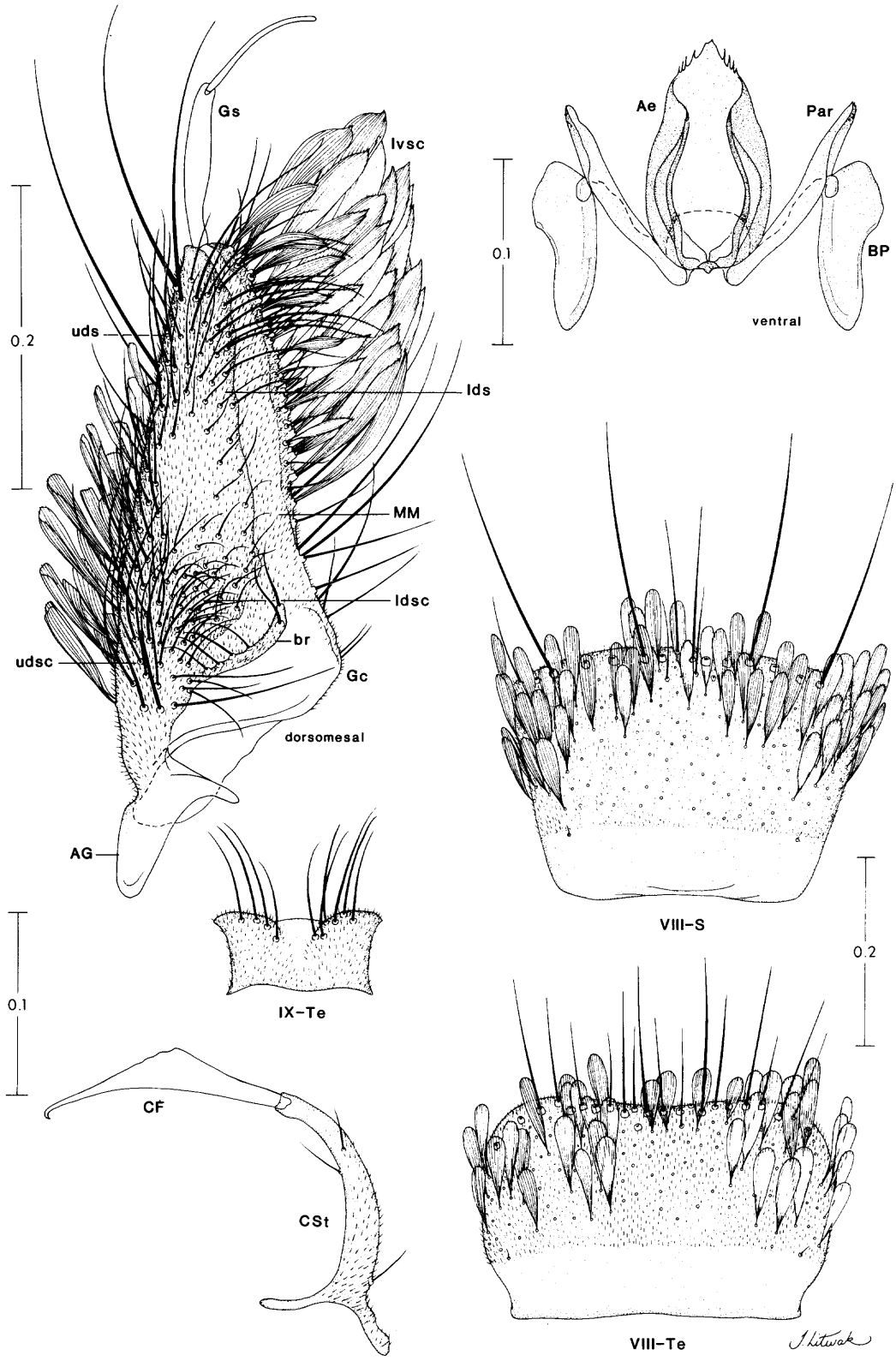

Fig 1. *Aedes (Finlaya) axitiosus.* Genitalia.

