1960

Malaysian Parasites XXXV-XLIX

W. W. Macdonald
Institute for Medical Research, Malaysia

STUDIES
from the
INSTITUTE FOR MEDICAL RESEARCH
FEDERATION OF MALAYA
No. 29

MALAYSIAN PARASITES

XXXV–XLIX

EDITED
BY
W. W. MACDONALD

1960

PRINTED AT THE GOVERNMENT PRESS
BY B. T. FUDGE, GOVERNMENT PRINTER
FEDERATION OF MALAYA
1960

Survey Dept., Federation of Malaya No. 160 - 1959

Studies from the Institute for Medical Research are official publications of the Government of the Federation of Malaya, and are published at irregular intervals.

The three volumes on Malaysian Parasites form Nos. 26, 28 and 29 in the series of *Studies* from the Institute for Medical Research. They may be purchased from

The Librarian, Institute for Medical Research,
Kuala Lumpur, Federation of Malaya.

Study No. 26 (1953, issued 1954), Malaysian Parasites I-XV
$M9, £1.1.0 sterling, $US3

Study No. 28 (1957), Malaysian Parasites XVI-XXXIV
$M18, £2.2.0 sterling, $US6

Study No. 29 (1960), Malaysian Parasites XXXV-XLIX
$M9, £1.1.0 sterling, $US3

PREFACE

This is the third *Study* of the series from this Institute on the external and internal parasites and the biting insects of the Malaysian region. The earlier two volumes were planned and edited by Dr J. R. Audy, and on his departure from Malaya in the middle of 1959 Mr W. W. Macdonald continued the work which had been begun and collated and edited the papers in this present *Study*.

In the two previous volumes (*Study* No. 26, 1954 and No. 28, 1957) the emphasis was on the taxonomy of Trombiculid mites. In the present volume the emphasis has changed, and mites are only considered in a few short papers which clarify or complete earlier work. Other parasites must now be considered, and the papers by Dr C. B. Philip on Tabanidae, or horse-flies, are, therefore, particularly welcome for these insects have been little studied in Malaya. More space has also been given to mosquitoes and ticks, and it is hoped that the wider scope will increase the interest and value of the series.

Like its predecessors, this volume illustrates the close links between this Institute and the workers in other countries. There is such a wide range of subjects to be investigated in Malaya that we welcome the collaboration of overseas colleagues. We are glad to acknowledge their assistance, and their contributions to the taxonomy of many groups of parasites have helped to pave the way for future research. Special mention must be made of the close liaison with the United States Army Medical Research Unit (Malaya) stationed at this Institute. This liaison has proved very fruitful, and several of the contributors to this volume are former members of that Unit. In addition, there has been continued collaboration with the Department of Parasitology, University of Malaya, the Queensland Institute of Medical Research, the Rocky Mountain Laboratory, Montana, as well as with a number of other Institutes.

Almost all the material on which the *Study* is based has been collected by the staff of the Division of Medical Zoology, the Division of Entomology, and the United States Army Medical Research Unit. Some of the collectors are mentioned by name in the text, but there are many others whose efforts have contributed to a greater or lesser degree, and it is fitting that they should not go unacknowledged.

KUALA LUMPUR
June, 1960

A. T. H. Marsden
DIRECTOR

CONTENTS

MALAYSIAN PARASITES XXXV-XLIX

LIST OF CONTRIBUTORS

J. R. AUDY, PH.D., M.B., B.S., Director, The George Williams Hooper Foundation for Medical Research, Professor of Tropical Medicine and Human Ecology, University of California Medical Center, San Francisco, U.S.A.

EDWARD W. BAKER, PH.D., Entomology Research Division, A.R.S., U.S. Department of Agriculture, Washington, D.C., U.S.A.

CHEONG CHEE HOCK, Department of Parasitology, Faculty of Medicine, University of Malaya, Singapore.

ROBERT DOMROW, B.A., B.SC., Queensland Institute of Medical Research, Brisbane, Australia.

HUGH L. KEEGAN, Lt. Colonel MSC., PH.D., M.S., Army Medical Service School, Brooke Army Medical Center, Fort Sam Houston, Texas, U.S.A.

LIM BOO LIAT, Division of Medical Zoology, Institute for Medical Research, Kuala Lumpur, Malaya.

W. W. MACDONALD, B.SC., Division of Entomology, Institute for Medical Research, Kuala Lumpur, Malaya.

M. NADCHATRAM, Division of Medical Zoology, Institute for Medical Research, Kuala Lumpur, Malaya.

CORNELIUS B. PHILIP, PH.D., SC.D. (hon.), M.S., B.S., Assistant Director, Rocky Mountain Laboratory, National Institutes of Health, Hamilton, Montana, U.S.A.

JOHN F. SCHACHER, M.S., Department of Tropical Medicine and Public Health, Tulane University School of Medicine, New Orleans, U.S.A.

ROBERT TRAUB, Lt. Colonel MSC., PH.D., M.S., B.S., U.S. Army Medical Research and Development Command, Office of the Surgeon General, Washington, D.C., U.S.A.

CONRAD E. YUNKER, PH.D., M.S., B.S., U.S. Public Health Service, Middle America Research Unit, Balboa Heights, Canal Zone; *and* Rocky Mountain Laboratory, Hamilton, Montana, U.S.A.

MALAYSIAN PARASITES XXXV

DESCRIPTIONS OF SOME TABANIDAE (DIPTERA) FROM THE FAR EAST

BY

CORNELIUS B. PHILIP*

Rocky Mountain Laboratory, Hamilton, Montana

The present report provides new systematic information on some horseflies and deerflies of the Far East and also furnishes descriptions of a number of new species. Emphasis is placed on those species from Malaysia for purposes of listing and keying in the next paper of this *Study* (Philip, 1960), which covers Malaya, Borneo, and Thailand. Also included are two new species from New Guinea together with several from areas adjacent to Thailand. Systematic assignments follow Oldroyd (1947, 1949) and Mackerras (*see* Philip, 1957). Pertinent literature, economic aspects, and distribution are also discussed in the next report, as well as acknowledgments for materials and assistance unless indicated in the present text.

The location of types and other specimens is indicated by the following abbreviations: British Museum (Natural History), BMNH; United States National Museum (USNM); Chicago Natural History Museum (CNHM); American Museum of Natural History (AMNH); and collections of L. L. Pechuman (LLP) and the author (CBP).

The text includes descriptions of 37 new species and 2 new subspecies in five genera, together with some nomenclatural changes.

SYSTEMATIC TREATMENT

Subfamily CHRYSOPINAE

Tribe RHINOMYZINI

Rhinomyza cincta n. sp. (Fig. 1)

A distinctively marked, medium-sized, reddish-brown species; abdomen black, attenuated, with basal ring which is contrasting orange above and enameled white beneath; large, round, creamy white mesanepisternal lobe in front of wing base, wing with one prominent crescentic band from hind wing margin below the stigma to apex; and legs unicolorous dark brownish black, black-haired.

Description (holotype ♀).—Length, 16 mm. Frons pearlaceous to smoky gray pollinose in different lights, moderately widened below, index 1: 2.7, vertex raised, subshiny black, three ocelli on a black tubercle below the vertex, a wrinkled, cordiform, basal, black callosity widely separated from the ocular margins, prolonged above into a narrow, indefinite line almost to the anterior ocellus. Subcallus rather small, brown, with lateral gray pollinosity and deep median sulcus. Face swollen, shiny brown, parafacials and cheeks sparsely brown pollinose, beard very sparse, brown. Antennae reddish-brown, style darker; scape half again longer than thick, cylindrical, plate biramous, the thumb slender, reaching end of plate. Palpi robust, dark-brown with black hairs, laterally compressed and nearly reaching tip of proboscis. Labella reddish-brown, a little less than half the total length of the proboscis.

Notum and chest peculiarly pale brown, the former with two submedian, narrow, dark-brown lines; the lateral margins, a posterior quadrate spot, and the scutellum dark-brown. The round mesanepisternal lobe and margins of prothoracic spiracle chalky white with sparse pale hairs; remaining vestiture

* From the U.S. Department of Health, Education, and Welfare, Public Health Service, National Institutes of Health, National Institute of Allergy and Infectious Diseases, Rocky Mountain Laboratory, Hamilton, Montana.

sparse, brown. No hind tibial fringe, but two small spurs evident. Wings yellow on the disc with ill-defined dark shadows in the middle of the basal cells; subapex widely hyaline; median dark-brown band not quite as wide as the middle of the discal and M_1 cells, arching forward along the costa to widen in the apex of cell R_4. Halteres pale yellow.

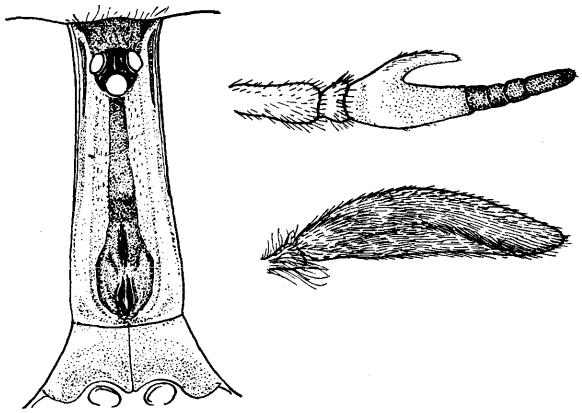


Fig. 1. *Rhinomyza cincta* n. sp.
Front, antenna, and palp

Abdomen with a very narrow whitish ring at base of segment 3 and of tergite 2, in addition to the basal ring described, a patch of blackish hairs beneath the scutellum on tergite 1. The basal white ring below occupies sternite 1 and anterior third of sternite 2. Tip attenuated, ovipositor-like.

Type Material.—Holotype ♀, Malaya, Selangor, Kuala Lumpur, 1950, U.S. Army Scrub Typhus Unit. In USNM.

Remarks.—This species is so close to the female of *R. fusca* as to suggest very recent derivation from common ancestry. The gray frons with more definite callosity, predominantly though sparsely black-haired notum, the more crescentic wing band from hind margin to apex of wing where it expands into cell R_4, and the chalk-white upper pleural lobes and all abdominal bands except for the bright yellow tergite 1, will distinguish it from *R. fusca*.

Tribe CHRYSOPINI

Chrysops fasciata Wiedemann

1821, *Chrysops fasciata* Wiedemann, *Dipt. exot., 1:* 103. (Syntype ♂, ♀, Java; Univ. Copenhagen Mus.› seen in 1953).

1847, *Chrysops rufitarsis* Macquart, *Dipt. exot.*, Suppl. iii, p. 174. (♂, Java).

There is such remarkable sexual dichromatism here that there is little wonder that Ricardo (1911*b*) overlooked the fact that Macquart had redescribed the male already correctly associated by Wiedemann. In addition to the type males above, Schuurmans Stekhoven (1926) records one male from Burma and two others from the east coast of Sumatra, as well as females from Assam, Malaya, N. Borneo, Sumatra, and Java. To be added is a male from Thailand (Chiengmai, 1952, *D.C.* and *E.B. Thurman*) and another female from Malaya (Kedah Peak, 3000′, 8. iii. 1928, BMNH).

I have seen Wiedemann's syntypes (♂, ♀) from "Batavia" (Java) in the Copenhagen Collection (both are in good condition), but did not find the type of *rufitarsis* in Macquart's collection in Paris, which is said to be in "Monsieur Payen's collection." No other female has been described which would better agree with the few available males, but it appears essential to establish the female syntype as lectotype to avoid any future, unforeseen confusion.

While the wing patterns of the two sexes agree, the general color of the facial pollinosity, legs, and abdomen of the female is yellow and brown, with a narrow, blackish band only across the incisure of tergite 2. These parts in the male are gray, black and white, with abdominal segments 2 and 3 entirely white except for a small antero-median black spot on sternite 2. The Thailand male also has the two basal segments of the antennae proportionately longer than has a female from Java which is available for comparison.

Chrysops indiana thailandensis n. ssp.

A robust, dark species with elongated antennae, very swollen tibiae, broad wing band, and yellow second abdominal segment with heavy inverted black v-shaped maculation, the lateral arms of which reach the outer hind corners of the tergite and continue on tergite 3.

It is related to *C. translucens* Macquart, but the crossband is wider, the tibiae more swollen, and last three tergites reddish-brown.

Description (holotype ♀).—Length, 10 mm. Frons taller than broad, buff gray pollinose across the middle, a large black callus bearing the ocelli across the vertex, and a large, black, ovoid, basal callosity barely separated from the eyes. Face protuberant, shining, black with narrow, attenuated, median, and two lateral, gray-buff pollinose stripes. Antennae nearly as long as thorax, two basal segments slender, brownish, the flagellum thicker and black. Palpi brown.

Thorax subshiny black without lines, scutellum dark-brown, with dorsal and pleural sparse, yellowish hairs and thick marginal patches of golden hairs. Legs reddish-brown, the tibiae black and unusually incrassate. Wings with costal border brown to the apex, the apical spot just wider than cell R_1, but not widened distally, the cross band wider than discal cell with outer margin straight from outer end of stigma to lower corner of cell M_2, and including all of the discal, cubital and M_3 cells plus the apex of the anal, no hyaline sinus in cubital cell; basal fourth of first basal cell, and less of second, infuscated also. Halteres blackish brown.

Abdomen with tergites 1 and 4 to 6, plus incisure of 3, reddish, with heavy, black, incisural bands on 1, 5, and 6, and black lateral margins on 4 to 6. Tergite 2 pale yellow with heavy, geminate black spot, the apex not reaching the anterior margin, tapering evenly to the outer hind corners, and enclosing a rather small, median, upwardly-pointed, yellow spot which continues backwards across tergite 3 as a widening yellow stripe. Sides of the last, except for reddish incisure, black as a continuation of the figure on tergite 2. Venter with first two sternites bright yellow, the remainder black, except for small, indefinite, brownish spots on the sides of sternites 4 and 5.

Type Material.—Holotype ♀, Thailand, Chiengmai, 4-10. v. 1952 (*D.C.* and *E.B. Thurman*), no. 630c. In USNM.

Remarks.—This was at first considered specifically distinct from the inadequately described female of *C. indiana* Ricardo from Khasi Hills, India, and only additional material can decide if the present decision that this is a melanistic variant is correct. Though Miss Ricardo hardly described and did not figure the wing, I suspect that her figure of *C. fasciata* with the crossband apical spot too wide for that species, is actually her *indiana*. If so, it differs from *thailandensis* in the wider, more diffuse, apical spot, and in the more extensive infuscation in the two basal cells.

Typical *indiana* differs from the above subspecies in the yellow face, paler antennae, legs and abdominal pattern, inverted V continuing on the third tergite only faintly, and the venter entirely yellow except for three faint brown stripes on the third sternite.

Chrysops stekhoveni n. sp.

A rather small deerfly with dark thorax and contrasting scutellum which is yellow basally, reddish apically; face yellow in the middle; second antennal segment markedly shorter than the first; tibiae swollen.

The abdominal pattern might be considered a variation of that of *C. fixissima* Walker and the wing pattern of that of *C. fasciata* Wiedemann, but the yellow face, and the scape

obviously longer than the pedicel, will distinguish this from either of those species. Compared to *C. signifer* Wlk., the front is conspicuously convergent above, the callosity is smaller and separated from the eye margins, and the scape is not as long as the front is tall when measured from the corners of the eyes to the vertex. In *C. signifer*, the latter measurements are equal.

Description (holotype ♀).—Length, 8 mm. The eye pattern could not be satisfactorily revived. Front taller than broad, convergent above, golden-yellow pollinose in the middle; a black, bare, tuberculate area across the vertex surrounding the ocelli; and a prominent, black, ovoid, basal callosity, broader than tall, and distinctly separated from the eyes. Area around antennal fossae, and midface between the lateral sutures, yellow with a broad, median stripe of yellow pollen two-thirds of the distance to the oral margins. An extension of yellow pollen along the eye margins is produced forward to the oral margin, and encloses a small, bare, dark-brownish spot outside the sutures. Cheeks bare, black with golden-yellow hairs. Antennae slender, the first two segments brown, little paler basally (flagellum missing), scape longer than pedicel as 3.0:2.5; pedicel with six pseudo-annulations. Palpi yellow with a brown lateral shadow.

Notum and scutellum black (probably discolored) with sparse, yellow hairs, the antealar tubercles contrasting bright reddish-yellow and with remnants of golden-yellow hair. Other remnants in front of the spiracles, underneath the wing bases, and across the prescutellar margin, suggest there may have been a distribution resembling that of *C. signifer*. Pleura dark with tufts of golden-yellow hair on the proepimeron. Coxae, fore and mid femora, and basal three-fourths of the hind femora, reddish, remainder of legs dark-brown, black-haired with some yellow hairs toward the coxae. Wings very much as in *C. fasciata*, the two basal and anal cells predominantly hyaline, the broad crossband a little wider than the discal cell, and widened to the margin to include cell M_3, the cubital cell and across the apex of the anal cell, the outer margin concave, the apical spot wider than cell R_1 and with a smoky rather than sharp hind margin, the hyaline triangle only slightly tinted. Halteres brown.

Abdomen basally bright yellow above and entirely so below; a pair of ovoid, smoky shadows behind the antero-lateral angles of the scutellum and not touching either margin of tergite 1; a black, almost mesally divided, transverse band on the hind margin of tergite 2, not more than one-third the width of the tergite on either side, and with indefinite, anterior, sinuous margin and corresponding yellow and black hairs; tergite 3 reddish on the basal half grading to dark-brown on the hind margin, black-haired; tergites 4 to 7 reddish with orange tints, black-haired, no median spots; the black, transverse band on tergite 2 tapers out just at the lateral margin, otherwise no black lateral markings. Venter with orange tinting posteriorly, entirely yellow-haired.

Type Material.—Holotype ♀, Borneo, E. Kalimantan Dist., Nunukan Is., xi. 1953 (*R. von Hentig*). In CNHM.

Remarks.—Unfortunately, this specimen is somewhat worn and its antennae are broken. Nevertheless, the characters are sufficiently distinctive from those of related East Indian species to make the specimen recognizable as previously undescribed.

Named for Dr. J. H. Schuurmans Stekhoven, Jr., whose comprehensive monograph (1926) is a major contribution to knowledge of tabanids of the Dutch East Indian Archipelago.

Chrysops translucens Macquart

1838, *Chrysops translucens* Macquart, *Dipt. exot., 1:* 158.

A well-preserved specimen from Malaya (Selangor, 9. v. 1948, *C. B. Philip*) permits the following additional characterization. The eye pattern could not be revived satisfactorily but appears to be a heavy one with the bilobed frontal spot broadly connected to the arrowhead, the occipital border rather narrow and contiguous to the eye margin, as are also the upper and lower frontal spots.

Description.—Front taller than broad. Midface with a short triangle of yellow-brown pollen below the antennae. Vestiture of entire body sparse over subshiny integument. Four dense patches of golden pile on the sides of the thorax, two in front of, and two below, each wing base. Notum with inconspicuous, short, silvery hairs plus a sparse, transverse, prescutellar row of the same. All tibiae more swollen than the femora, the last pair the least. Crossband of wing equal in width to the discal cell, serrated on its inner side, and strongly convex on the outer, widened behind to envelop the M_3, cubital and tip of the

anal cells, the cubital cell with a pale center. Apical spot at its juncture with the crossband just wider than cell R_1 and continued without widening to the apex of the wing. Abdominal pattern as described, but the narrow, black, lateral extensions of the second segment are on the rolled-under margins of the tergite, not the sternite, and do not connect with the black on the first tergite. The sixth, and to a lesser extent the fifth, segment with pale hairs.

Subfamily TABANINAE

Tribe DIACHLORINI

Cydistomyia mackerrasi n. sp. (Fig. 2)

A small, delicate, black and yellow-banded species with unusually long, slightly tinted wings which belongs to the *basalis*-group of Schuurmans Stekhoven (1926) from Java and Sumatra. This new species differs from the others in having less extensive yellow basally on the abdomen, the second tergite either predominantly black in the female, or with a wide black band in the male, the scutellum dark-brown in contrast to the yellow notum, the front in the female with a small but prominent tubercle at the vertex and reduced callosity, and the male without an occipital margin of small facets behind the large ones.

There appear to be no close relatives among New Guinea species reviewed by Oldroyd (1949). Superficially this must resemble *Chasmiella parvicallosa* Oldroyd, which has smaller labella and more distinct callosity.

Description (holotype ♀).—Length, 9 mm., wings, 10 mm. Eyes bare, black, unbanded (relaxed). Front buff pollinose with parallel sides, index 1:5.2; vertex slightly concave with a small brown tubercle and suggestion of a vestigial anterior ocellus; basal callosity represented by a narrow, semi-bare, yellow, median ridge. Subcallus, face, and cheeks buff pollinose, beard short and brown. Two basal antennal segments pale yellow, the first with pale yellow and a few black hairs, the second black-haired, neither produced dorsally. Plate reddish, about a third longer than wide but equal to the darker annuli in length, the basal angle low and obtuse, and as wide at base as the front. Palpi pale yellow, long and slender, black-haired. Labella brown, fleshy, longer than the yellow theca.

Thorax yellow, the scutellum contrasting dark-brown, with suggestions of two sublateral, brown lines. Pleura, chest, and fore and mid coxae yellow-haired, hind coxae blackish-haired. Femora reddish, the fore and hind pairs darker apically, with blackish hairs and some yellow ones basally on the fore and mid pairs. Tibiae and tarsi brown with black hairs. Wings lightly tinted but without apical shadows. Cell R_5 wide open; no spur veins; tegulae smoky. Subepaulets orange, bare. Halteres brown, knobs paler.

Abdomen yellow on the first tergite and on extreme bases of the second and third, and on all of the first three sternites, the remainder black; the incisures above and below on the last three segments very narrowly yellow with wider fringes of yellow hairs. Vestiture otherwise concolorous with underlying integument, black hairs on most of yellow sternites and on the narrow, basal ring on tergite 3.

Allotype ♂.—Length, 7 mm., wing, 9 mm. Area of enlarged facets in about upper two-thirds of eyes and rolled over the occipital margin behind, and the small facets tapering out behind about half-way to vertex. A patch of black hairs and a small, compressed, brown tubercle below eye level at the vertex. Face yellow and sunken below the cheeks, the hairs on the upper portion yellow, those below, including beard, brown. Palpi short, ovoid. Labella longer than theca, as in female. Thorax better preserved than in holotype with three longitudinal, brown streaks not reaching the hind margin of the notum, nor the middle one to the front margin; vestiture, including the scutellum, brown with some marginal yellow hairs on the notum. Abdomen short, compact, but little longer than the thorax. Hind margin of tergite 2 with a broad, yellow incisure leaving a wide dark band across the middle of the tergite. Otherwise like the female and readily associated.

Type Material.—Holotype ♀, Dutch New Guinea, Hollandia, 19. x. 1944 (*C.B. Philip*). In rather deep shade of rain forest. Presented to Queensland Institute of Medical Research, Brisbane, Australia. Allotype ♂, Papua (British New Guinea), "xi-xii, 1944." (*B. Struck*). In AMNH.

Remarks.—It is a pleasure to dedicate this attractive species to Dr I. M. Mackerras, Director of the Queensland Institute of Medical Research, who is making major contributions to clarification of systematic relationships not only of species in the region, but in supra-generic taxa of the world as well (*see* Philip, 1957).

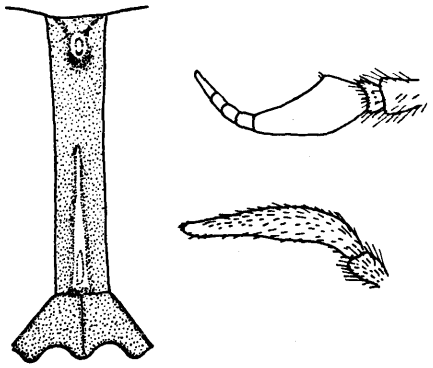


Fig. 2. *Cydistomyia mackerrasi* n. sp.

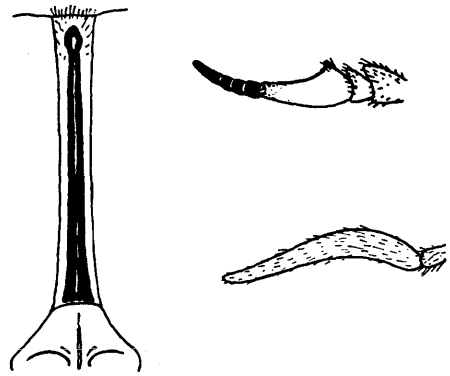


Fig. 3. *Cydistomyia rozeboomi* n. sp.
Front, antenna, and palp

Cydistomyia rozeboomi n. sp. (Fig. 3)

A rather small, slender species of uniform red-brown appearance, darker caudally; narrow front with long keel hardly expanded basally; palpi slender; femora yellow, and tibiae brownish.

The females have characters very much like the larger *T. angusticallosus* Schuurmans Stekhoven from Milne Bay, New Guinea, but the latter is a darker insect with black beard. The male is somewhat like *T. insurgens* Walker of Batjan Is. and *T. auriventer* Schuurmans Stekhoven of Sebesi Is., but the antennal plates in both of these are shorter, the basal angles lower, in addition to differences in body coloration or wing tinting.

Description (holotype ♀).—Length, 11.5 mm. Eyes bare, uniformly greenish (relaxed). Front yellow pollinose with short brown hairs at vertex; narrowest in the middle, and only slightly expanded above and below, index 1 (basal width): 7.0; keel dark-brown, about half as wide as the front below and tapered gradually to a small, sooty bump just before the vertex. Subcallus and face golden-yellow pollinose grading to citron-yellow pollinose and pilose on the lower cheeks. Antennae red, the annuli abruptly brown, scape with rufous and a few dark hairs basally, pedicel mostly black-haired; plate nearly twice longer than wide, the annuli a little shorter; dorso-basal angle low, obtuse, the excavation moderate. Palpi very slender, blunt apically, yellow-haired with a few black hairs dorso-basally, and about two-thirds the length of the proboscis which has brown labella, yellow theca.

Thorax pale brown, with grayish tomentum in front, covered with short yellow and sparse black hairs. Scutellum brown basally, the apical half red. Pleura and coxae pale yellow with concolorous hairs. Femora yellow and with yellow hairs, the fore pair with black hairs. Tibiae brownish with dark hairs, the mid pair reddish basally, tarsi dark-brown. Wing evenly fumose and only little accentuated apically; costal cell deep yellow; cell R_5 widely open, vein R_4 angulated with knot near the base but no spur vein. Subepaulets bare. Halteres brown.

Abdomen with first tergite yellow-brown and almost entirely golden-haired, remainder predominantly black-haired, tergites 2 to 4 reddish-brown with tall patches of golden-yellow hairs in the middle, on the sides, and sparsely on the incisures, tergites 5 to 7 dark-brown, black-haired except for a few golden hairs in the middle of 5 and on the edges of 5 and 6. Venter reddish-brown, entirely golden-haired, darker with mostly black hairs on the last two sternites.

Allotype ♂.—Length, 12 mm. Readily associated with the female by proportions of antennae (though plates are more slender as usual) and general color. Eyes bare, the enlarged facets occupying only about the upper half of area which is not sharply delimited and is gradually decreased along the occipital border so that there is no well-marked occipital margin of small facets. Tubercle in occipital notch very small and sunken. Second palpal segments slender, ovoid, and with blunt apical nipples. General vestiture of body longer than on female but dorsum of abdomen worn so that it appears plain reddish-brown, darker caudad.

Paratype ♀.—Length, 12 mm. In close agreement with the holotype, but golden hairs less extensive on abdomen and median patches also reduced in part by wear. Same data as holotype. In collection of the collector, a medical entomologist and friend of long standing to whom the species is cordially dedicated.

Type Material.—Holotype ♀ and allotype ♂, Dutch New Guinea, Cyclops Mt., 1000′, near Hollandia, 18. i. 1945 (*L.E. Rozeboom*). In collection CBP.

Remarks.—This is one of those Oriental species with indefinite abdominal pattern that must be keyed both ways in major couplets to presence or absence of triangles, and of wing tinting. Unless well preserved, the median, golden-haired triangles would not be seen, though they nearly cross the tergites in the holotype.

Tribe TABANINI

Tabanus abaculus n. sp. (Fig. 4)

A robust, steel-gray fly with dark banded abdomen, broad frons, predominantly white tibiae, white beard and glass-clear wings.

T. rufiventris Fabricius has obviously derived from the same stock, but is quickly distinguished by its brown, narrow-banded abdomen and other characters in the key.

Description (holotype ♀).—Length, 17 mm. Eyes (relaxed) uniformly coppery black. Frons brown pollinose which changes to pale buff on vertical view, index 1:5.7; prominent reddish-brown callosities as figured. Subcallus pale, creamy. Face and cheeks whitish pollinose and pilose, without upper brown crossband. Two basal, antennal segments and extreme base of third reddish with black hairs, remainder black; plate rather narrow, deeply excised, and almost a third longer than style. Palpi missing.

Notum purplish-gray with prominent gray lines anteriorly, scutellum paler gray, denuded but probably with white pile originally similar to patches behind the wing insertions. Femora and approximate apical thirds of tibiae dark-brown, the former with mostly pale hairs. Cells basad of humeral crossvein in extreme base of wings yellow, alula and remainder clear except for slight tinting of the costal cell outwardly; cell R_5 about half narrowed at outer margin, no spur veins. Halteres pale brown.

Abdomen steel-gray, each tergite, except the second, with wide, blackish-brown, basal bands notched in the middle; the second tergite has a pair of less distinct, brown, transverse shadows, with the basal margin gray; on the sternites there is a median, black, midventral band, the incisures narrowly gray; vestiture whitish and black in corresponding places.

Type Material.—Holotype ♀, Malaya, Trengganu, Dungun, Bukit Besi, 4-8. viii. 1958 (*R. Traub*). In USNM.

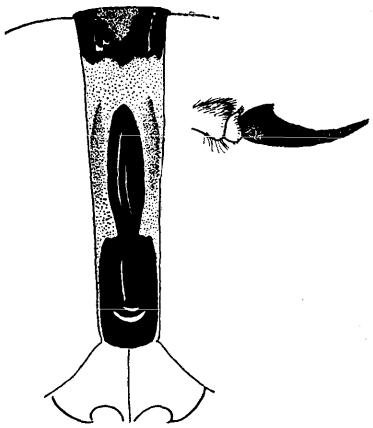


Fig. 4. *Tabanus abaculus* n. sp.
Front and antenna

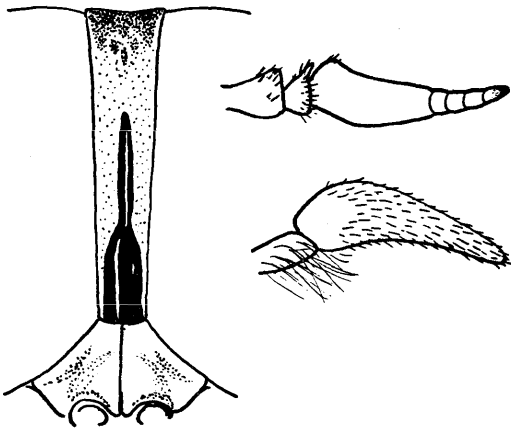


Fig. 5. *Tabanus abauristriatus* n. sp.
Front, antenna, and palp

Tabanus abauristriatus n. sp. (Fig. 5)

A rather small, dark species with orange antennae, red scutellum and abdomen, a wide, straight-sided, buff-red, longitudinal stripe with pale yellow hairs, and clear wings with deep yellow costal cells.

T. auristriatus Ricardo of S. W. India has some resemblance but differs in dark antennal style and palpi, pleural hairs black, fore legs not darker than the others, wings tinted and abdominal stripe golden-haired.

Description (holotype ♀).—Length, 11 mm. Frons yellow pollinose, parallel-sided, index 1:6; callosity reddish, elongate, separated from the eyes, but rather abruptly narrowed into a keel reaching little over half-way to vertex. Subcallus subshiny yellow (possibly worn), face and cheeks buff-gray, with sparse, white hairs. Antennae uniformly orange, two basal segments mostly pale-haired, a few black ones dorsally, plate long and slender, the tooth obtuse and low, style about half as long. Palpi rather slender, whitish with sparse, black hairs, tapered to a blunt point.

Thorax dark gray with sparse, yellow hairs and some black ones, scutellum red, pleura gray with pale pile. Fore legs, except paler coxae and tibial bases, distinctly darker than two hind pairs which are reddish with a darker basal shadow on mid femora. Venation normal. Halteres bright yellow.

Abdomen brick-red above and below, darkening on the last three segments, black-haired on the sides of the dorsum, pale yellow-haired on the mid stripe, edges and venter.

Paratype ♀.—Same data except 50 km. S.W., 14. vi. 1952. In collection CBP. In good agreement except the abdomen worn and the mid stripe evident only as an obscure, pale pollinose line to tergite 6. Subcallus also subshiny yellow. The shape of both specimens is somewhat tapered with tergite 7 nearly as wide as 6.

Type Material.—Holotype ♀, Cambodia, Khong, 40 km. S.W., 5. vi. 1952 (*C. Wharton*). In USNM.

Tabanus abbasalis n. sp. (Fig. 6)

A robust, brownish-black fly with black abdomen, the two basal tergites sharply bright orange, wings strongly fumose on the outer half, yellow basally, the tibiae black, whitish on the basal halves.

This belongs in the *basalis*-group of Schuurmans Stekhoven (1926) but is readily distinguished by the characters in the key. His *T. sziladyi* ♂ from "Sumatra or China," has wings not as yellow basally nor fumose beyond, and tergite 3 and venter are yellow.

Description (holotype ♀).—Length, 18 mm. Frons velvety brown with black hairs, index 1:7.5; callosity black, ovoid, separated from eyes, tapering gradually above into a long, black keel which is attenuated at the upper third of the frons. Subcallus, face and cheeks chocolate-brown pollinose, black pilose below. Antennae black, the two basal segments dark-brown, black-haired, plates a little longer than double their width, strongly excised, the teeth acute. Palpi black with concolorous hairs, robust but pointed.

Notum and scutellum reddish-brown, covered with rufous to golden hairs behind, and scattered black ones. Pleura and coxae brown with black hairs. Remainder of legs black and black-haired, the tibiae basally white and white-haired. The costal, basal, and anal cells of wings yellow, smoky beyond, cell R_5 open, no spur veins. Halteres orange.

Tergite 3 with indefinite brown shadings beneath the black hairs, inconspicuous median patches of white hairs on incisures of tergites 3 and 4; venter coal-black with narrow white-haired fringes.

Type Material.—Holotype ♀, Thailand, Chiengmai, 15. x. 1951 (*D.C.* and *E.B. Thurman*), "fly trap no. 151." In USNM.

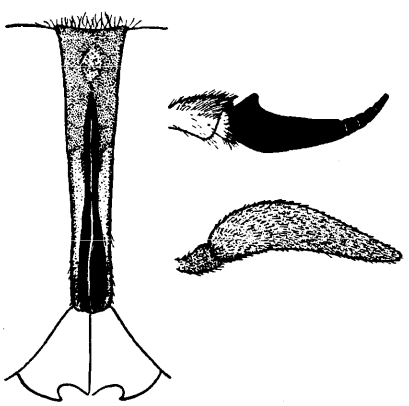


Fig. 6. *Tabanus abbasalis* n. sp.

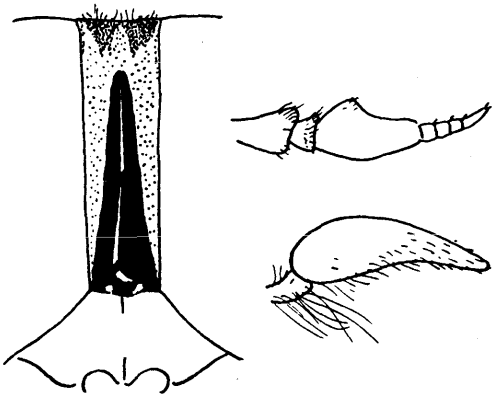


Fig. 7. *Tabanus acuminaris* n. sp.

Front, antenna, and palp

Tabanus acuminaris n. sp. (Fig. 7)

Another small, blackish species with red-sided, tapered abdomen related to *T. konis* n. sp., but with a little wider, parallel-sided frons, and heavier median keel, the red on sides of abdomen more extensive.

Description (holotype ♀).—Length, 13 mm. Eyes greenish (relaxed). Frons buff-gray pollinose, index 1:4.2; the callosity deep reddish, lower margin sinuate and nearly reaching the eyes, grading gradually into a darker median extension forming a tall triangle with apex above the upper third of frons. Subcallus, face, cheeks, beard and palpi as in *T. konis*. Antennae bright orange, about same shape.

Thorax and scutellum grayish pollinose with scattered pale yellow and black hairs. Legs as in *T. ardalus* n. sp. with widely reddish knees on two hind pairs of femora.

Abdomen black with sides of first three tergites broadly brick-red, and dusted all over with yellow-olive pollinosity as in *T. konis*, and covered with sparse, black hair. The indefinite, median, dark stripe anteriorly is irregular because of narrow lateral expansions along the incisures of tergites 2 and 3. Venter dusty olive-blackish with narrow pale reddish incisures, and short, sparse, pale yellow hairs.

Type Material.—Holotype ♀, Thailand, Chiengmai, 25. vii. 1952 (*D.C. Thurman*), in house. In USNM.

Tabanus anabates n. sp. (Fig. 8)

A medium-sized, yellow-brown species with banded abdomen, wings clear behind with a narrow, intense, contrasting brown costal band to the apex, antennae orange, beard white, and tibiae pale straw-yellow, almost white.

This species appears to have no close relatives in the region, the apical infuscation is narrower and sharper than usual, which, combined with the distinctive abdominal pattern, sets it apart. *T. soubiroui* Surcouf from Cambodia has some similarity, but the apical cloud in that is more diffuse and wider, tibiae including fore pair more reddish basally, venters not banded, and no triangles on tergites.

Description (holotype ♀).—Length, 13 mm. Frons rather narrow, slightly convergent below, index 1:6.5; like subcallus and upper parafacials, golden-yellow pollinose; callosity reddish, tall, ovoid, separated from eyes, and abruptly tapered into a blackish, narrow, median keel which reaches not quite to the upper third of the frons. Face and cheeks whitish pollinose and pilose. Antennae sparse black-haired on basal two segments, the plate about twice longer than tall and than the style, moderately excavated, the tooth sub-rectangulate. Palpi flesh-colored, rather slender, blunt apically, and shaggy black-haired.

Notum and scutellum olive-yellow pollinose overlying black integument, covered with golden and sparse, black hairs. Pleura, chest, and coxae gray pollinose, and whitish pilose. Femora and apical thirds of fore tibiae black, remainder of fore and all but apices of two hind pairs of tibiae pale yellowish-white with white hairs. Wings with costal shadow confined to costal cell, cell R_1 beyond stigma and crossing into cell R_3 along vein R_{2+3} and tip of R_4. Cell R_5 open, short spur veins present. Halteres brown.

Abdomen red-brown on basal three tergites, and black-haired except for a golden-haired, yellow-gray triangle crossing tergite 2, and a similarly colored, half-moon-shaped median spot on 3, which is repeated on 4 and 5 as expansions of pale yellow, golden-haired bands, tergites 6 and 7 also with pale incisures but entirely black-haired. Venter pinkish on two basal sternites, darkening caudally with wide pinkish incisures on sternites 3 to 5, last 2 sternites entirely black-haired.

Type Material.—Holotype ♀, Thailand, Lampang, Tern, 22. vii. 1952 (*D. C. Thurman*). In USNM.

Remarks.—Noted as "taken in a bus (converted cattle truck)" inspired the name from "rider" or "passenger." Related to this is a broken and discolored specimen in USNM from Kohn Kaen, Thailand, 20. iv. 1955 (*R. C. Elbel*) which probably represents another undescribed species. The wing is not as deeply infuscated beyond the stigma, the frons a little broader with tall, triangular, blackish callosity filling the lower frons, the antennae more slender, brownish, and legs unicolorous, brownish, abdomen missing. Description will have to await availability of complete specimens.

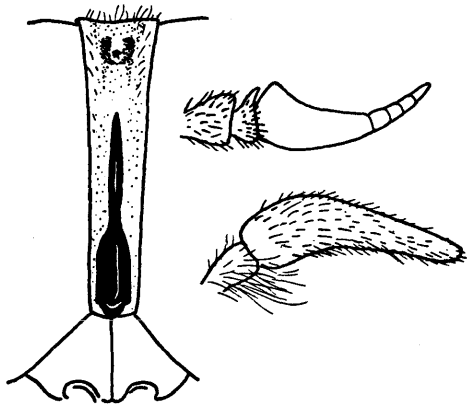


Fig. 8. *Tabanus anabates* n. sp.

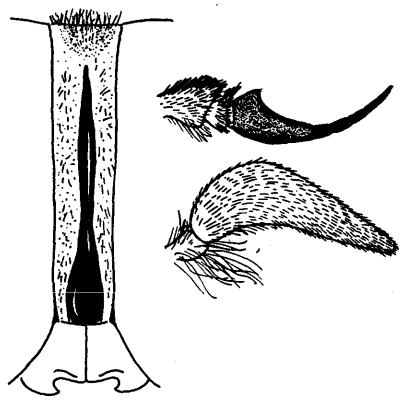


Fig. 9. *Tabanus annamensis* n. sp.

Front, antenna, and palp

Tabanus annamensis n. sp. (Fig. 9)

A large orange-reddish species of the *basalis*-group with predominantly black antennae, pale yellow to whitish tibial bases and ventral incisures, and last three tergites sharply jet black.

T. pallidepectoratus Bigot and *T. joidus* Bigot of E. India and Assam also are related. The former differs in narrower front (1: 10) convergent below, white beard, and reddish antennae; *joidus* also has red antennae and front convergent below, and though the index, 1: 6, is about the same, the beard is brownish. The inadequately described *T. pseudopallidepectoratus* Surcouf from Laos is also related but has yellower under parts and tibiae and, by comparative inference, narrower front and red antennae.

Description (holotype ♀).—Length, 20 mm. Frons parallel-sided, index 1:5.3, plus subcallus, orange-brown pollinose. Callosity mahogany-red, pear-shaped, separated from eyes, tapered into a strong, median, black keel which reaches to upper fourth of frons. Face and cheeks yellow pollinose, pale yellow pilose. Antennae with two basal segments and extreme base of plate reddish with black hairs, remainder black, plate strongly excised and but little longer than style, the tooth acute. Palpi dirty reddish, black-haired, rather thick basally and tapering to a blunt point.

Thorax and scutellum pale brownish-yellow, covered with golden-yellow and scattered black hairs. Pleura lighter yellow with pale yellow pile. Fore coxae and femora blackish-brown with mostly pale yellow hairs; two hind pairs of femora red with mixed black and paler yellow hairs; tibiae straw-yellow with pale hairs almost whitish in certain lights, blackish apically. Wings deep yellowish anteriorly, paler behind; cells R_5 open, no spur veins. Halteres pale yellow on knobs.

Abdomen rather elongate, reddish-orange with rufous-golden hairs on basal four tergites, some brown hairs basally on tergite 4, the remainder jet black. Venter black, sternite 1 and edges of 2 reddish, first four incisures broadly pale with almost whitish hairs, remainder jet black.

Type Material.—Holotype ♀, Annam, Annam Prov., Haut Donai, Col de Blao, 900 m., 30. ix. 1932 (*M. Pollane*). In USNM.

Tabanus ardalus n. sp. (Fig. 10)

So close to *T. konis* n. sp. from same locality that it can be described by the differences. It is also close to *T. hirtistriatus* Ricardo of Malaya but in that the frons is even narrower, more convergent below, the stripe more yellowish, and the wings with a distinct apico-costal shadow.

Description (holotype ♀).—Length, 10 mm. Frons a little narrower, 1:7.0, but also slightly convergent below; gray-buff pollinose, the callosity small, yellowish, widely separated from the eyes, not tridentate below, and tapered more abruptly into a narrow, brown, median line which reaches a little above the middle of the frons. Subcallus pale yellow pollinose. Antennae about same shape but brick-red. Scutellum

brown. Mid and hind femora infuscated for only the basal half and basal third respectively. Abdomen darker, reddish-brown, shadows on sides of first three tergites with a narrower pale pilose and pollinose, obscure triangle crossing tergite 2, and with similar median accentuation of pale hairs on following tergites but no general olive sheen viewed from behind; slender in shape but not quite as narrowed behind.

Type Material.—Holotype ♀, Thailand, Ban Ta Pui, Tak, Meh Ping River bank, 20. vii. 1952 (*D.C.* and *E.B. Thurman*). In USNM.

Remarks.—Three discolored females from near Saigon, Cochin China, in USNM, are near this if not the same. Minor differences are: a little longer, 12 mm., and more slender, with tergite 7 narrower, more protruded, median extension above callosity is a fine line, scutellum entirely black like the notum, and femora reddish only at the knees. Relationship will have to be determined by more and better-preserved material.

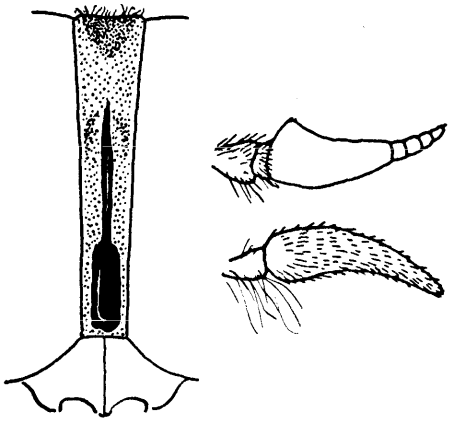


Fig. 10. *Tabanus ardalus* n. sp.

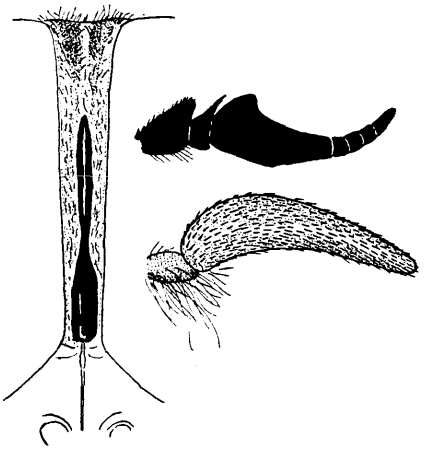


Fig. 11. *Tabanus audyi* n. sp.

Front, antenna, and palp

Tabanus audyi n. sp. (Fig. 11)

A medium-sized, dark-brown species of the *fumifer*-group with blackish appendages, smoky wings, a row of low, golden-haired triangles on the abdomen not expanded along the incisures, the venter dark with reddish sides and yellow incisures.

The lower yellow triangles, on darker brown abdomen, black, black-haired tibiae, black antennal scapes and callosity distinguish this from such related species as *T. malayensis* Ricardo. *T. brunnicolor* Philip is larger, has more prominent triangles, and more intense golden-haired underparts.

Description (holotype ♀).—Length, 16 mm. Eyes blue above, greenish on the lower half. Front rather narrow, index 1:8.0, dark-brown pollinose, almost blackish from front view. Callosity tall, ovoid, separated from eyes, tapering into a strong, median, black keel. Subcallus and upper cheeks deep yellow, face and lower cheeks buff pollinose, beard yellow. Antennae black, base of pedicel reddish, plate more slender and tooth sharper than in *brunnicolor*. Palpi blackish-gray, black-haired.

Notum, including antealar tubercles, and scutellum blackish with black hairs, and scattered golden-yellow ones especially around the hind margin. Pleura ashy-gray with pale and dark hairs intermixed. Chest and coxae pale yellow-haired, with golden-yellow hairs behind the wing insertions. Legs entirely black with black hairs, pale yellow hairs beneath on the two hind pairs of femora. Wings rather evenly fumose, not accentuated anteriorly or margining the veins as in some related species. Halteres reddish-brown.

Abdomen rather evenly dark-brown above, reddish below on the sides of the first three sternites, the mid ventral black patches widening behind to include most of sternite 4 and all of the last two, the sides and ventral incisures brassy-yellow-haired. Golden hairs above, only on the low median spots which are hardly triangular, and on sides of the first four tergites.

Type Material.—Holotype ♀, Malaya, Trengganu, Besut Dist., Gunong Tebu, v. 1958 (*R. Traub*). In USNM.

Tabanus aurilineatus Schuurmans Stekhoven

1926, *Tabanus aurilineatus* Schuurmans Stekhoven, *Treubia, 6* (Suppl.): 231. Type ♀, Sumatra (Vet. State Labs.); 1928, *Zool. Jb.*, (1), *54*: 425.

In the original description, two paratype females from "Malacca" (Malaya) are said to have, and figured showing, acute dorso-basal teeth on the antennal plates along with some other differences which agree with two females before me from Thailand (USNM). I suspect that these are specifically distinct, because of the narrower frons, and antennal teeth, but there is an insufficient series to determine possible intergradation and the specimens are too worn to provide adequate description or more than subspecific assignment below.

Tabanus aurilineatus gilvilineis n. ssp.

A medium-sized, yellowish, elongate fly with pale abdominal stripe, and wings with intensive apico-costal clouds.

Differs from the typical form as keyed. The narrower front suggests this may be specifically distinct but longer series to check variation will be needed to decide this question.

Description (holotype ♀).—Length, 15 mm. Eyes (relaxed) greenish, without bands. Frons rather narrow, convergent below (index 1:8), yellow pollinose, the callosity reddish, ovoid, narrowly separated from eyes and a strong dorsal keel to upper third of frons. Subcallus and upper cheeks yellow pollinose. Face and lower cheeks whitish pollinose and pilose. Antennae orange, black-haired basally, plate long and narrow, about three times longer than style, the tooth low but acute. Palpi rather slender, blunt apically, black-haired, a few yellow hairs basally.

Notum and scutellum, olive-yellow pollinose, integument blackish beneath (denuded). Pleura creamy pollinose, whitish pilose. Legs reddish-brown, mostly black-haired, but tibiae and tarsi darker apically, fore pair on basal half, and mid pair on basal three-fourths, yellow-haired. Wings tinted behind, strongly fumose on costal border with a paler center in cell R_3. No spur veins. Halteres yellow.

Abdomen reddish-brown, denuded, the median yellow line indistinct. Venter with narrow pale incisures, pale yellow-haired.

Paratype ♀♀.—With same data as holotype and in close agreement, except abdominal stripe a little plainer (collection CBP); ♀, Chiengmai, 31. viii. 1951 (*D.C.* and *E.B. Thurman*) in Museum Com. Dis. Center, Atlanta, Georgia, a little smaller and the abdominal stripe more distinct, yellow-haired.

Type Material.—Holotype ♀, Thailand, "Loei Dansai, Na Haeo," 12. v. 1955 (*R.E. Elbel*). In USNM.

Remarks.—*T. pugiunculus* Austen, ♂, Bangkok, must be near this but the antennae have an obtuse tooth, the wings are clear and the abdominal stripe is golden-haired, while the presumed female has a much wider front. A related female from Kedah, Malaya is smaller (14 mm.) and has legs and broad sides of abdomen predominantly rufous-haired, frontal index 1: 5.7.

A female of another related species which I cannot place, from Chiengmai, Thailand, resembles the preceding specimen in general color, same frontal index, reddish callosity, orange antennae with obtuse tooth, basally pale tibiae, and costally infuscated wings, but differs in blackish femora, and reddish-yellow abdomen with wide, bright, yellow-haired incisures which expand into broad, median triangles on the dorsum that do not quite cross the tergites. This is probably an undescribed species derived from common ancestry with the above.

Tabanus biannularis Philip new name (*see* also Philip, 1960, this *Study*)

1911, *Tabanus bicinctus* Ricardo, *Rec. Indian Mus., 6*: 132. Type ♀, S.W. India (BMNH). Not *T. bicinctus* Fabricius, 1805.

After comparing the type of this and a paratype of *T. griseipalpis* Schuurmans Stekhoven from Sumatra, plus material from other areas, including Malaya, in BMNH, I am not satisfied

that more than extremes of variation in the same species are represented, but longer series will be needed to feel confident of synonymy. A female of *bicinctus* is at hand from Chiengmai, Thailand, type locality of *griseipalpis*. While the latter is described as having tergites 5 and 6 with narrow pale incisures, some specimens are intermediate with only the sixth pale and approaching typical *bicinctus* in which both incisures are black. The other characters are a matter of degree. An overlooked character is the dark praescutellum, compared to a gray one like the scutellum, as in *T. leucocnematis* Bigot from Assam.

The group is a very distinctive one, and Szilàdy (1926) proposed a new subgenus *Callotabanus* (*see T. gertrudae* Philip) that is available if the group is ever set apart. The value of the name is reduced, however, by a few other species in the general region which have diverged a little further from the parent stock, e.g., *T. cenemidotus* Philip and *T. pallidescutum* Philip from the Philippines, with the characteristic bicolored legs and thorax, but with pollinose subcalli, median calli linear, not separated from callosities, and abdomens with triangles rather than rings. *T. equicinctus* Schuurmans Stekhoven from Thailand is another with white-banded abdomen, and predominantly whitish tibiae, but the subcallus is pollinose, scutellum but little lighter than notum, and median callus is spindle-shaped, but connected to callosity.

Tabanus cambodianus n. sp. (Fig. 12)

A little smaller than *T. abauristriatus* but so close in appearance that it can be described by the differences. *T. aublanti* Toumanoff, another small, yellow, Malaysian species, differs from both of these species in having a more compact abdomen, shorter, more excavated antennal plates and black annuli, legs uniformly yellow-brown.

Description (holotype ♀).—Length, 9.5 mm. Frons sooty-gray pollinose, narrow and convergent below, index 1:6.7; callosity brown, barely separated from eyes below, triangular and produced above into a fine, blackish line little over half-way to vertex. Subcallus yellow pollinose. Antennae also bright orange but plate relatively broader and shorter, the tooth subrectangulate. Scutellum concolorous with dark-gray notum. Basal halves of two hind pairs of tibiae blackish-brown. Abdominal buff-red stripe obscured by wear but indicated by pale pollinosity and a few pale yellow hairs.

Type Material.—Holotype ♀, Cambodia, Khong, 40 km. S.W., 10. vi. 1952 (*C. Wharton*). In USNM.

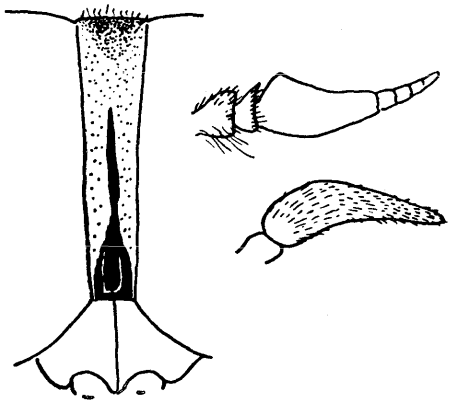


Fig. 12. *Tabanus cambodianus* n. sp.

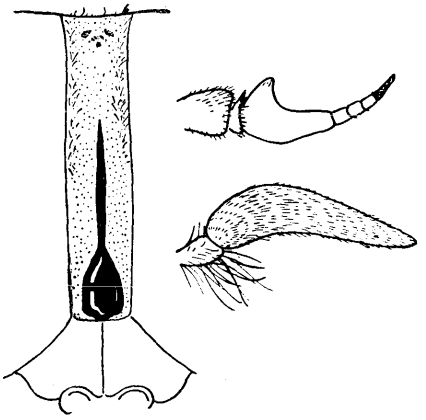


Fig. 13. *Tabanus fascius* n. sp.

Front, antenna, and palp

Tabanus cinnamoneus Doleschall

1858, *Tabanus cinnamoneus* Doleschall, *Natuurk. Tijdschr. Ned.—Ind.*, *17*:84 (Amboina, New Guinea).

A female in BMNH labelled "N. Borneo, Bettotan nr. Sandakan, Aug. 12, 1927" appears to be a variant from the species as redescribed by Oldroyd (1949). The front is a little narrower (1: 9. 5) with the median keel expanded below almost touching the eyes, the antennae and palpi darker, and cell R_5 closed and petiolate. *T. fulvissimus* Rondani is near it but has a wider front and open cell R_5. Though the type of the latter also from Borneo was seen by Ricardo (1911*a*) she gives the frontal index as 1: 6, and cell R_5 is presumed to be open since she does not mention it.

Tabanus fascius n. sp. (Fig. 13)

A medium-sized yellow-bodied fly with banded abdomen, pattern more prominent ventrally, orange-red, deeply-excised antennae, dark legs, and wings banded similar to the *optatus*-group.

There is obvious relationship to *T. rufiscutellatus* Schuurmans Stekhoven, and it was at first thought to be a dark variant, since that species occurs in Thailand. However, *T. fascius* differs in the more deeply excised antennal plate which is longer than the style, in black legs, the two hind pairs of tibiae dark reddish-brown, entirely black-haired, wing picture darker, yellow only at extreme base, paler in centres of discal, anal, and second basal cells, and abdominal incisures distinctly banded, especially below. Several of these features also distinguish it from *T. melanognathus* Bigot, a male of which has been reported from Laos. The lack of a white scutellum, and median triangles, at once separates *fascius* from *T. optatus* Walker.

Description (holotype ♀).—Length, 16 mm. Eyes green (relaxed). Frons, subcallus and face golden-yellow pollinose, beard yellow grading to pale yellow on upper face; the first parallel-sided, index 1:5.5; callosity pale red, rounded and widely separated from eyes, produced above into a narrow line halfway to vertex, about same shape as figured by Schuurmans Stekhoven (1926) for *T. rufiscutellatus*. Basal antennal segments with short, black hairs, tooth very prominent, as tall as plate is wide beneath, acute-angulate, style a little darker and a little shorter than plate. Palpi yellow, rather slender and blunt apically, with concolorous, and a few black, hairs.

Notum olive-yellow pollinose, the scutellum more reddish, and pleura pale yellow, mostly pale-yellow-haired with scattered black ones only on dorsum. The fore tibiae are but little more brownish than the black femora. Hind-tibial fringe prominent, black. Entire hind border of wings and apex distad of the stigma subhyaline. Halteres pale brown, paler on the upper part of the knobs.

Abdomen reddish-brown, darker (almost blackish) basally on tergites 3 to 5, and narrowly above the incisure across 2, sparsely black-haired on these parts, elsewhere golden-yellow; the tip not black. Venter with a wide, brown band across the middle of sternite 2, and blackish, black-haired bands across bases of the remainder, the incisures widely whitish with white hairs.

Type Material.—Holotype ♀, Cambodia, 40 mi. W.S.W. Khong, 10. vi. 1952 (*C. Wharton*). In USNM.

Tabanus flavohirtus n. sp. (Fig. 14)

This is another of the medium-sized, entirely yellowish, Far Eastern species, without thoracic or abdominal patterns, and with yellow appendages, but red antennae with elongate plates, very short annuli, narrow front, and tinted wings with short spur veins. Only the tarsi are dark.

T. sulfurescens Schuurmans Stekhoven of Sumatra appears closest but differs in narrower front (1: 10. 2), more black hairs on tibiae, and black hairs on the abdomen, above and below, leaving a wide, median, pale-haired stripe. *T. borniensis* Ricardo and *T. flavopilosus* Schuurmans Stekhoven of Borneo are not entirely yellow, and have black hairs on palpi and legs. *T. griseifacies* Schuurmans Stekhoven of Assam appears related also but its antennal plates are shorter and wider, the annuli longer, the callosity is less tall, and the cheeks gray with whitish beard. *T. flaviventris* Bigot of Assam has a wider front, palpi more tapered

and with some black hairs, hyaline wings; male without occipital margin of small facets. If this is a crepuscular species, its absence in Schuurmans Stekhoven's comprehensive monograph may be explained. Superficially, the male resembles *C. absol* Philip (1959) of the Philippines but *C. absol* also has broader plates, longer annuli, more pointed palpi, bare subepaulets and extensive dark hairs on the tergites.

Description (holotype ♀).—Length, 13 mm. Eyes bare, entirely greenish (relaxed). Frons very narrow, expanded above, index 1:8.7, golden-yellow pollinose and pilose, a small, dark dot at the vertex, callosity small, yellow, widely separated from eye margins, rounded below, and separated from subcallus, a little over twice taller than wide, like a slender spearhead, pointed above, and with an almost imperceptible, thin, dark line which reaches less than half-way to the vertex. Subcallus and face golden-yellow pollinose. Cheeks buff-gray, beard sparse, pale yellow, no dark hairs above. Antennae red with concolorous hairs basally, plate very elongate and slender, about 2½ times longer than wide at the low basal tooth, gently sinuous above and below, annuli subequal to width of plate. Palpi yellow with concolorous and no black hairs, fairly robust, not especially tapered, blunt apically. Proboscis with yellow theca, dark-brown labella.

Thorax, including scutellum, heavily golden pollinose obscuring dark-brown integument beneath, entirely yellow-haired. Legs yellow with yellow hairs, the tarsi brown with dark-brown hairs and a few on tips of tibiae. Wings lightly tinted with suggestion of deeper tints margining the radial veins beyond the stigmas, latter narrow, yellow; short spur vein on one wing, the other vein R_4 only angulated; cell R_5 wide open; subepaulets with black and yellow hairs intermixed. Halteres bright yellow.

Abdomen orange-yellow with concolorous hairs, black ones on the seventh segment; no integumental dark spots basally.

Allotype ♂.—Length, 13.5 mm. Closely resembles the female and readily associated. Head large; eyes bare, enlarged facets occupying at least two-thirds of the upper area which is pale brown and sharply demarcated, the lower border sinuous and a wide, posterior band of small facets to the vertex. Tubercle in occipital notch ovoid, reddish, and level with eyes. Frontal triangle, antennae and palpi orange-yellow. Face and cheeks with sooty-gray buff pollen (possibly discolored). Plates more slender than in female. Second palpal segments drop-shaped, blunt, no black hairs. Proboscis yellow, flagella lighter brown. Hind tibiae with more dark-brown hairs on apical half. No spur vein on one wing, a knot only on the other. A few brown hairs laterally among the yellow on tergites 2 and 3, and inconspicuously along the mid-venter.

Paratype ♀♀.—Length, 13-14 mm.; ♀, same data, also agrees closely with holotype ♀ (in collection CBP); ♀, Malaya, Trengganu, Besut Dist., Gunong Tebu, 400′, May 1958 (*R. Traub*); in USNM. The labella, like that of the holotype, is lighter brown; there is no evidence of a line above the frontal callosity; and both subepaulets in the Malayan ♀ are entirely yellow-haired and require magnification to confirm that they are not bare, in contrast to the adjacent black-haired costa, and there is a short spur vein present on one wing. The Malayan ♀ has a few inconspicuous, scattered, black hairs basally on the first three tergites, and the front, face, and antennae are more intensely orange.

Type Material.—Holotype ♀ and allotype ♂, Borneo, E. Kalimantan Dist., Munkan Is., 12. 1953 (*H. von Hentig*), at light. In CNHM.

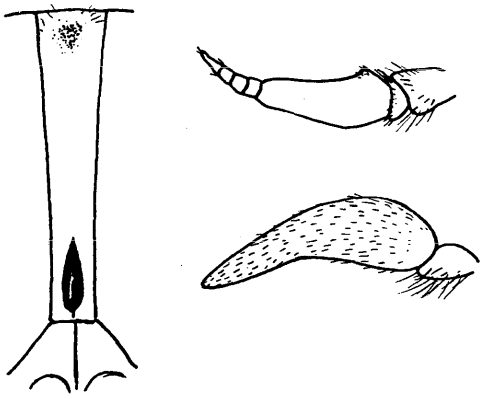


Fig. 14. *Tabanus flavohirtus* n. sp.

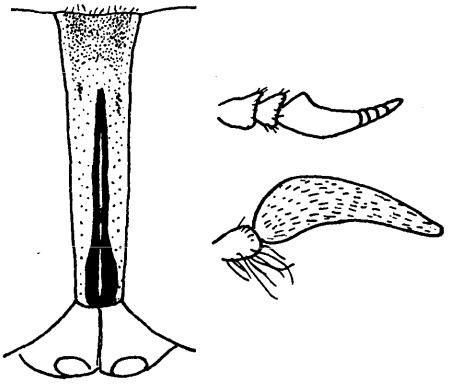


Fig. 15. *Tabanus fulvilinearis* n. sp.

Front, antenna, and palp

Tabanus fulvilinearis n. sp. (Fig. 15)

A rather small, slender, brownish-yellow species with an even, broad, pale reddish-yellow, abdominal stripe, clear wings, and red antennae.

It is nearest *T. flavitibiatus* Schuurmans Stekhoven from Sumatra in general color, frontal characters, and shape of antennae, but differs in having a wider abdominal stripe, which continues beyond tergite 5, thoracic lines, and pale yellow (not white) beard. In casual appearance this is close to *T. agnoscibilis* Austen, also of Thailand, but comparison with the type in BMNH shows the latter to differ in more tapering abdomen with last three tergites blackish, darker antennae and fore femora, notum and scutellum blackish without lines, and pleura whitish pilose. Infuscated femora and wider front at once separate *T. pugiunculus* Austen, also of Thailand.

Description (holotype ♀).—Length, 10 mm. Eyes bare, uniformly greenish (relaxed). Frons yellow pollinose, no bare spot at vertex, slightly widened above, index 1:6.5; callosity yellow, drop-shaped, separated from the ocular margins, tapered into a concolorous, median keel which attenuates about half-way to vertex. Subcallus sparsely yellow pollinose. Face and cheeks buff-gray pollinose, and pale yellow pilose including beard. Antennae red, the annuli a little darker and shorter than the plate, which is distinctly excavated and with an almost rectangular dorso-basal tooth; scape yellow-haired, an apical fringe of black hairs on pedicel. Palpi fairly robust basally, attenuated apically with yellow, and a few black, hairs. Theca and labella yellow.

Thorax and scutellum dull yellow, with heavy brown dashes above the wing bases which give the effect of an intermediate, indistinct, paler, longitudinal band; covered with sparse, pale yellow, and a few black, hairs. Pleural and leg hairs pale yellow, a few black ones outwardly on tibiae; legs and halteres entirely yellowish. Wings clear, costal cells faintly yellow, stigma inconspicuous, yellow, cell R_5 open, short spur veins persent, subepaulets with fewer setae than on costa.

Abdomen not attenuated though slender; pale reddish-yellow with a pair of wide, sublateral, longitudinal, dark-brown stripes on dorsum, leaving the edges also pale reddish-yellow; vestiture sparse, concolorous with the pattern. Venter entirely pale yellow with pale hairs.

Type Material.— Holotype ♀, Thailand, 21. v. 1894. In collection of CBP through the kindness of Dr S. Devakula.

Tabanus gertrudae new name

1911, *Tabanus flavicinctus* Ricardo, *Rec. Indian Mus.*, *4*:130. Type ♀, Shillong, Assam (BMNH). Not *T. flavocinctus* Bellardi, 1859, *Sagg. Ditt. Mess.*, *1*: 61 (Mexico).

1926, *Tabanus* (*Callotabanus*) *flavicinctus* Szilàdy, *Biol. hung.*, *1* (fasc. 7): 10.

Szilàdy (op. cit.) proposed the subgenus *Callotabanus* for a compact element of *Tabanus* sens. lat., and listed four species (the first of which was *T. flavicinctus* Ricardo) "as well as group I of Ricardo," but actually probably intended to include her group II to which the listed species are more closely related. To avoid ambiguity, *T. flavicinctus* Ricardo (= *T. gertrudae* Philip, n.n.) is hereby designated subgenotype, though the need for systematic separation of this group is not apparent at present, since parallel treatment of other equally distinct elements such as *T. ceylonicus*, would also then be needed.

Tabanus gilvellus n. sp.

A small, unpatterned, yellow fly, almost entirely yellow-haired, with yellow appendages, clear wings, and no abdominal pattern.

It has obvious relationship to the larger *T. ochrogaster* Philip (syn. *flaviventris* Bigot, not Macquart) from India and Assam but differs, in addition to being smaller, in having entirely yellow-haired palpi, pale brown thorax with red-tipped scutellum, and abdomen not darker at apex. *T. aublanti* Toumanoff from Indochina is another small, yellowish species but it is darker and has black hairs on the palpi and legs. *T. ochros* Schuurmans Stekhoven, also from Thailand, and *T. flavipus* Schuurmans Stekhoven, from India, are also related,

but both are larger, have white beards, and have black hairs on some appendages and on parts of the abdomen. The former is peculiar, if the author has correctly figured it, in having a tri-annulate style, though this is not mentioned in the description; the type of *ochros* was originally in Raffles Museum, Singapore, but recent inquiry by Dr I. M. Mackerras failed to locate it, and it is not among the Raffles collection in BMNH.

I dislike describing males without associated females, and especially with broken antennae, but this appears to be distinct from any of the several yellow-bodied species in the region, including *Cydistomyia* spp. in New Guinea.

Description (holotype ♂).—Length, 9 mm. Eyes with facets moderately enlarged in upper two-thirds, fine facets tapered out behind about half-way to vertex. Frontal triangle and face pale yellow pollinose, the cheeks and parafacials a little more grayish-buff, beard pale yellow. Two basal antennal segments and palpi orange, entirely yellow-haired, flagellum and labium missing.

Thorax pale brown, overlain with bright yellowish pollen and hairs, the apical half of scutellum, the legs, and all of the abdomen, orange-red. Pleura buff-gray pollinose with pale yellow hairs. Legs and abdomen with bright yellow to rufous hairs.

Type Material.—Holotype ♂, Thailand, Chiengmai, Pann, 5. iii. 1952 (*D.C.* and *E.B. Thurman*), "in hot springs pool." In USNM.

Tabanus griseilineis n. sp.

An undistinguished, medium-sized, dark-bodied species with mostly reddish abdomen and obscure, dark, median line which expands caudally to include the last three segments, red antennae darkening apically, parallel-sided front with black callosity widely separated from the eyes, bicolored legs, and wings slightly tinted behind a yellow costal cell, venation normal.

This was at first thought to be close to *T. monotaeniatus* Bigot from Assam or *T. abscondens* Walker from Burma. The former has the antennal plate black beyond the lower, indistinct, obtuse tooth and the style relatively shorter, palpi darker, more robust, beard not entirely white, and darker abdomen with a distinct, even, pale, middorsal stripe. The latter species has callosity nearly touching the eyes, and broader median black stripe on the abdomen with evidence of both median and sublateral pale markings.

Description (holotype ♀).—Length, 17.5 mm. Frons and subcallus buff pollinose, former parallel-sided, index 1:6; callosity blackish, tall, triangular with irregular lower margin, and tapered into a black, median keel which reaches a little above the middle of frons. Face and cheeks whitish pollinose and pilose. Antennae red, style sharply black and as long as plate, the latter only a third longer than wide, strongly excavated, the tooth subacute, palpi pale yellow, long and slender, rather blunt apically.

Thorax and scutellum blackish-gray dorsally with black and pale yellow hairs, a patch of black ones on praescutellum; pleura pale gray pollinose with mixed black and white pile. Femora blackish, gray pollinose, white pilose, knees narrowly reddish; tibiae reddish, the fore pair more pale yellow on basal half, black apically. Wings subhyaline, costal cell yellow, veins red, venation normal. Halteres with orange knobs.

Abdomen brick-red with narrow, dull, blackish, median line which widens to the middle third of tergite 4, and all of the remainder. Vestiture well-preserved, almost entirely black, except for inconspicuous, pale hairs on the extreme edges, and a few on the mid-hind margin of the first eight tergites. Suggestions of underlying pale pollinose, median triangles might give the wrong impression of a missing pale-haired mid-stripe in denuded specimens. Venter reddish with mostly black hairs, accentuated as large, median patches on sternites 2 to 4, the incisures paler with pale yellow hairs which widen laterally.

Type Material.—Holotype ♀, Thailand, "via," 1952 (*D.C.* and *E.B. Thurman*). In USNM.

Tabanus konis n. sp. (Fig. 16)

A small, dusty (hence the name), blackish species with bright orange antennae, blackish femora but reddish tibiae, clear wings, and sooty-black, tapered abdomen with dark-red sides on the first two tergites.

T. annamitus Bigot ♂ from Cochin China, and *T. abscondens* Walker from Burma have somewhat this appearance but both are much larger, the former has closed cell R_5, and the

latter has a red-margined scutellum with only the fore femora dark. The abdomens of neither are described as unusually tapered.

This forms a natural group with *T. ardalus* and *T. acuminaris* n. spp., undistinguished in appearance except for the tapered, slender abdomens with unusually protruded seventh tergites. In unworn specimens, the dusty, irregular black of the mid-line of each may be covered with a pale pollinose and pilose, obscure, median stripe, which disappears in worn specimens and is confusing to key.

Description (holotype ♀).—Length, 11 mm. Eyes (relaxed) greenish, unbanded. Frons and subcallus pale yellow pollinose, the former slightly narrower below, index 1:5.8; the callosity yellowish, ovoid, but tridentate below, barely separated from the eyes, tapered above into a heavy, black, median keel which attenuates in the upper third of the frons. Face and cheeks whitish pollinose and pilose. Basal two segments of antennae black-haired with a few yellowish hairs, plate not quite twice as long as wide, but a third longer than the style, tooth low, obtuse. Palpi pale yellow with black hairs, tapered to a point.

Thorax and scutellum blackish, unlined, with gray bloom accentuated in certain lights. Pleura gray with whitish pile. Femora, apical half of fore tibiae and tarsi blackish, with black to pale hairs on the two hind pairs of femora; hind pairs of tibiae reddish-yellow with mostly black hairs. Wings clear, venation normal, costal cells faintly yellow. Halteres with orange knobs.

Abdomen dull brown basally with indefinite black in the middle of tergites 1 to 3 and on the entire last four segments, mostly black-haired with pale hairs accentuated in the middle. Viewed from behind, an olive-yellow pollinosity covers the whole dorsum. Venter brown, darker behind, covered with sparse, pale yellow hairs.

Paratype ♀♀.—Three, same data as holotype, but 26. viii, "netted;" Lampoon, 8. viii. 1951 (*Thurmans*). In good agreement, though one has a black callosity and keel, and the abdominal pattern in another is obscured by a dried, recent blood-meal. One in collection CBP.

Type Material.—Holotype ♀, Thailand, Chiengmai, 20. viii. 1952 (*D.C.* and *E.B. Thurman*), "New Jersey type light trap." In USNM.

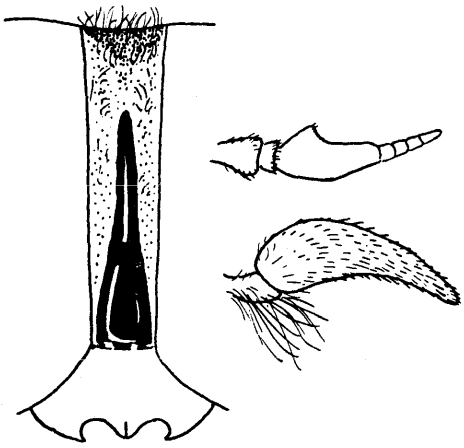


Fig. 16. *Tabanus konis* n. sp.

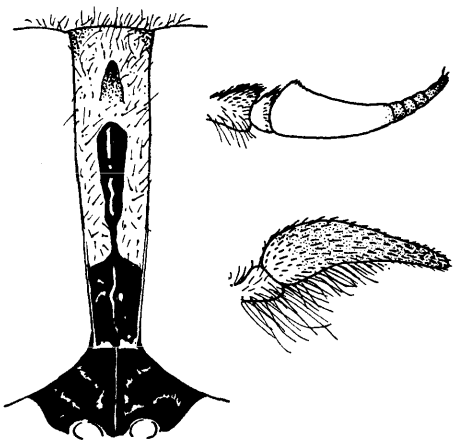


Fig. 17. *Tabanus macdonaldi* n. sp.

Front, antenna, and palp

Tabanus macdonaldi n. sp. (Fig. 17)

A small, black species of the *biannularis*-group with shining subcallus, yellow-banded thorax, white tibiae, two yellow, abdominal triangles, and wings with apical shadows.

The species is closest to *T. leucocnematus* Bigot but that has less slender antennal scape, black-haired femora, hind margins of tergites 3 and 4 and most sternites with heavy, yellow bands. The incompletely-described *T. tonglai* Surcouf of Laos also has yellow bands rather than isolated triangles on the abdomen.

Description (holotype ♀).—Length, 9.5 mm. Front dark-brown pollinose with short, black hairs, distinctly convergent below, index 1:7.8; a small, bare, flat tubercle at vertex; median callus black, spindle-shaped, a pollinose ridge below, if worn, would probably appear to connect with the dark-brown, quadrate callosity below, which is narrowly separated from the eyes and the shining, reddish-brown subcallus. Face and cheeks straw-yellow pollinose and pilose. Antennae dark-red, black-haired basally, plate about twice longer than wide with an obtuse basal angle. Palpi bluish-gray, black-haired, somewhat thickened basally and attenuated apically.

Notum and scutellum yellow pollinose with glistening concolorous hairs, a wide, brownish-black, black-haired band between the wing bases. Pleura straw-yellow pollinose and pilose; chest, coxae and tibiae whitish pollinose and pilose. Femora reddish-gray with long white pile. Tibiae with narrow, apical, dark rings, widest on the fore pair. Tarsi black.

Abdomen coal-black dorsally with obscure brown shadings on first two tergites, straw-yellow beneath. Two pale yellow, half-moon-shaped spots with glistening hairs on hind margins of tergites 4 and 5 widely separated from sides, and the outer corners with small, yellow-haired spots. Viewed from behind, narrow, obscure, brown, basal bands are seen at extreme bases of sternites.

Type Material.—Holotype ♀, Malaya, Selangor, Ulu Gombak, 19. viii. 1957 (*W. W. Macdonald*). In BMNH.

Tabanus nilakinus n. sp. (Fig. 18)

A medium-sized, purplish fly with row of tall, white-haired triangles on tapered abdomen, heavily fumose wings with some cells in radial sector with paler centres, and with short spur veins.

The species appears to have no described, close relatives.

Description (holotype ♀).—Length, 17.5 mm. Frons rather narrow, index 1:7.3, subparallel, pale buff pollinose, gray with black hairs at vertex; callosity reddish-brown, tall, ovoid, not touching eyes, abruptly narrowed into a narrow, median keel which reaches the upper third of frons. Subcallus and upper cheeks buff pollinose. Face and lower cheeks whitish pollinose and pilose. Basal two segments of antennae dark-red, black-haired, remainder dark-brown, plate a little longer than style, rather wide basally with an acute tooth. Palpi rather slender, elongate, tapered to a blunt point, deep yellow, black-haired.

Notum, scutellum, and abdomen reddish-purple with some gray pollinose lines anteriorly. Pleura pinkish with white pile. Femora black, black-haired above, pale-haired below; tibiae reddish, darkening apically, mostly black-haired. Halteres brown.

Triangle on tergite 2 tall and narrow, almost reaching anterior margin; those on 3 to 5 almost equilateral, their apices just above the middle, that on 6 small and inconspicuous. Outer corners also with white-haired triangles, the bases on hind margins not connected with median triangles. Terminal three segments distinctly narrowed. First five ventral incisures narrowly pale-haired, but no conspicuous, dark, median patches. Vestiture of abdomen predominantly black, white in appropriate places.

Type Material.—Holotype ♀, Thailand, "Loei Danjai, Darkhok," 27. v. 1955 (*R.E. Elbel*). In USNM.

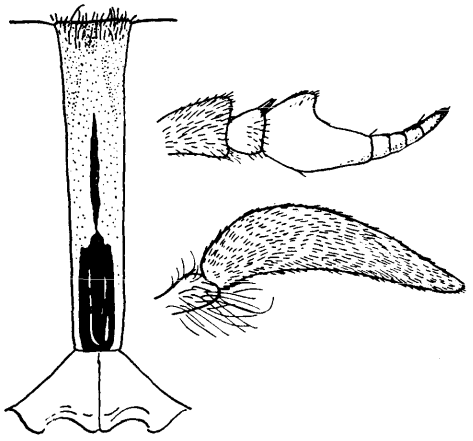


Fig. 18. *Tabanus nilakinus* n. sp.

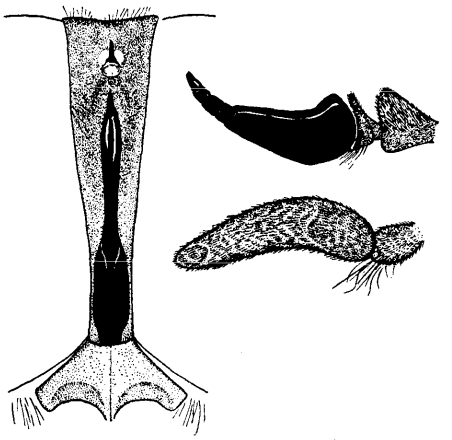


Fig. 19. *Tabanus pendleburyi* n. sp.

Front, antenna, and palp

Tabanus pendleburyi n. sp. (Fig. 19)

A large, blackish species with deep yellow wings, the first three abdominal tergites sharply contrasting, bright orange-red and the unusual character of three, vestigial ocelli below the vertex.

This was at first thought to be a large *T. ochroater* Schuurmans Stekhoven described from Sumatra, but that differs, in addition to smaller size (16 mm.), in that the front is less expanded above, being less than half as wide again as at the base, there are no vestigial ocelli indicated, the antennal plate is narrower, and the palpi more attenuated. The type is listed in Amsterdam but was not seen on a recent visit to enable checking of the discrepancy between the describer's key and the description in the number of orange basal tergites. *T. siamensis* Ricardo is also a smaller insect with the fourth segment largely reddish, antennae red, wings and beard brown.

Description (holotype ♀).—Length, 22 mm. Eyes bare (relaxed), no bands, blackish. Frons dark-brown pollinose, widened above as 0.6:1.4, index 1:7.3; frontal keel mahogany-brown, heavy and irregular above, and reaching nearly to a compact triangle of three flat vestigial ocelli set well below the vertex; upper pair are not outlined but are indicated by small, pale, integumental spots. Subcallus chocolate-brown with two large, dark-brown crescents above the antennal fossae. Face and cheeks deep blackish-brown with black pile. Antennae and palpi black with concolorous vestiture; the pedicels brown on the extreme bases; plates a little taller than half their length, and twice longer than style, dorsobasal tooth obtuse but prominent; palpi but little tapered, and blunt apically. Labella fleshy black, rather small.

Thorax including scutellum chocolate-brown, entirely black-haired. Legs black with black hairs, the hind-tibial fringes heavy. Wings deep yellow with the centres of some cells, and apex, a little paler, cell R_5 open. Halteres reddish-brown, paler on the knobs.

Abdomen coal-black; first three tergites sharply orange-red, vestiture concolorous with the underlying parts.

Paratype ♀.—Same locality as holotype, 5500′, 25. vi. 1951 (*D. Johnson*). In USNM. In close agreement, but antennal tooth a little sharper, thorax darker, scutellum almost black, and obscure, dark-red shadows basally on tergite 4.

Type Material.—Holotype ♀, Brit. N. Borneo: Mt. Kinabalu, Kenokok, 3,300′, 27. iv. 1929 (*Capt. H. M. Pendlebury*) 1937.412. In BMNH.

Remarks.—It is fitting to dedicate this fine new species to Captain Pendlebury, who spent many years in Malaya and contributed many records of Tabanidae in the Malaysian area.

The vestigial ocelli and basally orange abdomen suggest interesting parallel evolution to two boreal species, *Hybomitra cincta* Fabricius of North America and *H. nigricauda* Olsoufiev of eastern Siberia. The former is genotype species of *Dasyommia* Enderlein (= *Hybomitra* Enderlein). *T. fuscomaculatus* Ricardo from Upper Burma may have similarities also, although ocelli are not mentioned.

Tabanus ruficoloratus n. sp.

A medium-sized, reddish species with gray-lined thorax, red antennae, dark femora, and clear wings with yellow costal cells.

There is some resemblance to *T. uniformis* Ricardo from Malaya, in which the thorax and femora are more brown, callosity is rounded below and more widely separated from eye margins, antennal plates more obtuse angulate, palpi less attenuated, and venter is black-haired with pale incisures. *T. cepuricus* Surcouf from Laos is also related but has frontal index of 1:5, eyes with three blue bands, and a black, median spot on tergite 2. From members of the *fumifer*-complex, in which the abdominal triangles have been obscured by wear, this differs in combination of white beard, unicolorous black eyes, red antennae, uniformly

reddish, black-haired fore tibiae and abdomen, the venter without dark, median pattern. *T. aurisparsus* Schuurmans Stekhoven has dark plates, bicolored eyes, and blunter palpi, as well as more abdominal pattern.

Description (holotype ♀).—Length, 17 mm. Frons gray-buff pollinose, narrowed below, index 1:7.2; callosity dark-brown, tall, ovoid, with four minute teeth across lower margin, separated from eyes and abruptly narrowed into a fine line which does not reach upper third of frons. Subcallus pale pinkish pollinose. Face and cheeks whitish pilose and pollinose. Antennae brick-red, style abruptly brown, black-haired basally, plate moderately excised, the tooth rectangulate, style not quite as long. Palpi flesh-colored, unusually slender and elongated apically, moderately swollen basally, black-haired.

Notum and scutellum blackish with gray pollinosity in form of obscure lines; sparsely black-haired, with some yellow ones around sides and margin of scutellum. Pleura gray with mixed black and pale pile. Femora dark-brown to blackish with gray pollen, the knees reddish, mostly black-haired, with yellow pile beneath on the last two pairs; tibiae uniformly reddish with black hairs, some rufous ones underneath. Wings slightly tinted, the costal cells pale yellow. No spur veins. Halteres yellowish-orange.

Abdomen dull reddish-brown, entirely black-haired except for scattered, inconspicuous, rufous hairs on sides and incisures, more noticeable below. In certain lights, a pair of faint, divergent shadows are suggested in the middle, anteriorly of tergite 2.

Type Material.—Holotype ♀, Borneo, Sandakan, 1927 (*Baker*). In USNM.

Remarks.—Two females from Malaya (*W. W. Macdonald*) appear to be this species, but minor variation prevents definite assignment without longer series. The frontal callosity practically touches eyes at lower corners, antennal plates are more excised with subacute, dorsal teeth, and venters are entirely rufous-haired. One (Jungle, Kepong Rd., 20. vi. no year), has pale straw-yellow beard, the other (Rantau Panjang, 9. ii. 1956, on cow) has eyes (relaxed) entirely greenish, and veins of radial sector noticeably brown-margined. Thoracic lines are not distinct in either.

Tabanus sphinx n. sp. (Fig. 20)

A rather small, dark-brown species with narrow, pale incisures widening into low, median triangles, basal and median frontal calli separated, two hind pairs of legs unicolorous, and glass-clear wings.

This appears to be quite distinctive in the Malaysian area.

Description (holotype ♀).—Length, 12 mm. Eyes minutely hairy, purple with three narrow, green bands (relaxed). Frons subparallel-sided, index 1:5.2, buff-gray pollinose, a darker patch in certain lights surrounding an isolated, spindle-shaped, blackish, median callus, a rugose, black "W"-shaped bare area across vertex, and dark-brown, quadrate, basal callosity touching eyes at lower corners. Subcallus pinkish pollinose. Face and cheeks creamy pollinose and pilose. Antennae red, scape black-haired and somewhat enlarged, cap-like over pedicel, plate rather broad and short, but little excised, the tooth low, obtuse; style black, shorter than plate. Palpi deep dull yellow, black-haired, scarcely enlarged basally, blunt apically.

Notum and scutellum blackish-brown, unlined, with sparse black and brassy hairs. Pleura pinkish-gray, mostly pale-yellow-haired. Legs reddish, mostly pale-yellow-haired including hind tibial fringe; fore femora, apical third of fore tibiae, and tarsi dark-brown. No spur veins. Halteres brown.

Abdomen light chocolate-brown above with black hairs, pale yellow ones narrowly on incisures, on low median triangles, and on outer corners of tergites. A blackish collar behind the scutellum on tergite 1, and on 2 a black ovoid spot above the median triangle.

Paratype ♀.—Except for duplicate data, this might have been considered at least subspecifically distinct. The abdomen is brightened, the callus at vertex is lacking, the basal callosity is taller, deep reddish and narrowly, though distinctly, separated from eyes, plate a little more excised and tooth more angulate, only apical annulus darkened, and fore legs unicolorous reddish like the others. In collection CBP.

Type Material.—Holotype ♀ Thailand, Chiengmai, 2. iii. 1952 (*D.C.* and *E.B. Thurman*). In USNM.

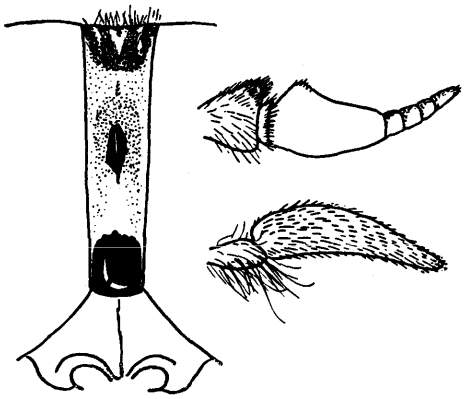


Fig. 20. *Tabanus sphinx* n. sp.

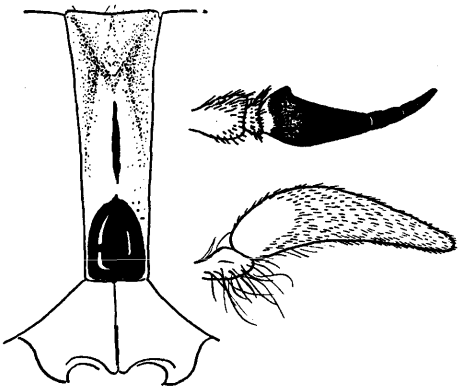


Fig. 21. *Tabanus subcanipus* n. sp.

Front, antenna, and palp

Tabanus subcanipus n. sp. (Fig. 21)

A medium-sized, purplish-red species with single, white abdominal stripe widened behind, wings infuscated baso-costally, rather wide front with subovoid red callosity not distinctly produced above, and black third antennal segment.

The abdominal stripe with bowed sides, and the isolated callosity, suggest *T. canipus* Schuurmans Stekhoven from Indonesia and Borneo, which, however, has clear wings, brown antennae, and no midventral black band.

Description (holotype ♀).—Length, 16.5 mm. Eyes (relaxed) blackish, unbanded. Frons pearlaceous-gray with an evanescent, brown, median spot, slightly narrowed below, index 1:4.3, a peculiarly rugose, black-haired triangle at vertex, very thin, short, median, reddish line indistinctly connected below to an isolated, reddish, pear-shaped callosity with rounded upper corners and tridentate lower margin. Subcallus pale pinkish, wrinkled. Face and cheeks whitish pilose and pollinose. Antennae long and slender, two basal segments pinkish with black hairs, the flagellum black with low, but acute, tooth and low hump on lower margin of plate. Palpi flesh-pink, little swollen, attenuated to a blunt point, mostly black-haired.

Notum and scutellum violet-reddish with indistinct gray lines, and sparsely pale yellow and black-haired. Pleura pinkish-gray with white pile. Femora bluish-gray with mostly pale hairs. Tibiae dull reddish, darkened on distal half of fore tibiae, mostly pale-haired including hind tibial fringe. Wings heavily and irregularly fumose anteriorly including basal, discal, and base of radial cells, the apex and hind margin clearer. No spur veins, cell R_5 wide open. Halteres smoky-brown, paler on the seams.

Abdomen bluish-black, black-haired, white-haired on tergal edges, a collar behind the scutellum and on a prominent, median stripe. The stripe crosses tergite 2, narrowly widens on 3 and 4, and stops abruptly on 5. Venter paler, gray-blue, white-haired, and a wide, black-haired, median band.

Paratype ♀♀.—10, same data as holotype, except different dates in v.-vi. In USNM and collection CBP. In two, the abdomen has brown shades laterally.

Type Material.—Holotype ♀, Cambodia, 40 km. W.S.W. Khong, 10. vi. 1952 (*C. Wharton*). In USNM.

Tabanus subhybridus n. sp. (Fig. 22)

A rather small, elongate, deep yellow species with broad, golden-yellow-haired stripe, orange appendages, and fumose wings with apical shadow.

Differs from the *hybridus* group, to which it most closely relates, as keyed. The lack of midventral dark patches, and dark upper facial hairs, removes it from the more yellow *hybridus*, to which it was at first assigned as an intensely colored variant.

Description (holotype ♀).—Length, 13 mm. Eyes (relaxed) greenish, unbanded. Frons narrow, a little divergent above, index 1:12, keel reddish-brown to upper third of frons, widened below but not touching eyes; frons, subcallus, face, and cheeks golden-yellow pollinose and pilose. Antennae orange, apical annulus brown, yellow and a few black hairs basally, plate slender and over twice longer than style, the tooth low, obtuse, the lower margin sinuous. Palpi yellow, somewhat thickened basally, rather pointed, with mixed yellow and black hairs.

Notum and scutellum rich olive-yellow pollinose overlying blackish integument, mostly deep yellow and sparsely black-haired. Pleura golden-yellow pollinose and pilose. Legs orange with concolorous hairs, the trochanters and tarsi blackish. Wings tinted, costal cells yellow, and a broad, smoky, apical shadow, cell R_5 open, no spur veins. Halteres orange.

Abdomen dark-orange with black hairs, golden-orange hairs on the edges, a few on the incisures, and on a broad, median stripe which widens to one-third the width of tergite 5; last two tergites blackish-brown without golden hairs. Venter orange pollinose and pilose, sternite 7 sharply black.

Type Material.—Holotype ♀, Malaya, Perak, 10 mi. W. Ipoh, 150′, 17. ix. 1958 (*R. Traub*). In USNM.

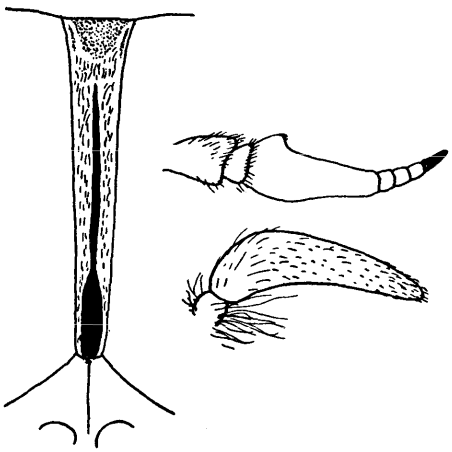


Fig. 22. *Tabanus subhybridus* n. sp.

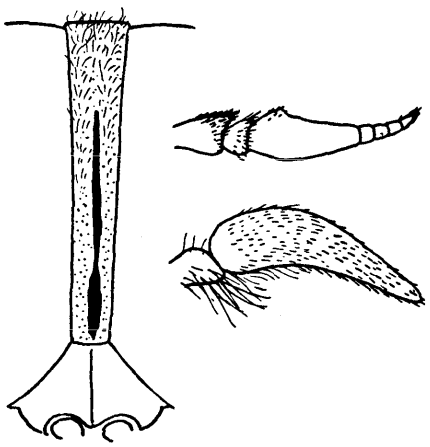


Fig. 23. *Tabanus taeniellus* n. sp.

Front, antenna, and palp

Tabanus taeniellus n. sp. (Fig. 23)

A small, dull, gray-brown species with single, pale, parallel-sided stripe on abdomen, very narrow frons, bicolored legs and clear wings.

T. agnoscibilis Austen of Thailand has obvious resemblance, but its beard and median stripe are pale yellow-haired, and tibiae not contrasting whitish. *T. hirtistriatus* Ricardo of Malaya is also close, but has a distinct apical shadow on the wings, the frons is more strongly convergent and narrower below, femora reddish on apical third or more, palpi more slender and black-haired, and antennal tooth rectangulate.

Description (holotype ♀).—Length, 11 mm. Eyes (relaxed) blackish, unbanded. Frons parallel-sided, index 1:8, buff-gray pollinose, a small, black, bare spot at vertex, callosity slender, keel-like but little expanded below, black, reaching to upper third of frons. Subcallus pale buff, face and cheeks whitish

pollinose and pilose. Antennae red, slender, black-haired on basal segments, plate with low obtuse tooth and longer than style, the apical annulus black. Palpi pale pink basally, attenuated apically, mostly white-haired.

Notum olive-gray pollinose with sparse pale and black hairs, scutellum black. Pleura, chest, and coxae pale gray pollinose, whitish pilose. Femora and apical third of fore tibiae black, whitish pilose on former with the extreme tips reddish. Tibiae pale straw-yellow to whitish with mostly white hairs. Wings with only costal cells faintly yellow, a short spur vein on one wing. Halteres orange-yellow.

Abdomen compact, blunt, the seventh tergite not protruded, blackish-brown with red shading on sides of tergite 2, a wide, gray pollinose, median stripe through tergite 6 with pale straw-yellow hairs. Venter blackish-gray, entirely pale yellow-haired.

Paratype ♀♀.—20, same data as holotype but various dates in vi. In USNM, Pasteur Institute, Paris, and collection CBP. The stripe is obscured in a few soiled specimens, and short spur veins are often present.

Type Material.—Holotype ♀, Cambodia, 40 km. W.S.W. Khong, 5. vi. 1952 (*C. Wharton*). In USNM.

Tabanus thurmani n. sp. (Fig. 24)

A medium-sized, orange-reddish species with tip of abdomen sharply jet black, antennae and bases of tibiae orange, wings with strong apical shadow.

T. joidus Bigot of Assam and *T. siamensis* Ricardo of Thailand are obviously related. The former, of which I have a homotype from Ledo, Assam (and probably composite in redescription by Ricardo, 1911*a*) has a longer, narrower abdomen, predominantly black-haired, though the venter is similarly banded, the thoracic integument is reddish-brown, pleural hairs pale yellow, and bases of tibiae broadly white with concolorous hairs. Austen has stated that the type of *T. siamensis* is unnaturally denuded, and discolored after preservation in spirit, which accounts for the "shining black" thorax, but abrasions in spots shows *thurmani* also blackish under the dense olive-orange pollinosity. However, *siamensis* differs in suggestions of median triangles (*see* key in Austen, 1922), partly yellow fifth tergite, and yellow hair fringes on the fifth and sixth sternites, but entirely yellow-red venter not basally banded; palpi are pale yellow with some pale hairs, and tibiae are said to be black-haired. The inadequately described *T. pseudopallidepectoratus* Surcouf from Laos could be the same, but, by inference from comparison with *T. pallidepectoratus* Bigot, is a larger insect than *T. thurmani*, the two hind pairs of tibiae more broadly reddish, tergite 5 with a yellow hair fringe, pale pollinose, and beard possibly yellow rather than brown. *T. xanti* Szilàdy from Celebes differs in basal four tergites black-haired, yellow fringes on last two, as well as no midventral black spots on sternites 2 and 3.

Description (holotype ♀).—Length, 14 mm. Frons, subcallus, face, and cheeks, reddish-brown pollinose with dark brown beard; the first slightly convergent below, index 1:7; the callosity long, ovoid, separated from eyes, and tapered above into a fine line which reaches the upper third. Antennae brown-haired basally, the plate rather slender, subrectangulate dorsally, gently excavated, and distinctly longer than the orange style. Palpi dull reddish, entirely black-haired, rather slender, not sharply pointed.

Thorax and scutellum deep olive-yellow with rufous and some inconspicuous black hairs on dorsum and pleura. Femora and apical half of fore tibiae subshiny black with black hairs, fore tibiae basally reddish-orange, and mid and hind tibiae entirely reddish-orange, with concolorous hairs, darkening to brown on the apical fourth to third. Wings yellowish with a smoky apical shadow, no spur veins, cell R_5 open. Halteres orange-yellow.

Abdomen with basal four tergites orange-red entirely covered with dense golden-rufous hairs, jet black thereafter. Venter broadly orange on sides of first three sternites, narrowly so on sides of four, and with broad orange incisures, and median black spots increasing in size caudad; sternites 5 to 7 black, entirely black-haired, the incisures of 5 and 6 very narrowly yellow pollinose but black pilose.

Type Material.—Holotype ♀, Thailand, Chiengmai, 24. v. 1952 (*D. C. Thurman*), in house at foot of mountain. In USNM.

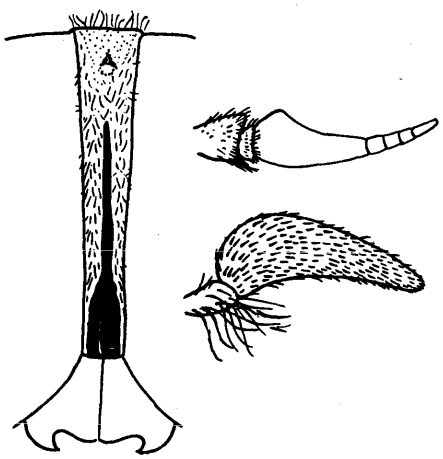


Fig 24. *Tabanus thurmani* n. sp.

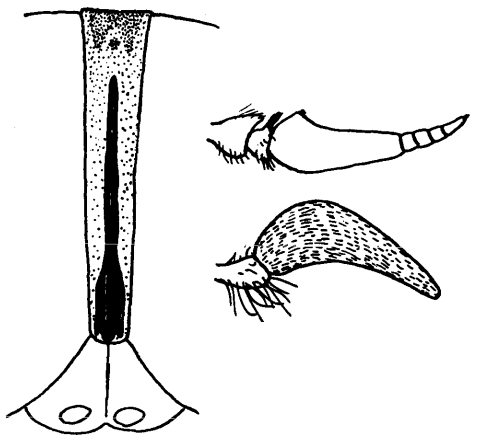


Fig. 25. *Tabanus traubi* n. sp.

Front, antenna, and palp

Tabanus toumanoffi n. sp.

This is a rather small, yellow-brown species of the *flexilis*-group with contrasting gray scutellum, bifasciate wing, closed cell R_5, narrow front, red antennae and blackish legs.

The wing and body patterns are very similar to *T. flexilis* Walker of Celebes and *T. vanderwulpi* Osten Sacken of the Philippines; variations in coloration and closure of cell R_5 of these are discussed elsewhere (Philip, 1959). The present species is much smaller than either, has spur veins, and abdomen more reddish basally and less prominently banded. *T. indonesiensis* and *T. granti* from Cambodia (Toumanoff, 1950) are also obvious relatives. While the former has similar body colors, and short spur veins, it differs in the apical band filling the marginal cells to the hind margin and the first basal cell completely fumose. *T. granti* is larger, has dark, unbanded abdomen, and no conspicuous inner band at apices of basal cells.

Description (holotype ♀).—Length, 14 mm. Eyes (relaxed) uniformly greenish. Frons buff-gray pollinose, nearly parallel-sided, index 1:7.5; the callosity black, keel-like, but little expanded below and not touching eyes, but extended to upper third of frons. Face and cheeks pale buff pollinose and pilose. Antennae red, sparse, black hairs basally, plate longer than black style, the tooth low, rectangulate. Palpi flesh-pink, somewhat swollen basally, pointed apically, with yellow and a few black hairs.

Thorax gray-brown, the scutellum and pleura contrasting dirty-whitish with pale yellow hairs; notal hairs sparse, yellow and black intermixed. Legs black, with brown shades on tibiae, mostly black-haired with some pale hairs at bases of femora. Wings with a rather narrow, inner band across the apices of the basal cubital and anal cells, and a wider outer one which leaves apex in most of cell R_4 and the hind margin clear.

Abdomen orange-reddish basally, darkening caudally with prominent, pale yellow incisures from segment 3 on, golden-yellow-haired laterally, on tergal incisures, and on entire venter; sparsely black-haired elsewhere.

Paratype ♀♀.—4, same data as holotype, in USNM, Pasteur Institute, Paris, and collection CBP. In close agreement including closed and petiolate cell R_5. The abdomen in one is darker brownish basally and ventrally.

Type Material.—Holotype ♀, Cambodia, 40 km. W.S.W. Khong, 5. vi. 1952 (*C. Wharton*). In USNM.

Tabanus traubi n. sp. (Fig. 25)

A rather small, unmarked yellow species, including appendages, narrow frons and broad apical shadows. Predominantly golden-yellow-haired.

There is some resemblance to *T. flavissimus* Ricardo of Ceylon which is a much larger insect, and has more slender, shorter, antennal plate, and wings with spur veins and no apical shadow. Resemblance to some yellow *Cydistomyia* is apparent, but the setulose subepaulets here are distinctive.

Description (holotype ♀).—Length, 11.5 mm. Eyes (relaxed) green. Frons golden-yellow pollinose, slightly narrowed below, index 1:9.3; callosity and keel mahogany-brown, separated from eyes below, the lower margin tridentate as figured. Subcallus golden pollinose, face and cheeks dirty yellow, beard bright yellow. Antennae orange, yellow-haired basally, plate slender and nearly twice longer than style, tooth low. Palpi orange with concolorous hairs, swollen basally and rather pointed. Theca yellow, labella dark-brown, small.

Notum and scutellum olive-yellow, unlined, overlying dark integument, denuded but apparently yellow-haired. Pleura pale yellow with bright yellow hairs. Legs orange with concolorous hairs, the trochanters and tarsi but little darker. Wings with costal cell intense yellow, the first basal, and base of cell R_3, yellow, translucent behind, an intense, apical, smoky shadow in radial sector beyond stigma which fades in the medial cells and in centre of cell R_4. No spur veins. Halteres orange.

Abdomen orange-red with concolorous hairs, a little paler below, the seventh segment inconspicuous but black and black-haired.

Type Material.—Holotype ♀, Malaya, Kedah, Langkawi Island, 2000′, 15-16. vii. 1958 (*R. Traub*). In USNM.

Tabanus vix n. sp. (Fig. 26)

A medium-sized, golden to orange-brown species with a row of large, golden-haired triangles that cross some tergites, no dark mid-ventral spots, antennae dark-brown, beard white, frons very narrow, and wings subhyaline with yellow costal cells.

This must be close to what Miss Ricardo (1911*a*) redescribed rather inadequately as *T. dives* Rondani (a composite species) after seeing the type. Their distinctness is convincing only when compared together. As *T. dives*, I have selected the form that approaches *T. stantoni* Ricardo of Malaya, which she considered "close if not identical." A Sandakan, Borneo, specimen differs from *vix* in having the pleura, chest, and face more grayish pollinose, the palpi paler flesh-pink, and the abdomen richer brown with narrower, golden-haired incisures which are not as broadened at the outer corners, the median triangles more equilateral and not as tall, and in some lights an accentuation of darker shadows outlining the triangles on tergites 3 to 5 which probably would be even less evident in worn specimens.

Description (holotype ♀).—Length, 16 mm. Eyes (relaxed) blue above, greenish on the lower half. Frons narrow, narrowed below, index 1:10.5, buff pollinose, callosity narrow, reddish, keel-like, separated from eyes and from top of buff-yellow subcallus, reaching upper fourth of frons. Face pale yellow grading to gray on lower cheeks. First two antennal segments reddish with black hairs, lacking the gray pollinosity seen in *dives*; third segment dark-brown, deeply excised, the tooth acute, style about two-thirds the length of the plate. Palpi reddish-yellow, black-haired, attenuated, but not sharply pointed.

Notum and scutellum reddish-brown covered with olive-greenish pollinosity when not discolored. Pleura, chest, and legs pale buff-reddish, with mostly pale hairs, the femora a little darkened. Cell R_5 open, no spur veins. Halteres pale yellow.

Abdomen as described, the incisures widely honey-yellow, accentuated by golden hairs, basally the short, black hairs rather inconspicuous and darkening the pattern but little. Venter entirely reddish-orange, the incisures paler, covered with golden-yellow hair.

Paratype ♀♀.—9, same data as holotype and in close agreement, the distinctness of abdominal pattern sometimes reduced by wear. There is an occasional tendency for accentuation of the triangles by expansion on tergites 4 and 5 to suggest a continuous median line of truncated spots.

Type Material.—Holotype ♀, British North Borneo, Langkom Kudat, 1938 (*L. M. Yutuc*). In USNM.

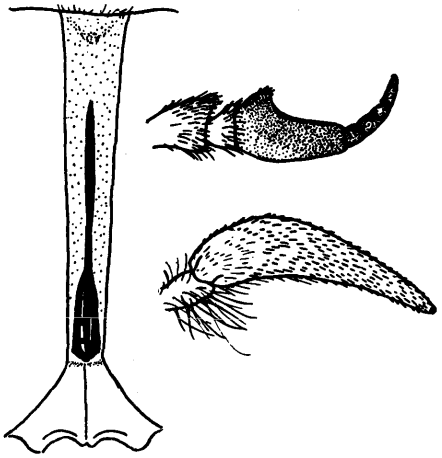


Fig. 26. *Tabanus vix* n. sp.

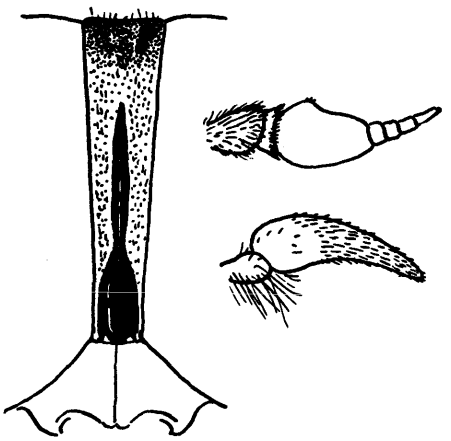


Fig. 27. *Tabanus zoster* n. sp.

Front, antenna, and palp

Tabanus xanthoimus n. sp.

A medium-sized, elongate, yellow-brown species with a single, golden, abdominal stripe in the form of a continuous row of tall, truncated triangles; long red antennae, and with costal and apical shadows on the wings.

The species is related to *T. flavistriatus* Schuurmans Stekhoven from Sumatra but differs in having white hairs of beard, pleura and coxae, unlined notum, and two caudal segments sharply black. *T. auristriatus* Ricardo from Kanara, India, has darker antennae and foretibial bases, thicker palpi, and yellow-haired incisures. The callosity is separated from the eyes in both of these species. *T. aurilineatus gilvilineis* n. ssp. from Thailand is close but differs in darker callosity separated from eyes, heavier keel above, darker brown dorsum with narrower, less serrated midline, pale hairs on base of mid-tibia, and last two abdominal segments not black. *T. fulvimedius* Walker and *T. pugnax* Austen from Taiwan, India, and/or Thailand have beards and abdominal incisures yellow-haired, and wings not as heavily fumose along costal margin; the antennal plates of the latter are shorter and broader.

Description (holotype ♀).—Length, 16 mm. Eyes bare, plain greenish (relaxed). Front narrow, index 1:8.0, slightly widened above, dull yellow pollinose with short, black hairs, no bare spot at vertex; callosity tall, tridentate and touching eyes below, yellow, tapering gradually into a dark-brown, median keel which is attenuated about one-third distance from vertex. Subcallus and upper cheeks, golden-yellow pollinose. Face and cheeks buff-gray with white beard. Antennae long and slender, entirely reddish, two basal segments black-haired; plate a little over twice longer than wide and than the annuli, the dorso-basal tooth low but acute. Palpi long, slender, blunt apically, covered with black hairs, white ones on the basal segment. Proboscis dark-brown.

Notum and scutellum golden-yellow pollinose and pilose with a few black hairs, unlined. Pleura, chest, and coxae abruptly buff-gray with whitish hairs. Legs brown with mostly black hairs, the tibiae paler basally with pale yellow hairs on the mid-pair, the fore-pair dirty-whitish and white-haired on basal half. Wings tinted, the costal margins brown to the apex; cell R_5 open, no spur veins, subepaulets setose. Halteres brown.

Abdomen yellow-brown, the last two segments above and below abruptly black, covered with black hairs; a row of yellow, golden-haired triangles and patches of yellow hairs on the outer corners of tergites 2 to 4 not connected along the incisures, a small, yellow spot on the anterior half of tergite 6 which terminates the midabdominal stripe. Sternites 1 to 5 yellow, black-haired with pale yellow hairs on sides and hind margins.

Type Material.—Holotype ♀, Assam, Ledo, viii. 1945 (*W. L. Jellison*). In collection of CBP as a gift from the collector.

Tabanus xuthus n. sp.

A medium-sized species with unicolorous black eyes (relaxed), dark thorax, and red abdomen without distinct pattern, red antennae resembling *T. ruficoloratus* above, but this has wider, parallel-sided front, more reddish hind legs, and paler vestiture underneath with a mid-ventral row of black-haired patches.

Description (holotype ♀).—Length, 18.5 mm. Frons buff-gray pollinose, index 1:5.6, suggestion of a low ocellar bulla in a patch of black hairs below the vertex, callosity tall, ovoid, dark-yellow gradually tapered into a strong, median keel to the upper third of frons. Subcallus and upper cheeks pale-creamy pollinose. Face and lower cheeks pearlaceous-whitish pollinose and snow-white pilose. Antennae brick-red, black-haired basally, plate a little shorter and wider than in *ruficoloratus*, the tooth obtuse, style abruptly black and shorter than plate. Palpi not quite as pale creamy as subcallus, sparsely black and white-haired, moderately thickened basally, slender and elongate apically.

Notum and scutellum blackish, without distinct lines, scattered dark and pale-yellow hairs with whitish patches around hind margin. Antealar tubercles brighter reddish than preceding. Pleura pinkish-gray with mostly whitish pile. Coxae, fore tibiae, except at apex, and two hind pairs of legs pinkish with mostly whitish hairs and a few scattered black hairs, accentuated on hind tibial fringe; fore femora dark, heavily gray pollinose with black hairs inwardly, white outwardly. Wings glass-clear, no spur veins. Halteres orange.

Abdomen brick-red above with indistinct, darker shadows across incisures, and obscure, paler, sublateral spots in certain lights, but entirely black-haired except for whitish along the extreme edges. Venter orange-red, whitish-haired along sides and narrowly white-haired across incisures, the integument but little darkened beneath large, median patches of black hairs.

Type Material.—Holotype ♀, "Trong Lower Siam", (*Dr. W. L. Abbott*). In USNM.

Tabanus zoster n. sp. (Fig. 27)

A small, brown species with lined thorax, narrow, pale, abdominal bands, short, broad, red antennae, mid legs unicolorous reddish but fore and hind femora dark-brown, and wings glass-clear with short spur veins. Upper eye facets of male strongly enlarged, the head subhemispherical and wider than thorax.

This is obviously related to *T. multicinctus* Schuurmans Stekhoven and *T. equicinctus* Schuurmans Stekhoven, but is separable on characters in the key.

Description (holotype ♀).—Length, 10 mm. Eyes (relaxed) black, unbanded. Frons dark-gray pollinose sides nearly parallel, index 1:6.2; callosity dark-brown, tall, triangular, tridentate at base, extending as median keel to upper third of frons. Subcallus and upper cheeks buff-gray. Face and lower cheeks whitish pollinose and pilose. Antennae orange-red, black-haired basally, plate short and nearly as tall as long, mildly excised, the tooth low, obtuse; annuli a little darker and nearly as long. Palpi pale yellow, swollen basally, and pointed, sparsely black and white-haired.

Notum and scutellum dark-brown, the former with a pair of brown, longitudinal lines above each wing base, the antealar tubercles and upper pleura dull pinkish, darkening to ash-gray on the chest. Fore and hind femora, and apical half of fore tibiae blackish-brown, the remainder pale reddish, the mid femora only slightly darker than mid tibiae, mostly pale-haired including hind tibial fringe. Halteres pale brown.

Abdomen dull reddish-brown becoming black on last three tergites, the seventh unusually prominent; all incisures but the first contrasting pale pollinose and pilose. Venter pinkish with pale-yellow hairs.

Allotype ♂.—Like the female and readily associated. A little lighter brown over-all, with thoracic lines less distinct. Enlarged eye facets occupying upper three-fourths of area, a wide band of small facets extending upward on occipital margin to vertex. Tubercle in occipital notch depressed below eye level. Palpi are short, ovoid, mostly white-haired.

Paratypes.—♂, 4 ♀♀, same data as holotype. In unworn specimens there are suggestions of expansion of the incisural bands to form pale yellow-haired, low, median triangles. One female has entirely white-haired palpi. In Com. Dis. Center Museum, Atlanta, Georgia, and collection C.B.P.

Type Material.—Holotype ♀ and allotype ♂, Thailand, Chiengmai, "in hot spring," 5. iii. 1952 (*D. C.* and *E. B. Thurman*). In USNM.

Tribe CHRYSOZONINI

Chrysozona abacis n. sp.

A small, delicate, dark-brown species without unusual features, but characterized by transverse, black callosity, slender, reddish antennae, chocolate-brown abdomen with gray bands, sublateral spots and a tall triangle on tergite 2, and the two hind pairs of tibiae with double pale rings. Named for the mosaic-like wing pattern.

Though generally smaller, it has some points in common with *H. lata* Ricardo and *H. immaculata* Ricardo of India, and *H. irrorata* Macquart of Malaysia, including single, incomplete, apical wing-band, and often a brown, crescentic spot on each parafacial. The first differs in more robust antennae, scape with an apical tooth and a little longer than plate, paler reddish legs, and pale triangles on the hind margins of cubital and M_2 cells. *H. immaculata* has taller, straight-margined callosity, no black spot between the antennae, brown, unlined thorax, and pale bars instead of paired spots toward the hind border of the marginal cells. *H. irrorata* has a narrower front, more reddish legs and abdominal base in addition to the keyed differences.

Description (holotype ♀).—Length, 7 mm. Frons broader than tall, gray pollinose with the paired spots black, rounded and isolated, the median one small and inconspicuous; callosity narrow, black, transverse with sinuous margins; a small, velvety blackish-brown spot between the antennae. Face gray with a pair of rather small, triangular, brown spots on the parafacials. Antennae cylindrical, slender, reddish, with black style, no apical tooth on the scape which is distinctly shorter than the plate. Palpi robust, blunt, brown with black hairs.

Thorax blackish with gray pollen anteriorly and across the praescutellum and base of scutellum. Pleura gray with white hairs. Fore coxae reddish, femora blackish-brown, with white hairs; tibiae dark-brown with two pale yellow rings on the two hind pairs, and a basal one on the fore pair. Wings with punctations fine and discrete in outer half, tending to be confluent from base of the discal cell inward; apical band single, rather heavy across cell R_3 from costal border, but broken thereafter with a small spot on the hind margin. No pale spots along hind margin in the marginal cells.

Abdomen chocolate-brown above, steel-gray with white hairs below; first tergite predominantly gray pollinose; tergites 2 to 4 with prominent, gray incisures and lateral margins, a tall, narrow, gray triangle crossing tergite 2; rows of sublateral, rounded gray spots on sides of tergites 2 to 5; entirely dark terminally.

Type Material.—Holotype ♀, Thailand, 29. iv. 1947, lot 1373. In collection CBP, through the courtesy of Dr S. Devakula.

Chrysozona cingulata (Wiedemann).

1828, *Haematopota cingulata* Wiedemann, *Auss. zweifl. Ins.*, *1*: 216.

1926, *Chrysozona cingulata* (Wiedemann). Schuurmans Stekhoven, *Treubia*, *6* (Suppl.): 75.

The peculiar, diagonal, pale bands on the wings and the broad, midthoracic band readily distinguish this Javanese species of which I have also seen females from Borneo. Schuurmans Stekhoven (1926) has described the only known males, and he states that the wing pattern is the same as in the females. For this reason I am doubtful about a male from Thailand (Chiengmai, vii. 1952, *D. C.* and *E. B. Thurman*) which differs in having the three diagonal pale streaks elongated, the medial cells shortened with base of M_2 widened (compared to females from N. Borneo) so that the "eye spot" is lengthened into a narrow, dark band which runs from the fork of R_{4+5} across all outer crossveins and to the base of the wing along the cubital stem, and the submarginal dark band also continues from an expanded costal spot beyond the stigma to wing base. The other peculiar characters, however, are in agreement with his description, i.e., the shape of the antennae, bare frontal triangle, and unicolorous tibiae and abdomen, except for the contrasting, pale gray tergite 1, which he does not mention.

Without corroborative females the identity of this specimen from Thailand remains doubtful.

Chrysozona jellisoni n. sp.

A small, dark-brown species with distinct, gray, tergal incisures and sides of tergites but no spots; single, broad, apical wing band, slender antennae, and white tibiae with black apices which relate to Ricardo's (1911*b*) group II.

C. indiana (Bigot) and *C. cana* (Walker) have abdominal stripes or spots. *C. borneana* (Rondani) has a lined notum but unlined pleura. *C. equitibia* Schuurmans Stekhoven also lacks basal tibial rings but differs in having a spot between the antennae, incomplete, apical wing band and no pleural stripes.

Description (holotype ♀).—Length, 9.5 mm. Front about as tall as broad, gently narrowed above, sparsely gray pollinose to subshiny black in the middle, the callosity black, transverse, narrow, and produced downward between the antennae as a red triangle; the paired spots moderate and rounded, the median spot very small. Face and cheeks gray pollinose with sparse, yellowish beard; a pair of small, lateral, black, transverse dashes. Antennae slender, red darkening on the plates to black on the annuli; no apical notches on the cylindrical scapes which are subequal in length to the plates. Palpi dirty-brown with black hairs, a little thickened basally.

Notum and scutellum chestnut-brown with appressed, brassy, and a few black, hairs; three narrow, faint, gray stripes anteriorly. Pleura chestnut-brown, with a distinct, gray stripe in front of the wing bases, and yellow to brown hairs. Coxae with yellow hairs; femora dark-brown with black hairs; fore tibiae on basal half, and two hind pairs on basal three-fourths, white with white hairs, also bases of mid and hind tarsi, remainder dark-brown with black hairs. Wings brown, the punctations small and distinct without accentuated rosettes, the apical band complete and unusually broad behind, all cells on the hind margin with apical triangles. Halteres brown on the knobs.

Abdomen chocolate-brown above and below with black hairs and distinct, though narrow, pale, incisural bands with whitish hairs that envelop the sides of the first two tergites but only widen on the third.

Type Material.—Holotype ♀, Assam-Burma area of the Ledo Road, 1945 (*W. L. Jellison*). In collection CBP.

Chrysozona lineola n. sp.

A rather large, dark fly with contrasting punctations on wings, no prominent thoracic stripes, but a broad, whitish midstripe on abdomen composed of truncated triangles unaccompanied by pale spots or incisures.

C. javana (Wiedemann) and *C. punctata* (Bigot) have less conspicuous abdominal stripes, but also pale spots or incisures, and the apical bands of wings are double.

Description (holotype ♀).—Length, 10 mm. Frons buff-gray pollinose, about as tall as wide, the sides parallel; median spot minute, paired spots rather small, sub-triangular; basal callosity narrow, dark-brown, almost straight across top except for a low median point. A large, black, velvety triangle between antennae. Face and cheeks whitish pollinose and pilose, a wide, velvety-black band across the top beneath the antennae. Antennae light-brown, scapes a little longer than hind metatarsi, smooth, robust but hardly swollen, covered with black hairs, not constricted or produced apically; plates a little shorter and widened basally to about thickness of scapes, darkening apically, the style black. Palpi dirty-yellow, nearly as long as proboscis, somewhat thickened basally, black-haired.

Notum dull, brownish, inconspicuously lined only anteriorly, antealar lobes and scutellum concolorous, but propleural lobes pale gray, covered with brassy hairs; no gray band across praescutellum, but apex of scutellum indistinctly paler. Pleura and coxae pale pinkish pollinose with pale yellow hairs. Legs blackish-brown with wide, white bands at bases of fore coxae and all tibiae, less prominent ones at distal third of two hind pairs of tibiae, the corresponding metatarsi pale. Wings brown, the punctations discrete and contrasting with double rosettes about the cross-veins and fork, the outer half of discal cell with a pair of spots, and an apical cross-bar, the marginal spots long and narrow almost crossing the apices of all marginal cells but M_3. Apical band single, heavy at fore and hind margins, tapering and disconnected inwardly, so that the points overlap behind vein R_4; an inconspicuous spur resting on R_5 might connect to the inner point in other specimens. Halteres brown with pale seams.

Abdomen elongate and but little tapered, black dorsally, the mid-stripe composed of connected, tall, truncate triangles, only tergite 2 with an indistinct narrow, gray, hind margin which widens to cross the entire lateral margins; outer corners of remainder gray; vestiture black, white over pale markings. Venter pale gray, white-haired laterally, with a contrasting broad, black, median band.

Type Material.—Holotype ♀, Thailand, Tak, Pra Tung Chung, 18. vii. 1952 (*D. C. Thurman*), taken on river raft. In USNM.

Nomenclatural Changes

Szilàdy (1926) proposed the following new names for preoccupied names of Oriental-Malaysian species published by Schuurmans Stekhoven (1926): *T. bipustulatus* for *T. bipunctatus* from New Guinea (uncertain position, Oldroyd, 1949); *T. fenestralis* for *T. fenestratus* from Hong Kong; *T. nigrinus* for *T. nigerrimus* from Sarawak, Borneo; *T. frondosus* (syn. *T. paralatifrons* Schuurmans Stekhoven, 1928) for *T. latifrons* from India; and *T. schurmansi* (sic, herewith emended *T. schuurmansi*) for *T. ruficornis* from "Java?".

New names proposed for other preoccupied names of Schuurmans Stekhoven, regarding which he was previously notified without indicating corrective response, are as follows: *T. longicornutus* for *T. longicornis* (1926) from Java (not *T. longicornis* Fabricius, 1775, *Syst. Ent.*, p. 790, Brazil=*Acanthocera*); *T. abaurantiacus* for *T. aurantiacus* (1930) from N. Celebes (not *T. aurantiacus* Bellardi, 1859, *Sag. ditt. mess.*, *1*: 67, Mexico); and *T. exolivaceus* for *T. olivaceus* (1926) from New Guinea (uncertain position, Oldroyd 1949, but type seen in Amsterdam by me, 1958, has hairy subepaulets; not *T. olivaceus* DeGeer, 1776, *Ins.*, *6*: 230, Surinam=*Chlorotabanus mexicanus* (Linn.)).

Under the Rules, *T. flavistriatus* Schuurmans Stekhoven (1926) from Sumatra preoccupies *T. flavostriatus* Kröber, 1929, *Konowia*, *8*: 188, from Argentina, and *T. flavolineatus*, new name, is proposed for the latter. Similarly, *T. flavocinctus* Bellardi, 1859, *Sagg. ditt. mess.*, *1*: 61, from Mexico (= *Hybomitra zonalis* (Kirby)) preoccupies *T. flavicinctus* Ricardo, 1911, *Rec. Indian Mus.*, *4*: 130, from India, and *T. gertrudae*, new name, is proposed for the latter. Also "Atylotus" (= *Tabanus*) *flaviventris* Bigot, 1892, *Mem. Soc. zool. Fr.*, *5*: 657, from Assam is preoccupied bv "Tabanus" (= *Stibasoma*) *flaviventris* Macquart, 1847, *Dipt. exot.* Suppl. *3*: 171, from Rio Negro, South America, and *T. ochrogaster*, new name, is proposed for the former. For those who still consider that *Sziladynus* (= *Hybomitra*) is at most a subgenus of *Tabanus*, *S. atripes* Kröber, 1934, *Ark. Zool.*, *26A*: 5, from China, is preoccupied by *T. atripes* van der Wulp, 1885, *Notes Leyden Mus.*, 7: 75, but I consider these as separate genera and hence do not consider that a new name is needed.

Dr. Alan Stone has called the writer's attention to two primary homonyms used in a previous report (Philip, 1956) on Far Eastern species. (a) *Tabanus auriventer* Schuurmans Stekhoven (1926) from Java preoccupies *T. auriventer* Philip (1956) from Korea, and *T. auriventralis*, new name, is proposed for the latter. (b) *T. griseus* Taylor (1919) from Queensland preoccupies *T. griseus* Kröber (1928) from Amur and reported by me from Manchuria; *T. griseinus*, new name, is proposed for Kröber's East Asian species.

Acknowledgments

Some of the material discussed in this report came from Dr Rupert L. Wenzel of the Chicago Natural History Museum and from Dr Max Beier of the Naturhistorisches Museum, Zoologische Sammlung, Vienna. Help from other individuals is acknowledged in appropriate places while sources of other collections studied are acknowledged in the following report, together with credit for study of pertinent types in European museums. At the suggestion of Dr I. M. Mackerras, Director of the Queensland Institute of Medical Research, who read the manuscript, several species discussed here were extracted from the larger report on Philippine species (1959) with improvement of both reports. Dr J. H. Schuurmans Stekhoven, Jr. supplied information on certain of his East Indian species.

SUMMARY

Described as new are: *Rhinomyza cincta*, *Tabanus abaculus*, *T audyi*, *T. macdonaldi*, *T. subhybridus*, *T. traubi* (holotype females from Malaya); *Chrysops stekhoveni*, *T. abbasalis*, *T. acuminaris*, *T. anabates*, *T. flavohirtus*, *T. pendleburyi*, *T. ruficoloratus* (holotype females from Borneo); *C. indiana* ssp. *thailandensis*, *T. ardalus*, *T. fulvilinearis*, *T. aurilineatus* ssp. *gilvilineis*, *T. griseilineis*, *T. konis*, *T. nilakinus*, *T. sphinx*, *T. thurmani*, *T. vix*, *T. xuthus*, *T. zoster*, *Chrysozona abacis*, and *C. lineola* (holotype females and holotype male of *T. gilvellus* from Thailand); *Cydistomyia mackerrasi* and *Cyd. rozeboomi* (holotype females from New Guinea); *Chrysozona jellisoni*, *T. xanthoimus* (holotype females from Assam); *T. annamensis* (holotype female from Annam); *T. abauristriatus*, *T. cambodianus*, *T. fascius*, *T. toumanoffi*, *T. subcanipus*, and *T. taeniellus* (holotype females from Cambodia).

Nomenclatural changes include the following new names: for Schuurmans Stekhoven's species, *T. longicornutus* for *T. longicornus* from Java, *T. abaurantiacus* for *T. aurantiacus* from N. Celebes, and *T. exolivaceus* for *T. olivaceus* from New Guinea; *T. flavolineatus* for *T. flavostriatus* Kröber (not Schuurmans Stekhoven), *T. gertrudae* for *T. flavicinctus* Ricardo (not Bellardi); *T. ochrogaster* for *T. flaviventris* Bigot (not Macquart); *T. auriventralis* for *T. auriventer* Philip (not Schuurmans Stekhoven); and *T. griseinus* for *T. griseus* Kröber (not Taylor).

REFERENCES

For citations not listed below, such as Ricardo and Schuurmans Stekhoven, see more complete bibliography at the end of the following paper of this *Study* (Philip, 1960).

KRÖBER O. (1928). Neue palaearktische Tabaniden. *Zool. Anz.*, *76*, 261-272.

OLDROYD H. (1947). The Diptera of the Territory of New Guinea. XIV. Family Tabanidae. Part II. Pangoniinae, except the genus *Chrysops*. *Proc. Linn. Soc. N. S. W.*, *72*, 125-142.

OLDROYD H. (1949). The Diptera of the Territory of New Guinea. XIV. Family Tabanidae. Part III. Tabaninae. *Proc. Linn. Soc. N. S. W.*, *73*, 304-361.

PHILIP C. B. (1956). Records of horseflies in Northeast Asia (Diptera, Tabanidae). *Jap. J. san. Zool.*, *7*, 221-230.

PHILIP C. B. (1957). A new era in ideas of systematic relationships of world Tabanidae inaugurated by Mackerras, and its impact on nomenclature of horseflies of the Western Hemisphere. *Ann. ent. Soc. Amer.*, *50*, 550-555.

PHILIP C. B. (1960). Malaysian Parasites, XXXVI. A summary review and records of Tabanidae from Malaya, Borneo, and Thailand. *Stud. Inst. med. Res. Malaya*, *29*, 33-78.

TAYLOR P. H. (1919). Australian Tabanidae [Diptera] No. IV. *Proc. Linn. Soc. N. S. W.*, *44*, 41-71.

MALAYSIAN PARASITES XXXVI

A SUMMARY REVIEW AND RECORDS OF TABANIDAE FROM MALAYA, BORNEO, AND THAILAND

BY

CORNELIUS B. PHILIP*

Rocky Mountain Laboratory, Hamilton, Montana

The present summary grew out of the preceding article (Philip, 1960) which provided descriptions of a number of new species of Malaysian and Oriental Tabanidae. The countries and islands included in this discussion admittedly do not comprise any natural zoogeographic subdivision of the Malaysian Archipelago as proposed by others in studies of other biological groups (references in Darlington 1957, Philip 1959). Local sampling in this family, however, has obviously been inadequate either to provide a more representative distributional report or to permit more than speculation regarding any zoogeographic evidence the family may provide in the over-all, bio-historical record of this area. This report, with keys for the identification of known indigenous species, can perhaps accelerate accumulation of data and material which will widen our knowledge of this parasitic group in the region. Interest in its faunal composition has been stimulated by the recent centenary ceremonies in Singapore commemorating Darwin and Wallace, with Haldane's (1959) address as a highlight.

In spite of the relative paucity of material, I have been fortunate to see pertinent types and specimens in the British Museum (Natural History) (BMNH), including two boxes, placed at my disposal by Mr H. Oldroyd, which were originally in the Raffles Museum, Singapore. Types and some other Indonesian specimens of Schuurmans Stekhoven in Natura Artis Magistra, Amsterdam, were seen through the kindness of Dr C. A. W. Jeekel. A few of Macquart's pertinent types were also studied in the Paris Museum through the courtesy of Professor E. Sèguy. Opportunity for these studies was provided through a travel grant from the Marsh Fund of the National Academy of Sciences.

Records were augmented by a few collections from Dr Robert Traub of the U. S. Army Medical Research Unit in Malaya and by a few specimens taken by me while a member of the first team of that unit in 1947. In addition, Mr W. W. Macdonald provided specimens from the Institute for Medical Research, Malaya. A small collection by Drs D. C. and Ernestine B. Thurman from Thailand was also placed at my disposal by Dr Harry Pratt of the Public Health Service, Atlanta, Georgia. The systematic revision of the family by Dr I. M. Mackerras (1955) has been followed in higher groups; in addition he also gave valuable advice and collaborated with me (1960) in a review of certain Far Eastern Chrysopinae, which resulted in the assignment of 3 Malayan species to a new genus near *Gastroxides*†, and one is here added to *Rhinomyza*.

Historical Background

As happens with other parasitic groups in this and other areas, early attention has been mainly of a sporadic and incidental nature dealing with occasional species found in scattered collections, of which a report by Pratt (1907) on a few Malayan tabanids is an example. Ricardo (1911 *a*, *b*) reviewed some species known from the Malay Peninsula in her treatment of Oriental species, and Austen (1922) added 8 new species from a limited collection to the total of only 6

* From the U.S. Department of Health, Education, and Welfare, Public Health Service, National Institutes of Health, National Institute of Allergy and Infectious Diseases, Rocky Mountain Laboratory, Hamilton, Montana.

† Owing to delay in the publication of Philip and Mackerras (1960), it is not possible to include in this *Study* the new names proposed in that paper. In particular, the three species referred to above as belonging to a new genus will be found here under "*Gastroxides*".

previously known from Thailand (Siam). Incidental to a more comprehensive monograph of Indonesian species, especially of Sumatra and Java, information on most of those species known from present areas was also reviewed by Schuurmans Stekhoven (1926 to 1932). While his keys and descriptions are often difficult to assess (e.g. *see* Szilàdy, 1926) his pioneer work is indispensable to a knowledge of the tabanid fauna of the Malaysian Archipelago.

A review of the Philippine fauna (Philip, 1959), based on similarly limited collections, has emphasized the parallel wealth of species, many undescribed, in every modest collection from these insular situations, as well as the preponderance of precinctive occurrence. The failure to find more than meagre overlapping with adjoining faunas is remarkable, and probably significant zoogeographically.

Though Palawan is considered to have been separated from Borneo more recently than the more ancient connections to the Philippine Archipelago proper (*see* Philip, op. cit., for references), the tabanid fauna there (and from Busuanga) is too little known (Table I, footnotes) to be useful even in this early report. Thailand has been included because it extends into the Malay Peninsula though the records are mostly from the northern part of the country where the fauna impinges on that of Burma and Indo-China.

Economic Importance in the Region

Aside from the considerable annoyance to domestic stock and wild animals due to attacks of these flies when abundant, they have been shown to be locally important, mechanical disseminators of the trypanosome disease of animals, surra. Mitzmain (1913 *a*, *b*) early proved the role of *Tabanus striatus* as a vector in the Philippines, and Kelser (1927) reviewed and extended these observations. The latter considered that the part played by tabanids was a mechanical but not a biological one; and that cattle and carabaos are carriers but are not affected "unless normal resistance is lowered." He found that 50 per cent of 141 carabaos and 22 per cent of 54 cattle in the Philippines carried circulating trypanosomes.

Nieschulz (1925-1927), working in Java, further showed that *T. immanis* and *Chrysozona cingulata* could transmit the disease, from which it follows that the importance of any species as a vector will depend on its habits and abundance in any focal area.

The well-known importance of the role of *Chrysops* spp. as transmitters of loiasis in West Africa suggests that sampling of tabanids of suitable habits in Malaya might be of incidental interest in the local filarial problem with *Wuchereria* (*see* Sandosham, 1957, for references).

Composition of the Fauna Discussed in this Report

A total of 137 species, plus 4 questionable, 2 subspecies, and one variety, is reported here from Malaya, Borneo and Thailand, plus 14 additional species from Palawan-Busuanga. Of these, 50 are recorded from Thailand, plus 4 questionable, 60 plus 4 questionable from Malaya (including Singapore), and 65 plus 1 questionable from Borneo, with several occurring in more than one country. A very substantial increase in this number can be expected. These are represented by 7 genera in the subfamilies Chrysopinae and Tabaninae. The more primitive subfamily Pangoninae is so far not known here, though a few representatives have been found in Indonesia and Australia and to the north in China and Burma. An unidentified species of *Erephopsis* (probably *Scaptia*) was also reported by Kröber (1924) from an unknown location in the Philippines.

The 106 species of tabanids plus 2 questionable records herein reported from Borneo and/or Malaya probably represent a much poorer proportion of the total tabanid fauna than do the 31 species of ticks to total ixodids of these two countries reported by Kohls (1957), or the 215 Malayan culicine mosquito species reported by Macdonald (1957).

It has not been possible to verify certain published records, which have therefore been left queried in Table 1. The small number of species found in two, or even in all three, of these countries is undoubtedly due to some extent to the paucity of collections. Only *Chrysops dispar*, *C. flavocincta*, *Tabanus ceylonicus*, and *T. brunnicolor* have been reported in all three. Of new species, 5 *Tabanus* and one *Rhinomyza* are described from Malaya in the preceding paper, 11 *Tabanus* and 2 *Chrysozona* from Thailand, and 6 *Tabanus* and one *Chrysops* from Borneo. Due to their wide distribution in the region, the vigorous and successful colonizers are *Chrysops dispar*, *T. ceylonicus*, *T. rubidus*, and *T. striatus*, though the absence of the last two in Borneo collections, so far, is rather amazing. It is obvious also that the species of the *T. fumifer-immanis* complex, of which *T. brunnicolor* is most widely dispersed, have undergone a vigorous burst of speciation. In this group, a knowledge of eye colors in the fresh condition will be an important adjunct to its elucidation.

TABLE I

OCCURRENCE OF DEERFLIES AND HORSEFLIES IN BORNEO, MALAYA, AND THAILAND

Species	Borneo	Malaya	Thailand
Eucompsa			
tecticallosa S. Stek.	+	−	−
Rhinomyza			
cincta Phil.	−	+*	−
"Gastroxides"			
aterrima (S. Stek.)	−	+	−
fusca (S. Stek.)	−	+	−
n. sp.	−	+	−
Chrysops			
alter Rond.	+	−	−
dispar Fabr.	+	+	+
fasciata Wied.	+	−	+*
fixissima Walk.	+	+*	−
flaviventris Macq.	−	+*	−
flavocincta Ric.	+	+*	+
indiana ssp. *thailandensis* Phil.	−	−	+*
signifera Walk.	−	+	−
stekhoveni Phil.	+*	−	−
translucens Macq.	+	+	−
Tabanus			
abaculus Phil.	−	+*	−
abbasalis Phil.	−	−	+*
acuminaris Phil.	−	−	+*
agnoscibilis Aust.	−	−	+
albitriangularis S. Stek.	−	+	−
albivittatus S. Stek.	−	+	−
anabates Phil.	−	−	+*
angustitriangularis S. Stek.	−	+*	−
ardalus Phil.	−	−	+*
atriventer S. Stek.	+	−	−
audyi Phil.	−	+*	−
aurilineatus S. Stek.	−	+	+
aurisparsus S. Stek.	−	+*	−
barnesi Aust.	−	−	+
biannularis Phil. (syn. *bicinctus* Ric.)	−	+	−
birmanicus Big.	−	+	−
borniensis Ric.	+	−	−
brunnicolor Phil. (syn. *brunneus* Macq.)	+*	+	+
brunnipennis Ric.	−	−	+
canipus S. Stek.	+	−	−
ceylonicus Schin.	+*	+	+
cinnamoneus Dol.	+?	−	−
circumalbatus S. Stek.	+	−	−

Species	Borneo	Malaya	Thailand
Tabanus—(cont.)			
crocinctipennis S. Stek.	+	−	−
cyclindricallosus S. Stek.	+	−	−
dissimilis Ric.	−	+	+
dives Rond.	+	−	−
effilatus S. Stek.	−	+	+
enderleini Phil. (syn. *nigripes* End.)	+	−	−
equicinctus Aust.	−	−	+
finalis Walk.	−	−	+
flavipilosus Ric.	+	−	−
flavohirtus Phil.	+*	−	−
flavothorax Ric.	+*	+	−
fulvilinearis Phil.	−	−	+*
fulvissimus Rond.	+	−	−
fumifer Walk.	+	+	−
fuscifrons S. Stek.	+	−	−
fusciventer S. Stek.	−	+	−
gilvellus Phil.	−	−	+*
gilvilineis Phil. (subsp. of *aurilineatus* S. Stek.)	−	+*	+*
griseilineis Phil.	−	−	+*
griseipalpis S .Stek.	+	−	+
hirtistriatus Ric.	−	+	−
hybridus Wied.	+	+	−
ignobilis Rond.	+	−	−
immanis Wied.	+	+	+?
inaequisignatus S. Stek. (var. of *significans*)	+	−	−
infamis Szil. (= ? *minimus* Wulp)	+	−	−
insidiator Aust.	−	−	+
invalidus Szil.	−	+	−
justorius Rond.	+	−	−
khasiensis Ric.	−	+	+?
konis Phil.	−	−	+*
latifascies S. Stek.	+	−	−
laticorpus Phil. (syn. *lativenter* S. Stek.)	+	−	−
lentisignatus S. Stek.	+	+?	−
leucocnematus Big.	−	+?	−
macdonaldi Phil.	−	+*	−
malayensis Ric.	+	+	−
melanognathus Big.	−	−	+?
minimus v. d. Wulp	+	+	−

TABLE I—(*cont.*)

OCCURRENCE OF DEERFLIES AND HORSEFLIES IN BORNEO, MALAYA, AND THAILAND—(*cont.*)

Species	Borneo	Malaya	Thailand
Tabanus—(cont.)			
multicinctus S. Stek.	−	−	+?
nephodes Big.	−	+	−
nexus Walk.	+	+?	−
nigrinus Szil. (syn. *nigerrimus* S. Stek.)	+	−	−
nigrotectus Big.	−	−	+
nilakinus Phil.	−	−	+*
ochros S. Stek.	−	−	+
optatus Walk.	+	+*	−
parabrunneus S. Stek.	+	−	+
parallelifrons S. Stek.	+	−	−
pauper Rond.	+	−	−
pendleburyi Phil.	+*	−	−
perakiensis Ric.	−	+	−
pictipennis Szil.	+	−	−
praematurus Aust.	−	−	+
pratti Ric.	+	+	−
pugiunculus Aust.	−	−	+
pugnax Aust.	−	−	+
rubicundulus Aust.	−	−	+
rubidus Wied.	−	+	+
rubriscutatus S. Stek.	+	−	−
ruficoloratus Phil.	+*	+?	−
rufiscutellatus S. Stek.	−	−	+
rufiventris Fabr.	−	+	−
serus Walk.	+	−	−
siamensis Ric....	−	−	+
siebersi S. Stek.	+	−	−
significans Ric.	−	+	−
simplissimus Walk.	+	+	−
sphinx Phil.	−	−	+*
stantoni Ric.	−	+	−
stekhoveni Philip (syn. *elegans* S. Stek.)	+	−	−
striatus Fabr.	−	+	+
subhybridus Phil.	−	+*	−
thurmani Phil.	−	−	+*
tinctothorax Ric.	−	+	+
traubi Philip.	−	+*	−
triceps Thunb.	−	−	+*
uniformis Ric.	−	+	−
varicolor Ric.	+	−	−
ventriflavimarginatus S. Stek.	+	−	−
virgulatus Aust. (= ?*rubidus* Wd.)	−	−	+
vix Phil.	−	−	+*
xuthus Phil.	−	−	+*
zebrinus S. Stek.	+	−	−
zoster Phil.	−	−	+*
Hybomitra			
rara (Ric.)	−	+	−
Chrysozona			
abacis Phil.	−	−	+*
angustisegmentata S. Stek.	+	+*	−
atomaria Walk.	+	−	−
bizonata S. Stek.	+	−	−
borneana Ric....	+	−	−
cilipes Big.	−	−	+
cingulata Wied.	+	−	+
cordigera Big.	−	+*	−
irregularis S. Stek.	+	−	−
irrorata Macq.	+	+	−
javana Wied.	−	+	−
lineola Phil.	−	−	+*
lunulata Macq.	+*	+	−
malayensis Ric.	−	+	−
mediatifrons S. Stek....	−	+	−
pachycera Big.	−	+	+
pungens Dol.	+	−	−
rubida Ric.	−	+	−
segmentata S. Stek.	+	−	−
splendens S. Stek.	+*	+	−

NOTES:

Starred species indicate new records including new species.

Palawan (P), in the Philippines, and Busuanga Island (B), at its northern tip, have been but little sampled. The following were listed by me (1959):

(B) *Cydistomyia longirostris* †(Schuurmans Stekhoven), *Tabanus hoogstraali* Philip, and *T. wenzeli* Philip;

(P) *T. cnemidotus*, *T. palawanensis*, *T. subimminis*, and *T. subjoidus*, all Philip. It is assumed that the Budapest Museum record by Szilády (1926) of "Palavan 1898 Doherty" for *Psylochrysops clavicrus* Thoms. (=*Chrysops signifer* Walker, *see* Philip, op. cit.) is in reference to this island also. Of special interest is the occurrence of *Cyd. longirostris* (taken on penned crocodiles) so far north of its original and only other discovery on two small islands off the S.W. coast of Sumatra. Probably obscure habits have prevented finding it between these locations.

† van der Wulp (1896, Catalog of the described Diptera of South Asia, the Hague, p. 60), mistakenly lists *Tabanus longirostris* Walker from Hindustan which he later (1899, *Tijdschr. Ent.*, *42:* 52) corrects to *Pangonia longirostris* Hardwicke. This, therefore, does not preoccupy Schuurmans Stekhoven's name. Since this report was completed, the following additional species, taken by Dr. H. E. Miliron on Palawan, were seen through courtesy of Dr. J. L. Gressitt of Bishop Museum, Honululu: *C. signifera* Walker, *T. brevicallus* Philip, *T. rossi* Philip, *T. effilatanus* Philip, *T. subimmanis* Philip, *T. attenuis* Philip, and *T. rufiventris* Fabricius. The last is a significant addition to the Philippine fauna from Malaysia *via* Borneo; it agrees with the Pahang specimen, listed later, in the brown facial band, but the abdomen is much darker blackish-brown.

STUD. INST. MED. RES.

Distribution Records

The records below concern only the published "Records" and "Material examined" from Malaya, Borneo, and Thailand. Only pertinent references together with synonyms are provided, for although in many cases the literature to a given species may be extensive, most of it will be found in Schuurmans Stekhoven's (1926) monograph. Where records are taken from this latter work, only the initials "S.S." have been used, with his later articles cited by year. In many instances of his records from the BMNH collections, they are only listed under "Material examined" when also seen by me during a visit in 1958.

Two boxes of tabanids accumulated largely by Captain H. M. Pendlebury in the Raffles Museum in Singapore had fortunately been transferred to the Institute for Medical Research, Kuala Lumpur before the war and thence to BMNH. These provided many additional records from both Malaya and Borneo but unfortunately certain Raffles types have not been accounted for.

Records of Tabanidae from Malaya, Borneo, and Thailand

Subfamily Pangoniinae

No species known in areas.

Subfamily Chrysopinae

Tribe 1. Bouvieromyiini

Eucompsa tecticallosa Schuurmans Stekhoven

1932*a*, *Arch. Naturgesch.* (N.F.), *1*:59. Type ♀, "Borneo, von Roeder" (Halle Mus.). No other records.

"Gastroxides" aterrima (Schuurmans Stekhoven)

1926, *Treubia*, *6* (Suppl.): 60. Allotype ♀, Malaya, Negri Sembilan, 2000-2790′, iv. 1918 (originally Raffles Museum, Singapore, now missing). Lectotype ♂, same data (Philip and Mackerras 1960, now in BMNH). Philip and Mackerras 1960, *Philipp. J. Sci.* (in press).

Material examined.—Malaya: ♂ lectotype; ♂ Pahang, Fraser's Hill, 4000′.

"Gastroxides" fusca (Schuurmans Stekhoven)

1926, *Treubia*, *6* (Suppl.): 61. Type ♀, Malaya, Selangor, Semangko Pass, 2700′, iii. 1912 (headless, now in BMNH). Philip and Mackerras, 1960, *Philipp. J. Sci.* (in press).

Material examined.—Malaya: ♀ (type); ♂, 2♀♀ Bukit Kutu, 3300-3500′ (*A. R. Sanderson* and *H. M. Pendlebury*).

"Gastroxides" n. sp. Philip and Mackerras

1960, *Philipp. J. Sci.* (in press). Type ♂, Malaya, Pahang, Cameron Highlands, 4000-4500′, 21. vi. 1935 (*H. M. Pendlebury*) (BMNH).

Material examined.—Malaya: 4 ♂♂ (incl. type) same data, 4500-5000′.

Tribe 2. Rhinomyzini

Rhinomyza cincta Philip

1960, *Stud. Inst. med. Res. Malaya*, *29*: 1. Type ♀, Malaya, near Kuala Lumpur (*R. Traub*). In USNM. No other records.

Tribe 3. Chrysopini

Chrysops alter Rondani

1875, *Ann. Mus. Civ. Stor. Nat. Genova*, 7: 460. Type ♀, Sarawak, Borneo (Genova Mus.). Schuurmans Stekhoven 1926, *Treubia*, 6 (Suppl.): 25. No other records.

Chrysops dispar Fabricius

1798, *Ent. Syst.* Suppl., p. 567 (*Tabanus*). Type ♂, India (seen in 1953 in Kiel Coll. in Copenhagen; antennae gone and some parts pest-destroyed but at least one of each pair of legs, both wings, and dorsum of abdomen present). Philip 1959, *Fieldiana, Zool., 33*: 549.

Syn. *Tabanus dispar* Fabricius 1798, *Ent. Syst.* Suppl., p. 567 (India).

Syn. *Chrysops dispar* Wiedemann 1821, *Dipt. exot.*, p. 102, comb nov.; Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 29.

Syn. *Haematopota lunatus* Gray 1832, Griffith *in* Cuvier, Anim. Kingd., *15*: 696.

Syn. *Chrysops bifasciatus* Macquart 1838, *Dipt. exot., 1*: 157.

Syn. *Chrysops ligatus* Walker 1848, *List Dipt. Brit. Mus., 1*: 195.

Syn. *Chrysops manilensis* Schiner 1868, *Reise Novara Dipt.*, p. 104; Ricardo 1911, *Rec. Indian Mus., 4*: 377 (new synonymy).

?Syn. *Chrysops semicirculus* Walker 1848, *List Dipt. Brit. Mus. 1*: 196.

?Syn. *Chrysops impar* Rondani 1875, *Ann. Mus. Civ. Stor. Nat. Genova, 7*: 460.

Variation and the eye pattern of this widespread Oriental species are discussed by the writer (1959).

Records.—E. India, Ceylon, China, Formosa, Philippines, Sumatra, Java.

Material examined.—Borneo: ♀ Brit. N. Borneo, Klias River; 2♀♀ Sarawak, ex coll. Bigot. Malaya: 21 ♀♀ Kedah, Alor Star, 2. iv. 1928; ♀ Kuala Lumpur, 28. vi. 1928; ♀ Selangor Museum Gard., 18. vi. 1936 (*Pendlebury*); 16 ♀♀ Langkawi Is., W. Coast, 21. iv. 1928; ♀ Singapore Bot. Gard., 11. v. 1911; ♀ Tegong, Malacca, 28. ii. 1936 (*Pagden*); 6 ♀♀ Pahang nr. Karak, Cintamani, "jungle light," 17-22. iv. 1937; 2 ♀♀ Kedah nr. Jitra Catchment area, 8. iv. 1928; 12 ♀♀ Selangor, Malaya, 23. iii. 1948 (*C. B. Philip*); ♀ Selangor, Seaport Estate nr. Kuala Lumpur, 2. v. 1948 (*C. B. Philip*); ♀ Malacca, iv. 1957 (*Dr. J. McMahon*), biting indoors, 7:15 p.m.; ♀ Trengganu, Bukit Besi, 7. viii. 1958. Thailand: ♂ ♀ Bangkok, viii. 1933 (*H. M. Smith*); ♀ Nakon Sri Tamarat, 7. v. 1922; ♀ "Lower Siam Trong" (*Abbott*); 2 ♀♀ Chiengmai, 25. viii. 1951 and 4-10. v. 1952 (*D. C. & E. B. Thurman*); ♂ ♀ same but 24. iv. and 18. x. 1952.

Chrysops fasciata Wiedemann

1821, *Dipt. exot., 1*: 108. Syntypes ♂ ♀, Java, Batavia (Copenhagen Mus., both intact in 1953). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 39; 1928, *Zool. Jb.*, (1), *54*: 425.

Syn. *C. rufitarsis* Macquart 1847, *Dipt. exot.*, Suppl. III, p. 147. Type ♂, Java (collection unknown).

Records.—Borneo: ♀, Mid. East B., 7. ix. 1925 (*Siebers*) (S.S., 1928); ♀ Sarawak, Wellington (S.S.). Malaya: ♀ unknown local. (*Pratt*) (S.S.). Other distribution: Andaman Is., Assam, Burma, Sumatra, Java, ? Amboina.

Material examined.—Malaya: ♀ Kedah Peak, 3000′, 8. iii. 1928. Thailand: ♂ Chiengmai, 18. x. 1925 (*D. C. Thurman*).

Chrysops fixissima Walker

1856, *Proc. Linn. Soc. Lond., 1*: 112. Type ♀, Sarawak, Borneo ex coll. Saunders (BMNH; flagellums gone).

Syn. *Chrysops unizonata* Rondani 1873, *Ann. Mus. Civ. Stor. Nat. Genova, 7:* 459. (Borneo).

Syn. *Chrysops testaceicallosus* de Meyere 1911, *Tijdschr. Ent. 54*: 170.

?Syn. *Psylochrysops unizona* Szilàdy 1926, *Biol. hung., 1* (7): 3.

Records.—Ceylon, Java, Sumatra.

Material examined.—Borneo: 3 ♀♀ Sandakan, (*Baker*) (USNM); 3 ♀♀ Sandakan 1895, 1898; 2 ♀♀ Sarawak, Kuching, 22. v. 1900 and 2. xi. 1916, ex coll. *Brunetti*; ♀ Sarawak, Trusan Ian, 1915; 2 ♀♀ Mt. Kinabalu, Kabawsu, 600′, 9-13. v. 1929 (*Pendlebury*); ♀ same but Kiau

3000′, 21. iv. 1929 (*Pendlebury*); ♀ Sarawak, Klias River, Mempakul, 18. x. 1922 (*G. F. Woodlett*). Malaya: ♀ Matang River, 28. x. 1916; 4♀♀ Selangor, Rantau Panjang, ii, ix. 1956 (*W. W. Macdonald*), cow bait; ♀ Selangor, Ulu Gombak, ii. 1956 (*W. W. Macdonald*).

Remarks.—Szilàdy (1926), while criticizing loose taxonomy of Schuurmans Stekhoven, has the exasperating habit of describing new species by a few differences from some described, but often not available species, thus making it impossible to key and confirm his own species without further study of presumed assignable specimens. He at least knew of Schuurmans Stekhoven's monographic work which included *C. fixissima* Walker in a key, and which appears to be related to his *Psylochrysops unizona* from Mt. Kinabalu, Borneo, but Szilàdy only established the latter by minimum differentiation of the face and abdomen from *Chrysops signifer*. Unfortunately, the types are now casualties of the Hungarian civil war, so that we may never know the correct status of Szilàdy's name. Many others of his species in the same publication will be difficult or impossible for other workers to interpret in the absence of species with which he inadequately compares his new ones.

Chrysops flaviventris Macquart

1838, *Dipt. exot., 1*, p. 159 (p. 172, orig.). Type ♀, India, ex coll. *Bigot* (BMNH, poor condition with broken appendages in 1958).

Syn. *Chrysops v-nigrum* de Meyere 1911, *Tijdschr. Ent., 54*: 277.

Syn. *Chrysops terminalis* Walker 1848, *List. Dipt. Brit. Mus., 1*: 195. (Walker's type was not found in BMNH in 1958).

The male has not been described. In BMNH, there is one "Penin. Siam, Trang, Benchong, at light, 29. iv. 1924 (I.H.N. Evans)" which is readily associated with females. Midfacial pollinose stripe is narrow, complete to oral margin, and hyaline sinus on hind margin in crossband of wings and in apices of two basal cells not as extensive as in females.

Records.—India, Ceylon, Sumatra, Java.

Material examined.—Malaya: 2 ♀♀ Langkawi Is., 15-16. iv. 1928.

Chrysops flavocincta Ricardo

1902, *Ann. Mag. nat. Hist.*, (7), *9*: 380. Type ♀, Khasi Hills, Assam (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 20; 1928, *Zool. Jb.*, (1), *54*: 435. Austen 1922, *Bull. ent. Res., 12*: 431.

There is unusual variation in the wing pattern even in specimens from the same localities. The type, seen in 1958, was described and figured by Ricardo as "the apex being quite clear," the crossband nearly attaining the hind border in the fourth posterior cell and "only just continuing into the fifth." A Thailand specimen compared, agrees in detail with the type but has a definite, narrow, apico-costal strip, while others vary from a faint apical suffusion in a Gombak female to a band wider than cell R_1 in one from Chiengmai, while the crossband may be much more abbreviated. The specimens are otherwise inseparable.

Records.—♀ Isle Borneo (*Macklot*) (S.S.). Thailand: 3 ♀♀ Doi Chom Chang, Chiengmai, 16. iv. 1921. Other distribution: India, Ceylon.

Material examined.—Borneo: Sarawak (*Wallace*). Malaya: ♀ Perak, Forest Reserve, 10 mi. W. Ipoh, 17. ix. 1958 (*R. Traub*); 3♀♀ Selangor, 16 mi. Ulu Gombak, 7. xii. 1955 (*W. W. Macdonald*). Thailand: 4 ♀♀ Chiengmai, 4-10. v. 1952. (*D. C. & E. B. Thurman*); ♀ from indecipherable locality in "Siam," 1500-1800 ft., 21. iv. 1939 (compared with type).

Chrysops indiana subsp. **thailandensis** Philip

1960, *Stud. Inst. med. Res. Malaya, 29*: 3. Type ♀, Thailand, Chiengmai, 4-10. v. 1952 (*D. C. & E. B. Thurman*). In USNM.

Chrysops signifera Walker

1861, *Proc. Linn. Soc. Lond.*, *5*: 271. Type ♂, Malaya Arch., Moluccas, Batchian (*A. R. Wallace*) (BMNH, intact).

? Syn. *Chrysops clavicrus* Thompson 1868, *Eugen. Resa Dipt.*, p. 452 (Malacca).

Syn. *Chrysops cincta* Bigot 1892, *Mém. Soc. zool. Fr.*, *5*: 602 (Philippines).

? Syn. *Chrysops atrisignatus* Schuurmans Stekhoven 1926, *Treubia*, *6* (Suppl): 45.

Study of both sexes from Samar, Philippines, convinced the writer (1959) that *C. cincta* is a synonym, and *C. clavicrus* and *C. atrisignatus* are possible variants. The eye pattern was also described. The Philippine, Moluccas, and Singapore records suggest the species should also occur in Borneo. A male from Samar, P. Is., and a female from Manila were in good agreement with Walker's and Bigot's respective types.

Records.—Batjan Is., Philippines, Malacca (type of *clavicrus*).

Material examined.—Malaya: ♀ Singapore (*H. N. Ridley*).

Chrysops stekhoveni Philip

1960. *Stud. Inst. med. Res. Malaya*, *29*: 3. Type ♀, Borneo, Nunukan, E. Kalimantan Distr., xi. 1953 (*R. von Hentig*). In Chi. Nat. Hist. Mus.

Chrysops translucens Macquart

1838, *Dipt. exot.*, *1*, p. 158 (p. 162, orig.). Type ♀, Java (coll. unknown, not seen with other Macquart types in BMNH or Paris, 1958). Schuurmans Stekhoven 1926, *Treubia*, *6* (Suppl.): 25.

Records.—Borneo ?: (Surcouf 1921, *Genera Insect.*, *175*: 155). Malaya: ♀ Kuala Lumpur (*Pratt*); 2 ♀♀ Negri Sembilan, Gunong Angsi, 2000-2700′, iv. 1918.

Material examined.—Malaya: ♀ Selangor, 9. v. 1948 (*C. B. Philip*); 2 ♀♀ Selangor, I.M.R. Lab., 27. vi. 1931 (*E. P. Hodgkin*); ♀ Selangor, Kanching Ridge, 693′, 10. vi. 1954 (*J. A. Reid*). Borneo: 5 ♀♀ Brunei, xi. 1954; 13 ♀♀ Sarawak, Limbong, 5th Div., vi. 1956.

Subfamily TABANINAE

Tribe 1. DIACHLORINI

Genus **Cydistomyia** Taylor

1919, *Proc. Linn. Soc. N.S.W.*, *44*: 47.

This peculiar, rather primitive genus has been elaborated in New Guinea (Oldroyd, 1949) and study of the types in Amsterdam reveals that several Indonesian species assigned by Schuurmans Stekhoven (1926) to *Tabanus* actually belong to this and related genera with bare subepaulets. Invasion of the Philippines was noted by the writer (1959), who stated that *C. longirostris* Schuurmans Stekhoven must have reached the northern tip of Palawan from Indonesia *via* Borneo. Unless a few of the species listed under *Tabanus* and unknown to the writer actually belong here, the lack of any specimens in collections studied from Malaya, Borneo, and Thailand emphasizes the paucity of collecting rather than absence of representation. However, peculiar, crepuscular or arboreal habits may in part account for failure to take them so far.

Tribe 2. TABININI

Tabanus abaculus Philip

1960, *Stud. Inst. med. Res. Malaya*, *29*: 7. Type ♀, Malaya, Trengganu, Dungun, Bukit Besi, 4-8. viii. 1958 (*R. Traub*). In USNM.

Tabanus abbasalis Philip

1960, *Stud. Inst. med. Res. Malaya, 29*: 8. Type ♀, Thailand, Chiengmai, 15. x. 1951 (*D. C. & E. B. Thurman*) "in fly trap no. 151." In USNM.

Tabanus acuminaris Philip

1960, *Stud. Inst. med. Res. Malaya, 29*: 9. Type ♀, Chiengmai, 25. vii. 1952 (*D. C. Thurman*) "in house." In USNM.

Tabanus agnoscibilis Austen

1922, *Bull. ent. Res., 12*: 453. Type ♀, Thailand, 3. ii. 1914 (*K. G. Gairdner*). In BMNH. No other records.

Tabanus albitriangularis Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 372. Type ♀, Malaya, Selangor, Batu Tiga, 16. ii. 10. (*Stanton*). (BMNH).

The Ipoh specimens below differ only in the beard, lateral margins of tergites, and all pale ventral vestiture white, not yellowish. The Bukit Besi ♀ is unusually small, only 12 mm.

Records.—Malaya: 2 other ♀♀ with same data. Other distribution: Sumatra.

Material examined.—4 ♀♀ Perak, 10 mi. W. Ipoh, 150′ elev., Forest Reserve, 17. ix. 1958 (*R. Traub*); ♀ same, but 8 mi. W. Ipoh, 1. x. 1958; ♀ Trengganu, Dungun, Bukit Besi, 4-8. viii. 1958 (*R. Traub*).

Tabanus albivittatus Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 308. Type ♀, Java ("Vet. State Labs."). Schuurmans Stekhoven 1928, *Zool. Jb.*, (1), *54*: 425.

Records.—Malaya: ♀ Perak, Jor camp, 2500′, 25. viii. 1922 (*E. Siemund*); this specimen in BMNH is labelled paratype, but was not so published. Other distribution: Java.

Material examined.—♀ Trengganu, Dungun, Bukit Besi, 4-8. viii. 1958 (*R. Traub*).

Tabanus anabates Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 9. Type ♀, Thailand, Lampang, Tern, 22. vii. 1952 (*D. C. Thurman*) "in passenger bus." In USNM.

Tabanus angustitriangularis Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 401. Type ♀, Java ("Vet. State Labs.").

This is close to, if not merely a variant of, *T. malayensis* Ric.; the latter appears to differ only in at least pale yellow-beard and in larger, more discrete, abdominal, yellow-haired triangles, and in more definite, golden-yellow-haired lateral fringes which are wider on the outer, hind corners. In local series, these somewhat minor differences do not seem to intergrade; single specimens, however, would be difficult to key without both forms available for comparison. Eyes are bicolored.

Records.—Java.

Material examined.—Malaya: 5 ♀♀ Selangor, vicinity Kuala Lumpur, 23. iii. 1948 (*C. B. Philip*); 5 ♀♀ same, but 9. v. 1948 (*Philip* and *Traub*); ♀ same, but Subang, 12. iii. 1958 (*R. Traub*), ♀ same, but Dipterocarp Forest, 13-16. v. 1958 (*R. Traub*); 2 ♀♀ Perak, 10 mi. W. Ipoh, Forest Reserve, 150′, 17. ix. 1958 (*R. Traub*).

Tabanus ardalus Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 10. Type ♀, Thailand, Ban Ta Pai, Tak, 20. vi. 1952 (*D. C. Thurman*) "bank of Meh Ping River." In USNM.

Tabanus atriventer Schuurmans Stekhoven

1928, *Zool. Jb.*, (1), *54:* 425. Type ♂, Mid. E. Borneo, Long Petak, 1299 m., 16. viii. 1925 (*Siebers*).

Records.—No others noted.

Tabanus audyi Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 11. Type ♀, Malaya, Trengganu, Besut District, Gunong Tebu, v. 1958 (*R. Traub*). In USNM.

Tabanus aurilineatus Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 231. Type ♀, Sumatra ("Vet. State Labs."); 1928, *Zool. Jb.*, (1), *54:* 425.

Records.—Malaya: 2 ♀♀ Tebing, Kelantan, vii. 1920 (*V. Knight*). Thailand: ♀ Khao Ram, 750′, 2. iii. 1922 (USNM); ♂ Rumpibun, 9. iii. 1928 (S.S. 1928). Other distribution: Sumatra.

Material examined.—Malaya: ♀ Kedah, nr. Jitra Catchment area, 9. iv. 1928.

Tabanus aurilineatus subsp. **gilvilineis** Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 12. Type ♀, Thailand (USNM). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 232 ("Malacca" specimens).

Material examined.—Thailand: 2 ♀♀ (type and paratype) Loei Dansai, Na Haeo, 12. v. 1955 (*Elbel*); ♀, Chiengmai, 31. viii. 1951 (*Thurmans*).

Tabanus aurisparsus Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 387. Type ♀, Java (Vet. State Labs.).

Material examined.—Borneo: ♀ Sandakan, 1927 (*C. F. Baker*) (USNM).

Tabanus barnesi Austen

1922, *Bull. ent. Res., 12:* 435. Type ♀, Thailand, Chiengmai, 10. v. 1921 (*Dr. M. E. Barnes*). No other records.

Tabanus basalis Macquart

1838, *Dipt. exot., 1:* 139. Type ♀, ? East India (Paris Mus.). Ricardo 1911, *Rec. Indian Mus., 6:* 147.

Syn. *Tabanus batavus* Ricardo 1912, *Tijdschr. Ent., 55:* 349 (Java). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 262.

Since the original type locality was given as "Inde orientalis," it is speculative whether the later assignment to "East India" might properly be East Indies since other records are from Java and Sumatra. Occurrence is possible in the present area.

Tabanus biannularis Philip, new name

Syn. *Tabanus bicinctus* Ricardo 1911, *Rec. Indian Mus., 4:* 132. Type ♀, India (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 310. Not Fabricius, 1805, *Syst. Antl.*, p. 102 (=*Diachlorus*).

Records.—Malaya: ♀ Sungei Krudda, Sungei Siput, Perak, 1907 (*Pratt*); ♀ Iras, Pahang, 27. vii. 1902 (*Durham*). Other distribution: India, ? Formosa.

Material examined.—Malaya: ♀ Perak, Larut Hills, 3700-4000′, 11. ii. 1932 (*Pendlebury*); 2 ♀♀ Selangor, Bukit Kutu, 3500′, 27. ix. 1932 (*Pendlebury*) and 28. vii. (*A. R. Sanderson*), (both in BMNH as *T. sexcinctus* Ric.); 2 ♀♀ Perak, Batang Padang, Jor Camp, 1800-2500′, 16. iii. 1923 (*Pendlebury*); ♀ (dark), Pahang, 2500′, 1916 (*T. R. Hubback*) "on *Rhinoceros sumatrensis*"; ♀ Selangor, 53 mi. Troo Bentong. 8. xii. 1931 (*E. P. Hodgkin*), in jungle; ♀ Selangor, Ulu Gombak, 16 mi., 12. viii. 1932 (*E. P. Hodgkin*); 2 ♀♀ Selangor, 16 mi. Bentong Rd., 3. iii. 1920 (*Malaria Bureau*).

Tabanus birmanicus Bigot

1892, *Mém. Soc. zool. Fr., 5:* 653. Type ♀, Burma (Paris Mus.). Ricardo 1911, *Rec. Indian Mus., 4:* 200.

Records.—Malaya: ♀ Kuala Lumpur (*Ricardo*). Other distribution: India, Burma, ? Formosa.

Tabanus borniensis Ricardo

1911, *Rec. Indian Mus., 4:* 216 (new name).

Syn. *Tabanus apicalis* Rondani 1875, *Ann. Mus. Civ. Stor. Nat. Genova, 7:* 459. Type ♀, Borneo (location unknown; not among Rondani's types seen by Miss Ricardo in Genoa Museum). Not *Tabanus apicalis* Wied., Brazil.

This species was strangely overlooked by Schuurmans Stekhoven (1926) but he described a specimen discussed by her as *T. flavipilosus*. The two females in BMNH determined by Miss Ricardo are not in good agreement with Rondani's description nor with one another, though this may be only variation. The callosities are not pitchy black, nor are the last four abdominal segments blackish, and only one has darkened fore femora. One with frontal index of 1: 8 has yellow-haired palpi but black-haired legs; the other with index 1: 10 has color of this vestiture reversed. The former may be the unlabelled type of *T. flavipilosus* since no other type was found in BMNH.

Records.—Borneo: 2 ♀♀ Sarawak (*Ricardo*, op. cit.).

Tabanus brunnicolor new name

Syn. *Tabanus brunneus* Macquart 1834, *Suites à Buffon, 1:* 203; 1838, *Dipt. exot. 1:* 129. Type ♀, Indies Orient. (Paris Mus., seen in 1958; good condition but antennae broken). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 279; 1928, *Zool. Jb.*, (1), *54:* 425. Not *Tabanus brunneus* Thunberg, *Nova Acta Soc. Sci. upsal., 9:* 56 (Cape of Good Hope).

A nomenclatorial problem is raised since the name is a primary homonym. Schuurmans Stekhoven (1926) places *T. javanus* "van der Wulp" as a synonym; this is probably a lapsus for *T. javanus* Fabricius, and possibly through citation in Wulp's *Cat. Dipt. South Asia* (p. 59). The smaller *T. javanus* Fabricius could not be a synonym of *T. brunneus* Macquart because of the wings with five spots and other differences. A new name for Macquart's species is, therefore, needed and is proposed as *T. brunnicolor* nom. nov.

Records.—Malaya: ♀ Pahang, 2500′, on Rhinoceros (S.S.). Borneo: ♂ Mid. East B., 12. viii. 1925 (*Siebers*). Thailand: ♀ Nakon Sri Tamarat, Khao Ram, 75-200′, 22. ii. 1922; ♀ "Lower Siam, Trong" (*Abbott*) (USNM, S.S. 1928). Other distribution: Java and Sumatra.

Material examined.—Borneo: 14 ♀♀ Brit. N. B., Mt. Kinabalu, 3000-5500′, 18. iii.-14. iv. 1929. Malaya: 6 ♀♀ Perak, Larut Hills, 3000-4500′, 6-21. ii. 1932 (*Pendlebury*); ♀ Perak, Taiping, 4500′, 4. iii. 1924 (*M. R. Henderson*); 2 ♀♀ Pahang, Fraser's Hill, 4000-4400′, 22. v.-7. vii. 1931; ♀ Fraser's Hill, 2. v. 1948 (*R. Traub*); ♀ Kedah, nr. Jitra Catchment area, 4. iv. 1928; ♀ Perak, 8 mi. W. Ipoh, Forest Reserve, 1. x. 1958 (*R. Traub*).

Tabanus brunnipennis Ricardo

1911, *Rec. Indian Mus., 4:* 160. Type ♀, S. W. India (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 152.

Records.—Thailand: ♀ Bangkok, 1908 (*Flower*). Other distribution: Malabar, S. India, Java.

Material examined.—Thailand: ♀, 15. v. 1949 (Lot 910); ♀ Chiengmai, iv. 1951 (*Thurman*); 4 ♀♀ same but 24. iv. and 17. v. 1952.

Tabanus canipus Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 229. Type ♀, Sumatra ("Vet. State Labs.").

Records.—Borneo: ♀ Upper Sibau River, vi. 1894 (*Buttikoefer*) (S.S.) Other distribution: Sumatra.

Tabanus ceylonicus Schiner

1868, *Reise Novara*, Diptera, p. 93. Type ♀, Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 431; 1928, *Zool. Jb.*, (1), *54:* 425; 1932, *Arch. Naturgesch.*, (N.F.) *1:* 56. Oldroyd 1949, *Proc. Linn. Soc. N.S.W., 73:* 329.

Syn. *Tabanus nitidulus* Bigot 1892, *Mém. Soc. zool. Fr., 5:* 679. Type ♀, Java (BMNH). Schuurmans Stekhoven (op. cit. p. 437) (as variety of *ceylonicus*).

Syn. *Tabanus kershawi* Ricardo 1917, *Ann. Mag. nat. Hist., 19* (8): 221.

There is some variation in black to brown of abdominal integument, and notal and genal vestiture. However, this cannot be recognized as "var." *nitidulus* Bigot, as Schuurmans Stekhoven has done, because Bigot's type is the typical black form, not the brown variant. Substitute name is not proposed because not warranted in the material I have seen. This has been a vigorous and successful colonizer from Ceylon to the Philippine and Solomon Islands.

Records.—Borneo: ♀ Bukit Cherakali, 22. vii. 1921; ♀ Kapaus nr. Sekadii, 3. ii. 1924 (*Winkler*); same but lower Melawi, 22. i. 1925 (S.S. 1932); ♀ Mouth Pahang River ("*V.K.*") Malaya: ♀♀ Kuala Lumpur (*Stanton*); ♀♀ Bidor, S. Perak (*Robinson* and *Annandale*) (S.S.). Thailand: ♀ S.E. Klong Yui, xii. 1914; 3 ♂♂ Chiengmai, Pann, 5. iii. 1952 (*D. C.* and *E. B. Thurman*) "in hot spring." Other distribution: Ceylon, Sumatra, Java, New Guinea, Solomons, Philippines.

Material examined.—Borneo: ♀ Sandakan (*Baker*); ♀ Brit. N. B., Sipitang, 17. xii. 1922 (*G. F. C. Woollett*); ♀ Matang, W. Sarawak, xii. 1913 (*G. Bryant*). Malaya: 6 ♀♀ Batu Tiga (*Stanton*), 3 of these are the brown variant; 5 ♀♀ Malay Penin., 6. ii. 1902 (*Annandale* and *Robinson*), 4 of these also brown); 2 ♀♀ Singapore, 1901 (*H. N. Ridley*) and iv. 1907 (*P. S. Falshaw*); ♀ Tapah Road, Perak, v. 1902 (*Durham*); ♀ Selangor, near Kuala Lumpur, Dipterocarp Forest, v. 1958 (*R. Traub*); 2 ♀♀ Selangor, Subang nr. Kuala Lumpur, 12. iii. 1958 (*R. Traub*); 2 ♀♀ Selangor, Rantau Panjang, 9. ii. 1956, cow bait; ♀ Trengganu, Besut Distr., Gunong Tebu, 400′, v. 1958 (*R. Traub*).

Tabanus cinnamoneus Doleschall

1858, *Natuurk. Tijdschr. Ned.—Ind., 17:* 84. Type ♂, Amboina (Vienna Mus.) Oldroyd 1949, *Proc. Linn. Soc. N.S.W., 73:* 314 (synonymy).

Syn. *Tabanus ceramensis* Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 84 (Ceram).

Typical *cinnamoneus* is recorded from New Guinea.

Material examined.—N. Borneo: ♀ (var. ?), Bettotan nr. Sandakan, 12. viii. 1927 (BMNH).

Tabanus circumalbatus Schuurmans Stekhoven

1932, *Arch. Naturgesch.*, (N.F.), *1:* 56. Type ♀, E. Cent. Borneo, Upper Mahakkam, Long Iram, 2. v. 1929 (*von Kuehlewein*).

No other specimens have been reported.

Tabanus crocinctipennis Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 499. Type ♀, Borneo, Bloe-oe, 25. ix. 1894 (*Dr Nieuwenhuys*) (Leyden Mus.).

No other specimens have been reported.

Tabanus cylindricallosus Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 241. Type ♀, Sarawak (*Saunders*) (BMNH).

Syn. *Tabanus cylindricallus* Szilàdy 1926, *Biol. hung., 1* (fasc. 7): 10.

No other specimens have been reported.

Tabanus dissimilis Ricardo

1911, *Rec. Indian Mus., 4:* 180. Type ♀, Selangor (*A. L. Butler*) (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 367; 1928, *Zool. Jb.*, (1), *54:* 425.

Records.—Malaya: 2 ♀♀ Selangor, 22. ii. 1908 (*M. Waldo*); 9 ♀♀ Singapore, 1895 to 1904 (*Ridley*); ♀ Singapore lighthouse; ♀ Singapore, iv. 1910 (*Buitendjik*); ♀ Poeloe Ceyer, v. 1923 (*Maribau*); ♀ Quedah, Malacca (*de Bije*); 3 ♀♀ Poeloe Doerian, Riorew Arch., vi. 1923 (*Dammerman*) (S.S.); 2 ♀♀ Malacca, Sungei Tengah, Sabak Bernam, 26. x. 1921. Thailand: 2 ♀♀ "Lower Siam, Trong" (*Abbott*) (USNM, S.S., 1928). Other distribution: Sumatra.

Material examined.—Borneo: ♀ Kuching. Malaya: ♀ (type) 3 ♀♀ Ponggol, vi. 1910 (*K.A. W.*); 3 ♀♀ Singapore; ♀ Raffles lighthouse, 19. ix. 1920 (*A. Monteiro*); ♀ Negri Sembilan, Port Dickson, 20. ii. 1933; 2 ♀♀ Polo Pisan lighthouse, viii. 1922 and 26. x. 1926; ♀ Singapore Race Course, 6. vi. 1911; ♀ Johore; ♀ Perak, Sungei Tengah, Sabak Bernam, 26. x. 1921 (*H.C.R. & E.S.*).

Tabanus dives Rondani

1875, *Ann. Mus. Civ. Stor. Nat. Genova, 7:* 457. Type ♀, Sarawak, Borneo (Mus. Genova). Ricardo 1911, *Rec. Indian Mus., 4:* 186.

Miss Ricardo apparently saw two syntype females in Genoa, and may be assumed to have established lectotype as "the smaller species of two specimens belonging to different species.....,"which she related to her *T. stantoni*, the larger to *T. univentris* Walker. This is another Bornean species overlooked by Schuurmans Stekhoven (1926).

Tabanus effilatus Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 154. Type ♀, Isle Madoera ("Vet. State Labs."). Philip 1959, *Fieldiana, Zool., 33:* 611.

Since this species has been taken in the Philippines (Philip, op. cit.) as well as Malaya, it undoubtedly occurs in Borneo as well.

Records.—Malaya: 4 ♀♀ Quedah (*de Bije*); ♀ no loc. (det. van der Wulp as *T. striatus*) (S.S.). Other distribution: Madoera, Sumatra.

Material examined.—Malaya: ♀ Selangor (*Butler*, paratype, BMNH); ♀ Singapore, biting horses and cattle, 18. viii. 1907 (*P. S. Fulshaw*); 2 ♀♀ Singapore (*White* and *Finlayson*); 7 ♀♀ Singapore, iii and v. 1924; 24 ♀♀ Penang, various localities, ii. 1955 and 1957 (*H. T. Padgen*); ♀ Kuala Lumpur; ♀ Perak, Larut Hills, 4500′, 21. ii. 1932 (*Pendlebury*) ♀ Selangor, 6. v. 1940 (*E. P. Hodgkin*); ♀ Selangor, Jugra, 31. x. 1955; 6 ♀♀ Selangor, Rantau Panjang, ii, ix. 1956, cow bait. Thailand: 2 ♀♀ "Lower Siam Trong" (*Dr W. L. Abbott*) (USNM).

Tabanus enderleini Philip, new name

Syn. *Phyrta nigripes* Enderlein 1924, *Mitt. zool. Mus. Berl., 11:* 394. Type ♂, Borneo, Muidai, vi. 1882 (*Grabowsky*) (Berlin Mus. No. 10, 943).

Syn. *Tabanus nigripes* Schuurmans Stekhoven 1932, *Tijdschr. Ent., 75* (Suppl.): 78. Not *Tabanus nigripes* Wiedemann, 1821, *Dipt. exot., 1:* 75 (Georgia, USA).

Schuurmans Stekhoven (op. cit.) was correct in transferring this species into *Tabanus* since *Phyrta* is not even recognized as a subgenus, but he overlooked the prior *T. nigripes* Wiedemann which necessitates a new name. He also described and figured a female from

North Borneo, a distinctive orange species with parallel front, index 1: 8, antenna with an acute tooth, tinted wings with closed cell R_5, and dark venter. This must resemble *T. cinnamoneus* Doleschall of New Guinea which, however, has open cell R_5.

There is also obvious relationship to *T. flexilis* Wulp of Celebes and the *ixion-vanderwulpi* complex of the Philippines with variegated wings. The variability and significance of the closure of cell R_5 are discussed by the writer (1959) in that group as well as variation in color of vestiture. It may well be that darker specimens with narrowly open cells R_5 will show up when both sexes and more specimens of *enderleini* are taken.

Tabanus equicinctus Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 282. Type ♀, Siam Peninsula, "Nakon Sri Tamarat, Khao Rama Kam," 1200′, 23. ii. 22 (*I. Xavier*) (Raffles Mus.); 1928, *Zool. Jb.*, (1), *54:* 425.

Syn. *Tabanus aequicinctus* Szilàdy 1926, *Biol. hung., 1* (fasc. 7): 10.

Records.—Thailand: paratype ♀ Khao Tong, 300′, 21. ii. 1922 (*Xavier*); ♀ Nakon Sri Tamarat, Khao Ram, 750′, 24. ii. 1922; 2 ♀♀ Khow Sai Dow, Trong, Lower Siam, 1000′, 1. ii. 1899 (*Abbott*) (USNM).

Material examined.—Thailand: ♀ Chiengmai, 2. iii. 1952 (*D.C. & E.B. Thurman*).

Tabanus finalis Walker

1854, *List Dipt.*, Suppl. V: 258 (n.n. for *T. apicalis* Walker 1848, *List. Dipt. 1:* 176). Type ♂, patria ignota (BMNH). Austen 1922, *Bull. ent. Res., 12:* 442.