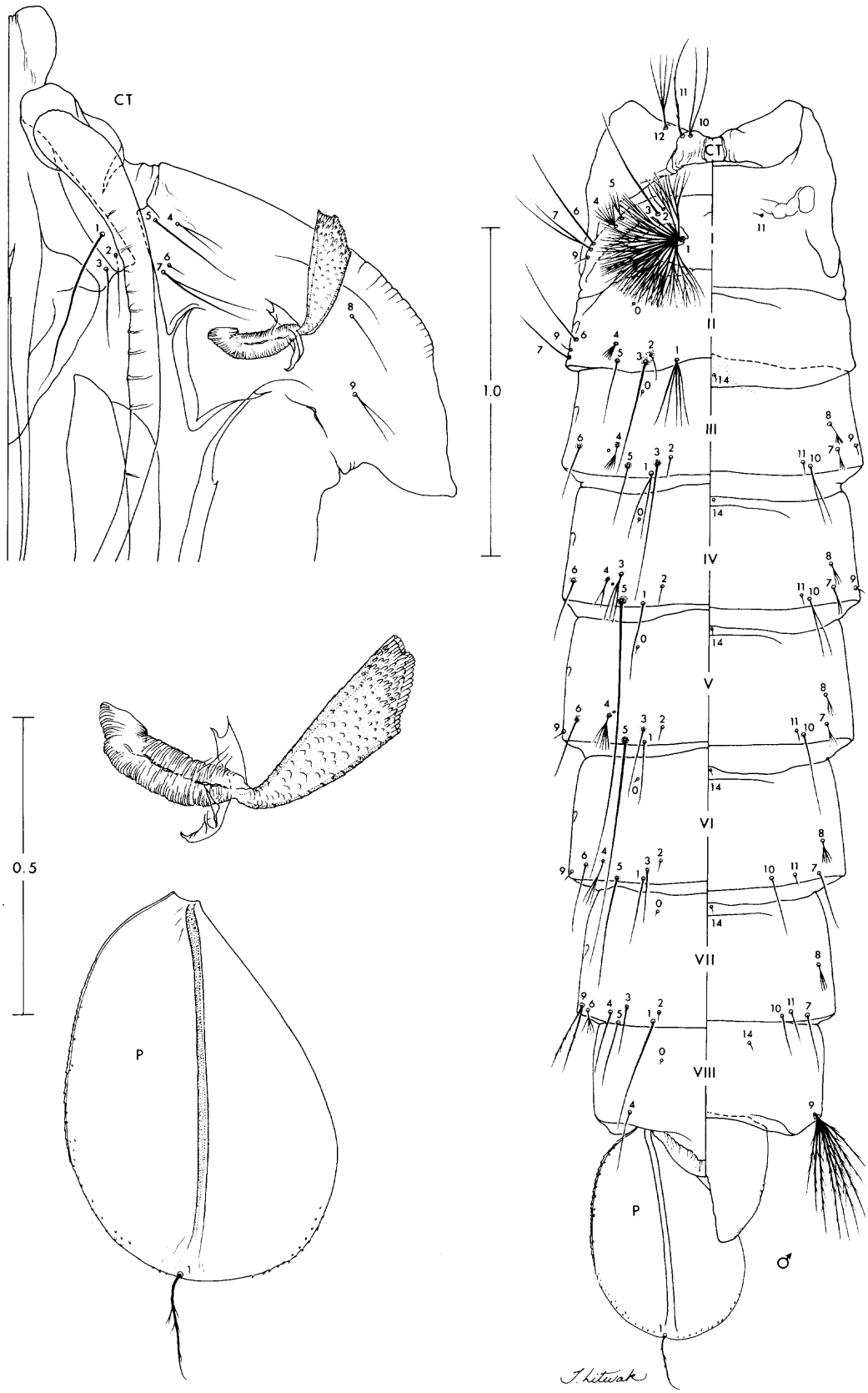

Fig. 2. *Aedes (Finlaya) axitiosus.* Pupa.

Table 2. Range and modal number of branches for pupal setae of *Aedes (Finlaya) axitiosus*.

Seta No.	Cephalothorax CT	Abdominal segments I	II	III	IV
0	-	-	1,2 (1)	1,2 (1)	1,2 (1)
1	1	15-19 (15,16)	3-8 (6)	1,2 (2)	1,2 (1)
2	1	1	1	1	1
3	1,2 (1)	1-3 (1)	1	1	2-5 (3)
4	2-4 (2)	4-7 (4,5)	2-5 (3)	3-7 (4)	1,2 (2)
5	1,2 (1)	2,3 (2,3)	1	1,2 (1)	1
6	1,2 (1)	1	1	1	1
7	1-3 (2)	1-3 (2)	1,2 (2)	1-4 (2)	1,2 (1)
8	1,2 (1)	-	-	2-6 (3)	2-4 (2)
9	1,2 (2)	1	1	1	1
10	2	-	-	1,2 (2)	2
11	1	2	-	1	1
12	2-4 (2)	-	-	-	-
13	-	-	-	-	-
14	-	-	-	1,2 (1)	1,2 (1)

Seta No.	Abdominal segments V	VI	VII	VIII	IX	Paddle P
0	1,2 (1)	1,2 (1)	1	1	-	-
1	1	1	1	-	-	1-6 (1)
2	1	1	1	-	-	-
3	1,2 (1)	1,2 (1)	1	-	-	-
4	5-7 (5)	2,3 (3)	1,2 (2)	1,2 (1)	-	-
5	1	1	1,2 (1)	-	-	-
6	1	1,2 (1)	2-5 (2)	-	-	-
7	2-7 (2)	1	1,2 (1)	-	-	-
8	2-4 (3)	3-6 (4)	1-3 (2)	-	-	-
9	1,2 (1)	1	2-4 (2)	5-10 (9)	-	-
10	1	1	1	-	-	-
11	1	1	1	-	-	-
12	-	-	-	-	-	-
13	-	-	-	-	-	-
14	1,2 (1)	1	1	1	-	-

ently without spicules. Seta 1-A 0.38-0.44 (mean 0.43) from base of antenna, with 8-11 branches; 2,3-A subapical, length of 2-A 0.35-0.44 (mean 0.40) length of antenna. *Thorax:* Lightly tanned, not spiculate. *Abdomen:* Lightly tanned, not spiculate. Seta 1-I-IV progressively longer on each succeeding segment, 1-V about same length as 1-IV; 6- I,II nearly as long as 6-III-VI, 6-II,VI double, 6-III-V double or triple; 13-III-V well developed, about as long as 1-IV,V. *Segment VIII:* Comb with 18-41 (mode 27) short, evenly fringed scales. *Siphon:* Moderately tanned, no spicules visible at 400x, integument with short transverse lines most visible basally; index 2.14-2.56 (mean 2.29); acus weakly developed, irregularly shaped, narrowly attached. Pecten on basal 0.4 of siphon, with 7-14 spines; spines increasing in size from base of siphon, each usually with a distinct denticle near midlength of ventral margin and several very fine denticles or spicules proximal to it. Seta 1-S with 4-6 (mode 6) aciculate branches, length about 1.3 width of siphon at point of attachment; distance from base of siphon/siphon length 0.36-0.46 (mean 0.42). *Segment X:* Saddle incomplete; moderately tanned; integument with short transverse lines bearing minute spicules, dorsocaudal margin with clusters of short multifid spicules, longer spicules borne dorsolaterally on posterior margin. Seta 1-X slightly shorter than dorsal length of saddle, single or double; setae of ventral brush (4-X) with 3-6 branches.