Records.—Thailand: "Siam, at light," 3. ii. 1914.

Tabanus flavipilosus Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 454. Type ♀, Sarawak, Borneo (reported in BMNH but not seen in 1958; however, see discussion under *T. borniensis*).

Syn. *Tabanus flavopilosus* Szilàdy 1926, *Biol. hung., 1* (fasc. 7): 10.

No other specimens have been reported.

Tabanus flavohirtus Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 14. Type ♀, Borneo, Munkun Is., E. Kalimantan Distr., at light, xii. 1953 (*H. von Hentig*). In Chi. Nat. Hist. Mus.

Records.—Borneo: ♂ ♀ same data as type. Malaya: ♀ Trengganu, Besut Distr., Gunong Tebu, 400′, v. 1958 (*R. Traub*).

Tabanus flavothorax Ricardo

1911, *Rec. Indian Mus., 4:* 201. Type ♀, Perak, F.M.S. (*Pratt*) (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 528.

Records.—Malaya: ♀ same data as type; ♀ Perak, Sungei Siput (*Pratt*); ♀ Sungei Krudda (*Pratt*); ♀ Singapore (Ridley); ♀ Johore (*Flower*); ♀♀ Batu Tiga (S.S.). Other distribution: Sumatra.

Material examined.—Borneo: ♀ Kuching. Malaya: ♀ (type); 2 ♀♀ Selangor, Dipterocarp Forest nr. Kuala Lumpur, 13-16. v. 1958, (*R. Traub*); 4 ♀♀ Perak, 10 mi. W. Ipoh, Forest Reserve, 150′, 17. ix. 1958 (*R. Traub*).

Tabanus fulvilinearis Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 16. Type ♀, Thailand, Bangken nr. Bangkok, 5. i. 1951 (*Boonsom*). In coll. C.B.P.

Tabanus fulvissimus Rondani

1875, *Ann. Mus. Civ. Stor. Nat. Genova, 7:* 458. Type ♀, Borneo (Genova Mus.). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 487; 1932, *Arch. Naturgesch.*, (N.F.), *1:* 56.

Records.—Borneo: 6 ♀♀ Upper Sibau River, 26. vi. 1894 (*Buttikoefer*); 2 ♀♀ Poetoe, Sibau, 23-30. vi. 1909 (*Lorentz*); ♀ Poetoes, vi. 1894 (*Buttikoefer*); 4 ♀♀ Boenoet, 26. vi. 1909 (*Lorentz*); 4 ♀♀ Sintang, 25. vi. 1909 (*Lorentz*); 3 ♀♀ Djongkong 1. vii. 1909 (*Lorentz*); ♀ So. Slope of G. Kenapai 21-31. xii. 1893; ♀ Sambas, v. 1907 (*B. Kloss*) (S.S.); ♀ Kapaus nr. Sehoda, 3. xi. 1924 (*Winkler*); 3 ♀♀ Borneo; 2 ♀♀ Sintang (*von Roeder*) and 21. i. 1924 (*Winkler*) (S.S. 32). Other distribution: Java.

Material examined.—Borneo: ♀ (*Xantus*); ♀ Sintang, 25. vi. 1909 (*Lorentz*); 2 ♀♀ Barumfuss, Kukenth., 1894. Malaya: ♀ Kuala Lumpur (*Dr H. T. Stanton*); 3 ♀♀ Matang River, 24. ii. and 21. iii. 1916.

Tabanus fumifer Walker

1857, *Proc. Linn. Soc. Lond., 1:* 110. Types ♀ ♂, Sarawak, A. R. Wallace ex coll. Saunders (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 392 (excludes type ♂); 1928, *Zool. Jb.*, (1), *54:* 425; 1932*a*, *Arch. Naturgesch.*, (N.F.), *1:* 56; 1932*c*, *Mém. Mus. Hist. nat. Belg., 4:* 11. Kröber 1934, *Ark. Zool., 26A* (8): 8.

Schuurmans Stekhoven considers this species to be one of the commonest and most variable in the Indonesian Region. He has, however, questioned the identity of the damaged type which I believe he has misinterpreted (*see* discussion under *T. malayensis*). The front of the type agrees best with his fig. 194k (1926) and has index of 1: 9.5; antennae are present, and in spite of repaired abdomen, vestiture is adequate behind tergite 2 to determine that the incisures are not yellow expansions of the median triangles as he keys *fumifer*; the triangles are not as prominent as *T. malayensis* and *T. brunneus*, and are easily worn off, which suggests that some specimens may appear to have unpatterned abdomens that would not key.

The Manila female reported by Kröber (op. cit.) was examined on loan through courtesy of Dr Erik Kjellander of Stockholm Museum, and this assignment appears better than any other. There is obvious close relationship to a specimen from Sarawak that agrees with the type of *T. fumifer* in BMNH also from Sarawak. Occurrence of this species in the Philippines had been left with question in my review (1959).

I suspect, however, that many published records are misidentifications.

Records.—Borneo: 2 ♀♀ Sarawak (*Wellington*); ♀♀ Martapoera Tanah Intan, Tarip; ♀ Mahakkan, 1894 (*Nieuroenthius*); ♀ Djonkong, 1. vii. 1909 (*Lorentz*) (S.S.); ♂ Mid. E., 6. viii. 1925 (*Siebers*) (S.S., 1928); ♀ Putus Sibau, Kapaus, 14. ii. 1925; 2 ♀♀ Lower Melawi, Kapaus, 18-22. i. 1925 (*von Roeder*); ♂ Nangi Serwai, 18. xii. 1924 (*Winkler*); ♂ 4 ♀♀ Tandjong, 31. xii. 1895; ♀ (*von Roeder*) (S.S. 1932*a*); ♀ Samarinda, 8. xi. 1929 (S.S. 1932*c*). Malaya: 5 ♀♀ Singapore, v. 1924 and 1904 (*Ridley*); ♀ Quedah, Malacca (*de Bije*); ♀ Goenoeng, Tampin, 26. vi. 1920; 9 ♀♀ Darien Typus, 1909 (*Stanton*); ♀ Selangor (*Butler*); ♀ Sungei Besi, Selangor, 4. vii. 1902; ♂ Kukub, S. Johore, 1909 (*Forbes*); 11 ♀♀ Batu Tiga, i. 1909. 17. ii. 1910 and 15. v. 1910 (*Stanton*) (S.S.). Other distribution: Sumatra, Java.

Material examined.—Malaya: ♀ (type); ♂, ♀♀ Singapore, vi. 1902 and 2. vi. 1920; ♀ Negri Sembilan, Seremban, 31. i. 1904; 2 ♀♀ Dindings, xii. 1902; ♀ mouth Penang River, vii. 1915 ("*V.K.*"); 2 ♀♀ Sungei Buloh, 11. ix. 1922; ♀ Batu Bokarat, 18. viii. 1920; ♀ Selangor, Dipterocarp Forest nr. Kuala Lumpur, vi, vii. 1958 (*R. Traub*).

Tabanus fuscifrons Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 485. Type ♀, Sintang, Borneo, viii-ix. 1894 (*Goedhuis*) (Leyden Mus.).

Records.—No other specimens reported.

Tabanus fusciventer Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 257. Type ♀, Sumatra ("Vet. State Labs.").

Material examined.—Malaya: ♀ Perak, 5 mi. W. Ipoh, 10. x. 1956 (*R. Traub*); ♀ Selangor, Kanching Ridge, 2. iii. 1959 (*W. W. Macdonald*).

Tabanus gilvellus Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 16. Type ♂, Thailand, Chiengmai, Pann, 5. iii. 1952 (*D. C. & E. B. Thurman*) "in hot spring." In USNM.

Tabanus griseilineis Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 17. Type ♀, Thailand, "*via*," 1952, (*D. C. & E. B. Thurman*). In USNM.

Tabanus griseipalpis Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 312. Type ♀, Sumatra ("Vet. State Labs."); 1928, *Zool. Jb.*, (1), *54:* 425; 1932, *Arch. Naturgesch.*, (N. F.), *1:* 56.

Schuurmans Stekhoven (1932) included this in Szilàdy's subgenus *Callotabanus*, and while it is representative of a distinctive element in the genus *Tabanus*, parallel treatment of other groups such as *T. ceylonicus* and *T. optatus* would then be required with very little utility.

Records.—Borneo: ♀ E. Cent., Upper Mahakkam, Long Iram, 2. v. 1929 (*von Kuehlewein*). Thailand: ♀ (paratype) Nakon Sri Tamarat, Khao Lung 1500-2000′, 16. iii. 1922 (*Pendlebury*); 2 ♀♀ Kow Sai Trong, Lower Siam, 1000′, 1. ii. 1899 (*Abbott*) USNM. Other distribution: Java, Sumatra, "Siam Peninsula."

Tabanus hirtistriatus Ricardo

1911, *Rec. Indian Mus., 4:* 158. Type ♀, Perak (*Stanton*) (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 226; 1932, *Arch. Naturgesch.*, (N.F.), *1:* 56.

Records.—Borneo: ♀ Sintang (S.S. 1932). Malaya: 4 ♀♀ Negri Sembilan, Darien Typus (*Dr. H. T. Stanton*) (Ricardo). Other distribution: Sumatra.

Material examined.—Malaya: ♀ (type): 5 ♀♀ Trengganu, Besut Distr., Gunong Tebu, 400′, v. 1958 (*R. Traub*).

Tabanus hybridus Wiedemann

1828, *Auss. Zweifl. Ins.*, p. 557. Type ♀, Macao (Vienna Mus.). Schuurmans Stekhoven 1926, Treubia, *6* (Suppl.): 235.

Schuurmans Stekhoven (op. cit.) calls attention to variation in this species which impels me to assign present Malayan specimens here though these are even more divergent, paler yellow including femora and faces, the thoraxes are more pale greenish-buff, and the sides of the abdomen are more broadly black-haired than he describes. *T. subhybridus* n. sp. was at first thought to be a dark variant.

Records.—Borneo: 2 ♀♀ (*Buttikoefer*) ♀ Sarawak. Malaya: ♀♀ Sungkai, S. Perak, Perak; Batu Tiga (*Stanton*). Other distribution: Sumatra, Macao.

Material examined.—Malaya: ♀ Selangor, Bukit Kutu, 3000-3400′, iv. 1915; ♀ Pahang, Cameron Highlands, Jor Camp, 4800′, 10. x. 1923; ♀ Selangor, vicinity Kuala Lumpur, 23. iii. 1948 (*C. B. Philip*); 2 ♀♀ Selangor, near Kuala Lumpur, v. 1958 (*R. Traub*).

Tabanus ignobilis Rondani

1875, *Ann. Mus. Civ. Stor. Nat. Genova, 7:* 457. Type ♀, Borneo, Sarawak (Genova Mus.). Ricardo 1911, *Rec. Indian Mus., 4:* 180. Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 371.

Records.—N. Borneo: ♀ Sandakan (*Cator*); Schuurmans Stekhoven (op. cit.) is doubtful about this determination.

Material examined.—Borneo: ♀ Mt. Maranpoh, Dent. Prov., no date (*Janson*).

Tabanus immanis Wiedemann

1828, *Auss. Zweifl. Ins., 1:* 129. Type ♀, Java ("In Leyden Museum"). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 402; 1928, *Zool. Jb., (1), 54:* 425; 1932, *Arch. Naturgesch.*, (N.F.), *1:* 56.

Without seeing the type, Schuurmans Stekhoven (op. cit.) interpreted this to be a common, variable Malaysian species near *T. fumifer* Walker with a median row of golden-haired triangles but without expansion along incisures though Miss Ricardo (1911*a*) had not recognized the species. However, in view of Wiedemann's well-known careful descriptions, I believe he would have referred to such triangles rather than describing "in certain lights a paler median stripe and almost square side spots" (transl.) on rusty brown abdomen. Face "moldy grey" would imply the beard was not yellowish. These and other of the original characters can be seen on a few both worn and unworn specimens from Selangor. Front, thorax, legs, wings, and venter of these are as in *T. malayensis*, but differ in having white to pale straw-yellow beards and paler underparts, antennal tooth semirectangulate rather than acute, abdomens more rusty red with suggestions of dark shadows along the incisures giving the effect, especially viewed from behind, of large, red, lateral spots or squares above them with a rather narrow, median line accentuated by yellow hairs particularly at the incisures (as described for *T. undulans* Schuurmans Stekhoven). These markings remain as a paler integumental line crossing tergites 4, 3, and onto 2 in worn specimens. They differ also in having no revivable green on the lower half of the eyes.

It is unfortunate that no specimens similar to these are at hand from Borneo. Listed as synonyms are *T. univentris* Walker (1848, *List. Dipt.* I, p. 151, Borneo), and *T. stantoni* Ricardo (1911, *Rec. Indian Mus., 4*: 206, Malaya). I consider the last as a distinct species, and the type of *T. univentris* (BMNH) is too worn for recognition, but the lack of midventral dark spots preclude synonymy here.

Two females (Perak, Forest Reserve near Ipoh, 17. ix. 1958, *R. Traub*) are morphologically similar with reddish abdomens and black lateral hairs, but are worn in the middle so that neither yellow-haired triangles nor pale, pollinose, median stripes are evident. They cannot be assigned here with certainty.

Published records below may or may not include my interpretation of the species (*see* also discussion under *T. malayensis*).

Records.—Borneo: 2 ♂♂ Mid. E., 12. viii. & 24. x. 1925 (*Siebers*); ♀ Tandjoing (*Speyer*); ♀ (*von Roeder*). Malaya: 8 ♀♀ Batu Tiga, Labuan Padang, 23. xii. 1907 (*Pratt*); 2 ♀♀ Batu Tiga, 15. v. 1910, and Klang Road (*Stanton*); 2 ♀♀ Petaling, 4. vi. 1913; 2 ♀♀ Kuala Kubu, 2. ii. 1910; 2 ♀♀ Kuala Lumpur, 1896, and 1903 (*Durham*); 3 ♀♀ Selangor, 10. v. and 11. xii. 1909, and vi. 1921; ♀ Sci Chemabang, N.B. Bulok, Beluka, 150′, vi. 1921 (*Abrahams*) (S.S.). Other distribution: Java, Sumatra, Nias Is.

Material examined.—2 ♀♀ Selangor, Dipterocarp Forest near Kuala Lumpur, vi-vii. 1958 (*R. Traub*); ♀ Pahang, Kuantan, 29. x. 1935 (*V. Surgeon*), off water buffalo.

Tabanus infamis Szilàdy

1926, *Biol. hung., 1* (7): 19. Type ♀, Borneo (Vienna Museum).

One gathers from the meagre description that this belongs in the *ceylonicus*-group while one other character accidentally mentioned, the white beard, relates it to *minimus* Wulp (though only the brownish *simplissimus* Walker is compared!) from which one other remark, "first tergite with a vestigial, dark, transversely oval spot, second tergite with a longitudinal one" seems to differentiate it, but "owing to the bad condition of this specimen the description may be somewhat erroneous as to colors." The type will have to be seen to decide on relationships.

Tabanus insidiator Austen

1922, *Bull ent. Res., 12:* 437. Type ♀, 4 paratypes, Chiengmai, Doi Chom Chang, 5000′, 16. iv. 1921 (*Barnes*). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 315. No other records.

Tabanus invalidus Szilàdy

1926, *Biol. hung., 1* (7): 16. Syntype ♀♀, "Sinhap" (which the describer interprets as Singapore) (Vienna Mus.).

I have not been able to recognize or key this inadequately described species, which the describer relates to *T. indianus* Ric. (difficult *immanis*-group) but the wider front (about 1: 6 according to figure) and strongly hooked antennae are quite different.

Tabanus justorius Rondani

1875, *Ann. Mus. Civ. Stor. Nat. Genova, 7:* 455. Type ♀, Sarawak, Borneo (Genoa Mus.). Ricardo 1911, *Rec. Indian Mus., 4:* 192 (redescribes type).

Material examined.—I have seen two females of this distinctive species from British North Borneo, one from Mt. Marapah, Dent. Prov. (*Janson*).

Tabanus khasiensis Ricardo

1911, *Ann. Mag. nat. Hist., 3* (8): 487. Type ♀, Khasi Hills, Assam (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 289.

Records.—Malaya: ♀ Penang (*Ridley*). Thailand: not recorded, but should occur since it has been taken on both sides.

Tabanus konis Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 17. Type ♀ (plus 3 others), Thailand, Chiengmai, 26. viii. 1952 (*Thurmans*) "flower garden". In USNM.

Tabanus laticorpus Philip, new name

Syn. *Tabanus lativenter* Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 390. Type ♀, Borneo, Sintang, 25. vi. 1909 (*Lorentz*) (Amsterdam Mus. but not seen in 1958). Schuurmans Stekhoven 1932, *Arch. Naturgesch.*, (N.F.), *1:* 56 (compares to *T. pauper* Rondani). Not *Tabanus lativentris* Macquart 1838, *Dipt. exot., 1*: 153.

Records.—Borneo: 2 ♀♀ Djongkong, 1. vii. 1909 (*Lorentz*); ♀ no locality.

Tabanus lentisignatus Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 506. Type ♂, Sarawak, Borneo (*Wallace*) (BMNH).

Unfortunately, I missed this species in BMNH for there is a discrepancy in the description. Type and one other are labelled as ♀♀, but the text plainly indicates 2 ♂♂.

Records.—Malaya: ♂? Tebing Tinggi, Kelantan, vii. 1920 (*V. Knight*) (S.S.); these are same data as for ♂ *T. flavothorax.*

Tabanus leucocnematus Bigot

1892, *Mém. Soc. zool. Fr., 7:* 656. Type ♀, India (USNM). Ricardo 1914, *Arch. Naturgesch.*, (A), *80* (8): 122. Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 321.

Records.—? Malaya: ♀ Malacca, "Kelanton" (*Dr. Horn*). This Malacca record by Ricardo was overlooked by Stekhoven, but until occurrence is confirmed in Malaya by other catches, I have placed the record in doubt.

Tabanus macdonaldi Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 18. Holotype ♀, Malaya, Selangor, Ulu Gombak, 19. viii. 1957 (*W. W. Macdonald*). In BMNH. No other records.

Tabanus malayensis Ricardo

1911, *Rec. Indian Mus., 4:* 178. Type ♀, Darien Typus, Negri Sembilan, F.M.S., Pres. by Dr. Stanton (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 382; 1928, *Zool. Jb.*, (1), *54:* 425; 1932, *Arch. Naturgesch.*, (N.F.), *1:* 56.

This belongs in the difficult Indonesian *immanis-fumifer* group, variation in which is discussed by Schuurmans Stekhoven (1926) in studying a large amount of material, and whose keys plus those of Ricardo (op. cit.) appear almost hopelessly confused. With the limited material at my disposal, there is obvious likelihood that little clarification can be anticipated, particularly until the type of *T. immanis* Wiedemann from Java can be studied. Morphological similarity is common and tinctorial differences are likely to be untrustworthy.

T. malayensis may be the most abundant of the group in Malaya, but I am not at all satisfied that it is more than a variant of *T. fumifer* Walker with an intensified abdominal pattern. Typical specimens, like most of the group, have bicolored eyes, blue in the upper half and green in the lower which is revivable, but to add to the confusion, an occasional specimen otherwise indistinguishable from *malayensis* has entirely black eyes when relaxed. These patterns need to be checked in the fresh state. Schuurmans Stekhoven erroneously separates this and *brunneus* Macquart with "peculiar white, triangular or halfmoon-shaped spots" in his key. Unfortunately, the lateral yellow hair patches on the tergites which he and Miss Ricardo stress in distinguishing this from *fumifer* vary in extent according to light and view from sides or rear. This may be true also of "segmentations yellow-haired or yellow-fringed" and the underlying integument on which difficulties are compounded by frequently worn specimens. Separation of *fumifer* by narrow, incisural expansions of the median triangles as provided by Schuurmans Stekhoven will not hold in material I have studied and division of specimens between this and *immanis* on this basis is purely arbitrary, especially since the type of the former from Sarawak and other topotypic specimens do not show such yellow-haired incisures. While the abdomen of the type of *fumifer* has been repaired, enough vestiture remains from tergite 3 caudad to check this feature.

A proportion of Malayan material does show heavier, yellow triangles, which may still show vaguely in the integument of worn specimens, and this has been the only basis, admittedly an unsatisfactory one, for assignation. In *T. fumifer*, these triangles appear smaller with less defined apices, and may completely disappear on wear, leaving a uniformly reddish-appearing abdomen. The keys to the group provided here can only be used with caution (and admittedly often with no less frustration than previous ones).

Records.—Borneo: 2 ♀♀ Mid. E., 10 & 26. viii. 1925 (*Siebers*). (S.S. 1928); 2 ♀♀ (*von Roeder* and *Banquay*) (1932). Malaya: 2 ♀♀ Kuala Lumpur, 23. ii. 1910 (*Stanton*) and 1903 (*Durham*); ♀ Batu Tiga, 16. ii. 1910; 3 ♀♀ Singapore, 1904 (*Ridley*) (S.S.); 2 ♀♀ Kuala Lumpur, 11. ix. 1922 (S.S. 1928). Other distribution: Java, Sumatra, Nias Is.

Material examined.—Borneo: 2 ♀♀ Langkon, 8. iv. 1938 (*K. S. Chen*); ♀ Sarawak, Kuching, i. 1901 (*Brunetti*); 4 ♀♀ Sarawak, 1907-1909 (*C. J. Brooks*). Malaya: ♀ (type); 2 ♀♀ Kedah Peak, 3300′, 19. iii. 1928 and 20. iv. 1930; 2 ♀♀ Selangor, Bukit Kutu, 500′ iv. 1915 and 5.

ix. 1929 (*Pendlebury*);♀ Perak, Larut Hills, 3700-4000′, 10. ii. 1932 (*Pendlebury*); ♀ N. of Teluk Anson, S. of Sungei Lampsan, Lower Perak, on *Rhinocerus sundaicus* (*Vernay*); 2 ♀♀ Selangor, nr. Kuala Lumpur, 23. iii. 1948 (*C. B. Philip*); ♀ Selangor, Dipterocarp Forest nr. Kuala Lumpur, 13-16. v. 1958 (*R. Traub*); ♀ same, vi-vii. 1958 (*R. Traub*); 5 ♀♀ Trengganu, Dungun, Bukit Besi, 4-8. viii. 1958 (*R. Traub*).

Tabanus melanognathus Bigot

1890, *Nouv. Arch. Mus. Hist. nat., Paris*, (3), *2:* 204.Type ♂, Laos (BMNH).

Syn. *Tabanus nonoptatus* Ricardo 1911, *Rec. Indian Mus., 4:* 226. Syntypes, ♂ from India, ♀ unknown loc. (Ind. Mus. and BMNH).

If the same situation obtains with Bigot's record of "Laos" here as for *Chrysozona cilipes* Bigot and *T. nigrotectus* Bigot, as called to attention by Austen (1922), then this too could come from So. Thailand.

Tabanus minimus van der Wulp

1892, *Sumatra Exped., Diptera*, p. 18. Type ♀, Sumatra (Leyden Mus.). Ricardo 1911, *Rec. Indian Mus., 4:* 221 (wrong syn. under *T. simplissimus* Walker). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 426.

? Syn. *Tabanus infamis* Szilàdy 1926, *Biol. hung., 1* (7): 19 (Borneo).

Records.—Borneo: ♀ Djonkong (*Lorentz*); 22 ♀♀ Tanak, Intan, Martapoera, on buffalo, viii. 1923 (*Tarip*) (S.S.). Malaya: ♀♀ (*Fraser*) (S.S.). Other distribution: Sumatra, Java.

Material examined.—Malaya: ♀ Selangor, Kuala Lumpur, 11. ii. 1924 (*H. M. Pendlebury*); ♀ Kedah Peak, 3000-3300′, 12. iii. 1928 (*H. M. Pendlebury*); 3 ♀♀ Selangor, vicinity Kuala Lumpur, 23. iii. and 9. v. 1948 (*C. B. Philip*); ♀ Selangor, Subang, 12. iii. 1958 (*R. Traub*); ♀ Selangor, Kuala Lumpur, 16. i. 1936 (*Buckley*), on cattle; ♀ Selangor, Rantau Panjang, 9. ii. 1956, cow bait.

Tabanus multicinctus Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 283. Type ♀, Sumatra (Vet. State Labs.).

Records.—Thailand: ♀ Khao Tong, 4. ii. 1922 (*J.X.*). The describer figures this specimen with different front than Indonesian specimens, with callosity touching the eyes. I suspect he confused a possibly discolored specimen of his *T. equicinctus* here. Until other captures confirm presence of *multicinctus* in Thailand, the record will have to remain in doubt.

Tabanus nephodes Bigot

1892, *Mém. Soc. zool. Fr., 5:* 656. Type ♀, India (BMNH). Ricardo 1911, *Rec. Indian Mus., 4:* 145.

This species was omitted by Schuurmans Stekhoven (1926).

Records.—India.

Material examined.—Malaya: 4 ♀♀ West Coast, Langkawi Is., 19-29. iv. 1928.

Tabanus nexus Walker

1875, *Proc. Linn. Soc. Lond., 1:* 110. Type ♀, Sarawak, Borneo, ex. coll. Saunders (BMNH). Schuurmans Stekhoven 1932, *Arch. Naturgesch*, (N.F.), *1:* 56.

Records.—Borneo (*von Roeder*) (S.S.). Other distribution: Sumatra.

Material examined.—Malaya: 2 ♀♀ assigned here in BMNH from Batu, 14. vi. 1910 and Kuala Lumpur (*Dr A. T. Stanton*) are doubtfully this as the palpi are more pointed and abdomens more orange-reddish with faint yellow midlines.

Tabanus nigrinus Szilàdy

1926, *Biol. hung., 1* (7): 10 (new name).

Syn. *Tabanus nigerrimus* Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 497. Type ♀, Sarawak, Baram River, Long Majam, 5. x. 1920 (*Moulton*). (Originally Raffles Mus., Singapore). Not *T. nigerrimus* Zetterstedt, 1842, *Dipt. Scand., 1:* 115.

No other specimens have been reported from Malaya or Borneo.

Tabanus nigrotectus Bigot

1890, *Nouv. Arch. Mus. Hist. nat., Paris, 2:* 204. Type ♀, Laos. Austen 1922, *Bull. ent. Res., 12:* 437 (type actually from So. Thailand, identical to *Chrysozona cilipes*, which see). Other distribution: ♀♀ in USNM seen from Cambodia and Borneo.

Material examined.—Thailand: ♂ Chiengmai, viii. 1952 (*D. C. & E. B. Thurman*).

Tabanus nilakinus Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 19. Type ♀, Thailand, Loei Dansai, Bangkok, 27. v. 1955 (*R. E. Elbel*). In USNM.

Tabanus ochros Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 452. Type ♀, Thailand, Rompibon, 8. iii. 1922 (orig. Raffles Mus.). No other records.

Tabanus optatus Walker

1856, *Proc. Linn. Soc. Lond., 1:* 33. Type ♀, Borneo, Sarawak (*A. R. Wallace*) ex coll. Saunders (BMNH). Ricardo 1911, *Rec. Indian Mus., 4:* 139 (synonymy). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 533; 1928, *Zool. Jb.*, (1), *54:* 425.

Syn. *Tabanus alboscutatus* Rondani 1875, *Ann. Mus. Civ. Stor. Nat. Genova, 7:* 456. (Borneo).

Syn. *Tabanus equestris* van der Wulp 1885, *Notes Leyden Mus., 7:* 77 (♂ Sumatra, 2 ♀♀ Java, 4 ♀♀ Borneo).

Records.—Borneo: 7 ♀♀ Tanah Intan, Martapoera, viii. 1923 (*Tarip*); 3 ♀♀ (*Muller*); 4 ♀♀ Borneo (*Rondani*); ♀ Mid. E. Borneo, 7. xi. 1925 (*Siebers*). Other records: India, Sumatra, Java.

Material examined.—Borneo: ♀ (type); ♀ (ex coll. Bigot). Malaya: ♀ Pahang, Kuantan, 29. x. 1925, on water buffalo; 3 ♀♀ Pahang, Kuantan, 29. x. 1935 (*V. Surgeon*), off water buffalo; ♂ Kelantan, Tebing Tinggi, vi. 1920 (*V. Knight*); ♂ Kuala Lumpur, at light, 7. iv. 1931; 3 ♀♀ Selangor, nr. Kuala Lumpur, 9. v. 1948 (*C. B. Philip*). A ♀ "New Guinea, 1911, Gjellerup" in Vienna Museum is a new record if the label is reliable.

Tabanus parabrunneus Schuurmans Stekhoven

1932, *Tijdschr. Ent., 75* (Suppl.): 78. Type ♀, N. Borneo.

Material examined.—No. Borneo: 6 ♀♀ Kinabalu, 6300′, vii. 1951 (*D. Johnson*) (USNM).

Tabanus parallelifrons Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 378. Type ♀, Sintang, Borneo, viii. 1894 (*Dr. Goedhuis*) (Leyden Mus.).

Records.—Borneo: ♀ same data as type.

Tabanus pauper Rondani

1875, *Ann. Mus. Civ. Stor. Nat. Genova, 7:* 456. Type ♀, Sarawak, Borneo (Genoa Mus.). Ricardo 1911, *Rec. Indian Mus., 4:* 207.

Though this large reddish species was omitted by Schuurmans Stekhoven (1926), he nevertheless states that his *T. lativenter*, also from Borneo, is close but differs in more yellowish vestiture of head, face, and chest. The midabdominal triangles may be plainer, but Ricardo states that Rondani's type is not in good condition which might obscure these markings.

No other records are known.

Tabanus pendleburyi Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 20. Type ♀, Brit. N. Borneo, Mt. Kinabalu, Kenokok, 3300′, 27. iv. 1929 (*Capt. H. M. Pendlebury*) (BMNH).

Material examined.—Borneo: 2 ♀♀ type and paratype, Mt. Kinabalu.

Tabanus perakiensis Ricardo

1911, *Rec. Indian Mus., 4:* 204. Type ♀, Malaya, Kuala Lumpur (*Stanton*) (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 447; 1928, *Zool. Jb.*, (1), *54:* 425.

Records.—Malaya: ♀ Perak (*Pratt*) (Ricardo). ♀ Perak, Jor Camp, 2000′, 28. viii. 1922 (S.S. 1928). Other distribution: Formosa.

Material examined.—Malaya: ♀ (type); ♀ Perak, Batang Padang, Jor Camp, 1500′, 29. v. 1923 (*H. M. Pendlebury*); ♀ Trengganu, Besut Distr., Gunong Tebu, 400′, v. 1958 (*R. Traub*); ♀ Selangor, Dipterocarp Forest nr. Kuala Lumpur, 16. v. 1958 (*R. Traub*); ♀ Perak, 10 mi. W. Ipoh, Forest Reserve, 150′, 17. ix. 1958 (*R. Traub*); ♀ Gombak, iv. 1949 (*R. Traub, B. Insoll*); 2 ♀♀ Selangor, Ulu Gombak ii. iii. 1956.

Tabanus pictipennis Szilàdy

1926, *Biol. hung., 1* (7): 17. Type ♀, Borneo (Vienna Mus.).

This inadequately described species belongs in the *immanis-fumifer* group but could not be keyed. It has bright reddish-yellow abdomen with golden-haired triangles above and discontinuous median black spots below; very narrow front with callosity possibly touching eyes at lower corners (about 1: 12 according to figure); and bicolored legs. *T. parabrunneus* Schuurmans Stekhoven and *T. stantoni* Ricardo are related but have wider fronts. A study of the type will be necessary to identify this in its difficult complex.

Tabanus praematurus Austen

1922, *Bull. ent. Res., 12:* 440. Type ♀, Thailand, Chiengmai, Doi Chom Chang, 5500′, 15. iv. 1921 (*Barnes*). In BMNH.

Material examined.—Thailand: ♀ Chiengmai, 4-8. iv. 1952 (*D. C. & E. B. Thurman*).

Tabanus pratti Ricardo

1911, *Rec. Indian Mus., 4:* 143. Type ♀, Kelantan, Malacca, 1904 (*Rolle*) (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 328; 1928, *Zool. Jb.*, (1), *54:* 425.

Records.—Borneo: ♀ Sarawak, 1908 (*Willington*). Malaya: ♀ Batu Tiga, Selangor (*Pratt*) (Ricardo); ♀ Pahang (S.S. 1928).

Material examined.—Malaya: ♀ Pahang, Gunong Tahan; ♀ Johore; ♀ Perak, Bulliar, 1929 (*A. Horn*).

Tabanus pugiunculus Austen

1922, *Bull. ent. Res., 12:* 451. Type ♂, Thailand, near Bangkok, vi. 1921 (*Barnes*). In BMNH.

Records.—Thailand: ? ♀ Phrapatoon, viii. 1906 (*Wooley*).

Tabanus pugnax Austen

1922, *Bull. ent. Res., 12:* 449. Type ♀, paratype ♀, Thailand, Chiengmai, Doi Chom Chang, 5500′, 12. iv. 1921 (*Barnes*). In BMNH. No other records.

Tabanus rubicundulus Austen

1922, *Bull. ent. Res., 12:* 442. Syntypes, 2 ♀♀, S. Siam, Chantabun, Mouhot (*Saunders*). In BMNH.

Material examined.—Thailand: ♀ Chiengmai, Doi Sutep, 3000′, 23. iii. 1952 (*D. C. & E. B. Thurman*).

Tabanus rubidus Wiedemann

1821, *Dipt. exot., 2:* 19. Types, 3 ♀♀, Bengal (Copenhagen Mus.). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 186. Austen 1922, *Bull. ent. Res., 12:* 448.

Syn. *Tabanus lagenaferus* Macquart 1838, *Dipt. exot., 1:* 148 ("Patria Ignota") (new synonymy).

Syn. *Tabanus albimedius* Walker 1850, *Dipt. Saund.*, p. 48 (E. India). Ricardo 1911, *Rec. Indian Mus., 4:* 156 (synonymy).

Syn. *Tabanus umbrosus* Walker 1850, *Dipt. Saund.*, p. 50 (E. India).

Syn. *Tabanus priscus* Walker 1848, *List. Dipt., 1:* 176 (loc. unknown).

Syn. *Atylotus lachrymans* Bigot 1892, *Mém. Soc. zool. Fr., 5:* 669 (Java).

? Syn. *Atylotus abbreviatus* Bigot 1892, *Mém. Soc. zool. Fr., 5:* 670 (Java).

? Syn. *Atylotus conicus* Bigot 1892, *Mém. Soc. zool. Fr., 5:* 650 (♂ Malaya).

This common and widespread Oriental species has had a varied history as the extensive synonymy indicates. It is a common pest of stock in Indonesia as attested among Schuurmans Stekhoven's (1926) list of over 2000 specimens (1105 in Buitenzorg Museum, Java, alone). It is not improbable that it, like *T. striatus*, is concerned in transmission of surra where that disease occurs. Records for Malaya are not as abundant as for India and Indonesia, but there is one record of it, as well as *T. malayensis*, attacking rhinoceros (Hubback, 1919). It is strange, however, that none appear to have been taken in Borneo.

The type of *T. lagenaferus* from "Patria ignota" was seen in Paris and is an undoubted synonym from the head characters though the body pattern is obscured by mold.

Two males from Thailand (Chiengmai, 5. iii and Chiengmai, 20. iv. 1952, *D. C. & E. B. Thurman*, the latter taken with a typical male of *rubidus*) have the same abdominal coloration and general appearance as typical *rubidus* but differ only in entirely black scutellums, and entirely small eye facets; there is no upper, pale area of enlarged facets. It is not known whether these represent variation or a closely related species. Critical differences in females caught during the same period are not apparent, but see comment under *T. virgulatus*.

Records.—Thailand: 2 ♀♀, Chiengmai, Doi Sutep, 1200′, 7-9. iv. 1921 (*Barnes*). Malaya: 6 ♀♀ Singapore, ix. 1923, and 2. v. 1924 (*C. B. Kloss*); ♀ Singapore, 18. vii. 1907 (*Falshaw*); ♀ Kuala Lumpur (*Pratt*); ♀ Petaling, 4. vi. 1910 (*Stanton*); ♀ Pahang 2500′, 1916 (*Hubback*) on *Rhinoceros sumatrensis*. (As *T. abbreviatus*): ♀ Singapore biting horses and cattle (*Falshaw*); ♀ Selangor, biting men and horses (*Butler*) (Ric.). Other distribution: Ceylon, India, China, Sumatra, Java, Nias Is.

Material examined.—Malaya: ♂ (type of *conicus*); 4 ♀♀ Singapore, v. 1924; ♀ Singapore, ii. 1924 (*C. B. Kloss*); ♀ Kuala Lumpur, 2. xi. 1923; ♀ Kuala Lumpur; ♀ Pahang, Gali Raub, xii. 1918; 2 ♀♀ Seaport Estate nr. Kuala Lumpur, 2-9. v. 1948 (*C. B. Philip & R. Traub*); ♀ Penang, Batu Feringgi, 29. i. 1956 (*H. T. Padgen*; det. as *T. abbreviatus*); ♂ ♀ Selangor, v, xi. 1940 (*J. A. Reid, E. P. Hodgkin*); 2 ♀♀ Selangor, Rantau Panjang, ii, viii. 1956, cow bait; ♀ Selangor, I.M.R., 7. v. 1956; ♀ Malacca, 1. iv. 1957 (*C.M.O.*), in house. Thailand: 6 ♂♂, 11 ♀♀, Chiengmai, 19-22. iv and 4-10. v. 1952 (*D. C. & E. B. Thurman*); ♂, 2 ♀♀ Bangkok, 1931 (*Hugh Smith*); 2 ♀♀, Bangkok, 24. iii. 1924 (*Barnes*); ♂ ♀ Prae, 18. x. 1951 and 19. iii. 1952 (*D. C. & E. B. Thurman*); ♀ same, but Payao, 11. iv. 1952.

Tabanus rubriscutatus Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 486. Type ♀, Borneo, Sibau River, vi. 1894 (*Buttikoefer*) (Leyden Mus.).

No other specimens have been reported.

Tabanus ruficoloratus Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 20. Type ♀, Borneo, Sandakan, 1927 (*Baker*). In USNM.

Material examined.—(?) Malaya: ♀ Selangor, Jungle, Kepong Rd., 20. vi. 19—(*Malaria Bureau*); ♀ Selangor, Rantau Panjang, 9. ii. 1956, cow bait.

Tabanus rufiscutellatus Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 539. Type ♀, Batavia, Java ("Vet. State Labs.").

Since I have seen 5 females of this distinctive species from Thailand (courtesy Dr Devakula, data not now available), and the type series came from Java and Sumatra, it would appear likely that specimens will eventually be taken somewhere in Malaya.

Tabanus rufiventris Fabricius

1805, *Syst. Antl.*, p. 96. Type ♀, East India (Copenhagen Mus., seen in 1953). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 271 (synonymy); 1928, *Zool. Jb.*, (1), *54:* 425. Isaac 1924, *Mem. Dep. Agric. India, Ent., 8:* 53-62 (reared).

Syn. *Tabanus crassus* Walker 1850, *Dipt. Saund., 1:* 50 (♂, E. India).

Syn. *Tabanus sanguineus* Walker, *ibid*, p. 54 (Java).

Syn. *Tabanus leucosparsus* Bigot 1890, *Nouv. Arch. Mus. Hist. nat.*, Paris, *2:* 203 (Siam).

Syn. *Atylotus assamensis* Bigot 1892, *Mém. Soc. zool. Fr., 5:* 653 (Assam).

Ricardo (1911*a*) did not recognize this species, but if Schuurmans Stekhoven's (1926) synonymy is correct, it has a wide range from eastern Asia to Java. Fabricius' type in Copenhagen from East India is intact and, according to Professor Tuxen, lacks a prominent brown band across upper face at base of antennae. This band is present on a Pahang specimen studied, and the abdominal triangles are lower than figured by Schuurmans Stekhoven which may relate this specimen to his *T. pseudorufiventris* from Sumatra. I lack material to determine variation. If Isaac (op. cit.) is correct in his rearing, there is remarkable bisexual dichromatism.

Records.—Malaya: ♀ Pahang, Kuantan, 6. ix. 1936, in jungle; ♀♀ Kelantan, Darien Typus, Negri Sembilan, Kuala Lumpur, and Jelebu (S.S.). 2 ♀♀ Kuala Lumpur 21, 26. vi. 1921 (S.S. 1928). Other distribution: East India, China, Formosa, Burma, Sumatra, Java, Nias Is.

Material examined.—Malaya: ♀ Pahang, Kuala Tahan, 500′, 25. xi. 1931.

Tabanus serus Walker

1862, *Proc. Linn. Soc. Lond., 6:* 20. Type ♀, Mysol (*A. R. Wallace*) (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 415 (synonymy). Oldroyd 1949, *Proc. Linn. Soc. N. S. W., 73:* 326.

Syn. *Tabanus facilis* Walker 1864, *Proc. Linn. Soc. Lond., 7:* 206 (Mysol.).

Syn. *Atylotus laglaisei* Bigot 1892, *Mém. Soc. zool. Fr., 5:* 673 (Isle of Waigeo).

Other distribution: New Guinea.

Material examined.—N. Borneo: ♀ Kinabatanga Distr., SE end of Dewhurst Bay, 2-26. vi. 1950 (*R. F. Inger & D. D. Davis*) (CNHM).

Tabanus siamensis Ricardo

1911, *Rec. Indian Mus., 4:* 212. Type ♀, paratype ♀, Thailand, vi. 1906 (*W. Palmer*). In BMNH. Austen 1922, *Bull. ent. Res., 12:* 455.

Tabanus siebersi Schuurmans Stekhoven

1928, *Zool. Jb.*, (1), *54:* 425. Type ♀, Mid. E. Borneo, x. 1925 (*Siebers*).

Records.—Borneo: 2 ♀♀ Mid. E. Borneo, Long Petah, 450 m. (*Siebers*).

Tabanus significans Ricardo

1911, *Rec. Indian Mus., 4:* 182. Type ♀, Kuala Lumpur (*H. C. Pratt*) (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 331.

Records.—Malaya: ♀ Darien Typus (*Stanton*) (Ricardo). ♀ Beseht, Bandar, 28. iii. 1920 (*Corporal*) (S.S.).

Tabanus simplissimus Walker

1857, *Proc. Linn. Soc. Lond., 1:* 111. Type ♂ ♀, Sarawak, Borneo (*Saunders*) (BMNH), now both headless. Ricardo 1911, *Rec. Indian Mus., 4:* 221 (*T. minimus* van der Wulp, wrong synonymy). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 440; 1932, *Arch. Naturgesch.*, (N.F.), *1:* 56.

Records.—Borneo: 2 ♀♀ Kapaus, Mt. Sehada 3. ii. 1924 (*Winkler*). Malaya: ♀♀ Perak (*Pratt*), Kuala Lumpur, Selangor, (*Durham*); Railway, Sungei Besi, Selangor (*Durham*) and (*M. Waldo*), Bidor, S. Perak (*Robinson & Annandale*); ♂ Singapore (*Ridley*) (Ricardo). 4 ♀♀ Batu Tiga (*Stanton*); 2 ♀♀ Kuala Lumpur, 21. ii and 27. iv. 1910 (*Stanton*); ♂ ♀ Singapore, 1898 (*Ridley*); ♀ Perak (*Pratt*) (S.S.).

Material examined.—Borneo: ♂ ♀ (types). Malaya: ♀ Kedah Peak at light, 3259′, 18. iv. 1938; ♀ Selangor, 23. iii. 1948 (*C. B. Philip*); 2 ♀♀ Selangor, Seaport Estate nr. Kuala Lumpur, 2. v. 1948 (*C. B. Philip & R. Traub*); 2 ♀♀ Selangor, near Kuala Lumpur, v. 1948 (*R. Traub*); ♀ Selangor, Kuala Lumpur (*R. Traub*); 27 ♀♀ Gunong Tebu, Trengganu, Besut Distr., v. 1958 (*R. Traub*).

Tabanus sphinx Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 21. Type ♀, Thailand, Chiengmai, 2. iii. 1952 (*D. C. & E. B. Thurman*). In USNM.

Tabanus stantoni Ricardo

1911, *Rec. Indian Mus., 4:* 174. Syntype ♀♀, "long series from Batu 'Tisa' [Tiga] Labuan Padang," Selangor and Kuala Lumpur, Malaya (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 402.

? Syn. *Tabanus univentris* Walker 1848, *List. Dipt. 1:* 151 (Borneo).

? Syn. *Tabanus dives* Rondani 1875, *Ann. Mus. Civ. Stor. Nat. Genova, 7:* 457 (in part). (Sarawak, Borneo): Ricardo 1911, *Rec. Indian Mus., 4:* 186.

Schuurmans Stekhoven (op. cit.) synonymized this and *T. univentris* Walker under *T. immanis* Wiedemann where both types are assigned at present in BMNH. Though no type was designated originally, the one subsequently so labelled from the Batu Tiga series (23. xii. 1907, *Pratt*) may be taken as lectotype. The type of *T. univentris* is too worn and thorax too shrivelled to be certain of synonymy here. Ricardo (op. cit.) was herself uncertain of synonymy, after study of the type of *T. dives* in Genoa.

If I have correctly identified *T. immanis*, it appears that *T. stantoni* is similar but not the same, as distinguished in the key. The latter is larger and the front is definitely wider below, though Schuurmans Stekhoven includes unusual latitude in this character in both figures and text. I am, however, not sure which of his records from Malaya under *immanis* are assignable here.

Records.—Malaya: ♀♀ (type series).

Material examined.—Malaya: ♀ Selangor, Subang, 12. iii. 1958 (*R. Traub*); ♀ Kedah, Langkawi Is., 15-16. vii. 1958 (*R. Traub*); 2 ♀♀ Pahang, 29. x. 1935 (*V. Surgeon*), off water buffalo.

Tabanus stekhoveni Philip, new name

Syn. *Tabanus elegans* Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 474. Type ♀, Borneo, W. Sarawak, 2. iii. 1914 (*Bryant*). In BMNH. Not Thünberg 1827, *Nova Acta Soc. Sci. upsal., 9:* 61.

Tabanus striatus Fabricius

1787, *Mantissa Ins.*, p. 356; 1794, *Ent. Syst., 4:* 371. Types ♂ ♀, Java and China (in 1953 the writer found only the type ♀ from China in Copenhagen Mus., a worn specimen with broken antennae). Mitzmain 1913, *Philipp. J. Sci., 8* (Sec. B): 197-221; 1913, ibid, *8:* 223-229 (biology and dis. trans.). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 163; 1928, *Zool. Jb.*, (1), *54:* 425; 1932, *Arch. Naturgesch.*, (N.F.), *1:* 56. Philip 1959, *Fieldiana, Zool., 33*:606. Austen 1922, *Bull. ent. Res., 12:* 445.

? Syn. *Tabanus chinensis* Thünberg 1827, *Nova Acta Soc. Sci. upsal., 9:* 61 (China and Cape of Good Hope).

? Syn. *Tabanus dorsilinea* Wiedemann 1824, *Anal. Ent.* p. 22 (♂ E. India).

Syn. *Tabanus sinicus* Walker 1848, *List. Dipt., 1:* 16 (♂ Hongkong).

Syn. *Tabanus hilaris* Walker 1850, *Ins. Saund., Dipt.*, p. 49 (♂ India).

Syn. *Tabanus partitus* Walker 1856, *Proc. Linn. Soc. Lond., 1:* 9 (Singapore).

Syn. *Tabanus manilensis* Schiner 1868, *Reis. Nov., Dipt.*, p. 84 (Philippines).

Syn. *Tabanus rufocallosus* Bigot 1892, *Mém. Soc. zool. Fr., 5:* 679 (Java).

? Syn. *Tabanus strophiatus* Surcouf 1923, *Bull. Soc. ent. Fr.*, 10 Oct. 1923, p. 197 (new name for "*striatus auctorum*").

The variation and abundance of this vigorous colonizer in the Orient and Malaysia is indicated by the writer (op. cit.) with relation to the Philippine fauna where Mitzmain (op. cit.) provided biological observations and confirmed its local importance in transmission of trypanosomiasis (surra), the serious livestock disease. Surcouf (op. cit.) recognized this confusion but does not appear to have clarified it. It appears likely that *T. chinensis* Thünberg is a synonym but this cannot be decided until the type, presumably in Uppsala, is studied. Contrariwise, *T. tenens* Walker of India which has often been assigned as a synonym, is different but is preoccupied by *T. triceps* Thünberg as checked on loan of the type by the writer (op. cit.) (lectotype) which had been attributed to "Cayenne et Brazillia" on basis of the poorest two of three syntypes. I have seen both species from Thailand and specimens of each taken together in India without intergradation.

T. striatus is widespread in Malaya but not apparently one of the most abundant horseflies in present, limited collections. Upwards of 2000 records are listed by Schuurmans Stekhoven (1926) for Indonesia, of which 1232 are from Buitenzorg in Java alone, and many taken on livestock. Again, as with *T. rubidus*, records from Borneo are strangely absent.

Records.—Malaya: ♀ Kuala Lumpur (*Pratt*): ♀ Singapore (*Wallace*); ♀ Selangor, Lara Head (*Durham*); 3 ♀♀ Poeloe Bantar, 2. iv. and 2-3. vi. 1910 (S.S.), ♂ ♀ Kuala Lumpur, ii. 1920 (S.S. 1928). ♀ Perak, Kuala Kangsar, 1. iv. 1901 (S.S. 1932). Other distribution: India, China, Madoera, Soembawa, Timor Islands, Philippines, Sumatra, and Java.

Material examined.—Malaya: ♀ Taiping, 1911 (*W. B. Orme*) (misident. as *T. tenens*); ♀ Kuala Lumpur, 22. vi. 1929; ♀ Kuala Lumpur; ♀ Kedah Peak, 3950′, 25. iii. 1928; ♀ West Coast, Langkawi Is., 21. iv. 1928; ♀ Malacca, 5. iii. 57 (*J. E. MacMahon*), "biting on tennis court, pm". Thailand: 2 ♀♀ Chiengmai, 19. v. 1952 (*D. C. & E. B. Thurman*); ♀ same, but Payao, iv. 1952.

Tabanus subhirtus Ricardo

1911, *Rec. Indian Mus., 4:* 219 (new name).

Syn. *Atylotus cinerascens* Bigot 1892, *Mém. Soc. zool. Fr., 5:* 669. Type ♀, Java (BMNH). Not *Tabanus cinerascens* King 1827, *Narrat. Survey Coasts Australia, 2:* 467 (Australia).

Although there are no Malayan records, it should eventually be taken there since Ricardo (op. cit.) mentions Bengal and Bombay specimens.

Tabanus subhybridus Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 22. Type ♀, Malaya, Perak, Forest Reserve, 10 mi. W. of Ipoh, 150′, 17. ix. 1958 (*R. Traub*) (AMNH); 2 ♀♀ (paratypes) Selangor, 16 mi. Bentong Rd., 3. iii. 1920, and 53 mi. Troo Bentong Rd., 8. xii. 1931 (*E. P. Hodgkin*).

Tabanus thurmani Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 24. Type ♀, Thailand, Chiengmai, 24. v. 1952 (*D. C. Thurman* No. 767), "in house". In USNM. No other records.

Tabanus tinctothorax Ricardo

1911, *Rec. Indian Mus., 4:* 202. Type ♀, Malaya, Selangor, Bukit Koetoe, 3500′ (*Robinson*) (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 492; 1928, *Zool. Jb.*, (1) *54:* 425; 1932, *Arch. Naturgesch.*, (N.F.), *1:* 56.

Records.—Malaya: ♀ Kinta Valley, South Perak, ix. x (*Ridley*); ♀ Perak, Jor, Batang Padang, vi. 1923; ♀ Bukit Lansai, S. Ujong, vii. 1910; ♀ Johore, Summit Mt. Ophir, 11. viii. 1905; ♀ Pahang, Cameron Highlands, 4800′, vi. 1923 (*Chasen*) (S.S.). ♀ Perak, Jor Camp, 2000′, 26. viii. 1922, ♀ Perak, Temangoh; ♂ Selangor, Bukit Kutu, 3000′, viii. 1915 (S.S. 1928). ♀ Perak (S.S. 1932). Thailand: ♀ Nakon Sri Tamarat, Khao Luang, 2000′, 14. iii. 1922 (S.S. 1928).

Material examined.—Malaya: ♀ (type); ♀ Selangor, Ginting Budai (*C. B. Kloss*); ♀ Bukit Ganlai, Sungei Ujong, vii. 1910; 4 ♀♀ Pahang, Lubok Tamang, Lipis Distr., 3500′, vi. 1923 (*F.N.C.*); ♀ same (*Pendlebury*); 9 ♀♀ Pahang, various dates, Cameron Highlands, 4000-4981′ (*F. N. Chapman & H. M. Pendlebury*) (one at light); 2 ♀♀ Perak, Maxwell's Hill, 3500′, 22. viii. 1908; ♀ Perak, Batang Padang, Jor Camp, 1800′, 25. vi. 1923 (*Pendlebury*); ♀, same, 2000′, 24. viii. 1922; ♀ Kuala Lumpur, 11. ix. 1910; 2 ♀♀ no local.; ♀ Trengganu, Besut Distr., Gunong Tebu, v. 1958 (*R. Traub*); ♀ Selangor, Dipterocarp Forest nr. Kuala Lumpur, 13-16. v. 1958 (*R. Traub*); 2 ♀♀ Perak, Maxwell's Hill, 3000′ and 4600′, 22-23. vi. 1958 (*R. Traub*); ♀ Perak, viii. 1958 (*R. Traub*).

Tabanus traubi Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 26. Type ♀, Malaya, Langkawi Is., Kedah, 15-16. vii. 1958 (*R. Traub*).

Tabanus triceps Thunberg

1827, *Nova Acta Soc. Sci. upsal., 9:* 59. Lectotype ♀, wrongly attributed to Brazil (Uppsala Museum, *see* Philip 1959).

Syn. *Tabanus tenens* Walker 1850, *Ins. Saund. Dipt., 1:* 49 (E. India).

Syn. *Tabanus sinicus* Walker 1848, *List Dipt., 1:* 163 (♂ China).

? Syn. *Tabanus megalops* Walker 1854, *List Dipt., 5* (Suppl. 1): 247 (♂ Java).

For a discussion of synonymy see *T. striatus*. I have seen and compared specimens from India with types of all of the above. The type ♂ of *T. megalops* is the only specimen in much material that has been attributed to Java, which may have been a mislabel in view of its source from the "Hon. E. India Co."

I have identified one specimen from Thailand, but since it is not as vigorous an emigrant as *T. striatus*, I doubt that it gets into Malaya. Toumanoff (1953) has described variety *cambodiensis* from Indochina with median stripe not crossing onto tergite 2.

Tabanus uniformis Ricardo

1911, *Rec. Indian Mus., 4:* 218. Type ♀, Malaya, Darien Typus, Negri Sembilan, jungle road (*Stanton*) (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 461.

Records.—♀♀, same data as type (S.S.).

Tabanus varicolor Ricardo

1911, *Rec. Indian Mus., 4:* 172 (new name).

Syn. *Tabanus variegatus* Rondani 1875, *Ann. Mus. Civ. Stor. Nat. Genova, 7:* 458. Type ♀, Borneo, Sarawak (Genova Mus.). Not *Tabanus variegatus* DeGeer 1776 (S. Amer.) or Fabricius 1805 (N. Amer.).

No other records. The type was not found in Genova Museum by Miss Ricardo, and Schuurmans Stekhoven (1926) does not mention the species.

Tabanus ventriflavimarginatus Schuurmans Stekhoven

1926, *Treubia, 6* (Suppl.): 475. Type ♀, Borneo, Boengan River, vii. 1894 (*Dr. Nieuwenhuys*) (Leyden Mus.).

No other records.

Tabanus virgulatus Austen

1922, *Bull. ent. Res., 12:* 446. Type ♀, Bangkok, xi. 1919 (*Godfrey*). In BMNH.

No other records. I suspect that this is a variant of *T. rubidus*, but since the scutellum is not brown margined, this might be the female of males with entirely small eye facets discussed under *rubidus*, but the males of both forms have antennal plates more reddish than the females, a specific difference in Austen's key.

Tabanus vix Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 26. Type ♀, 9 ♀♀ paratypes, Brit. N. Borneo, Langkon Kudat, 1938 (*L. M. Yutuc*). In USNM and coll. C.B.P.

Tabanus xuthus Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 28. Type ♀, Thailand, "Trong Lower Siam," (*Dr. W. L. Abbott*). In USNM.

Tabanus zebrinus Schuurmans Stekhoven

1932, *Arch. Naturgesch.*, (N.F.), *1:* 56. Type ♀, E. Cent. Borneo, Upper Mahakkam, Long Iram, 2. v. 1929 (*von Kuehlewein*).

No other records.

Tabanus zoster Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 28. Type ♀, ♂♂♀♀, Chiengmai, Pann, 5. iii. 1952 (*D. C. & E. B. Thurman*), "in hot spring."

Hybomitra rara (Ricardo) new comb.

1911, *Rec. Indian Mus., 4:* 128. Type ♀, Kuala Lumpur (*H. C. Pratt*) (BMNH).

This is a very peculiar, pallid species, that one would have expected from its hairiness, and evident relationships, to favor a mountain habitat. The distinct, though small, ocelligerous tubercle and microscopically hairy eyes relate it to northern *Hybomitra*. If correctly associated, this is the southernmost Asiatic record. The hoary appearance resembles some beach inhabiting species of other genera in other parts of the world, and together with the yellow, bare subcallus distinguish it from all other Malaysian species.

It is interesting that this distinctive species was omitted by Schuurmans Stekhoven (1926).

Records.—Malaya: ♀ (type).

Material examined.—Malaya: ♀ (type); ♀ Pahang, Cameron Highlands, G. Berumbun, 23. vii. 1938; ♀ Trengganu, Gunong Tebu, 6. v. 1958 (*W. W. Macdonald*), on summit; ♀ Trengganu, Besut Distr., Gunong Tebu, 400′, v. 1958 (*R. Traub*).

Tribe 3. CHRYSOZONINI

Chrysozona abacis Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 29. Type ♀, Thailand, 29. iv. 1947 (In coll. C.B.P.).

Chrysozona angustisegmentata Schuurmans Stekhoven

1928, *Zool. Jb.*, (1), *54:* 425. Type ♀, Mid. E. Borneo, 25. viii. 1925 (*Siebers*).

No other records.

Material examined.—Malaya: 2 ♀♀ Selangor, Ulu Gombak, iii. 1956-58 (*W. W. Macdonald*); ♀ Selangor, 16 mi. Bentong Rd., 3. iii. 1920.

Chrysozona atomaria (Walker)

1856, *Proc. Linn. Soc. Lond., 1:* 112. Type ♀, Borneo, Sarawak (*A. R. Wallace*) (BMNH). Ricardo 1906, *Ann. Mag. nat. Hist.*, (7) *18:* 117.

Records.—Borneo: ♀ (type); 2 ♀♀ Sarawak (*Stevens*).

Chrysozona bizonata Schuurmans Stekhoven

1932, *Arch. Naturgesch.*, (N.F.), *1:* 56. Type ♀, Borneo, S. Malang, 28. i. 1925 (*Winkler*).

No other records.

Chrysozona borneana (Rondani)

1875, *Ann. Mus. Civ. Stor. Nat. Genova, 7:* 451. Type ♀, Borneo (Genova Mus.). Ricardo 1911, *Rec. Indian Mus., 4:* 329.

No further records.

Chrysozona cilipes (Bigot)

1893, *Nouv. Arch. Mus. Hist. nat., Paris, 2* (3): 205. Type ♀, "Laos" (Paris Mus.). Austen 1922, *Bull. ent. Res., 12:* 432 (type actually from S. Thailand between Chantanbun and Battambang).

Other distribution: Cambodia.

Chrysozona cingulata (Wiedemann)

1828, *Auss. Zweifl. Ins., 1:* 216. Type ♀, Java (presumably Vienna Mus.). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 75. Philip 1960, *Stud. Inst. med. Malaya, 29*: 29.

Records.—Java.

Material examined.—Borneo: 9 ♀♀ N. Borneo nr. Sandakan, Samawang, 1-13. vii. 1927, in jungle or at light (*Kloss* & *Pendlebury*). Thailand: ♂ ♀, Chiengmai, 17. viii. 1952 (*D. C.* & *E. B. Thurman*), "light trap."

Chrysozona cordigera (Bigot)

1891, *Bull. Soc. zool. Fr., 16:* 76. Type ♀, Bengal (BMNH). Surcouf 1921, *Genera Insect., 175:* 33.

Syn. *Haematopota fuscifrons* Austen 1908, *Ann. Mag. nat. Hist.*, (8), *1:* 411. (unnecessary change of name). Ricardo 1911, *Rec. Indian Mus., 4:* 357.

Bigot himself published a later *Haematopota cordigera* from West Africa (=*C. guineensis* Bigot, see Surcouf op. cit.) the same year which led Austen (op. cit.) to propose mistakenly a new name for the prior Bengal species.

Material examined.—Malaya: ♀ Negri Sembilan, Bukit Sangga, 17. i. 1930 (*Pendlebury*).

Chrysozona irregularis (Schuurmans Stekhoven)

1926, *Treubia, 6* (Suppl.): 101. Type ♀, Borneo, Sarawak, Mount Dulit (misspelled Bukit in the description), 1901 (*Everet*) (BMNH).

The type is in poor shape, but additional specimens permit augmentation of the description. Length 9-10 mm. There is some variation in the wing pattern including marginal, pale triangles not on the type, though front and legs are the same. There is a small median frontal spot which is evanescent when viewed from above. The incisures are more often yellow than white. Propleural lobes are pale, as in a post-humeral and scutellar rim with yellow hairs. The legs are blackish brown, and mid and hind tibiae two-thirds and one-half whitish.

Records.—Borneo: 2 ♀♀ Mid. E. Born., Long Petah, 1200 m. (*Siebers*) (S.S. 1928, who also augments description). 2 ♀♀ Bukit Radj., 2200 m. 15-20. xii. 1924 (*Winkler*) (S.S. 1932*a*).

Material examined.—Borneo: 7 ♀♀ Mt. Kinabalu, Kenokuk, 3300′, 22-28. iii (5) and Marli Park, 5000′, 27. iv-1. v (2) 1922 (*Pendlebury*).

Chrysozona irrorata (Macquart)

1838, *Dipt. exot., 1:* 167. Type ♀, Patria ignota but from Java Museum (Paris Mus., fragments). Ricardo 1911, *Rec. Indian Mus., 4:* 352. Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 87; 1928, *Zool. Jb.*, (1), *54:* 425; 1932, *Arch. Naturgesch.*, (N.F.), *1:* 56.

Fragments of the type in a tube in Paris include one whole wing, and a midtibia with two white rings. The pattern of the wing is as presently conceived with the apical band reduced to a pair of small spots in cell R_3, and another behind vein R_4, no marginal triangles; but the punctations are smaller, more discrete, the rosettes not as plain as in specimens from Borneo and Malaya. Moreover, these have more triangular frontal callosities, more slender antennal scapes in relation to the plates, and lack the paired lateral spots beside the antennal bases figured by Schuurmans Stekhoven (1926). One small Selangor female has both hind pairs of legs almost uniformly brown, and callosity nearly black.

There is in BMNH a specimen named in Macquart's handwriting from "Java ex coll. Bigot ex Verrall" which is wrongly labelled type.

Both Ricardo and Schuurmans Stekhoven pointed out the similarity of *C. pungens* (Doleschall) but in material I have studied, the latter has apical wing bands reaching fore border, apical triangles in most marginal cells, darker abdomens with more distinct pale incisures, and callosities, more transverse, less produced upward between the paired spots. Possibly these will eventually be found to be specifically or subspecifically different.

Records.—N. Borneo: ♀ Kobele, 1895 (*D. Carter*); ♀ Upper Mahakkam, Long Iram, 2. v. 1929 (*Kuehlewein*) (S.S. 1932). Malaya: ♀ Negri Sembilan, 1900 (*Ridley*); 2 ♀♀ Pahang, 500-1000′, 3-8. xii. 1921 (*K. Teku*); 2 ♀♀ Selangor, Kuala Kumpur, 12-23. x. 1921 (S.S. 1928). Other distribution: Sumatra.

Material examined.—Borneo: 5 ♀♀ Betotan nr. Sandakan, 22. viii. 1927 (*Kloss & Pendlebury*); ♀ Mt. Kinabalu, Kenokok, 3300′; 2 ♀♀ N. Borneo, Kinabatangan Distr., SE end Dewhurst Bay 2-26. vi. 1950 (*R. F. Inger & D. D. Davis*, who appended a note "these are the 'jobs' that continuously annoy you in the jungle!"). Malaya: 2 ♀♀ Selangor, Kuala Lumpur, 21 mi. Gombak Valley, 23. x. 1921 (*Pendlebury*); ♀ Kuala Lumpur (*Stanton*); 2 ♀♀ Selangor, Bukit Kutu, 3500′, 16. xii. 1926 (*Pendlebury*); ♀ Selangor, Ulu Gombak, 28. x. 1958 (*W. W. Macdonald*); 4 ♀♀ Pahang, Kuala Teku, Jungle, 500-1200′, 7-8. xii. 1921 and 25. xi. 1922 (*Pendlebury*); ♀ Negri Sembilan, 1900 (*H. N. Ridley*); ♀ Langkawi Is., Kedah, 15-16. vii. 1958 (*R. Traub*).

Chrysozona javana (Wiedemann)

1828, *Dipt. exot.*, p. 100. Types ♀ ♂, Batavia, Java (Copenhagen Museum, intact, seen in 1953). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 113.

Records.—Malaya: ♀♀ Negri Sembilan, Jelebu (*Stanton*); ♀ (*Pratt*) (S.S.). Other distribution: India, Sumatra, Java.

Material examined.—Malaya: ♂ ♀ (types); 2 ♀♀ Kuala Lumpur; ♀ Kuala Lumpur, 1909 (*Stanton*); 3 ♀♀ Darien Typus, 1909 (*Stanton*); ♀ Perak, 23. iv. 1907 (*H. C. Pratt*); ♀ Selangor 16 mi. Ulu Gombak, 12. viii. 1932 (*E. P. Hodgkin*); ♀ Selangor, I.M.R., 12. vi. 1957.

Chrysozona lineola Philip

1960, *Stud. Inst. med. Res. Malaya, 29:* 30. Type ♀, Thailand, Tak, Pra Tung Chung, 18. vii. 1952 (*D. C. Thurman*), on raft in Meh Ping River. In USNM.

Chrysozona lunulata (Macquart)

1847, *Dipt. exot.*, Supp. III, p. 175. Type ♀, Java (*Payen*) (Paris Mus.). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl): 123 (synonymy); 1928, *Zool. Jb.*, (1), *54:* 425; 1932, *Arch. Naturgesch.*, (N.F.), *1:* 56.

Syn. *Haematopota stantoni* Ricardo 1916, *Bull. ent. Res., 4:* 403 (Malaya).

Records.—Borneo: Upper Mahakkan, Long Iran, 2. v. 29 (*Kuehlewein*). Malaya: 3 ♀♀ Kuala Lumpur (*Dr A. Stanton*; incl. type of *stantoni*); ♀ Selangor, 1896 (*Ridley*) (S.S.); ? ♂ Selangor, Kuala Lumpur, 17. ix. 1922. Other distribution: Java.

Material examined.—Malaya: ♀ Kedah nr. Jitra Catchment area, 6. iv. 1928 (*Pendlebury*); 2 ♀♀ West Coast, Langkawi Is., 1000′, 23-29. iv. 1928 (*Pendlebury*); ♀ Selangor, Ginting Sempak, 2000′, (*C. B. Kloss*); ♀ Selangor, near Kuala Lumpur, Dipterocarp Forest, v. 1958 (*R. Traub*); ♀ Selangor, 53 mi. Troo Bentong Rd., 8. xii. 1931 (*E. P. Hodgkin*), in jungle; ♀ Selangor, Ulu Gombak, 10. vi. 1957.

Chrysozona malayensis (Ricardo)

1916, *Bull. ent. Res., 4:* 404 .Type ♀, Malaya, Kuala Lumpur (*Stanton*) (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 133.

Records.—Malaya: ♀ same data as type.

Material examined.—Malaya: ♀ (type); ♀ Gunong Tampin, 29. vi. 1920.

Chrysozona mediatifrons (Schuurmans Stekhoven)

1926, *Treubia, 6* (Suppl.): 132. Type ♀, Sumatra (Amsterdam Mus., not found in 1958). Schuurmans Stekhoven 1928, *Zool. Jb.*, (1), *54:* 425.

Records.—Borneo: ♀ Mid. E. Born. 28. viii. 1925 (*Siebers*) (S.S.). Malaya: ♀ Goenoeng Tampin, on person, 29. vi. 1920. Other distribution: Sumatra.

Chrysozona pachycera (Bigot)

1890, *Nouv. Arch. Mus. nat., Paris, 2:* 206. Type ♀, Siam (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 130. Austen 1922, *Bull. ent. Res., 12:* 432.

Syn. *Haematopota validicornis* Ricardo 1911, *Rec. Indian Mus., 4:* 333 (Siam).

Syn. *Potisa pachycera* Surcouf 1909, *Bull. Mus. Hist. nat., Paris,* p. 454.

Records.—Malaya: ♀ no loc. (*Stanton*). Thailand: ♀ (type *validicornis*); ♀ Phrapatoon, 1907 (*see* Austen 1922). Other distribution: Cambodia.

Material examined.—Thailand: 18 ♀♀ Chiengmai, various dates, mostly light traps (*D. C. & E. B. Thurman*).

Chrysozona pungens (Doleschall)

1856, *Naturrk. Tijdschr. Ned.—Ind., 16:* 407. Type ♀, Java. Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 103.

See *C. irrorata* for discussion of relationship. This species appears to have unusual variation in the apical wing band, making it difficult to key.

Records.—Borneo: ♀ no loc. (*Diard*) (S.S.). Other distribution: Sumatra, Java.

Material examined.—Thailand: ♀ Chiengmai, Doi Sutep, 3500′, 12. vi. 1952 (*D. C. & E. B. Thurman*).

Chrysozona rubida (Ricardo)

1906, *Ann. Mag. nat. Hist.*, (7), *18:* 120. Type♀, Burma (BMNH). Schuurmans Stekhoven 1926, *Treubia, 6* (Suppl.): 78.

Records.—Malaya: ♀♀ no loc. (*Pratt*) (S.S.).

Chrysozona segmentata (Schuurmans Stekhoven)

1932, *Arch. Naturgesch.*, (N.F.), *1:* 56. Type ♀, Borneo, Bidang Menabah, 700 m., 15-26. xii. 1924 (*Winkler*).

No other records.

Chrysozona splendens (Schuurmans Stekhoven)

1926, *Treubia, 6* (Suppl.): 95. Type ♀, Malaya, Bukit Kutu, 15. v. 1903 (*Pratt*) (BMNH).

Material examined.—N. Borneo: 2 ♂♂ nr. Sandakan, Bettotan, at light, 31. vii. 1937 (*Kloss* and *Pendlebury*). Malaya: ♂ Selangor, Kuala Lumpur, 13 mi. from Sungei Buloh, 17. ix. 1922 (*Pendlebury*); ♀ Selangor, nr. Kuala Lumpur, 9. v. 1948 (*C. B. Philip*); 4 ♀♀ Perak, 10 mi. W. Ipoh, 150′, 17. ix. 1958 (*R. Traub*). Thailand: ♀ (village ?), 5500′, 7. iv. 1939 (*Dr Devakula*).

Systematic Keys

Key to genera of Tabanidae in present report

1. Antennae with third segment composed of more than 5 annulations, the basal one differing mainly in thickness but not length; hind tibiae with spurs [subfamily Pangoniinae; no species recorded as yet for Borneo, Malaya, or Thailand]
   Antennae with a terminal style composed of not more than 4 annuli, and a basal, elongated segment ("plate"); hind tibiae with or without spurs.....2
2. Ocelli well developed on vertex between the eyes; hind tibial spurs well developed [subfamily Chrysopinae].....3
   Ocelli absent, or rarely rudimentary and nonfunctional; hind tibial spurs absent [subfamily Tabaninae].....6
3. Antennae with an acute, thumb-like process dorsobasally on plate (biramous); abdomen of ♀ tapering to a usually protruding point; usually large (over 14 mm.), dark species with pictured wings.....*Rhinomyza* Wied.
   Antennae not biramous; abdomen blunt, not tapered; usually smaller species, wing variable.....4

4. Antennae shorter than thickness of head, the basal two segments short, rounded or triangular in outline.....5

Antennae longer than thickness of head, the basal two segments plainly longer than wide, cylindrical.....*Chrysops* Meig.

5. Antennal style slender with 4 annuli; wings with 2 dark bands; frons (♀) with elongate, bare callus.....new gen. nr. *Gastroxides*

Antennal style shorter, triannulate; wings diffusely brownish; frons without bare callosity .....*Eucompsa* End.

6. Subepaulet at base of costa of the wing well-developed, with setate as pronounced as on the adjoining costa; frons of female usually rather narrow to very narrow.....*Tabanus* Linn.
Subepaulet small and scale-like, nonsetulose; frons of female often wide to very wide.....7

7. Wings smoky with peculiar pale spots, wavy lines or punctulations; rather small flies with dark, slender bodies, triannulate styles, and tibiae often ringed.....*Chrysozona* Meig.

Wings clear, suffused or with apical shadows, but not with "water-markings"; more compact; often yellowish, *Tabanus*-like flies, the styles usually with 4 annuli, and tibiae sometimes bicolored but without rings..... [*Cydistomyia* Taylor]*

[*No species of *Cydistomyia* have been recognized in present areas under study.]

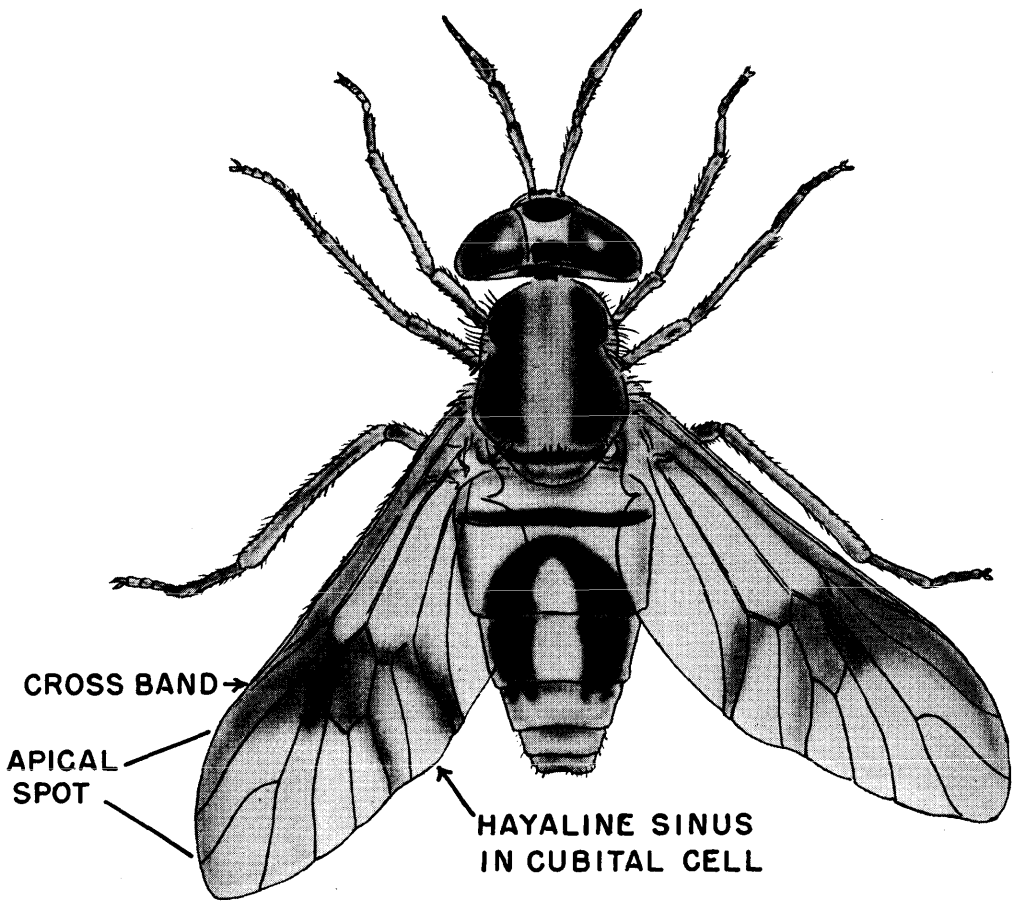


Plate I *Chrysops dispar* Fabricius

Showing inverted V on the abdomen and the features of wing picture used in the keys.

Key to chrysopine species

1. Antennae biramous; wings with prominent, crescentic band; abdomen pointed (♀); thorax dark with contrasting white, round spot on pleura (M).....*Rhinomyza cincta* Philip

   Antennae without forked plate; wings often with prominent cross-bands, but not broadly crescentic with the apical spot; abdomen not pointed; thorax may be dark, but there is no large integumental white spot on pleura, though upper margins may have golden hair-patches 2

2. Frons (♀) wider at base than tall, without any callosity, convergent above; antennal style short, triannulate; wings diffusely brownish and abdomen strongly banded (B)..... .....*Eucompsa tecticallosa* S. Stek.

   Not such species; females with frontal callosities, 4-annulate styles, and wings with definite patterns..... 3

3. First two segments of antennae short, rounded, or sub-triangular; frontal callosities tall and elongate ("*Gastroxides*" spp.).....4

   First two antennal segments cylindrical and plainly longer than tall; frontal callosities ovoid, transverse.....[*see* key to *Chrysops*]

4. Larger species (15-16 mm.) with markedly swollen tibiae; tarsi yellowish, contrasting to otherwise dark-brown legs (M).....*"G." aterrima* (S. Stek.)

   Under 15 mm.; tibiae not noticeably enlarged; tarsi variable.....5

5. Uniformly dark-brown species; length, 12-14 mm.; legs dark-brown, tarsi yellowish (M)..... .....*"Gastroxides"* n. sp. (♂)

   Dorsum of thorax and scutellum, and two basal, abdominal segments yellowish; length, 10-12 mm.; tibiae and tarsi distinctly darker than femora (M).....*"G." fusca* (S. Stek.)

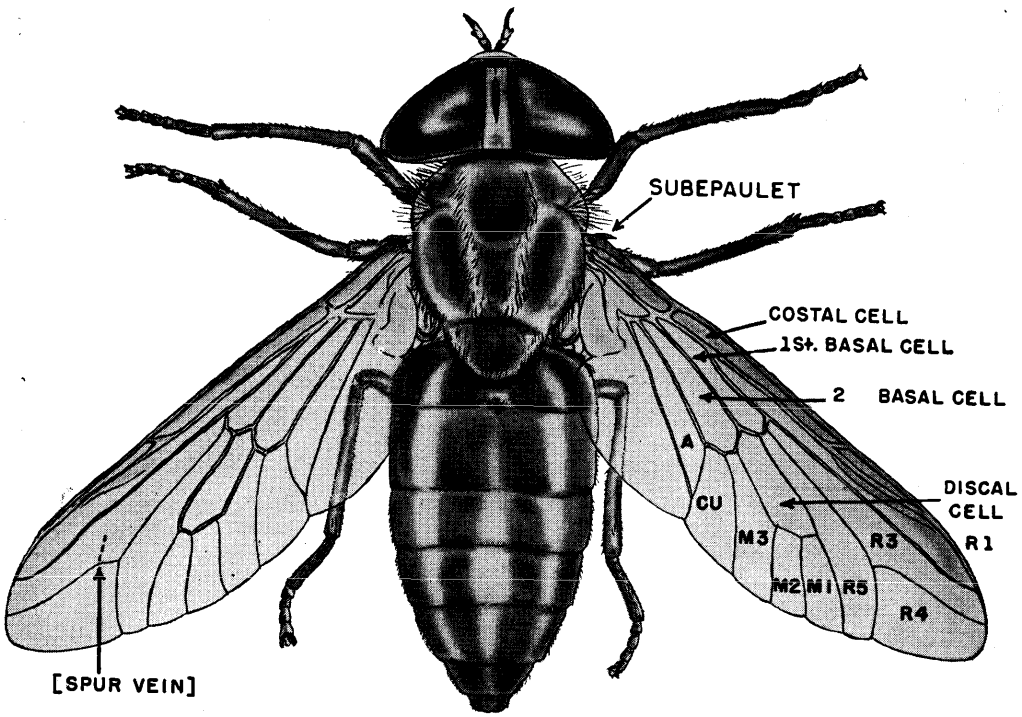


Plate II *Tabanus striatus* Fabricius

Showing the features of wings (including location of spur vein when present in other species) used in the keys and descriptions.

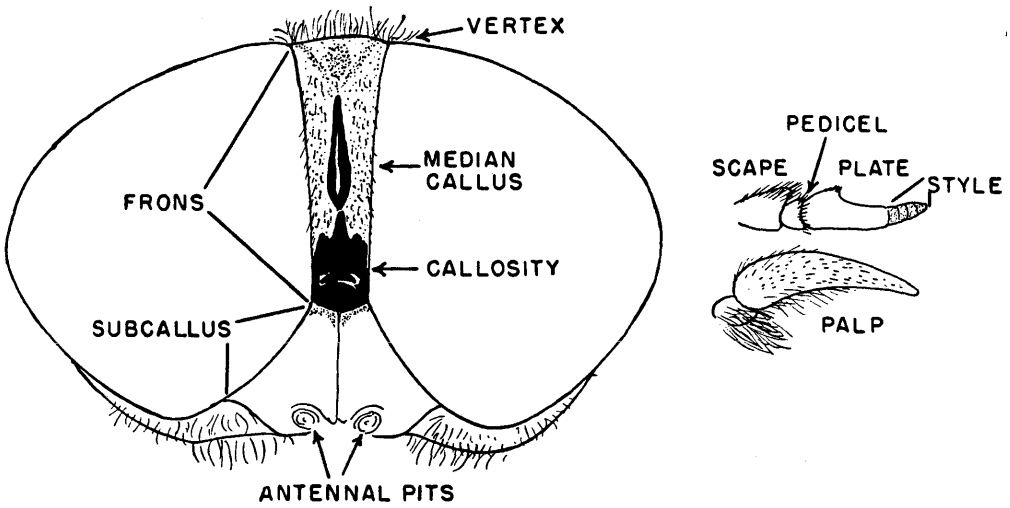


Fig. 1. *Tabanus striatus* Fabricius

Showing the head characters used in keys and descriptions; lower structures including face and proboscis omitted.

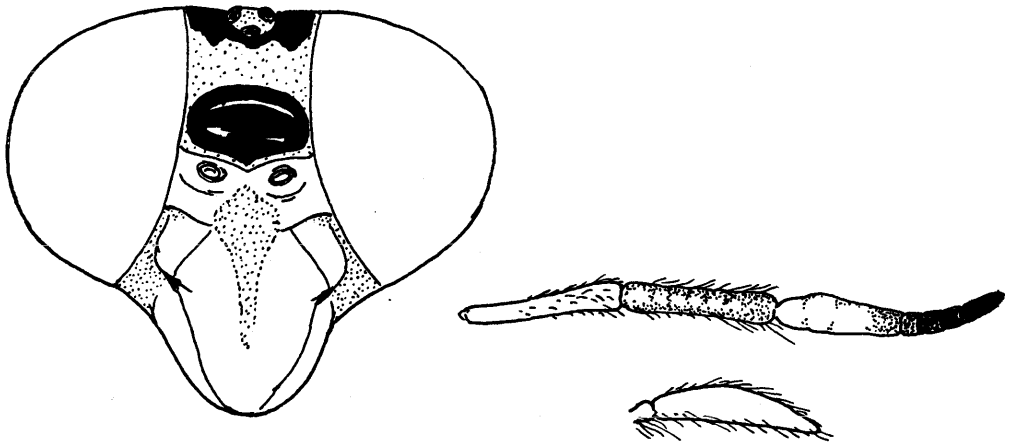


Fig. 2. *Chrysops dispar* Fabricius

Showing the three ocelli on the vertex of the head, the ovoid frontal callosity above the antennal pits, and the mid-facial pollinose stripe; together with the antennal segments, scape, pedicel and flagellum; and the terminal segment of the palp.

Key to Chrysops

1. Abdomen mainly black with a basal pale ring on each of the two basal segments.....2
   Abdomen mainly yellow to reddish with a variable dark pattern.....4
2. Hind femora and tibiae blackish becoming reddish before the apices (B).....*alter* Rond.
   Hind femora and tibiae uniformly blackish or brown.....3
3. Larger species, 9 mm.; face yellow in the middle (excluding midfacial pollinosity); wing picture with dark costal border (apical spot) beyond crossband wider than cell R_1 outward of the stigma, and crossband forked around both sides of cubital cell; tibiae swollen (M).....*translucens* Macq.
   Smaller species, 7-8 mm.; face black; apical spot a very narrow, costal margin, cubital cell hyaline; tibiae not swollen (B, T).....*flavocincta* Ric.

4. Abdomen with inverted V-marking on second segment; tibiae normal or swollen.....5
Abdomen with a black apex, or narrow black bands on some segments, but tergite 2 without inverted V; tibiae distinctly swollen.....7

5. Tibiae strongly swollen; crossband reaching hind border broadly, filling the cubital cell (T) .....*indiana* subsp. *thailandensis* Philip
Tibiae normal or slightly swollen; crossband forked around base of cubital cell.....6

6. The V is confined to the second segment (M).....*flaviventris* Macq.
The arms of the V cross the third and sometimes encroach onto the fourth segments (T, M, B) .....*dispar* Fabr.

7. Face predominantly yellow between lateral pollinose stripes.....8
Face black or dark-brown outside median yellow-pollinose stripe.....9

8. Size small, 8 mm.; second antennal segment distinctly shorter than the first; two dark transverse bands on second and third tergal incisures (B).....*stekhoveni* Philip
Size larger, over 9 mm.; second antennal segment but little shorter than the first; dark ring confined to tergite 2, tergite 3 but little darkened apically (B, M).....*fixissima* Walk.

9. Antennae long and slender, the individual segments longer than the height of the frons (♀); black bands on tergites 2 and 3 joined outwardly to enclose an abbreviated, narrow yellow band at base of 3, but not connected to a narrow lateral black margin on edges of 2 to 4 (M, ? B).....*signifera* Walk.
Two basal segments each distinctly shorter than frons (♀); abdominal pattern otherwise.....10

10. Tergites 2 and 3, and base of 4 entirely whitish; apex of abdomen black (T).....*fasciata* Wied.(♂)
Tergite 3 and apex of 2 darkened, the remainder reddish (M, T).....*fasciata* Wied.(♀)

Key to Tabanus *and related species*

1. Rather small, hoary, whitish fly with microscopic hairs on eyes, bare subcallus, and expanded, black median callus separated from yellow basal callus, a distinct tubercle at vertex of frons; size about 10 mm. (M).....[*Hybomitra rara* (Ric.)]
Not such species.....2

2. Small species, seldom over 12 mm.; subcallus bare and shining black or brown; front medium to very narrow; legs with dark femora and contrasting whitish to pale yellow tibiae with dark apices.....3
Not with this combination of characters, if subcallus is bare or worn, species is larger and tibiae not white.....9

3. Front narrow, index usually over 7; median callus linear and usually joined to basal callosity; bodies essentially unicolorous; wings clear or tinted on fore border.....4
Front broader, index 5-6; median callus expanded, isolated or seldom joined to basal callus by a narrow constriction; bodies with contrasting pale scutellums and bands on some abdominal segments; wings often with apical shadows.....6

4. Species grayish-black with pale hairs on body and white beard; wings clear (B, M)...*minimus* Wulp
Species brown to coal-black with darker vestiture; wings tinted, yellow along costal border.....5

5. Beard black; abdomen black to uniformly red-brown (M, B, T).....*ceylonicus* Schin.
Beard yellow; abdomen red-brown above, yellowish below (B, M).....*simplissimus* Walk.

6. Abdomen with two median, pale yellow triangles; scutellum yellow-haired (M)...*macdonaldi* Phil.
Abdomen with two or more pale bands; scutellum seldom yellow-haired.....6a

6a. Upper cheeks and palpi brown, chiefly black-haired; median callus surrounded by velvety, dark pollinosity.....7
Upper cheeks and palpi grayish-blue, chiefly white-haired; no sooty spot around median callus 8

7. Size over 10 mm.; wings with apical shadow, no spur vein; [abdomen with wide, white incisural bands on tergites 3 and 4 only] (M).....*biannularis* Phil.
Size under 10.5 mm.; wings clear, spur vein present; abdomen with more than two wide white incisural bands elevated to median triangles.....*albivittatus* S. Stek.

8. Abdomen black with white markings; in addition to broad bands elevated to low triangles on tergites 3 and 4, narrow incisural bands occur on 5 and 6 (B).....*griseipalpis* S. Stek.
Abdomen brown basally with glistening, yellow-haired bands on tergites 3 and 4 (T)..... .....*insidiator* Aust.

9 (2). Medium- to large-sized species (13-20 mm.) abdomen basally above bright yellowish orange with concolorous hairs, the terminal 2 to 4 tergites sharply jet black and black-haired though there may be pale haired fringes on the incisures; wings deeply infuscated.....10

Otherwise; when abdomen darkens caudally, the transition is more gradual.....16

10. Only basal two tergites bright yellow to orange.....11

Basal three or four tergites orange.....12

11. Antennae, palpi, tibiae and scutellum predominantly reddish to brown; beard brown; cell R_5 closed (? T).....*basalis* Macq.

Antennae, palpi and beard black; tibiae white and white-haired basally, widely black apically; scutellum and notum concolorous brown; cell R_5 open (T).....*abbasalis* Phil.

12. Venter orange on basal four segments (T).....*siamensis* Ric.

Venter predominantly or entirely brown to black.....13

13. Venter and legs uniformly colored, entirely black-haired.....14

Venter with prominent pale-haired incisures, tibiae pale basally with concolorous pale hairs.....15

14. Size large, over 20 mm.; venter and appendages black (B).....*pendleburyi* Philip

Size smaller, 16 mm.; venter and appendages dark-brown (Sumatra).....*ochroater* S. Stek.

15. Size medium (14 mm.); beard brown; thorax olive-yellow; antennae, bases of tibiae and ventral incisures including vestiture orange-red (T).....*thurmani* Phil.

Size large (20 mm.); beard pale yellow; thorax reddish; third antennal segment mostly black; tibial bases and ventral incisures pale yellow to whitish (Annam).....*annamensis* Phil.

16 (9). Robust entirely blackish-bodied species, beard, and at least legs and palpi black, wings deep yellow to blackish.....17

Not such species; if black there is some paler pattern present.....19

17. Wings black, cell R_5 closed, spur vein present; antennae orange, halteres with white knobs (T).....*nigrotectus* Big.

Wings yellow-brown, cell R_5 open, spur vein absent (?), antennae dark, halteres brown.....18

18. Smaller species, 13 mm.; wings brown (B).....*stekhoveni* Phil.

Large species, over 20 mm.; wings yellow (B).....*nigrinus* Szil.

19. Medium-sized, reddish-brown species with narrow, pale, incisural bands above and below on segments 2 to 4 or 5, antennal plates with acute, forward projecting, dorso-basal teeth and wings smoky, yellowish basally (T).....*praematurus* Austen

Not such species.....20

20. Wings with a broad, dark band below or just beyond the stigma fading before the hind margin, and leaving the apex and base of the wings lighter in color; cell R_5 often closed at wing margin; abdomen often with a median row of small, pale triangles.....21

Wings otherwise, clear or darkened not in the form of a median band though there may be an indefinitely-outlined, apico-costal shadow or the base may be more yellow than the apex and hind margin without clear apex; abdomen variable.....26

21. Abdomen unicolorous, without pattern or at most patches of pale hairs on outer corners of tergites.....22

Abdomen with median row of pale triangles, which are sometimes the expansions of incisural bands.....25

22. Cell R_5 closed at wing margin; abdomen black, with white hair patches laterally (T).....*barnesi* Austen

Cell R_5 open; abdomen not black.....23

23. Abdomen uniformly dark-brown; frons narrow, index about 8; midtibiae predominantly white and white-haired (B, M).....*flavothorax* Ric.

Abdomen reddish-yellow; frons broad, index 3.5-5; tibiae yellow with concolorous hairs.....24

24. Beard and palpi yellow-haired; front about 1:4; abdominal hair red-brown (T).....*rufiscutellatus* S. Stek.

Beard and palpi white-haired; front about 1:5; abdomen black-haired with yellow-haired incisures (? T).....*melanognathus* Big.

25. Abdomen dark-brown with pale triangles but no bands; notum and scutellum concolorous; frons narrow, index about 8; cell R_5 (first cell below apex of wing) closed at margin and petiolate (M).....*nephodes* Big.

Abdomen basally reddish with pale incisures widening to low median triangles; scutellum contrasting gray-white; frons broad, about 4.5; cell R_5 open (B, M).....*optatus* Walk.

26 (20). Abdomen with one or three contrasting, longitudinal pale stripes, the median one sometimes a series of connected, truncated triangles and the lateral ones often discontinuous.....27

Abdomen with pattern varied otherwise or unicolorous; suggestions of a faint narrow, abbreviated or discontinuous, pale pollinose, median stripe may occur on worn specimens.....48

27. Abdomen with three stripes, the shorter, lateral ones may be jagged, or broken into spots; tibiae and usually femora reddish.....28

Abdomen with one contrasting pale stripe; tibiae paler yellow to white.....35

28. Large species, usually over 14 mm.; basal callosity of females not touching eyes and frontal index at least 6; median stripe a series of truncated triangles not usually wider on tergites 3 and 4.....29

Medium-sized species, usually under 15 mm.; basal callosity touching eyes or not; index wider about 4; median stripe more even, often expanded on tergites 3 and 4 and narrowed or absent on 2.....32

29. Antennal plate red, deeply excised, the tooth acute, the brown style longer than plate; abdomen entirely (except last sternite) red with three rows of dorsal gray triangles, only the median one of which is continuous; eyes of male with upper facets not enlarged (T)..... ? sp. [NOTE:—*See* discussion in text under *T. rubidus* Wied.]

Not such species.....30

30. Abdomen and callosity dark blackish-brown; antennal plate rufous (T).....*virgulatus* Aust.

Abdomen gray to reddish-brown; callosity paler; plates dark.....31

31. Abdomen grayish-brown, broad, terminating bluntly (M, T).....*rubidus* Wied.

Abdomen reddish-brown, narrowed and tapering behind tergite 2 like an ovipositor, the sublateral pale lines easily obscured by wear (M, T).....*effilatus* S. Stek.

32. Lateral pale lines on abdomen a pair or more of isolated or disconnected spots; only the median line thus presents a continuous stripe in appearance.....33

Lateral pale lines jagged, a series of connected triangles so that the trilineate appearance is accentuated..... 34

33. Callosity subquadrate, with no dorsal extension; sublateral pale spots not prominent, and sometimes obscured by wear; incisures pale; wings nearly clear (B).....*siebersi* S. Stek.

Callosity, a heavy keel, tapered upward; sublateral pale spots strongly accentuated on, often confined to, tergite 2; incisures not pale; wings with strong costal and apical shadows (M) .....*brunnipennis* Ric.

34. Fore legs bicolored; annuli dark; males and often females with median line interrupted at or narrowed on tergite 2; sides of basal callosity entirely contiguous to eye margins; proboscis black (M, T).....*striatus* Fabr.

Legs and antennae essentially unicolorous; median line little narrowed on tergite 2; callosity narrowed above and separated from eyes below; proboscis with reddish theca, brown labella (? T).....*triceps* Thunb.

35 (27). Median stripe gray or white, usually white-haired.....36

Median stripe yellow, yellow-haired.....38

36. A group of small, dusty-blackish-bodied species with sides of abdomen reddish to brown, blackish femora and red tibiae, clear wings, in which the whitish-haired median stripe is seen only in infrequent unworn specimens (T).....[*see* couplets 60-61]

Species in which the pale stripe is still plain in worn specimens, and with unicolorous legs, or if the tibiae are pale, the callosity is quadrate and with little or no dorsal extension.....37

37. Front narrow, index about 11, callosity triangular, long median callus present; beard white; abdominal line to sixth tergite bright yellow, parallel-sided; wings with an apical shadow (M) .....*hirtistriatus* Ric.

Front broader, index about 4, callosity quadrate with little or no upward extension; beard pale yellow; abdominal line irregular or fading behind tergite 3; wings clear (B).....*canipus* S. Stek.

38. Abdominal yellow stripe broad with straight sides or widened behind to the fifth or sixth tergites..... 39

Abdominal stripe less distinct, narrower, paler, more jagged, or confined to first 2 segments.....44

39. Abdomen slender and elongated, the seventh segment nearly as prominent as the preceding; frontal index 5 to 8, with heavy callosity tapered upward; beard white; wings with infuscation strongly intensified along costal margin and apically in radial sector.....40

Abdomen seldom tapering, the seventh segment not unusually protruding; frontal index narrower, about 10, with small, often isolated callosity; beard yellow; wings clear or tinted, with usually fainter apical shadows.....41

40. Frontal index about 5; antennae with obtuse dorso-basal tooth; femora chiefly pale-haired (M, T).....*aurilineatus* S. Stek.
Front narrower, index 7-8; tooth low but acute; femora chiefly black-haired (M, T).....*aurilineatus* subsp. *gilvilineis* nov.

41. Yellow vestiture, and most underlying integument, intense golden to orange, including that in beard, on legs and entire venter; thorax velvety golden-brown with concolorous hairs; abdominal golden-haired stripe widening behind to occupy over one-third of and stopping abruptly on tergite 5, tergite 6 blackish-brown, entirely black-haired (M).....*subhybridus* Philip
Yellow vestiture pale to lemon yellow, hind tibiae mostly black-haired on the dorsum; yellow stripe less expanded behind to less than one third the width of tergite 5 and continuing across tergite 6; thorax pale yellow to greenish pollinose with pale or lemon-yellow and black hairs.....42

42. Size small, 10 mm.; wings clear; venter uniformly pale yellow pollinose and pilose; viewed from behind, the broad pale abdominal band appears to continue across the scutellum onto the notum flanked by two heavy brown stripes (T).....*fulvilinearis* Phil.
Size medium, 12 to 16 mm.; wings tinted, costal cell yellow; no stripe on notum.....43

43. Venter yellow to yellow-brown with median series of obscure, narrow, dark-brown, black-haired patches; upper cheeks rusty-brown with sparse black hairs; antennae pale brown, usually darker apically (B, M).....*hybridus* Wied.
Venter coffee-brown without median dark patches; upper cheeks yellow with pale yellow hairs; antennae orange (B).....*latifascies* S. Stek.

44 (38). Front very narrow, index greater than 8.....44a
Front broader, index not narrower than 7.5.....45

44a. Callosity small and isolated, without upward extension; antennal scape and venter yellow-haired; wings with red-brown apical shadow (B).....*cylindricallosus* S. Stek.
Callosity narrowly tapered into a linear keel; scape and a wide, prominent midventral band black-haired; wings with heavy, blackish apical cloud (M).....*fusciventer* S. Stek.

45. Abdomen blackish-brown with median stripe of yellow hairs on first two tergites only; palpi and beard red-brown (T).....*birmanicus* Big.
Abdominal stripe longer, reaching nearly to tip of abdomen.....46

46. Wings distinctly infuscated (strongly tinged with sepia) (frontal index 7.5-9, T).....*pugnax* Aust.
Wings clear.....47

47. Wing stigma inconspicuous, yellow; front narrow, index about 7 (T).....*agnoscibilis* Aust.
Wing stigma conspicuous, brown; front rather broad, index 4-4.5 (T).....*pugiunculus* Aust.

48(26). Small to medium-sized (seldom as much as 14-16 mm.) yellow to reddish species without abdominal pattern, with narrow fronts (indices at least 8) and small, isolated callosities with or without upward, fine extensions.....49
Otherwise, if uniformly yellow to reddish, size larger.....57

49. Beards pale to deep yellow.....50
Beards white.....55

50. Uniformly bright yellow to orange including appendages, with concolorous hairs; antennae long, slender, orange; callosity yellow, narrow, ovoid with or without dorsal extension.....51
Yellow-brown to red-brown species with considerable black hair; antennae yellow-brown; plates shorter with teeth low but more distinct; callosity dark with linear dorsal extensions...54

51. Wings entirely clear including costal cells; small species, about 9 mm., with pale thorax, the apical half of scutellum, entire abdomen and appendages bright orange; upper two-thirds of facets of male eyes moderately enlarged (T).....*gilvellus* Philip (♂)
Wings at least tinted.....52

52. Medium-sized (14 mm.) bright yellow to orange species, antennae reddish with black hairs basally and on palpi, style with only 3 annuli; tibiae pale yellow with white hairs, apices dark; wings with apical shadows; abdomen orange basally, brown with black hairs basally, the incisures orange pollinose and pilose (T).....*ochros* S. Stek.
Not such species, the antennal style 4-annulate.....53

53. Bright yellow with tinted wings and apical shadow faintly intensified; callosity without dorsal extension; size 14 mm. (B).....*flavohirtus* Philip
Bright orange with wings more fumose apically; callosity with dorsal extension; 12 mm. (M).....*traubi* Philip

54. Abdomen yellow-brown, darkening apically, black-haired, 4 basal sternites yellow-haired; legs dark-reddish, tibiae black-haired, size 13.5 mm. (B).....*fuscifrons* S. Stek.
Abdomen red-brown, black-haired above and below with patch of yellow hairs on mid-hind margin of tergite 2; legs yellow with concolorous hairs; size 10.6 mm. (B)...*rubriscutatus* S. Stek.

55. Callosity isolated, ovoid, black without dorsal extension; abdomen yellow on basal three segments, black thereafter, black-haired with yellow-haired incisures; size 13 mm. (B).....*borniensis* Ric.
Callosity yellow-brown with dorsal extension; abdomen otherwise.....56

56. Wings with pale brown apical shadow; frontal index 9.2, a wine-red spot at vertex; mid tibia yellow-brown, black-haired; abdomen red-brown with concolorous hairs above and below; size 12 mm. (B).....*flavipilosus* S. Stek.
Wings without apical shadow; index 8, no spot at vertex; mid tibia red-brown, predominantly yellow-haired abdomen yellow-brown with yellow hairs above, black below, size 14-16 mm. (M) .....*uniformis* Ric.

57(48). Rather small (12 mm.) dark species, brown abdomen with narrow pale bands, low triangle and black median spot on tergite 2; legs entirely red, or some darkening on fore pair only; frons with a quadrate lower callosity barely or not quite touching eyes, no dorsal extension, and an isolated median callus; eyes with minute hairs (T).....*sphinx* Philip
Not with this peculiar combination of characters.....58

58. Abdomen dull, brick-red with a rather narrow, obscure, dusty gray-black median stripe which widens on tergite 4, the terminal segments and all dorsal hairs except at outer corners and a few inconspicuous ones in the middle, black; venter brick-red with blackish median patches and mostly black-haired, but pale-haired incisures; antennae red, styles black; wings clear, costal cells pale yellow (length 16 mm.) (T).....*griseilineis* Philip
Not such species.....59

59. Like the preceding, but smaller (11-12 mm.), the abdomen more tapering and brownish-red confined to sides of first three tergites, the median gray-black broader, more jagged, some scattering whitish hairs medially, which, in unworn specimens, form an easily-worn obscure, even-sided gray band; antennae and legs, except femora basally, orange-red; wings clear; costal cells faintly yellow.....60
Not such small blackish species with reddish-brown sides on the first three tergites.....62

60. Front narrow, index 1:7; callosity small, ovoid, yellow, abruptly produced into a narrow median black line above; antennae brick-red; scutellum and abdomen basally brown, caudally blackish, a mid-line of pale hairs; hind femora reddish on apical two-thirds (T)...*ardalus* Philip
Front wider than 1:6; callosity reddish, triangular, sinuous or tridentate across base, tapered gradually into a tall darker median keel; antennae bright orange; scutellum blackish; abdomen brick- to brownish-red on sides of basal half; hind femora blackish to knees.....61

61. Front parallel-sided, the heavy triangular callosity widely separated from eyes; abdomen brick-red on sides basally.....*acuminaris* Philip
Front narrower, usually slightly convergent below, the callosity barely separated from eyes at lower corners; abdomen brownish-red on sides basally.....*konis* Philip

62. Abdomen unicolorous, without distinct pale bands or spots, though there may be scattered pale hairs on the incisures or edges.....63
Abdomen with some distinct pale pattern of bands or median triangles.....75

63. Dorsum of thorax and abdomen practically unicolorous.....64
Body with thorax markedly darker or lighter than abdomen.....70

64. Body predominantly black-to olive-brown.....65
Body yellowish to orange (large species, 22 mm.), or at least abdomen uniformly reddish in smaller specimens.....68

65. Size large, over 20 mm.; two white hair-tufts at base of wings; wings saffron-yellow (B).....*crocinctipennis* S. Stek.
Size medium, 12 to 17 mm.; wings smoky-brown, at least as an apical shadow, or clear.....66

66. Size small, 12 mm.; wings clear; venter ash-gray, entirely pale-haired (? M).....*subhirtus* Ric.
Size 13 to 17 mm.; wings tinted; venter dark with pale incisures.....67

67. Venter with white-haired incisures (M).....*perakiensis* Ric.
Ventral incisures yellow-haired (B).....*ventriflavimarginatus* S. Stek.

68. Size large, 23 mm.; body reddish-brown, predominantly black-haired; femora dark, tibiae and antennae reddish; venter red-brown with black hairs not accentuated as median patches (B) ..... *pauper* Rond.

Size usually under 20 mm.; body and vestiture yellowish to orange; legs unicolorous 69

69. Cell R_5 closed and petiolate, legs black (B) ..... *enderleini* Philip

Cell R_5 open; legs red-brown (front broad) (B) ..... *fulvissimus* Rond.

70(63). Thorax darker than reddish abdomen 71

Thorax lighter than brown to blackish abdomen 74

71. Thorax dark chocolate-brown, abdomen lighter, havanna-brown; a small, dark, ovoid, median spot on tergite 2 (B, ? M) ..... *lentisignatus* S. Stek.

Thorax blackish-brown, abdomen almost brick-red without median black spot on tergite 2 72

72. Antennal plates dark; beards usually yellow (included here are rather nondescript worn or discolored specimens of the *immanis-fumifer* complex that have lost all traces of dorsal abdominal pattern if any was present originally) ..... (*Tabanus* spp.).

Antennal plates red, styles dark; beards snow white 73

73. Front relatively broad (index 1:5.6), callosity red, and widely separated from eyes; palpi pale yellow with white and sparse black hairs; mid and hind legs unicolorous yellowish red; venter pale yellow-haired with black median patches (T) ..... *xuthus* Philip

Front narrower (1:8.7), callosity brown, narrowly separated from eyes; palpi pale red covered with brown hairs; abdomen, including edges of tergites and entire venter, rufous-haired (B) ..... *ruficoloratus* Philip

74. Wings smoky, centers of some cells clearer; size 26 mm. (B) ..... *atriventer* S. Stek.

Wings yellow basally with smoky apical and hind margin; size under 25 mm. (M) ..... *tinctothorax* Ric.

75(62). Wings mostly subhyaline, but with an intense, rather narrow, costal brown band to apex; antennae orange; beard and tibial bases whitish; abdomen reddish-brown with broad golden-haired bands and triangles ..... *anabates* Philip

Not such species with intense apico-costal fumosity 76

76. Dark species with prominent white-haired, pale bands on the abdomen which may widen into flat, median, whitish triangles; if the abdomen is dark-brownish basally, the tibiae are widely white or pale yellow with apices sharply black 77

Variable species, usually reddish to brownish; if there are pale, narrow, incisural bands on a reddish-brown abdomen, these expand into median yellow triangles, and the tibiae grade gradually from red to black apically 85

77. Black species with white bands above and below, and low median triangles, black-brown legs, rather wide frons (index about 4) and quadrate black callosity not touching eyes, beard white, spur vein present (? T) ..... *multicinctus* S. Stek.

Not with this combination of characters 78

78. Small gray-brown species (10-12 mm.) with very narrow front; contrasting white, narrow transverse bands on dark-brown abdomen, venter not so banded; two hind pairs of tibiae predominantly pale yellow, and with short, wide, red antennae (T) ..... *zoster* Philip

Larger species, 13 to 17 mm 79

79. Rather small, gray-black species, 13 mm., with snow-white tibiae narrowly black apically, including the fore pair; the venter banded like the dorsum from sternite 3 on (T) ..... *equicinctus* S. Stek.

Size 14 mm. and above, venter with a wide black longitudinal stripe 80

80. Front broad, parallel-sided, index about 4, the mahogany-brown callosity almost filling the lower part and connected above to spindle-shaped median callus; tibiae widely pale basally 81

Front narrower, usually narrowed below, index about 7, with a tapering brown or black median callus and keel separated from eye margins; legs black 83

81. Abdomen brownish-red basally, and with rather narrow, gray incisural bands behind; costal cell yellow 82

Abdomen predominantly gray on basal two segments and with wide gray bands behind; wings entirely clear (M) ..... *abaculus* Philip

82. Size large, about 20 mm.; thorax lilac-gray (M) ..... *rufiventris* Fabr.

Size medium, 14 mm.; thorax brown (B) ..... *circumalbatus* S. Stek.

83. Palpi dark, beard black or red; spur vein absent; wings and frons variable.....84
Palpi yellow, beard white; frons narrowed below; wings brownish accentuated along veins, spur vein present (B).....*justorius* Rond.

84. Beard orange-red; frons narrowed below, index 9, callosity black; wings brown (M).....*pratti* Ric.
Beard black; frons parallel, index 7, callosity brown; wings faintly tinted (M).....*khasiensis* Ric.

85(76). Callosity touching eye margins at least at lower corners; beard white; wings clear, costal cells yellow.....86
Callosity viewed from above plainly separated from eyes; beards and wings variable.....87

86. Abdomen almost brick-red basally with edges of tergites yellow-haired, thorax and legs reddish (B).....*ignobilis* Rond.
Abdomen brown with white-haired edges; thorax and femora blackish (M).....*dissimilis* Ric

87. Abdomen reddish-yellow at base with three rows of rather indistinct grayish spots, and paired, isolated, dark streaks on tergites 3 to 5, black apically (body slender, 17 mm.) (B)...*varicolor* Ric.
Not such species.....88

88. Rather large (17 mm.) lilac-red species with dark appendages, strongly fumose wings, white beard, short spur veins, and abdomen with tall, white triangles which are not the expansions of pale tergites though outer corners of tergites are prominently white-haired (T).....
.....*nilakinus* Philip
Not such species.....89

89. Abdomen red-brown with median row of large, nontriangular, pale spots confined to tergites 2 to 4, increasing in size to a prominent, half-moon shaped spot on 4 (thorax lined, scutellum white-haired, 18 mm.) (M).....*significans* Ric.*
Not such species.....90

90. Dorsum and usually legs deep blackish-brown, though Bornean specimens may have abdomen basally, and tibiae, reddish; antealar tubercules often unicolorous with dark thorax; fronts broader (1:7-8.5), more parallel-sided; eyes green on lower half; robust species, usually over 16 mm. with golden-haired, low, half-moon shaped, yellow spots on dark-brown abdomen...90a
At least abdomen and tibiae reddish-brown; fronts usually narrower and strongly convergent below; antealar tubercles reddish or with reddish tints; eyes and size variable, but if dark-brown, smaller, under 17 mm.....93

90a. Callosity black; tibiae black, almost entirely black-haired; abdomen blackish-brown, the median triangles very low (M).....*audyi* Philip
Callosities reddish to brown; tibiae usually with more pale hairs; abdominal triangles more prominent.....91

91. Abdominal spots are not expanded along incisures, and surrounded above by dull blackish, geminate spots; antennal plates moderately excised, the tooth low.....92
Abdominal triangles are smaller and expansions of narrow yellow incisures, and a small black spot above the apex of the triangle on tergite 2; plates strongly excised, the tooth tall and acute (B).....*parabrunneus* S. Stek.

92. Front a little wider, index 1:7, slightly convergent below; thorax uniformly dark chocolate-brown; antennal plate more deeply excised, the tooth slightly acute; vestiture of underparts deep golden to orange-yellow (B, M, T).....*brunnicolor* Philip
Front parallel-sided, a little narrower, 1:8.5, thorax reddish-brown with two black-brown stripes; antennal tooth obtuse, underparts paler yellow-haired (B).....*parallelifrons* S. Stek.

93. Beard snow white.....94
Beard pale to deep yellow.....98

94. Long spur vein present at base of vein R_4; antennal plates red and almost as wide as long (T)
.....*rubicundulus* Aust.
No spur veins; antennae more slender, often black on third segment.....95

95. Large reddish-brown species (20-23 mm.) with antennae and callosity red, median pale triangles obscure (incisures and sides of tergites yellow-haired) (B).....*pauper* Rond.
Smaller species (13-18 mm.) with antennae and callosity darker; triangles larger and more distinct.....96

---

* "forma" *inaequesignatus* S. Stek. (1932*a*) Borneo, differs only in half-moon shaped instead of round spot on tergite 3.

96. Abdomen brown, black-haired, except yellow-haired triangles and outer corners of tergites; venter with large black-haired spots forming a median band (M).....*angustitriangularis* S. Stek.
Abdomen bright red, the triangles are expansions of golden-fringed incisures, often crossing tergites 4 and 5, the incisures, sides, and venters, with black hairs absent or inconspicuous...97

97. Abdomen rich red with darker shadows outlining the equilateral triangles, golden-haired incisures narrow; venter with some scattering black hairs in the mid-line not forming a band (B).....*dives* Rond.
Abdomen orange-red, the triangles taller and not with darker outlines, golden-haired incisures broad; venter entirely yellow-haired (B).....*vix* Philip

98. Abdomen reddish-brown with median row of low, white-haired triangles; incisures and edges of tergites yellow-haired; size 13-16 mm. (M).....*albitriangularis* S. Stek.
Abdomen with median yellow-haired triangles or spots.....99

99. Lateral borders of tergites black-haired except for small tufts of pale hairs at lower corners, incisures not with yellow fringes of hairs.....100
Lateral borders of tergites broadly yellow-haired, usually expanding along incisures.....101

100. Abdomen reddish-brown with tall yellow triangles almost crossing tergites (B).....*nexus* Walk.
Abdomen dark mahogany-brown, the paler yellow triangles lower, half or less the length of the tergites.....[some *angustitriangularis* S. Stek.]

101. Two hind pairs of legs practically unicolorous reddish, femora little or not darker than tibiae...102
Femora markedly darker than tibiae.....103

102. Abdomen bright orange-brown with many scattered concolorous hairs, which also comprise tall, narrow, median, easily denuded triangles, and without midventral black-haired patches; antennal plates predominantly black (B).....*aurisparsus* S. Stek.
Abdomen reddish-brown, mostly black-haired with small median tufts of yellow hairs not triangular, and with midventral patches of black hairs; plates predominantly reddish (B) .....*serus* Walk.

103. Large reddish-brown species (22.5 mm.) with broad front (index 1:5.5), dark chest, and unusually stout broad abdomen with dark venter, and wide pale incisures (B).....*laticorpus* Philip
Smaller species (20 mm. and less), narrower fronts and paler underparts.....104

104. Abdomen reddish to bright reddish-brown with median row of tall triangles, and sometimes suggestions of obscure, pale, sublateral spots in certain lights; venter with or without midventral black band; eyes variable.....105
Abdomen dark reddish to chocolate-brown with median row of lower triangles without obscure sublateral pale spots; median band of black spots on venter; eyes green on lower half.....106

105. Larger species, 18-20 mm.; golden-yellow-haired triangles (in unworn specimens) large, equilateral with distinct apices just over half the length of tergites; antennal plate narrow, deeply excised, the tooth acute; frontal index 1:7.3, the triangular, tall black callosity widely separated from eye margins by half its own width; eyes green in lower half (M).....*stantoni* Ric.*
Smaller species, seldom as much as 18 mm.; triangles narrower and, viewed from behind, their apices indefinite, overlying gray line on tergites 3 to 5; plate a little wider, the tooth not as tall, subrectangulate; index about 1:10, the blackish, tapering, keel-like callosity nearly touching the eyes at lower corners; eyes black (relaxed) (B, M).....*immanis* Wied.

106. Abdomen rich chocolate-brown with yellow, median and lateral triangles more pronounced; frontal callus club-shaped, less tapering into median extension; antennal plate blackish, more slender and excised, tooth sharper; average size smaller, about 16 mm. (B, M)..... .....*malayensis* Ric.
Abdomen brown with yellow triangles reduced and easily worn; frontal callus a rather evenly tapering keel; antennal plate reddish-brown, broader, tooth acute but lower; average size larger, about 18.5 mm. (B, M).....*fumifer* Walk.

Because of insufficient information, the following have been omitted or included with doubt: *T. borniensis* Ric. (Borneo); *T. dives* Rond. (Borneo); *T. pictiventris* Szil. (Borneo); *T. invalidus* Szil. (Singapore); *T. zebrinus* S. Stek. (Central Borneo); *T. finalis* Walk. ("Siam").

* *T. pictiventris* Szilàdy (Borneo) would separate on narrower front (about 1:12) and sharper, black, mid-ventral, half-moon spots if it reaches this couplet.

Key to Chrysozona

1. Wing pattern with pale markings very reduced except for a heavy apical band and a large spot crossing from costa in front of stigma through basal half of discal cell; all tibia white basally (B).....*bizonata* S. Stek.
   Wing pattern otherwise; mid and hind tibiae often dark with pale rings.....2
2. Wing pattern in the form of heavy connected, pale streaks and bands.....3
   Wing pattern punctate, forming pale rosettes; when some markings are confluent they are not in form of unusually heavy bands 5
3. Tibiae, and abdomen beyond the first segment, uniformly blackish-brown without pale rings or incisures (T).....? *cingulata* Wied. (♂)
   Tibiae and abdomen with some pale pattern.....4
4. Wing with a submarginal crescentic band, and a central eye spot; all tibiae with white bases; abdomen with a longitudinal stripe (B).....*cingulata* Wied.
   Wing with a prominent diagonal band across the discal cell into the anal area, and other spots and bars not in rosette pattern; middle and hind tibiae with obscure double rings; abdomen with pale incisures (M).....*rubida* Ric.
5. Fore and hind tibiae unusually hairy with prominent fringes; hind femora white-haired dorsally; antennae unusually long, scape equalling pedicel and plate together (T).....*cilipes* Big.
   Tibiae not unusually hairy and scape not unusually long.....6
6. Wing with hind borders of marginal cells entirely dark, without pale spots or triangles.....7
   Wing with pale triangles of spots resting on hind borders of at least some marginal cells.....9
7. Usually larger species (9 mm.); callosity brown or black-brown, triangular; abdomen pale or reddish-brown basally, inornate except for indistinct or prominent pale incisures but no sublateral gray spots.....8
   Smaller delicate species (7 mm.); callosity black, narrow, transverse; abdomen chocolate-brown, when well preserved showing a gray pattern of distinct pale incisures, indefinite isolated spots, and a median triangle on tergite 2 (apical band irregular but reaching costal margin above) (T).....*abacis* Philip
8. Two hind pairs of tibiae white on basal one-half to two-thirds; notum and scutellum with pale margins; abdomen brown with broad pale incisures; apical band of wings touching costal but not hind margins (B, M).....*irregularis* S. Stek.
   Two hind pairs of tibiae brown, with indistinct paired rings; no pale margin around thorax; apical band reduced to small internal spots (B, M).....*irrorata* Macq.
9. Face entirely gray pollinose, or sometimes with small brown punctations, but no prominent dark patches.....10
   Face with black pollinose velvety patches at least on the parafacials or each side of the antennae 15
10. Front almost filled with the enlarged, confluent basal and median callosities.....11
    Frontal callosity not unusually produced above, separated from the median velvety black spots 12
11. Apical band of wing double or forked; the outer branch composed of spots; abdomen with a pale triangle in middle of second segment; callosity uniformly black-brown (M).....
    .....*mediatifrons* S. Stek.
    Apical spot single, broad and curved; abdomen without median triangle; callosity black-brown but with lower border yellow above antennae (M).....*cordigera* (Big.)
12. Front with a vertically elongated median spot between the two lateral spots (M)...*malayensis* Ric.
    Front with only the paired, lateral spots prominent; the median spot often reduced or wanting...13
13. Antennal scapes (first segments) and plates unusually inflated, thicker than the palpi (M, T).....
    .....*pachycera* Big.
    Antennae slender, not thicker than palpi.....14
14. Scape nearly as long as plate; tibiae white basally, black apically; apical band single (B).....
    .....*borneana* Rond.
    Scape shorter than plate; mid and hind tibiae with paired, pale rings; apical spot sometimes double (B, T).....*pungens* Dol.
15. Middle and hind tibiae at least half to predominantly white.....16
    Tibiae dark with one or two narrow, pale rings.....17

16. Abdomen chocolate-brown with pale incisures and a median triangle on tergite 2; thorax unicolorous; apical band crescentic (M).....*lunulata* Macq.

Abdomen reddish basally with pale incisures but without pale triangle; thorax with gray hind border in front of scutellum; apical band straight or sinuous (B).....*angustisegmentata* S. Stek.

17. Abdomen with median row of truncated triangles forming a contrasting pale longitudinal stripe its full length.....18

Abdomen otherwise, without stripe on more than tergite 2.....19

18. Apical band double behind costal margin; discal cell with two cross bars, the rosette around crossveins at its apex single; antennae rather short, the scape and plate subequal and somewhat thickened (M).....*javana* Wied.

Apical band broad at each wing margin, but tapering inward, overlapping, and disconnected at vein R_4; discal cell with paired spots and an apical bar in the distal half forming part of a double rosette about the crossveins; antennae elongate, the scapes longer than the plates (T) .....*lineola* Philip

19. Antennal scapes brown, robust, as thick as or thicker than palpi; callosities expanded over half the frontal area (apical band single; hind tibiae with one broad white ring) (B)...*atomaria* Walk.

Antennal scapes not unusually thickened, or black if somewhat thickened; callosities not unusually expanded.....20

20. Antennae black, scapes shining and somewhat thickened; callosity black, swollen; upper cheeks and face with black band below antennae; tergite 2 with pale triangle; second ring on hind tibiae faint and incomplete (M).....*splendens* S. Stek.

Antennae brown, slender; callosity brown, not swollen; face?; tergite 2 without median pale triangle; hind tibiae with two complete rings (B).....*segmentata* S. Stek.

SUMMARY

A review of published and new records, as well as keys to Tabanidae of Malaya, Thailand, and the Borneo-Palawan Archipelago, are provided. New names are proposed as follows: from Borneo—*Tabanus enderleini* for *T. nigripes* Enderlein, not Wiedemann; *T. stekhoveni* for *T. elegans* Schuurmans Stekhoven, not Thunberg; *T. laticorpus* for *T. lativenter* Schuurmans Stekhoven, not Macquart; and from India, Thailand and Malaya—*T. biannularis* for *T. bicinctus* Ricardo, not Fabricius.

Of some 153 species and subspecies in seven genera reported from the above localities, only four are known to be common to all, while seven occur in Thailand and Malaya, and fifteen in Malaya and Borneo.

BIBLIOGRAPHY

AUSTEN E. E. (1922). Some Siamese Tabanidae. *Bull. ent. Res.*, *12*, 431-455.

DARLINGTON J. P. (1957). Zoogeography. John Wiley and Sons: New York.

HALDANE J. B. S. (1959). The theory of natural selection today. *Nature, Lond.*, *183*, 710-713.

HUBBACK T. R. (1919). Big-game shooting. *In* Sport and Motoring in Malaya. Malay States Information Agency, ed. C. W. Harrison, Kuala Lumpur.

KELSER R. A. (1927). Transmission of surra among animals of the equine species. *Philipp. J. Sci.*, *34*, 115-141.

KOHLS G. M. (1957). Malaysian Parasites, XVIII. Ticks (Ixodoidea) of Borneo and Malaya. *Stud. Inst. med. Res. Malaya*, *28*, 65-94.

KRÖBER O. (1924). Die Tabaniden der Philippinen. *Arch. Naturgesch.*, Abt. A (Heft I), 27 pp.

MACDONALD W. W. (1957). Malaysian Parasites, XVI. An interim review of the non-anopheline mosquitoes of Malaya. *Stud. Inst. med. Res. Malaya*, *28*, 1-34.

MACKERRAS I. M. (1955). The classification and distribution of Tabanidae (Diptera). *Aust. J. Zool.*, *3*, 439-511.

MITZMAIN M. B. (1913*a*). The biology of Tabanus striatus Fabricus, the horsefly of the Philippines. *Philipp. J. Sci.*, (B) *8*, 197-221.

MITZMAIN M. B. (1913*b*). The mechanical transmission of surra by Tabanus striatus Fabricus. *Philipp. J. Sci.*, (B) *8*, 223-229.

STUD. INST. MED. RES.

NIESCHULZ O. (1925). Zoologische bijdragen tot het Surraprobleem. I. Experimenteele overbrenging van Tryp. evansi door *Tabanus stantoni* Ricardo en *T. ceylonicus* Schiner. *Dept. Landbouw, Veeartsenijk. Meded., Buitenzorg*, no. 53, 7 pp.

NIESCHULZ O. (1926). Overbrengingsproeven mit *Tabanus rubidus*, Wied., *T. striatus*, Fabr., en *Stomoxys calcitrans*, L. *Dept. Landbouw, Veeartsenijk. Meded., Buitenzorg*, no. 55. (Abstract in *Rev. appl. Ent.*, (B), *15*, 191.)

NIESCHULZ O. (1927). Overbrengingsproeven met *Haematopota cingulata* (Wied.). *Ned. -ind. Bl. Diergeneesk.*, *38*, no. 5. (Abstract in *Rev. appl. Ent.*, (B), *15*, 211.).

OLDROYD H. (1949). The Diptera of the Territory of New Guinea. XIV. Family Tabanidae. Part III. Tabaninae. *Proc. Linn. Soc. N. S. W.*, *73*, 304-361.

PHILIP C. B. (1959). The Philippine Expedition 1946-1947: Tabanidae (Diptera). *Fieldiana, Zool.*, *33*, 543-625.

PHILIP C. B. (1960). Malaysian Parasites, XXXV. Descriptions of some Tabanidae (Diptera) from the Far East. *Stud. Inst. med. Res. Malaya*, *29*, 1-32.

PHILIP C. B. AND MACKERRAS I. M. (1960). On Asiatic and related Chrysopinae (Diptera: Tabanidae). *Philipp. J. Sci.* (in press).

PRATT H. (1907). Observations on the family Tabanidae. *Rep. Inst. med. Res. F.M.S.*, *1907*, 7-10.

RICARDO G. (1911*a*). A revision of the species of *Tabanus* from the Oriental region. *Rec. Indian Mus.*, *4*, 111-258.

RICARDO G. (1911*b*). A revision of the Oriental species of the genera of the family Tabanidae other than *Tabanus*. *Rec. Indian Mus.*, *4*, 321-400.

RICARDO G. (1916). Two new species of *Haematopota* from the Federated Malay States. *Bull. ent. Res.*, *6*, 403-404.

SANDOSHAM A. A. (1957). Malaysian Parasites, XXXII. Infection of animals by major groups of helminths: an interim tabulation. *Stud. Inst. med. Res. Malaya*, *28*, 403-408.

SCHUURMANS STEKHOVEN J. H., JR. (1926). The tabanids of the Dutch East Indian Archipelago. *Treubia*, *6* (Suppl.), 1-551.

SCHUURMANS STEKHOVEN J. H., JR. (1928). The blood-sucking arthropods of the Dutch East Indian Archipelago. IX. Recent collections of tabanids from Sumatra, Middle East Borneo, Soemba, etc. *Zool. Jb.*, (1), *54*, 425-448.

SCHUURMANS STEKHOVEN J. H., JR. (1932*a*). Blood sucking arthropods of the Dutch East Indian Archipelago. X. Further notes on tabanids of India, Sumatra, Java, Borneo, Celebes, and some of the Moluccas. *Arch. Naturgesch.*, (N. F.), *1:* 56-94.

SCHUURMANS STEKHOVEN J. H., JR. (1932*b*). Tabanids from Sumatra and Borneo. *Tijdschr. Ent.*, *75* (Suppl.), 78-83.

SURCOUF J. (1922). Dipteres piqueurs du Laos (Tabanidae). *Bull. Soc. ent. Fr.*, pp. 13-15 (Séance 11 janvier).

SZILADY Z. (1926). New and old world horseflies. *Biol. hung.*, *1* (7), 1-30.

TOUMANOFF C. (1950). Contribution a l'étude des tabanides de l'Indochine. Première note: Description de quatre espèces nouvelles. *Bull. Soc. Pat. exot.*, *43*, 372-381.

TOUMANOFF C. (1953). Contribution a l'étude des tabanidés de l'Indochine. (Troisième note: Description d'une espèce nouvelle). *Bull. Soc. Pat. exot.*, *46*, 200-205.

APPENDIX

In the course of editing the preceding paper by Dr Philip I have corrected many of the spellings of Malayan place-names; undoubtedly most of the errors were caused by misinterpretation of badly-written or faded labels on specimens. A number of other spellings are certainly wrong but I have left them as they were, for some occur elsewhere in Tabanid literature and require explanation and others I have been unable to interpret. I have therefore listed below some of these localities, with a few brief notes, in order that future collectors might be assisted when they wish to revisit some of the places.

Batu Bokarat (*T. fumifer*).—This is more likely to be Batu Berkarat (Batu=stone; Berkarat=rusty), but I have not yet been able to trace such a locality.

Batu Tiga (and Labuan Padang) (several species).—This is situated in Selangor between Kuala Lumpur and Klang.

Beseht, Bandar (*T. significans*).—I am unable to interpret this; Bandar is a not uncommon place-name, and perhaps the most likely locality is the Bandar district in Selangor, near Jugra Hill.

Bukit Lansai and Bukit Ganlai, Sungei Ujong: Negri Sembilan (*T. tinctothorax*).—These are probably meant to be the same. Sungei Ujong is an old name for the town of Seremban, but I am uncertain which Bukit (=hill) is meant. The most likely is Bukit Langsat.

Bukit Sangga: Negri Sembilan (*Chrys. cordigera*).—This may be Bukit Saga near Tampin, but if there is a Bukit Tangga in Negri Sembilan, this would be more likely.

Bulliar: Perak (*T. pratti*).—I am unable to interpret this.

Gali Raub: Pahang (*T. rubidus*).—This may be Kampong Gali near Raub.

Ginting Budai: Selangor (*T. tinctothorax*).—This should be Ginting Bidai, an old pass, south of Ginting Sempah, at the head of Sungei Klang.

Goenoeng Tampin (several species).—This is the Dutch spelling of Gunong Tampin, Negri Sembilan.

Iras: Pahang (*T. biannularis*).—This is most likely to be Tras in Pahang.

Jor Camp: Perak (several species).—This is on the road from Tapah to Cameron Highlands.

Kelantan, Malacca (*T. pratti*) and Malacca, "Kelanton" (*T. leucocnematus*).—Both refer to the state of Kelantan (*see* note under Quedah).

Kuala Teku: Pahang (*Chrys. irrorata*).—This is situated near the base of Gunong Tahan, the highest mountain in Malaya.

Lara Head: Selangor (*T. striatus*).—I have been unable to trace this.

Matang River (*Ch. fixissima, T. fulvissimus*).—In Perak.

Polo Pisan Lighthouse (*T. dissimilis*).—This is most probably Pulau Pisang Lighthouse, off Johore.

Quedah, Malacca (several species).— This refers to Kedah, Malaya. Some years ago the term Malacca was used by several collectors to denote Malaya as a whole and not just the state of Malacca.

Sci [? Sri] Chemabang, N. B. Bulok, Beluka (=belukar) (*T. immanis*).—I am unable to interpret this. Belukar=scrub, or secondary jungle.

Tegong: Malacca (*Ch. dispar*).—This might mean Tebong, situated near the Malacca boundary, and near Tampin.

Temangoh: Perak (*T. tinctothorax*).—This is probably Temengor in Upper Perak.

53 mi. Troo Bentong (several species).—This probably means the 53rd milestone on the Tras-Bentong Road in Pahang. The milestones were numbered from Kuala Lipis.

EDITOR.

MALAYSIAN PARASITES XXXVII

AN INTRODUCTION TO THE ECOLOGY OF THE MOSQUITOES OF THE LOWLAND DIPTEROCARP FOREST OF SELANGOR, MALAYA*

BY

W. W. MACDONALD

Institute for Medical Research, Kuala Lumpur

AND

ROBERT TRAUB

United States Army Medical Research Unit (Malaya), Institute for Medical Research, Kuala Lumpur

CONTENTS

* These studies were supported jointly by the Federation Government, the U. S. Army Medical Research and Development Command, and by a grant from Colonial Development and Welfare Funds.

Introduction

Towards the end of 1955 the U.S. Army Medical Research Unit (USAMRU) began extensive collections of adult mosquitoes in Ulu Gombak Forest Reserve, Selangor. The mosquitoes were identified by one of us (W. W. M.) and the staff of the Division of Entomology of this Institute (I.M.R.), after which they were returned to USAMRU for attempted isolation of viruses. These catches were virtually the first regular forest collections in Malaya since Leicester's classical work at the beginning of the century (Leicester, 1908), and the problem which they immediately posed was one of taxonomy and nomenclature. Many of the species were unrepresented in the Institute collection, doubts often arose over the correct identification of specimens, and, consequently, much of the material could be identified only to a species group. The position was aggravated by the fact that virologists require large numbers of mosquitoes alive, or very recently killed, for their virus isolation work, and entomologists prefer mosquitoes on pins for definitive identification. In the event, most of the identifications were done while the mosquitoes were alive, but representative specimens were put aside for more leisurely examination.

It became clear from the adult catches of USAMRU that the mosquitoes of Ulu Gombak would repay closer study. Most species could not be separated satisfactorily with the existing keys, the larvae and males of many were unknown, and practically nothing was known of their breeding and biting habits. Following the recommendations of a conference on virus diseases held at the Institute for Medical Research in 1954 (Institute for Medical Research, Malaya, 1955), the investigation of those, and allied, problems has been a main concern of one of us (W. W. M.) for several years, and the following account is based principally on the collections of his unit. Since, however, the work of the I.M.R. and of the USAMRU teams has been in some ways complementary, and at times overlapping, it is convenient to present this introductory account jointly.

The work at Ulu Gombak has been supplemented by collections in other forest areas of Selangor, chiefly Ulu Langat Forest Reserve, Ampang Forest Reserve, Templer Park, and Bukit Lagong Forest Reserve, while a few collections have also been made in the forests of Negri Sembilan, Perak, Pahang, and Trengganu. Complementary investigations, which will not be discussed here, have gone on concurrently in coastal areas of Selangor, and in scrub terrain or "mosaic vegetation".

The Forest and the Collecting Areas

The lowland forest of Malaya is evergreen tropical rain forest, dominated by trees of the family Dipterocarpaceae. Such forest is typical of Malaysia generally, where there is heavy rainfall, well-distributed over the year, and constant high temperatures and humidities, and dipterocarp forest is the climatic climax formation over much of this subregion. Discussions of the characters and features of Malaysian rain forest are given by Symington (1943), Wyatt-Smith (1952*a*, *b*) and Richards (1952). Following Symington (*l.c.*), five climatic climax forest formations are recognized in Malaya, each being characteristic of a different altitudinal zone. These are:

1. Lowland dipterocarp forest, which covers the plains and the foothills of the main range to an elevation of about 1,000 ft.
2. Hill dipterocarp forest, which covers much of the main range at elevations from 1,000 to 2,500 ft.
3. Upper dipterocarp forest, which extends between the altitudinal limits of 2,500 and 4,000 ft.
4. Montane oak forest, usually characteristic of elevations between 3,500 and 5,000 ft.
5. Montane ericaceous forest, which is found above 5,000 ft.

The altitudinal limits and the specific composition of each of those formations can not be rigidly defined, nor are they necessarily similar throughout the country. Under special climatic or topographical conditions the limits of each formation may be shortened or extended, and on coastal hills in particular the altitudinal limits may be telescoped.

Our collecting has been done principally in the first of the formations, i.e., lowland dipterocarp forest, but the mosquito fauna may not vary much between this and the higher dipterocarp formations. For example, almost all the mosquitoes recorded from The Gap*, which lies at about 3,200 ft. in the upper dipterocarp forest zone, have been collected also in Ulu Gombak Forest Reserve. On the other hand, there may be a gradual reduction in the number of species as one goes higher, and probably a number of lowland species do not extend into or beyond upper dipterocarp forest. Only more intensive and extensive collecting will provide the additional data that are required, but it is clear from our limited collections that there is a distinct change in the mosquito fauna when the montane oak or ericaceous forests are sampled, as at Fraser's Hill (4,280 ft.) and Cameron Highlands (5,000-6,000 ft.). The faunas of these high zones are poorer in species, and there are some species, e.g., *Toxorhynchites klossi*, *Tripteroides vicinus*, *Anopheles lindesayi* and *An. wellingtonianus*, which are not found at lower altitudes.

Unfortunately, lowland dipterocarp forest in Selangor has been extensively logged, so that there is little primary, undisturbed forest left. The areas with which we are concerned here, where mosquitoes have been investigated, are best described as secondary forest in which the tall dipterocarp trees have been thinned and secondary species have become established. In some respects this has proved an advantage, for among the secondary flora are bamboos, and the mosquitoes associated with these grasses are among our most interesting and abundant species.

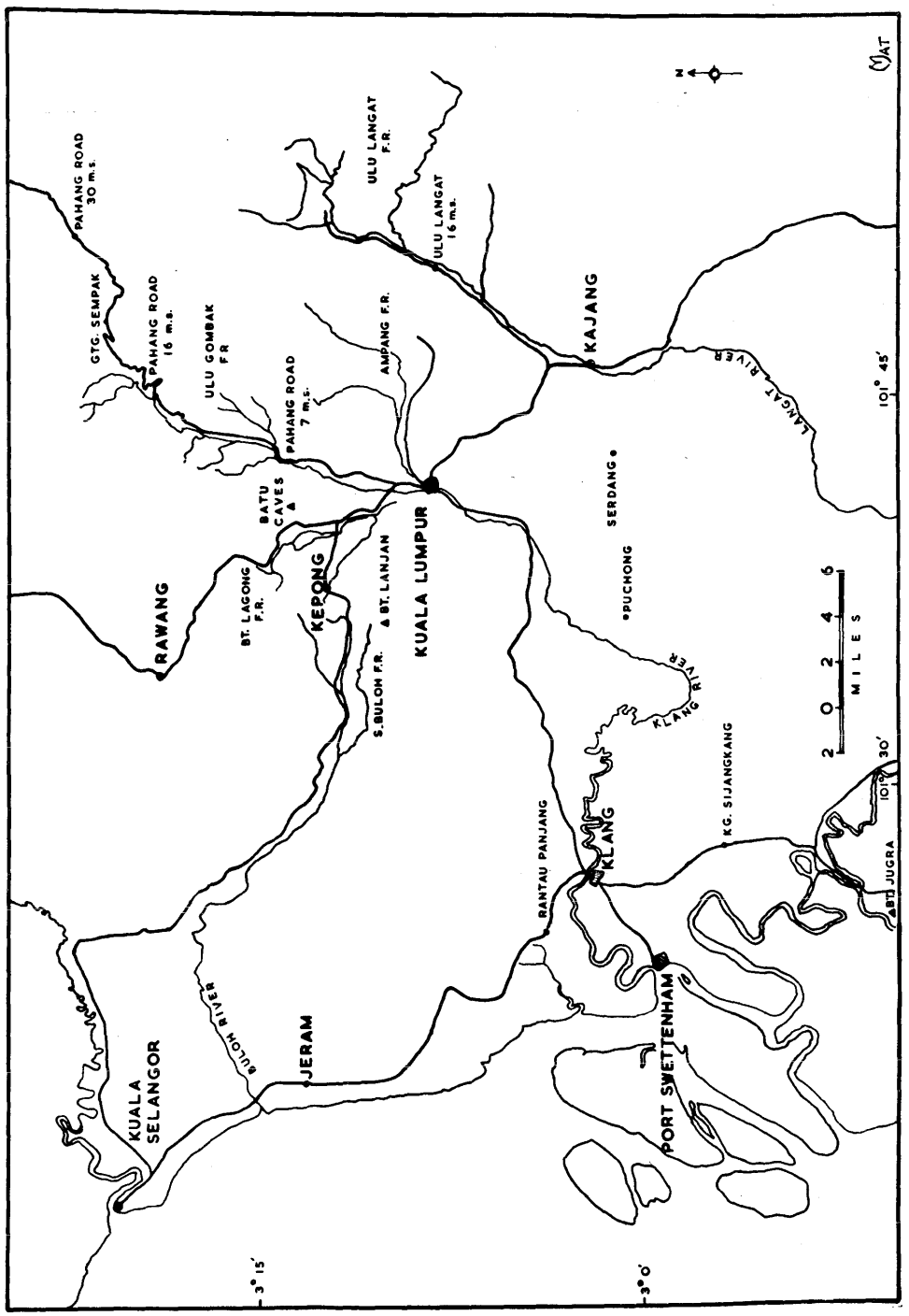
The collecting areas which will now be described briefly are as much as 15 or 20 miles apart, but the forest is continuous from one to another. The main differences between them lie in the degree of disturbance or interference by man, and this in turn is reflected in the secondary flora and in the mosquito fauna.

ULU GOMBAK FOREST RESERVE

This reserve has been the principal collecting area (*see* map). Through the forest-clad valley flows the River Gombak, which, rising near Genting Sempak, runs to Kuala Lumpur where it joins the River Klang. In the lower part of the valley, a few miles north of Kuala Lumpur, the forest has been cleared and the land given over to rice cultivation and rubber plantations. Forest is not now reached until about the 10th milestone, though when Leicester collected at Ulu Gombak in 1903-04 he was able to collect forest mosquitoes at the 5th milestone. Through the forested part of the valley wood-cutters' tracks are common, and logging is in progress in several areas.

Our collecting has been mostly between the 13th and 16th milestones, at an elevation of nearly 1,000 ft., where the land is hilly and the forest largely secondary. The crowns of the remaining giant dipterocarps, rising 100 ft. or more, are well-separated from one another and form a rather sparse emergent layer. There is no sharp discontinuity between the main storey (60-100 ft.) and the under-storey (25-60 ft.) so that these strata together form a more or less continuous canopy. The shrub and herb layers are quite dense, as would be expected in secondary forest, making travel difficult except along paths.

* Localities not shown on the accompanying map of Selangor were included in a map of Malaya in a previous account of mosquitoes in this series (Macdonald, 1957).



Map of Selangor, Malaya, showing the location of mosquito-collecting sites.

Bamboos of several species are a prominent feature of this reserve, especially near the roadside. The chief of these for our purposes are *Gigantochloa scortechinii* Gamble and *Dendrocalamus pendulus* Ridley, from both of which numerous collections of mosquito larvae have been made. Holttum (1958) has given a taxonomic account of Malayan bamboos, including those two species, but there is little information available on their ecology.

ULU LANGAT FOREST RESERVE

Situated due east of Kuala Lumpur (*see* map), this reserve is very similar in many respects to Ulu Gombak. The upper forested region has essentially the same flora, including bamboos, and the mosquito fauna shows every indication of being identical. Davidson and Ganapathipillai (1956) have given an account of the anophelines of the lower, populated portion of the valley, where they investigated the vectors of malaria.

AMPANG, KANCHING, BUKIT LAGONG, AND SUNGEI BULOH FOREST RESERVES

These reserves have been visited only occasionally. Each is much less disturbed than either Ulu Gombak or Ulu Langat and this is reflected both in the flora and in the mosquito fauna. Bamboos are less common, so that many species of mosquito which are associated primarily with bamboo are either absent or rare. North of Batu Caves and adjoining Kanching F. R. is Templer Park, a national park, which includes a large area of old tin-mining ground and some forest. This forest is disturbed, part of it has been treated silviculturally by the Forestry Department, and there are several small areas where bamboos are common.

Collecting and Rearing Techniques

The adult collections of USAMRU have already been briefly mentioned. Those were made using mosquito collectors as bait at various times during the day and evening, at stations near the 15 m. and 17 m. Ulu Gombak or Pahang Road. At the same time animal-baited traps were tried, but since these produced very few mosquitoes their use was discontinued. The human-bait catches were made principally on the ground, but, in addition, tree-top catches were made on a platform 90 ft. high on an old fig tree. Since the object of those early catches was to collect large numbers of mosquitoes for virus isolation attempts, the times of catching and the number of catchers were not standardized. Consequently, although a great deal of useful material was collected, no conclusions on biting times and seasonal abundance can be drawn from the results. At the same time the identification of the mosquitoes was not as precise as became possible later. With the exception of some results from the tree-top catches, these collections will therefore not be included in this account. Similarly, an analysis of the mosquitoes inoculated into mice for virus isolation attempts will not be given here, but it may be stated that no virus was recovered from Ulu Gombak (Institute for Medical Research, Malaya, 1957).

To fill the need for more precise data on the biting times and seasonal fluctuations of the various species at Ulu Gombak, sunrise-to-sunset catches were begun early in 1958, and these catches have continued on alternate weeks throughout 1958 and 1959. Occasional 24-hour catches of the pattern described by Haddow (1954) have also been made, but since the catch between sunset and sunrise has been consistently poor both in numbers and in species, most interest has been taken in, and emphasis placed upon, day catches. A few regulated catches have also been made on the tree-top platform mentioned previously.

In addition to the regular catches at Ulu Gombak, a few irregular adult catches have been made at Ulu Langat, Bukit Lagong, and Sungei Buloh Forest Reserves.

More than 500 larval collections have been made in the lowland dipterocarp forest of Selangor during the past three or four years, so that almost all the apparent breeding-places have now been well-sampled; but while larvae of the great majority of known species have now been collected, there still remain a number undetected. If the larvae could have been

readily identified much more could have been accomplished by larval surveys, but since a high proportion of the larvae encountered have never been described, or even collected before, a great deal of effort has gone into the rearing of each larval collection. With few exceptions, each larva of every collection has been individually reared to the adult stage, and the larval and pupal skins of many of them preserved and mounted, the correlation of the skins with the adults being the principal object of individual rearing. Since as many as 50-60 larvae may be collected from a single breeding-place, the number of collections has had to be curtailed. But the policy of rearing each larva individually is profitable in any area whose fauna is not well known, for even after collecting for three years, both new and unrecorded species have been found at Ulu Gombak.

There is one other technique which has contributed to our knowledge of forest mosquitoes. This has been the rearing of sibling series of specimens from individual females. Sometimes a species occurs more or less regularly in adult catches, whereas attempts to find the breeding-places fail. In such cases we have endeavoured to feed a wild-caught female and induce her to lay her eggs in the laboratory. From such an egg-batch an excellent series of larvae, pupae, and adults can usually be obtained, and in those groups where males are necessary for positive identification this may be the only way of determining the true status of the female parent. Many species will lay their eggs on damp filter paper in a tube such as was described by Macdonald (1956) for *Ae. aegypti* egg-laying. This applies more particularly to species of *Aedes*, *Heizmannia*, and *Armigeres* subgenus *Armigeres*, which lay their eggs individually. Species of *Culex* and *Armigeres* subgenus *Leicesteria*, which lay their eggs as a raft or a ribbon, are best kept in a small jar with water.

Since many species do not readily feed in captivity, for example most species of *Heizmannia*, the mosquito collectors in the field have often allowed each mosquito to feed to repletion, in the hope that the catch would include one or more species required for egg-laying. In this manner the first, and only, known series of *Heizmannia achaetae* adults with associated skins was obtained. It may be of interest to add that even when a female is collected unfed, and subsequently refuses to feed in the laboratory, it is worthwhile retaining her in a tube with damp filter paper in case there are a few eggs left over from the previous oviposition. By this method seven eggs of the rare species *Udaya lucaris* were obtained, and from the eggs the only known larvae, pupae and males were reared (Macdonald and Mattingly, 1960).

Besides providing valuable series of specimens, the technique of inducing wild-caught females to lay eggs in the laboratory also allows observations to be made on the different methods of egg-laying, and on the effect of subjecting the eggs to slow drying such as they might meet in nature.

The Breeding-places

Before discussing the mosquito fauna itself it is necessary to tabulate and summarize briefly the breeding-places that have been sampled. Those are shown in Table I, which also includes the number of species that has been collected from each habitat. A number of the table headings can be subdivided further, and additional data are in fact given in later tables and in the text.

Table I

THE TYPES AND NUMBERS OF BREEDING-PLACES SAMPLED, TOGETHER WITH THE NUMBER OF SPECIES COLLECTED FROM EACH, IN LOWLAND DIPTEROCARP FOREST, SELANGOR

Breeding-place	Tree-holes	Artificial containers	Bamboo stumps	Fallen and Upright Split bamboo	Upright bamboo internodes with holes	Plant Containers	Rock-pools	Temporary Pools	Permanent pools and swamps	Totals
No. of collections	100	72	58	54	164	33	16	6	29	532
No. of species	46	20	35	40	41	15	10	9	27	127

Tree-holes.—These require little explanation. The holes may range in size from small cavities holding only 100 mls., or less, to large, deep holes containing several litres of water. All those examined have been situated near ground level, so that tree-holes in the canopy have not been investigated. No effort was made to group the holes by size, or by any other criterion, but in view of the large number of species that has been recorded from this habitat (46 species of 11 genera), it now seems likely that a careful study of individual holes and cavities might reveal characteristics common to some but not to others that might be related to the presence or absence of the various mosquito species.

Artificial containers.—These include bamboo pots and plastic jars, chiefly the former, that have been placed in various situations and examined at intervals. Most of the containers have been near ground level, but there were also three series of bamboo pots placed at heights between ground level and 94 ft.; those were examined weekly and the larvae, when present, were sampled. Almost all the species collected from artificial containers have been found also in tree-holes.

Bamboo stumps.—This habitat is a common source of a good variety of species. In almost all cases the stumps were between ground level and a height of 6 ft., but occasionally a collection has been made from a taller bamboo whose upper portion had broken off. As in the case of tree-holes, the volume of water in bamboo stumps varied a lot, depending mainly, of course, on the depth of the internode as well as on weather conditions.

Fallen and upright split bamboos.—This group includes fallen bamboos principally, but in all cases the bamboos have been split along the long axis and water has collected in one or other of the internodes. In most cases the cracks have been of sufficient size to allow easy ingress by the mosquitoes, but occasionally in upright bamboos the vertical split was so narrow that many species would be unable to pass through.

Upright bamboos with holes.—Holes in the wall leading inside the internodes are not uncommon in upright bamboos, and they have been divided by size into three groups: small holes, less than 5 mm. along the greatest axis; moderate-sized holes, 5-10 mm.; and large holes more than 1 cm. along the longest axis. The small and moderate-sized holes have, as a rule, been bored by beetle larvae, but a full account of the formation of the different types has been given elsewhere (Macdonald, 1960*b*, this *Study*). An interesting and complex mosquito fauna is found inside the internodes, and not only is the size of the entrance hole of significance, but so also is the age and condition of the bamboo.

Plant containers.—These records include collections from the leaf axils of plants such as bananas (*Musa*) and keladi (*Colocasia* and/or *Alocasia*), collections from the inflorescence of the wild ginger plant *Zingiber spectabile*, from fallen leaves, and a few from pitcher plants. Some mosquito species seem to be very closely associated with only one species of plant, so that one might describe them as plant-specific.

Rock-pools.—These have usually been situated beside one or other of the Selangor rivers, but a few collections were also made from small pools of rain-water on boulders at the forest edge.

Temporary pools.—These include all small bodies of water which are dependent mainly on rain-water for their existence. Included are small pools of seepage water and the occasional collections of water in hoof prints; but, in general, this is not a common nor important group of breeding-places in forest.

Permanent pools and swamps.—Permanent bodies of ground water are not common in lowland dipterocarp forest, but the records include a number of collections from an old, disused

aqueduct at Ulu Gombak. This aqueduct measures about 5 ft. across and contains standing water to a depth of several inches during most of the year: it also contains a large amount of fallen vegetable debris such as leaves and branches. It is therefore best classified as a permanent pool, and it provides a breeding-place for a number of species which are probably secondary, introduced species in the forest.

It has become increasingly evident during the course of collecting that very detailed recording of the breeding-places is necessary before the individual preferences of the various species can be defined. Some species of most genera can be associated with a simple observable niche, but there are others whose preferences and habits are obscure. The most unsatisfactory group are those species which breed in tree-holes and bamboo-stumps. It is certain, for instance, that the 46 species recorded from tree-holes do not have identical breeding requirements, including as they do many species of the same genera and subgenera, but at present there are insufficient data to subdivide these breeding-places further. Progress will be made when the regular study of a limited number of tree-holes is possible, but ultimately it may prove necessary to define the several niches within each single breeding-place, and to clarify the complex inter-and intra-specific relationships.

The Mosquitoes of the Forest

The following arrangement follows that of an earlier review of Malayan mosquitoes (Macdonald, 1957), which included notes on species distribution and in which the authors of each species were given in full: only species not mentioned in that review will be given in full here. At the same time many references to taxonomic accounts of the various groups are omitted since those were also given earlier. In this account emphasis is placed on the ecology of the forest species, and wherever there are sufficient data an attempt is made to define the niche occupied by each.

Despite the great variety of species in dipterocarp forest, and especially at the forest fringe, it is exceptional for mosquitoes to be a serious nuisance either by day or by night, and many of the species listed in the following pages have never been taken attacking man. This situation contrasts with that in swamp forest, where one finds fewer species but usually much larger numbers of individuals, chiefly of the genus *Mansonia*. Similarly, in the *Nipa* and coconut plantations along the coast the same situation obtains; only about half as many species as occur in inland forest are known, but several of them, chiefly species of *Aedes*, occur in very large numbers at times, and they attack man vigorously.

It is well perhaps to emphasize that the rich variety of species in forest may be characteristic only of secondary or disturbed forest, particularly where bamboos are established. No extensive observations have yet been made in primary forest, but there are indications that the mosquito fauna may be poor both in numbers and in species. It is certainly wrong to think of primary dipterocarp forest as harbouring large numbers of voracious mosquitoes, or other biting insects. Generally speaking, mosquitoes are more abundant in the botanically more simple formations, where one or two types of mosquito breeding-place usually outnumber all others, and so produce large numbers of only a few mosquito species. Such conditions are fulfilled in swamp forest and in the *Nipa* palm-mangrove zone.

Except in the case of the genus *Anopheles*, work on the systematics and taxonomy of Malayan mosquitoes is still far from complete, and in the following notes it has been necessary to refer to some species by numbers. In most of these cases a few descriptive notes have been added, and those might be helpful in recognizing the species until full names and descriptions can be provided. The number given to a species is only a temporary measure, but to avoid future confusion, representative specimens of each species will be deposited in the British

Museum (Natural History), and, as the systematics of the various groups are clarified, it is hoped that the numbered specimens will serve as a link between the future taxonomic descriptions and the ecological notes given in this paper.

Genus **Toxorhynchites** Theobald

Only four species of this non-biting genus have been collected by us in lowland forest—*leicesteri*, *magnificus*, *metallicus* and *quasiferox*; their breeding habits are shown in Table II. In addition, two other species, *funestus* and *raris*, were each collected once by Leicester (1908) from bamboos in forest near Kuala Lumpur; and there is also a single female of *funestus* in the I.M.R. collection recorded from 11¾m. Pahang Road (*E. P. Hodgkin*), i.e. from Ulu Gombak. A total of six species are therefore known to occur in lowland dipterocarp forest.

TABLE II

THE COLLECTIONS OF *Toxorhynchites* RECORDED FROM VARIOUS BREEDING-PLACES IN LOWLAND DIPTEROCARP FOREST, SELANGOR

Species	Total collections	Tree-holes	Bamboo pots	Bamboo stumps	Bamboos, fallen, split	Bamboos, with large holes	Bamboos, with moderate holes	Bamboos, with small holes	Ginger flower bracts	*Orchidantha* axil
funestus	—				?					
leicesteri	2				2					
magnificus ...	18			1		2	9	6		
metallicus ...	24	1	5	10	2	3	3			
quasiferox ...	17	12	1			1	1		1	1
raris	—				?					

Of these, *magnificus*, *metallicus* and *quasiferox* are most common, and each occupies a distinctive larval niche. The first, *magnificus*, breeds almost entirely in upright bamboo internodes, the entrance to each internode being a small or moderate-sized (occasionally large-sized) hole in the bamboo wall. In view of the large size of the adult mosquitoes the method by which the female enters the internode to lay her eggs is rather a mystery. The second species, *metallicus*, breeds mainly in bamboo stumps, but larvae may be found occasionally in split bamboo, tree-holes, or in internodes with moderately large holes in the wall. The third species, *quasiferox*, clearly prefers tree-holes although a few collections have been made from other habitats; two collections from plant axils suggest an unusual degree of plasticity in the behaviour of the female when she is selecting a site for egg-laying.

The remaining three forest species have this in common—each was collected from bamboos; but the larval habitat which seems least exploited by any species is "fallen, split bamboo" and this is very surprising in view of the large numbers of other mosquito larvae which are usually present, and which would serve as food for the carnivorous *Toxorhynchites* larvae.

It is very noticeable that in collections containing *Toxorhynchites* there is usually, though not always, only one *Toxorhynchites* larva. In the species which have been investigated (*see* Horsfall, 1955) eggs are laid singly on the water surface, but there seems to be no evidence that only one egg is ever laid, though this may at times be the case. The explanation of the single larva in collections is probably that this larva represents the sole survivor of the original batch and that during their very long larval life *Toxorhynchites* prey and feed on one another just as readily as they do on the larvae of other genera.

Of the remaining four Malayan species of *Toxorhynchites*, three are pitcher plant breeders; and whilst pitcher plants are not typical of lowland dipterocarp forest, *Nepenthes ampullaria*

may occasionally be found under some circumstances. In such cases, *T. acaudatus* is likely to be present. The fourth species, *T. splendens*, is found in coastal areas (*see* also Macdonald, 1957).

Genus **Tripteroides** Giles

Five species of *Tripteroides* have been previously recorded from lowland dipterocarp forest, but practically nothing has been known about their habits. Two or three others have now been collected, but unfortunately the systematics of these have not yet been clarified. Accordingly, three species are at present known by numbers. Table III summarizes the data on the breeding habits of each species, but before elaborating on these, it is worth recording how discrepancies in ecological data can suggest errors in taxonomy. In Table III 32 collections of "*coeruleocephalus*" are recorded: adult mosquitoes from all of those collections had been routinely examined and identified as *coeruleocephalus*. When the breeding-places were listed and analyzed, however, it was realized that the collections fell into two groups—those from bamboo internodes with small or moderate-sized holes in the bamboo wall, and those from tree-holes or from artificial containers. In other words there was a clear suggestion that two species were being confused; and such proved to be the case. Specimens from most of the early collections are no longer available, but it appears from subsequent collections that only the bamboo-breeders were *coeruleocephalus*, while those from tree-holes were species no. 2, an unidentified species belonging perhaps to the *powelli*-group. A third species, species no. 1, may also have occurred in some of the early collections, since the females cannot at present be easily distinguished from females of species no. 2.

Rather similar doubts have arisen over the identity of *aranoides*. As Table III shows, larvae of this non-ornate species have been collected from a wide range of habitats in lowland forest; but the majority of collections have come from bamboo internodes, and it is therefore probable that only one forest species is present. However, since an apparently similar species may be collected from, among others, such habitats as highland pitcher plants, lowland pitcher plants, and artificial containers inside houses, it is clear that there are grounds for re-examining the status of *aranoides*. The species was described from a single Malayan female from Taiping, Perak, by Theobald (1901: 274) but there is no information available which might help decide the habitat of the larvae. It is interesting to note that Baisas and Ubaldo-Pagayon (1952), in revising the *Tripteroides* of the Philippines, record all 10 of their non-ornate species as nepenthicolous, while all but 3 of the 20 species and sub-species of ornate *Tripteroides* were non-nepenthicolous in habitat.

TABLE III

THE COLLECTIONS OF *Tripteroides* RECORDED FROM VARIOUS BREEDING-PLACES IN LOWLAND DIPTEROCARP FOREST, SELANGOR

Species	Total collections	Tree-holes	Artificial containers	Bamboo pots	Bamboo stumps	Bamboos, fallen, split	Bamboos, upright, cracked	Bamboos, with large holes	Bamboos, with moderate holes	Bamboos with small holes	Ginger flower bracts	Rock pools
aranoides	56		1	11	6	5	3		16	13		1
"*coeruleocephalus*"	32	6	3						21	2		
coeruleocephalus ...	7					1		2	2	2		
similis	4					4						
species no. 1 ...	2	1				1						
species no. 2 ...	16	10	2	3							1	
species no. 3 ...	1	1										
aeneus	not yet collected											
proximus	possibly species no. 2											

T. aranoides is a very common species in larval collections from Ulu Gombak, but the adult has never been taken in biting catches. This is the only non-ornate species which has been found in forest; all the other species fall into the ornate group with blue head scales, spotted femora, etc.

T. coeruleocephalus is also common in the bamboos of lowland forest. As already mentioned, the adult mosquito is rather similar to several other species, but the larva and pupa are very distinct. Leicester (1908), in describing this species, did not mention the early stages, but Daniels (1908: 266), contrasting *mendacis* and *coeruleocephalus*, drew attention to the long, relatively narrow, larval siphon and to the long, very thin, pupal trumpet. Like *aranoides*, *coeruleocephalus* demonstrates a preference for bamboo internodes, entering the internode through small or moderate-sized holes in the bamboo wall.

T. similis has been collected only occasionally, and each of four collections was made from fallen, split bamboo.

Species no. 1 is probably a new, undescribed species. The adult male is most distinctive on account of highly modified fore and mid tarsi, and modified fore claws; these features are quite unique, so far as is known, in the genus. Since only two collections have been made in lowland forest, from a tree-hole and a fallen bamboo, the breeding preferences are uncertain. Two other collections were, however, made outside Selangor: the first from a tree-hole on Gunong Tebu, Trengganu (*W. W. Macdonald*); the second from a discarded tin can in the forest fringe at Fraser's Hill (*J. A. Reid*).

Species no. 2 is quite common at Ulu Gombak, breeding principally in tree-holes. The early stages and the male distinguish it from *coeruleocephalus* and species no. 1 respectively. In the male, unequal mid claws and the simple, larger fore claw serve to separate it from the following species.

Species no. 3 is not common, but in addition to the single collection shown in Table III (from Templer Park), several collections have been made outside Selangor. In the male, the prominent tooth of the larger fore claw, together with equal mid claws, are distinctive.

It may be that species no. 2 is the same as *T. proximus* recorded by Edwards (1915) from Ulu Klang (Selangor) and from Ulu Gombak, but Edwards' description is inadequate for a decision on this point.

Edwards (1921) has described another species, *T. aeneus*, which came from "edge of stream, Ampang jungle," but we have not seen any specimen which could be ascribed to this species. Nevertheless, *aeneus* must be regarded as a lowland forest species.

In this brief account we have not mentioned nepenthicolous species, principally because pitcher plants are not typical of lowland dipterocarp forest except in some areas where there are special soil conditions. Pitcher plant collections from forest outside Selangor have produced a species we have been calling *aranoides* and at least one other species which is related to *T. nepenthis*, and which may be new.

The genus *Tripteroides* is therefore well-represented in lowland dipterocarp forest and the larvae are common, but only rarely is a specimen taken in biting catches. A female *coeruleocephalus* which was reported attacking man in the canopy of a patch of Kuala Lumpur forest (Macdonald, 1957) is almost certainly a misidentification. Unfortunately females can not yet be identified reliably, but taking into consideration the availability of breeding-places in this patch of forest it seems likely that the specimen was a tree-hole breeder, perhaps species no. 2.

Genus **Topomyia** Leicester

The genus *Topomyia* is primarily a group of forest mosquitoes, and no species is known to take blood. Identification of the females is difficult in a number of cases, particularly when the mesonotal stripe is rubbed, but the male terminalia, figured by Edwards (1922), are very characteristic for each species. Probably most species breed in plant axils, but two, *decorabilis* and *spathulirostris*, are found in bamboo internodes, and another, *tenuis*, has been collected occasionally from tree-holes. Table IV shows the species recorded from lowland dipterocarp forest together with the breeding-places that are known.

There are several reasons for thinking that *aureoventer* is a synonym of *tipuliformis:* thus, only females of *aureoventer* and only males of *tipuliformis* have ever been collected; secondly, both have been reared from the same plant axils on several occasions; and lastly, no differences can be seen between the larval and pupal skins of the respective male and female adults. On the other hand, Edwards (1922: 441) mentions a female in the British Museum (Nat. Hist.), collected but not described by Leicester, which he thought might be the female of *tipuliformis*. Since pronounced differences are usually present between the larvae of different species of *Topomyia*, or at any rate between those larvae which are known, the similarities between the larvae and pupae of *aureoventer* and *tipuliformis* are themselves almost sufficient to conclude that Leicester (1908) described the same species twice.

TABLE IV

THE COLLECTIONS OF *Topomyia* RECORDED FROM VARIOUS BREEDING-PLACES IN LOWLAND DIPTEROCARP FOREST, SELANGOR

Species	Total collections	Tree-holes	Bamboos, upright, cracked	Bamboos, dead, with moderate holes	Bamboos, alive, with moderate holes	Bamboos, dead, with small holes	Bamboos, alive, with small holes	keladi axils (Araceae)	Banana axils	*Orchidantha* axils (Lowiaceae)	Ginger flower bracts	*Pandanus* axils (screw-pine)
aureoventer (?=*tipuliformis*)	2							1	1			
decorabilis ...	4			4								
dubitans	1							1				
gracilis	1							1				
spathulirostris ...	36		1	5	10	14	6					
tenuis	7	2									5	
tipuliformis ...	4							3		1		
species no. 1 ...	1											1
argyropalpis ...	adults only											
nigra	adults only											
minor	not yet collected											
argenteoventralis ...	not yet collected											
rubithoracis ...	not yet collected											

T. dubitans, gracilis and *tipuliformis* are all found in plant axils such as *Colocasia, Alocasia,* (jointly grouped as "keladi"), wild bananas, etc., and one collection of *tipuliformis* was from the axil of *Orchidantha longiflora* (Lowiaceae), a ground herb comparable to the better known *Colocasia.* Additional collections of all three species are required before breeding preferences and specific differences in those preferences will become apparent.

T. decorabilis has been found only in the internodes of dead bamboos, the highest collection being situated at a height of 23 ft. In each case the entrance into the internode was a moderate-sized beetle hole. As Edwards (1922) pointed out, the adults have several unusual features, and it is interesting to find that the larvae also are unusual. Like the related species *T. imitatus* of the Philippines (Baisas, 1946), which has very similar male terminalia, the larva of *decorabilis*

has enlarged maxillae with "articulated horns", very like the maxillae of *Goeldia* and *Tripteroides* sub-genus *Rachisoura*. The relationship between *imitatus* and *decorabilis* is perhaps strengthened by the fact that the single larva of *imitatus* which was collected came from the "cut joint" of a bamboo.

T. spathulirostris has been collected more often than any other species, and it also breeds in bamboo internodes. However, there does not seem to be any particular preference for living as opposed to dead bamboos, and the entrances into the internodes vary from very small to moderate-sized beetle holes.

T. tenuis is the only other species whose preferences are more or less well-defined. This is the species which is commonly found breeding in the bracts of the inflorescence of *Zingiber spectabile* (Zingiberaceae), a striking ginger found from Negri Sembilan northwards (Henderson, 1954).

An unnamed species, species no. 1, has been collected once from the axils of *Pandanus* (screw-pine); it may be that this species is one of those mentioned in the following paragraph.

Of the remaining species, *argyropalpis* and *nigra* have each been collected only as adults at Ulu Gombak, by sweep-netting, and the early stages are unknown. *T. minor* has been recorded by Leicester (1908) from forest near Kuala Lumpur, but the two other Malayan species, *argenteoventralis* and *rubithoracis* are known only from The Gap, i.e., in upper dipterocarp forest, though it seems very likely that both might occur in lowland forest also.

Genus **Malaya** Leicester (=**Harpagomyia** de Meijere)

Stone and Knight (1957) have revalidated the name *Malaya*, and the more familiar name *Harpagomyia* has therefore been relegated as a synonym.

Larvae of this genus which were collected at Ulu Gombak from axils of 'keladi' (*Colocasia* and *Alocasia*: Araceae) were unfortunately not retained, but it is most likely that they were *M. jacobsoni* (Edwards), a species not previously recorded from Malaya but adults of which have been taken at Ulu Gombak. As is well known the mosquitoes of this genus obtain food from ants of the genus *Cremastogaster* (*see* also Horsfall, 1955: 335), and one of us has made the following observations on the feeding habits of *M. jacobsoni*.

At Ulu Gombak the mosquitoes are very common when the annual crop of young bamboos appears towards the end of the year. At those times *Cremastogaster* ants may be seen feeding on the juices of the succulent growing tip of each young bamboo, and, having fed, they then return downwards with their abdomens distended. Hovering a short distance from the bamboo culm, or flying up and down in a vertical plane, may be seen the female *M. jacobsoni*. As many as 6-10 mosquitoes may congregate around one bamboo, and, at irregular intervals, each mosquito alights in front of a downwardly-travelling ant, inserts its proboscis into the mouth of the ant, and acquires a droplet of fluid. The ant and the mosquito remain in contact for as long as 20-30 seconds though more often for shorter periods, then the mosquito continues its flight parallel to the bamboo until another ant is selected and the operation is repeated.

It seems likely that there may be an annual rise and fall in the numbers of *M. jacobsoni*, the rise being related to the appearance of young bamboos, since adults and larvae appear to be rare at times of the year when young bamboos are absent.

Genus **Hodgesia** Theobald

Both Malayan species of this widespread genus, *malayi* and *quasisanguinea*, have been collected in lowland forest, but the breeding-places of only *malayi* have been found; larval collections were made mostly from the standing, shallow water of the disused aqueduct at

Ulu Gombak, but also from seepage and ground pools. Occasional adults of both species have been taken in biting catches during the day and early evening, but neither species is common. Of the two, *quasisanguinea* has been collected rather more often in adult catches.

Genus **Zeugnomyia** Leicester

Z. gracilis, the only Malayan species of this genus, is found principally in fallen leaves on the forest floor. *Aedes jugraensis* and *Uranotaenia obscura* are often associated with *gracilis*. Only rarely has the adult been taken in biting catches, although Leicester (1908: 233) describes it as a vicious biter. Since fallen leaves with water are only found after rain, one may deduce that *gracilis* has some means of surviving through dry spells. Probably the eggs can withstand drying, but this should be confirmed. The larvae are certainly able to survive for some time on a leaf from which most of the water has evaporated, and one may find larvae on leaves which are wet or damp. Edwards and Given (1928) describe the larvae, which are reputed to be predacious on those of *Ae. jugraensis* and *Ur. obscura*. The same authors mention the ability of *gracilis* larvae to attach themselves to a leaf by their mouthparts when the water in the leaf is poured off; this adaptation is not limited to *gracilis* as Edwards and Given suggest (*see* also *Ur. obscura*).

Genus **Uranotaenia** Lynch Arribalzaga

A number of species of *Uranotaenia* are well-represented in forest larval collections, but adults are very rare in biting catches. Once again the breeding-places can best be summarized in tabular form, Table V. Most species have been collected only occasionally, but three—*lutescens*, *modesta* and *obscura*—are quite common.

A single collection of *bimaculata* was made at Ulu Gombak from an internode of an old, dead, fallen bamboo, the entrance into the internode being one or other of two small beetle holes. Only a single specimen of *bimaculata* was reared from this collection, but in the I.M.R. collections there are three other old specimens one of which is labelled "bamboo." Another specimen has been taken at Ulu Gombak by sweep-netting.

TABLE V

THE COLLECTIONS OF *Uranotaenia* RECORDED FROM VARIOUS BREEDING-PLACES IN LOWLAND DIPTEROCARP FOREST, SELANGOR

Species	Total collections	Tree-holes	Artificial containers	Bamboo stumps	Bamboos, fallen, split	Bamboos, with moderate holes	Bamboos, with small holes	Fallen leaves	Aqueduct	Ground pool
bimaculata ...	1						1			
bimaculiala ...	1								1	
cf *bicolor*... ...	1	1								
campestris ...	1								1	
cf *longirostris* ...	2								1	1
lutescens	22	1	2	2	12	5				
modesta	35	15		12	4	4				
obscura	11							11		
cf *recondita* ...	2			1	1					
testacea	1								1	
trilineata... ...	adults only									
species no. 4 ...	adults only									
species no. 7 ...	adults only									
argyrotarsis ...	not yet collected									
unimaculiala ...	not yet collected									

Ur. bimaculiala, *campestris*, cf *longirostris* and *testacea* have each been collected from still, standing water. Only a few collections have been made, and while these reflect to some extent the limited collecting from standing water in forest, it is probably true to say that none of the four species is a common forest mosquito. *Ur. testacea* has also been collected on several

occasions by sweep-netting; and both *bimaculiala* and *campestris* have been collected from ground pools in the open, non-forested, lower Ulu Gombak valley. The identity of the species recorded as cf *longirostris* is in doubt. There is another species, from coastal areas, which is similar in some respects but is probably specifically distinct. Leicester (1908: 217) did not mention the locality where he collected the type, but it is quite possible that the coastal species is *longirostris* s. str. and that those specimens from Ulu Gombak forest belong to an undescribed species.

Ur. cf *bicolor* has been found only once at Ulu Gombak (in a tree-hole), but collections of apparently the same species were made from tree-holes near the base of Gunong Tebu, Trengganu. The identity of the specimens is in doubt since *bicolor* s. str. is probably a pool-breeder in open country. The type came from "the marshy edges of a jungle stream in Kuala Lumpur" (Leicester, 1908: 225), and collections have been made of Leicester's species in seepage pools, and in a small temporary pool in a hoof-print, around Kuala Lumpur. It seems unlikely that the same species is also a tree-hole breeder in forest, but the material in the I.M.R. collection has not yet been critically examined.

The habits of *lutescens* can be better defined. Larvae are found principally in fallen, split bamboos, but they may also occur in bamboo internodes with moderate-sized holes, or in bamboo stumps and (rarely) tree-holes.

Ur. modesta, on the other hand, shows a clear preference for tree-holes and bamboo stumps, with only occasional collections being made from fallen or upright bamboo internodes. The preferences of *lutescens* and *modesta* extend therefore over the same range of breeding-places, but, as Table V shows, the species are distinctly different in their primary selections.

Ur. obscura, like *Z. gracilis*, is confined to wet, fallen leaves on the forest floor, and when the water of a leaf is poured off, the *obscura* larvae may be seen anchoring themselves by their mouthparts to resist the flow of water. The larvae are in fact quite difficult to dislodge.

Larvae of one other species, *Ur.* cf *recondita* Edwards, have been collected; once from a bamboo stump and once from a fallen, split bamboo. As in the case of several other species, confirmation of the identification is required, particularly since *recondita* has not previously been recorded from Malaya.

Adults of three of the remaining species, *trilineata*, species no. 4, and species no. 7, have been collected by sweep-netting at Ulu Gombak, but the larval habits are unknown; Leicester (1908: 206), however, records *trilineata* from pools beside jungle streams. Two other species, *argyrotarsis* and *unimaculiala* have been recorded from forest by Leicester but have not yet been collected by us; *argyrotarsis* is reported to be a jungle pool breeder (Leicester, 1908: 215).

A few distinguishing features of species no. 4 and species no. 7 may be mentioned briefly.

Species no. 4.—Rather like *bimaculata*, but in addition to the pair of prominent, dark-brown spots in front of the wings, there is another pair anteriorly, above the posterior pronotum. There is also a dark-brown spot in front of the mid-lobe of the scutellum. Ground colour of mesonotum light brown, pleurae pale, legs dark-brown, abdominal tergites dark-brown.

Species no. 7.—The single male resembles *testacea* closely, but segments IV and V of the hind tarsi are not white. The specimen also lacks the slender hairs which are present on the mid-femur of *testacea* males. Mesonotum and pleurae as in *testacea*. Abdomen rubbed, but apparently unicolorous.

Genus **Orthopodomyia** Theobald

This genus has been reviewed recently (Macdonald, 1958), and the breeding habits of the five Malayan species summarized. All the available data are now presented in Table VI.

TABLE VI

THE COLLECTIONS OF *Orthopodomyia* RECORDED FROM VARIOUS BREEDING-PLACES IN LOWLAND DIPTEROCARP FOREST, SELANGOR

Species	Total collections	Tree-holes	Bamboo pots	Bamboo stumps	Bamboos, fallen, split	Bamboos, upright, cracked	Bamboos, with large holes	Bamboos, with moderate holes	Bamboos, with small holes	*Polystictus xanthopus*
albipes	54	1	1	5	8	5	1	29	4	
andamanensis ...	7	6		1						
anopheloides ...	2	2								
maculipes ...	9	9								
wilsoni	5				1	1		2		1

O. albipes is the most common species, having been collected more than 50 times; but although the larvae are common, adults are rare in biting catches. Larvae may be found in a wide range of bamboo breeding-sites, but the preferred habitat appears to be internodes which can be entered through moderate-sized holes. The collections were about equally divided between living and dead bamboos; and although most of the collections were from near ground level, others came from internodes at heights ranging from 3 to 22 ft.

O. andamanensis, *anopheloides* and *maculipes* have been collected almost entirely from tree-holes, and although two of the species may at times be found together, it is not unlikely that a more careful study of the tree-holes would reveal differences which could be detected by the mosquitoes, and which could be correlated with the presence or absence of each species.

The breeding preferences of *O. wilsoni* Macdonald seem to overlap those of *albipes*, and at present no clear distinctions can be drawn between them. As concluded elsewhere (Macdonald, 1958) *wilsoni* and *albipes* are more closely related to each other than to the remaining three species; nevertheless, there must be a significant difference in their ecology which results in one species, *albipes*, being ten or eleven times more common than the other. *Polystictus xanthopus* Fr. (Polyporaceae), shown in Table VI as a breeding-place of *wilsoni*, is a small fungus. A photograph was published by Chu (1958), who recorded *Aedes* (*F.*) *greeni kanaranus* (=*aureostriatus kanaranus*) breeding in it.

Genus **Ficalbia** Theobald

This genus has been treated systematically by Mattingly (1957*a*). Most species breed in ground-pools, but those of subgenus *Ravenalites* have been recorded from tree-holes, bamboo stumps, etc. The only common forest species in Malaya, *fusca*, belongs to that subgenus. *F. fusca* has been collected from tree-holes (6 times) and rarely from bamboo internodes with small or moderate-sized holes (one collection from each habitat), but it is not confined to lowland forest. Collections have been made at Fraser's Hill and Cameron Highlands, and also from a tree-hole near the mangrove zone on the Selangor coast.

F. luzonensis has been taken at the 11 m. Ulu Gombak road from a swampy area near the roadside, which is best classified as forest fringe. This species is, however, more typical of ground pools in open, non-forested localities.

Genus **Mansonia** Blanchard

The mosquitoes of this genus are most typical of swamp forest, where they breed in enormous numbers. Elsewhere larvae may be found in ground pools sometimes associated with particular aquatic plants, to the roots of which the larvae attach. In lowland dipterocarp forest occasional adults of *annulata*, *bonneae*, *dives*, *indiana* and *uniformis* have been taken in biting catches, but adults are uncommon except where there are nearby swampy pools suitable

for breeding. Larvae of *bonneae* have been collected from swampy pools at the forest edge at Sungei Buloh, where adults were also common, but since *Mansonia* mosquitoes are generally rare in dipterocarp forest, little attention has been given to searching for breeding-places, which is a laborious business owing to the special habits of the larvae.

In swamp forest this group is very important, particularly because several species are vectors of filariasis. Wharton (1957) has published observations on the rearing and maintenance of a colony of *uniformis*, and, in the course of work on filariasis, has also recorded data on the *Mansonia* breeding-places in swamp forest, their feeding preferences, etc. (Institute for Medical Research, Malaya, 1958).

Genus **Aedomyia** Theobald

The single Malayan species, *catasticta*, is not known to occur in lowland dipterocarp forest.

Genus **Aedes** Meigen

This genus is one of the most important and best represented groups of forest mosquitoes, and so many species have been collected that it is most convenient to discuss them under subgeneric headings.

Subgenus **Mucidus** Theobald

Not recorded from lowland dipterocarp forest.

Subgenus **Ochlerotatus** Lynch Arribalzaga

Not recorded from lowland dipterocarp forest.

Subgenus **Finlaya** Theobald

This is an important subgenus and 23 species have been collected in forest; in most cases breeding-places have been found and in all but one (*albocinctus*) the early stages have been collected or reared from eggs. For convenience the species may be discussed in the groups proposed by Knight and Marks (1952).

Group A (*kochi*-group)

In an earlier review (Macdonald, 1957) *avistylus* was noted as occurring in the Malay Archipelago, but there are in fact no records from Malaya itself. The only confirmed species of the group is *poicilius* which has been taken near, but not in, forest in Ulu Langat valley during a biting catch. This species is perhaps characteristic of wet and swampy areas. In addition to the records given previously (Macdonald, *l.c.*), several larval collections have been made in Pahang from the axils of *Pandanus* (screw-pines), growing in swamp forest, at heights up to 20 ft. (*R. H. Wharton*). This woody plant may be found in lowland dipterocarp forest, but not commonly.

In the IMR collection there is an additional species of the *kochi*-group, not previously recorded, which is related to *flavipennis* (Giles) and is almost certainly a plant axil breeder, perhaps with rather similar habits and distribution to *poicilius*.

Group B (*terrens*-group)

Three Malayan species of this group can be recognized, but their specific identities require confirmation. They are recorded as cf *assamensis*, cf *khazani* and cf *prominens*. All three occur in lowland forest, and each breeds in tree-holes or bamboo stumps and, rarely, split bamboo

(Table VIII). Several collections of cf *prominens* were made from a bamboo pot situated at a height of 32 ft. Occasional specimens of each species have been taken in biting catches.

Group D (*aureostriatus*-group)

Two subgroups are represented in Malaya and the more important is the *chrysolineatus*-subgroup. There are five species of this subgroup being provisionally recognized, but the relationships of two of them, species near *formosensis* and near *harveyi*, require closer study. The species near *harveyi* may prove to be in part *chrysolineatus*.

The breeding-places are summarized in Table VII, from which it is clear that the preferences of the species can not be very sharply defined. The first, *chrysolineatus*, has not been collected very often, but fallen bamboos may be the preferred habitat. The second, a species near *formosensis*, is rare, and has been collected only once at Ulu Gombak and once from Ulu Langat, but it has also been caught biting in some numbers near Kepong. The species near *harveyi* is common, and it is associated principally with bamboos, although a few collections have also been made from tree-holes. The apparent catholic preferences of this species (Table VII) may, however, be misleading, since the characters used to distinguish it from *chrysolineatus* are unsatisfactory and it is possible that the two species have been in part confused.

TABLE VII

THE COLLECTIONS OF THE *Aedes* (*Finlaya*) *aureostriatus* GROUP RECORDED FROM VARIOUS BREEDING-PLACES IN LOWLAND DIPTEROCARP FOREST, SELANGOR

Species	Total collections	Tree-holes	Bamboo pots	Bamboo stumps	Bamboos, fallen, split	Bamboos, with moderate holes	Bamboos, with small holes	Fallen leaves	Rock-pools	Temporary pools
chrysolineatus	9	1	2		4				1	1
species near *formosensis*	2			1	1					
species near *harveyi* ...	20	4	5	4	5	2				
jugraensis	31	2	1	4	14	1	1	7	1	
saxicola	16	2		1	1				12	
aureostriatus										
var. *greeni*	5	5								
var. *mikiranus* ...	1	1								

Ae. jugraensis is the most common species of the subgroup and nearly half of the collections have come from fallen, split bamboos. Occasional collections have also been made from bamboo stumps, tree-holes, etc., but the most important secondary source of larvae has been fallen leaves. These latter collections seem at variance with the others since the mosquito fauna of fallen leaves is generally composed of species which are not found commonly elsewhere, e.g. *Uranotaenia obscura* and *Zeugnomyia gracilis*, but at present there is nothing else to suggest that two species are being confused.