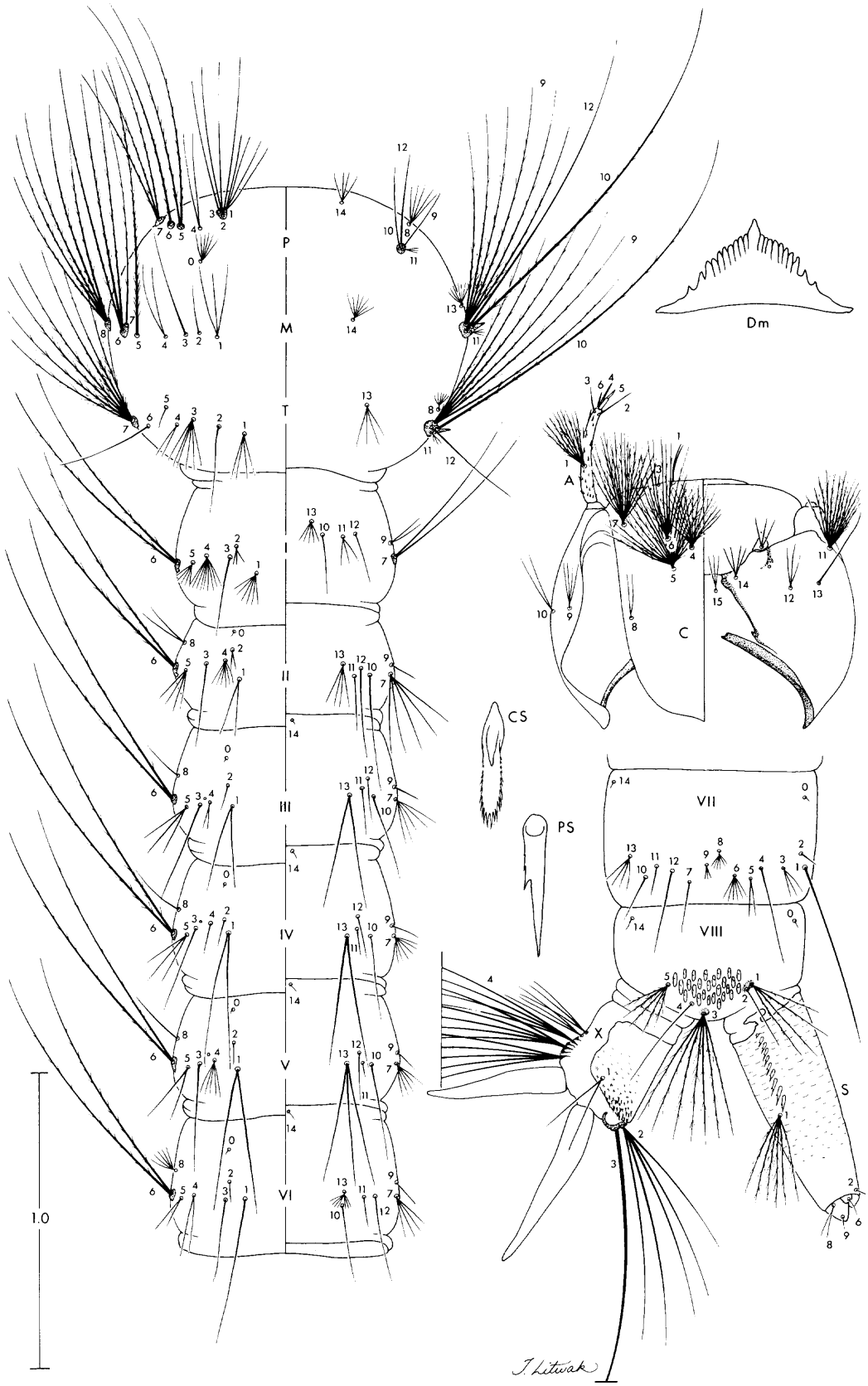

Fig. 3. *Aedes (Finlaya) axitiosus.* Larva.