The last species of the subgroup, *saxicola*, is clearly a rock-pool breeder. The adults reared from the two collections from a bamboo stump and a fallen bamboo require closer examination although superficially they agree with the description of *saxicola*.

All five species are found in lowland dipterocarp forest but, in addition, *chrysolineatus*, *saxicola* and the species near *harveyi* occur at higher altitudes in montane forest, e.g. at Fraser's Hill and at Cameron Highlands. Whereas the subgroup is well-represented in larval collections, it is significant that the adults are rarely attracted to man in biting catches. Probably each will feed on man but the preferred host is as yet undetermined.

There is one other Malayan species of group D: this is *aureostriatus*, belonging to the *aureostriatus*-subgroup. Almost all specimens belong to var. *greeni*, and a few agree with the description of var. *kanaranus*, including one female from a canopy catch, but the varietal

differences are of doubtful significance. No larval differences corresponding with the minor adult differences have been observed between the two varieties. All six larval collections from lowland forest, together with two others from Jugra Hill near the coast, have come from tree-holes. Adults are uncommon in biting catches with human bait, but, as was mentioned, the species may bite in the canopy.

Group E (*mediovittatus*-group)

Only one Malayan species can be referred to this group, a species near *macfarlanei*. Larvae have been collected at Ulu Langat from a rock-pool (with *saxicola*), and from a concrete pit beside Ampang Reservoir at the forest fringe. No adults have been collected in biting catches. The larvae agree quite well with the brief description of *macfarlanei* larvae given by Barraud (1934: 181), and since this species has been recorded from Sumatra by Brug and from Cochin China by Borel, the Malayan material may well be *macfarlanei* s. str.

Group F (*alboannulatus*-group)

Two species of this group occur in forest, *albotaeniatus* and *albocinctus* Barraud. The first is quite common, breeding in all of the habitats provided by bamboos and occasionally in tree-holes (Table VIII); adults may be taken in biting catches, usually in the early morning or late afternoon. The other species is rare; only a single female has been collected, and this was taken in a biting catch in the canopy at a height of 90 ft.

TABLE VIII

THE COLLECTIONS OF THE *Aedes* (*Finlaya*) *terrens* AND *alboannulatus* GROUPS RECORDED FROM VARIOUS BREEDING-PLACES IN LOWLAND DIPTEROCARP FOREST, SELANGOR

Species	Total collections	Tree-holes	Bamboo pots	Bamboo stumps	Bamboos, fallen, split	Bamboos, with large holes	Bamboos, with moderate holes	Bamboos, with small holes
albocinctus	adult only							
albotaeniatus	26	4	3	5	7	1	5	1
cf *assamensis*	5	2		2	1			
cf *khazani*	1	1						
cf *prominens*	18	11	5	2				

Group H (*geniculatus*-group)

This group includes the *niveus*-subgroup, an interesting and important complex of forest species whose systematics have been revised by Knight and Stone (1946) and, more recently, by Colless (1958, 1959). In the lowland forest of Selangor 10 species have now been collected, including one which is probably new (Table IX). Several of these, together with a few other members of the subgroup, have also been found in non-forested areas, for instance by the coast.

The forest species fall into two groups: the larger includes *albolateralis*, *inermis* Colless, *litoreus* Colless, *pexus* Colless, *pseudoniveus*, *subniveus*, and *vanus* Colless, which breed principally in tree-holes, with occasional collections in bamboo stumps; the remaining group includes only *niveoides* and *novoniveus* both of which prefer bamboo stumps, fallen bamboos and bamboo internodes which have moderate or large-sized holes in the wall. In the absence of bamboos, *niveoides* certainly, and *novoniveus* possibly, will breed in tree-holes.

The undetermined species, *Aedes* species no. 9, is difficult to distinguish from *niveoides* in the adult stage, but there are clear larval and pupal differences. Although no larvae have been collected in the field, a small sibling series was obtained from a wild-caught female which was taken in a biting catch at Ulu Gombak.

TABLE IX

THE COLLECTIONS OF THE *Aedes* (*Finlaya*) *geniculatus* GROUP RECORDED FROM VARIOUS BREEDING-PLACES IN LOWLAND DIPTEROCARP FOREST, SELANGOR

Species	Total collections	Tree-holes	Bamboo pots	Bamboo stumps	Bamboos, fallen, split	Bamboos, with large holes	Bamboos, with moderate holes
albolateralis	32	25	6		1		
inermis	15	13		1	1		
litoreus	1	1					
niveoides	18		1	9	1	1	6
novoniveus	25		10	6	6		3
pexus	4	3		1			
pseudoniveus	10	6	3	1			
subniveus	3	3					
vanus	1	1					
species no. 9	adults only						
dissimilis	13	9		4			

The main interest of the *niveus*-subgroup lies in the biting habits. Not only have most species been taken biting in the canopy but they are canopy dwellers by preference, and they form the major proportion of the canopy mosquito fauna. Unfortunately some species cannot be identified reliably with the female stage alone, e.g., *pseudoniveus* and *subniveus*, and when the mesonotal scaling is rubbed identification may not be possible. Consequently, the data derived from adult catches are not as accurate as might be desired.

The relative abundance of the individual species can be assessed from the collections recorded in Table IX, but *pseudoniveus* (including *subniveus*) is relatively more common in adult catches than in larval collections, and is often the most abundant species both on the ground and in the canopy. Although the canopy is the preferred adult habitat, most, if not all, species will readily bite at ground level. The available data are insufficient for final conclusions to be drawn about the biting-cycles, but, on the ground, adults will bite throughout the day, though never in large numbers. In the canopy there are indications of an increase in biting activity in the hour before sunset, and this high activity continues for one or two hours after sunset.

The single remaining species of group H is *dissimilis* (of the *dissimilis*-subgroup). Like most species of the *niveus*-subgroup, *dissimilis* breeds in tree-holes and bamboo stumps (Table IX); occasional adults are taken in ground-level biting catches during the day.

Subgenus **Christophersiomyia** Barraud

Only one species is known from Malaya, *gombakensis*, recently named and described by Mattingly (1959). This is an uncommon species and both larval collections that have been made came from tree-holes. The adults have rarely been taken in biting catches at Ulu Gombak.

Subgenus **Stegomyia** Theobald

This subgenus is one of the best represented in lowland forest, both in larval and in adult collections. There are many fewer species than in the subgenus *Finlaya*, but several are widely distributed both in forest and in non-forested areas. The recorded breeding-places in Selangor forest are shown in Table X.

Ae. albolineatus breeds principally in tree-holes but may also occur in one or other of the bamboo habitats. Although the larvae are quite common, adults have been taken only occasionally in daytime, ground catches.

Ae. albopictus is at times the most common mosquito in forest catches, appearing regularly throughout the year. Tree-holes are the principal natural breeding-places, but bamboo pots, including those at heights up to 50 ft., are readily utilized for breeding. Similarly, *albopictus*

will breed in a variety of natural bamboo breeding-sites, and, occasionally, in rock-pools. Biting is by day with peaks of activity in the early morning and late afternoon, but the peaks are not so pronounced in forest as in non-forested areas, where biting is minimal during the hot dry period at the middle of the day. Although *albopictus* bites predominantly near ground level, adults may be taken in canopy catches.

TABLE X

THE COLLECTIONS OF *Aedes* SUBGENUS *Stegomyia* RECORDED FROM VARIOUS BREEDING-PLACES IN LOWLAND DIPTEROCARP FOREST, SELANGOR

Species	Total collections	Tree-holes	Bamboo pots	Bamboo stumps	Bamboos, fallen, split	Bamboos, upright, cracked	Bamboos, with moderate holes	Bamboos, with small holes	Rock-pools
albolineatus	39	25	9	2	1		1	1	
albopictus	71	18	37	5	7		1	1	2
desmotes	adults only								
mediopunctatus	15		9		1	1	1	3	
pseudalbopictus	18		13	1	4				
w-albus	2	2							
species No. 10	1				1				
species No. 12	14		13	1					

So far only adults of *desmotes* have been collected in forest, and from those, sibling series have been reared in the laboratory. The adults are not common and they have all been taken at ground level by day. The thorax of the adult mosquito is strongly compressed laterally, suggesting that *desmotes* can penetrate narrow openings to reach the breeding-places (compare also *Armigeres* subgenus *Leicesteria* and *Udaya*).

Excluding for the moment the collections from artificial bamboo pots, *mediopunctatus* would appear to show a preference for relatively inaccessible breeding-places, such as bamboo internodes with small holes, and it is perhaps noteworthy that each of the collections from natural breeding-places came from bamboos which were dead or dying. The collections from bamboo pots are a little surprising in view of the absence of the species from bamboo stumps and tree-holes. Most collections were near ground level, but one was taken from a natural breeding-place at a height of 17 ft., and several of the pot collections were from 32 ft. Occasionally adults have been taken biting in the canopy, but probably the usual habitat is nearer ground level. During ground catches the peak biting activity is around midday and early afternoon (contrast *albopictus*), but in the canopy the peak is later, just before sunset.

Ae. pseudalbopictus is very similar in appearance to *albopictus*, but unlike *albopictus* no collections have yet been made from tree-holes. Rather strangely perhaps, fallen bamboos and bamboo pots provide the principal breeding records, and it seemed from the distribution of the collections that *pseudalbopictus* preferred the more highly situated bamboo pots at 32 and 52 ft. rather than those at ground level. The adults have a similar biting-cycle to that of *albopictus* and they occur commonly in ground catches.

Ae. w-albus has been collected in forest only twice as larvae, on both occasions from tree-holes. The adults are uncommon in biting catches.

A single male of the species recorded as *Aedes* species no. 10 was reared from a fallen bamboo collection. This specimen has since been sent to the British Museum (Nat. Hist.) with its associated skins.

Aedes species no. 12 has been collected more often. This species, which is probably undescribed, is very distinctive in appearance, with a narrow mesonotal stripe and patches of pleural scales which almost join to form stripes very like those of *scutellaris*. A series has been lodged in the British Museum (Nat. Hist.). As in the case of *pseudalbopictus*, collections have come mainly from bamboo pots, but with the exception of one collection from 32 ft. all were made near ground level. The single bamboo stump collection was from Ulu Langat, the remainder from Ulu Gombak. No adults have yet been taken in any biting catch.

Subgenus **Neomelaniconion** Newstead (=**Banksinella** Theobald)

There is little to be added to the earlier summary of the two Malayan species (Macdonald, 1957: 21). Occasional females of the species we record as *imprimens* (?=*auratus* Leicester) have been taken in biting catches at Ulu Gombak, but no larvae have been found as yet. The other species, *lineatopennis*, does not occur in forest.

Subgenus **Aedimorphus** Theobald

Four species have been collected at Ulu Gombak—*alboscutellatus*, *caecus*, *orbitae* and *vexans*. Of these, *alboscutellatus* and *vexans* have been collected from ground pools; *orbitae* has been taken a number of times from small temporary pools, such as form in cart-tracks and hoof-prints; while the larvae of *caecus* have not yet been collected in forest. Both *caecus* and *vexans* are more typical of open country than of forest and the specimens collected at Ulu Gombak probably represent secondary introductions from the forest fringe.

Adults of *alboscutellatus* and of *orbitae* are occasionally taken in daytime ground catches, but neither is a common species.

Subgenera **Skusea** Theo., **Rhinoskusea** Edw. and **Cancraedes** Edw.

Not recorded from lowland dipterocarp forest.

Subgenus **Aedes** Meigen

Little additional information can be added to the earlier review (Macdonald, 1957). Leicester and Edwards have described 8 species which are recorded from forest near Kuala Lumpur—*fragilis*, *incertus*, *indecorabilis*, *leicesteri*, *malayi*, *perditus*, *uncus* and *virilis*—but from our observations all of them are rare species. Only *incertus* and *leicesteri* have been identified with confidence from lowland forest, but *fragilis* has been collected from small patches of secondary forest in Kuala Lumpur. Four additional species have been collected from Ulu Gombak and Ulu Langat, and one of those agrees well with descriptions of *andamanensis*; the remaining three probably include previously described species, but confirmation is required.

Only one larval collection of *Aedes* has been made—from the Ulu Gombak aqueduct—and only three unidentified females were reared from this collection. All the remaining specimens were taken in adult catches or by sweep-netting.

The subgenus *Aedes* is perhaps better represented in coastal areas than in inland forest, and certainly in the former the group forms a more appreciable part of the biting population; in forest specimens are rarely taken in biting catches.

Subgenus **Paraedes** Edwards

This subgenus was recently reviewed systematically by Mattingly (1958), and most species are recorded from coastal areas rather than from inland forest. Leicester apparently collected *ostentatio* from forest at $4\frac{1}{2}$ m. Pahang Road (Ulu Gombak), but there are no recent forest records. A single female of a new species has, however, been taken in a daytime biting catch at Ulu Gombak; this specimen has been deposited in the British Museum (Nat. Hist.), and was briefly mentioned by Mattingly (1958: 2).

Genus **Udaya** Thurman

Udaya was recently raised to generic status by Mattingly (1958: 4), and the only two species, *argyrurus* (Edw.) and *lucaris* Macdonald and Mattingly, both occur in the lowland forest of Malaya, though they might be described as rare. Breeding-places of only *argyrurus* have been found—in upright bamboo with cracks (once), fallen, split bamboos (twice), bamboo internodes with small holes (twice), and an internode with a moderate-sized hole (once).

The adults of *argyrurus* are very strongly compressed laterally, particularly the thorax, and this is probably an adaptation to the preferred bamboo breeding-sites—which are reached through holes or narrow cracks in the bamboo wall (*see* also *Armigeres* subgenus *Leicesteria*, and *Aedes* (*S.*) *desmotes*). A few females have been taken in daytime biting catches.

Only two females of the remaining species, *lucaris*, have been collected, but a short sibling series was obtained from the eggs of one of them (*see* also Macdonald and Mattingly, 1960).

Genus **Heizmannia** Ludlow

Work on this genus has so far been less rewarding than might have been expected, for whereas adults are almost always represented in biting catches, and at times they form the major proportion of the catch, the breeding-places of most species cannot yet be satisfactorily defined. Barraud (1934: 300) states simply that the larvae may be found in tree-holes and bamboo stumps, but from the very considerable number of mosquito collections from these habitats in Malayan forest, *Heizmannia* larvae have been present only five times.

Nevertheless the genus is very well-represented in lowland dipterocarp forest, and all the known Malayan species occur, for instance, at Ulu Gombak, and probably also at Ulu Langat. In addition, some species, e.g. *H. scintillans*, may be collected in swamp forest, and even in fairly open country.

Although the genus has been recently revised by Mattingly (1957*b*), as a result of which most Malayan species can be readily identified, there remains a proportion of each adult catch which can not be named with confidence. This applies particularly to the *scintillans—indica—metallica* group, which is often common in catches. In the previous review of Malayan non-anophelines (Macdonald, 1957), three species were not named. The following names can now be substituted: n.sp. near *communis*=*macdonaldi*; n. sp. near complex=*stonei*; n. sp. (=*H. indica* auct.)=*reidi*; each was described and named by Mattingly(1957*b*).

The recorded breeding-places are shown in Table XI, from which it may be seen that the larvae of five species have not yet been collected; however, the early stages of two of these, *achaetae* and *reidi*, have been obtained by laboratory rearings from egg-batches. Of the five species whose larvae have been collected, *aureochaeta*, *communis*, *macdonaldi* and *scintillans* appear to have a preference for breeding in bamboo internodes with small or moderate-sized holes; in the case of *macdonaldi* there is a preference for young dead or dying bamboos. The remaining species, *stonei*, has been collected only twice, on both occasions from a tree-hole. But the number of larval collections does not indicate the true abundance of these mosquitoes; and the individual figures may be misleading, for the species *macdonaldi*, although apparently the best-represented as larvae, is in fact much less common in adult catches than *scintillans* or *aureochaeta*.

TABLE XI

THE COLLECTIONS OF *Heizmannia* RECORDED FROM VARIOUS BREEDING-PLACES IN LOWLAND DIPTEROCARP FOREST, SELANGOR

Species	Total collections	Tree-holes	Bamboos, fallen, split	Bamboos, with moderate holes	Bamboos, with small holes
achaetae	adults only				
aureochaeta	2			2	
communis	4		1		3
indica	adults only				
macdonaldi	8		1	4	3
metallica	adults only				
reidi	adults only				
scintillans	5	1		3	1
stonei	2	2			
species no. 1	adults only				

Since the adults are quite common at certain times of the year, the biting-cycles of the species can be better defined than the breeding-places. The general pattern seems to be rather similar in each case: periods of low activity in the early morning and late afternoon, but high activity during late morning and early afternoon. No biting has been recorded during the night, nor elsewhere than at ground level. This pattern of biting behaviour is rather unusual in that the activity peak is reached at the hottest time of the day; most other mosquitoes show a depression in their biting curves at that time, although there are some exceptions e.g. *Armigeres moultoni*.

Because larvae were difficult to find in the field, a number of sibling series have been reared from egg-batches laid by wild-caught females. Unfortunately, the mortality rate among adult *Heizmannia* mosquitoes brought into the laboratory is high, particularly if the mosquitoes are unfed; and even fully-fed adults often die within a day or two of their capture. Since all species of *Heizmannia* have been found to be very reluctant to feed in the laboratory, the adults are best allowed to feed in the field when they come to attack human bait. Since no observations have been recorded previously on the eggs or egg-laying, a few words may be added on this subject.

The eggs are readily laid on damp filter paper, and they are laid scattered individually, not as a raft. Oviposition occurs 3-4 days after the blood-meal, but delays of up to 9 days have been recorded. After being laid the eggs are best kept on moist filter paper for several days and allowed to dry slowly before being immersed in water. On immersion it is unusual for the larvae to hatch immediately, and quite commonly they will not hatch until nearly a week later. The hatching behaviour of the eggs may vary from one specimen to another of the same species, and sometimes among eggs of the same batch. In one case a batch of some 46 eggs was laid by a female *stonei* four days after feeding; half of the eggs were immersed in water 4 days later, but hatching only began after a further 12 days (14 adults were reared); the remaining eggs were kept dry for 3 weeks and then immersed, but there was no hatching until 17 days later when the first of seven larvae hatched over a period of 3-4 days.

A number of egg batches of *scintillans* have been maintained. In six cases the eggs were retained for a period of 3 days to mature; on immersion in water, hatching commenced on a different day in each case—after 2, 3, 6, 7, 9 and 10 days respectively. The most effective period for maturation of the eggs may be 6-7 days.

In the laboratory the larval life may be quite lengthy, often 2-3 weeks or more; the pupal stage usually lasts three days, occasionally four.

Very marked fluctuations in the numbers of *Heizmannia* have been recorded throughout nearly two years' observations. There seems to be some correlation between the peaks and periods of high rainfall, and this would suggest breeding-places which are open, such as tree-holes and bamboo stumps, but there are still a number of puzzling features to be resolved before a clear statement will be possible. The fluctuations in numbers bear no similarity to those of *Armigeres* subgenus *Leicesteria* (*see* Macdonald, 1960*b*, this *Study*), nor do they coincide with those of the known open-container breeders, such as *Aedes*. They will therefore probably not be fully understood until the breeding-places can be clearly defined.

Genus **Armigeres** Theobald

This genus is well-represented in the forest, particularly the subgenus *Leicesteria*. However, since a full account of the systematics and ecology of *Leicesteria* is given elsewhere (Macdonald, 1960*b*, this *Study*), only the subgenus *Armigeres* need be discussed in detail here.

Subgenus **Armigeres** Theobald

Although 11 species have been collected in forest, none is very common either in adult or in larval collections; some species are certainly rare, others are taken periodically in small numbers. The larval collections that have been made are shown in Table XII, from which it is clear that there are still many gaps to be filled. The habits of most species can not therefore be satisfactorily defined, but a few tentative conclusions may be drawn.

Barraud (1934: 320) gives the breeding-places of *aureolineatus* as "coconut-shells, etc." but Leicester's single collection and ours came from the shell of an unidentified jungle fruit. The larvae have never been collected from coconut-shells in Malaya. This is a rare species in Malaya recorded only from Ampang forest and Ulu Gombak.

The collections of *confusus* (Table XII) suggest that it may select bamboo stumps; the collections from bamboo pots included a few from 20 ft. and 32 ft. As many as 100 eggs may be laid by a single female after a blood-meal.

TABLE XII

THE COLLECTIONS OF *Armigeres* SUBGENUS *Armigeres* RECORDED FROM VARIOUS BREEDING-PLACES IN LOWLAND DIPTEROCARP FOREST, SELANGOR

Species	Total collections	Tree-holes	Bamboo pots	Bamboo stumps	Bamboos, fallen, split	Ginger flower bracts	Shell of a jungle fruit	Rock-pool
aureolineatus	1						1	
confusus	8		5	2				1
conjungens	4					4		
'durhami'	2		2					
jugraensis	3	2			1			
maiae...	2	2						
maximus	adults only							
moultoni	adults only							
subalbatus	1							1
species no. 1	2			1	1			
species no. 3	adults only							

One of the few species with well-defined habits is *conjungens*. Larvae may quite often be found breeding in the water which collects in the bracts of the inflorescence of the wild ginger plant *Zingiber spectabile*; *Topomyia tenuis* is often associated with it. Close observations on *Z. spectabile* have not yet been made, but the impression gained is that this plant flowers principally at the beginning of the main rains in August or September; and there is a corresponding rise in the numbers of *Ar. conjungens*.

Both *jugraensis* and *maiae* may be primarily tree-hole breeders, but additional collections are required to confirm this. The females of these two species are very alike and no convenient character for their separation has yet been found. An area of white scales on the halteres may perhaps serve to distinguish *maiae*.

Ar. maximus is an inadequately described species which has been taken on a few occasions in catches at the forest fringe of Ulu Langat and Sungei Buloh. The females do not readily feed on man, and, in the laboratory, prefer guinea-pig. The early stages are unknown.

The status of the species shown as *subalbatus* (=*obturbans*) and *'durhami'* is uncertain. No males have been collected from forest yet, and the material available requires more critical study than has so far been possible. Thurman (1958) and Stone and Thurman (1958) have to some extent clarified the identity of the species in what might be called the *subalbatus*-complex,

but the identification of some Malayan specimens, particularly females, still presents problems. *Ar. subalbatus* is more typical of urban areas, breeding at times in septic tank systems, and of coastal areas, often breeding in fallen, damaged coconuts (*see* Macdonald, 1960*a*), but since it is probably a forest-dweller primarily, the identification of our specimens may well be correct. Two other species which are found in forest but have become successfully adapted in suburban and coastal areas respectively are *confusus* and *moultoni*.

The position regarding '*durhami*' is more uncertain. At present we prefer to confine the name to those specimens which we have collected in montane forest fringe, as at Fraser's Hill; these specimens fit Edwards' original description more exactly than do those from lowland areas, and the type locality is Bukit Kutu, Selangor, situated near Fraser's Hill.

The two unnamed species are quite distinct. The first, species no. 1, is probably the same as that described by Borel from Indochina (1930: 178) as "*Armigeres* sp. ?" since the terminalia agree with his figure. The second, species no. 3, is very similar to *moultoni*, but the white scaling on the hind femur is more extensive and the male terminalia are distinct; a sibling series was reared from an egg-batch.

All those species which have been collected in biting catches have been taken by day, and although the numbers have generally been small, it seems that most species, with the exception of *moultoni*, feed during the late afternoon. In the case of *moultoni*, although the larvae have not been collected, good numbers have been taken at times in adult catches, from which it appears that the highest biting activity is reached during the early afternoon. It may be noted, however, that in the less shaded conditions of the *Nipa*-palm plantations of the coast, *moultoni* shows indications of two peaks of activity, one about two hours after sunrise and another two or three hours before sunset. In other words there is less activity during the hot part of the day, as one might expect. Undoubtedly the degree of shade is an important factor influencing biting times. Similarly, outside the forest, *subalbatus* has two peaks of activity; the main peak falls in the half-hour before and the half-hour after sunset, with another in the equivalent period at sunrise. Although principally a day-biter, *subalbatus* has also been collected during the night in non-forested areas.

In all the species that have been observed in the laboratory, and that includes most Malayan species, egg-laying usually takes place 3-4 days after a blood-meal and the eggs are laid singly as in the case of many species of *Aedes* and *Heizmannia*. In those species which have been investigated, the eggs can be slowly dried and stored for a period, after which they will hatch on immersion in water. This feature has obviously a survival value in nature.

Most species are easily kept alive under laboratory conditions, and will feed fairly readily on man or guinea-pig.

Subgenus **Leicesteria** Theobald

The distribution of this subgenus is closely related to the distribution of forest bamboos, and the ecology of the species, so far as it is known, is discussed in the following paper of this *Study* (Macdonald, 1960*b*). Here it is only necessary to record that 13 species have been collected in lowland dipterocarp forest, and that these form an important and common constituent of the mosquito population. Several species have the thorax strongly compressed laterally, an adaptation to entering bamboo internodes through very small holes in the bamboo culm.

Genus **Culex** Linnaeus

As in the case of the genus *Aedes*, the subgenera of *Culex* are best considered separately. While the genus as a whole is not a forest group, there are a number of species which may

occur there in moderate numbers. A few of these might be correctly described as forest species, but most are more typical of scrub vegetation and have probably become secondarily adapted to the conditions in the forest fringe and in secondary forest.

Most species bite at night, but in the shade of the forest it is not uncommon to find adults biting by day, especially in the morning. Generally the eggs are laid as a raft, but there are many species on which observations have not yet been made, and it is possible, though unlikely, that eggs are laid individually in some cases.

Subgenus **Lutzia** Theobald

Only one of the two Malayan species has been collected in lowland forest, *halifaxi*. This species is rather uncommon, and larvae have been collected on only a few occasions—once from a forest pool, once from a tree-hole, and once from a cavity in a fallen, rotting tree-trunk. The adults have been collected only rarely.

Subgenus **Acalleomyia** Leicester

Not recorded from forest. Nothing could be said about the distribution or habits of the single species, *obscurus*, a few years ago (Macdonald, 1957), but a number of collections have since been made in coastal areas. Larvae are found principally in the axils and stumps of *Nipa*-palms.

Subgenus **Mochthogenes** Edwards

A single species has been collected a number of times from the still water in the small aqueduct at Ulu Gombak. This species is certainly not *malayi*, but no comparison has been possible with the other recorded Malayan species, *hackeri*. The male terminalia resemble those of the Indian species *castrensis*, though the Malayan specimens are probably specifically distinct.

Subgenus **Neoculex** Dyar

The single Malayan species, *brevipalpis*, is common in lowland forest; it is, in fact, probably the most common species of *Culex* in larval collections, and may also be taken in biting catches. The principal breeding-places are tree-holes (36 of 59 collections), but larvae may also be found in fallen split bamboo (8/59), bamboo stumps (5/59), bamboo pots (7/59), and in bamboo internodes with moderate holes (2/59) or with small holes (1/59).

This species is not by any means limited to forest, but may occur in suburban areas and also in coastal districts.

Subgenus **Lophoceraomyia** Theobald

The subgenus *Lophoceraomyia* is well-represented in forest, but there have been many difficulties in identifying the various species. More than 100 larval collections have been made, and from many of these, reared adults, each with its associated larval and pupal skin, have been preserved for future study. The bulk of this large collection is now being studied by Dr D. H. Colless, and only when the systematics have been clarified will it be possible to discuss the ecology of the individual species.

For the time being all that can be said is that eight species, several probably new, have been recognized by Dr Colless from the forest collections. These include *cinctellus*, *mammilifer*, *minor*, *quadripalpis*, and *rubithoracis*. The main sources of larvae have been tree-holes (28 of 109 collections), bamboo stumps (26/109), and fallen, split bamboos (28/109). In addition, collections have been made from pools—from the edges of marsh, pools beside streams, etc.—and occasional collections have been made from rock pools and, once, from a fallen leaf on the forest floor.

A few adults are not uncommon in biting catches, usually after sunset but occasionally during the day in shade. During the day catches *cinctellus* occurs in small numbers, and this same species has also been collected biting in the canopy.

Subgenus **Culiciomyia** Theobald

There are only three species of this subgenus so far recorded from lowland forest, but like many others of the genus *Culex* they probably only occur in secondary forest, which they may have entered from nearby scrub vegetation. The first, a species near *bahri*, has been collected only twice—from a small temporary pool in a timber-lorry track, and from a fallen, split bamboo. The second species is probably that described by Leicester (1908: 158) as *graminis*, which is a doubtful synonym of *fragilis*. (This latter species, *fragilis*, is typically found in coastal areas in Malaya, but this would not necessarily preclude its occurrence in forest.) Larvae have been collected from jungle pools on two occasions. The third species, *nigropunctatus*, has been collected from swamp pools at Ulu Gombak, but is more typical of non-forested areas. It is almost certainly a secondary introduction into the forest fringe, where small populations may be maintained. None of the three species in common.

Subgenus **Culex** Linnaeus

Once again a number of species may occur casually in secondary forest, and it is very doubtful whether any has become established in primary forest. Only *mimulus* and *pseudovishnui* have been collected both as larvae and as adults in the areas under discussion, and in each case the larvae came from ground pools. Small numbers of *pseudovishnui* have been taken quite regularly in biting catches, often in day catches and occasionally in the canopy.

In addition, the following species have occurred occasionally in biting catches:—"*bitaeniorhynchus*" (there are probably several Malayan species being confused under this name), *fuscocephalus*, and *gelidus*.

Genus **Anopheles** Meigen

Although most of our collecting in forest has been directed towards culicine and megarhinine mosquitoes, both the larvae and the adults of a number of anophelines have also been collected. The systematics and ecology of most Malayan species are now relatively well-known and recorded, but for the sake of completeness a brief account of the forest species may be included here.

More complete data are provided by Gater (1934, 1935), Reid (1949), Reid and Hodgkin (1950), and Colless (1956, 1957).

Subgenus **Anopheles** Meigen

Ten species of this subgenus have been collected and most are pool-breeders. One of the most common is *aitkeni*, which has been collected from small pools of clean water beside the River Gombak as well as from the Ulu Gombak aqueduct. The adults are not uncommon in biting catches, and may be taken by day in shade.

An. montanus has been collected from rather similar larval breeding-sites to those of *aitkeni*: from ground pools, the aqueduct, and from side pockets of the river. Also from the aqueduct in the past (1933-1935), but not recently, has come *barbumbrosus*, while recently two undescribed species near *barbirostris* have been found there; and one of the latter has also been taken from swampy land at 11 m. Ulu Gombak Road and from a ground pool at the 17th mile.

An. annandalei and *asiaticus* have quite different breeding habits from the others: several collections of the former have been made from tree-holes, while *asiaticus* has been taken mainly from fallen, split bamboo.

The three remaining species of the subgenus, *roperi*, *umbrosus*, and a species near *letifer*, have been collected occasionally in adult catches on human bait, or as larvae from the aqueduct.

Subgenus **Myzomyia** Blanchard

Most of the seven species collected, as was the case in the preceding subgenus, are ground-pool breeders. *An. l. leucosphyrus* seems to prefer muddy pools, such as the small pools of water that collect in wheel tracks, and *balabacensis introlatus* occurs in the aqueduct, whereas *riparis macarthuri* breeds in cleaner, seepage pools and the side pools of streams; larvae of *kochi* may be found at the forest fringe in open, muddy pools, and *maculatus* breeds in pools of seepage water. Both the remaining two species, *hackeri* and *watsoni*, breed in fallen, split bamboos, but neither is very common.

None of these species of *Anopheles* has been taken very regularly in our adult catches, principally because, as was explained earlier, the catches have been mostly made by day. It is of interest to note, however, that *An. l. leucosphyrus* and the closely related *balabacensis introlatus* were taken in larger numbers in the canopy than at ground level.

Summary

1. During the past 3-4 years investigations have been made into the ecology of the mosquitoes of the lowland dipterocarp forest of Selangor, Malaya. In this account of the work, a short summary of the main features of the forest is given, and the areas where mosquitoes were collected are defined; most collecting has centred around Ulu Gombak Forest Reserve, an area of disturbed or secondary forest.

2. In the course of the investigations more than 500 larval collections were made, each larva being reared to the adult stage, and regular adult catches have continued for more than two years. The breeding-places in the forest are defined and shown in tabular form together with the number of species that has been collected from each.

3. The mosquitoes are then discussed by genera, and in most groups the collections of each species from each type of breeding-place are summarized in tabular form. The preferred breeding-places, the biting habits, the egg-laying habits, etc., are discussed in the text in each case where data are available.

4. Altogether 163 species have been collected either as larvae or as adults, and in each case series were preserved for future systematic study. At least 25, and perhaps more than 30, of those species are new and undescribed, or have been described recently in part or entirely from Selangor forest specimens; the early stages of many more species were collected for the first time. There are, in addition, about 11 other species recorded from Malayan forest which were not collected in these investigations.

Acknowledgements

It is fitting that we record first our indebtedness to the assistants and mosquito collectors of the Division of Entomology of this Institute, each of whom has contributed assistance in the field and in the laboratory; in particular, Mr S. Mahadevan, who has been principal assistant to one of us for several years, and Mr A. Ganapathipillai, senior assistant in the Division, deserve special mention. In addition, several of the field staff of the United States Army Medical Research Unit contributed towards the adult and larval mosquito collecting. Thanks are due to Che Mohamed bin Omar, who drew the map, and we are grateful also to Mr J. Wyatt-Smith of the Forest Research Institute for advice on several botanical questions, to Mr R. N. Hilton of the Rubber Research Institute for the identification of *Polystictus xanthopus*, and to Dr J. A. Reid of this Institute who was ready at all times to discuss problems and to offer helpful suggestions.

REFERENCES

BAISAS F. E. (1946). Notes on Philippine mosquitoes, XII. *Topomyia. Mon. Bull. Bur. Hlth Philipp.*, *22*, 31-47.

BAISAS F. E. AND UBALDO-PAGAYON A. (1952). Notes on Philippine mosquitoes, XVI. Genus *Tripteroides*. *Monogr. Inst. Sci. Tech., Manila, 2*, 1-198.

BARRAUD P. J. (1934). Fauna of British India. *Diptera. Vol V*: *Culicidae. Tribes Megarhinini and Culicini*. London: Taylor and Francis.

BOREL E. (1930). *Les moustiques de la Cochinchine et du Sud-Annam*. Paris: Masson et Cie.

CHU FENG-I (1958). Advances in the study of culicine mosquitoes of Hainan, South China. *Indian J. Malar., 12*, 109-113.

COLLESS D. H. (1956). The *Anopheles leucosphyrus* group. *Trans. R. ent. Soc. Lond., 108*, 37-116.

COLLESS D. H. (1957). Further notes on the systematics of the *Anopheles leucosphyrus* group (Diptera: Culicidae). *Proc. R. ent. Soc. Lond.*, (B) *26*, 131-139.

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. Parasit., 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. Parasit., 53*, 166-179.

DANIELS C. W. (1908). Notes on the mosquitoes on the river and coast districts of the eastern side of the Peninsula. *Stud. Inst. med. Res. F.M.S., 3*, (3), 262-266.

DAVIDSON G. AND GANAPATHIPILLAI A. (1956). Observations on the bionomics of the adults of some Malayan anopheline mosquitoes. *Ann. trop. Med. Parasit., 50*, 137-146.

EDWARDS F. W. (1915). Diagnoses of new Bornean Culicidae. *Bull. ent. Res., 5*, 283-285.

EDWARDS F. W. (1921). Mosquito notes.—II. *Bull. ent. Res., 12*, 69-80.

EDWARDS F. W. (1922). A synopsis of adult Oriental culicine (including megarhinine and sabethine) mosquitoes. Part II. *Indian J. med. Res., 10*, 430-475.

EDWARDS F. W. AND GIVEN D. H. C. (1928). The early stages of some Singapore mosquitos. *Bull. ent. Res., 18*, 337-357.

GATER B. A. R. (1934). *Aids to the identification of anopheline larvae in Malaya*. Singapore: Government Printing Office.

GATER B. A. R. (1935). *Aids to the identification of anopheline imagines in Malaya*. Singapore: Government Printing Office.

HADDOW A. (1954). Studies of the biting-habits of African mosquitos. An appraisal of methods employed, with special reference to the twenty-four-hour catch. *Bull. ent. Res., 45*, 199-242.

HENDERSON M. R. (1954). *Malayan wild flowers: monocotyledons*. Kuala Lumpur: Malayan Nature Society.

HOLTTUM R. E. (1958). The bamboos of the Malay Peninsula. *Gdns' Bull., 16*, 1-135.

HORSFALL W. R. (1955). *Mosquitoes: their bionomics and relation to disease*. London: Constable and Co. Ltd.

INSTITUTE FOR MEDICAL RESEARCH, MALAYA (1955). Conference on virus diseases. *Rep. Inst. med. Res. Malaya, 1954*, 100-106.

INSTITUTE FOR MEDICAL RESEARCH, MALAYA (1957). United States Army Medical Research Unit (Malaya). *Rep. Inst. med. Res. Malaya, 1956*, 100-109.

INSTITUTE FOR MEDICAL RESEARCH, MALAYA (1958). Filariasis investigation. *Rep. Inst. med. Res. Malaya, 1957*, 91-99.

KNIGHT K. L. (1946). The *Aedes* (*Finlaya*) *niveus* subgroup of Oriental mosquitoes. *J. Wash. Acad. Sci., 36*, 270-280.

KNIGHT K. L. AND MARKS E. N. (1952). An annotated checklist of the mosquitoes of the subgenus *Finlaya*, genus *Aedes*. *Proc. U.S. nat. Mus., 101*, 513-574.

LEICESTER G. F. (1908). The Culicidae of Malaya. *Stud. Inst. med. Res. F.M.S., 3*, (3), 18-261.

MACDONALD W. W. (1956). *Aedes aegypti* in Malaya. II.—Larval and adult biology. *Ann. trop. Med. Parasit., 50*, 399-414.

MACDONALD W. W. (1957). Malaysian Parasites, XVI. An interim review of the non-anopheline mosquitoes of Malaya. *Stud. Inst. med. Res. Malaya, 28*, 1-34.

MACDONALD W. W. (1958). Description of a new species of *Orthopodomyia* Theobald from Malaya, with a note on the genus in that country (Diptera: Culicidae). *Proc. R. ent. Soc. Lond.*, (B) *27*, 121-126.

MACDONALD W. W. (1960*a*). Some ecological factors influencing the distribution of Malayan mosquitoes. In *Proceedings of the Centenary and Bicentenary Congress of Biology, Singapore 1958.* University of Malaya Press.

MACDONALD W. W. (1960*b*). Malaysian Parasites, XXXVIII. On the systematics and ecology of *Armigeres* subgenus *Leicesteria* (Diptera, Culicidae). *Stud. Inst. med. Res. Malaya, 29,* 110-153 (this *Study*).

MACDONALD W. W. AND MATTINGLY P. F. (1960). A new species of *Udaya* from Malaya and a description of the early stages of *U. argyrurus* (Edwards, 1934) (Diptera: Culicidae). *Proc. R. ent. Soc. Lond.*, (B) *29,* 22-28.

MATTINGLY P. F. (1957*a*). *The culicine mosquitoes of the Indomalayan area. Part I. Genus* Ficalbia *Theobald.* London: British Museum.

MATTINGLY P. F. (1957*b*). *The culicine mosquitoes of the Indomalayan area. Part II. Genus* Heizmannia *Ludlow.* London: British Museum.

MATTINGLY P. F. (1958). *The culicine mosquitoes of the Indomalayan area.* Part III. *Genus* Aëdes *Meigen, subgenera* Paraëdes *Edwards,* Rhinoskusea *Edwards and* Cancraëdes *Edwards.* London: British Museum.

MATTINGLY P. F. (1959). *The culicine mosquitoes of the Indomalayan area.* Part IV. *Genus* Aëdes *Meigen, subgenera* Skusea *Theobald,* Diceromyia *Theobald,* Geoskusea *Edwards and* Christophersiomyia *Barraud.* London: British Museum.

REID J. A. (1949). A preliminary account of the forms of *Anopheles leucosphyrus* Dönitz (Diptera: Culicidae). *Proc. R. ent. Soc. Lond.*, (B) *18,* 42-53.

REID J. A. AND HODGKIN E. P. (1950). The *Anopheles umbrosus* group (Diptera: Culicidae). *Trans. R. ent. Soc. Lond., 101,* 281-334.

RICHARDS P. W. (1952). *The tropical rain forest.* Cambridge University Press.

STONE A. AND KNIGHT K. L. (1957). Type specimens of mosquitoes in the United States National Museum, V: The Sabethini (Diptera, Culicidae). *J. Wash. Acad. Sci., 47,* 117-126.

STONE A. AND THURMAN E. B. (1958). *Armigeres (Armigeres) baisasi,* a new mosquito from the Philippine Islands (Diptera: Culicidae). *J. Wash. Acad. Sci., 48,* 240-243.

SYMINGTON C. F. (1943). Foresters' manual of dipterocarps. *Mal. Forest Rec.*, no. 16, 244 pp.

THEOBALD F. V. (1901). *A monograph of the Culicidae of the world.* Vol. 2. London: British Museum.

THURMAN E. B. (1958). Revalidation of three species of *Armigeres* Theobald, 1901 (Diptera: Culicidae). *J. Wash. Acad. Sci., 48,* 389-393.

WHARTON R. H. (1957). Studies on filariasis in Malaya: notes on the breeding of *Mansonia (Mansonioides)* mosquitoes in the laboratory. *Ann. trop. Med. Parasit., 51,* 297-300.

WYATT-SMITH J. (1952*a*). Malayan forest types. *Malay. Nat. J.*, 7, 45-54.

WYATT-SMITH J. (1952*b*). Malayan forest types. *Malay. Nat. J.*, 7, 91-98.

MALAYSIAN PARASITES XXXVIII

ON THE SYSTEMATICS AND ECOLOGY OF *ARMIGERES* SUBGENUS *LEICESTERIA* (DIPTERA, CULICIDAE)

BY

W. W. MACDONALD

Institute for Medical Research, Kuala Lumpur

CONTENTS

INTRODUCTION

The genus *Armigeres* Theobald, 1901 is almost entirely an Oriental group of mosquitoes. Two subgenera are recognized, *Armigeres* Theobald, 1901 and *Leicesteria* Theobald, 1904. The subgenus *Leicesteria* is represented in Ceylon, India, Burma, Yunnan, Indochina, Thailand, and Malaya, through the Malay Archipelago eastwards to Ceram, and northwards to the Philippines, Hong Kong, China and Taiwan. The subgenus *Armigeres* is present in all of those countries and extends further east as far as Northern Australia and the Solomon Islands, and further north to Japan. In the case of *Leicesteria* the centre of distribution, and perhaps of evolution, lies between Assam and Malaya, in which area all the known species occur; eastwards through the Sunda Islands and westwards through India the number of recorded species falls sharply. In Malaya 12 of the 14 known species have been collected, together with one completely new species which is described in this present paper.

The subgenus *Leicesteria* is usually well represented in mosquito catches made in Malayan forest where bamboos are growing, and it was the difficulty encountered in identifying this part of the catch that initiated the present study. The material examined has been collected principally during the past two or three years, and it is almost entirely Malayan. There has been little opportunity to study collections from elsewhere in the range of the subgenus, but short series of several species from the Philippines, Taiwan, and the Sunda Islands have been seen: these are mentioned in the text. On the other hand, it has been possible to collect and examine better specimens and more complete series than has been done in the past; and for most species sibling series have been reared from the egg batches of wild-caught females.

The previous accounts of *Leicesteria* have been short and systematic in character (Edwards, 1914; Barraud, 1927, 1934), and they have also been incomplete in two respects: first, most of

the larvae, and in some cases the males, were unknown; secondly, almost nothing was recorded about the habits of the mosquitoes. In the present account these omissions are partially filled, but it is recognized that there still remain problems and gaps in our knowledge, particularly of the habits of the adults, that require further study.

Little can be said about the relations of *Leicesteria* to disease, but in a small series of dissections of females caught in forest one stage III filaria larva was found in the thorax of one out of 103 *Ar. dolichocephalus*, and 5 stage II larvae were present in the thorax and abdomen of one of five *Ar. pendulus*. This suggests that some species of *Leicesteria* may play a part in the transmission of animal filariasis. Attempts to isolate viruses from pools of wild-caught *Leicesteria* have been made on a small scale, but without success. Nevertheless, several species are at times so common in forest that they cannot be ignored as potential vectors of virus diseases.

A general account of the collecting areas, collecting methods, etc., together with a map of the localities mentioned, has been given elsewhere (Macdonald and Traub, 1960, this *Study*), and that account will serve as an introduction to the present paper.

Terminology and Diagnostic Characters

Genus **Armigeres** Theobald

Subgenus **Leicesteria** Theobald

Leicesteria Theobald, 1904, *Entomologist, 37:* 211.
Chaetomyia Leicester, 1908, *Stud. Inst. med. Res. F. M. S., 3* (3): 100.
Brevirhynchus Theobald, 1908, *Rec. Indian Mus., 2:* 293.
Leicesteriomyia Brunetti, 1912, *Rec. Indian Mus., 4:* 452.

The genus *Armigeres* is classified with the aedine group of mosquitoes, which includes *Aedes* and *Heizmannia* as well as such non-Malayan genera as *Eretmapodites* and *Haemagogus*. Besides certain structural characters which are held in common, there are also similarities in the habits and behaviour of these genera. For instance, they are primarily forest mosquitoes, and most species bite by day and readily attack man. The subgenus *Leicesteria*, nevertheless, has a number of unusual features, perhaps chief of which is the habit of laying eggs in a raft; for aedine mosquitoes lay their eggs singly as a rule and in most genera the eggs can withstand drying.

Characters which may serve to separate *Armigeres* from other Oriental genera have been listed by Edwards (1932) and Barraud (1934); and, more recently, Mattingly (1957 *a*, *b*, 1958) has begun a revised key to the genera and subgenera of Indomalayan culicines. The main distinguishing characters of the genus are, briefly: margin of squama fringed; alula fringed with narrow scales; spiracular setae absent; postspiracular area scaled, and in subgenus *Armigeres* with setae; mesonotum with no acrostichal or dorso-central setae, but usually with a few prescutellar setae; pulvilli absent; anterior tarsal claws of female almost always toothed.

The subgenera *Armigeres* and *Leicesteria* are easily separated by the presence in the former of postspiracular setae and of a lower mesepimeral seta: postspiracular setae are absent in all *Leicesteria*, and only a single species, *flavus*, has one or two lower mesepimeral setae. In the case of females an additional simple character is the relatively long palps of *Leicesteria*, usually half as long as the proboscis, or longer.

The principal features of the subgenus *Leicesteria* are as follows:

Adult.—Medium-sized to large species. Head covered with broad flat scales, usually with a few upright scales on the nape. Eyes bordered by a narrow rim of white scales. Clypeus scaled in some species. Female palps from slightly less than half to nearly three-quarters the length of the proboscis. Proboscis dark, sometimes with a line of dull, pale scales on the underside; the apical third of the proboscis curves slightly downwards. Torus of antenna with both brown and white scales on the inner face; first segment

of the flagellum with a patch of white scales at the base. Mesonotum may be laterally compressed and produced forwards in a hump over the head; this is more pronounced in some species than in others. Anterior pronotal lobes well separated and sometimes reduced by the hump of the mesonotum. Scutum covered with narrow scales. No acrostichal or dorso-central setae; a few prescutellar setae. Fringe of white or yellowish scales round the mesonotum. Scutellum with broad white or black scales. Postnotum bare except in the case of *flavus* in which there is a small group of setae and scales. Pleurae with patches of white scales. No spiracular setae. Postspiracular area without setae, but covered with flat white and black scales. No lower mesepimeral setae except in the case of *flavus* in which there are one or two. Undersides of femora pale-scaled; outer surface of hind femur pale almost to the knee. Undersides of tibiae either pale-scaled or with a narrow line of pale scales running the entire length. Fore tibia shorter than the others except in the case of *flavus* in which the hind tibia is shortest. Tarsal banding in some species. Pulvilli absent. In the females, with the exception of *annulipalpis*, fore and mid claws equal and toothed, hind claws equal and simple; in *annulipalpis* all the claws are equal and simple. In the males, fore claws unequal, the larger toothed; mid claws equal and toothed, except in *annulipalpis* in which they are simple; hind claws equal and simple. Wings with squama fringed, otherwise without distinctive features. Knob of halteres clad with both brown and white scales. Abdomen with large, lateral, tergal patches of white, and sometimes yellow, scales; some species with dorsal bands or patches of scales. The male terminalia are fairly simple and are distinctive for each species; the spines on the basal lobe together with the shape of the style and its appendages are useful diagnostic characters.

Larva.—The antennae are of moderate length, not spiculate, between 5 and 8 times as long as broad; antennal hair single or bifid, usually situated near the middle of the shaft. Clypeal spines (head seta 1) slender and tapering. Mentum dark-brown in colour, triangular in shape, with a central tooth and 6-9 laterals. Comb patch of variable size; according to the species the comb scales may number between 4 and 85. Siphon short, usually about as long as broad; siphonal hair usually single or bifid, but there may be as many as 5 branches. No pecten. Ventral brush of 10, or occasionally of 12, tufts. Anal papillae long, rounded at the tips.

Whilst the larvae can be easily distinguished from those of other genera, a simple character for the separation of the two subgenera, *Armigeres* and *Leicesteria*, is not at present known. It is however probable that future study of the larvae of *Armigeres* will reveal a good subgeneric character.

Pupa.—The pupae have not yet been critically examined and no characters are known for the separation of species. The trumpet is rather similar in all species, usually between two and three times as long as broad. The paddles are fringed, and the apical seta short and single.

The following 15 species are now recognized*:

1. *Armigeres* (*Leicesteria*) *flavus* (Leicester, 1908)
2. *Armigeres* (*Leicesteria*) *magnus* (Theobald, 1908)
3. *Armigeres* (*Leicesteria*) *annulitarsis* (Leicester, 1908)
4. *Armigeres* (*Leicesteria*) *dolichocephalus* (Leicester, 1908)
5. *Armigeres* (*Leicesteria*) *inchoatus* Barraud, 1927
6. *Armigeres* (*Leicesteria*) *pectinatus* (Edwards, 1914)
7. *Armigeres* (*Leicesteria*) *dentatus* Barraud, 1927
8. *Armigeres* (*Leicesteria*) *omissus* (Edwards, 1914)
9. *Armigeres* (*Leicesteria*) *longipalpis* (Leicester *in* Theobald, 1904)
10. *Armigeres* (*Leicesteria*) *balteatus* n. sp.
11. *Armigeres* (*Leicesteria*) *digitatus* (Edwards, 1914)
12. *Armigeres* (*Leicesteria*) *pendulus* (Edwards, 1914)
13. *Armigeres* (*Leicesteria*) *traubi* n. sp.
14. *Armigeres* (*Leicesteria*) *annulipalpis* (Theobald, 1910)
15. *Armigeres* (*Leicesteria*) *vimoli* Thurman and Thurman, 1958

* Thurman (1959) and Stone, Knight and Starcke (1959) have recently placed *flavus* in a separate subgenus, *Leicesteriomyia* Brunetti, 1912. I see insufficient justification for this course and prefer to leave *flavus* as a member of the subgenus *Leicesteria*. The exceptional features of *flavus* are the postnotal setae, the lower mesepimeral setae, and the short hind tibiae; and in the ecology of the group also *flavus* differs in some respects from the others. Nevertheless, these features are more than balanced by the number held in common with other species of *Leicesteria*, and, in particular, by the unusual egg-laying habits (*see* p. 136). In the larval stage *magnus* forms a natural link between *flavus* and the remaining species, and I therefore prefer to regard *flavus* as lying at the end of a series, both in its systematics and in its ecology, within the subgenus *Leicesteria*, though it might reasonably be placed in a separate species-group.

KEYS TO SPECIES

In the following keys several new characters are introduced and these require a brief discussion. In the adults the propleural-fore coxal scale patch has proved useful: the scale patch may be as in *dentatus* (fig. 1a) with two bands of black scales sandwiched between white scales; in such cases the lower band is usually the larger, the upper often much narrower. Alternatively, only the lower black band may be present, as in *digitatus* (fig. 1b), the remainder of the patch being composed of white scales. A second major character is provided by the scale patch on the mesepimeron: either this scale patch tapers slightly downwards and stops before the lower suture of the sclerite (fig. 1a), or it extends to the lower margin of the mesepimeron often covering as much as the lower quarter of the sclerite (fig. 1b). Even in badly damaged specimens the extent of the mesepimeral scaling can often be determined.

When specimens are old little reliance can be placed on the lateral yellow scaling on the tergites. These yellow markings are usually distinct in some species, e.g. *dolichocephalus* and *annulitarsis*, but less distinct in others, e.g. *dentatus* and *omissus*. However, the main difficulty often lies with those species which do not have yellow scaling but whose white lateral tergal markings are discoloured by grease, and may appear yellowish. In general, if yellow scales are present they contrast with the adjoining white scales, even with those which are discoloured, whilst in their absence the tergal scales are unicolorous. Specimens which are discoloured and greasy may be restored by immersion for an hour or two in ether or benzene, as described by Oldroyd (1958: 99, 132).

In the adult key the least satisfactory couplet is the last, in which *pendulus* and *traubi* are separated. The males are easily distinguished since the terminalia of *pendulus* are markedly everted, but the females are very similar. In addition to the characters given in the key, several supplementary features are mentioned after the description of *pendulus*.

In the larval key most of the characters used are self-explanatory, or else they are illustrated in the figures. Once again *pendulus* and *traubi* are very alike and the distinguishing characters given are not very satisfactory. The siphon-saddle ratio is a slightly modified form of that used by Colless (1957); in this case measurements were made of the dorsal margin of the siphon and not of the posterior margin.

Adults

1. Hind tarsi with narrow, basal, pale rings.....2
   Hind tarsi entirely dark.....7
2. Abdominal tergites II-VI with narrow, apical patches of pale yellow scales; postnotum with a small tuft of pale scales and setae; 1 or 2 lower mesepimeral setae present; hind tibiae distinctly shorter than fore tibiae.....*flavus* (p.116)
   Abdominal tergites without yellow, apical patches; no postnotal setae or scales; no lower mesepimeral setae; hind tibiae not shorter than fore tibiae.....3
3. Abdominal tergites II-VII with dull, pale, basal markings; clypeus with scales in ♀. *magnus* (p. 117)
   Abdominal tergites II-VII without basal markings; clypeus with or without scales.....4
4. Abdominal tergite II with median, basal, white patch; ♀ palps with clear white ring about the middle; ♂ mid claws simple.....*annulipalpis* (p. 134)
   Abdominal tergite II without median, basal, white patch; ♀ palps usually without central white ring; ♂ mid claws toothed.....5
5. Clypeus scaled; ♀ palps white at tip; larger ♂ fore claw simple.....*annulitarsis* (p. 119)
   Clypeus without scales; ♀ palps dark at tip; larger ♂ fore claw toothed.....6
6. Lateral tergal markings of both white and yellow scales.....*dolichocephalus* (p.121)
   Lateral tergal markings entirely white.....*inchoatus* (p.122)
7. Propleural-fore coxal scale patch with two bands of black scales sandwiched between white scales (fig. 1a).....8
   Propleural-fore coxal scale patch with a single band of black scales between white scales (fig. 1b).....10
8. Lateral tergal markings entirely white; sternites largely white or with narrow, apical, dark bands; scale patch on mesepimeron widens towards the lower suture and barely reaches the suture .....*pectinatus* (p. 123)
   vimoli (p. 135)
   Lateral tergal markings of both white and yellow scales, at least on the more distal segments; sternites usually with clear, apical, dark bands.....9

9. White scale patch on mesepimeron extends to the lower suture and may cover the lower 1/5 of the sclerite.....*omissus* (p.126)
White scale patch on mesepimeron does not reach the lower suture (fig. 1a).....*dentatus* (p.124)
10. Lateral tergal markings of both white and yellow scales.....*dolichocephalus** (p.121)
Lateral tergal markings entirely white.....11
11. White scale patch on mesepimeron extends to the lower suture.....12
White scale patch on the mesepimeron does not reach the lower suture.....13
12. Clypeus with a prominent patch of white scales; lateral tergal markings usually extend to the dorsum to form apical or subapical bands; sternites pale-scaled or with narrow, apical, dark bands.....*longipalpis* (p. 126)
Clypeus without scales; no dorsal abdominal bands; sternites with clear, apical, dark bands.....*digitatus* (p. 130)
13. Lateral tergal markings usually extend to the dorsum to form apical or subapical bands; ♀ palps half or slightly more than half the length of the proboscis.....*balteatus* n.sp. (p. 128)
No dorsal abdominal bands; ♀ palps at least 2/3 the length of the proboscis.....14
14. Abdominal sternites mainly pale-scaled or with ill-defined, apical, dark bands; clypeus with a small patch of pale scales (very easily rubbed off).....*pendulus* (p. 131)
Abdominal sternites with sharply-defined, apical, black bands, covering 1/3-1/2 of segments III and IV; clypeus without scales.....*traubi* n. sp. (p.132)

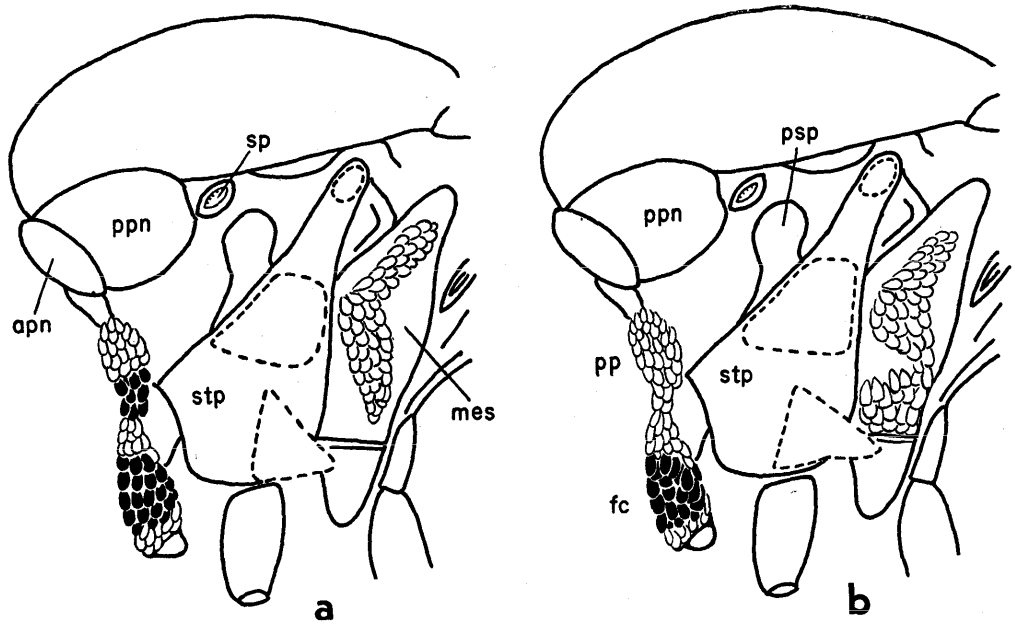


Fig. 1. Showing the propleural-fore coxal scale patch and the mesepimeral scale patch of (a) *Armigeres* (*Leicesteria*) *dentatus* Barr. and (b) *Ar.* (*L.*) *digitatus* (Edw.): apn, anterior pronotum; fc, fore coxa; mes, mesepimeron; pp, propleuron; ppn, posterior pronotum; psp, postspiracular area; sp, spiracle; stp, sternopleuron.

Larvae

1. Anal segment with a sclerotized ventral plate in addition to the dorsal plate (the saddle).....2
Anal segment without a ventral plate.....3
2. Ventral plate on anal segment large and prominent, covering about 1/3 of the segment.....*flavus* (p.116)
Ventral plate very small, situated just proximal to the ventral brush; comb of only 4-6 teeth.....*magnus* (p.117)
3. Seta 5 on abdominal segment VIII finely branched (fig. 2a).....4
Seta 5 on this segment stout, single or bifid (fig. 2b).....6
4. Abdominal segments I-VII with large, very prominent, lightly sclerotized tubercles from which arise lateral, dorsal and ventral setae (fig. 3b).....*dolichocephalus* (p.121)
Abdominal segments without prominent tubercles.....5

* *dolichocephalus* is keyed out at two places since the tarsal banding is often indistinct and may be overlooked.

5. Siphon-saddle ratio=2:1; antennal hair usually inserted 2/5 or less of the length of the shaft from the base.....*omissus* (p. 126)
   Siphon-saddle ratio=2.5-3:1; antennal hair usually inserted 2/5-/1/2 of the length of the shaft from the base.....*annulitarsis* (p.119)
6. Abdominal segments I-V with stout, single, ventral setae raised on prominent, lightly sclerotized tubercles (fig. 3c).....*pectinatus* (p.123)
   Setae on abdominal segments not so.....7
7. Comb of more than 60 scales.....8
   Comb of less than 60 scales.....9
8. Prominent dorsal setae on abdominal segment VII bifid, rising from a lightly, but distinctly, sclerotized plate.....*longipalpis* (p.126)
   These setae with 3-5 branches and not arising from a sclerotized plate (only 3 specimens seen).....*annulipalpis* (p.134)
9. Abdominal segments I-IV or II-IV with a large, ventral patch of very fine spicules (fig. 3a).....*digitatus* (p.130)
   Abdominal segments without patches of fine spicules.....10

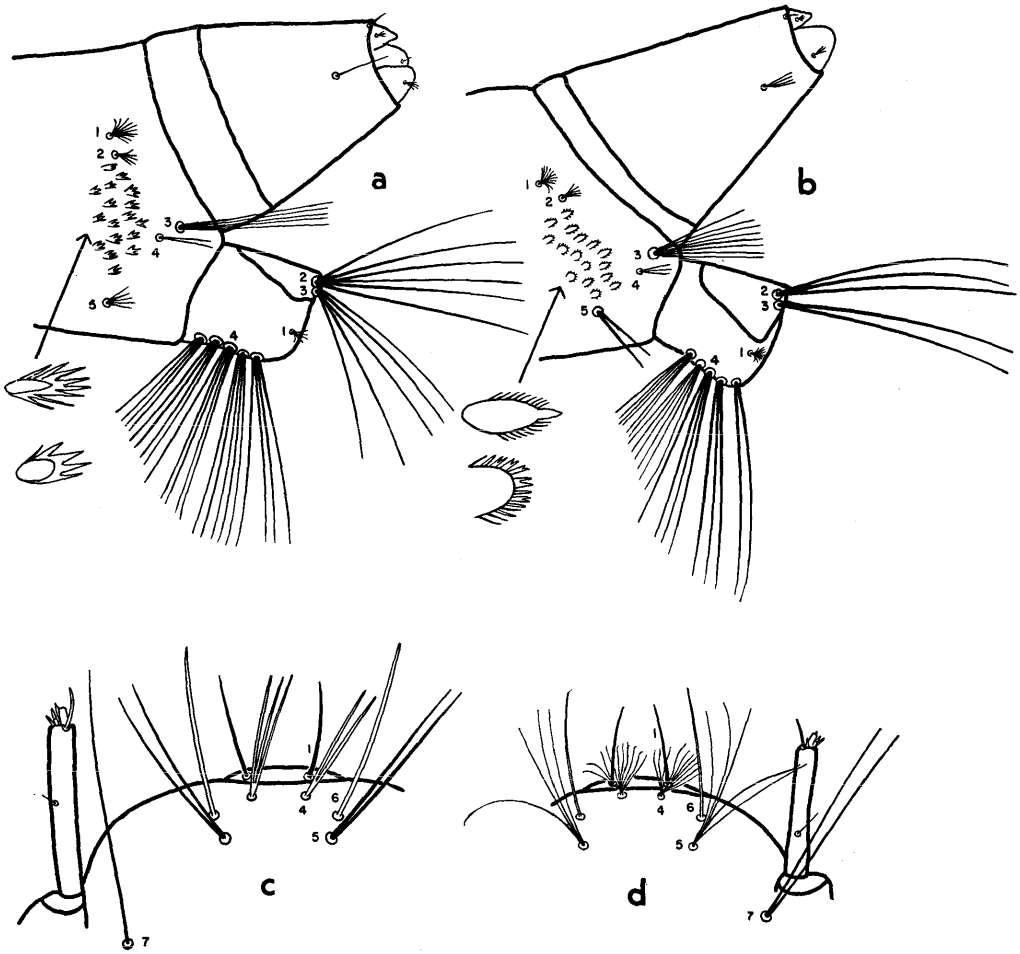


Fig. 2. Segment VIII, anal segment, and siphon of larvae of (a) *Armigeres* (*Leicesteria*) *omissus* (Edw.) and (b) *Ar.* (*L.*) *dentatus* Barr.; and anterior region of larval head of (c) *Ar.* (*L.*) *balteatus* n. sp. and (d) *Ar.* (*L.*) *traubi* n. sp.

10. Comb of 13-20 scales, many with a stout, blunt, central tooth and a strong basal fringe, the remainder uniformly fringed (fig. 2b); mesothoracic pleural tuft (setae 9, 10 and 12) with 8 or more branches, adjoining seta 8 usually with 6 or more branches.....*dentatus* (p.124)

Comb of varying number of scales, but mostly uniformly fringed or with a small, sharp, central tooth; mesothoracic pleural tuft (setae 9, 10 and 12) usually with 6 or fewer branches (occasionally 7, rarely 8 branches), adjoining seta 8 with less than 6 branches.....11

11. Siphon-saddle ratio=3.5-5:1, seldom less than 3.5:1; comb of 36-49 scales, mostly broad and uniformly fringed without a distinct central tooth.....*inchoatus* (p.122)

Siphon-saddle ratio=about 3:1; comb scales varied.....12

12. Head setae 4 and 5 with rather thicker branches than usual, few in number, and not spreading much; seta 4 with 1-4 branches (fig. 2c); comb of 37-49 fringed, bluntly-pointed scales, many with a small, sharp, central tooth; antennal hair usually inserted near the middle of the shaft; lateral setae on abdominal segments I-III number 5-8, 5-7, 2-7 resp.....*balteatus* n. sp. (p.128)

Branches of head setae 4 and 5 not thicker than usual, generally lax and spreading; seta 4 often many-branched (fig. 2d); comb of varying number of scales; antennal hair usually inserted 1/4-2/5 the length of the shaft from the base; lateral setae on abdominal segments I-III number 3-7, 2-6, 1-3 resp.....13

13. Comb of 12-30 scales; shaft of antenna often less than 6 times as long as the basal width; siphon hair single, sometimes bifid.....*pendulus* (p.131)

Comb of 21-47 scales; shaft of antenna 6-7 times as long as the basal width; siphon hair with 2-4 branches.....*traubi* n. sp. (p.132)

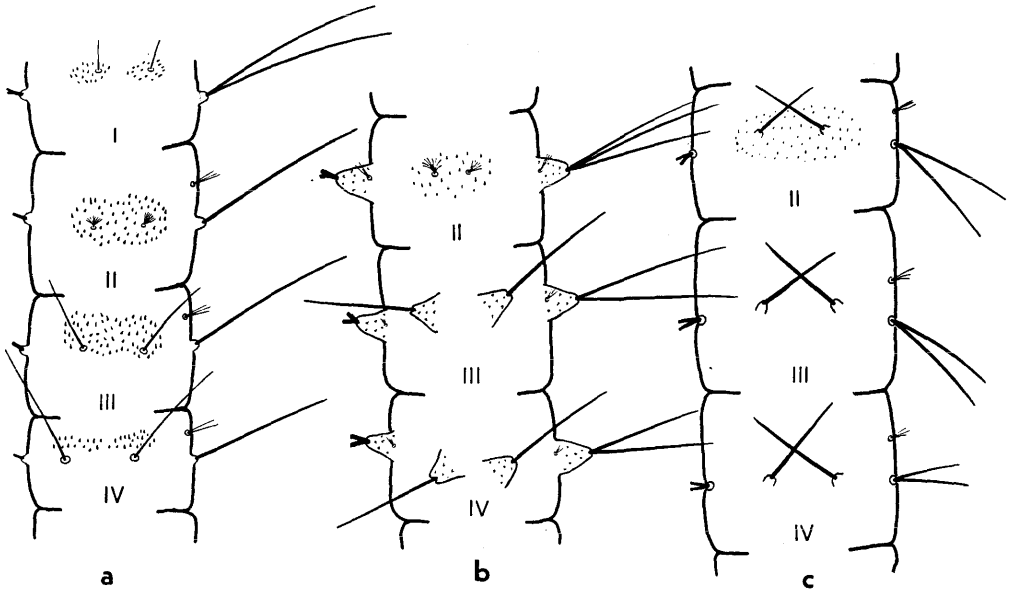


Fig. 3. Abdominal segments of larvae of (a) *Armigeres* (*Leicesteria*) *digitatus* (Edw.), (b) *Ar.* (*L.*) *dolichocephalus* (Leic.) and (c) *Ar.* (*L.*) *pectinatus* (Edw.).

Descriptions

Armigeres (**Leicesteria**) **flavus** (Leicester, 1908)

Chaetomyia flava Leicester, 1908, *Stud. Inst. med. Res. F.M.S.*, *3* (3): 101.
Leicesteria apicalis Theobald, 1908, *Rec. Indian Mus.*, *2:* 291.
Brevirhynchus apicalis Theobald, 1910, *Rec. Indian Mus.*, *4:* 7.

Types: *flavus*, ♀ lectotype from "Bamboo, Ulu Klang Jungle, 8 miles fr. Kuala Lumpur, 25/9/03" and 2 paratypes without data, in Brit. Mus.; *L. apicalis*, ♂ and ♀ from Lushai Hills, Assam, 26. v. 1904 (*E. C. Macleod*) in Indian Mus., Calcutta; *B. apicalis*, ♀ from Sylhet, Assam, 26. vi. 1905 (*Major Hall*) in Indian Mus., Calcutta.

ADULT ♀.

Head.—Dorsum covered with flat, dark scales interspersed with a variable number of pale scales; a group of pale, upright scales on the nape. Palps and proboscis dark, the palps half or slightly less than half the length of the proboscis, sometimes with a few pale scales at the base of the terminal segment. Clypeus dark in colour without scales. Torus yellowish with white scales anteriorly and brown scales posteriorly on the inner surface; flagellum dark-brown with white scales at the base of the first segment.

Thorax.—Not markedly compressed laterally nor produced forwards over the head. Scutum covered with narrow dark-brown and bronze scales, with a broad border of narrow, golden scales running from the wing roots round the front. A small group of scattered prescutellar setae. Scutellar lobes covered with flat, dark-brown and pale yellowish scales. Anterior pronotal lobes with broad, pale scales below and broad, dark-brown scales above; posterior pronotum with broad, pale scales below and narrow, dark scales, sometimes with a sprinkling of pale scales, above. Pleurae with patches of broad, pale scales: propleural-fore coxal scale patch with a single band of dark scales; postspiracular scale patch mainly pale; lower mesepimeron with one or two long setae, and the mesepimeral scale patch does not extend below these setae. A small group of pale scales and setae on the postnotum.

Legs.—Undersides of femora white-scaled; the outer surface of the hind femur pale almost to the knee. Tibiae often with a line of pale scales on underside; hind tibia distinctly shorter than fore tibia. Fore and mid tarsi with faint pale rings, and hind tarsus with clearer rings, at the base of each segment, sometimes indistinct on the more distal segments. Fore and mid claws equal and toothed, hind claws equal and simple.

Abdomen.—Tergites II-VI dark-brown, each with a narrow, median, apical patch of pale yellow scales, VIII almost covered with pale yellow scales; I-VII with large, lateral patches of creamy-white scales which do not extend to the dorsum nor connect with the dorsal, median patches. Sternites clad entirely with creamy, yellowish scales.

ADULT ♂.

Coloration as in female. Palps with clear, pale rings at the middle of the long segment and at the bases of the penultimate and terminal segments; longer than the proboscis by nearly the length of the terminal segment. Segment IV of fore tarsus slightly shorter than V and less than half as long as III. Fore claws unequal, the larger claw toothed; mid claws equal and toothed; hind claws equal and simple.

Terminalia (fig. 4).—Basal lobe of coxite with three blunt spines; style not expanded distally, and with five or six finger-like appendages terminally.

LARVA.

Head.—Seta 1 single, long and tapering, arising from a stout tubercle; seta 4 with 8-15 fine branches; seta 5 with 2-8 branches; seta 6 single, long and quite stout; seta 7 bifid or trifid; seta 8 with 2-6 branches; seta 9 bifid, stout; seta 10 bifid; seta 11 with 6-8 branches; seta 12 with 5-10 branches; seta 13 single or bifid; seta 14 with about 10 branches; seta 15 with 4-5 branches. Mentum dark-brown with a central tooth and 6-8 laterals. Antenna smooth, 5 times as long as the basal width; antennal hair single, inserted about 2/5-1/2 the length of the shaft from the base.

Abdomen.—Segment VIII: seta 1 small, with more than 12 branches; seta 2 with 1-6 branches; seta 3 very stout and outstanding, with 5-11 branches; seta 4 with 3-7 branches; seta 5 with 2-12 branches. Comb patch of 10-14 comb-like scales. Siphon short and stout, less than 1½ times as long as broad; siphonal hair bifid, inserted 5/6-7/8 the length of the siphon from the base. Siphon slightly more than three times as long as the saddle. Anal segment: with both a dorsal and a ventral sclerotized plate, the dorsal plate (the saddle) larger than the ventral plate; seta 1 small, with about 10 branches; seta 2 with 3-6 branches; seta 3 bifid; seta 4 (ventral brush) with 10 tufts of 2-4 branches each (mostly 2). Gills large and pendulant in living larvae.

Distribution.

India, Burma, Yunnan, Indochina, Thailand, Malaya, Sumatra, Java, Borneo, Philippines, Taiwan, China.

Notes.

In addition to several long series from Malaya, 5 ♂♂ and 5 ♀♀ from "Shui-li, Nan-tou, Taiwan: Bamboo stump, Aug. 4 1954 (*J. K. Ni*)" have been examined.

Armigeres (Leicesteria) magnus (Theobald, 1908)

Brevirhynchus magnus Theobald, 1908, *Rec. Indian Mus., 2:* 293.
Leicesteria annulitarsis Leicester, 1908. *Stud. Inst. med. Res. F.M.S., 3* (3): 99 (♂ only).
Toxorhynchites rectirostris (Giles MS.) Theobald, 1910, *Monogr. Culic., 5:* 214.

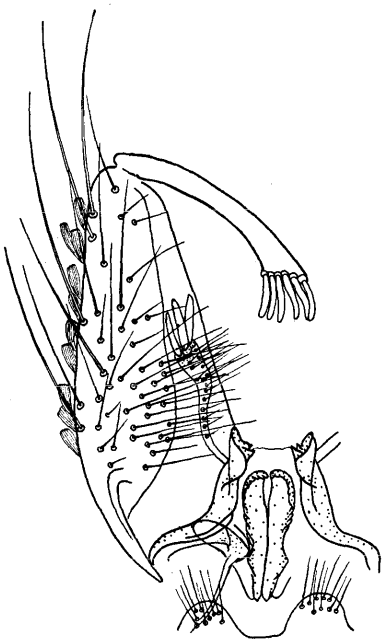


Fig. 4. *Armigeres* (*L.*) *flavus* (Leic.)

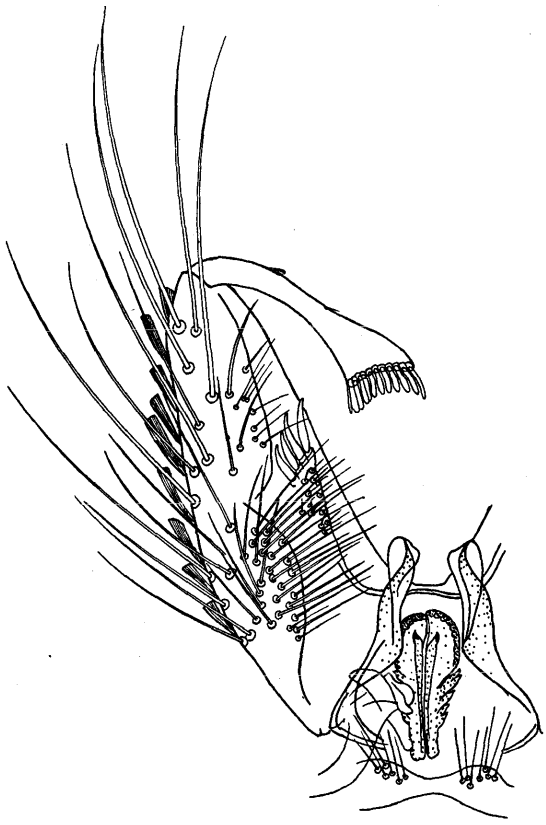


Fig. 5. *Armigeres* (*L.*) *magnus* (Theo.)

Male terminalia.

Types: *magnus*, ♂ and ♀ from Sylhet, Assam, 10. v. 1905 (*Major Hall*) in Indian Mus., Calcutta; *annulitarsis*, ♂ from "Bamboo, Ulu Klang jungle, 8/10/03" and numbered "69 ♂" in Brit. Mus.; *rectirostris*, ♀ from "Philippine Is., Jan., 1905, *Lieut E. R. Whitmore*" in Brit. Mus.

ADULT ♀.

Head.—Largely covered with flat, dark scales but with patches of pale scales and a small group of pale, upright scales on the nape. Palps slightly more than half the length of the proboscis; tips of palps pale; there may be some pale scales at the base of the terminal segment. Clypeus with two basal patches of broad scales. Inner face of torus with pale and dark scales.

Thorax.—Not markedly compressed laterally nor produced forwards over the head. Scutum dark with scattered pale scales and a border of white scales which are broad in front of the wing roots and narrow over the posterior pronotal area; scutellar lobes covered with flat, dark and pale scales. Anterior pronotal lobes largely covered with broad, white scales, but with some dark scales above; posterior pronotum with white scales below and either white, dark, or mixed dark and white scales above. Propleural-fore coxal scale patch with a single band of black scales on the fore coxa. Mesepimeral scale patch broad, extending to the lower suture.

Legs.—Undersides of femora and sometimes of tibiae and tarsi pale-scaled; pale rings at the bases of the tarsal segments, most clear on the hind tarsus. Fore and mid claws equal and toothed; hind claws equal and simple.

Abdomen.—Tergites dark, with median, dull, pale, basal markings on II-VII; on the anterior segments these basal markings may be indistinct, but on segments VI and VII they usually form a broad basal band; tergite VIII largely covered with dull, pale scales. On segments I-VII broad, lateral patches of pale scales; on I-III these scales are entirely white, on IV-VII the basal scales are yellow, sometimes a few are brown, and the apical scales are white; on VI and VII the lateral, yellow scales may join the dorsal, basal band. Sternites with dull white scales basally, and broad, apical, dark bands on III, IV and V, and a narrow, apical, dark band on VI.

ADULT ♂.

Coloration much as in female. Palps with an ill-defined, pale area in the middle of the long segment and narrow, pale rings at the bases of the two distal segments; longer than the proboscis by about the length of the last segment. Proboscis dark, with a small patch of white scales at the base on the underside. Clypeal scales absent (? always). Fore claws unequal, the larger toothed; mid claws equal and toothed; hind claws equal and simple.

Terminalia (fig. 5).—Coxite heavily clad with stout setae ventrally; basal lobe with four blunt spines. Style expanded distally bearing about 12 digitate appendages; the shaft of the style with an occasional small scale or seta on the outer surface.

LARVA.

Head.—Seta 1 single, long and tapering; seta 4 usually with 7-8 branches; seta 5 with 2-6 branches; seta 6 single, long and stout; seta 7 single or bifid, long and stout; seta 8 bifid; seta 9 single or with small, accessory, secondary branch, stout; seta 10 single; seta 11 small, 5-7 branches; seta 12 with 3-4 branches; seta 13 bifid or trifid; seta 14 with 4-5 branches; seta 15 with 4-5 branches. Mentum dark-brown with a central tooth and six laterals. Antenna smooth, 5 times as long as the width at the base; antennal hair single, inserted about 2/5 the length of the shaft from the base.

Abdomen.—Segment VIII: seta 1 small, with about 12 or more branches; seta 2 with 2-4 branches; seta 3 very stout and outstanding, with 3-5 branches; seta 4 with 2-4 branches; seta 5 with about 12 branches. Comb of 4-6 comb-like scales. Siphon short and stout, about as broad as long; siphonal hair bifid, inserted 4/5-5/6 the length of the siphon from the base. Siphon about three times as long as the saddle. Anal segment: with a large dorsal plate (the saddle) and a small sclerotized plate on the ventral side just proximal to the ventral brush; seta 1 small, with six or more branches; seta 2 with 4-5 branches; seta 3 trifid; seta 4 (ventral brush) with 12 tufts, usually of 2-3 branches each (mostly 2-branched).

Distribution.

Ceylon, India, Burma, Yunnan, Indochina, Thailand, Malaya, Sumatra, Java, Borneo, Philippines, Hong Kong, Taiwan.

Notes.

There have been conflicting descriptions of the clypeus of the male. Leicester (1908) and Borel (1930) both state that the clypeus is scaled; Baisas (1935), on the other hand, says that the clypeus is bare; whilst Barraud (1927, 1934) omits all mention of clypeal scaling so presumably the clypeus was bare in his material. In all my males (30 specimens) the clypeus is bare, but it may be that the scales are easily lost. Clearly no reliance can be placed on this character.

In addition to several series of specimens from Malaya, 5 ♂♂ and 5 ♀♀ from "Chu-Shan, Nan-tou, Taiwan: Bamboo stump, Feb. 1955 (*C. L. Chung*)" have been examined, and 2 ♂♂ and 3 ♀♀ from the Philippine Islands.

Armigeres (Leicesteria) annulitarsis (Leicester, 1908)

Leicesteria annulitarsis Leicester, 1908, *Stud. Inst. med. Res. F.M.S.*, *3* (3): 99 (♀ only).

Types: 2 ♀♀ syntypes marked "Own person, jungle, Pahang Road, 5¾ mile fr. Kuala Lumpur, evening, 4/4/03" and "Jungle 6 miles fr. Kuala Lumpur, 15/11/03", both numbered "69" in Brit. Mus. There are 2 other ♀♀ of Leicester's in the Brit. Mus, but they are not marked as syntypes. Data are "Jungle, 6 miles from Kuala Lumpur, 20/12/03" and "Pahang Rd jungle, 5¾ mile fr. Kuala Lumpur, 18/3/02, evening *G. F. Leicester*".

ADULT ♀.

Head.—Dorsum largely covered with flat, dark scales, but with a median patch of pale scales and a prominent lateral strip of pale scales; a small group of upright scales on the nape. Palps clearly white-tipped, and about half the length, or slightly more, of the proboscis. Clypeus with pale scales forming two patches antero-laterally. Torus with pale and dark scales on the inner face; basal segment of flagellum with a patch of white scales.

Thorax.—Moderately compressed laterally, not strongly produced over the head. Scutum dark with a fringe of white scales, broad at the sides, narrow round the front. Scutellar lobes covered with flat, dark and pale scales. Mesepimeral scale patch does not extend to the lower suture. Propleural-fore coxal scale patch with a single band of black scales on the fore coxa.

Legs.—Pale scaling on outer surface of hind femur does not reach the knee. Fore, mid and hind tarsi with clear pale rings at the base of each segment; sometimes indistinct on more distal segments. Fore and mid claws equal and toothed; hind claws equal and simple.

Abdomen.—Tergites I-VI black dorsally; VII sometimes with basal pale scales; VIII with a dull yellow, basal band or entirely yellow: I-VII with lateral, white markings, and lateral, basal, yellow patches on IV-VII. Sternites usually with clear, apical, black bands, but sometimes these are reduced and very narrow.

ADULT ♂.

Coloration much as in female. Palps with clear rings on the long segment and at the bases of the two end segments. Fore tarsal segments III and IV each shorter than segment V. Fore tarsal claws unequal, the larger not toothed, the smaller very much reduced in size; mid claws equal and toothed; hind claws equal and simple.

Terminalia (fig. 6).—Basal lobe of coxite with a row of seven blunt spines; proximal to the spines a patch of long setae. Style not expanded distally, terminating in five digitate appendages of about equal length.

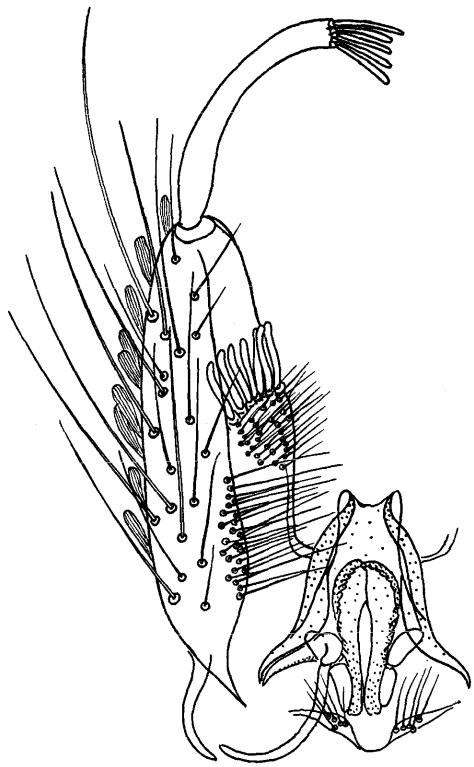


Fig. 6. *Armigeres* (*L.*) *annulitarsis* (Leic.)

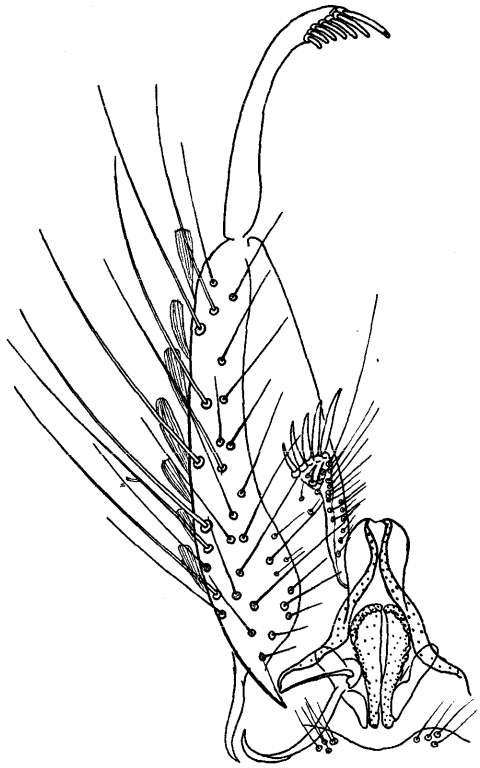


Fig. 7. *Armigeres* (*L.*) *dolichocephalus* (Leic.)

Male terminalia.

LARVA.

Head.—Seta 1 single; seta 4 with 6-11 branches; seta 5 with 4-6 branches; seta 6 single; seta 7 with 2-4 branches; seta 8 bifid or trifid; seta 9 bifid or trifid; seta 10 bifid or trifid; seta 11 small, with 1-3 branches; seta 12 with 4-8 branches; seta 13 with 1-4 branches; seta 14 with 5-9 branches; seta 15 with 6-8 branches. Mentum dark-brown, with a central tooth and 7-8 laterals. Antenna smooth, about 6 times as long as the basal width; antennal hair single or bifid, inserted 2/5-1/2 the length of the shaft from the base (occasionally nearer the base).

Abdomen.—Segment VIII: seta 1 with about 12 branches; seta 2 with 4-5 branches; seta 3 stout, with 5-6 branches; seta 4 trifid; seta 5 with 5-6 branches. Comb of 15-27 comb-like scales. Siphon a little longer than broad; siphonal hair single or bifid, inserted 3/4-4/5 the length of the siphon from the base. Siphon about three times as long as the saddle. Anal segment: with a dorsal sclerotized plate (the saddle) but no ventral plate; seta 1 with 5-6 branches; seta 2 with 6 branches; seta 3 with 3-5 branches; seta 4 (ventral brush) with 10 tufts of 3-6 branches each (mostly 4-5).

Distribution.

India, Indochina, Thailand, Malaya, Sumatra, Java, Taiwan.

Armigeres (Leicesteria) dolichocephalus (Leicester, 1908)

Leicesteria dolicocephala Leicester, 1908, *Stud. Inst. med. Res. F.M.S.*, *3* (3): 95.
Leicesteria dolichocephala, spelling corrected by Brunetti, 1912, *Rec. Indian Mus.*, *4:* 455.

Types: 4 ♀♀ syntypes from "Pahang Rd. jungle, 5¾ miles fr. Kuala Lumpur, 8/9/03", "Jungle, 6 miles fr. Kuala Lumpur, 15/11/03" and "Jungle, 5 miles fr. Kuala Lumpur, 16/11/03" (2 specimens) in Brit. Mus. All four are numbered "68".

ADULT ♀.

Head.—Dorsum covered with dark scales, with a few white sometimes forming a median strip; some white upright scales on the nape; laterally, white scales, then dark, then white again. Palps and proboscis dark, palps half as long as proboscis; the proboscis may have a strip of dull, pale scales on underside. Clypeus without scales. Torus with white and brown scales on inner side; first segment of flagellum with patch of white scales on inner face.

Thorax.—Moderately laterally compressed and noticeably produced over the head; anterior pronotal lobes reduced. Scutum covered with narrow, dark-brown and pale brown scales; mid lobe of the scutellum, and sometimes side lobes, with pale scales; mesonotal fringe of broad, pale scales, but round the front margin the broad scales are mixed with narrow ones or the scales are all narrow. Anterior pronotal lobes largely covered with broad, white scales with some dark scales above; posterior pronotum with broad, white scales below and dark scales above. Propleural-fore coxal scale patch with a single black band. Mesepimeral scale patch extends to the lower suture and covers the lower region of the sclerite.

Legs.—Under femora pale-scaled; the pale scaling of the outer hind femur stops short of knee; undersides of tibiae with dull, pale scaling usually along whole length; fore tibia very noticeably the shortest. Tarsi with indistinct pale rings at the bases of the segments—not always clear, though usually distinct on segments I and II and sometimes III. Claws as usual.

Abdomen.—Lateral tergal markings white and yellow: I-III markings all white; IV-VII, and sometimes III, with prominent, basal, yellow markings which join with the more apical white patches; the latter run obliquely towards the dorsum but do not extend appreciably on it; on tergite VII, however, there may be a suggestion of a basal band of yellowish scales, which has encroached from the lateral basal patches, but usually this basal band is incomplete medially. Tergite VIII is largely covered with dull, yellowish scales, at least on the basal half. Sternite II white; sternites III-VII with clear, apical, black bands, of diminishing width from III to VII; otherwise sternites white-scaled with basal, lateral, yellow spots.

ADULT ♂.

Coloration as in female. Palps dark with indistinct pale ring in centre of long segment, longer than proboscis by less than the length of the terminal segment. More narrow than broad scales round front margin of mesonotum. Claws as usual.

Terminalia (fig. 7).—Basal lobe of coxite with a row of five spines; proximal to the spines a patch of setae. Style curves distally and terminates in a row of seven appendages of graded lengths.

LARVA.

Head.—Seta 1 single, arising from a small tubercle; seta 4 with 6-9 branches; seta 5 with 3-5 branches; seta 6 single, long and tapering; seta 7 trifid; seta 8 bifid or trifid; seta 9 bifid or trifid; seta 10 with 2-4 branches; seta 11 small, bifid or trifid; seta 12 with 4-5 branches; seta 13 bifid; seta 14 with 4-6 branches; seta 15 with 4-6 branches. Mentum dark-brown with a central tooth and 7-8 laterals. Antenna smooth, about 7 times as long as the basal width; antennal hair single, inserted a little less than half the length of the shaft from the base.

Abdomen (fig. 3b).—Distinguishes this species from all others of the group. Segments I-VII are characterized by large, prominent, lightly spiculate tubercles from which arise stout, lateral, dorsal and ventral setae: on segments I-VI there is a pair of lateral tubercles; on segment III-V a pair of ventral tubercles; and on segments V-VII a pair of dorsal tubercles. Segment II with a patch of fine spicules. Segment VIII: seta 1 with 5-10 branches; seta 2 with 3-5 branches; seta 3 not so outstanding as in other species, with 3-4 branches; seta 4 with 2-4 branches; seta 5 small, usually with about 12 or more branches, rarely with only two or three. Comb of 16-26 scales, each with a large central spine and usually with several accessory lateral spines. Siphon a little longer than broad; siphonal hair with 1-4 branches, situated 5/6-7/8 the length of the siphon from the base. Siphon a little more than twice as long as the saddle. Anal segment: with a dorsal sclerotized saddle, but no ventral plate; seta 1 with 3-5 branches; seta 2 bifid or trifid; seta 3 single or bifid; seta 4 (ventral brush) with 10 tufts of 2-4 branches each.

Distribution.

Indochina, Thailand, Malaya, Sumatra, Java.

Armigeres (Leicesteria) inchoatus Barraud, 1927

Armigeres (Leicesteria) inchoatus Barraud, 1927, *Indian J. med. Res., 14:* 544.

Type: Holotype ♂ from Tindharia, Darjeeling district, India, x. 1922, in Brit. Mus.

ADULT ♀.

Head.—Largely dark-scaled, sometimes with a small patch of pale scales on the dorsum; a few dark upright scales on the nape. Palps slightly longer than half the proboscis; usually, but not always, with a clear ring of pale scales at the base of the terminal segment. Clypeus bare. Torus with both brown and pale scales on the inner face; first segment of the flagellum with pale scales.

Thorax.—Slightly compressed laterally and slightly produced over the head. Scutum covered with brown scales; scutellar lobes with flat, dark scales interspersed with a few pale ones; usually a streak of pale scales in front of the mid-lobe. Mesonotal fringe of broad, white scales except round the front margin where the scales are narrower; a patch of narrow, white scales in front of and above the wing root. Anterior pronotal lobes and posterior pronotum with broad scales, white below and dark above. Propleural-fore coxal scale patch with a single band of black scales. Mesepimeral scale patch extends nearly but not quite to the lower suture and usually widens slightly at the base.

Legs.—Undersides of femora pale-scaled; pale scaling on outer side of hind femur does not reach the knee; tibiae with variable amount of pale scaling on undersides, and small patch of white scales at the base, not forming a ring. Tarsi with pale rings at the base of each segment, usually most distinct on the mid and hind tarsi. Fore and mid claws equal and toothed, hind claws equal and simple.

Abdomen.—Lateral white markings on tergites II-VII arise from the base of the segments and curve obliquely towards the dorsum; no bands are formed; no yellow markings are present. There may be a few pale scales basally on tergite II, but not a band as in *annulipalpis*. Sternites III-VII with broad, basal bands of white scales and usually distinct, apical, black bands.

ADULT ♂.

Coloration as in female. Palps with a clear pale ring at middle of long segment, and usually distinct, white, basal bands on the two terminal segments; longer than proboscis by about the length of the terminal segment. Usually the scutellar lobes are largely pale-scaled. Again, as in the female, there may be a few pale scales at the base of abdominal tergite II. Fore claws unequal, larger claw toothed, smaller claw very narrow and not easily seen; mid claws equal and toothed; hind claws equal and simple.

Terminalia (fig. 8).—Basal lobe of coxite with a row of five graded spines; proximal to the spines is a patch of setae. Style widens distally and terminates in about nine digitate appendages, the outer of which is thinner and longer than the remainder.

LARVA.

Head.—Seta 1 single; seta 4 with 4-10 branches; seta 5 with 4-5 branches; seta 6 single; seta 7 single; seta 8 single or bifid; seta 9 single; seta 10 single; seta 11 with 1-4 branches; seta 12 with 4-5 branches; seta 13 single or bifid; seta 14 with 4-6 branches; seta 15 with 6-8 branches. Mentum dark-brown, with a central tooth and 7-9 laterals. Antenna smooth, about 6 times as long as the basal width; antennal hair single, inserted about 2/5 the length of the shaft from the base.

Abdomen.—Segment VIII: seta 1 with about 9-12 branches; seta 2 with 3-4 branches; seta 3 stout and outstanding, with 5-9 branches; seta 4 bifid or trifid, situated close to seta 3; seta 5 single or bifid and very stout. Comb of 36-49 fringed scales. Siphon about 1½ times as long as broad; siphonal hair single, inserted 3/4-4/5 the length of the siphon from the base. Siphon about four times as long as the saddle. Anal segment: with a dorsal, but no ventral, plate; seta 1 with 3-4 branches; seta 2 with 4-5 branches; seta 3 with 2-4 branches; seta 4 (ventral brush) with 10 tufts of 2-6 branches each.

Distribution.

East Himalayas, Thailand, Malaya.

Notes.

Barraud (1934: 328) states that the type ♂ and allotype ♀ are in the British Museum, and presumably he himself lodged them there. However, I am informed by Mr P. F. Mattingly that only the ♂ is in the Museum; the ♀ has not been traced.

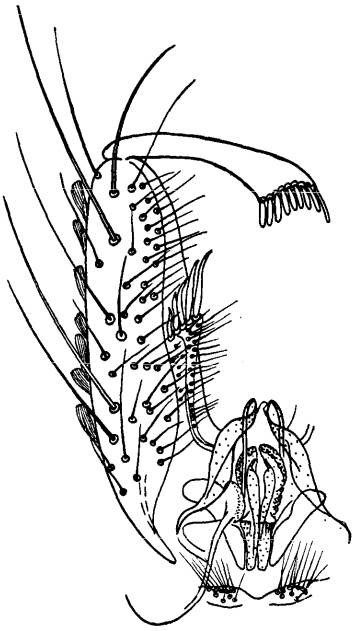


Fig. 8. *Armigeres* (*L.*) *inchoatus* Barr.

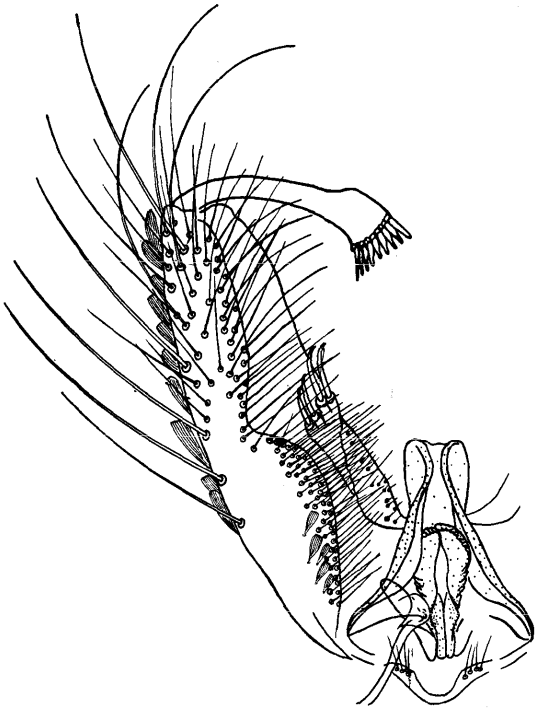


Fig. 9. *Armigeres* (*L.*) *pectinatus* (Edw.)

Male terminalia.

Armigeres (Leicesteria) pectinatus (Edwards, 1914)

Leicesteria pectinata Edwards, 1914, *Bull. ent. Res.*, *4:* 263.

Types: Holotype ♂ from Jugra, Selangor, "leaf in jungle, 3/9/04" in Brit. Mus. Mr Mattingly has marked the following specimens in the Brit. Mus. as paratypes: one ♂ without data, and one ♀ marked "Nebory [? Nebong] leaf, Jugra, jungle, 7/9/04".

ADULT ♀.

Head.—Dark scales on the dorsum with a small median streak of white scales; pale upright scales on the nape; laterally a white streak of scales, then a patch of dark, and white ventrally. Eyes bordered with white scales. Palps and proboscis dark, palps half the length of the proboscis. Clypeus dark, without scales. Torus with white scales on the inner and anterior faces, a few darker scales posteriorly; flagellum with pale scales on the first segment.

Thorax.—Not very compressed laterally, nor produced over the head. Mesonotal fringe of broad scales. Anterior pronotal lobes and posterior pronotum with broad, white scales below the broad, dark scales above. Propleural-fore coxal scale patch with two bands of black scales between white scales, a

small upper band on the propleuron, the lower band on the fore coxa. Pleurae with usual patches of white scales; mesepimeral scale patch barely reaches the lower suture, usually widening on the lower mesepimeron. Claws as usual.

Abdomen.—Lateral tergal markings entirely white; on IV-VI the markings are boot-shaped, the toe pointing dorsally, often with a distinct "heel". Sternites all white or with narrow, apical, black borders.

ADULT ♂.

Coloration as in female. Proboscis extensively pale-scaled on the underside. Palps with a faint pale ring near the middle of the long segment. Mesepimeral scale patch extends to the lower suture. Fore claws unequal, the larger toothed and the smaller more than half as long as the larger; mid claws equal and toothed; hind claws equal and simple. Sternites as in female.

Terminalia (fig. 9).—Ventral surface of coxite heavily clad in setae, and with a few scales basally; basal lobe with four spines, slightly set apart in pairs, each spine arising from a distinct cylindrical base: proximal to the spines the usual patch of setae is absent. Style distinctly enlarged distally, with a row of nine digitate appendages terminally.

LARVA.

Head.—Seta 1 single, arising from a small tubercle; seta 4 with 5-9 branches; seta 5 with 3-5 branches; seta 6 single; seta 7 single; seta 8 bifid or trifid; seta 9 single; seta 10 with 1-3 branches; seta 11 small, with 1-3 branches; seta 12 with 6-7 branches; seta 13 single or bifid; seta 14 with 4-5 branches; seta 15 with 7-9 branches. Mentum dark-brown with a central tooth and 7-8 laterals. Antenna smooth, about 6 times as long as the basal width; antennal hair single or bifid, inserted 1/2-3/5 the length of the shaft from the base.

Abdomen (fig. 3c).—Segment I with a pair of prominent lateral setae, each with 2-5 branches, also a pair of smaller but distinct ventral setae; segment II with a central patch of very fine spicules, lateral setae with 1-5 branches, ventral setae stout and prominent, raised on small tubercles; segment III lateral setae single or bifid, ventral setae stout and prominent, raised on small tubercles; segments IV and V with small lateral setae, but prominent, stout, ventral setae similar to those on segments II and III. Segment VIII: seta 1 with 6-8 branches; seta 2 single or bifid; seta 3 stout and prominent, with 2-4 branches; seta 4 bifid; seta 5 single and tapering. Comb of quite variable number of scales, between 18-46, each bluntly pointed with a basal lateral fringe, and slightly hooked terminally. Siphon short and stout, about as broad as long; siphonal hair bifid, inserted about 3/5 the length of the siphon from the base. Siphon about twice as long as the saddle. Anal segment: with a dorsal but no ventral sclerotized plate; seta 1 with 4 branches; seta 2 with 4-7 branches; seta 3 with 3-4 branches; seta 4 (ventral brush) with 10 tufts of 3-5 branches each.

Distribution.

? Indochina, Malaya, Java, Borneo.

Notes.

Borel (1930) records *pectinatus* from Cochinchina but since he only collected females, his identification is in doubt. One or two characters in his description—scales on the clypeus, clear bands on the sternites—are at variance with my specimens.

Armigeres (Leicesteria) dentatus Barraud, 1927

Armigeres (*Leicesteria*) *dentatus* Barraud, 1927, *Indian J. med. Res.*, *14:* 547.

Type: Holotype ♂ from Nongpoh, Khasi Hills district, Assam 3.xi.1921 (*S. R. Christophers*) in Brit. Mus.

ADULT ♀.

Head.—Dorsum dark-scaled with a few pale scales, dark upright scales on nape; white scales dorsolaterally and dark laterally, white ventrally. Palps and proboscis dark, palps about half the length of the proboscis. Clypeus bare. Torus with pale and dark scales, pale anteriorly and round the rim, dark posteriorly and nearer the base; first segment of the flagellum with white scales on inner face.

Thorax.—Not markedly compressed laterally but produced over the head; anterior pronotal lobes partly "suppressed" by mesonotum. Scutum dark. Dark and pale flat scales on scutellar lobes. Both anterior pronotal lobes and posterior pronotum with broad, white scales below and broad, dark scales above. Propleural-fore coxal scale patch with two bands of black scales. Mesepimeral scale patch tapers bluntly and does not reach the lower suture (fig. 1a). Mesonotal fringe of yellowish-white scales, broad along the sides and narrow round front margin. Claws as usual.

Abdomen.—Lateral tergal markings mainly white, usually boot-shaped on IV-VI; small, basal, yellowish markings, sometimes indistinct, on V-VII. Sternites III-VII with clear, apical, dark bands, remainder of segments white except for yellowish basal bands on VI and VII which merge with the white scaling.

ADULT ♂.

Coloration as in female. Proboscis with a line of pale scales on the underside extending from near the base to 2/3-3/4 the length of the proboscis. Palps dark except for a faint, pale ring near the middle of the long segment; longer than proboscis by about length of terminal segment. Claws as usual.

Terminalia (fig. 10).—Basal lobe of coxite with a row of four spines and a more proximal patch of setae. Style widens slightly distally, and terminates in a row of about 10 digitate appendages.

LARVA.

Head.—Seta 1 single; seta 4 with 10-14 branches; seta 5 with 2-7 branches; seta 6 single; seta 7 bifid or trifid; seta 8 bifid or trifid; seta 9 bifid; seta 10 with 1-3 branches; seta 11 small, with 4-6 branches; seta 12 with 6-8 branches; seta 13 with 2-4 branches; seta 14 with 9-20 branches; seta 15 with 6-10 branches. Mentum dark-brown in colour, with a central tooth and 8-9 laterals. Antenna smooth, about 6 times as long as the greatest width; antennal hair single, inserted 1/4-1/3 the length of the shaft from the base.

Abdomen.—Segment VIII (fig. 2b): seta 1 with 12-14 branches; seta 2 with 5-6 branches; seta 3 stout and prominent, with 6-12 branches; seta 4 bifid or trifid; seta 5 stout and prominent, single or bifid. Comb of 13-20 scales, most with a short, blunt, central tooth and strong basal fringe, otherwise with a uniform fringe. Siphon slightly longer than wide; siphonal hair with 2-5 branches, inserted 2/3-3/4 the length of the siphon from the base. Siphon about 2½ times the length of the saddle. Anal segment: with a dorsal, but no ventral, sclerotized plate; seta 1 with 10-12 branches; seta 2 with 3-5 branches; seta 3 bifid or trifid; seta 4 (ventral brush) with 10 tufts of 2-8 branches each.

Distribution.

Assam, Thailand, Malaya.

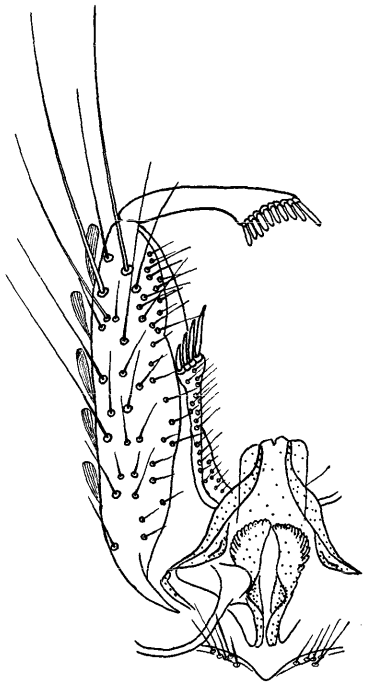


Fig. 10. *Armigeres* (*L.*) *dentatus* Barr.

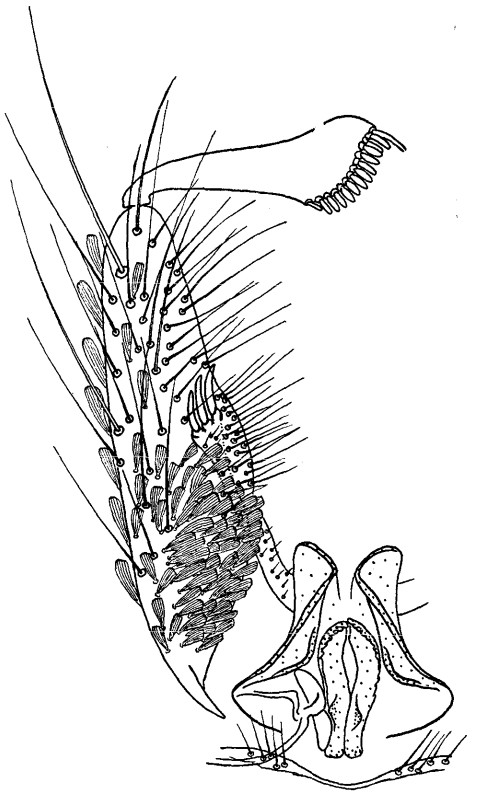


Fig. 11. *Armigeres* (*L.*) *omissus* (Edw.)

Male terminalia.

Armigeres (Leicesteria) omissus (Edwards, 1914)

Leicesteria omissa Edwards, 1914, *Bull. ent. Res., 5:* 76.

Types: Holotype ♂ from "Columbo, Ceylon, 1913, *Maj. S. P. James*" in Brit. Mus. together with the following paratypes: one ♀ with same data as holotype, and 4 ♀♀ marked "Peradeniya, Ceylon, ix: 1910, *E. E. Green.*" The Peradeniya specimens have associated larval and pupal skins.

ADULT ♀.

Head.—In dried specimens, rather flattened and protruding forwards more than usual. Palps as long as or slightly longer than half the proboscis. Clypeus bare. Torus and flagellum as usual.

Thorax.—Moderately laterally compressed, strongly produced over the head; anterior pronotal lobes partly "suppressed" by mesonotum. Scutum dark-brown with scattered, narrow, pale scales; mesonotal fringe of broad, white scales right round, with, in addition, some narrower scales round the front margin; scutellar lobes dark with some pale scales, mostly massed on the middle lobe. Posterior pronotum with broad, white scales below and broad, dark scales above. Propleural-fore coxal scale patch with two bands of black scales between white scales. White scale patch on the mesepimeron extends to the lower suture and may cover the lower 1/5 of the sclerite.

Abdomen.—Dark dorsally except for a pale, basal band on segment VIII; lateral tergal markings white with some yellow scaling basally on segments VI and VII, and sometimes on segment V. Sternites III-VII with clear, dark, apical bands, otherwise clad in dull white scales except for a yellow, basal band on VI and VII.

ADULT ♂.

Proboscis with line of pale scales underneath on the basal three-quarters. Palps dark except for a faint, pale ring at the middle of the long segment (due to a few pale scales or to denudation). Palps longer than proboscis by less than the length of the terminal segment. Thorax not so markedly produced over the head as in female, and, consequently, anterior pronotal lobes not so reduced. Claws as usual. Sternites II-V largely dark, with basal, lateral, white patches; VI and VII largely pale-scaled with apical dark bands.

Terminalia (fig. 11).—Ventral surface of coxite heavily clad in scales basally; basal lobe with three blunt spines and a more proximal small scale patch. Style greatly enlarged distally, terminating in a row of about 14 digitate appendages.

LARVA.

Head.—Seta 1 single; seta 4 plumose, with up to 20 or more branches; seta 5 with 6-9 branches; seta 6 single or bifid; seta 7 with 1-4 branches; seta 8 bifid or trifid; seta 9 with 1-3 branches; seta 10 bifid or trifid; seta 11 with 3-5 branches; seta 12 with 6-8 branches; seta 13 bifid or trifid; seta 14 with 7-14 branches; seta 15 with 5-12 branches. Mentum dark-brown in colour, with a central tooth and 7-9 laterals. Antenna smooth, between 5 and 6 times as long as the basal width; antennal hair single or bifid, inserted less than 1/3 the length of the shaft from the base.

Abdomen.—Outstanding lateral setae on segments I-III with 2-6 branches. Segment VIII (fig. 2a): seta 1 with 9-14 branches; seta 2 with 3-8 branches; seta 3 with 4-6 branches, stout and outstanding; seta 4 single or bifid; seta 5 with 4-6 branches. Comb of 12-29 scales, each fringed with sharp-pointed spines of which the central one may be most prominent. Siphon about as long as broad; siphonal hair single, long and prominent, inserted slightly less than 3/4 the length of the siphon from the base. Siphon twice as long as the saddle, or a little less. Anal segment: with a dorsal, but no ventral, sclerotized plate; seta 1 with 3-6 branches; seta 2 with 6-9 branches; seta 3 with 6-7 branches; seta 4 (ventral brush) with 10 tufts of 3-8 branches each.

Distribution.

Ceylon, India, Thailand, Malaya, ? Java, Taiwan.

Notes.

In addition to Malayan material, 5 ♂♂ and 5 ♀♀ from Wu-lai, Tai-pei, Taiwan, ix. 1954 (*H. M. Lin*) were examined. The larvae had been collected from *Colocasia* axils.

Armigeres (Leicesteria) longipalpis (Leicester *in* Theobald, 1904)

Leicesteria longipalpis Leicester *in* Theobald, 1904, *Entomologist, 37:* 211.
Leicesteria cingulata Leicester, 1908, *Stud. Inst. med. Res., F.M.S., 3* (3): 97 (in part, 3 ♀♀ syntypes only).
Armigeres cingulatus of Barraud, 1927, *Indian J. med. Res., 14:* 545.
Leicesteria cingulata of Borel, 1930, *Moustiques de Cochinchine,* p. 202.

Types: longipalpis, holotype ♂ and allotype ♀ both marked "mosquito No. 6, Kuala Lumpur, *Dr. Leicester*" in Brit. Mus.; *cingulata*, types lost.

ADULT ♀.

Head.—Largely dark-scaled with some flat, white scales on the dorsum and a small patch of pale, upright scales on the nape; a band of pale scales laterally. Palps and proboscis dark, the palps about half the length of the proboscis. Clypeus with prominent white scales in two groups antero-laterally. Torus with pale scales anteriorly and brown scales posteriorly: flagellum with pale scales on first segment. There may be a line of dull, pale scales running nearly the whole length of the underside of the proboscis.

Thorax.—Not laterally compressed nor strongly produced over the head. Scutum mainly dark-scaled but with scattered pale scales. Mesonotal fringe white, of broad scales at the sides and narrow in front. Scutellar lobes with flat, dark and pale scales. Anterior pronotal lobes pale below, dark above, posterior pronotum pale below with dark and pale scales above. Propleural-fore coxal scale patch with a single band of black scales on the fore coxa. Mesepimeral scale patch extends to the lower suture and widens near the base. Claws as usual.

Abdomen.—Lateral white markings on tergites II-VII arise from the base of the segments and curve obliquely to the dorsum, usually forming dorsal, apical or subapical, pale bands on those segments; sometimes the bands are incomplete. No lateral yellow markings. Sternites usually pale-scaled, or with very narrow, apical, dark bands.

ADULT ♂.

Coloration and banding as in female. Palps longer than the proboscis by about half the length of the terminal segment; dark, without pale scales, but there is often a bare ring near the middle of the long segment. Proboscis usually with a line of dull, pale scales on the underside reaching from the base to near the tip. Fore tarsus III more or less equal in length to V, IV about half those lengths. Fore claws unequal, the larger toothed, the smaller little longer than the tooth on the large claw; mid claws equal and toothed; hind claws equal and simple.

Terminalia (fig. 12).—Coxite with a clear patch of scales on the ventral surface; basal lobe with three blunt spines and a proximal area of setae. Style of unusual shape: much wider than in the other species, with 3 small digitate appendages arising from the outer margin subterminally; a small group of setae on the dorsal surface.

LARVA.

Head.—Seta 1 single; seta 4 with 11-13 fine branches; seta 5 bifid or trifid; seta 6 single and stout; seta 7 single or bifid; seta 8 quite long, with 1-3 branches; seta 9 single; seta 10 single or bifid; seta 11 with 3-4 branches; seta 12 with 5-8 branches; seta 13 with 2-4 branches; seta 14 with more than 12 branches; seta 15 with 7-9 branches. Mentum triangular, dark-brown in colour, with a central tooth and 7 laterals. Antenna smooth, about 7 times as long as the basal width, antennal hair single, inserted a little beyond the middle of the shaft.

Abdomen.—Segment VIII: seta 1 with 10-12 branches, occasionally more; seta 2 bifid or trifid; seta 3 with 5-6 branches; seta 4 with 4-5 branches; seta 5 stout and single. Comb of 70-85 scales, with or without a small, central, sharp-pointed spine, otherwise uniformly fringed; the distal scales are several times larger than those at the base of the comb. Siphon about as broad as long; siphonal hair single, inserted 4/5-5/6 the length of the siphon from the base. Siphon three times, or a little less than three times, as long as the saddle. Anal segment: seta 1 with 6-8 branches; seta 2 trifid; seta 3 bifid; seta 4 (ventral brush) with 10 tufts of 2-5 branches each.

Distribution.

India, Indochina, Thailand, Malaya, Sumatra, Borneo, Boeton.

Notes.

Confusion in the past over the correct identity of *longipalpis* has been caused by Leicester describing this species twice: his *longipalpis* were atypical in that the abdominal tergal banding was incomplete. Later, he described more typical specimens with complete tergal banding as *cingulata*. See also the notes on *balteatus*.

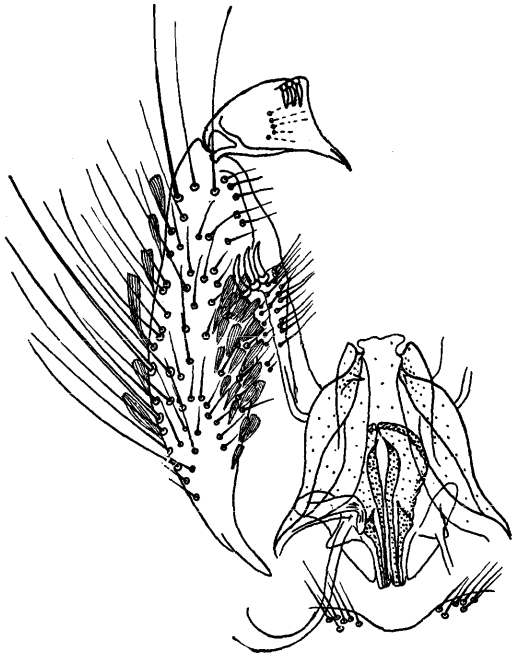


Fig. 12. *Armigeres* (*L.*) *longipalpis* (Leic.)

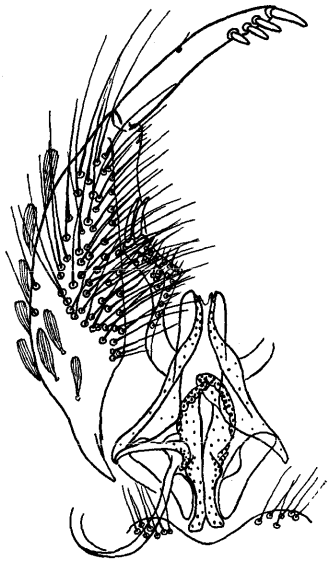


Fig. 13. *Armigeres* (*L.*) *balteatus* n. sp.

Male terminalia.

Armigeres (Leicesteria) balteatus n. sp.

Leicesteria cingulata Leicester, 1908, *Stud. Inst. med. Res. F.M.S.*, *3* (3): 97 (in part, specimens other than the three ♀♀ syntypes).
Leicesteria cingulata of Edwards, 1914, *Bull. ent. Res.*, *4:* 260.

Types: Holotype ♂, 0314/9, allotype ♀, 0314/20, and three male and three female paratypes, all from sibling series, coll. no. 0314 (*W. W. M.*), each with associated larval and pupal skins and originating from a female mosquito caught at 16 m. Ulu Gombak, Selangor, Malaya, 19. viii. 1957, in Brit. Mus. (Nat. Hist.). Three male and three female paratypes with same data, each with associated skins, in U. S. Nat. Mus.

ADULT ♀.

Head.—Largely dark-scaled with a few pale, upright scales on the nape; pale scales laterally. Palps and proboscis dark, palps slightly more than half the length of the proboscis. Clypeus usually bare, but in a few specimens examined there are a few flat, dull, pale scales; these are in no way comparable with the prominent clypeal scales of *longipalpis*. Torus clad mainly with pale scales, but some brown scales posteriorly; flagellum with pale scales on the first segment. Proboscis may have some dull, pale scales on the underside.

Thorax.—Not markedly compressed laterally, slightly produced forwards over the head. Scutum brown-scaled; mesonotal fringe of broad, yellowish scales from in front of wing root to posterior pronotum, and narrow, yellowish scales round front margin. Scutellar scales broad and flat, either brown or dull white in colour. Anterior pronotal lobes and posterior pronotum with broad, white scales below and broad, dark scales above. Propleural-fore coxal scale patch with a single, black band of scales on the fore coxa. Mesepimeral scale patch does not extend to the lower suture.

Legs.—Undersides of femora and tibiae pale; outer side of hind femora with a pale strip which stops distinctly short of the knee. Fore claws equal, each with a minute tooth; mid claws equal, each with a minute tooth; hind claws equal and simple.

Abdomen.—Lateral markings, as in *longipalpis*, curve obliquely to the dorsum usually forming apical or subapical bands on II-IV and sometimes on the more posterior segments. No yellow markings. Sternites III-VII almost entirely white-scaled or with more or less distinct, black, apical bands.

ADULT ♂.

Coloration and banding as in female. Palps with indistinct rings at the middle of the long segment and at the bases of the two terminal segments. Proboscis with a line of dull, pale scales on underside. Fore claws unequal, the larger toothed, the smaller about half the length of the larger; mid claws equal and toothed, the teeth minute and not easily seen; hind claws equal and simple.

Terminalia (fig. 13).—Coxite with a more discrete area of setae than usual on the ventral surface; basal lobe with two blunt spines and a proximal patch of setae. Style tapers slightly distally with a row of four graded digitate appendages terminally; an occasional seta on the outer surface.

LARVA.

Head (fig. 2c).—Seta 1 single; seta 4 single, broad, or with 2-4 broad branches; seta 5 with 1-4 branches; seta 6 broad and single; seta 7 single; seta 8 with 1-4 branches; seta 9 single; seta 10 single or bifid; seta 11 single or bifid; seta 12 with 5-9 branches; seta 13 single or bifid; seta 14 with 4-6 branches; seta 15 with 4-7 branches. Mentum triangular, dark-brown in colour, with a central tooth and 7-8 laterals. Antenna smooth, 8 times as long as the basal width; antennal hair single or bifid, inserted at, slightly beyond, or slightly basal to, the middle of the shaft.

Abdomen.—Segment VIII: seta 1 with 8-12 branches; seta 2 single or bifid; seta 3 with 6-10 branches; seta 4 bifid or trifid; seta 5 stout, single or bifid. Comb of 37-49 scales, with or without a small, central, sharp-pointed spike, otherwise uniformly fringed. Siphon about as long as broad; siphonal hair single, inserted about 2/3-3/4 the length of the siphon from the base. Siphon three times, or a little less than three times, as long as the saddle. Anal segment: with a dorsal, but no ventral, sclerotized plate; seta 1 with 4-6 branches; seta 2 with 5-7 branches; seta 3 with 3-5 branches; seta 4 (ventral brush) with 10 tufts of 3-9 branches each.

Distribution.

Thailand, Malaya, Sumatra, Borneo.

Notes.

When Leicester described *Leicesteria cingulata* (1908:97) he was unaware that a character which he regarded as stable was in fact variable: this character is the apical banding on the abdominal tergites of the adults. Two species may have apical bands—*longipalpis* and *balteatus*—but only one of them, *longipalpis*, has prominent, narrow, white scales on the clypeus. With these two points in mind, it becomes clear from Leicester's description of *cingulata* that he had in fact *longipalpis* in front of him. Earlier, Leicester (1904:211) had described *longipalpis* as having "no dorsal banding, though the white lateral bands almost meet over the apices of the segments", and this difference caused him to raise a new species for the specimens with complete bands.

At the same time he had a male and a female with abdominal banding but without clypeal scales. He mentioned these specimens under his "Remarks" at the end of the description of *cingulata*, but refrained from naming another new species on a single character with so little material. Unfortunately the types of *cingulata* were lost, and, as far as can be determined, the British Museum received the "aberrant" specimens. Edwards (1914) then figured the terminalia of, presumably, the aberrant male, and since they were very different from those of *longipalpis*, he concluded that this was evidence of the distinctness of *cingulata*. Since then several workers have been puzzled by specimens whose terminalia agree with *longipalpis* but otherwise fulfil Leicester's description of *cingulata*.

Whilst it would be convenient to retain, if possible, the name *cingulata* for the species I have re-named *balteatus*, this course is not possible. Following the Copenhagen Decisions on Nomenclature, No. 137 (3), (Hemming, 1953), the "aberrant" specimens in the British Museum cannot be regarded as syntypes of *cingulata*, and they must therefore be disregarded.

Armigeres (Leicesteria) digitatus (Edwards, 1914)

Leicesteria digitata Edwards, 1914, *Bull. ent. Res.*, *4*: 262.

Types: Holotype ♂ marked "Larvae fr. bamboo, Ulu Gombak, *Daniells*, 2/9/03" and numbered "6 ♂" in Brit. Mus. Mr Mattingly has marked the following in the Brit. Mus. as paratypes: one ♂ with same data as holotype except that it is marked 2/9/08 instead of 2/9/03, presumably in error; another ♂ marked "About my person, 1 myle (*sic*), Pahang Rd., 5¾ miles fr. Kuala Lumpur, evening 4/4/03", without number; one ♀ marked "Jungle, The Gap, 16/4/04"; one ♀ marked "The Gap, at edge of stream in jungle, 16/4/04"; and one ♀ marked "Pahang Rd. jungle, 6 miles fr. Kuala Lumpur, mid-day, 19/10/03"; also 1 ♂ and 2 ♀♀ from the Philippines, coll. *C. S. Banks*, the ♂ without other data except the number "Acc. No. 5609, Lot 9", and the ♀♀ with data "Mailum, Negros, P. I., 9-vi-06".

ADULT ♀.

Head.—Dorsum as usual. Palps more than half but less than 2/3 the length of the proboscis. Clypeus bare. Torus mainly white-scaled but a few brown scales posteriorly.

Thorax.—Mesonotum moderately produced over the head, and anterior pronotal lobes partially reduced. Mesonotal fringe of broad, white scales which extend round the front margin. Posterior pronotum with broad, white scales below and dark or pale scales above. Propleural-fore coxal scale patch with a single, black band on the fore coxa. Mesepimeral scale patch extends to the lower suture and widens near the base. Fore and mid claws equal and toothed; hind claws equal and simple.

Abdomen.—Lateral white markings on tergites do not form bands dorsally; on tergites IV-VII the markings are approximately boot-shaped. No lateral yellow markings. Sternites with clear, apical, dark bands, not as broad, however, as in *traubi*.

ADULT ♂.

Palps longer than proboscis by about half the length of the terminal segment. Posterior pronotum may be white below and dark above, or may be entirely covered in broad, white scales, or may be intermediate. As in the female the sternal apical bands are much narrower than in *traubi*. Fore claws unequal, larger claw toothed; mid claws equal and toothed; hind claws equal and simple.

Terminalia (fig. 14).—Basal lobe of coxite with 8 tapering spines grouped in a double row distal to a patch of setae. Style of fairly uniform width throughout its length, terminating in a group of 5 subequal digitate appendages.

LARVA.

Head.—Seta 1 single; seta 4 with 10-13 branches; seta 5 with 5-8 branches; seta 6 stout and single; seta 7 bifid; seta 8 quite long, with 1-3 branches; seta 9 single or bifid; seta 10 single or bifid; seta 11 small, with 1-3 branches; seta 12 with 5-7 branches; seta 13 single or bifid; seta 14 single; seta 15 with 7-9 branches. Mentum triangular, dark-brown in colour, with a central tooth and 8 laterals. Antenna smooth, about 6-7 times as long as the basal width; antennal hair single, inserted 2/5 the length of the shaft from the base.

Abdomen (fig. 3a).—Segments I-IV or II-IV with a large, ventral patch of fine spicules. Segment VIII: seta 1 with 6-8 branches; seta 2 bifid or trifid; seta 3 with 4-6 branches; seta 4 single or bifid; seta 5 single and stout. Comb of 14-41 scales, each with a large central spine and lateral fringe. Siphon a little longer than broad; siphonal hair single and quite stout, inserted slightly more than half-way up the siphon. Siphon a little more than twice as long as the saddle. Anal segment: seta 1 with 3-6 branches; seta 2 with 3-5 branches; seta 3 bifid; seta 4 (ventral brush) with 10 tufts of 2-5 branches each.

Distribution.

India, Thailand, Malaya, Sumatra, Java, Philippines.

Notes.

In addition to Malayan material, one damaged female from the Philippine Islands was examined.

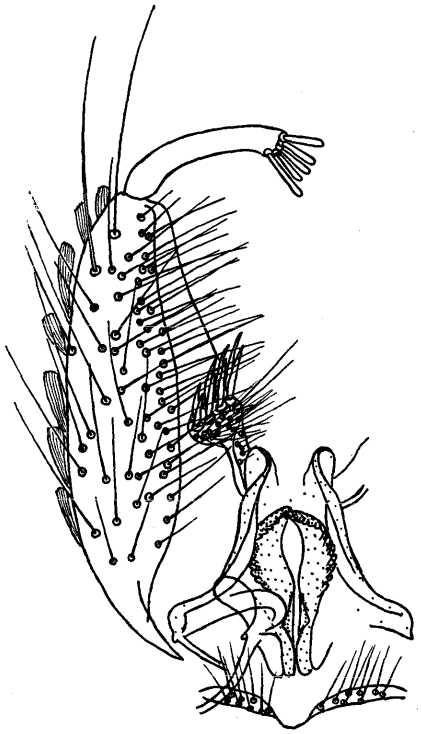


Fig. 14. *Armigeres* (*L.*) *digitatus* (Edw.)

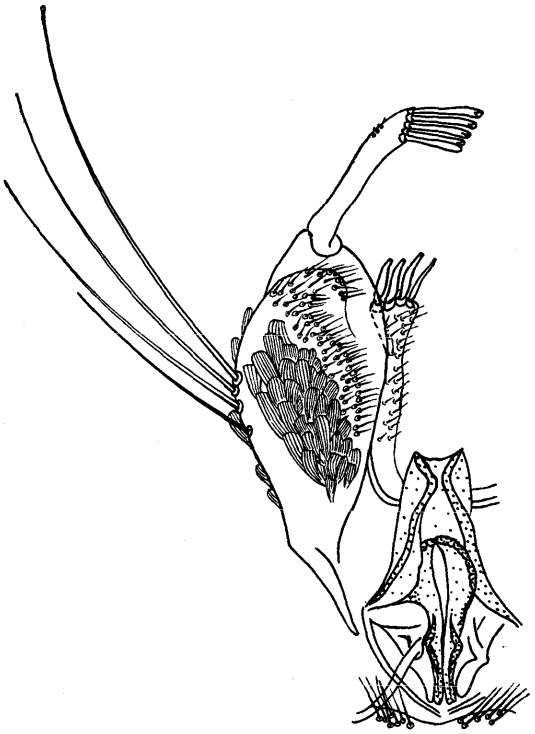


Fig. 15. *Armigeres* (*L.*) *pendulus* (Edw.)

Male terminalia.

Armigeres (Leicesteria) pendulus (Edwards, 1914)

Leicesteria pendula Edwards, 1914, *Bull. ent. Res.*, *4:* 261.

Types: Holotype ♂ marked "At edge of stream in jungle, The Gap, 16/4/04", without number, in Brit. Mus. Mr Mattingly has marked the following in the Brit. Mus. as paratypes: one ♂ marked "Jungle, the Gap, 16/4/04" and numbered "69B"; one ♂ marked "Edges of stream in jungle, the Gap, 16/4/04" with the same number; and one ♂ with the same number marked "The Jungle, The Gap, 16/4/04".

ADULT ♀.

Head.—Dorsum covered in dark scales, with a few pale ones; dark, upright scales on the nape. Dorso-lateral white patch, below which is a lateral dark patch, and ventral white area of scales. Palps and proboscis dark, palps about 2/3, rarely less, sometimes more, the length of the proboscis. Clypeus with two small antero-lateral patches of scales which are rather easily detached. Torus with brown and pale scales on its inner face; flagellum with the usual patch of pale scales on the first segment but near the base only.

Thorax.—Not very compressed laterally, moderately produced over the head. Scutellar scales largely dark. Mesonotal fringe of white scales which are narrow round the front margin. Propleural-fore coxal scale patch with a single band of black scales on the fore coxa. Mesepimeral scale patch does not reach the lower suture. Fore claws equal and toothed; mid claws equal and toothed; hind claws equal and simple. According to Barraud (1934:320) the tarsi may at times be very faintly ringed.

Abdomen.—Lateral white markings approximately boot-shaped on tergites V and VI, without a distinct heel as in *pectinatus*, rather similar therefore to *digitatus*. Sternites more or less all white, or may have very narrow, ill-defined, black, apical bands on some segments.

ADULT ♂.

Coloration and markings much as in female. Palps with ill-defined, pale ring near the centre of the long segment. As in the female, the clypeal scales are easily detached. Sternites may have fairly distinct apical bands. Claws as usual. Very distinctive on account of the partially everted terminalia, which may hang at an angle to the abdomen.

Terminalia (fig. 15).—The outer margin of the coxite bears only a few stout setae; the ventral surface has a dense area of scales bounded on the inner side by a row of short setae; the basal lobe is prominent, and terminates in four finger-like spines. The style is neither expanded nor does it taper; terminally it bears five moderately long appendages, and usually there are a few small setae on the outer surface.

LARVA.

Head.—Seta 1 single; seta 4 with 6-12 branches; seta 5 with 3-7 branches; seta 6 single; seta 7 single or bifid; seta 8 with 2-5 branches; seta 9 bifid; seta 10 with 1-3 branches; seta 11 small, with 3-5 branches; seta 12 with 5-9 branches; seta 13 bifid or trifid; seta 14 with 10-16 branches; seta 15 with 4-12 branches. Mentum triangular, dark-brown in colour, with a central tooth and 5-7 laterals. Antenna smooth, about 5 times as long as the basal width; antennal hair single, inserted 1/4 to slightly more than 1/3 the length of the shaft from the base.

Abdomen.—Segment VIII: seta 1 with 11-16 branches; seta 2 with 1-3 branches; seta 3 stout and prominent, with 5-8 branches; seta 4 bifid or trifid; seta 5 stout, single or bifid. Comb of 12-30 scales, mostly uniformly fringed, a number with a more or less clearly defined central tooth. Siphon about as broad as long; siphonal hair single, sometimes bifid, inserted about 2/3-4/5 the length of the siphon from the base. Siphon about 3 times as long as the saddle. Anal segment: with a dorsal, but no ventral, sclerotized plate; seta 1 with 7-9 branches; seta 2 with 3-5 branches; seta 3 trifid; seta 4 (ventral brush) with 10 tufts of 3-5 branches each.

Distribution.

Malaya.

Notes.

The female of *pendulus* is rather similar to that of *traubi* in some respects, but in addition to the differences mentioned in the key, the mesonotal fringe round the front margin of *pendulus* is composed of narrow, white scales, whereas in *traubi* those scales are broad. In *pendulus* also, the scutellar scales are dark on the whole, whilst in *traubi* they are often white on the central lobe with a distinct forward extension of white scales on to the scutum.

In the larva, *pendulus* and *traubi* are again very similar, and the differences given in the key are unfortunately not very satisfactory; however, the number of scales in the comb patch is often diagnostic although there is some overlap between the species.

Armigeres (Leicesteria) traubi n. sp.

Types: Holotype ♂, 0555/8, allotype ♀, 0555/1, and one male and three female paratypes, each with associated larval and pupal skins; two other male paratypes, without associated skins; all reared from larvae found breeding in the internode of a dead bamboo, coll. no. 0555 (*W. W. Macdonald*), Ulu Gombak, Selangor, Malaya, 18.iii.1958: deposited in Brit. Mus. (Nat. Hist.). The following paratypes have been deposited in the U. S. Nat. Mus: two ♀♀ and two ♂♂ with same data as holotype, but only the females with associated skins; together with one ♂, 0512/24, and one ♀, 0512/18, 11.ii.1958 (*W. W. Macdonald*), from same locality, and one ♂ 0537/1, 12.iii.1958 (*W. W. Macdonald*), from same locality, each with associated skins and bred from larvae from the internodes of young, dead bamboos.

ADULT ♀.

Head.—Dorsum clad in dark scales with a patch of white scales sometimes forming a median line; dorso-laterally the scales are white, laterally black, and ventro-laterally white; a few upright scales on nape. Palps and proboscis dark, the palps slightly more than two-thirds the length of the proboscis. Clypeus dark, without scales. Torus with scales on the inner and anterior surfaces, mainly brown but pale in front and round the rim; flagellum dark-brown with pale scales at the base of the first segment.

Thorax.—Moderately laterally compressed and produced forwards over the head. Scutum covered with narrow brown scales, with a patch of pale scales in front of the scutellum usually joining with flat, pale scales on the mid lobe of the scutellum; side lobes of the scutellum covered with flat, dark scales. Scutum with a fringe of broad, white scales, both at the sides and round the front. Anterior pronotal lobes and posterior pronotum with broad, white scales below and broad, dark scales above. Propleural-fore coxal scale patch with a single black band on fore coxa. Mesepimeral scale patch does not reach the lower suture.

Legs.—Undersides of all femora and outer side of hind femur white-scaled; outer hind femur white-scaled to the knee, or almost so. Undersides of fore and mid tibiae with a line of dull pale scales. Fore tibia distinctly shorter than the others. Fore and mid claws equal and toothed, hind claws equal and simple.

Abdomen.—Tergites I-VII black, with lateral patches of white scales which on II-VII curve backwards and inwards but do not extend far on the dorsum and never meet there; tergite VIII with a narrow, white, basal band. Sternites III-VI with broad, basal bands of white scales and clear, black, apical bands, the black bands often occupying 1/4 or more of the segments; VII usually with a dark basal band, median white band, and apical black band.

ADULT ♂.

General coloration as in female. Palps with an ill-defined, pale ring at the middle of the long segment, otherwise dark; longer than the proboscis by about the length of the terminal segment. Fore tarsal segment III a little longer than V. Fore claws unequal, the larger toothed, the smaller very small and about the length of the tooth on the larger; mid claws equal and toothed; hind claws equal and simple. The mesepimeral scale patch is broader at the base than is the case with the female; the scales extend closer to the lower suture but are still distinctly separated from it.

Terminalia (fig. 16).—Coxite moderately setose; basal lobe with four quite long spines. Style of uniform width throughout, terminating in a row of seven digitate appendages.

LARVA.

Head (fig. 2d).—Seta 1 single; seta 4 with 10-15 branches; seta 5 with 4-7 branches; seta 6 single; seta 7 with 1-3 branches; seta 8 with 2-4 branches; seta 9 bifid or trifid; seta 10 single or bifid; seta 11 bifid or trifid; seta 12 with 3-7 branches; seta 13 bifid or trifid; seta 14 with 4-8 branches; seta 15 with 7-11 branches. Mentum triangular, dark-brown in colour, with a central tooth and 7-8 laterals. Antenna smooth, 6-7 times as long as the basal width; antennal hair single or bifid, inserted 1/4-1/3 the length of the shaft from the base.

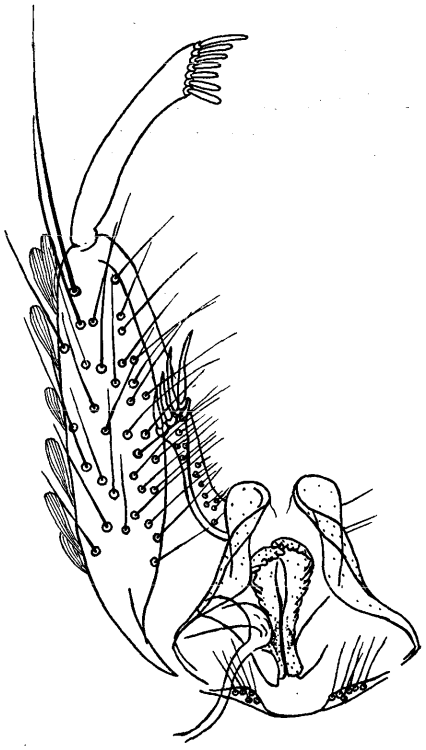


Fig. 16. *Armigeres* (*L.*) *traubi* n. sp.

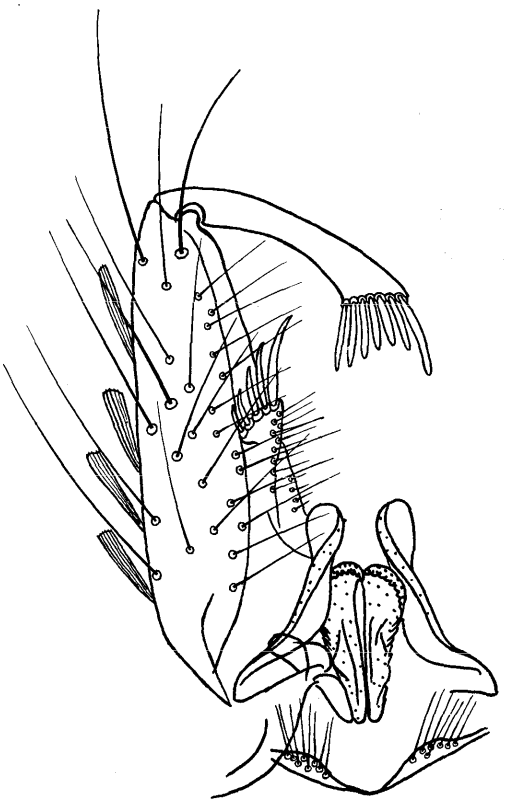


Fig. 17. *Armigeres* (*L.*) *annulipalpis* (Theo.) Male terminalia.

Abdomen.—Segment VIII: seta 1 with 9-14 branches; seta 2 with 2-4 branches; seta 3 with 5-8 branches; seta 4 with 2-5 branches; seta 5 stout, single or bifid. Comb of 21-47 bluntly-pointed or rounded scales, raggedly fringed. Siphon a little longer than broad; siphonal hair with 2-4 branches, inserted 2/3-4/5 the length of the siphon from the base. Siphon about 3 times as long as the saddle. Anal segment: seta 1 with 6-8 branches; seta 2 with 3-5 branches; seta 3 bifid or trifid; seta 4 (ventral brush) with 10 (occasionally 8) tufts of 2-5 branches.

Distribution.

Malaya.

Notes.

With similarities to *pendulus* which are discussed under that species.

Armigeres (Leicesteria) annulipalpis (Theobald, 1910)

Brevirhynchus annulipalpis Theobald, 1910, *Rec. Indian Mus., 4:* 6.

Type: Holotype ♀ from Madathoray, S. W. Base of Western Ghats, Travancore, 16.ix.1908 (*N. Annandale*) in Indian Mus., Calcutta.

ADULT ♀.

Head.—Dorsum as usual. Palps about half the length of the proboscis with a very distinct ring of white scales at the base of the terminal segment; a few pale scales on the upper surface of the middle segment. Proboscis dark. Clypeus with two prominent patches of white scales. Inner face of torus and first segment of the flagellum clad in white scales.

Thorax.—Not markedly compressed laterally; moderately produced over the head. Scutum covered with narrow, brown and golden scales; scutellar lobes covered with flat, dull yellow scales; mesonotal fringe of broad and narrow pale yellowish scales, broad at the sides and narrow round the front margin. Anterior pronotal lobes largely covered with broad, white scales with some dark-brown scales above; posterior pronotum with broad, white scales below and darker scales with a yellowish tinge above. Propleural-fore coxal scale patch with a single band of black scales on the fore coxa. Lower mesepimeral scale patch extends to the lower suture, and covers much of the lower mesepimeron.

Legs.—Pale scaling on outer surface of hind femur extends only three-quarters the length of the femur; fore, mid and hind tibiae each with a patch of white scales near the base; fore and mid tarsi with basal white scales on segments I-III, hind tarsi with basal white rings on all segments. Fore, mid and hind claws simple and equal.

Abdomen.—Lateral white markings on tergites II-VI curve to the dorsum but do not join to form complete bands; lateral yellow scaling at the base of tergites IV-VII. Dorsally, tergite II has a basal patch of white scales; there may be some scattered yellow scales on tergites III-V, and tergites VI-VIII may be almost covered with flat yellow scales. Sternites white with clear, apical, black bands, the more distal segments with a variable amount of yellow scaling.

ADULT ♂.

Coloration and markings much as in female. Palps longer than proboscis; two end segments each with basal white scaling, incomplete on the upper surface; long segment with a clear basal band and a broader white band near the middle. Leg scaling as in female; fore claws unequal, the larger toothed, mid claws equal and simple, hind claws equal and simple.

Terminalia (fig. 17).—Coxite lightly clad in setae; basal lobe with a row of five graded spines. Style slightly expanded distally, bearing seven digitate appendages.

LARVA.

Head.—Seta 1 single, tapering; seta 4 with 2-9 branches; seta 5 with 3-4 branches; seta 6 single; seta 7 bifid; seta 8 single; seta 9 bifid; seta 10 bifid or trifid; seta 11 not seen; seta 12 with 6 branches; seta 13 with 4 branches; seta 14 not seen; seta 15 with 5-9 branches. Mentum dark-brown with a central tooth and 6 or 7 laterals. Antenna smooth, 7-8 times as long as the basal width; antennal hair single, inserted about midway along the shaft, or slightly beyond the midway point.

Abdomen.—Segment VIII: seta 1 with 10-12 branches; seta 2 bifid; seta 3 stout and outstanding, with 8-9 branches; seta 4 bifid or trifid; seta 5 long, stout and single. Comb of more than 60 uniformly fringed scales. Siphon short and stout, about as broad as long; siphonal hair single, inserted 2/3-3/4 the length of the siphon from the base. Siphon about 2½ times as long as the saddle. Anal segment: with a large dorsal plate (the saddle); seta 1 trifid; seta 2 with 6-7 branches; seta 3 with 4-5 branches; seta 4 (ventral brush) with 10 tufts of 3-8 branches each.

Distribution.

India, Burma, China, Thailand, Sumatra, Flores, Kabaena, Boeton, Ceram.

Notes.

It is rather remarkable that this species has not been collected from Malaya. The descriptions given are based on specimens from Ceram, Kabaena and Boeton, kindly sent to me by Dr Bonne-Wepster, who informs me that larvae were collected from bamboo stumps and fallen, split bamboos.

Armigeres (Leicesteria) vimoli Thurman and Thurman, 1958.

Armigeres (Leicesteria) vimoli Thurman and Thurman, 1958, *J. Wash. Acad. Sci., 48:* 187.

Type: Holotype ♀ from Doi (Mountain) Sutep, Chiengmai Province, Thailand, 21.ii.1953 (*Deed C. Thurman, Jr.*) in U.S. Nat. Mus.

This species is known from a single female. From the description and from additional data kindly supplied by Dr Alan Stone of the U. S. National Museum, specimens would run down in the key to *pectinatus*. The propleural-fore coxal scale patch has two bands of black scales between white bands; the lateral tergal markings on the abdomen are all white; and the mesepimeral scale patch covers the area above the lower suture. According to Dr Stone the scales on the lower mesepimeron seem to be separated from a patch on the upper mesepimeron but this could very well be due to loss of the intermediate scales. In several species I have observed that the scales near the centre of the mesepimeron may be rubbed leaving an impression of two separate patches.

The scales on the posterior pronotum may possibly be diagnostic: in *pectinatus* these scales are broad and white below, and broad and black above; in *vimoli* they are recorded as being pale yellow and shaggy. Nevertheless, this is unlikely to be a reliable character.

ECOLOGY OF THE SPECIES

Distribution

The range of the subgenus as a whole has been summarized in the introduction, and the distribution of the individual species is given after the descriptions in the previous section. It is only necessary here therefore to indicate the type of terrain or vegetation pattern in which *Leicesteria* might be expected to occur, for a list of localities is often of limited interest and value.

The results of some thousands of mosquito collections in a number of areas in Malaya clearly show that the distribution of *Leicesteria* is closely related to, and that of many individual species completely dependent on, the distribution of certain species of bamboos; for bamboos provide the principal breeding-places, and most species of *Leicesteria* are so selective that they are found only where such breeding-places are available. Since bamboos are secondary elements of the forest flora, and are not found in undisturbed or primary forest, except along river banks or in man-made clearings, *Leicesteria* mosquitoes are absent from primary forest. For example, in the catchment area around the reservoir in Ampang Forest Reserve, Selangor, where no tree-felling is allowed (although in the past there may have been some selective logging), both bamboos and *Leicesteria* mosquitoes are absent, whereas not many miles away in Ulu Gombak to the north and in Ulu Langat to the east, where the forest has been extensively thinned by logging, bamboos are common and *Leicesteria* forms an important component of the mosquito population.

Outside Malaya this relationship with bamboos almost certainly holds true for most species of *Leicesteria*. Most of the locality records of species collected in India, Thailand, and Indonesia,

for instance, together with the sparse records of breeding-places, suggest regions where bamboos are growing. Where forest bamboos are no longer present in appreciable numbers, as for example on Singapore Island and perhaps in southern Java, *Leicesteria* is poorly represented. It is equally true, of course, that the distribution of bamboos throughout the tropics is much more extensive than that of *Leicesteria* mosquitoes. However, in view of the unusual breeding requirements which must be satisfied, not only with regard to the species of bamboo, but also to such factors as their age, condition, height, and parasite pattern, the more restricted distribution of the mosquitoes is not surprising. It is of interest to compare and contrast the more simple, and more easily satisfied, ecological requirements of such subgenera as *Aedes Stegomyia* and *Culex Culex*, both of which groups have a correspondingly wide distribution (Macdonald, 1960).

A few species, more particularly *Ar. flavus* and *Ar. magnus*, may prove to be exceptions to the general thesis that *Leicesteria* mosquitoes and bamboos go together. For example, there have been records of larval collections from tree-holes, pitcher plants, and from the axils of *Colocasia* plants. Nevertheless, every species has also been taken from bamboos, and without much doubt these grasses provide the preferred habitats for most of them. Breeding in non-bamboo containers is probably in most cases a secondary adaptation to local conditions.

Both in coastal areas and in the swamp forest of Malaya, where bamboos do not normally occur, *Leicesteria* is either absent or poorly represented. The usual habitat may therefore be summarized as inland, secondary or disturbed forest where bamboos have become established. The following observations have been made principally in Ulu Gombak Forest Reserve, Selangor, an area of secondary lowland dipterocarp forest whose features have been discussed elsewhere (Macdonald and Traub, 1960). Accordingly, the conclusions which will be drawn apply particularly to this area. The two species of bamboo which were investigated are *Gigantochloa scortechinii* Gamble and *Dendrocalamus pendulus* Ridley, both of which are quite common at Ulu Gombak. Holttum (1958) records *G. scortechinii* as one of the most common bamboos in the foothills of the main range of mountains in Malaya, and *D. pendulus* as "very abundant in the valleys of the Main Range, not recorded outside Malaya". It is probable that the Malayan distribution of many species of *Leicesteria* coincides with that of these two bamboos, but it is clearly desirable that other species of bamboo should be investigated, both within Malaya and in regions such as Assam, Thailand and Indonesia. Most work was done with the mosquito fauna of *G. scortechinii*, but since there has been nothing to suggest that the two species of bamboo differ significantly in their relationships to *Leicesteria*, no distinctions are being made between collections from one or the other.

The breeding habits

The eggs and egg-laying

When Strickland (1917) captured *Ar. flavus* on two or three occasions with an egg-mass attached to one hind leg he suggested that this peculiarity was an adaptation enabling the mosquito to deposit her eggs in some relatively inaccessible breeding-site. Strickland also observed that when one of those *flavus* was left in a jar with water, the mosquito dipped the egg-mass methodically into the water, and the young larvae emerged from the egg capsules and swam away "as livelily as a crowd of children coming out of the school on a holiday". During the past few years several specimens of *flavus* with an egg-mass on the hind legs have been captured on human bait, but in no case were the heads of the young larvae protruding from the egg capsules as recorded by Strickland, and when these mosquitoes were introduced into a jar containing water the whole egg-mass was deposited on the water surface. As was recorded earlier (Macdonald, 1957), the egg-mass is typically attached to, and held between,

both hind legs, the eggs lying in an angle formed by each tibia and first tarsal segment. Undoubtedly the egg-masses on Strickland's specimens had become detached from one of the hind legs. Since *flavus* breeds mainly in bamboo stumps, fallen split bamboo, and tree-holes, where there is ample space for the female to alight on the water surface, the suggestion that the egg-laying habits may reflect an inaccessibility of the breeding-site is unfounded. At the same time, this peculiarity in the egg-laying habits is not confined to *flavus*, but is characteristic of perhaps the majority of *Leicesteria* species.

For example, *Ar. annulitarsis* also lays an egg-batch on the hind legs, holding the eggs between the tibia and the first tarsal segment, before depositing them on the water. When the mosquito is retained in a tube with only damp filter paper, however, egg-laying is either delayed or the eggs are laid scattered over the filter paper. There is little doubt that the normal behaviour is for an egg-batch to be laid on the hind legs and then after a delay, which in the laboratory may last several hours, the eggs are released on the water.

Ar. balteatus, *inchoatus* and *magnus* are essentially similar. One specimen of *inchoatus* laid 63 eggs in two batches, one of which was first observed on the water while the other was still attached to the hind legs. In the case of *magnus*, on the other hand, a female laid a few eggs singly on the water surface, but later, when transferred to another jar with water, laid an egg-raft on hind tarsal segments I and II, this raft being released on the water after about 20 minutes.

Ar. dolichocephalus behaves rather differently. This species apparently lays the eggs in a ribbon. Ribbons of eggs have been collected on several occasions. In the first case there were 9 or 10 short ribbons, the longest of these comprising 31 eggs and the total eggs numbering 174. (In view of this large number, and the relatively large size of each, it is probable that more than one mother had laid these eggs.) The ribbons were easily handled and not readily broken; the individual egg capsules were strongly rugose. Several larvae had hatched on the morning following their collection, and many capsules contained fully-formed first instar larvae. On a second occasion 5 ribbons of eggs were collected, comprising 26, 21, 20, 13 and 5 eggs respectively. A number of larvae hatched from all these ribbons, but unfortunately none of them survived more than a few days. However, the very characteristic abdominal tubercles of *dolichocephalus* (fig. 3b) were well-developed even in the first instar, and these formed the basis of the identification.

In general, *Leicesteria* eggs hatch about two days after being laid. In addition to all the species already mentioned above, this was confirmed for both *dentatus* and *pendulus*. Unlike the eggs of some, if not all, species of *Armigeres* subgenus *Armigeres*, which lay their eggs singly, the eggs of *Leicesteria* cannot withstand drying. Thus if eggs are laid on damp filter paper, they will hatch after a few days just as they would if they had been laid on water, and the young larvae will die unless they are transferred to water. This was confirmed with the eggs of *annulitarsis* and *dolichocephalus*. Generally speaking, mosquito eggs which have been laid in a raft or ribbon, as in most species of *Culex*, hatch in this manner, whereas eggs which are laid singly, as in species of *Aedes*, can withstand a period of dryness and will not hatch until they have been immersed in water.

In the case of *flavus* it seems likely that the females which were caught with egg-masses attached to the hind legs were searching for breeding-places, but there is nothing to suggest that the eggs could be carried for more than a day or two at most without hatching. On the contrary, it would appear from Strickland's observations that the egg capsules dehisce after a period of exposure to the atmosphere; this then would be the explanation of the apparently incongruous record of young larvae protruding from their egg capsules while still attached to the legs of the adult.

The breeding-places

Perhaps the most interesting feature of the biology of many species of *Leicesteria* is the utilization of the hollow internodes of living and dead bamboos as breeding-sites, particularly when the entrance into the internode is a small hole in the culm only 1 or 2 mm. in diameter. The adult mosquitoes are quite large, so that the gravid females, and the offspring when they emerge, must literally squeeze through the openings. That this is easily accomplished can be confirmed experimentally by enclosing *dolichocephalus*, for example, on one side of the wall of a bamboo over a small hole, and then watching it pass through to the other side. Patience is often required to see the whole operation since some hours might elapse before the mosquito is stimulated to wriggle through the opening, and the actual passage is completed in a second or two. This facility for penetrating small openings, noted also by Leicester (1908:97), is demonstrated in the laboratory by the ease with which adults can escape from cages constructed of standard mosquito netting, even if in a double layer.

An adaptation directly related to this habit is of course the lateral compression of the thorax in a number of species; and the lateral compression has resulted in the mesonotum being produced forwards over the head in a hump, probably to accomodate the thoracic wing muscles. It is significant that the thoraces of *flavus* and *magnus* are hardly modified at all; this may be related to their breeding in open containers. The greatest degree of compression is seen in *dolichocephalus*.

The usual procedure in searching for breeding-places has been to select bamboos of different age and condition, saw each into sections, and examine each internode, the sections being measured as they were cut. When a collection of mosquito larvae was found in an internode, the holes in the wall of that internode were measured, and a note made of the height at which the internode stood before being cut. Unfortunately, in order to examine the internodes of an upright bamboo for mosquito larvae, one must destroy the whole bamboo. Not only does this mean the destruction of potential or actual breeding-places, but it results in the creation of breeding-places of a different type, principally bamboo stumps and split bamboo.

However, before discussing the mosquitoes themselves and their individual preferences for one type of breeding-site over another, it is necessary to explain two questions that arose at the beginning of these investigations. These were: first, how are the holes in the bamboo culms formed?; and, secondly, where does the water that is present in some internodes come from?

The origin of holes in bamboo culms

The formation of holes in bamboos has usually been ascribed to beetles or to beetle larvae, and there is now no doubt that the holes which serve *Leicesteria* are principally those formed by the larvae. In Ulu Gombak the responsible beetle is a species of *Anisodera* (Fam. Chrysomelidae), *An. goryi* Baly,* which attacks young growing bamboos. The evidence suggests that the beetle lays a single egg on the upper region of an internode, and that the young larva which hatches from the egg immediately begins burrowing through the bamboo culm; the outer opening of this burrow being approximately ovoid in cross-section and measuring 1-2 mm. along its greatest axis. Neither egg-laying nor eggs have, however, been observed. Holes that have been recently bored are easily detected, for below the lower rim of each there accumulates a little pile of chewed (? or excreted) bamboo fragments which adhere to the outer bamboo wall. The inner opening of the burrow is about twice the size of that

* Mr E. B. Britton, of the British Museum (Nat. Hist.), informs me that the Museum collection contains specimens from Thailand and Java as well as Malaya, but that the distribution of the species is probably wider than this suggests.

on the outside, so that in section the whole burrow is funnel-shaped, the larva beginning its passage at the narrow end and enlarging the burrow as it proceeds. Probably this gradual enlargement is due to the beetle larva feeding to a greater extent on the softer, inner tissue of the bamboo. The time taken by the larva to complete its passage through the culm is unlikely to be more than a day or two at most, and when the passage is finished the way is then open for *Leicesteria* to enter inside the internode.

The contribution of the beetle larva to the mosquitoes is, however, not yet finished. A little later in its life the larva makes another passage through the bamboo culm, this time from the inside outwards, and this passage is much larger than the first, the outer opening often measuring about 9 or 10 mm. by 5 or 6 mm. However, this second passage does not usually extend completely to the outside; the larva stops when it reaches the sheath around the culm, and the final break-through is made by the adult beetle.

Thus each internode which has been attacked by *Anisodera* shows a small entrance passage, a few millimeters wide, and a moderate-sized exit passage, which is invariably nearer the base of the internode. As might be expected, the larger exit passage allows a wider range of mosquitoes to penetrate inside the internode and to utilize the breeding-site. One cannot always be certain, therefore, whether the mosquito larvae found inside are the progeny of an adult which entered when there was only a small entrance or of one which entered through the large opening.

In Berar, Madras and Lower Burma, Stebbing (1914) has recorded *Estigmena chinensis* Hope, a chrysomelid beetle related to *Anisodera,* which also attacks young bamboos. It may be that over its distribution range this species occupies a rather similar niche to that of *An. goryi.*

The principal characteristic of bamboos which are attacked by beetles is that all of them are young and still growing. At this stage the culm is soft and easily bored. After the bamboo has grown to its full height the culm becomes impregnated with silica and consequently much more resistant to attack. One might therefore distinguish three stages during the life of the bamboo: first, the young growing stage which is very susceptible to attack for perhaps about 2-4 weeks; next, the full-grown stage when the culm is still soft and may be attacked but probably not very commonly; and lastly, the mature stage when the culm has hardened and is quite resistant to attack. Old culms which were attacked in the early part of their lives retain the beetle entrance and exit holes, but in such old specimens *Leicesteria* mosquitoes are either absent or the species found are different from those which characterize the young bamboos. This may well be because the larger of the beetle passages allows a wider range of competing species to enter into the internode, or, alternatively, it is likely also that the water in older bamboos is less attractive to some species of *Leicesteria* for egg-laying, for there are gross differences to the eye between the water of young and old internodes. In the young internodes the water is fairly clean, and is mixed with an exudate from the growing bamboo which affords an attractive medium; in the old internodes the water may be dirty with many months' accumulated dejecta of a varied arthropod bamboo fauna.

Occasional collections of mosquito larvae have been made from internodes with a large opening in the wall. Sometimes these openings were man-made, but there are more common causes that require mention. When a young bamboo is growing, most often when it is between 1.5 and 4 m. high, a host of insects feed on the juices of the succulent growing tip. In addition, however, the growing tissues of the tip may be attacked and eaten by some unidentified animal which leaves a ragged hole, about 4 or 5 cm. across: it is suggested tentatively that the animal involved may be the tree-mouse, *Chiropodomys gliroides.* Not uncommonly another form of damage is seen. In this case there is a round, symmetrical hole, about 2 cm. in diameter, near

the tip of the bamboo; sometimes there may be two or three such holes, and in one young bamboo there was a vertical row of twelve. It is possible that these holes were made by a woodpecker, but confirmation is required.

Often those holes lead only to the compact tissues of the growing tip, but sometimes an internode is in process of formation near the point of attack and the hole leads to a hollow internode where mosquitoes might breed. With rare exceptions, bamboos which suffer damage to the growing tip stop growing and die. And young bamboos which are dying attract one or two species of *Leicesteria* which are not found in living specimens.

There are other bamboo-borers which might burrow through culms and so provide *Leicesteria* mosquitoes with passages. There are, for example, one or two unidentified species of small beetles, whose adults are occasionally found boring galleries in young bamboos; and at Ulu Gombak there is a myrmecine ant, *Tetraponera* sp., which bores a small, perfectly round hole in young culms and nests inside the internode. Occasionally another ant, *Camponotus* sp., has been taken nesting in bamboos and in such cases there were several ragged, rectangular holes, measuring 10 x 6 mm. or more, through which the ants passed to and fro; it is uncertain, however, whether the ants created the holes or whether they utilized pre-existing ones. On a few occasions the large caterpillar of a moth of the family Pyralididae has been found living inside an internode, but this is an uncommon occurrence. The caterpillar burrows a round passage to the outside but stops at the outermost layer of the culm. The final break-through is probably made by the pupa just before the adult emerges.

The most common borers are, nevertheless, *Anisodera* larvae, and the others probably play a secondary role in providing *Leicesteria* with passages through the culms.

The origin of the water in bamboo internodes

When an undamaged bamboo internode is cut open the interior is usually dry, though occasionally a small amount of watery fluid may be present. On the other hand, when the culm has been bored by beetle larvae there is nearly always a moderate or large volume of fluid inside. For convenience this fluid is being referred to simply as water, though it is very bitter in taste and hardly drinkable. In young internodes which have been very recently attacked by beetles, there may only be about 10 mls. of water or less, but this is still sufficient to attract some mosquito species, e.g. *dolichocephalus*, to lay eggs. A week or less after being bored, the internode of a growing bamboo will commonly contain more than 100 mls., and another week later the volume may have doubled. Since the entrance passage of an *Anisodera* larva is so small, it seemed most unlikely that water from outside the internode, such as rainwater, could seep through in sufficient quantities to explain the volumes that were often present inside. There remained the possibility, therefore, that the water came from the bamboo itself, exuding from the points of damage created by the boring insect; for the following reasons, this is undoubtedly the correct explanation.

Bamboos grow very rapidly, and, in the case of *Gigantochloa scortechinii*, regular measurements of about 100 young individuals showed that an average daily increase in height of 20 cms. (or 7-8 ins.) was common. As a result, during the growing period there is a considerable flow of water under increasing tension from the ground level region of low diffusion pressure deficit to the growing tip of the bamboo where there is a region of high diffusion pressure deficit. Consequently, it seemed reasonable to expect that as water-bearing tissues were destroyed by boring or browsing insects, such as beetle larvae, water would be released into the internode. To confirm this suggestion small holes were bored in undamaged internodes of young, growing bamboos, and the openings were then sealed with waterproof tape. Several days or a week later, the internodes were cut open and the volume of water inside measured.

In each case the bored internodes contained moderate or large volumes of water (as much as 150 mls. after four days), whereas adjoining internodes which were left undamaged were dry, or almost so. Moreover, a brownish stain often marked the inner wall of the culm from the point of damage to the water below, showing the course of the exuding fluid. In the case of fully-grown bamboos, the flow of water in the culm diminishes and little is released into damaged internodes. However, owing to the slow rate of evaporation, water which has accumulated probably remains inside for several months.

The size of opening through which Leicesteria *species will pass to reach their breeding-sites*

Although some species of *Leicesteria* are uncommon and were poorly represented in the larval collections, the data on others are more complete. The collections made in forest have been summarized in Table I, where the breeding-places are divided into three groups: first, tree-holes, bamboo stumps, and artificial stumps, all of which have large openings and are easily accessible to all mosquitoes; next, fallen split bamboos and upright bamboos with vertical cracks, both of which are moderately to very accessible; and lastly, bamboo internodes which must be entered through small, moderate-sized, or large holes in the bamboo wall, and which are relatively inaccessible. Small holes include those made by young, newly-hatched beetle larvae and those made by ants, always measuring less than 5 mm. along the greatest axis, and usually only 1-3 mm. Moderate-sized holes refer principally to the exit passages of *An. goryi* beetles, measuring 5-15 mm., but usually about 10 mm., along the greatest axis.

It is quite clear from the table that bamboo internodes with small or moderate-sized holes are the principal breeding-places, for these sites provide 104 occurrence records of ten species compared to only 24 records of six species from all other breeding-places. That many species prefer internodes with small holes is also clear, for these sites provide two-thirds of all occurrence records; and it is interesting to note that whereas *Leicesteria* species were represented in 67 of the 101 mosquito collections from internodes with small holes, they were present in only 15 of the 84 collections from internodes with moderate-sized holes. This, together with the figures showing the number of other mosquito species present (bottom of Table I), lends point to the earlier suggestion that interspecific competition may be a factor that has helped determine the habits of *Leicesteria*.

Differences in the species composition in living and dead or dying bamboos, and in the vertical stratification of breeding-places

Table I showed only the relationship between the species and the size of opening through which each would penetrate, and it might suggest that a number of species have near identical breeding requirements. This is not necessarily so. Further distinctions can be made between those which breed in young as opposed to fully-grown bamboos; and, again, between species that are found in living and species found in dead or dying bamboos; and, finally, the height at which the collection was located (which may indicate the level of flight of the parent mosquito) may also prove diagnostic. The collections of those species which have come from upright bamboos have been analyzed along these lines, and the data are presented in Table II. These data bring out previously hidden differences in the ecology of the species. Thus it is clear, for example, that *dolichocephalus*, *dentatus* and *annulitarsis* prefer young, living bamboos at heights below 3 m., while at the other end of the series are *traubi* and *pendulus* which occur only in dead or dying bamboos, principally young specimens. There may be intermediate species with more catholic habits, such as *digitatus*, but probably each species has some distinctive feature. For instance, perhaps the height of the internodes from the ground is the main factor influencing the choice of *balteatus*.

TABLE I

THE NUMBER OF COLLECTIONS AND THE TYPES OF BREEDING-PLACES OF SPECIES OF *Leicesteria* IN LOWLAND DIPTEROCARP FOREST, SELANGOR

	Collections of larvae	Easily accessible breeding-sites			Moderately accessible breeding-sites		Relatively inaccessible bamboo internodes with holes		
	No.	Tree-holes	Bamboo stumps	Artificial stumps	Fallen split bamboo	Upright cracked bamboo	Large holes	Moderate-sized holes	Small holes
Total mosquito collections ...	479	100	59	72	44	10	9	84	101
Leicesteria, all species	106	1	11	2	6	—	4	15	67
flavus	18	1	9	2	3	—	3	—	—
magnus	1	—	1	—	—	—	—	—	—
pectinatus	2	—	1	—	1	—	—	—	—
inchoatus	3	—	—	—	—	—	—	3	—
balteatus	2	—	—	—	—	—	—	2	—
omissus	5	—	—	—	1	—	—	1	3
longipalpis	2	—	—	—	1	—	—	—	1
digitatus	18	—	—	—	—	—	1	7	10
traubi	18	—	—	—	—	—	—	5	13
dentatus	30	—	—	—	—	—	—	2	28
dolichocephalus	20	—	—	—	—	—	—	2	18
pendulus	4	—	—	—	—	—	—	—	4
annulitarsis	5	—	—	—	—	—	—	—	5
Total *Leicesteria* species occurrence records	128	1	11	2	6	—	4	22	82
Other mosquito species represented	75	45	32	19	34	8	8	28	17

TABLE II

THE AGE, CONDITION, AND HEIGHT OF THE BAMBOO BREEDING-PLACES OF SPECIES OF *Leicesteria* IN LOWLAND DIPTEROCARP FOREST, SELANGOR

Species	No. of collections from upright internodes	Age of bamboo		Condition of bamboo		Height of internodes from which collections were made			
		Young	Fully-grown	Living	Dead or dying	Below 3 m.	3-6 m.	6-9 m.	Above 9 m.
Total mosquito collections ...	174*	98	64	99	73	137	15	5	3
dolichocephalus	20	20	—	19	1	17	3	—	—
dentatus	30	30	—	21	9	26	2	2	—
annulitarsis	5	5	—	5	—	4	—	1	—
omissus	4	4	—	3	1	2	—	2	—
digitatus	18	12	6	5	13	11	5	1	1
inchoatus	3	—	3	—	3	—	2	1	—
balteatus	2	—	2	—	2	—	—	1	1
pendulus	4	4	—	—	4	3	1	—	—
traubi	18	16	2	—	18	15	1	—	2

* In a number of cases the field data required for this table were not recorded; as a result, the age of 12 internodes, the condition of two, and the height of 14 collections are not included. Twenty of the collections recorded from inaccessible bamboo internodes in Table I are excluded since they were made from *fallen*, though not split, bamboos.

Many of the dead and dying bamboos were only a few weeks old, and in almost all cases death was caused by damage to the tissues of the growing tip, referred to earlier. Occasionally, mixed collections of larvae from a young, dying bamboo have included *dolichocephalus* and *dentatus* as well as *traubi* and perhaps *digitatus*. The explanation is undoubtedly that the *dolichocephalus* and *dentatus* eggs were laid when the bamboo was alive, and later, when it was attacked and was showing the first signs of decay, *traubi* and perhaps *digitatus* eggs were laid. This sequence of events was supported by the emergence pattern of one such mixed collection which contained all four species.

The breeding preferences of the individual species of Leicesteria

The apparent preferences of each species can now be summarized, bearing in mind that more collections of all of them are desirable, and that the following summary makes no claim to completeness, since a number of species are still inadequately known.

Ar. flavus is distinctly different from the other species in its preferences. This is the only species which has been commonly collected from "open", easily accessible breeding-places, such as bamboo stumps. Only occasionally has *flavus* been recorded from the long series of collections from upright bamboos, and in each case there was a large hole leading into the internode. In general the few available literature records confirm this apparent preference of *flavus* for bamboo stumps, but Edwards and Given (1928) have also recorded larvae from pitcher plants in Singapore.

Ar. magnus has not been collected often enough in the larval stage for any statement on its preferences. As Table I shows, larvae have been collected only once, from a bamboo stump, but this collection requires a few words of explanation. The larvae came from the base of a bamboo shoot which had been recently cut, and the remaining stump contained a thick, putrid fluid which had exuded from the bamboo. The other bamboo stumps which were examined contained rain water, and these appear to hold little attraction for *magnus*. As was mentioned in a previous section, there is a record of larvae being collected from pitcher plants in Hong Kong (Barraud, 1934). Specimens received from Taiwan were reared from a bamboo stump collection, and Baisas (1935) records the species from "tree holes and bamboo joints."

Ar. annulitarsis has been collected only five times, on each occasion from the internode of a young, living bamboo with small holes, usually at heights below 3 m. Associated with it were *dolichocephalus* and *dentatus*. Borel (1930) recorded larvae from a bamboo stump.

Ar. dolichocephalus is very characteristic of young, growing bamboos, and the gravid female seems to select internodes which have only recently been attacked by beetle larvae: the entrances are therefore very small holes. Most of the collections were below a height of 3 m. This species has been the most common in adult catches.

Ar. inchoatus has been collected only three times and all three collections were from the same bamboo, but from different heights (4, 6, and 7 m. approx.). There may be a preference for fully-grown, dead or dying bamboos, such as this one was, but confirmation is desirable. In such bamboos the entrance passage into the internode is usually of moderate size, and there is no certainty yet that *inchoatus* will squeeze through small holes.

Ar. pectinatus is rather uncommon and has been collected only twice—once from a bamboo stump and once from a fallen split bamboo. Whether or not this species will pass through beetle holes to enter an internode is not known.

Ar. dentatus seems to be very similar in its breeding habits to *dolichocephalus* and *annulitarsis*. All the collections were from young bamboos, most of which were alive and growing and had only recently been attacked by beetle larvae. Most were near ground level, but a few were located between 3 and 9 m.

Ar. omissus readily breeds in young, living bamboos which have been recently attacked by beetle larvae, but has also been taken once from a fallen split bamboo. In addition, Barraud (1934) records bamboo stumps as a breeding-place, and Taiwan specimens came from *Colocasia* axils.

Ar. longipalpis has been collected once from a fallen split bamboo, and once, with *traubi*, from a young, dead bamboo. There is therefore little that can be said about the preferred habitat of this species. It is a relatively uncommon species.

Ar. balteatus was collected on both occasions from the internodes of a fully-grown, dead bamboo. One collection, with *traubi*, was a little less than 10 m. high, the other, with *digitatus* and *inchoatus*, was 7 m. high. This suggests a preference for rather higher breeding-sites than is usual, but more data are required.

Ar. digitatus has been collected both from living and from dead bamboos, at heights ranging from 1 m. to 12 m. Most collections have come from young, dying bamboos, but there has been no single factor common to all the collections which would form the basis for a statement on the precise preferences. Baisas (1935) records "small numbers in tree holes and bamboo joints" in the Philippines.

Ar. pendulus has, so far as can be determined, rather similar preferences to those of *traubi*. Each of the four collections has come from a young, dead or dying bamboo, and on each occasion the entrance into the internode has been a small beetle passage. All the collections were below 4.5 m., and in two of them *traubi* was also present.

Ar. traubi has been collected quite often, and, accordingly, the behaviour pattern can be more clearly defined. All the collections have come from dead or dying bamboos which were, with two exceptions, young specimens. As might be expected from the age and condition of the bamboos, the collections were mostly from internodes below 3 m. high. Perhaps *pendulus* is the species most like *traubi* in its choice of breeding-places, but *balteatus* and *inchoatus* are also characteristic of dead bamboos, though so far both these species have only been found in fully-grown bamboos.

Since a number of species have been collected only occasionally, generalizations about the preferences of those species must be made with care. At the same time, the collections which have been recorded must be viewed against the background of a long series of mosquito collections, from a variety of breeding-places, in most of which species of *Leicesteria* have been absent. (For a fuller list of forest habitats which were examined *see* Macdonald and Traub (1960), this *Study*.) It is reasonable to draw the general conclusions that most species select bamboo internodes as breeding-sites, that many enter the internodes through very small openings in the bamboo culm, and that internodes of a particular age, condition, and height may be selected by the gravid female.

It is to be expected that any changes in the composition of the bamboo flora, particularly in the age composition, will affect the mosquitoes. This will be discussed more fully in a later section, but it may be said here that species which breed principally in young bamboos, such as *dolichocephalus*, *dentatus*, *annulitarsis* and *traubi* are the most common, and show the largest fluctuations in numbers throughout the year.

Other mosquitoes associated with Leicesteria *in bamboos*

The number of species other than *Leicesteria* which have been collected from each type of habitat is shown at the bottom of Table I; but not all of those have occurred with *Leicesteria*. Since the breeding preferences of other forest mosquitoes have already been discussed (Macdonald and Traub, 1960, this *Study*), it is only necessary to mention a few of the more common species which, like *Leicesteria*, select bamboo internodes with small holes in the culm.

Perhaps the most abundant has been *Topomyia spathulirostris*, a small, easily recognized species with a spatulate proboscis; and with it is often *Tripteroides aranoides*, a mosquito with a wide range of breeding-places. Others that may occur include *Tripteroides coeruleocephalus*, *Orthopodomyia albipes*, *Aedes mediopunctatus*, *Udaya argyrurus*, and several species of *Heizmannia*. One of the most puzzling is *Toxorhynchites magnificus*, for it seems hardly credible that this very large mosquito could pass through a hole no more than 2 mm. across. Yet larvae have been found, though only rarely together with *Leicesteria*, in internodes which had been recently bored by *Anisodera goryi*. It is perhaps just possible that the adult female could eject an egg through the hole in the culm in the manner of the Central American species *Sabethes chloropterus*, though in the case of that species the hole leading to the breeding-place is very much larger than 2 mm. (Galindo, 1958): Galindo's laboratory observations were made using a hole of 1-inch diameter.

Occasionally, larvae of *Leicesteria* have been observed preying on one another, but this is not common and there are certainly no obligate carnivores comparable to species of *Toxorhynchites* and *Culex Lutzia*.

The biting habits

Leicesteria mosquitoes bite principally by day, for in five 24-hour catches at Ulu Gombak, and in several other catches which included pre-sunrise and post-sunset periods, only occasional adults were taken other than by day. For most purposes, therefore, catches made from sunrise to sunset can be said to cover the main phase of the biting-cycle. Catches of this pattern, "12-hour catches", have been made at Ulu Gombak on alternate weeks for nearly two years. In these catches a team of 3 men served as bait for the mosquitoes, three such teams alternating for the duration of the catch; in the 24-hour catches 3 men again served as bait, but they were part of a single team of 5 men who worked on a rota system similar to that devised by Haddow (1954), who gives full details of the operation of such catches. In addition, several catches were made by two men on a small platform at a height of 28 m. (about 90 ft.) while two others made concurrent catches at ground level.

Although all 13 Malayan species of *Leicesteria* have been taken in catches at Ulu Gombak, only *dolichocephalus*, *annulitarsis* and *flavus* have been collected in sufficient numbers to be worth discussing. The biting cycles of each are shown in Table III and fig. 18. Following Williams (1937, 1939) and Haddow (1954), the geometric, rather than the arithmetic, means have been calculated for each hour's catch. Fig. 18, which is derived from the data given in Table III, requires little explanation. Each of the three species is most active in the hours after sunrise and before sunset, with a period of reduced activity about the middle of the day. This is most pronounced in *annulitarsis* and *flavus*, in both of which the main peak is the evening one. However, whereas *flavus* has a relatively short burst of activity both in the morning and in the evening, *annulitarsis* shows a prolonged period of biting activity lasting about 3 hours after sunrise and, after 5 hours negligible activity, continuing for the last 4 hours of the day, the main peak being reached during the 2 hours before sunset. *Ar. dolichocephalus*, on the other other hand, has a higher level of activity throughout the day and less pronounced peaks than either *flavus* or *annulitarsis*. There is no clear evening peak; instead, the mosquitoes are quite active from soon after midday until sunset.

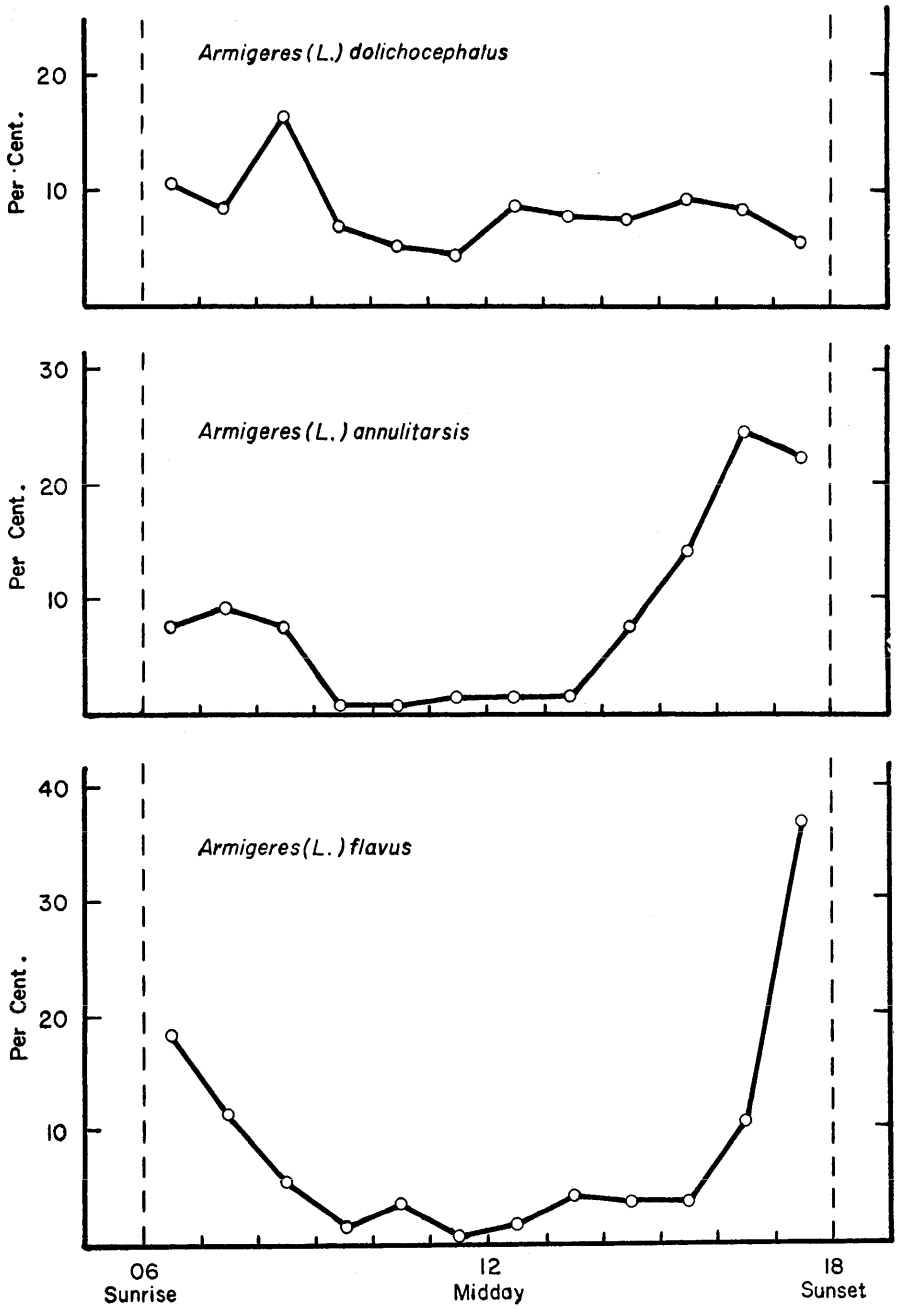


Fig. 18. The biting-cycles of *Armigeres* (*Leicesteria*) *dolichocephalus*, *annulitarsis* and *flavus* at Ulu Gombak, Selangor as shown by geometric means. The means have been converted to a percentage basis to facilitate comparison.