Table 3. Range and modal number of branches for fourth-instar larval setae of *Aedes (Finlaya) axitiosus.*

Seta No.	Head	Thorax			Abdominal segments		
	C	P	M	T	I	II	III
0	1,2 (1)	5-8 (6)	-	-	-	1	1
1	1*	3-7 (4)	2-4 (3)	2-4 (3)	4-8 (5)	1-4 (2)	1-3 (3)
2	-	3-5 (3)	1	1	2-4 (3)	1,2 (1)	1,2 (1)
3	1	1,2 (1)	1	4-8 (6)	1,2 (1)	1,2 (1)	1
4	10-13 (12,13)	2	2	2	6-9 (7)	4-7 (5)	1-3 (2)
5	11-18 (17)	2,3 (2)	1	1,2 (1)	3-5 (3)	3,4 (3)	2-5 (3)
6	9-12 (10)	1	2,3 (3)	1,2 (1)	2,3 (2)	2	2,3 (2)
7	11-16 (14)	3-5 (4)	1	6-10 (9)	2	3-7 (4)	4-8 (5,7)
8	2,3 (2)	3-7 (6)	5-9 (7)	6-8 (8)	-	2	1
9	2-5 (3)	1,2 (1)	5-8 (7)	5,6 (5)	2-4 (2)	1,2 (1)	1
10	2,3 (2)	1	1	1	1	1	1
11	12-17 (14)	1-4 (3)	2-4 (2)	2-4 (2)	2-5 (3)	1	1,2 (1)
12	3,4 (3)	1	1	1	1,2 (1)	1	1
13	1	-	6-10 (6,7)	2-5 (3,4)	3-5 (5)	2-5 (5)	2-4 (3)
14	2-4 (3)	3,4 (4)	5-7 (7)	-	-	-	1
15	2,3 (3)	-	-	-	-	-	-

Seta No.	Abdominal segments					
	IV	V	VI	VII	VIII	X
0	1	1	1	1	1	-
1	1-3 (2)	1,2 (2)	1	1	2-5 (5)	1,2 (2)
2	1	1	1	1	1	4,5 (4)
3	1	1	1	2-4 (3)	6-8 (8)	1
4	1,2 (1)	4,5 (5)	1,2 (2)	1	1	3-5
5	2,3 (3)	2,3 (2,3)	2,3 (2)	2	3-5 (3,4)	-
6	2,3 (2)	2,3 (2)	2	5-7 (7)	-	-
7	4-8 (6)	4-6 (5)	3,4 (4)	1	-	-
8	1,2 (1)	1	3-8 (3,4)	5-9 (6)	1-S,	4-6 (6)
9	1	1	1	2,3 (2,3)	-	-
10	1	1	1	1	-	-
11	1	1	1	1	-	-
12	1	1	1	1	-	-
13	2-4 (3)	2-4 (2,3)	7-10 (8)	3-5 (4)	-	-
14	1	1	1	1	1	-
15	-	-	-	-	-	-

*Bifurcate or trifurcate at tip.

Type data. The type series includes 4 males and 2 females with the following collection data: MALAYSIA, Sabah, Tenom, Rayoh, tree hole, 45.7 m, 10 April 1970, Sulaiman and Chia. Each specimen has associated larval and pupal exuviae and the males have the genitalia dissected and mounted on slides. The specimens are identified with the following collection numbers: S-472-15 (holotype male); S-472-12, S- 472-14, and S-472-16 (paratype males); S-473-18 and S-473-19 (paratype females). The series is deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC.

Etymology. *Aedes axitiosus* -- L. *axitiosus*, acting together, in combination: so named for the harmonious, serial efforts of the authors which resulted in the recognition, study, and description of this new species.

Bionomics. Like other members of the Niveus Subgroup, *axitiosus* is a phytotelmic species. It was collected from tree holes in association with *Ae. (Scutomyia) albolineatus*

(Theobald), *Ae. (Stg.) albopictus* (Skuse), *Culex (Lophoceraomyia) mammilifer* (Leicester), *Cx. (Lop.) minor* (Leicester), *Uranotaenia (Pseudoficalbia) bicolor* Leicester, and another, unidentified species of *Uranotaenia.* Nothing is known about the bionomics of the adults.