TABLE III

THE BITING-CYCLES OF *Armigeres* (*Leicesteria*) *dolichocephalus*, *annulitarsis* AND *flavus* AT ULU GOMBAK, SELANGOR

Hours	0600-0700	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	Total
Ar. dolichocephalus (36 catches)													
No. collected	36	35	32	24	18	18	49	25	28	31	32	26	354
Geometric mean × 100 ...	55	44	59	37	27	24	47	43	42	49	46	30	
Geometric mean as % age ...	10.7	8.2	16.6	6.9	5.1	4.5	8.8	8.0	7.8	9.3	8.5	5.6	
Ar. annulitarsis (37 catches)													
No. collected	14	15	10	1	1	2	2	2	12	18	30	36	143
Geometric mean × 100 ...	19	22	18	2	2	4	4	4	19	34	60	54	
Geometric mean as % age ...	7.8	9.3	7.7	0.8	0.8	1.6	1.6	1.6	7.8	14.1	24.6	22.3	
Ar. flavus (40 catches)													
No. collected	22	15	6	2	4	—	2	5	4	4	13	49	126
Geometric mean × 100 ...	38	23	11	4	7	—	4	8	7	7	21	75	
Geometric mean as % age ...	18.5	11.3	5.3	1.7	3.5	—	1.7	4.0	3.5	3.5	10.4	36.7	

All that may be said about the remaining species is that they follow a general pattern of high activity in the hours after sunrise and before sunset, with a period of reduced activity during the middle of the day. The three species that have been discussed are, however, sufficiently different from one another to suggest that some of the others may also have distinctive features.

The results of several catches in the forest canopy show that *Leicesteria* species do not bite, or rarely bite, at tree-top level. All species have occurred in ground catches only.

All species feed readily on man, but, as is the case with almost all forest mosquitoes, little can be said about the natural feeding habits in the field. Attempts made by sweep-netting to collect blood-fed mosquitoes for precipitin tests were unsuccessful, and they were therefore discontinued. There is quite a large array of mammals in lowland dipterocarp forest, and some of those are probably the major hosts of the mosquitoes. Among the mammals recorded from Ulu Gombak, for instance, is a variety of insectivores and bats, several primates, a few carnivores, a large number of rodents, an edentate, and a mouse deer, some 67 species in all (Institute for Medical Research, Malaya, 1958). Until blood-fed mosquitoes can be collected in reasonable numbers, however, the preferred natural hosts of *Leicesteria* must remain unknown, unless exposure of different bait-animals can give some clues.

Seasonal changes in the populations

Many groups of mosquitoes show fluctuations in their numbers which can be closely correlated with rainfall. Among such groups are the species which breed in tree-holes, rock-pools, leaf axils, and other containers such as these, which hold water only after recent rainfall. In the case of most species of *Leicesteria* there is no simple relationship with rainfall; though *flavus* and one or two other species are possibly exceptions. From what was said about the breeding habits it will be clear that *Leicesteria* species in general depend first on the presence of young bamboos, and secondly on bamboo-boring beetle larvae. Any relationship between the numbers of *Leicesteria* and rainfall is therefore indirect. At Ulu Gombak, for instance, a crop of young bamboos begins to appear at the beginning of the main wet season in August or September, and, very soon afterwards, *Leicesteria* mosquitoes become more common. Although rainfall may be heavy at other times of the year, there is no increase in the numbers of *Leicesteria* unless young bamboos have increased in number.

Fig. 19 has been drawn to show the changes in numbers of all species of *Leicesteria* over a period of two years, but since observations are still in progress a complete series of results is not yet possible. The figure shows the geometric means of the two or three 12-hour catches of *Leicesteria* which were made each month from February, 1958 to October, 1959. Prior to February, 1958 the data shown represent only 7 hours catching two or three times a month; namely, a 4-hour period in the morning which was begun approximately 2 hours after sunrise, and a 3-hour period in the evening which ended at sunset.

When adult catches were begun in early November, 1957 at Ulu Gombak, large numbers of *Leicesteria* were collected. For example, in a 3-hour period before sunset, four collectors attracted about 80 *Leicesteria* adults in each of 5 catches, and in 4-hour morning catches in the same 24-hour period, about 60 were taken. Thus an average of 140 mosquitoes of this subgenus were being collected in 7 hours. When continuous 12-hour catches began in early February, 1958, the numbers were falling, and from March onwards fewer than 15 specimens of *Leicesteria* were taken during each catch until the following October. There was a rise in October and November with the appearance in September of a new bamboo crop, but not such a striking rise as had been expected. The main reason for this relative failure was a shorter and lighter wet season than is usual, which resulted in a poor crop of new bamboos. During

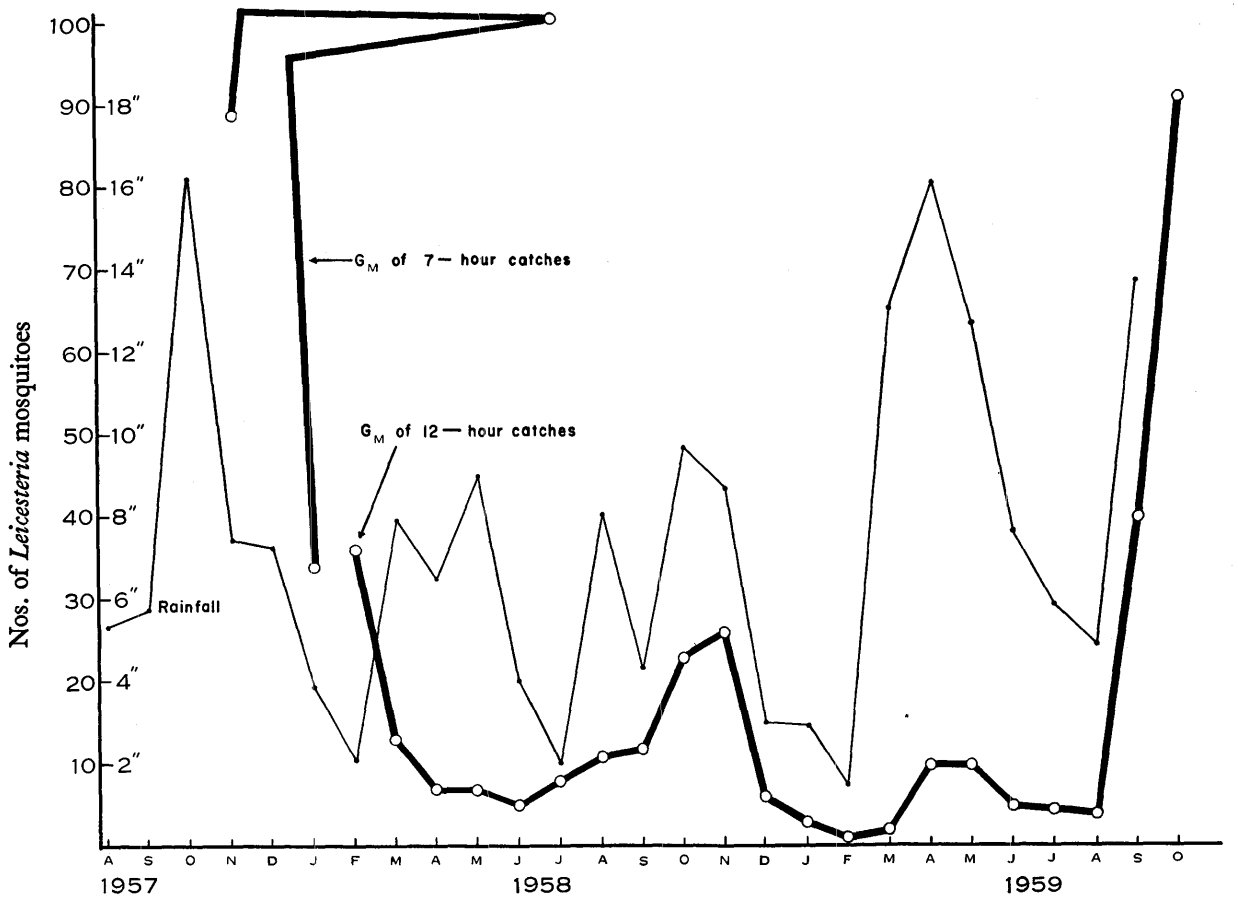


Fig. 19. Showing the fluctuations in numbers of *Armigeres* subgenus *Leicesteria* mosquitoes over a period of two years at Ulu Gombak, Selangor. Each monthly record, except where indicated, represents the geometric mean of two or three 12-hours catches (from sunrise to sunset) using three men as bait. For comparison, rainfall data from a nearby recording station are also shown.

December, 1958 no more bamboo shoots were appearing, and, as a result, the population of *Leicesteria* did not build up to the 1957 level. Thus, in December, 1958, fewer than 10 specimens of *Leicesteria* were being collected in a 12-hour catch, whereas in December of the previous year two catches each of only 7 hours produced 148 and 236 respectively.

In 1959, young bamboo shoots appeared in August, and early in September the number of *Leicesteria* began to increase. At the time of writing (October, 1959) new shoots are still appearing and there is every indication that the *Leicesteria* population will equal or surpass that of 1957.

Two points arising from Fig. 19 are worth noting: first, the high peak of November, 1957-January, 1958 would have been higher if 12-hour catches had been made at that time; and secondly, despite heavy rainfall during March-May, 1958, and again during March-May, 1959, there was little or no rise in the *Leicesteria* numbers. As might be deduced, the low *Leicesteria* population under conditions of high rainfall was simply due to the scarcity of young bamboos at those times.

So far it has been convenient to treat all species of *Leicesteria* together, but, as was shown earlier, not all species are dependent on young bamboos. There are a few which, by the nature of their known breeding-places, might be expected to be less dependent on changes in the bamboo flora. Among these might be the species which have been collected from old or fallen bamboos, e.g., *pectinatus*, *inchoatus*, *balteatus* and *longipalpis*, or a species such as *flavus* which breeds in bamboo stumps. With the exception of *flavus*, the numbers of those species have not, in fact, risen very appreciably at any time during the period of observations. The species which showed the largest fluctuations, and which made up the bulk of the catches, have been *dolichocephalus*, *annulitarsis*, *flavus*, and *dentatus*: and, to a lesser extent, *pendulus*, *traubi*, *digitatus* and *omissus*. That is to say, with the exception of *flavus*, the dominant species have been those which breed in young, living or dying bamboos.

While no other group of forest mosquitoes has shown such striking annual changes in population numbers as does *Leicesteria*, there are many species which would merit further study. Regular fluctuations have, for example, been suggested in the case of *Malaya jacobsoni*, again related indirectly to the bamboo flora (Macdonald and Traub, 1960). Perhaps too much emphasis has been placed in the past on the uniformity of conditions in tropical rain forest with the implication of stable animal numbers. Too few long-term studies have been made of the animals and insects of forest for any final conclusions to be justified. It may be that regular cyclic phenomena are more common than appears on the surface.

SUMMARY

1. Illustrated descriptions are given of the members of the *Armigeres* subgenus *Leicesteria* group of Oriental mosquitoes, together with keys to the adults and larvae. Fifteen species are treated, of which two are described as new.

2. The recorded distribution of each species is given, and distribution of the mosquitoes is related to the distribution of bamboos, since these grasses provide the preferred breeding-sites.

3. A number of species enter the hollow bamboo internodes through very small or moderate-sized holes in the bamboo culm, some species showing pronounced morphological adaptations to this end. The origin of the holes has been investigated and they are shown to be formed principally by larvae of the beetle *Anisodera goryi* (Chrysomelidae).

4. A watery fluid is usually present in internodes which have been attacked by *An. goryi*. This is discussed, and evidence is presented to show that the fluid is released by the growing bamboo when water transport tissues are destroyed by the feeding activities of the beetle larvae.

5. The breeding preferences of the species of *Leicesteria* are summarized, and the selection of breeding-sites has been related to the age, condition, and height of the internodes, and to the size of opening through which each species will pass.

6. The biting habits of the group are discussed, and the biting-cycles of *dolichocephalus*, *annulitarsis* and *flavus* are shown graphically. All species bite at ground level and by day, with greatest activity in the early morning and late afternoon.

7. Finally, seasonal fluctuations in the numbers of *Leicesteria* mosquitoes are shown to be related to changes in the bamboo flora. In Selangor, Malaya, there seems to be an annual crop of young bamboos, which begins to shoot at the start of the main rains about September. With the appearance of these young stages, which provide the main breeding-sites, *Leicesteria* mosquitoes become very common. At other times of the year, even when rainfall is heavy, young bamboos are scarce and the numbers of *Leicesteria* are correspondingly low.

Acknowledgements

I am indebted to Dr J. Bonne-Wepster of the Institute for Tropical Hygiene, Amsterdam for the loan of specimens collected in Indonesia; to Dr Yao-Tsing Wu of the Malaria Research Institute, Taiwan, who provided material from Taiwan; and to Dr F. E. Baisas of Manila for Philippine material; also to Dr A. P. Kapur of the Zoological Survey of India, Calcutta and Dr Alan Stone of the U.S. National Museum, both of whom kindly supplied information about the type specimens in their collections. I am particularly grateful to Mr P. F. Mattingly of the British Museum (Nat. Hist.) who provided all the data pertaining to the many types in the British Museum. Mr A. Watson (British Museum) identified the Pyralidid caterpillar, and Mr E. B. Britton (British Museum) and Herr E. Uhmann (Germany) the chrysomelid beetles. In Malaya, Mr F. G. Charlton of the Drainage and Irrigation Department very kindly made available the rainfall figures for Ulu Gombak. Finally, it is a pleasure to acknowledge the help of my assistants and mosquito collectors, especially Mr A. Ganapathipillai and Mr S. Mahadevan, each of whom contributed towards some phase of the work; and to record my indebtedness for many helpful discussions to Dr J. A. Reid, Senior Entomologist of this Institute.

References

Baisas F. E. (1935). Notes on Philippine mosquitoes, I. The *Armigeres* group. *Philipp. J. Sci.*, *56*, 485-497.

Barraud P. J. (1927). A revision of the culicine mosquitoes of India. Part XX. The Indian species of *Armigeres* (including *Leicesteria*), with descriptions of two new species. *Indian J. med. Res.*, *14*, 533-548.

Barraud P. J. (1934). *Fauna of British India. Diptera, Vol. V: Culicidae. Tribes Megarhinini and Culicini.* London: Taylor and Francis.

Bonne-Wepster J. (1934). New mosquitos (Dipt.) from the Netherlands Indies. *Stylops*, *3*, 272-276.

Borel E. (1930). *Les moustiques de la Cochinchine et du Sud-Annam.* Paris: Masson et Cie.

Colless D. H. (1957). Notes on the culicine mosquitoes of Singapore. II.—The *Culex vishnui* group (Diptera, Culicidae), with descriptions of two new species. *Ann. trop. Med. Parasit.*, *51*, 87-101.

Edwards F. W. (1914). On the Oriental culicid genus *Leicesteria*, Theobald. *Bull. ent. Res.*, *4*, 255-263.

Edwards F. W. (1932). Diptera Fam. Culicidae. *Genera Insect.*, *194*, 1-258.

Edwards F. W. and Given D. H. C. (1928). The early stages of some Singapore mosquitos. *Bull. ent. Res.*, *18*, 337-357.

Galindo P. (1958). Bionomics of *Sabethes chloropterus* Humboldt, a vector of sylvan yellow fever in Middle America. *Amer. J. trop. Med. Hyg.*, *7*, 429-440.

HADDOW A. J. (1954). Studies of the biting-habits of African mosquitos. An appraisal of methods employed, with special reference to the twenty-four-hour catch. *Bull. ent. Res.*, *45*, 199-242.

HEMMING F. (Ed.) (1953). *Copenhagen decisions on zoological nomenclature.* London: International Trust for Zoological Nomenclature.

HOLTTUM R. E. (1958). The bamboos of the Malay Peninsula. *Gdns' Bull.*, *16*, 1-135.

INSTITUTE FOR MEDICAL RESEARCH, MALAYA (1958). Division of virus research and medical zoology. *Rep. Inst. med. Res. Malaya, 1957*, 54-68.

LEICESTER G. F. *in* THEOBALD F. V. (1904). New Culicidae from the Federated Malay States. *Entomologist*, *37*, 211-213.

LEICESTER G. F. (1908). The Culicidae of Malaya. *Stud. Inst. med. Res. F.M.S.*, *3*, (3), 18-261.

MACDONALD W. W. (1957). Malaysian Parasites, XVI. An interim review of the non-anopheline mosquitoes of Malaya. *Stud. Inst. med. Res. Malaya*, *28*, 1-34.

MACDONALD W. W. (1960). Some ecological factors influencing the distribution of Malayan mosquitoes. In *Proceedings of the Centenary and Bicentenary Congress of Biology, Singapore 1958.* University of Malaya Press.

MACDONALD W. W. AND TRAUB R. (1960). Malaysian Parasites, XXXVII. An introduction to the ecology of the mosquitoes of the lowland dipterocarp forest of Selangor, Malaya. *Stud. Inst. med. Res. Malaya*, *29*, 79-109. (This *Study*).

MATTINGLY P. F. (1957*a*). *The culicine mosquitoes of the Indomalayan area. Part I. Genus* Ficalbia *Theobald.* London: British Museum.

MATTINGLY P. F. (1957*b*). *The culicine mosquitoes of the Indomalayan area. Part II. Genus* Heizmannia *Ludlow.* London: British Museum.

MATTINGLY P. F. (1958). *The culicine mosquitoes of the Indomalayan area. Part III. Genus* Aëdes *Meigen, subgenera* Paraëdes *Edwards*, Rhinoskusea *Edwards and* Cancraëdes *Edwards.* London: British Museum.

OLDROYD H. (1958). *Collecting, preserving and studying insects.* London: Hutchinson & Co. Ltd.

STEBBING E. P. (1914). *Indian forest insects of economic importance. Coleoptera.* London: Eyre and Spottiswoode.

STONE A., KNIGHT K. L. AND STARCKE H. (1959). *A synoptic catalog of the mosquitoes of the world.* The Thomas Say Foundation, Vol. VI. Washington: Entomological Society of America.

STRICKLAND C. (1917). A curious adaptation of habit to its environment of a Malayan mosquito. *J. Straits Br. Asiat. Soc.*, *75*, 39.

THURMAN E. B. (1959). A contribution to a revision of the Culicidae of Northern Thailand. *Univ. Maryland Agr. exp. Station*, Bull. A-100, 182 pp.

WILLIAMS C. B. (1937). The use of logarithms in the interpretation of certain entomological problems. *Ann. appl. Biol.*, *24*, 404-414.

WILLIAMS C. B. (1939). An analysis of four years' captures of insects in a light trap. Part I. General survey; sex proportion; phenology; and time of flight. *Trans. R. ent. Soc. Lond.*, *89*, 79-131.

MALAYSIAN PARASITES XXXIX

SUSA, NEW GENUS RELATED TO *ASCOSCHONGASTIA* EWING (ACARINA, TROMBICULIDAE), WITH DESCRIPTIONS OF TWO NEW SPECIES

BY

J. R. AUDY AND M. NADCHATRAM

Institute for Medical Research, Kuala Lumpur

The genus *Ascoschongastia* Ewing at present comprises three obviously similar subgenera (*Ascoschongastia* s.s., *Laurentella** Audy, *Elianella* Verc.), plus two dissimilar species-groups which are accommodated for want of a better allocation (the genus and these groups have been discussed by Audy & Womersley 1957, and Audy *et al.* 1960). The first atypical group, the *oculicola*-group, has been described as a new subgenus, *Oculicola*, by Domrow (1960) in the present *Study*. The second group, the *debilis*-group, is the subject of the present paper. In spite of the fact that Domrow's two new species of *Oculicola* link the *debilis*-group more closely to *Ascoschongastia*, the presence of 2 instead of 3 genualae-I in the *debilis*-group, together with the reduction in the number of tentacular setae (on the palpal tarsus), and the characteristic scutum, make it possible that the *debilis*-group is related to *Schoutedenichia* Verc. almost as much as it is to *Ascoschongastia*. As Domrow (*loc. cit.*) points out, the nymphs of *A.* (*O.*) *oculicola* (Wom.) suggest that this species at least is an aberrant offshoot from *Ascoschongastia*, and his reasoning is sound that there is justification for regarding this species or group as a subgenus until more material has been studied. Unfortunately, no nymphs of the *debilis*-group are yet known: they will be of considerable taxonomic interest.

Susa new genus

Type species: *Neoschongastia debilis* Gater, 1932

Diagnosis of larva.—Trombiculines without eyes, with small rectangular or subtrapezoidal scuta which have 5 scutal setae, no anterolateral "shoulders", the posterior margin rectilinear or slightly concave, relatively short anterolateral (AL) setae, and globose or sub-globose sensillae; with 5 setae plus the usual tarsala on the tentaculum (palpal tarsus); with relatively short and thick legs, 2 genualae on leg-I and a tibiala on leg-III. Differs from typical *Ascoschongastia* and *Laurentella* in the absence of anterolateral scutal "shoulders" and presence of 2 (not 3) genualae-I; from subgenus *Oculicola* in the 2 genualae-I; from *Pseudoschongastia* in having 5 (not 3) scutal setae and legs 7-7-7 (not 7-6-6) segmented; from *Schoutedenichia* in having a tibiala-III. *Ascoschongastia* s.s. and *Pseudoschongastia* also differ in having extra-scutal PL setae. All the 4 known species are parasitic in the ears of shrews and rats in the Malaysian subregion.

Description of larva.—Elongate to broad oval larvae, colour pallid in life. Eyes absent. *Gnathosome:* cheliceral blade variable but without distinct tricuspid cap, which is represented by small dorsal subapical denticle. Galeal seta barbed, well developed. Palpal femoral seta usually much reduced and nude; tentaculum with tarsala and 5B or 4B setae and a subterminala (tentacular formula 5B or 4BS); palpal claw 3-pronged. *Scutum:* not strongly sclerotized, small, rectangular to subtrapezoidal; AM seta not advanced anterior to AL setae and anterior margin without "shoulder", posterior margin concave, "eyebrow" ridges distinctly extended to form almost complete rings round the sensillary bases; sensillae broad clavate to globose, the stem with short spicules and the head with numerous long barbs. The AL seta is shortest (not more than 19μ), PL the longest. *Body setae:* dorsal setae short pectinate, numbering more than 54 and irregularly arranged; one or more pairs of humeral setae; 2 pairs of sternal setae. *Legs:* 7-7-7 segmented, segments relatively short and thick. Ordinary leg setae not elongate, distinctly barbed. Leg I: with all the usual specialized setae, the microtarsala being proximal and slightly posterior to the base of the tarsala; tarsus relatively broad and short with only one "bar" (sclerotized annulus), not strongly sclerotized (species of *Ascoschongastia* frequently have a proximal bar and a distal semi-bar); 2 tibialae, a microtibiala; 2 genualae, anterior and posterior, with one distal microgenuala. Leg II: the usual pre-

* *Laurentella* is here taken to include the "*TAA*-group" (Audy, 1956) of exclusively intranasal species. Although this group is distinctive, it can be placed in *Ascoschongastia* without hesitation.

tarsala and tarsala, with microtarsala anteroproximal to base of tarsala; 2 tibialae in tandem, 1 genuala. Leg III: 1 tibiala, 1 genuala. Coxae 1-setose; seta on coxa-III placed near anterior margin. The setation of scutum and body generally resembles that of the Gahrliepiines.

Remarks.—This is the *debilis*-group of Audy (1956), who provisionally placed it within the subgenus *Laurentella*. It is described as a new genus instead of subgenus because the combination of scutal shape, 2 genualae-I, and tentacular formula of 5B or 4BS, makes it possible that this group is more closely related to *Schoutedenichia* than it is to *Ascoschongastia*—it is worth noting that the tibiala-III in one of our specimens of *debilis* is absent (the absence of the tibiala-III, associated with 2 genualae-I, is characteristic of *Schoutedenichia*, *Traubacarus*, and *Gahrliepia*).

The name of this genus is derived from the Malay word *susah*, referring to a difficult problem or to a worried person, thus summarizing our attitude towards this and several other perplexing groups.

Susa debilis (Gater), new combination. (Figs. 1-7)

Neoschongastia debilis Gater, 1932.

Schongastia (*Ascoschongastia*) *debilis*, Wom. 1952.

Euschongastia debilis, Wharton & Fuller 1952.

Euschongastia (*Laurentella*) *debilis*, Audy 1956.

Ascoschongastia (*Laurentella*) *debilis*, Domrow 1957, Womersley & Audy 1957, Audy 1957.

Diagnosis of larva.—Readily separated from the other species by the relatively broad subrectangular scutum and the palpal formula of b.N.BNN.4BS.

Redescription of larva.—Body small, partially and fully engorged larvae 210×130μ to 340×260μ (gnathosome included); subovate, pallid. *Gnathosome:* cheliceral blade (28μ) moderately broad, with a small ventral denticle (*see* fig. 3) and an inconspicuous minute dorsal subapical denticle (not shown in the figure). Galeal seta B, with 3-4 barbs. Palpae slightly angulate laterally at femoro-genual joint; palpal formula b.N.BNN. 4BS (subterminala on tarsus). Claw (13μ) with 2 subequal accessory prongs. *Scutum* almost rectangular, posterior margin slightly sinuous but almost rectilinear; puncta sparsely but evenly distributed except near edges; setae distinctly barbed; sensillae broadly clavate. Standard measurements in microns (mean of 3: CORU. 23056, from which fig. 2 was drawn, plus two others): AW 38, PW 50, SB 17, ASB 14, PSB 12, AP 21, AM 25, AL 19, PL 30, Sens 22×8. *Body setae:* DS (22-30μ) numbering 55-57, irregularly arranged, with two or more pairs which may be called humeral setae (e.g. 4.13.4.8.7.10.2.5.4); caudal setae (CS), 10-14 (25μ); VS 14 (16μ). *Legs:* I-III 170, 150, 185μ long. Leg I: tarsus plus pretarsus 42×24μ, proximal bar (annular sclerotization) poorly developed, parasubterminala one-third length of subterminala, tarsala 16μ. Leg II: tarsus plus pretarsus 32×21μ, microtarsala only slightly anterior and proximal to base of tarsala. Leg III: tarsus plus pretarsus 44×19μ, tibiala short (absent on one side in one specimen); 2 or 3 of the posterior distal setae on the tarsus are relatively elongate, carry a few inconspicuous barbs, and may appear nude (fig. 7). Coxa-III 46×17μ.

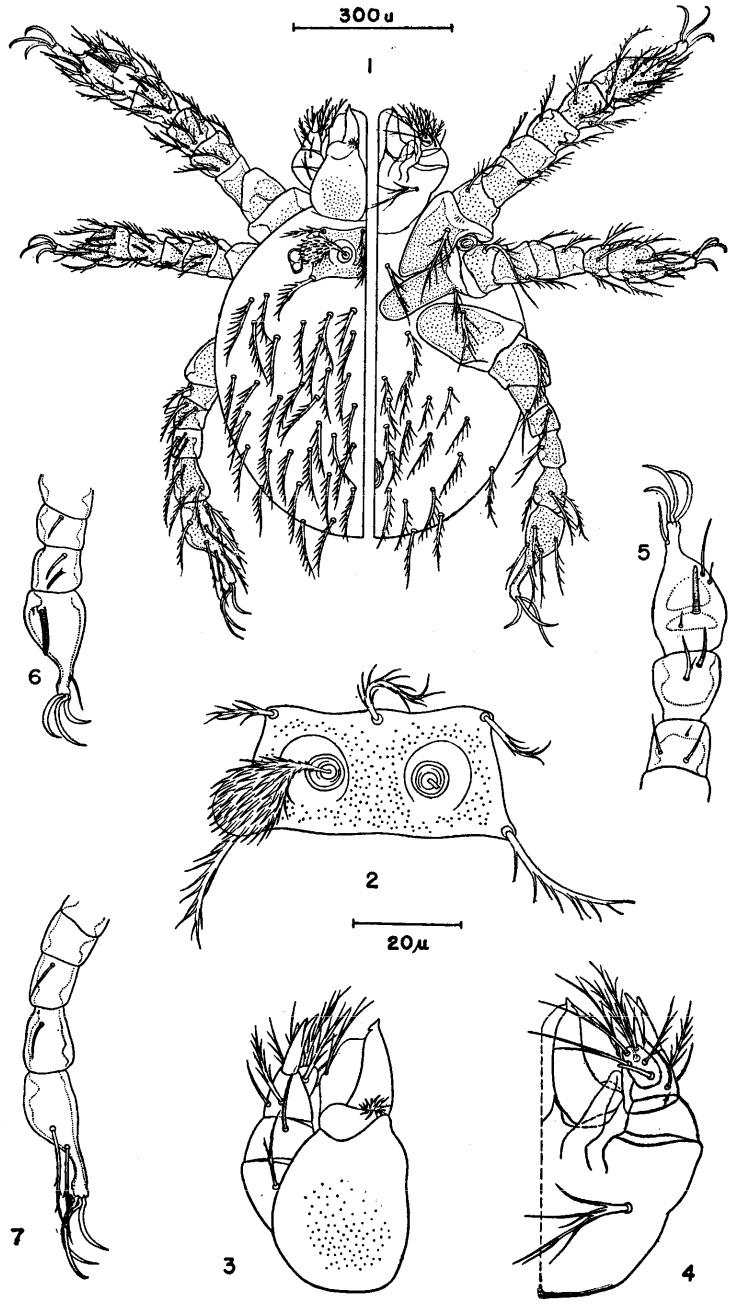
Records.—Only found in relatively small numbers and rarely on small ground-living animals: the maintaining hosts for this chigger may be shrews. Originally described from a tree-rat, *Rattus cremoriventer cremoriventer*, from Selangor, post-war records (Audy, 1956) are: 1 on *R. annandalei*, 29. xi. 1949; 3 on *R. mulleri*, 3. iii. 1950; 1 on *R. sabanus*, 25. xi. 1952 (and since then, 1 on this rat, 9. x. 1958); 1 on *R. jalorensis*, 1. vi. 1948; 1 on *R. whiteheadi*, 10. ii. 1950; 1, 3, and 3 from the shrew *Crocidura malayana* on 1. v. 1953, 21. i. 1954; and 7 from a water-shrew, *Chimarrogale hantu* Harrison, 1958 (host species described since records and checklist by Audy, 1956, 1957). The solitary specimens from the various rats must be regarded as incidental infestations.

Susa labuanensis (Womersley), new combination. (Figs. 8-15)

Schongastia (*Ascoschongastia*) *labuanensis* Wom., 1952.

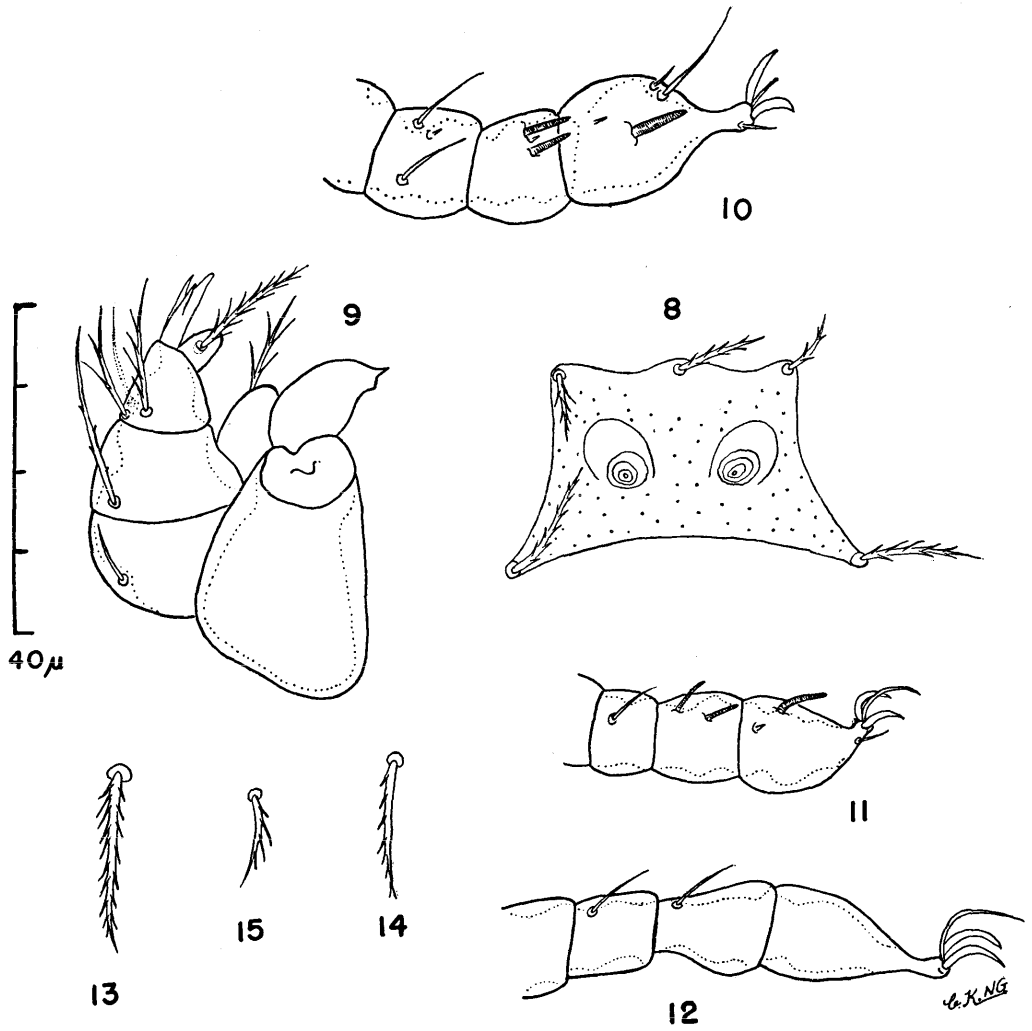
Euschongastia (*Laurentella*) *labuanensis*, Audy 1956, 1957, Womersley & Audy 1957.

Diagnosis of larva.—Distinguished from *debilis* by the smaller subtrapezoidal scutum and the palpal formula.



Figs. 1-7. *Susa debilis* (Gater)

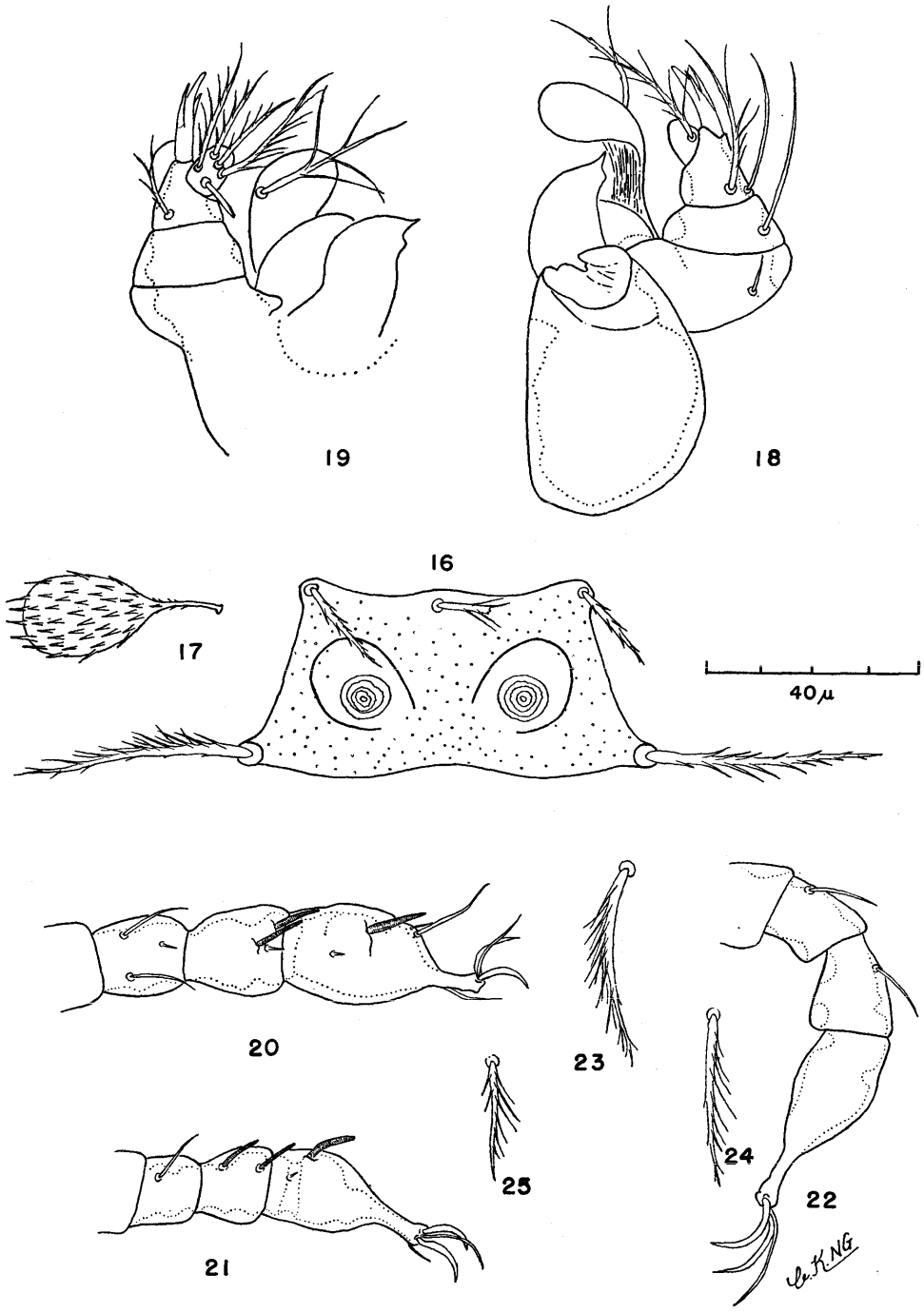
1, dorsal/ventral aspects of larva; 2, scutum; 3, 4, gnathosome, dorsal and ventral; 5, 6, 7, legs I, II, III, sensory setae.



Figs. 8-15. *Susa labuanensis* (Womersley)

8, scutum; 9, gnathosome; 10, 11, 12, legs I, II, III, sensory setae; 13, 14, 15, dorsal, caudal and ventral setae.

Redescription of larva (from 2 paratypes).—Body partially engorged 390×300μ. *Gnathosome*: chelicerae broad and stout, denticles inconspicuous. Galeal seta with 2 to 4 barbs. Palpal formula N. B.BBN.4BS; palpal tarsus not distinct in the paratypes, but Mr. Womersley has described the palpal tarsus as having 4 or 5 ciliated setae as well as subapical and sub-basal sensory rods (i.e. subterminala and terminala); claw with 2 subequal accessory prongs. *Scutum:* small, roughly rectangular, anterior margin slightly sinuous, posterior margin concave with PL angles extended; puncta few and sparsely distributed; all scutal setae relatively short; sensillae missing in all specimens. Standard scutal measurements (mean of type and 4 paratypes): AW 29, PW 41, SB 13, ASB 14, PSB 11, AP 22, AM 16, AL 10, PL 19. *Body setae:* DS (20-24μ) number ca. 62 arranged approximately 2.10.10.10.10.10.6.4, plus ca. 40 CS & VS (20μ & 11μ). *Legs:* I-III 180, 150, 180μ long. Leg I: tarsus swollen, tarsus plus pretarsus 35×24μ, proximal bar present, tarsala 18μ. Leg II: tarsus and pretarsus 28×20μ, tarsala 12μ. Leg III: tarsus plus pretarsus 31×19μ; tibiala and genuala present. Coxal setae arising from anterior margin. Coxa-III 36×24μ.



Figs. 16-25. *Susa macdonaldi* n. sp.

16, scutum; 17, sensilla (detached on specimen); 18, 19, gnathosome, dorsal and ventral; 20, 21, 22, legs I, II, III; 23, 24, 25, dorsal, caudal and ventral setae.

Remarks.—Described by Womersley from 5 specimens from an unidentified rat (*not* "marsupial rat" as recorded), Labuan island, British North Borneo, 17. ix. 1945 (*R. N. McCulloch*). The following characters recorded in the original description are here amended: "galeal seta nude, claw 2-pronged, seta on palpal femur with short setules" (galeal seta is barbed, claw is 3-pronged, seta on palpal femur nude). We are very grateful to Mr. Womersley for the loan of the paratypes.

Susa macdonaldi n. sp. (Figs. 16-25)

Euschongastia (*Laurentella*) "ALT-TM" (40030), Audy 1956.

Diagnosis of larva.—Close to *labuanensis*, from which it is easily distinguished by its large size (cf. scuta and coxae), the palpal formula, and the greater number of dorsal setae.

Description of larva.—Described from a solitary specimen. Body engorged broad oval, 660 × 400μ (including gnathosome). *Gnathosome:* Cheliceral blade relatively broad (28 × 13μ), apex pointed, subapical denticles poorly developed. Galeal seta well developed with 4-5 long barbs. Palp slightly angulate; palpal formula N.N.BNB.5B, seta on femur short and indistinct, all other setae long, nude or distinctly barbed. Palpal claw (20μ) slender; the dorsolateral accessory prong strong and reaching half-way along the axial prong, the ventromedial prong being small. *Scutum:* poorly chitinized and not clearly seen; posterior margin slightly concave; punctae small and fairly numerous. Sensillae broadly clavate. (Sensillae detached from specimen, one of them is situated at top right side of specimen in front of leg II.) Standard measurements of unique type in microns: AW 50, PW 75, SB 28, ASB 18, PSB 12, AP 32, AM—, AL 19, PL 44, Sens 37μ × 15. *Body setae:* DS (31-40μ) irregularly arranged with humerals not distinct, roughly 14.10. 12.10.4.12.10.8.4. = ca. 84; plus 18-20 CS (34μ); plus ca. 60 VS (22μ). *Legs:* I-III 240, 175, 225μ long. Leg I: tarsus plus pretarsus 65 × 31μ, proximal "bar" present, tarsala 22μ; 2 tibialae relatively stout and blunt-tipped. Leg II: tarsus plus pretarsus 50 × 28μ, tarsala 16μ. Leg III: tarsus plus pretarsus 62 × 26μ. Coxa-III 58 × 38μ.

Type material.—Unique holotype CORU. 101134 ex R.40030-2/59, *Rattus alticola*, at base camp (ca. 4,000 ft. elev.), Mt. Trus Madi, British North Borneo, 21. vii. 1953 (*J. R. Audy*; for joint Anglo-American Research Expedition, 1953).

Remarks.—This species is named for the senior author's colleague W. W. Macdonald, Entomologist, who has been collaborating with the Division of Virus Research and Medical Zoology in the study of culicine mosquito ecology in relation to the transmission of viruses.

Susa reidi n. sp. (Figs. 26-35)

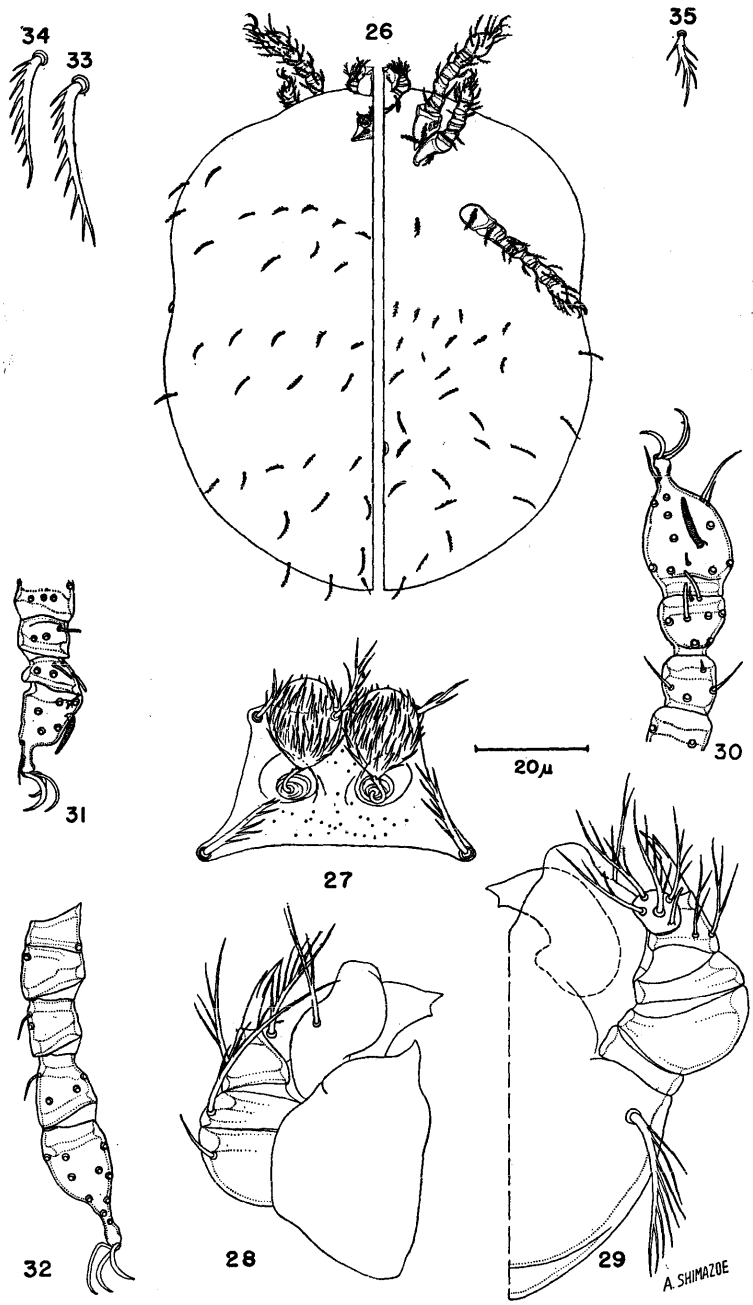
Euchongastia (*Laurentella*) "*ALT-B*" (*40592*), Audy 1956.

Diagnosis of larva.—Close to *labuanensis* and *macdonaldi*, from which it is distinguished by the palpal formula of N.b.BBB.5B.

Description of larva.—Described from a solitary specimen. Body elongate oval 480 × 310μ (incl. gnathosome). *Gnathosome:* chelicerae short, broad, curved with a small dorsal tooth. Galeal seta with few delicate long barbs. Palp not laterally angulate, palpal formula N.b.BBB.5B; claw (13μ) slender, accessory prongs unequal, in distal third. *Scutum* almost trapezoidal, anterior margin sinuous, posterior margin slightly concave, lateral margins also concave; puncta sparse; sensillae globular (sensillae absent from original specimen CORU.40592). Standard measurements (of CORU.40592) in microns; AW 28, PW 40, SB 14, ASB 22, PSB 18, AP 22, AM —, AL 9, PL 30. *Body setae:* DS (21-28μ) numbering ca. 72, very irregularly arranged approximately 6.12.10.12.8.8.8.4.4; plus ca.15 CA (25μ); plus ca. 40 VS (15μ). *Legs:* I-III 170, 140, 165μ long. Leg I: tarsus and tibia swollen in the neighbourhood of the tarso-tibial joint, tarsus plus pretarsus 42 × 28μ, proximal bar poorly developed, tarsala 18μ. Leg II: tarsus plus pretarsus 30 × 20μ, tarsala 11μ. Leg III: tarsus plus pretarsus 31 × 19μ. Coxa-III 40 × 29μ.

Type material.—Holotype, CORU. 40592, ex *Rattus alticola*, Beaufort, British North Borneo, 15. v. 1952 (*J. R. Audy* for Anglo-American Medical Research Expedition, 1952); one paratype, B.19081-7 ex *Rattus rajah* group, Paring, Mt. Kinabalu, alt. 1,600 ft., British North Borneo, 20. vii. 1953 (*R. Traub*, Anglo-American Medical Research Unit).

Remarks.—At the time of writing this paper, only the original specimen (which lacks chelicers and sensillae) was available for description. The paratype, collected by Lt.-Colonel Robert Traub, had however been compared with the original specimen and the two found



Figs. 26-35. *Susa reidi* n. sp.

26, dorsal/ventral aspects of larva; 27, scutum; 28, 29, gnathosome, dorsal and ventral; 30, 31, 32, legs I, II, III; 33, 34, 35, dorsal, caudal and ventral setae.

to be indistinguishable. The figures are drawn from the paratype and they agree in characters with the holotype. This species is named for Dr J. A. Reid, Senior Entomologist at the Institute for Medical Research, to whom we are indebted for many courtesies.

Discussion

There is a tendency for the scutum to retract in this genus, and this is best shown in *reidi* where the PL setal bases are borne on narrow tongues of scutum. We should therefore be prepared to find species, properly belonging to this genus, where this retraction has gone further and the PL setae are extra-scutal. This may or may not suggest affinities with *Pseudoschongastia.* The peculiar swelling of tarsus and tibia, best shown here with leg-I of *reidi,* is also encountered in leg-I and also frequently in leg-III of species of *Ascoschongastia* and *Traubacarus,* especially the intranasal "*TAA*-group" of *Ascoschongastia* (*Laurentella*) (Audy, 1956, p.8, fig. 1 *ET*). Another feature of interest is the somewhat outstanding and almost nude posterior subterminal setae on tarsus-III of *debilis* (fig. 7): it remains to be seen whether or not these are homologous with an extraordinary expanded seta which we have seen on tarsus-III of species of *Laurentella* (intranasal *TAA*-group—Audy, 1956, fig. 1 *ET*) and also, more recently, on an atypical *Traubacarus.*

The key and the table of characters summarize the main points of difference between the species.

Key to larvae

1. PW more than 70μ, palpal genu with a long nude seta, tibia with a long, strongly barbed dorsal seta ..... *macdonaldi* n. sp.
   PW less than 70μ, palpal setae relatively short 2
2. PW ca. 60μ seta on palpal genu short nude; sensilla broadly clavate ..... *debilis* (Gat.).
   PW less than 50μ 3
3. Seta on palpal femur short nude; PL 30μ; ca. 72DS ..... *reidi* n. sp
   Seta on palpal femur barbed; PL 19μ; ca. 62 DS ..... *labuanensis* (Wom.)

Table

Specific characters, genus Susa

Character:	*debilis*	*labuanensis*	*macdonaldi*	*reidi*
Palpal formula	b.N.BNN.4BS	N.B.BBN.4BS?	N.N.BNB.5B	N.b.BBB.5B
Scutum:				
shape, approx.	rect.	rect.	rect.	trapez.
PLs peninsular	no	yes	yes	yes
AW:PW:AP	39:59:22	29:41:22	50:75:32	28:40:22
AL:AM:PL	17:23:28	10:16:19	19:? :44	9:? :30
Sensillae	broad clavate	?	broad clavate	globose
Dorsal setae approx.... ...	57	62	84	72
Coxa-III (in μ)	46×27	36×24	58×38	40×29

Summary

A new genus, *Susa,* is raised to accomodate the *debilis*-group, hitherto accommodated in *Ascoschongastia,* subgenus *Laurentella. Susa debilis* (Gater), type-species, and *S. labuanensis* (Wom.), new combinations, are redescribed. *Susa macdonaldi* and *S. reidi* are new species. All these except the type are from rats from Borneo and Labuan.

ACKNOWLEDGEMENTS

We are very grateful to Lt.-Colonel Robert Traub, recently chief of the U.S. Army Medical Research Unit at the Institute for Medical Research, for allowing free access to his material and particularly for arranging, and making available, the drawings. We are grateful to the Officer Commanding, 406 General Medical Laboratory, Camp Zama, Tokyo, for his collaboration in getting drawings of chiggers made; to Asanume Shimazoe of that Laboratory for the superb drawings of *debilis* and *reidi*, and to Mr. Ng Chong Kee of the U.S. Army Research Unit for the drawings of *macdonaldi* and *labuanensis*.

REFERENCES

AUDY J. R. (1956). *Laurentella*, a new subgenus of trombiculid mites, with notes on biology and medical importance. *Bull. Raffles Mus.*, *28*, 5-26.

AUDY J. R. (1957). A checklist of trombiculid mites of the Oriental and Australasian regions. *Parasitology*, *47*, 217-294.

AUDY J. R., LAWRENCE R. AND VERCAMMEN-GRANDJEAN P. H. (1960). Section on Trombiculidae in F. Zumpt (Editor) *Arthropods parasitizing vertebrates in Africa south of the Sahara* (*Ethiopian region*), vol. 1, (Chelicerata). (*In press*).

AUDY J. R. AND WOMERSLEY H. (1957). Malaysian Parasites, XXIX. New species of Oriental and Australian Trombiculidae (Acarina). *Stud. Inst. med. Res. Malaya*, *28*, 359-382.

DOMROW R. (1957). Malaysian Parasites, XXXI. Nymphs of *Ascoschongastia* Ewing and *Laurentella* Audy (Acarina, Trombiculidae). *Stud. Inst. med. Res. Malaya*, *28*, 394-402.

DOMROW R. (1960). Malaysian Parasites, XLII. *Oculicola*, new subgenus of *Ascoschongastia* Ewing (Acarina): Trombiculidae from eyes of mammals. *Stud. Inst. med. Res. Malaya*, *29*, 177-184 (this *Study*).

HARRISON J. L. (1958). *Chimarrogale hantu* a new water shrew from the Malay peninsula, with a note on the genera *Chimarrogale* and *Crossogale* (Insectivora, Soricidae). *Ann. Mag. nat. Hist.*, (13), *1* 282-290.

MALAYSIAN PARASITES XL

NYMPHS OF *LEPTOTROMBIDIUM* AND *TROMBICULINDUS* (ACARINA, TROMBICULIDAE)

BY

ROBERT DOMROW

Queensland Institute of Medical Research, Brisbane

Certain genera of Trombiculidae, e.g. *Trombicula*, *Schongastia*, *Neoschongastia* and *Euschongastia*, have until recently been taken in a very broad sense. Some progress is now being made in breaking them into smaller compact groups of generic or subgeneric status. An example of this is the treatment of *Euschongastia* s.l. by Audy & Domrow (1957). Among the species removed from this genus were four in which the nymphs are indistinguishable, while their larvae are separable on one character only. These were included (Domrow, 1957*b*) in the two subgenera *Ascoschongastia* and *Laurentella* of the genus *Ascoschongastia*.

Likewise Audy (1957*b*, 1960) has recognized *Leptotrombidium* as a full genus distinct from *Trombicula*. This usage is adopted in the present paper, where *Leptotrombidium* is considered as comprising two subgenera, *Leptotrombidium* s.s. and *Trombiculindus* Radford. As in *Ascoschongastia*, larvae and nymphs of both subgenera are known, the larvae being again separable by one character only, while the nymphs are indistinguishable.

Genus **Leptotrombidium** Nagayo *et al.*

Leptotrombidium (type species *Trombidium akamushi*) is one of the oldest group names in the Trombiculidae, having been erected in 1916 as a genus on the basis of both larval and postlarval stages. However in a later paper (1921) its authors considered it a synonym of *Trombicula* Berlese, 1905. *Leptotrombidium* then fell into disuse until about 1950, and an idea of its extensive neglect may be gained by consulting the very full documentation of the species concerned given by Wharton & Fuller (1952).

Wharton (1946, 1947) defined a close-knit *akamushi*-group within *Trombicula* s.l., and this pointed the way for Womersley and Wharton & Fuller, who in their monographs (1952) revived *Leptotrombidium* as a subgenus of *Trombicula* s.l. This usage was widely accepted (Audy, 1954, 1957*a*, Womersley & Audy, 1957), but it is now clear that *Leptotrombidium* deserves generic rank.

Diagnosis.—A diagnosis limited to contain the *akamushi*-group of Wharton is too restrictive, while Womersley's subgenus is heterogeneous. Probably the best view of *Leptotrombidium* is that of Audy (1954). An acceptable diagnosis is as follows—*larvae* with transverse rectangular scuta, without shoulders in front of AL setae; AL and PL setae sometimes approximated; sensillae filiform, with distal ciliations; palpal formula n (b). n (b). b (n) nn. 7b-n; palpal claw three-pronged; galeal seta branched (but nude in *myzantha*); bases of chelicerae angulate laterally; legs 7.7.7, without mastisetae on apical segments of III, but with tibiala III; body setae normal or variously expanded; usually parasitic on mammals, but occasionally on birds; *postlarval stages* without eyes; area sensilligera transverse and dumbbell-shaped, not as wide as crista is long; tectum dentate; paracristal setae subequal; sensillae filamentous, very fine and ciliated distally; palpal tarsus with sensory rod, nine ciliated setae and four nude apical setae; hypostome with four pairs of nude galeal setae; inner angles of coxae I cut

off by transverse bar to form two precoxal plates, which are bounded posteriorly by strut running in from coxae II; tarsi I without preapical dorsal process; legs with five kinds of setae described below; inner genital setae 3. 3, usually ciliated; body setae frequently clavate.

Subgenus **Leptotrombidium** Nagayo, Miyagawa, Mitamura & Imamura, 1916

Type species: *Trombidium akamushi* Brumpt, 1910

Diagnosis.—Larvae with dorsal body setae slender and straight-sided, not expanded or modified in any way; PL scutal setae sometimes approximated to AL setae. Postlarval stages as in generic diagnosis.

Synonymy.—Kedania Kishida, 1909 (type *K. tanakai=T. akamushi*) antedates *Leptotrombidium.* However the original private edition of Kishida's paper appears to be lost, and Philip (1947) considers *Kedania* to date from 1917, when the article was reprinted in a recognized scientific journal. To resurrect *Kedania* now would be quite uncalled for.

Mehracula Sinha, 1954 (type *M. roonwali* Sinha, 1954) is now accepted by its author (1957) as a synonym of *Leptotrombidium.*

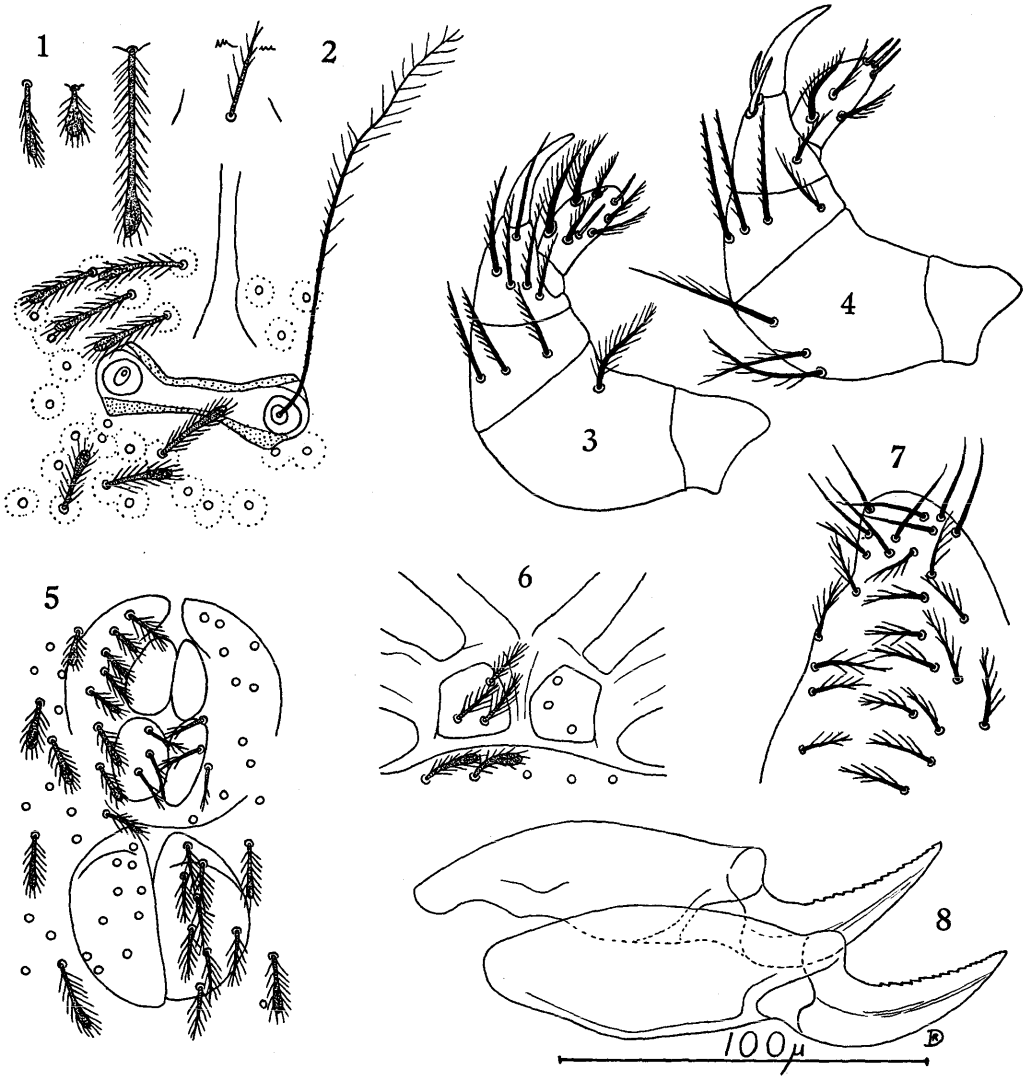
Plumosicola Sinha, 1954 is a synonym of *Trombiculindus* (*see* below), but one of the included species, *intermedia* (Nagayo), is a typical *Leptotrombidium.*

Leptotrombidium (Leptotrombidium) langati (Audy & Womersley, 1957) (Figs. 1-8)

Description of nymph.—A small species of unknown colour in life. Length of idiosoma (from tip of hypostome and including terminal body setae) 582-642μ. Genital area broadly oval, about 62μ long, with two pairs of genital discs; anterior discs 21.7-26.4μ, posterior discs 21.7-23.3μ long. Genital plates fairly well defined, with nine or ten slightly clavate setae each. Inner genital setae arranged 3.3, with three to six fine branches apically. Anal plates set immediately behind genitalia, elongate, about 48μ long, with nine or ten tapering ciliated setae each. The setae on the ventral cuticle adjacent to the anal plates are, however, clavate. *Gnathosoma:* Chelicerae typical, 144-148μ long; blade serrate dorsally, 59-64μ long. Hypostome with four pairs of nude galeal setae to 28μ long. Basis capituli with about eighteen setae, mostly ciliated on one side only. *Palpi* with usual five segments. Femur with three to five ciliated setae, of which one external seta is ciliated on both sides; genu with six to eight ciliated setae; tibia with single internal ciliated seta near insertion of tarsus, two inner accessory combs (only one on one side of one specimen), an external nude seta near base of claw, and four (five on one side of one specimen) ciliated external setae; tarsus with external basal sensory rod, four nude apical setae and nine ciliated setae. Palpal claw 33μ long. *Legs* normal, seven-segmented. Coxae I with inner corners cut off by transverse strut to form typical precoxal plates, which are bounded posteriorly by inward extension from coxae II; each with two or three tapering ciliated setae. The setae on the ventral cuticle immediately behind the precoxal plates are clavate. Tarsus I 88-104μ long, 64-73μ high; tibia I 62-73μ long. Ratio LTI/HTI 1.39-1.44; ratio LTI/LtI 1.42-1.50. No preapical dorsal process on tarsus I. *Scutum:* Area sensilligera transverse and dumbbell-shaped, not well developed behind sensillary bases. Crista normal. Tectum dentate anteriorly, with single slender tectal seta. Paracristal setae subequal, clavate. Sensillae long and filamentous, with barbules on basal third and short ciliations on remainder of shaft. Eyes absent. The standard data are given below. *Setation:* With at most one or two tapering ciliated setae close to area sensilligera; otherwise all dorsal setae clavate. Anterodorsal setae 20-26μ, middorsal setae 17μ, posterodorsal setae 59μ long. Terminal setae ciliated only on dorsal surface of asymmetrical club. Leg setae as figured for *L.* (*T.*) *fordi* below; feathered setae 28μ, slender solenidia 23μ, thick solenidia 12μ, tapering nude setae 17μ, microsetae 3.1μ long. Leg I also with some clavate setae on five segments from trochanter to tibia.

STANDARD DATA IN MICRA OF NYMPHAL SCUTUM OF *L.* (*L.*) *langati* (A. & Wom.)

	CTL	ASL	SB	ASL/SB	PSL	TS	SS	SENS
	—	—	48.1	—	10.8	—	27.9	—
	—	—	49.6	—	12.4	—	32.6	124
	—	—	46.5	—	10.8	—	—	121
	69.8	—	44.9	—	12.4	26.4	34.1	118
	62.0	77.5	43.4	1.78	10.8	23.3	27.9	124
Means	65.9	77.5	46.5	1.78	11.4	24.8	30.6	122



Figs. 1-8. *Leptotrombidium* (*Leptotrombidium*) *langati* (Audy and Womersley, 1957)

1, setae from telofemur I, middorsum, and end of body (from left to right); 2, scutum; 3, 4, external and internal views of palp; 5, genitalia and anus in normal positions; 6, precoxal plates; 7, hypostome; 8, chelicerae in lateral view.

Material examined.—Two nymphs with two correlated larval pelts (slides CORU 38314 a & b and 38326 a & b) bred from engorged larvae removed from *Rattus sabanus* No. R 35641, Ulu Langat Forest Reserve, Selangor, Malaya on 12. i. 1954. The nymphs emerged 18 and 21 days later, 30. i. and 2. ii. 1954. Also three nymphs with three correlated pelts (slides CORU 38687 a & b, 38708 a & b and 38727 a & b) bred from engorged larvae removed from *R. sabanus* No. R 36391, same locality, on 20. iii. 1954. These nymphs emerged 30 to 37 days later, 19 to 27. iv. 1954.

Notes.—The nymph of *L.* (*L.*) *langati* is very similar to those of *L.* (*L.*) *keukenschrijveri* (Walch) and *L.* (*L.*) *muridia* (Womersley), which I have described in an earlier paper (1957*a*). The latter two species, as well as the two *Trombiculindus* species described below, have several tapering ciliated setae around the area sensilligera and behind the precoxal plates, while in *L. langati* all these setae are clavate. An additional character present only in *L. langati* is the presence of clavate setae on the five central segments of leg I. *Leptotrombidium* nymphs have also been described by Womersley (1952), Sasa (1953) and Sasa & Miura (1955, 1956). The specific identification of these nymphs, as in other genera, is exceedingly difficult.

Subgenus **Trombiculindus** Radford, 1948

Type species: *Trombiculindus squamosus* Radford, 1948

Trombiculindus was erected as a genus on the basis of the modified dorsal setae of the larvae, which otherwise resemble very closely those species of *Leptotrombidium* with AL and PL scutal setae closely approximated. Re-examination of the two nymphs described by Womersley (1952) has shown them to be inseparable from nymphs of *Leptotrombidium* s.s. Previously *Trombiculindus* was widely regarded as a subgenus of *Trombicula* s.l., though Sinha (1954) followed Radford (1954) in using the name generically.

Diagnosis.—Larvae with dorsal body setae variously modified, ranging from lanceolate or bifurcate setae with barbules along their shaft to overlapping squamose setae without any trace of marginal barbules; PL scutal setae closely approximated to AL setae. Postlarval stages as in generic diagnosis.

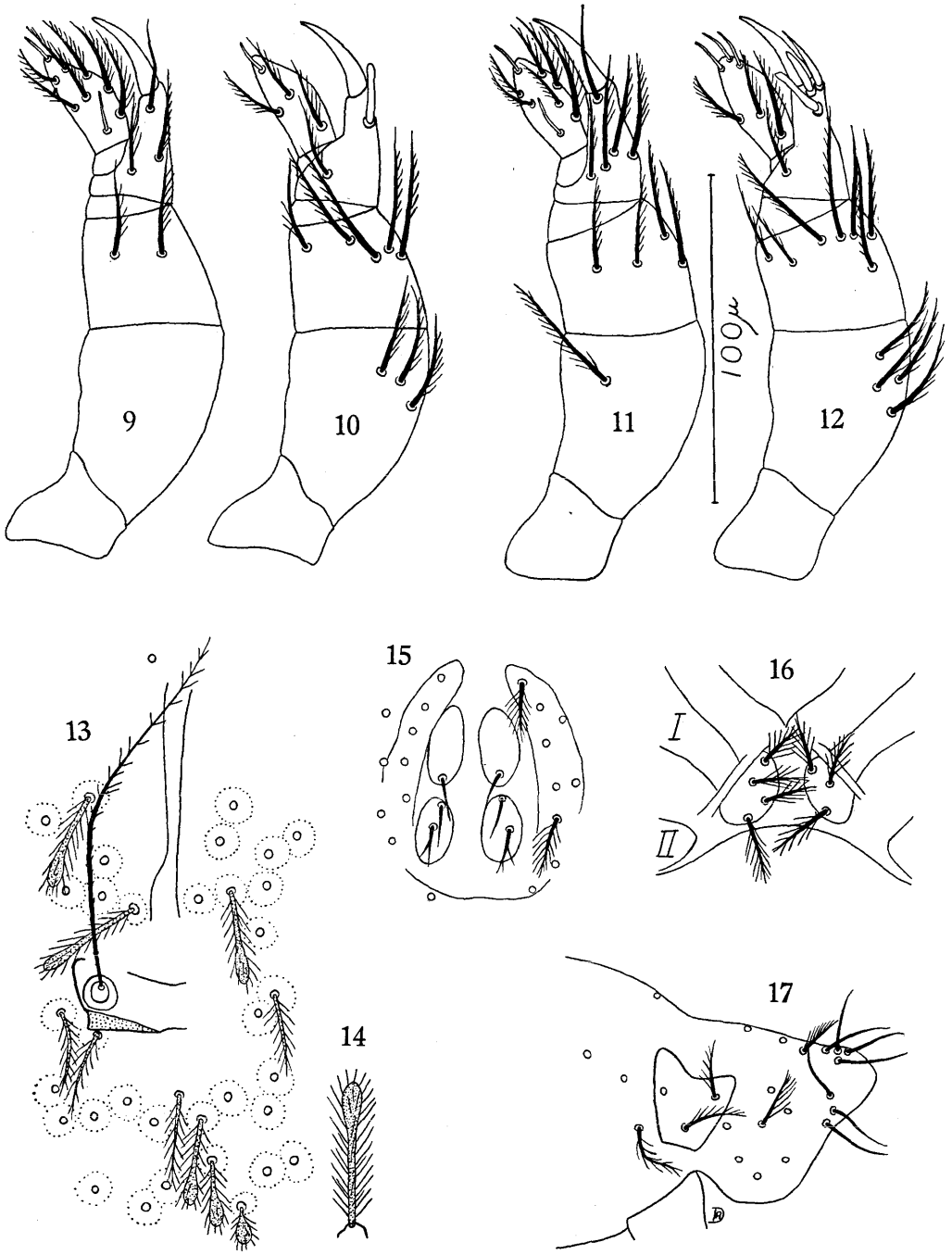
Synonymy.—*Plumosicola* Sinha, 1954 (type *Trombicula plumosa* Radford, 1953) is a synonym of *Trombiculindus*, as the type species belongs here. One of the other species (*hastata*) is also a *Trombiculindus*, while the third belongs to *Leptotrombidium* s.s. (*see* above).

Leptotrombidium (**Trombiculindus**) **hastata** (Gater, 1932) (Figs. 9-22)

Description of nymph.—Idiosomal length not exceeding 610μ. Genital area 71.3μ long; anterior discs 23.2μ, posterior discs 20.5μ long. Genital plates fairly well defined, with eight or nine ciliated setae each. Inner genital setae arranged 3.3; nnb and nnb. Anal plates elongate, 46.5μ long, with five to seven ciliated setae each. *Gnathosoma:* Chelicerae 140μ long; blade slightly serrate dorsally, 51μ long. Hypostome somewhat distorted, but fairly blunt apically, with four slender nude galeal setae on one side, and three on the other, to 22.5μ long. Basis capituli with about seventeen ciliated setae. *Palpi:* Left palp armed as follows—femur with five ciliated setae; genu with eleven ciliated setae; tibia with single internal ciliated seta near insertion of tarsus, three inner accessory combs, an external nude seta near base of claw, and four ciliated external setae; tarsus with external basal sensory rod, four apical nude setae, and nine ciliated setae. Right palp armed as follows—femur with three ciliated setae; genu with seven ciliated setae; tibia with single internal ciliated seta near insertion of tarsus, one inner accessory comb, an external nude seta near base of claw, and two external ciliated setae; tarsus with external basal sensory rod, two apical nude setae, and ten ciliated setae. Palpal claw 28μ long. *Legs:* Coxae I with typical precoxal plates (but hard to see in available specimen), with three or four ciliated setae each. Ciliated setae behind precoxal plates tapering, not clavate. Tarsus I 124μ long, 65μ high; tibia I 79μ long. Ratio LTI/HTI 1.91; ratio LTI/LtI 1.57. *Scutum:* Area sensilligera of usual shape; tectal structures missing. Paracristal setae uniform in length and clavate. Sensillae long and filamentous, with barbules on basal half merging into short ciliations on distal half. Eyes absent. The standard data are given below. *Setation:* Body setae immediately behind scutum tapering to point, and mixed with clavate setae which quickly become shorter (to 14μ long), and then increase to 46.5μ long at end of body. Terminal setae ciliated only on dorsal surface of club. Leg setation similar to that figured for *L.* (*T.*) *fordi* below and *L.* (*L.*) *keukenschrijveri* (in Domrow, 1957*a*); ciliated setae to 26.4μ, both slender and tapering solenidia to 27.1μ, stout solenidia to 12.4μ, microsetae to 3.1μ long.

STANDARD DATA IN MICRA OF NYMPHAL SCUTUM OF *L.* (*T.*) *hastata* (Gater)

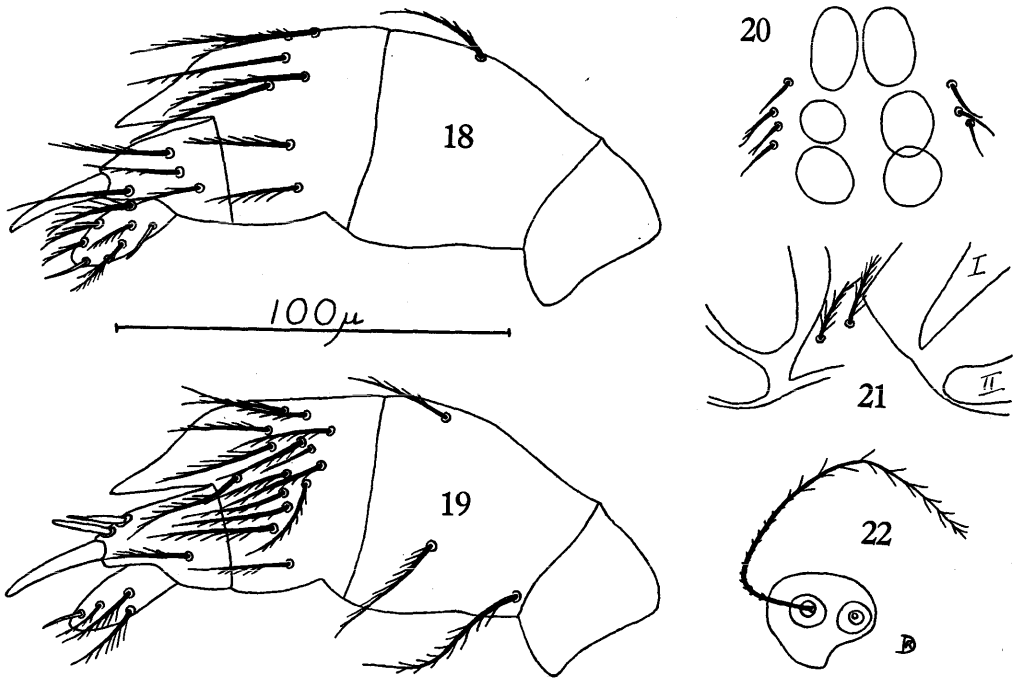
CTL	ASL	SB	$\frac{ASL}{SB}$	PSL	TS	SS	SENS
72.8	—	—	—	14.0	—	31.0	112



Figs. 9-17. *Leptotrombidium* (*Trombiculindus*) *hastata* (Gater, 1932)

9, 10, external and internal views of right palp; 11, 12, external and internal views of left palp; 13, 14, scutum with middorsal and posterior body setae; 15, genitalia; 16, precoxal plates; 17, hypostome.

Description of abnormal nymph.—Rather smaller than normal nymph. Idiosoma stout and rounded, length in somewhat distended condition 484μ. Genitalia with three pairs of distinct discs; inner genital setae arranged 3.4, mostly nude, but with slight tendency to branching. *Gnathosoma* much deformed, consisting only of a single palp articulated by normal single trochanter between coxae I, immediately in front of "precoxal" area. Palpal tarsus and tibia quite normal; genu with weakly sclerotized, pointed lobe extending forward over tibia towards accessory combs, with 22 setae, all of which are normally formed and ciliated, except one short simple seta on internal face; femur with four setae, one of which is set close to trochanter, and ciliated on both sides. Basis capituli, hypostome and chelicerae entirely absent. *Legs* as in adult, but apical segments of leg I somewhat stunted; length tarsus I 103μ, height tarsus I 62μ, length tibia I 60μ. Ratio LTI/HTI 1.66; ratio LTI/LtI 1.72. Coxae I and II slightly deformed, without any trace of precoxal structure except for short inwardly directed posterior strut on left coxa II; with two ciliated setae between coxae I. *Scutum* represented by small, irregular, but clearly defined plaque bearing two short sensillae. Cristal and tectal structures entirely absent. *Setation:* Setae around scutum and on body and legs normal.



Figs. 18-22. *Leptotrombidium* (*Trombiculindus*) *hastata* (Gater, 1932)

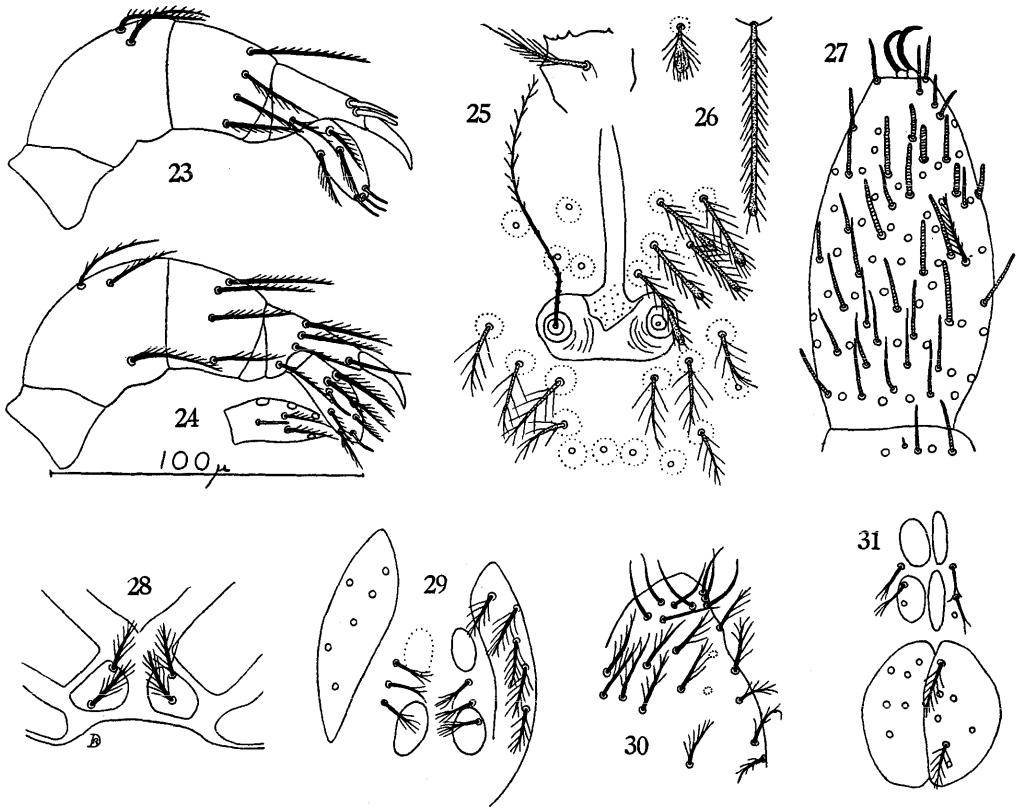
18, 19, external and internal views of single palpal tarsus; 20, abnormal genitalia with three pairs of genital suckers; 21, incipient "precoxal" area; 22, abnormal scutum.

Material examined.—Two nymphs bred from engorged larvae (slides CORU 14105 and 14107) from *Rattus sabanus* No. R 10376, Kepong, Bukit Lagong Forest Reserve, Selangor, Malaya, 10. iii. 1950, M. Nadchatram. Slide 14105 is the abnormally developed specimen, while 14107 is normal and labelled as "type".

Note.—The abnormalities of the specimen described above are not confined to one particular portion of the body; they are widespread, involving the gnathosoma (and correlated with this, the precoxal area), the scutum and the genitalia. The scutum is rudimentary, but the precoxal area, and particularly the single palp, are, within limits, quite typical of the nymphal stage. The genitalia, however, are particularly interesting, showing a combination of nymphal and adult characters. Three pairs of genital discs (an adult, not a nymphal character) are present, while the accessory inner genital setae are few in number, unmodified, and typical of the nymphal stage. Some teratomorphs afford valuable taxonomic information, but this is not so in the present specimen.

Leptotrombidium (Trombiculindus) fordi (Womersley, 1952) (Figs. 23-31)

Description of nymph.—Length of idiosoma not exceeding 582μ. Genital area oval, 64μ long; anterior discs 13.2μ, posterior discs 14.7μ long. Genital plates fairly well defined, with five to seven ciliated setae each. Inner genital setae arranged 3.3, all with two to five fine branches apically. Anal plates about 50μ long, with seven to eleven ciliated setae each. *Gnathosoma:* Chelicerae 128μ long; blade slightly serrate dorsally, 50.3μ long. Hypostome fairly blunt apically, with eight nude galeal setae to 18.6μ long. Basis capituli with about fifteen setae, mostly ciliated on one side only. *Palpi:* Femur with four or five ciliated setae; genu with seven to ten ciliated setae; tibia with single internal ciliated seta near insertion of tarsus, two inner accessory combs, an external nude seta near base of claw, and four ciliated external setae; tarsus with external basal sensory rod, four apical nude setae, and nine ciliated setae. The relative positions of the two ciliated setae on the external face of the tarsus vary, *see* fig. 24. Palpal claw 23.3μ long. *Legs:* Precoxal plates each with two ciliated setae. Setae behind precoxal plates not clavate. Tarsus I 116μ long, 60μ high, tibia I 70μ long. Ratio LTI/HTI 1.93; ratio LTI/LtI 1.66. *Scutum:* Area sensilligera and crista normal. Tectum with sides clearly marked, and anterior margin weakly dentate. Tectal seta long and fine, with slender ciliations. Paracristal setae subequal, clavate. Sensillae long and filamentous, with barbules on basal third and weak ciliations on remainder of shaft. Eyes absent. The standard data are given below. *Setation:* Body setae immediately behind scutum tapering to point, to 23.3μ long. These merge into clavate setae, which shorten to 14μ middorsally, and lengthen again to 56μ posteriorly. The posterior body setae are very weakly clavate apically. Leg setae as figured; feathered setae to 24.8μ, both slender and tapering solenidia to about 21.7μ, thick solenidia to 10.8μ, microsetae to 3.1μ long.



Figs. 23-31. *Leptotrombidium* (*Trombiculindus*) *fordi* (Womersley, 1952)

23, 24, internal and external views of palpal tarsus; 25, 26, scutum with middorsal and posterior body setae; 27, setation of tarsus I in lateral view; 28, precoxal plates; 29, genitalia, somewhat distorted; 30, hypostome; 31, genitalia and anal plates (drawn close together for convenience).

STANDARD DATA IN MICRA OF NYMPHAL SCUTUM OF *L.* (*T.*) *fordi* (Wom.)

CTL	ASL	SB	$\frac{ASL}{SB}$	PSL	TS	SS	SENS
72.8	85.3	32.6	2.62	11.6	38.7	24.8	86.8
—	—	—	—	—	35.6	24.8	—

Material examined.—Two nymphs bred from engorged larvae (slides 2012-N1 and 2012-N5) from *Rattus rattus brunneusculus*, Imphal, Burma, 20. xii. 1945, K.L. Cockings.

Notes.—Gater (1932) originally placed *L.* (*T.*) *hastata* in *Trombicula*, while Womersley (1952) placed both *hastata* and *fordi* in *Neotrombicula*, believing a complete sternum to be present rather than two precoxal plates. Audy (1954) was the first to associate these two species with *Trombiculindus*. The nymphs of these two *Trombiculindus* species show a close similarity to *Leptotrombidium* in all characters.

Although the larvae of *L.* (*T.*) *fordi* and *L.* (*T.*) *hastata* are distinct, their nymphs are separable only by the following tenuous characters—the number of setae on the precoxal plates, the degree of ciliation of the inner genital setae, and the shape of the clavate terminal body setae.

The variation in the armature of the palpal tibia and tarsus detailed in the above descriptions is of interest. These variations should be recognized as such, for there seems to be a basic pattern for these two segments in nymphal trombiculids (*see* Domrow, 1956). Seven elements are included. Four concern the tibia—a simple palpal claw with an outer nude seta and two inner accessory combs near its base, and an inner, usually branched seta near the insertion of the tarsus. The other three concern the tarsus—a baso-external sensory rod, and a variable number of nude apical setae and normal branched setae. In *Leptotrombidium* there are four nude apical setae (three set internally and one externally), while the nine ciliated setae are arranged as follows—three on inner edge, and two each on outer edge, outer face and inner face.

Having described or examined nymphal trombiculids of several genera and subgenera, I am becoming convinced that a clear-cut specific separation of the postlarval stages will seldom be possible. At a supraspecific level, however, the postlarval stages are of great value in clarifying a classification still largely based on larval characters. In laboratory breeding experiments with engorged larvae freshly taken from their host, the ease of recovery of the larval pelts provides a key to the identity of the nymphs, because the larvae are almost invariably much more easily recognized than the nymphs. To identify a wild-caught nymph is another matter. On microscopic examination it may (and probably will) closely resemble a known nymph, but the possibility that it is another species cannot be ruled out, for there are by far more larval species than known nymphs. Furthermore, to hatch out larvae from eggs laid in the laboratory presupposes the presence of both sexes, or at least prefertilized females, while to obtain larvae from nymphs is more tedious still. And finally the probability of the loss or damage of the original postlarval material in obtaining larvae is a further factor to be considered.

ACKNOWLEDGEMENTS

In writing this and other papers in the present *Study*, I am grateful to Drs. J. R. Audy, E. H. Derrick and I. M. Mackerras and Messrs. H. M. Hale, M. Nadchatram and H. Womersley. Their readiness to lend material and their kind advice and helpful criticism are valued. Miss E. Wood has typed my manuscripts with her usual care.

SUMMARY

Leptotrombidium is granted full generic status, including the typical subgenus and *Trombiculindus* Radford. The larvae of the two subgenera are separable only on one larval character, the modification or not of the dorsal setae, while the nymphs are inseparable. The nymphs of *L.* (*L.*) *langati*, *L.* (*T.*) *hastata* and *L.* (*T.*) *fordi* are figured and described.

STUD. INST. MED. RES.

REFERENCES

AUDY J. R. (1954). Malaysian Parasites, IX. Notes on the taxonomy of trombiculid mites with description of a new subgenus. *Stud. Inst. med. Res. Malaya, 26,* 123-170.

AUDY J. R. (1957*a*). A checklist of trombiculid mites of the Oriental and Australasian regions. *Parasitology, 47,* 217-294.

AUDY J. R. (1957*b*). The zoogeography of the genus *Leptotrombidium,* trombiculid mite vectors of scrub typhus. *Proc. 9th Pacif. Sci. Cong., 17* (in press).

AUDY J. R. (1960). Trombiculid vectors of scrub-typhus: records and changes of names. I. Genus *Leptotrombidium* (Trombiculidae). *Med. J. Malaya,* (in press).

AUDY J. R. AND DOMROW R. (1957). Malaysian Parasites, XXIII. A revision of Oriental and Australasian species of *Euschongastia* Ewing, including *Walchiella* Fuller, and description of a new subgenus, *Derrickiella* (Acarina, Trombiculidae). *Stud. Inst. med. Res. Malaya, 28,* 121-152.

AUDY J. R. AND WOMERSLEY H. (1957). Malaysian Parasites, XXIX. New species of Oriental and Australian Trombiculidae (Acarina). *Stud. Inst. med. Res. Malaya, 28,* 359-382.

BRUMPT É. (1910). *Précis de Parasitologie.* Paris, 2nd edition. 915 pp.

DOMROW R. (1956). Three new Australian chigger nymphs (Acarina, Trombiculidae). *Proc. Linn. Soc. N. S. W., 81,* 144-152.

DOMROW R. (1957*a*). Malaysian Parasites, XXII. Four *Trombicula* nymphs (Acarina, Trombiculidae). *Stud. Inst. med. Res. Malaya, 28,* 113-120.

DOMROW R. (1957*b*). Malaysian Parasites, XXXI. Nymphs of *Ascoschongastia* Ewing and *Laurentella* Audy (Acarina, Trombiculidae). *Stud. Inst. med. Res. Malaya, 28,* 394-402.

GATER B. A. R. (1932). Malayan trombidiid larvae, Part I (Acarina: Trombidiidae) with descriptions of seventeen new species. *Parasitology, 24,* 143-174.

KISHIDA K. (1917). [Supplemental contribution on study of kedani]. *Iji Shimbun, 974:* 2-4, 671-675.

NAGAYO M., MIYAGAWA Y., MITAMURA T. AND IMAMURA A. (1916). [On *Trombidium* and the akamushi]. *Dobutsugaku Zasshi, 28,* 300-313, 379-394.

NAGAYO M., MIYAGAWA Y., MITAMURA T., TAMIYA T., AND TENJIN S. (1921). Five species of tsutsugamushi (the carrier of Japanese river fever) and their relation to the tsutsugamushi disease. *Amer. J. Hyg.,* 1, 569-591.

PHILIP C. B. (1947). Observations on tsutsugamushi disease (mite-borne or scrub typhus) in northwest Honshu Island, Japan, in the fall of 1945. II. Systematic comment on the Japanese vole-mites. *Amer. J. Hyg., 46,* 60-65.

RADFORD C. D. (1948). *Trombiculindus squamosus* gen. nov., sp. n. A new genus and species of larval mite (Acarina: Trombiculidae). *Proc. zool. Soc. Lond., 118,* 126-128.

RADFORD C. D. (1954). The larval genera and species of 'harvest-mites' (Acarina, Trombiculidae). *Parasitology, 44,* 247-276.

SASA M. (1953). Description of nymphs and adults of Japanese trombiculid mites reared in the laboratory. *Jap. J. exp. Med., 23,* 407-450.

SASA M. AND MIURA A. (1955). Notes on nymphs and adults of tsutsugamushi of Japan, and their laboratory rearings. (Studies of tsutsugamushi, Part 83). *Jap. J. exp. Med., 25,* 197-209

SASA M. AND MIURA A. (1956). Studies on tsutsugamushi, Part 89. Description of the nymphs of *Trombicula kuroshio. Jap. J. exp. Med., 26,* 25-28.

SINHA T. B. (1954). New species of larval mites from India (Acarina: Trombiculidae). *Parasitology, 44,* 329-337.

SINHA T. B. (1957). *Mehracula* Sinha, 1954, a synonym of *Leptotrombidium* Nagayo *et al.*, with corrigenda. *Parasitology, 47,* 295-296.

WHARTON G. W. (1946). The vectors of tsutsugamushi disease. *Proc. ent. Soc. Wash., 48,* 171-178.

WHARTON G. W. (1947). Studies on North American chiggers, 1. The "akamushi" group. *J. Parasitol., 33,* 260-264.

WHARTON G. W. AND FULLER H. S. (1952). A manual of the chiggers. *Mem. ent. Soc. Wash., 4,* 1-184.

WOMERSLEY H. (1952). The scrub-typhus and scrub-itch mites (Trombiculidae, Acarina) of the Asiatic-Pacific region. *Rec. S. Aust. Mus., 10,* 1-673.

WOMERSLEY H. AND AUDY J. R. (1957). Malaysian Parasites, XXVII. The Trombiculidae (Acarina) of the Asiatic-Pacific region: a revised and annotated list of the species in Womersley (1952), with descriptions of larvae and nymphs. *Stud. Inst. med. Res. Malaya, 28,* 231-296.

MALAYSIAN PARASITES XLI

NYMPHS OF *VERCAMMENIA* AND *FONSECIA* (ACARINA, TROMBICULIDAE)

BY

ROBERT DOMROW

Queensland Institute of Medical Research, Brisbane

The interesting, monotypic chigger genus *Vercammenia* was described (Audy and Nadchatram, 1957) from larvae from various Malayan frogs, being especially compared with *Blankaartia* [*Tragardhula*] and *Eutrombicula* s.l. Nymphs of *V. hendricksoni* have since been reared, and are described below. Definite eyes are present in *Blankaartia* and *Eutrombicula* nymphs, but the nymph of *Vercammenia* has no trace of eyes. Nor does it agree in other characters with either of the above two genera.