Systematics. Further study of the Niveus Subgroup will undoubtedly result in the recognition of additional new species. Presently 26 species and two subspecies are included in the group. Females of *axitiosus* resemble four of these species in having the scutal pale area completely divided by dark scales. These species include *inermis* Colless from Singapore and West Malaysia, *ganapathi* Colless from West Malaysia, *mohani* Knight from India, and *nishikawai* Tanaka, Mizusawa and Saugstad from the Ryukyu Archipelago of Japan. Based on the structure of the male genitalia, *axitiosus* appears to be most closely related to *inermis*. The apex of the aedeagus of these two species is developed quite differently than that of any other species in the Niveus Subgroup. *Aedes axitiosus* differs from *inermis* in the following features: (1) in the adults, presence of pale scales on the prescutellar area; (2) in the male genitalia, basal ridge attached instead of detached and claspette filament much less expanded on convex margin; and (3) in the larva, comb scales evenly fringed at sides and apex instead of spinelike with pointed apex and fine fringe at sides. The pupa of *inermis* has not been described.

Of the four species listed above, only *inermis* and *ganapathi* may possibly occur in sympatry with *axitiosus*. Adults of *ganapathi* are easily distinguished from those of *axitiosus* by the absence of both prealar scales and pale scales on the prescutellar area. Larvae of *ganapathi* resemble *inermis* in the structure of the comb scales and are readily distinguished from larvae of *axitiosus* on the basis of this character. The pupa of *ganapathi* is also undescribed.

Besides *axitiosus*, only three other species of the Niveus Subgroup are known to occur on the island of Borneo (Colless, 1958). These include *alboniveus* Barraud, *pexus* Colless, and *pseudoniveus* (Theobald). The adults of these species differ from *axitiosus* in having dark scales on the prescutellar area, and both *pexus* and *pseudoniveus* also lack prealar scales. Females of *axitiosus* are immediately recognizable by the completely divided scutal pale area and males by the distinctive genitalia. The larva of *axitiosus* seems to be unique among these species with regard to the development of the comb scales. The comb scales are spinelike in *alboniveus, pexus,* and *pseudoniveus,* as they are in *inermis* and *ganapathi*. The pupal stages of these species are also unknown.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to Bruce Harrison, John Reinert and Ronald Ward for making suggestions and comments on the manuscript; to Taina Litwak for preparing the illustrations; and to James Pecor for typing the text and tables.

REFERENCES CITED

Colless, D.H. 1958. Notes on the culicine mosquitoes of Singapore IV. -- The *Aedes niveus* subgroup (Diptera, Culicidae): Introduction and description of five new species and of one new subspecies. Ann. Trop. Med. Parasitol. 52:468-483.

Colless, D.H. 1959. Notes on the culicine mosquitoes of Singapore V. -- The *Aedes niveus* subgroup (Diptera, Culicidae): Previously described species and keys to adults and larvae. Ann. Trop. Med. Parasitol. 53:166-179.

Gould, D.J., C.L. Bailey and S. Vongpradist. 1982. Implication of forest mosquitoes in the transmission of *Wuchereria bancrofti* in Thailand. Mosq. News 42:560-564.

Harbach, R.E. and K.L. Knight. 1980. Taxonomists' glossary of mosquito anatomy. Plexus Publishing, Inc., Marlton, NJ. 415 pp.

Harbach, R.E. and K.L. Knight. 1982. Corrections and additions to *Taxonomists' glossary of mosquito anatomy.* Mosq. Syst. (1981) 13:201-217.

Knight, K.L. and B.A. Harrison. 1987. A new *Aedes (Finlaya)* of the niveus-subgroup (Diptera: Culicidae). Mosq. Syst. 19:212-236.

Rozeboom, L.E. and B.D. Cabrera. 1964. Filariasis in Mountain Province, Luzon, Republic of the Philippines. J. Med. Entomol. 1:18-28.

Rudnick, A. 1986. Dengue virus ecology in Malaysia, pp. 51-153. *In:* A. Rudnick and T. W. Lim (Eds.), Dengue Fever Studies in Malaysia. The Institute for Medical Research, Kuala Lumpur, Malaysia. Bulletin No. 23:xi + 241 pp.