The larval stages of the reptile-specific genus *Fonsecia* Radford, 1942 have been reviewed by Brennan and Loomis (1959). The genus is clearly defined, all species possessing peg-like anterolateral scutal setae. Only the larval stages were known until recently, when nymphs of the only Malayan species, *F. celesteae*, were successfully reared.* These are also described below.

In view of the present fluid state of trombiculid taxonomy, I hesitate to discuss the relationships of these two characteristic nymphs.

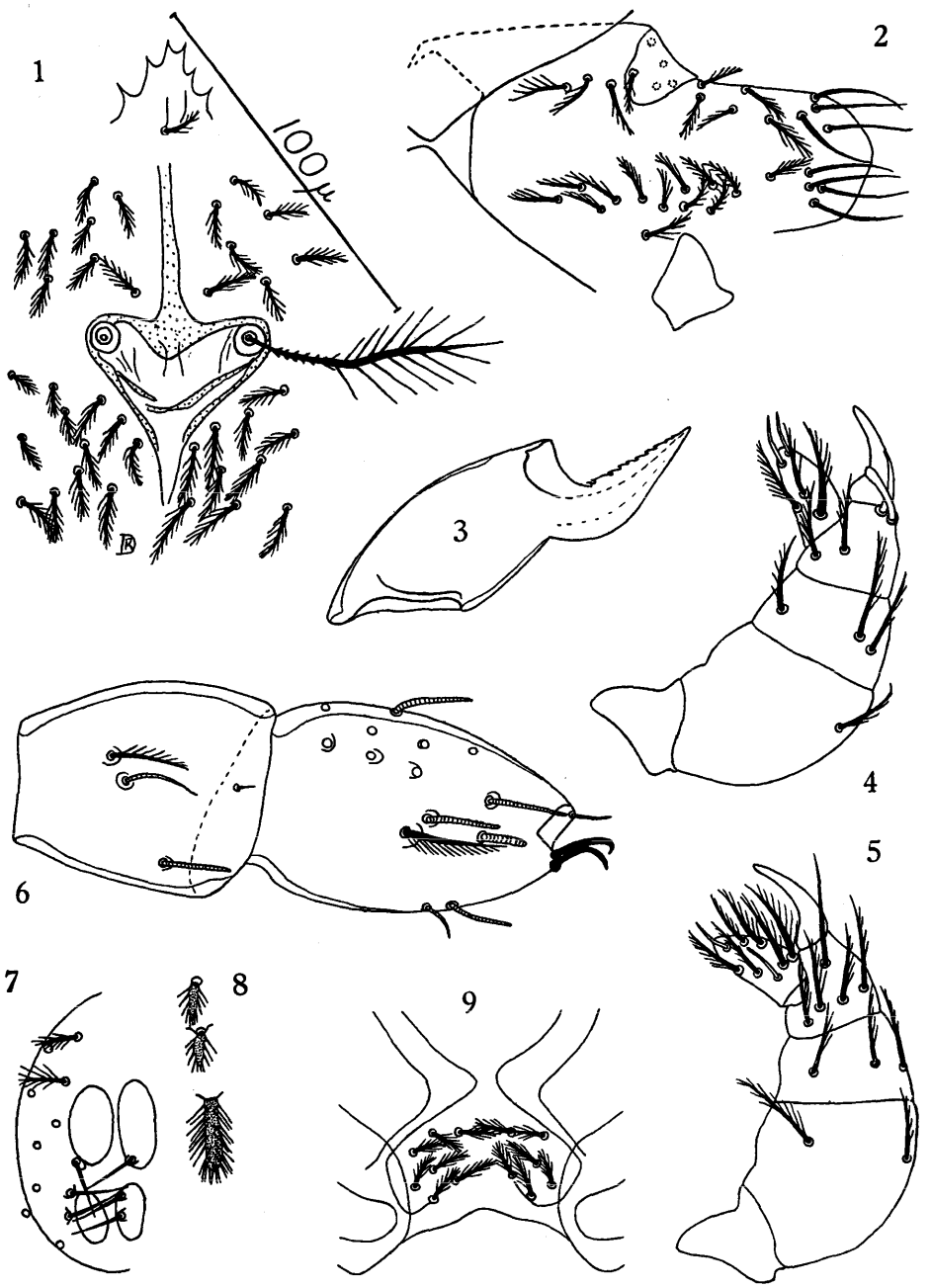
Vercammenia hendricksoni Audy & Nadchatram, 1957 (Figs. 1-9)

Description of nymph.—A slender, but rather large, creamy species. Idiosomal length 765 to 810μ in mounted specimens. Genital area just behind coxae IV, oval, about 61μ long, and without clearly demarcated genital plates; surrounded by about eight pairs of ciliated setae. Two pairs of genital discs present, length of anterior pair 22μ, posterior pair 14μ. Three pairs of nude inner genital setae with well defined insertions. Anal plates elongate and narrow, length 29μ; with three or four ciliated setae each. *Gnathosoma* with two irregular longitudinal rows of about thirteen ciliated setae on ventral surface, and with four pairs of slender, nude galeal setae from 20 to 28μ long (only seven galeals are present in two specimens). Hypostome narrower in front of palpal trochanters, and rounded apically. Chelicerae stout, 110μ long; blade 45μ long, with about ten fairly strong retrorse teeth on concave dorsal edge. *Palpi* with usual five segments; femur with three or four ciliated setae; genu with four to six ciliated setae; tibia with single (two on one side of one specimen) internal ciliated seta near insertion of tarsus, two inner accessory combs, an external nude seta near base of claw, and four (or five) ciliated external setae; tarsus with external basal sensory rod, three nude terminal setae and nine ciliated setae. Palpal claw 28μ long. *Legs* normal, seven-segmented. With incipient precoxal plates between fused coxae I & II, each with five to seven ciliated setae. Length tarsus I 79μ, height tarsus I 54μ, length tibia I 68μ. Ratio LTI/HTI 1.46; ratio LTI/LtI 1.16. Tarsus I without preapical dorsal process. *Scutum:* Area sensilligera cordate, well developed behind level of sensillary bases. Crista about as long as area sensilligera, and preceded by hyaline tectum with strongly dentate, convex anterior margin. Tectal seta short and ciliated. Paracristal setae subequal and numerous. Entire scutum surrounded by normal striate cuticle bearing setae as shown. Eyes absent. Sensillae short, with thickened shaft; with distinct barbs on basal third, and about fifteen long ciliations on remainder of shaft. The standard data are given below. *Setation:* Anterior dorsal setae evenly tapering, about 21μ long; middorsal setae shorter, to 12μ, with flattened shafts and lateral ciliations; posterior setae to 23μ, with cylindrical, thickened, straight-sided shafts and numerous ciliations all over. Types of leg setae as figured, often set in small depressions. Ciliated setae to 30μ, slender solenidia to 22μ, thick solenidia to 12μ, microsetae to 5μ long.

STANDARD DATA IN MICRA OF NYMPHAL SCUTUM OF *V. hendricksoni* A. & N.

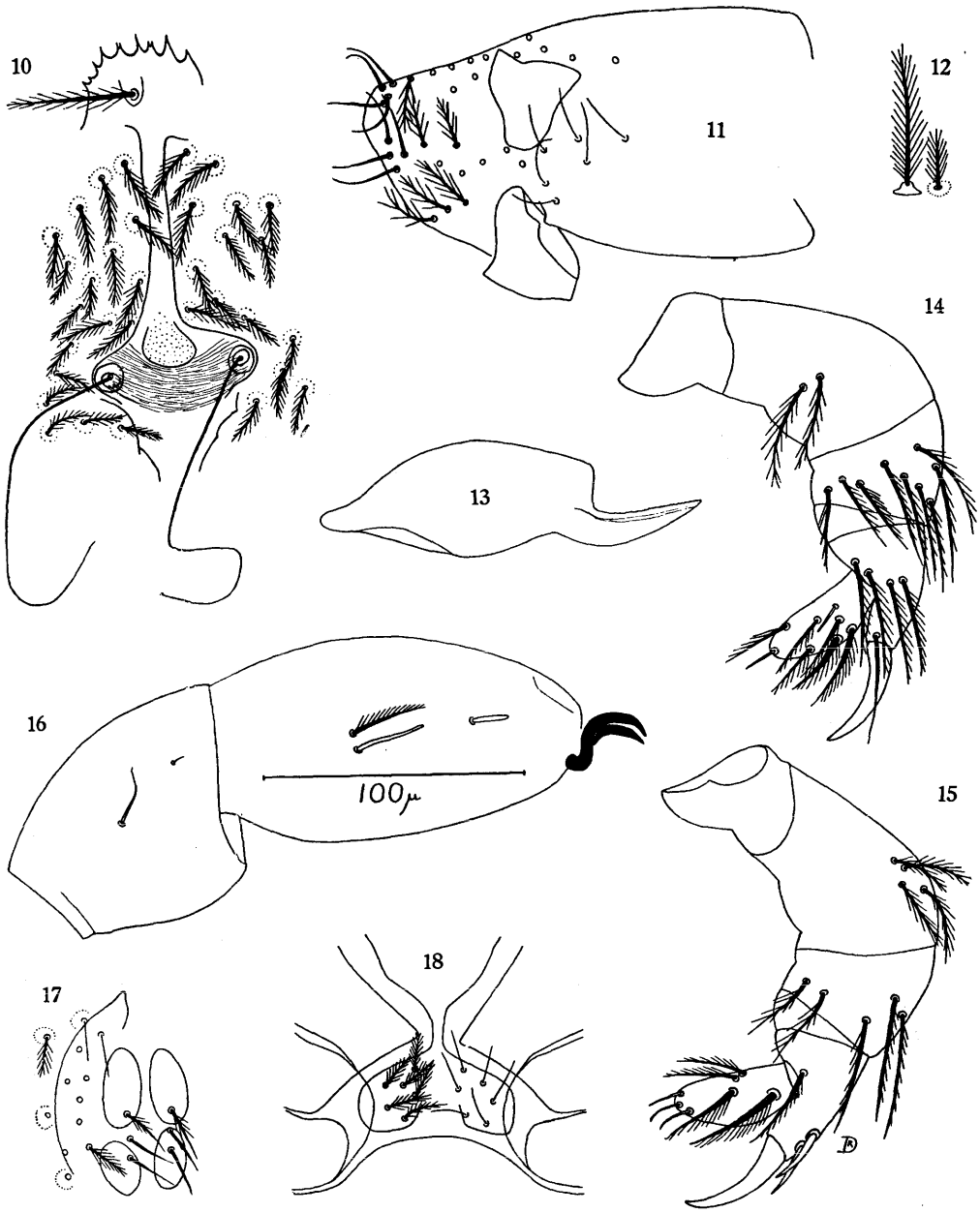
	CTL	ASL	SB	ASL/SB	PSL	PAD	TS	SS	SENS
	47	57	39	1.47	20	42	12	12	73
	50	61	40	1.52	20	43	—	13	70
	47	59	39	1.51	22	40	13	16	70
Means	48	59	39	1.50	21	42	13	14	71

* From the same material *F. celesteae* adults have also been reared by Mr M. Nadchatram.—Ed.



Figs. 1-9. *Vercammenia hendricksoni* Audy and Nadchatram, 1957

1, scutum and surrounding cuticle; 2, hypostome and anterior margins of coxae I, ventral view; 3, chelicera in lateral view; 4 and 5, internal and external views of palp; 6, tarsus and tibia I in lateral view; 7, genitalia; 8, two middorsal body setae (above) and one terminal body seta (below); 9, precoxal area.



Figs. 10-18. *Fonsecia celesteae* Audy, 1957

10, scutum; 11, ventral view of gnathosoma; 12, terminal and dorsal body setae; 13, chelicera in lateral view; 14, external view of palp; 15, internal view of palp; 16, tarsus and tibia I in lateral view; 17, genitalia; 18, precoxal area.

Material examined.—Three nymphs and one correlated larval pelt (slides CORU 60463b, 60464b, 60726a & b), bred from engorged larvae from the thigh and body of a frog, *Rana macrodon* Dumeril & Bibron, No. R49888, Gunong Tebu, Trengganu, Malaya, 9. v. 1958. Two of the nymphs emerged 28 days later (6. vi. 1958), and the third 33 days later (11. vi. 1958).

Fonsecia celesteae Audy, 1957 (Figs. 10-18)

Description of nymph.—A moderately stout-bodied species of unknown colour in life. Idiosomal length 796-840μ in mounted specimens. Genital area just behind coxae IV, oval, 87-96μ long, and without clearly demarcated genital plates; surrounded by eight to ten pairs of ciliated setae. Two pairs of genital discs present, length of anterior pair 26-31μ, posterior pair 23μ. Three pairs of inner genital setae present, of which the anterior pair have five to six basal branches, while the posterior two pairs are apparently nude (in one specimen four nude setae only are present on one side). Anal plates 68-74μ long, with fourteen to sixteen ciliated setae each. *Gnathosoma* with about 28 ciliated setae ventrally (this figure is approximate, as the structure is distorted in all specimens), and with eight (but only seven in three cases) nude galeal setae to 25μ long. Hypostome slightly narrower in front of insertion of palpal trochanters, and rounded apically. Chelicerae fairly stout, 160-169μ long; blade 59-64μ long, with several weak denticulations dorsally. *Palpi* with usual five segments; femur with three to seven ciliated setae; genu with eleven to fifteen (but only nine on one side of one specimen) ciliated setae; tibia with single (but lacking on one side of one specimen) internal ciliated seta near insertion of tarsus, two inner accessory combs (but four on one side of one specimen), an external nude seta near base of claw, and four or five (six on one side of one specimen) ciliated external setae; tarsus with external basal sensory rod (lacking on one side of one specimen), four or five nude terminal setae, and nine to thirteen (usually ten) ciliated setae. Palpal claw 43-47μ long. *Legs* normal, seven-segmented. With fairly well marked precoxal plates between fused coxae I & II, each with five to eight ciliated setae. Length tarsus I 136-143μ, height tarsus I 79-90μ, length tibia I 102-105μ. Ratio LTI/HTI 1.59-1.76; ratio LTI/LtI 1.32-1.35. Tarsus I without preapical dorsal process. *Scutum:* Area sensilligera diamond-shaped, with anterior quarter strongly sclerotized, and remainder weakly defined, but covered by striae which are transverse, in contrast with the longitudinally striate body cuticle surrounding the scutum. Crista longer than area sensilligera, and terminating anteriorly in dentate tectum, which bears a single ciliated seta (tectal seta absent in one specimen). Paracristal setae numerous and subequal, arranged as shown. Eyes absent. Sensillae long, nude, and extremely attenuate, so that their distal third is impossible to trace among the pelage formed by the ciliated body setae. In only one specimen was it possible to trace a sensilla throughout its entire length. The standard data are given below. *Setation:* Anterior dorsal setae evenly tapering, ciliated, 23-26μ long; middorsal setae similar, 16-19μ long; postdorsal setae not swollen along their shaft, or apically, 51μ long. Types of leg setae as figured, not set in noticeable depressions. Ciliated setae to 34μ, slender solenidia to 27μ, thick solenidia to 14μ, microsetae to 4μ long.

STANDARD DATA IN MICRA OF NYMPHAL SCUTUM OF *F. celesteae* Audy

	CTL	ASL	SB	ASL/SB	PSL	PAD	TS	SS	SENS
	88	108	51	2.12	16	42	50	20	—
	81	101	50	2.02	17	39	47	19	—
	91	110	53	2.08	19	46	54	25	155
	—	—	—	—	—	—	47	25	—
	79	102	51	2.00	19	45	50	23	—
	82	104	51	2.04	17	45	—	20	—
Means	84	105	51	2.05	18	43	50	22	155

Material examined.—Six nymphs (slides CORU 70004-5b, 70022-3b, 70044-5b) bred from engorged larvae from the body of a snake, *Zaocys fuscus* (Gthr.), No. R56412, Bukit Lanjan, Selangor, Malaya, 25. v. 1959. These nymphs, as well as those of *Vercammenia* described above, were bred by Mr M. Nadchatram, to whom I am most grateful for sending me this material to describe.

SUMMARY

Nymphs of two Malayan trombiculid genera previously known only from the larval stage are described—*Vercammenia hendricksoni* from a frog, *Rana macrodon*, and *Fonsecia celesteae* from a snake, *Zaocys fuscus*.

References

AUDY J. R. AND NADCHATRAM M. (1957). Malaysian Parasites, XIX. *Vercammenia*, new genus of chiggers hypodermal in Amphibia (Acarina, Trombiculidae). *Stud. Inst. med. Res. Malaya, 28*, 95-102.

BRENNAN J. M. AND LOOMIS R. B. (1959). A review of the reptile chiggers, genus *Fonsecia* (Acarina, Trombiculidae), with descriptions of two new American species. *J. Parasitol., 45*, 53-64.

RADFORD C. D. (1942). The larval Trombiculinae (Acarina: Trombidiidae) with descriptions of twelve new species. *Parasitology, 34*, 55-81.

MALAYSIAN PARASITES XLII

OCULICOLA, NEW SUBGENUS OF *ASCOSCHONGASTIA* EWING (ACARINA): TROMBICULIDAE FROM EYES OF MAMMALS

BY

ROBERT DOMROW

Queensland Institute of Medical Research, Brisbane

The puzzling species *Schongastia oculicola* Womersley, 1952 was described from larvae collected attached to the conjunctivae of a Ceylonese rodent, and from nymphs bred therefrom by the late S. H. Jayewickreme. A fuller description of both stages, based on the original material (which is in quite good condition), and a further series of sixteen fresh larvae from the same habitat and locality, is given below. The larva of a related species, recently found in the eyes of a north Queensland water-rat and musky rat-kangaroo, is also described.

Womersley (1952) considered the chelicerae of *oculicola* to be serrate, and accordingly placed it in *Schongastia*, subgenus *Schongastia*. However, the chelicerae are not serrate, and in addition the characteristic mastitarsala-III of *Schongastia* s.s. is absent. Nor is the nymph of *oculicola* like known *Schongastia* nymphs.

Audy (1954) tentatively transferred *oculicola* to *Doloisia** but later (1956) moved it to *Euschongastia*, noting its possible relationship to *Laurentella*, a group formerly included in *Euschongastia*. Later still, Audy & Domrow (1957) preferred to regard it as forming a monotypic species group within the still unallocated larvae of *Euschongastia* s.l.

Several well defined groups (e.g. *Ascoschongastia* and its subgenus *Laurentella*, *Walchiella*, *Derrickiella*, *Helenicula*) have recently been removed from *Euschongastia*, while still further species have been assigned to other groups, e.g. *Schoutedenichia* and *Traubacarus*. The recognition of *oculicola* as a separate entity is now supported by the discovery of a second, closely related species in the eyes of other mammals in Australia. This complex cannot be left in *Euschongastia* either on larval or on nymphal grounds, and I therefore propose to erect a new subgenus *Oculicola* within the genus *Ascoschongastia* for these two oculicolous species. In the diagnosis of the new subgenus stress is laid both on morphological and biological characters.

Genus **Ascoschongastia** Ewing†

Oculicola n. subgen.

Diagnosis.—Nymph with accessory combs on palpal tibia well developed, and as large as tibial claw; inner seta on palpal tibia branched; area sensilligera cordate; sensillae slightly thickened, with long ciliations; tectal seta longer than crista; basal pair of paracristal setae

* *Doloisia* and its sister genus *Traubacarus* form a compact and easily recognizable group. Their larvae have scuta with weakly developed shoulders. The number of setae on the palpal tarsus is reduced, four or fewer being typical of *Traubacarus*. In contrast with this, the humeral setae are multiple, as are the coxal setae of the legs. The legs are further characterized by the reduced number of genualae I (two instead of the usual three), correlated with the absence of tibiala III. The nymphs of the two subgenera are likewise readily recognized, and are, in fact, inseparable generically. They are characterized by two features of the palpal tibia—the slender and much elongated claw, and the strong nude seta on the inner face. In all other trombiculid nymphs I have seen, the claw is short and rather stout, while the inner seta is branched like the other setae on the palpi (the external seta set near the base of the claw apart, which is always nude).

† The following references will indicate the sense in which *Ascoschongastia* is used in the present *Study*: Audy (1956), Audy and Domrow (1957), Audy and Womersley (1957, p. 372), Domrow (1957). The *debilis*-group, tentatively included in *Ascoschongastia* by Audy (1956), is now separated as a new genus, *Susa*, by Audy and Nadchatram (1960) in the present *Study*—the authors discuss the reasons for separating this group from *Ascoschongastia*.

strikingly longer than remainder; with three pairs of galeal setae, the central pair much stronger than the other two (possibly representing a fused pair); sternum incipient. *Larvae* with chelicerae non-serrate, but with a retrorse spinule externally; palpal tarsus 5b or 6b, with subterminala absent; scutum without shoulders; PL>AM>AL; sensillae globose; humeral setae duplicated or single; first row of dorsal setae even, or with central pair of setae displaced anteriorly; all legs 7-segmented; coxal setation 1.1.1; 3 genualae I; tibiala III present; mastitarsala III absent; living in eyes of rats and rat-kangaroos in Ceylon and Queensland. Subgenotype *Schongastia* (*Schongastia*) *oculicola* Womersley, 1952.

Relationships of the Subgenera of *Ascoschongastia*

The genus *Ascoschongastia* as at present understood contains four subgenera—*Ascoschongastia* s.s., *Laurentella*, *Elianella*, and *Oculicola*. Audy (1956) has commented on the tendency for some of these groups to be found in mucoid environments. The first three are well defined groups, and have scuta with distinct shoulders, the AL setae being set well back from the anterolateral corners, so that they lie on a line behind the AM seta. The palpal tarsal formula is 6b, while three genualae-I and a tibiala-III are present. The remaining subgenus, *Oculicola*, does not fit comfortably into the genus, nor is it very clearly differentiated from the genus *Susa* Audy & Nadchatram. When Audy (1956) placed the *debilis*-group provisionally in *Ascoschongastia*, he noted that it did not fit comfortably. Although this group is now the genus *Susa*, there are fewer cogent reasons for making *Oculicola* a genus rather than a subgenus. Neither *Oculicola* nor *Susa* possesses the scutal shoulders so characteristic of the three "typical" subgenera. *Susa* has a concave posterior scutal margin, palpal tarsal formula 4BS or 5b, galeal setae barbed, and only two genualae-I. Nymphs of *Susa* are unknown, but nymphs of *A.* (*O.*) *oculicola* do at least show some affinities with those of *Ascoschongastia*.

The two species here included in *Oculicola* have three genualae-I and nude galeal setae. They do, however, also show major differences. *A.* (*O.*) *oculicola* has a convex posterior scutal margin, duplicated humeral setae, and 6b for the palpal tarsal formula. *A.* (*O.*) *scaevola*, on the contrary, has a concave posterior scutal margin, single humeral setae, and palpal formula 5b, and is, in these characters, similar to *Susa*.

The nymph of *A.* (*O.*) *oculicola*, although so striking, shows several characters in common with those of *Ascoschongastia* s.s. and *Laurentella*—slender ciliated sensillae, elongate basal paracristal setae, palpal tibiae with normal claw and branched seta on inner face. *Oculicola* nymphs may, however, be recognized by the very long tectal seta, the low ASL/SB ratio, and the unusual number of six galeal setae.

In view then of the similarity in general facies and habitat of these two oculicolous species, I prefer at present to place them in the same subgenus *Oculicola* of the genus *Ascoschongastia*.

Ascoschongastia (Oculicola) oculicola (Womersley, 1952) (Figs. 1-2)

*Description of nymph**.—A slender species, colour in life unknown. Idiosomal length about 700μ, breadth of propodosoma 245μ, breadth of hysterosoma 210μ (in mounted specimens). Genital area oval, about 62μ long, with two pairs of genital discs. Genital plates not distinctly demarcated. Three pairs of nude inner genital setae present. Anal plates elongate, 44μ long, more heavily sclerotized anteriorly, with six to eight ciliated setae each. *Gnathosoma* heavy and well sclerotized. Chelicerae visible in dorsal view only, but apparently of normal contour and without serrations on concave dorsal edge of blade; length including blade 100μ. *Hypostome* pointed, with six nude apical setae, of which the anterior and

* An oil immersion lens was used in the preparation of the figures, together with a squared micrometer grid in the eyepiece, thus ensuring their accuracy.

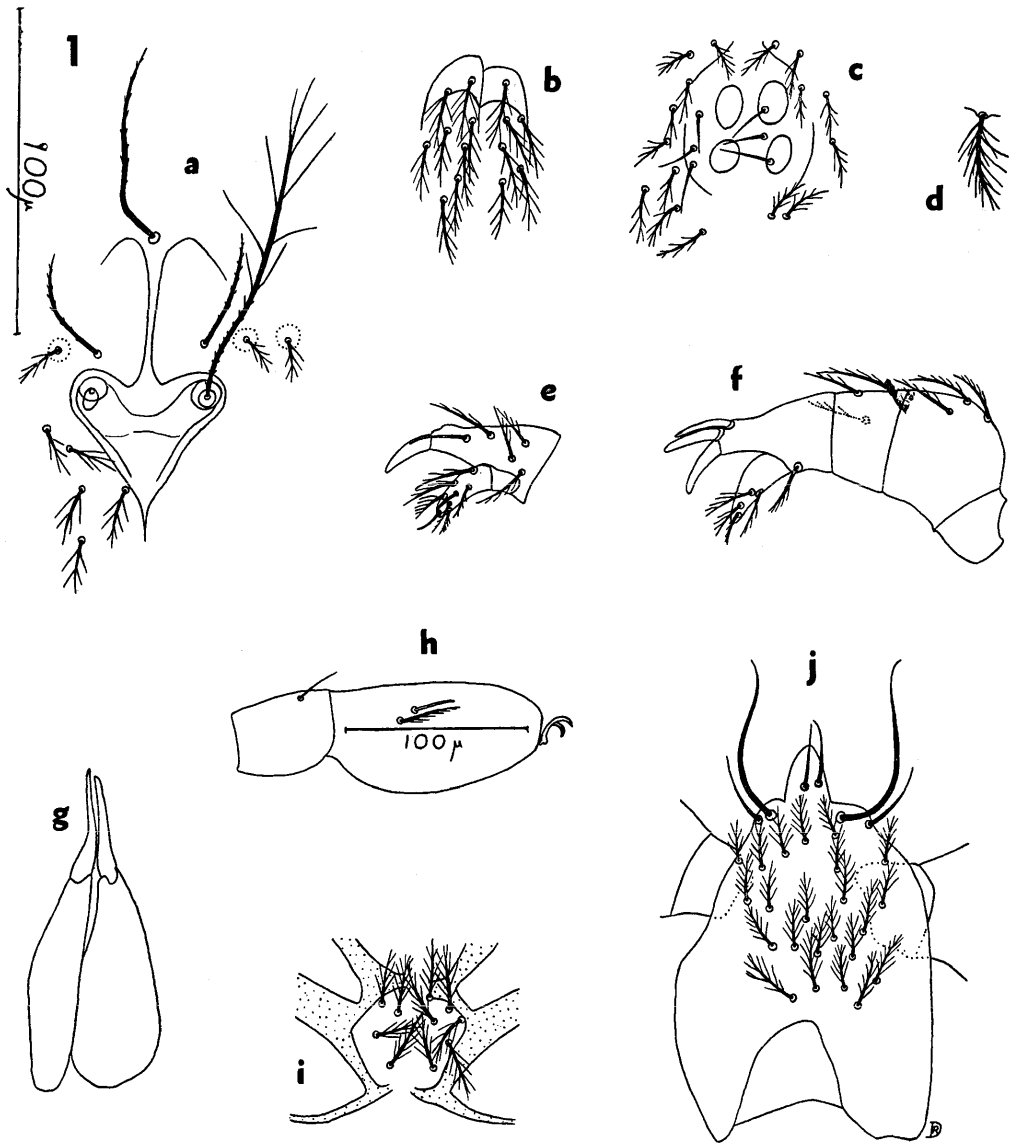


Fig. 1. *Ascoschongastia* (*Oculicola*) *oculicola* (Womersley)—Nymph

a, scutum; b, anal plates; c, genitalia; d, terminal body seta; e, inner view of palpal tarsus and tibia; f, outer view of entire palp; g, dorsal view of chelicerae; h, lateral view of tarsus and tibia I; i, sternum; j, ventral view of hypostome.

posterior pairs are much weaker than the central pair. Basis capituli with about twenty-four ciliated setae. *Palpi* with usual five segments; femur and genu with about three ciliated setae each; tibia with single internal ciliated seta near insertion of tarsus, two very strongly developed inner accessory combs, an external nude seta near base of claw, and about four external ciliated setae; tarsus slender, with external

basal sensory rod, one nude terminal seta and about ten ciliated setae. The marked enlargement of the tibial combs is possibly a reflection of the strong palpal claw of larva. Apart from this, the armature of the palpal tibia is quite normal. *Legs*: Leg I largest, leg IV slightly larger than II and III, which are subequal; all seven-segmented; precoxal complex represented by incipient pentagonal sternum with about ten ciliated setae and weakly sclerotized posterior margin. Tarsus I quite stout, much larger than tibia I. Length tarsus I 118μ, height tarsus I 60μ, length tibia I 61μ. Ratio LTI/HTI 1.97, ratio LTI/LtI 1.93. Tarsus I without preapical dorsal process. *Scutum*: Area sensilligera heart-shaped, with posterior apodeme well developed. Crista short, with large tectum. Tectal seta weakly ciliated and exceedingly long, being longer than the crista. Sensillae very slightly thickened, basal third with barbules which merge into sparse, long and fine ciliations apically. Eyes absent. Pair of paracristal setae near base of crista very long and finely ciliated. Eyes absent. The standard data are given below. *Setation*: Body setae tapering and simply ciliated, to 29μ long posteriorly. Legs with usual three types of sensory setae — finger-shaped solenidia to 18μ long, nude tapering setae, and ciliated setae. In addition to these, one or two outstanding solenidia, which are noticeably longer (to 38μ) and more slender than the other solenidia, are scattered on varying segments from tibia to telofemur III and IV.

STANDARD DATA IN MICRA OF NYMPHAL SCUTUM OF *A.* (*O.*) *oculicola* (Wom.)

	CTL	ASL	SB	ASL/SB	PAD	TS	SS	SENS
	48	51	33	1.55	38	67	40	100
	46	50	35	1.43	41	62	35	105
	42	47	30	1.57	38	—	38	98
	53	59	38	1.55	47	73	42	114
Means	47	52	34	1.53	41	67	39	104

Material examined.—Four nymphs (two with associated larval pelts) bred from engorged larvae from the conjunctivae of *Mus cervicolor fulvidiventris* (Blyth) (= *Leggada booduga fulvidiventris*) by S. H. Jayewickreme, Nalanda, Ceylon, July, 1944. I am grateful to Dr J. R. Audy and Messrs. H. M. Hale and H. Womersley for the opportunity of examining these specimens.

Description of larva.—A medium-sized yellowish species, average length and breadth of idiosoma of two unengorged specimens 356μ and 186μ respectively; of six fully engorged specimens 492μ and 300μ. Cuticle normally annulate when unengorged, but the annulations disappear in engorged specimens, leaving the cuticle taut and marked with radiating linear punctae around the scutum. *Body setation:* Dorsal setae very weakly barbed, similar to PL scutal setae, arranged 4.6.8.8.6.4.2, humerals to 45μ long and duplicated, and central pair of first row displaced anteriorly. Middorsal setae to 38μ long. With two pairs of intercoxal setae; ventral setae arranged 14.6.6.6.4.2, the more anterior setae being ciliated; midventral setae to 27μ long. *Gnathosoma:* Cheliceral blades a little stout, but of normal contour, with minute subapical tooth dorsally just behind apical cap. (Species of *Schongastia* s.s. typically have long, rather slender chelicerae with numerous and distinct dorsal serrations). External side of blade with larger sharp spine projecting backwardly, which is visible in both dorsal and ventral views. Galeal seta nude. Maxillary seta strong and ciliated. *Palpi:* Omitting the usual ventro-external tarsala, the palpal formula is b.b.NbB.B+ 5b, *i.e.* subterminala absent. The five ventral tarsal setae are weakly ciliated, while the dorsal is strongly so. Ciliations on ventral tibial seta very long and fine. Palpal claw with three distinct, diverging prongs, which are directed ventrally. *Scutum* rather broader than long, pentagonal. Anterior margin concave, with marked convexity around insertion of AM seta, which is set behind the level of AL setae. AL, and especially PL setae set on prominent "corners". AM seta plumose, AL setae ciliated, PL setae very weakly barbed; PL>AM>AL. Lateral margins concave. Posterior margin convex, tapering quickly to a blunt point. Entire surface (with exception of small area behind AM seta) punctate. Sensillae set fairly close together, nearer to level of PL than to that of AL, globose, and with faint barbules on club. Without brows above sensillary bases. The standard data are given below. Eyes double, fairly close to PL setae; diameter of anterior lens 7μ, of posterior lens 5μ. *Legs* all seven-segmented, with unisetose coxae. The special sensory setation is as follows—*tarsus I* with pretarsala, subterminala, parasubterminala, tarsala and microtarsala; *tibia I* with stout tibiala and microtibiala, and rather slender tibiala behind

them; *genu I* with three genualae and microgenuala as figured; *tarsus II* with pretarsala, tarsala and microtarsala; *tibia II* with a stout and a slender tibiala; *genu II* with slender genuala; *tarsus III* without mastitarsala characteristic of *Schongastia* s.s.; *tibia and genu III* with one slender tibiala and genuala respectively. All tarsi with single basal bar, and all tibiae with apical and basal semibar. The non-specialized setae of the legs have long, very fine ciliations, apparently to facilitate movement on the moist surface of the eye.

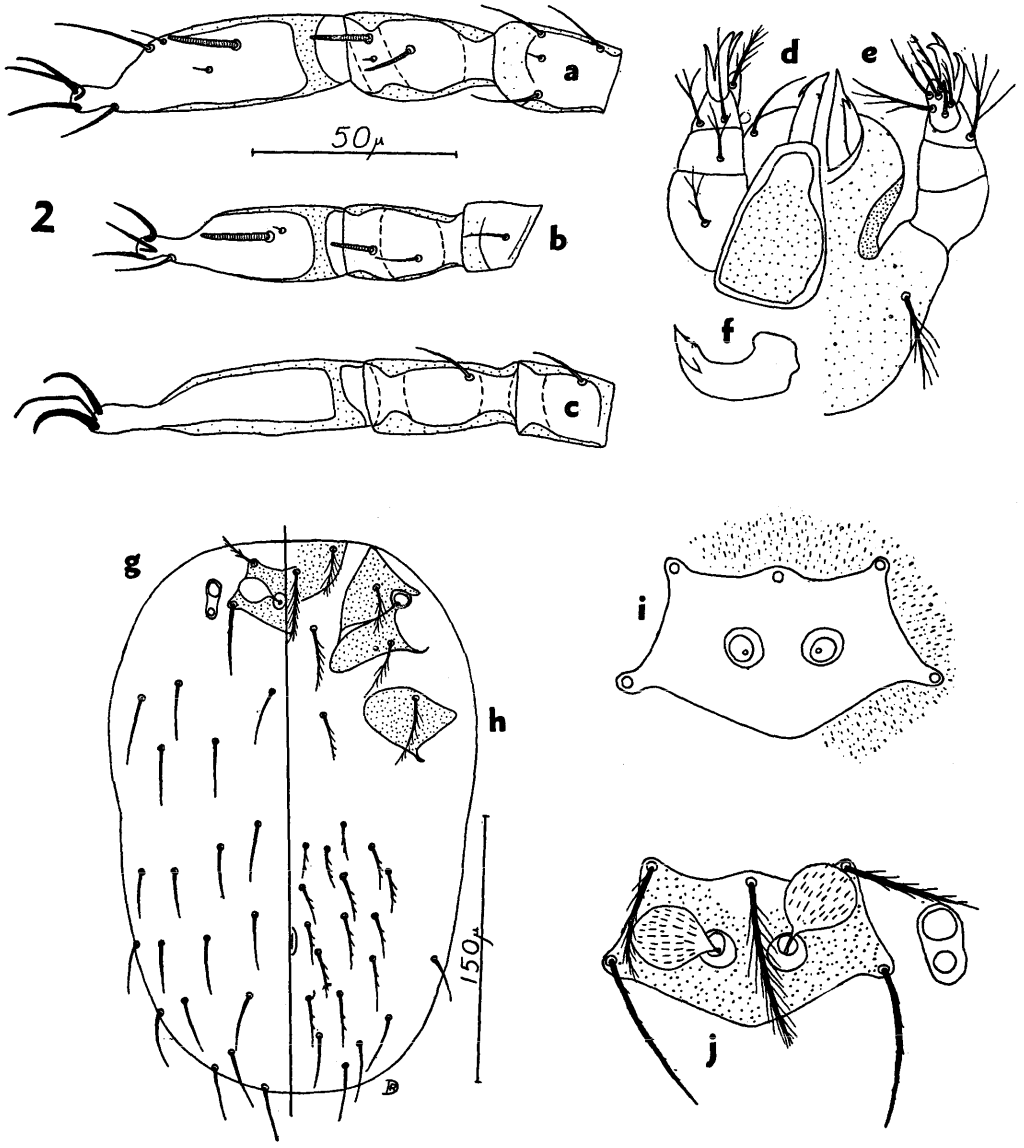


Fig. 2. *Ascoschongastia* (*Oculicola*) *oculicola* (Womersley)—Larva

a, b and c, specialized setation of legs I, II and III; d, e, dorsal and ventral views of gnathosoma; f, lateral external view of chelicera; g, h, dorsal and ventral views of idiosoma; i, scutum of engorged specimen to show texture of distended cuticle; j, detail of scutum and eyes.

STANDARD DATA IN MICRA OF LARVAL SCUTUM OF *A.* (*O.*) *oculicola* (Wom.)

Host	AW	PW	SB	ASB	PSB	SD	AP	AM	AL	PL
Mus	46	68	16	22	19	41	28	42	28	44
„	50	75	19	23	21	44	30	40	30	44
„ (LP)	42	63	15	22	18	40	28	—	28	45
„ (LP)	42	67	17	22	21	42	27	41	—	—
Tatera ...	48	71	18	23	22	45	30	48	34	45
Millardia	45	64	13	22	19	41	28	40	29	42
„	45	64	16	23	19	42	27	—	33	45
„	46	70	17	22	21	42	27	—	33	44
„	45	64	15	22	16	38	24	44	33	41
„	44	67	15	21	17	38	25	—	30	44
„	46	68	16	22	18	40	27	—	30	42
„	48	71	18	23	21	44	30	—	30	46
Means	46	68	16	22	19	41	28	43	31	44
Range from	42	63	13	21	16	38	24	40	28	41
to	50	75	19	23	22	45	30	48	34	46

Material examined.—In addition to the two larval pelts (LP) listed above, the following fresh material has been mounted from spirit—tube 1, two larvae from one *Mus cervicolor fulvidiventris* (Blyth); tube 3, eight larvae from four *Millardia meltada meltada* (Gray); tube 6, one larva from one *Tatera ceylonica* (Wroughton); tube 7, five larvae from five *Millardia meltada meltada* (Gray). All these specimens were collected from the conjunctivae of the rodents by S. H. Jayewickreme at Embilipitiya, South Ceylon, during December, 1944.

In addition to the very pale yellow specimens of *A.* (*O.*) *oculicola*, tube 1 contained one gahrliepiine which appears to be *Gahrliepia* (*Schongastiella*) *ceylonica* Womersley, 1952 and tube 6 one specimen of *Leptotrombidium* (*Leptotrombidium*) *deliensis* Walch, 1922, the latter readily recognized as a stranger by its deep orange colour in spirit.

The new spirit material was received from Dr J. R. Audy through the courtesy of Mr W. J. Niles, who worked in Ceylon with the original collector. I am grateful to them all for the opportunity of seeing this fresh material.

Ascoschongastia (Oculicola) scaevola n. sp. (Fig. 3)

Types.—Holotype larva and one paratype larva in Queensland Museum, Brisbane; one paratype larva each in Queensland Institute of Medical Research, Brisbane; South Australian Museum, Adelaide; British Museum (Natural History), London; Institute for Medical Research, Kuala Lumpur; United States National Museum, Washington. These seven larvae were found "loose among the tears on the left eyeball of a water-rat", *Hydromys chrysogaster* Geoffroy, Innisfail, north Queensland, 27. vi. 1958 (*J. L. Harrison* coll.). None were seen in the right eye.

A further 43 paratypes have since been added to the original series. These have the following collection data—"attached to nictitating membrane, and on white of eyeball; also some on eyelid among eyelashes" of a musky rat-kangaroo, *Hypsiprymnodon moschatus* Ramsay, trapped in rain forest on hills (altitude less than 1000′) immediately behind Etty Bay, near Innisfail, 6. viii. 1958, J. L. H. coll.

Description of larva.—As in *A.* (*O.*) *oculicola* except as follows. A medium-sized cream coloured species; idiosomal length 413 to 490μ, av. 448μ; idiosomal width 275 to 310μ, av. 296μ (these measurements are from mounted, slightly flattened specimens). Cuticle annulate. *Body setation:* Dorsal setae very weakly barbed, similar to PL scutal setae, arranged 2.6.6.6.4.2, the humerals being single. Humeral setae 43 to 51μ, middorsal setae 31 to 37μ long. Ventral setae arranged 18.4.8.4.4, those around anus 23μ long; those in front of anus more heavily barbed than caudal setae. *Gnathosoma:* Cheliceral blades a little stout, but of normal contour; with minute subapical tooth dorsally, just behind apical cap. External face of blade with small retrorse tooth ventrally. *Palpi:* Omitting the usual ventro-external tarsala, the palpal formula is n.n.nnn. B+4b, *i.e.* subterminala absent. The dorsal tarsal seta is slightly more ciliated than the other four. Palpal claw with central prong strongly curved; flanked internally by slender, rather straight prong, and externally by shorter, more curved prong. All prongs directed ventrally. *Scutum* rather broader than long, trapezoidal. Anterior margin concave, with slight convexity around insertion of AM seta, which is set slightly behind level of AL setae. PL setae set on "corners". All scutal setae

very weakly barbed; AM and PL setae evenly tapering, but AL setae very fine in distal half; PL>AM>AL. Lateral margins straight, but slightly concave in front of PL setae. Posterior margin concave, although the two halves of the margin themselves are very slightly convex. Entire surface punctate, but punctae weaker on crescentic areas behind sensillary bases, and semicircular area behind AM seta. Sensillae set fairly close together, nearer to level of PL than to that of AL, globose, with sparse stronger barbules on one face, and numerous finer barbules on other. With distinct brows above sensillary bases. The standard data are given below. *Eyes:* diameter of anterior lens 8μ, of posterior lens 5μ.

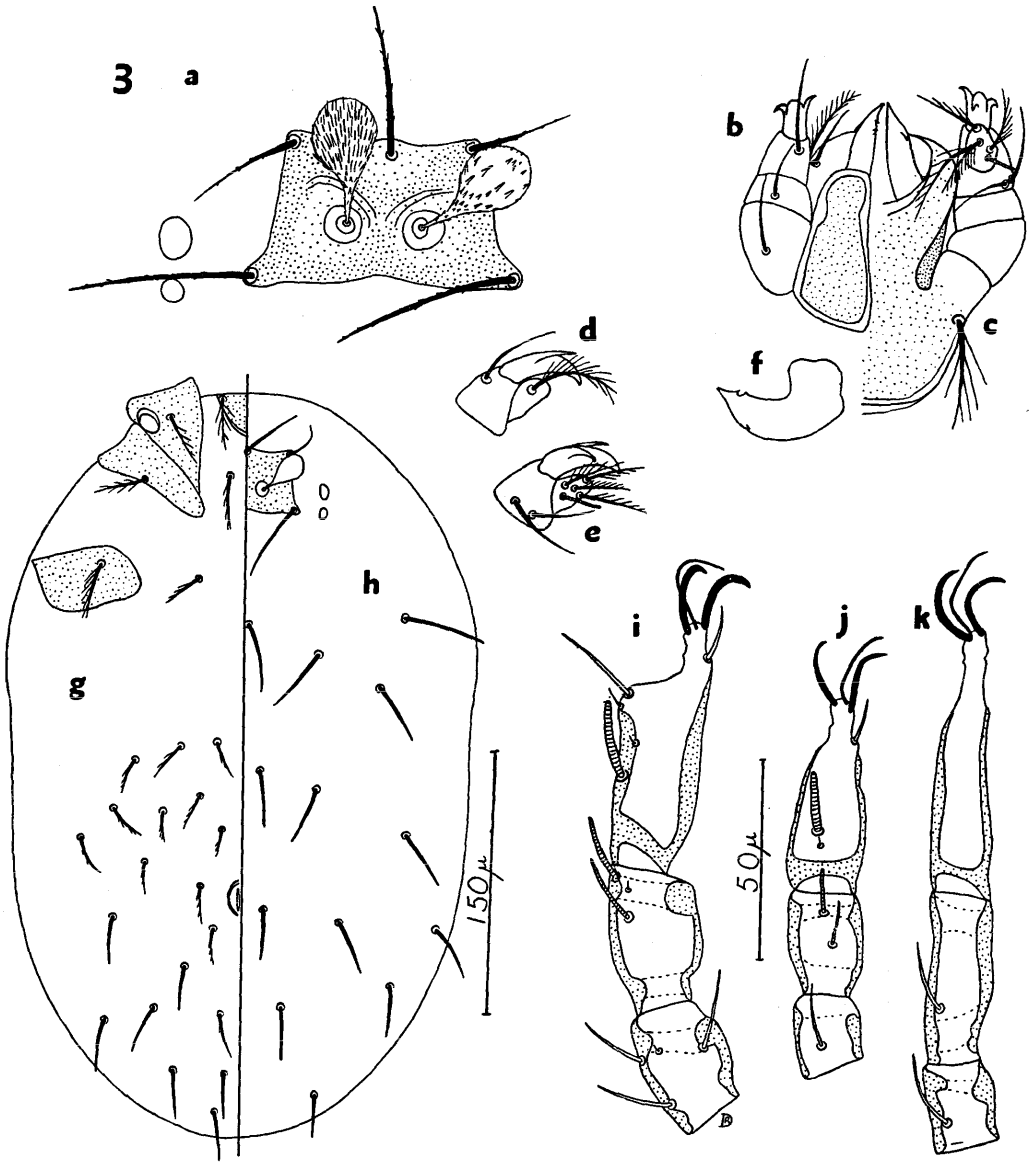


Fig. 3. *Ascoschongastia* (*Oculicola*) *scaevola* n. sp.—Larva

a, scutum; b, c, dorsal and ventral views of gnathosoma; d, e, dorsal and ventral views of palpal tibia and tarsus; f, lateral external view of chelicera; g, h, ventral and dorsal views of idiosoma; i, j, and k, specialized setation of legs I, II and III.

STANDARD DATA IN MICRA OF LARVAL SCUTUM OF *A.* (*O.*) *scaevola* n. sp.

	AW	PW	SB	ASB	PSB	SD	AP	AM	AL	PL
	42	64	20	23	16	39	34	—	31	50
	45	64	19	25	17	42	37	—	—	50
	43	65	19	25	19	43	37	45	30	54
	42	62	19	23	16	39	34	—	31	50
	43	64	19	22	17	39	34	40	30	47
	43	62	18	23	16	39	33	—	—	—
Means	43	64	19	24	17	40	35	43	31	50
Range from	42	62	18	22	16	39	33	40	30	47
to	45	65	20	25	19	43	37	45	31	54

ACKNOWLEDGEMENTS

In addition to those mentioned in the text and in another paper in this *Study*, I am greatly indebted to Dr J. R. Audy for his friendly advice during the preparation of this paper, and to Dr J. L. Harrison for his detailed collection data.

SUMMARY

A new subgenus *Oculicola* is erected within the genus *Ascoschongastia*. The subgenotype *A.* (*O.*) *oculicola* (Womersley) is redescribed in both nymphal and larval stages, while the larva of *A.* (*O.*) *scaevola* n. sp. is also described. Both species are found in the eyes of various mammals, the subgenotype in *Mus*, *Tatera* and *Millardia* in Ceylon, and *A.* (*O.*) *scaevola* in *Hydromys* and *Hypsiprymnodon* in Queensland.

REFERENCES

AUDY J. R. (1954). Malaysian Parasites, IX. Notes on the taxonomy of trombiculid mites with description of a new subgenus. *Stud. Inst. med. Res. Malaya, 26,* 123-170.

AUDY J. R. (1956). *Laurentella*, a new subgenus of trombiculid mites, with notes on biology and medical importance. *Bull. Raffles Mus., 28,* 5-26.

AUDY J. R. AND DOMROW R. (1957). Malaysian Parasites, XXIII. A revision of Oriental and Australasian species of *Euschongastia* Ewing, including *Walchiella* Fuller, and description of a new subgenus, *Derrickiella* (Acarina, Trombiculidae). *Stud. Inst. med. Res. Malaya, 28,* 121-152.

AUDY J. R. AND NADCHATRAM M. (1960). Malaysian Parasites, XXXIX. *Susa*, new genus related to *Ascoschongastia* Ewing (Acarina, Trombiculidae), with descriptions of two new species. *Stud. Inst. med. Res. Malaya, 29,* 154-162 (this *Study*).

AUDY J. R. AND WOMERSLEY H. (1957). Malaysian Parasites, XXIX. New species of Oriental and Australian Trombiculidae (Acarina). *Stud. Inst. med. Res. Malaya, 28,* 359-382.

DOMROW R. (1957). Malaysian Parasites, XXXI. Nymphs of *Ascoschongastia* Ewing and *Laurentella* Audy (Acarina, Trombiculidae). *Stud. Inst. med. Res. Malaya, 28,* 394-402.

WOMERSLEY H. (1952). The scrub-typhus and scrub-itch mites (Trombiculidae, Acarina) of the Asiatic-Pacific region. *Rec. S. Aust. Mus., 10,* 1-673.

MALAYSIAN PARASITES XLIII

NEOSCHONGASTIA IN MALAYA (ACARINA, TROMBICULIDAE)

BY

ROBERT DOMROW

Queensland Institute of Medical Research, Brisbane

AND

M. NADCHATRAM

Institute for Medical Research, Kuala Lumpur

Two species of *Neoschongastia* Ewing have already been recorded from Malaya. A form which was probably *N. gallinarum* was taken by Fletcher *et al.* (1928), and Womersley (1952), with fresh material, confirmed the presence of this species in Malaya. The second record is that of Audy (1956*a*, *b*), who listed *N. riversi* from flying lizards, a rare occurrence of this normally bird-parasitic genus. A third species, apparently a variant of *N. americana*, is recorded in the present paper, from a night-jar.

As Malayan chiggers have been intensively collected for many years, the genus *Neoschongastia* is apparently not well represented in this region. All the available larval records are brought together in the present paper, while the newly reared nymph of *N. riversi* is described. A redescription of the nymph of *N. gallinarum* is also given.

We would add that a further *raison d'etre* for this paper is to secure the publication of the painstaking work of the artists, A. Shimazoe and S. Shibata, whose names appear on illustrations of the larval stages used below. We are grateful to Dr J. R. Audy and Lt. Col. R. Traub for making the drawings of the larval specimens available to us.

Neoschongastia gallinarum (Hatori, 1920)

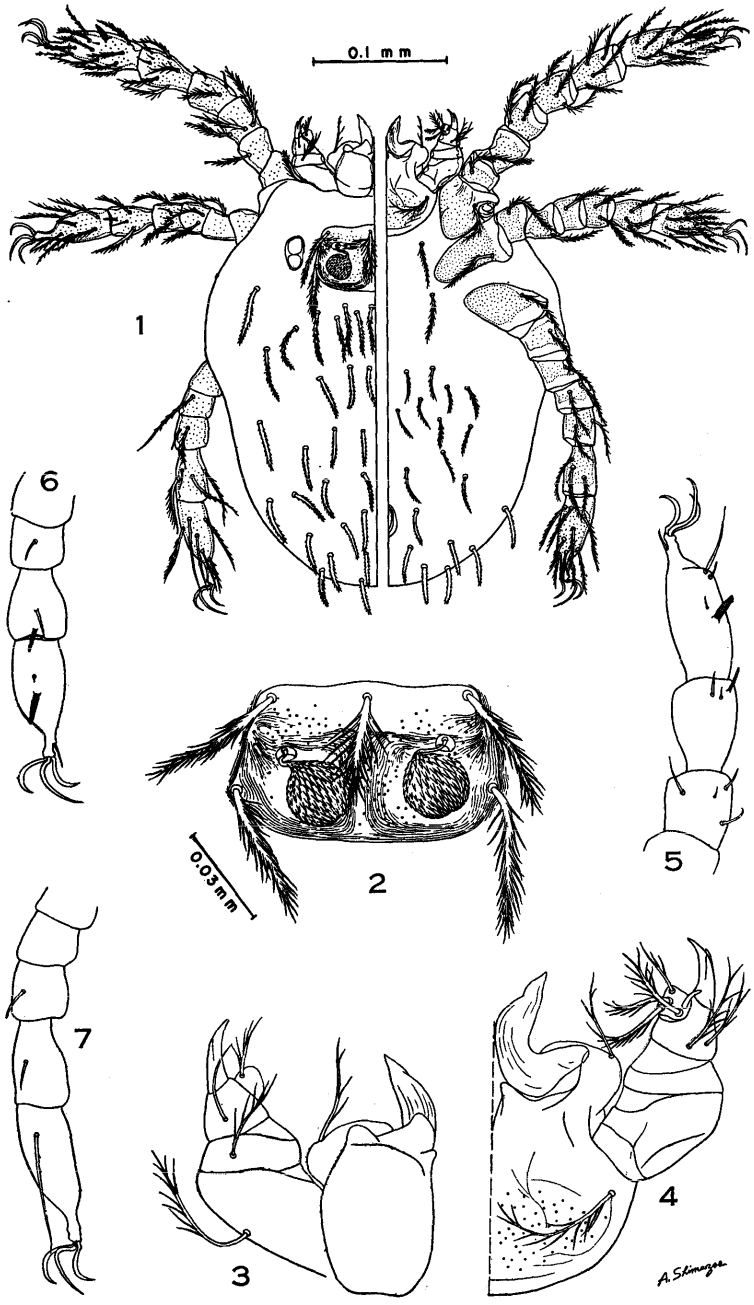
Larva.

Diagnostic characters.—Body subovate, 390×320μ, pale orange to orange in life. Galeal setae barbed. Dorsal setae 2.10-13.8.6.8.6.6.2. Two pairs sternal setae present. Coxal formula 1.1.1. Mastitarsala III present, but with few weak basal barbules (Womersley, 1952, in his text, also says this seta is present, but keys the species out as if it were absent).

STANDARD DATA IN MICRA OF LARVAL SCUTUM OF *N. gallinarum* (Hatori)

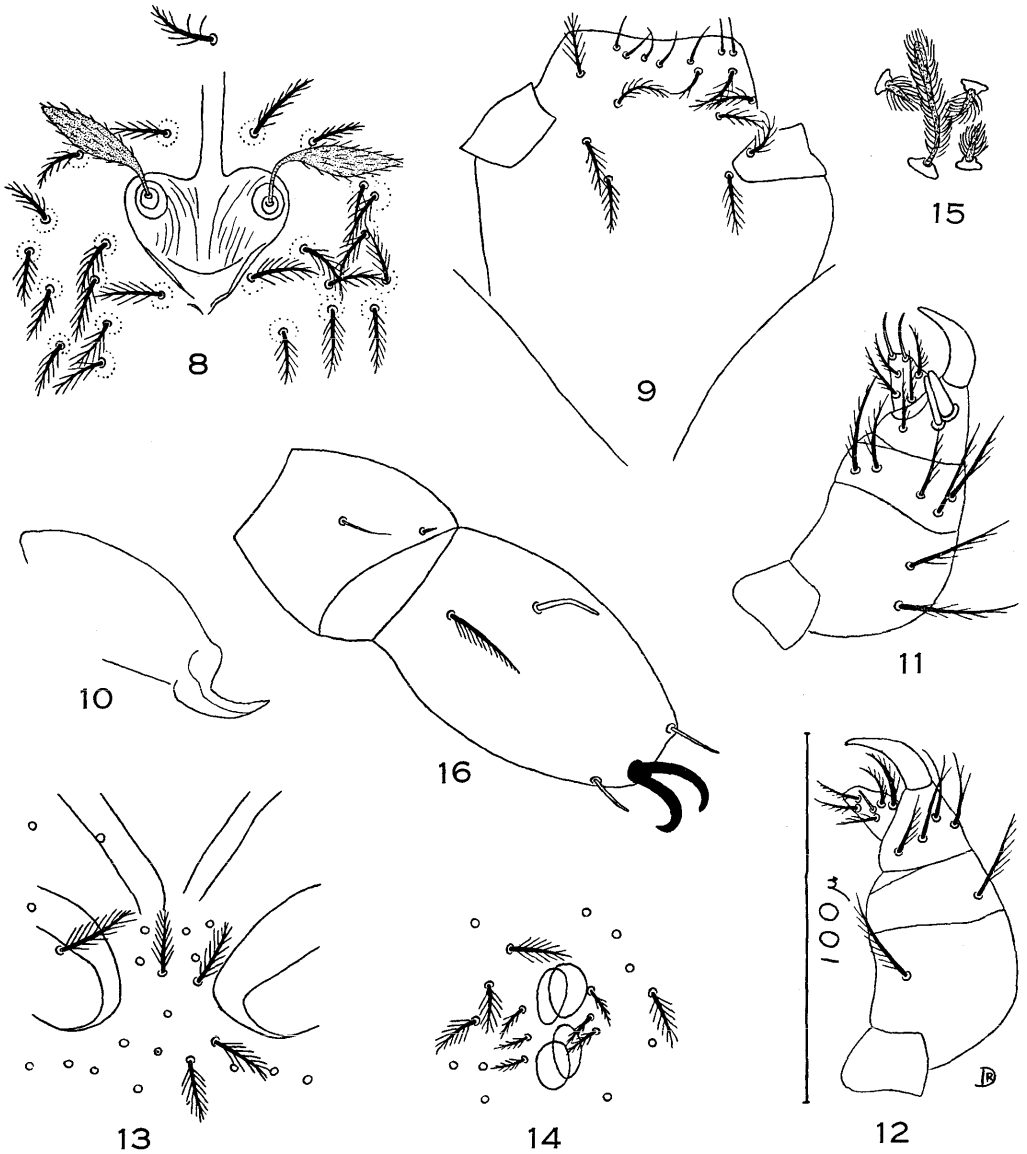
	AW	PW	SB	ASB	PSB	AP	AL	AM	PL	SENS	DS	VS
Mean (3 larvae)	55	69	43	19	29	30	49	34	40	29×18	35	23
Range	1	4	2	3	2	3	2	2	2	2	1	—

Material examined.—Eight specimens collected with large numbers of *Eutrombicula wichmanni* "in colonies on bottom of small punched-out ulcers with rolled over edges, especially around upper leg and beneath tail" of domestic fowl, Kuala Lumpur, Selangor, Malaya, 8 October, 1949.



Figs. 1-7. *Neoschongastia gallinarum* (Hatori, 1920)—Larva

1, dorsal/ventral aspects of larva; 2, scutum; 3, 4, gnathosoma, dorsal and ventral view; 5, 6, 7, legs I, II, III, sensory setae.



Figs. 8-16. *Neoschongastia gallinarum* (Hatori, 1920)—Nymph

8, scutum and surrounding setae; 9, ventral view of hypostome; 10, chelicera; 11, 12, internal and external view of palp; 13, inter-coxal area; 14, genitalia; 15, body setae; 16, tarsus and tibia I in lateral view.

Nymph.

Colour in life pale yellowish orange. Idiosomal length 627μ in mounted specimen. Genital area just behind coxae IV, without genital plates. Two pairs of genital discs present, length anterior pair 14μ, length posterior pair 12μ. Three pairs of inner genital setae present, all barbed, but not as strongly as the adjacent body setae. Anal area indistinct. *Gnathosoma* with about ten ciliated setae ventrally, and seven nude galeal setae apically, which are to 12μ long. Hypostome distorted by pressure, but apparently rounded apically. Chelicerae also somewhat flattened, but of normal facies, 80μ long, with blade 25μ

long. *Palpi* with usual five segments; femur with three or four ciliated setae; genu with five or six ciliated setae; tibia with one or four internal ciliated setae near insertion of tarsus, two inner accessory combs (of which the distal is much thicker than the basal), one or two external nude setae near base of claw, and two or five ciliated external setae; tarsus with external basal sensory rod, two nude terminal setae, and seven or nine ciliated setae. Palpal claw 23μ long. *Legs* normal, seven-segmented. Without precoxal plates between fused coxae I & II. Length tarsus I 82μ, height tarsus I 51μ, length tibia I 49μ. Ratio LTI/HTI 1.61; ratio LTI/LtI 1.67. Tarsus I without preapical dorsal process. *Scutum* with cordate area sensilligera, which is partially covered by striate cuticle. Crista as long as area sensilligera. Tectum indistinct, with single ciliated tectal seta. Paracristal setae subequal, about two on each side, tapering and ciliated. Eyes absent. Sensillae clavate and with weak barbules, with greatest diameter medially, as figured. The standard data are given below. *Setation:* Anterior dorsal setae fairly slender, and evenly tapering, to 20μ long; middorsal setae somewhat shorter, to 14μ long. Posterior body setae with fine, curved ciliations, and of two kinds—short stout setae to 11μ long, and longer, slightly clavate setae to 37μ long. Leg setae typical, solenidia to 18μ, feathered setae to 25μ, microsetae to 4.6μ long.

STANDARD DATA IN MICRA OF NYMPHAL SCUTUM OF *N. gallinarum* (Hatori)

CTL	ASL	SB	ASL/SB	PSL	PAD	TS	SS	SENS
39	43	33	1.30	20	33	22	24	44

Material examined.—One nymph reared from larva from domestic fowl, Kuala Lumpur, Selangor, Malaya, 18-x-1949, J. R. Audy.

Notes.—The specimen described above is that figured by Womersley (1952), and is the only nymph ever reared of this species. It is in reasonable condition, but pale and considerably flattened, the dorsal and ventral surfaces being separated by barely 5μ, according to the micrometer on the fine-focus adjustment. We are unable to detect precoxal plates in this nymph, or those of *N. riversi* described below, although these plates are recorded by Sasa *et al.* (1957) and Crossley (in ms) for Japanese and American species of *Neoschongastia*.

Neoschongastia riversi Wharton & Hardcastle, 1946

Larva.

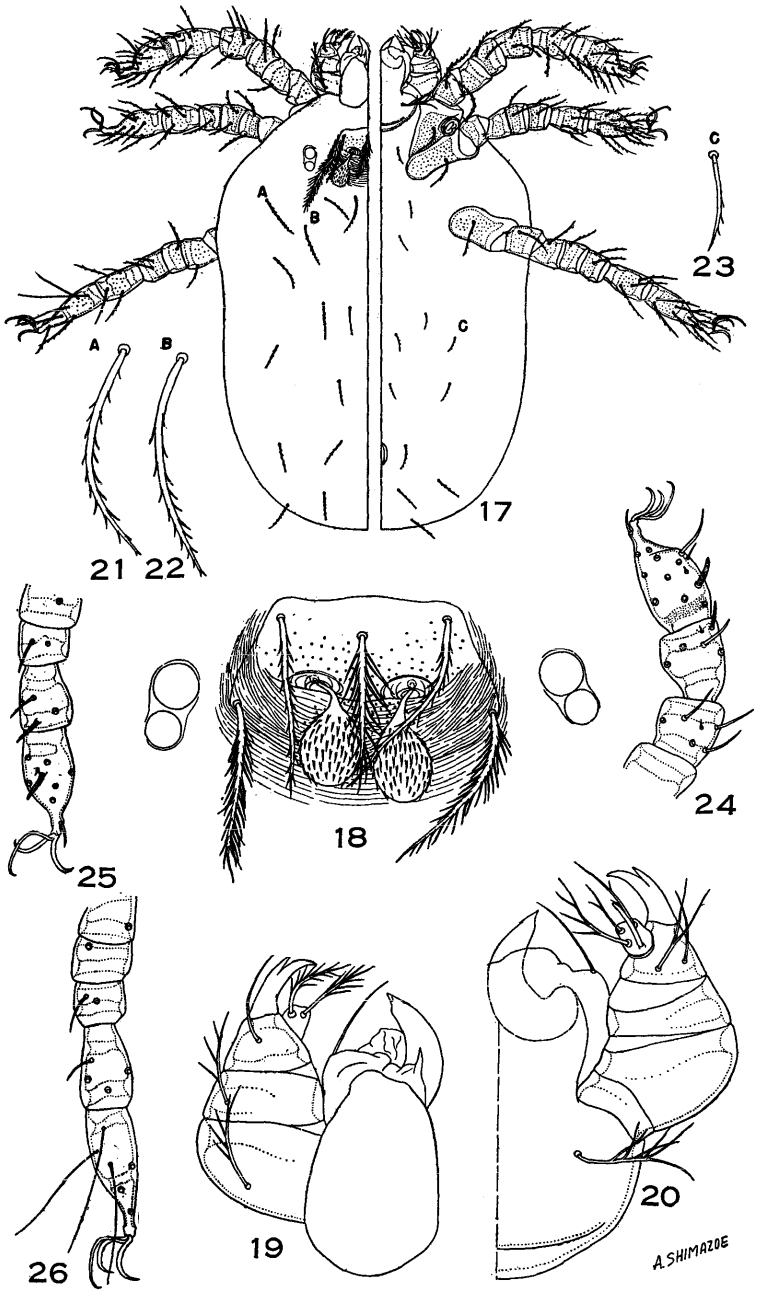
Diagnostic characters.—Body elongate oval, 350×200μ, yellow in life. Galeal setae nude. Three pairs of sternal setae present. Coxal formula 1.1.1. Dorsal setae arranged 2.8.6.2.4.4.2. In this, as in most *Neoschongastia* species, the pattern of cuticular striae over the scutum, and the relative lengths and degree of ciliation of the scutal setae are very useful in confirming the specific identity.

Notes.—There are some small discrepancies between the present material and the figures given by Wharton and Hardcastle (1946), but in view of the over-all general agreement we confidently assign our specimens to Wharton and Hardcastle's species. It must be remembered that in 1946 the depiction of setal ciliations was somewhat conventionalized, while the sensory setal pattern of the legs was not yet fully understood. The ciliated leg setae are rather finer and less strongly ciliated than depicted below. Indeed, in some cases it is difficult to see, even under oil immersion, whether a seta is nude or not. We believe three mastitarsalae III are present, while it is probable that a mastitibiala III also occurs, at least occasionally. A telofemorala III has not been noted. Another difficult character is the palpal formula, which in our specimens is b.b.nnb.5b. The ventral tibial seta is very weakly branched, even to the extent of being simply bifurcate.

STANDARD DATA IN MICRA OF LARVAL SCUTUM OF *N. riversi* W. & H.

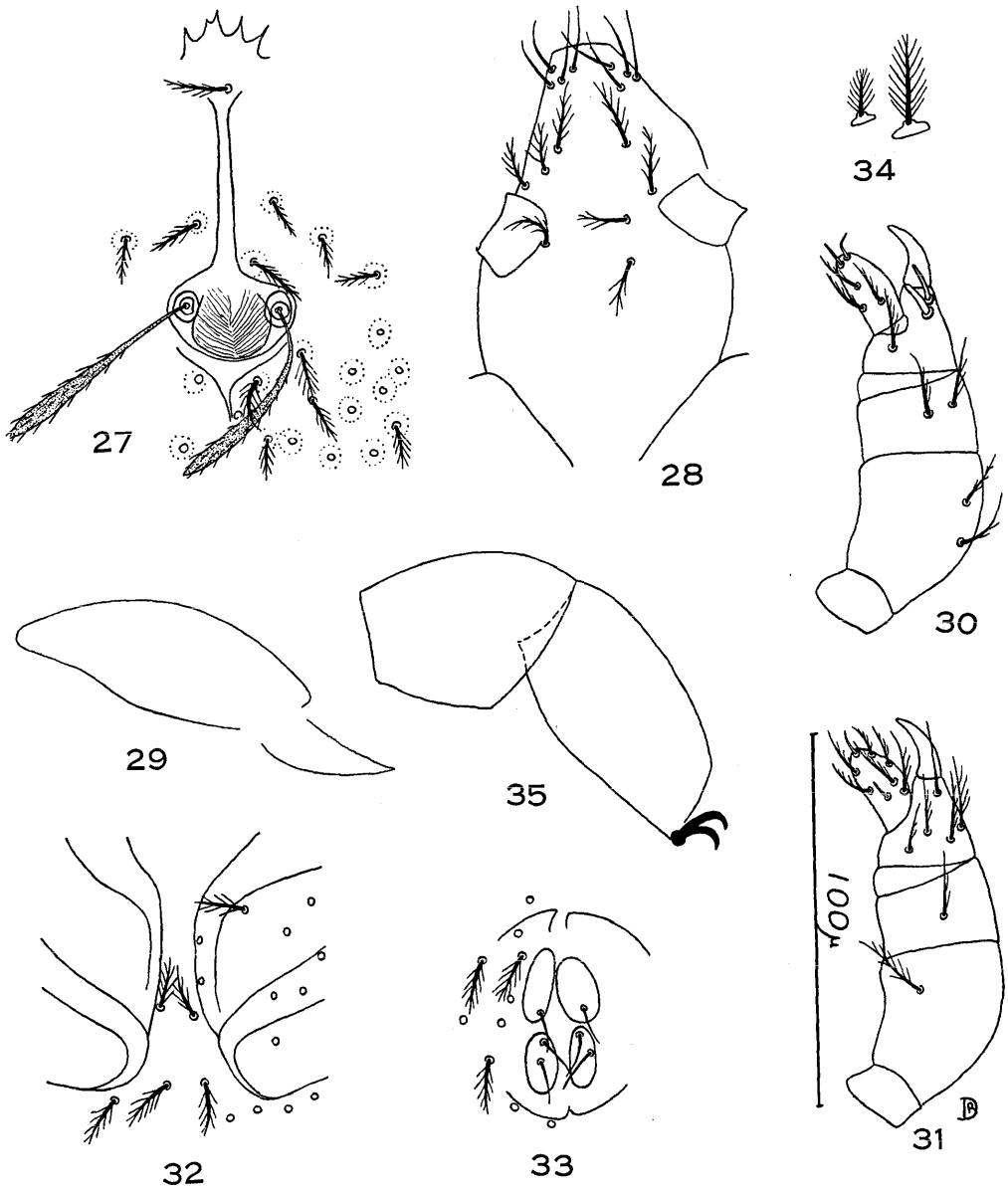
	AW	PW	SB	ASB	PSB	AP	AL	AM	PL	SENS	DS	VS
Mean (4 larvae)	39	59	19.5	22	19	23.5	44.5	38	38	29×15	29.5	15
Range	3	5	3	1	3	3	2	5	4	3	5	4

Material examined.—Larvae from "flying lizards (*Draco*) from forest ..... scattered, firmly attached to lower surface of wing-membrane, mixed with *E. tweediei*" as follows—eighteen larvae from *D. fimbriatus* Kuhl, host No. R37516, Bukit Lagong F.R., Selangor, Malaya, 13. viii. 1954; eight larvae from *D. maximus* Boulenger, host No. R42949, Bukit Lagong



Figs. 17-26. *Neoschongastia riversi* Wharton and Hardcastle, 1946—Larva

17, dorsal/ventral aspects of larva; 18, scutum and eyes; 19, 20, gnathosoma, dorsal and ventral view; 21, 22, 23, humeral, dorsal and ventral setae; 24, 25, 26, legs I, II, III, sensory setae.



Figs. 27-35. *Neoschongastia riversi* Wharton and Hardcastle, 1946—Nymph

27, scutum and surrounding setae; 28, ventral view of hypostome; 29, chelicera; 30, 31, internal and external view of palp; 32, inter-coxal area; 33, genitalia; 34, mid-dorsal and posterior body setae; 35, tarsus and tibia I.

Forest Reserve, Selangor, 20. ix. 1955; seven larvae from *D. maximus*, host No. R43517, Bukit Lagong F.R., 24. x. 1955.

Nymph.

As in *N. gallinarum*, except where noted. Colour in life orange. Idiosomal length 520-550μ. Genital area oval, 54-60μ long, with weakly demarcated genital plates. Two pairs of genital discs present; anterior pair 18-20μ long; posterior pair 14-16μ long. Three pairs of nude inner genital setae present. Anal plates 38μ long. *Gnathosoma* with about eight ciliated setae ventrally, and eight nude galeal setae apically, which are to 19μ long. Chelicerae 110μ long, with blade 40μ long. *Palpi:* Femur with two or three ciliated setae; genu with three or four ciliated setae; tibia with one (occasionally two) ciliated seta near insertion of tarsus, two inner accessory combs (subequal in size), one nude external seta near base of claw, and three or four ciliated external setae; tarsus plump, with external basal sensory rod, three nude terminal setae, and nine ciliated setae. Palpal claw 18μ long. *Legs:* Length tarsus I 71-75μ, height tarsus I 39-46μ, length tibia I 59-63μ. Ratio LTI/HTI 1.62-1.84; ratio LTI/LtI 1.15-1.21. *Scutum* with subcordate area sensilligera, which is partially covered by striate cuticle. Crista longer than area sensilligera, terminating in dentate tectum, bearing a single tectal seta. Paracristal setae subequal, about three on each side, tapering and ciliated. Sensillae clavate and with weak barbules, with greatest diameter apically, as figured. The standard data are given below. *Setation:* All body setae slender and tapering; anterodorsal setae to 15μ, middorsal setae to 9μ, terminal setae to 23μ long. Leg setae as usual; solenidia to 22μ, feathered setae to 25μ long.

STANDARD DATA IN MICRA OF NYMPHAL SCUTUM OF *N. riversi* W. & H.

	CTL	ASL	SB	ASL/SB	PSL	PAD	TS	SS	SENS
	43	53	25	2.12	12	—	17	19	67
	45	53	26	2.04	12	25	19	19	67
	45	54	26	2.08	14	—	17	18	65
	48	59	26	2.27	16	28	17	19	62
Means	45	55	26	2.13	14	27	18	19	65

Material examined.—Four nymphs (slides CORU 41379-82) reared from engorged larvae from a flying-lizard, *Draco maximus* Boulenger, host No. R43517, Bukit Lagong, Malaya, 24-x-1955.

Notes.—The lizard forming the basis of this breeding experiment carried larvae of both *N. riversi* and *Eutrombicula* (*Eltonella*) *tweediei* Audy, which were all placed in one rearing chamber. Nymphs of both species were obtained, and at first glance appear identical, both having similar scutal standard data, and expanded sensillae. Closer examination, however, shows *E. tweediei* nymphs (slides CORU 41383-4) to have weak parasensillary eyes, barbed inner genital setae, and rather slender palpal tarsi.

A seventh nymph bred from this lizard (slide CORU 41378) is not an *Eltonella*, but has standard data rather different from those of *N. riversi* (CTL 38, ASL 47, SB 25, ASL/SB 1.88, PSL 12, SS 17, SENS 50). Perhaps it is a stray specimen of *Ascoschongastia* (*Laurentella*) *audyi* (Womersley) on an abnormal host.

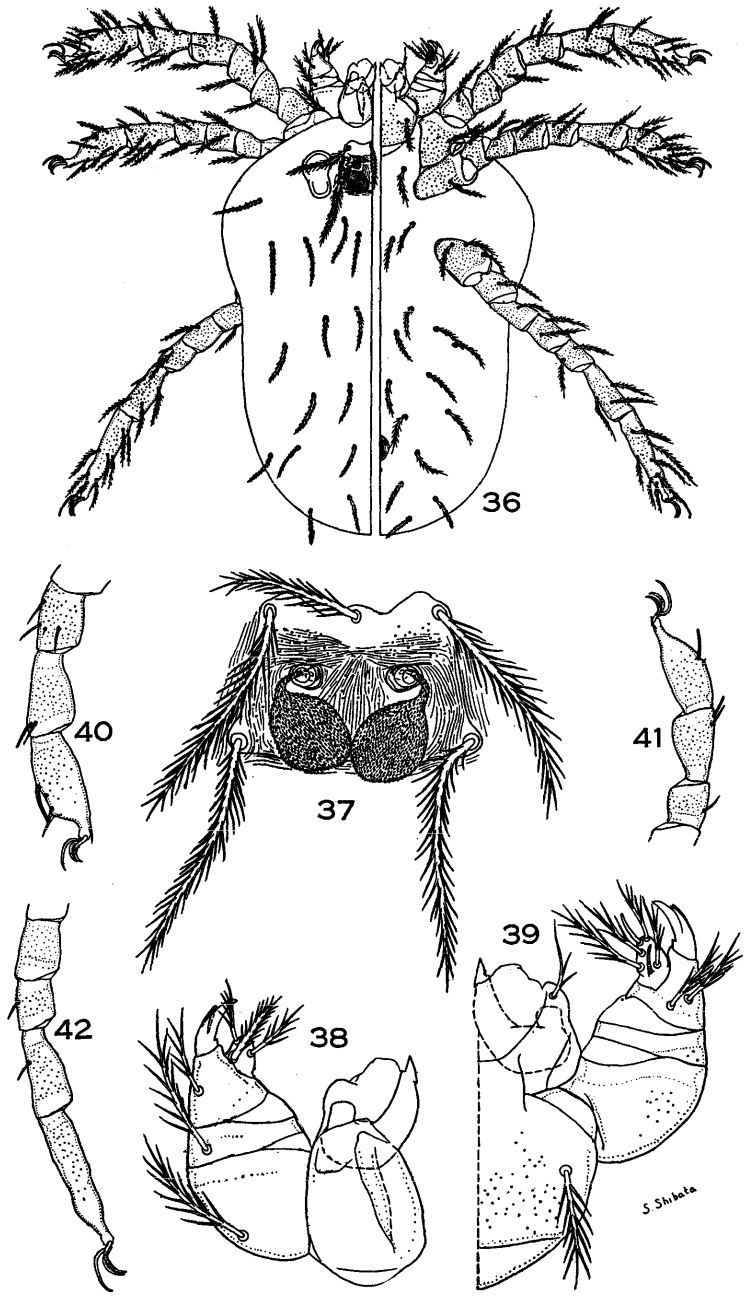
Neoschongastia americana (Hirst, 1921)

Larva.

Diagnostic characters.—Galeal setae branched. Coxal formula 1.1.3. Dorsal setae arranged 2.8.6.4.6.4.2. Mastitarsala III absent. Minute ciliations present on tarsal claws.

STANDARD DATA IN MICRA OF LARVAL SCUTUM OF *N. americana* (Hirst).

	AW	PW	SB	ASB	PSB	AP	AL	AM	PL	SENS	DS	VS
Mean (4 larvae)	46	62.5	25	20	25.5	34	59	34	57	35×19	40	22
Range	7	9	5	1	8	3	11	7	3	3	5	2



Figs. 36-42. *Neoschongastia americana* (Hirst, 1921)—Larva

36, dorsal/ventral aspects of larva; 37, scutum; 38, 39, gnathosoma, dorsal and ventral view; 40, 41, 42, legs I, II, III, sensory setae.

Notes.—Some difference of opinion appears to exist regarding mastitarsala III in this species. It is not present in our series, nor was it figured by Wharton and Hardcastle (1946), or Sasa and Jameson (1954). Hirst (1922) and Womersley (1952), however, show this seta to be present. A further difference is found in the sternal setae, which are typically 4, but 6 in our material, arranged as figured. It seems that this is a highly variable species, widespread in America, Japan, S.W. Pacific, and S.E. Asia; Wharton and Hardcastle (1946) described a subspecies *N. a. solomonis* from the Solomon Islands. For the present we are content simply to call our specimens the form of *N. americana* that occurs in Malaya, rather than attempt a subspecific determination.

Material examined.—Several larvae from a night-jar, *Caprimulgus macrourus bimaculatus* Peale, host No. R45199, Sungei Buloh, Selangor, Malaya, 25. iv. 1956.

Nymph.

The nymph of this species is unknown.

Summary

Three species of *Neoschongastia* (*N. gallinarum, N. riversi, N. americana*) are now known from Malaya. Figures and all available records are given for the three larvae, while the nymphs of *N. gallinarum* and *N. riversi* are described in detail.

References

Audy J. R. (1956*a*). Trombiculid mites infesting birds, reptiles, and arthropods in Malaya, with a taxonomic revision, and descriptions of a new genus, two new subgenera, and six new species. *Bull. Raffles Mus.*, *28*, 27-80.

Audy J. R. (1956*b*). Malayan trombiculid mites. 2. Naked-eye observations on attached chiggers, with a simple checklist of Malayan species, and details of preferred hosts. *Bull. Raffles Mus.*, *28*, 86-101.

Fletcher W., Lesslar J. C. and Lewthwaite R. (1928). The aetiology of the tsutsugamushi disease and tropical typhus in the Federated Malay States. A preliminary note. *Trans. R. Soc. trop. Med. Hyg.*, *22*, 161-174.

Hatori J. (1920). Report on the tsutsugamushi disease in Formosa. 5. *Taiwan Igakkai Zasshi*, *209*, 317-352.

Hirst S. (1922). *Mites injurious to Domestic Animals.* British Museum (Natural History) Economic Series, No. 13, p. 60.

Sasa M. and Jameson E. W. (1954). The trombiculid mites of Japan. *Proc. Calif. Acad. Sci.*, (4) *28*, 247-321.

Sasa M., Ueno Y., Miura A. and Tanaka H. (1957). Notes on the bionomics of *Neoschongastia* spp. and *Trombicula hasegawai*, the summer tsutsugamushi at Hachijo Islands, together with descriptions of their post-larval stages. (Studies on tsutsugamushi, Part 96). *Jap. J. exp. Med.*, *27*, 217-234.

Wharton G. W. and Hardcastle A. B. (1946). The genus *Neoschongastia* (Acarinida: Trombiculidae) in the western Pacific area. *J. Parasitol.*, *32*, 286-322.

Womersley H. (1952). The scrub-typhus and scrub-itch mites (Trombiculidae, Acarina) of the Asiatic-Pacific region. *Rec. S. Aust. Mus.*, *10*, 1-673.

MALAYSIAN PARASITES XLIV

A NEW GENUS OF MITES FROM A THAI MONGOOSE (ACARINA, CHEYLETIDAE)

BY

ROBERT DOMROW

Queensland Institute of Medical Research, Brisbane

AND

EDWARD W. BAKER

United States Department of Agriculture, Washington, D. C.

The family Cheyletidae Leach, 1814 in the broad sense comprises "two groups of mites, those with small, poorly developed, non-grasping palpi (*Myobia*, etc.) and those with large, highly developed, grasping palpi (*Cheyletus*, etc.)." Baker (1949) accordingly restricted the family to the *Cheyletus*-like forms, omitting such individually distinct genera as *Myobia*, *Harpyrhynchus*, *Ophioptes*, *Psorergates* and *Syringophilus*, all of which are now placed in separate families.

Of the genera of Cheyletidae in this restricted sense, two are characterized by lacking comb- and sickle-like setae on the palpal tarsus—*Cheyletiella* Canestrini, 1886 and *Neocheyletiella* Baker, 1949. In *Cheyletiella* all tarsi are without claws, but with many-rayed pulvilli; while in *Neocheyletiella* all tarsi are with distinct claws. The new genus described below agrees with *Neocheyletiella* in having tarsal claws, but is otherwise abundantly distinct in the structure of the gnathosoma and dorsal shield pattern.

There are also biological differences. Both known species of *Cheyletiella* are from lagomorphs, while seven of the eight known species of *Neocheyletiella* are from birds (the host of the eighth is unknown). The new genus described below is from a carnivore, a Thai mongoose of the genus *Herpestes*.

Nihelia n. gen.

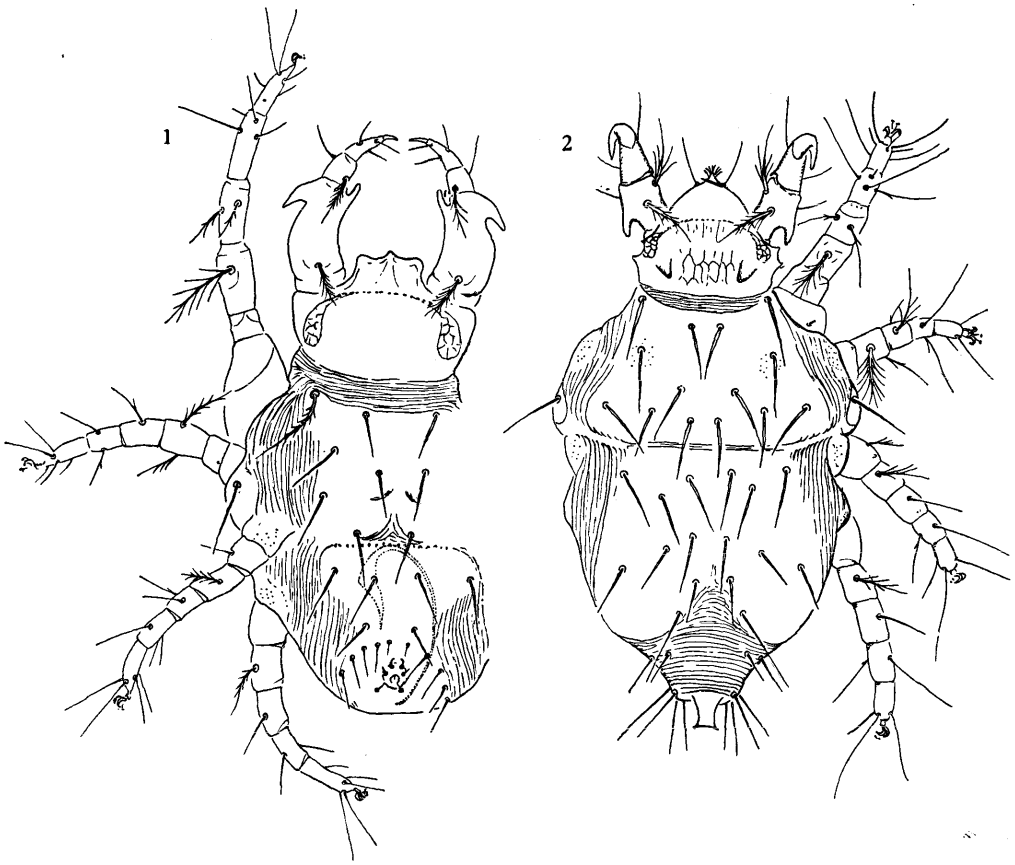
Diagnosis.—Two subequal dorsal shields present in both sexes. Aedeagus with dorsal exit. *Gnathosoma* with strong retrorse spine above peritreme in female. *Palpi* in female with three free segments—basal, tibia and tarsus; in male with four segments—basal, genu, tibia and tarsus (the trochanterocoxal region is indistinct). Basal segment and tibia of female palpi with external and internal retrorse spine respectively. Basal segment of male palpi with internal forwardly directed spur, in addition to retrorse external spine distally, and a blunt process dorsobasally. Tibial claw well developed, but much stronger in female than in male. Palpal tarsus of both sexes much reduced, nodule-like, and without comb- or sickle-like setae; with three short simple setae only. *Legs:* All tarsi with two claws and bifurcate pulvillus. Many dorsal setae on legs and palpi plumose. Setae on apical segments simple, rod-like.

Type species: *Nihelia calcarata* n. sp.

Nihelia calcarata n. sp.

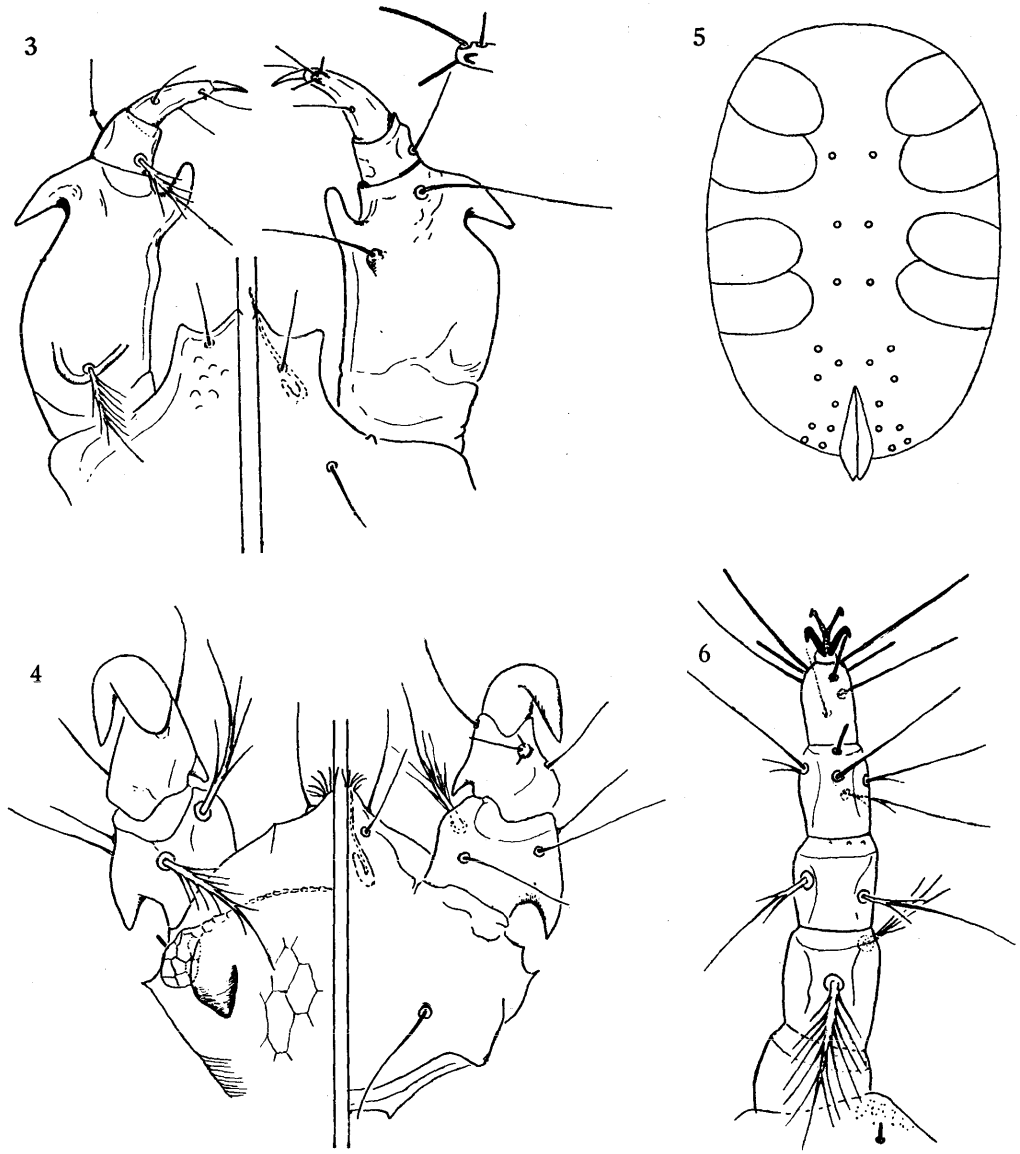
Type material.—Holotype female and allotype male in United States National Museum, Washington, D.C. One pair of paratypes in Queensland Institute of Medical Research, Brisbane, and two paratype females in British Museum (Natural History), London. All six specimens from host B15074, a mongoose of the genus *Herpestes* (Herpestidae, Carnivora), Kanchunaburi, Muang, Thailand, 25. vi. 1952, R. E. Elbel coll. The slides were examined by the courtesy of Lt. Col. Robert Traub MSC.

Description of female.—Length of body to tip of gnathosoma 478μ; greatest width 280μ. *Dorsum* with two shields, of which the posterior is slightly the larger. Anterodorsal shield concave anteriorly to accept the gnathosoma, with a simple seta in each anterolateral corner, and twelve additional simple setae arranged 4.8. Postdorsal shield deeply emarginate posteriorly, with sixteen simple setae arranged 6.6.2.2. Between legs II and III are two small lateral platelets, each with a single simple seta. Body cuticle with longitudinal striae laterally, and transverse striae posteriorly. Venter with two setae between fused coxae I & II and four between fused coxae III & IV; with six setae in front of genitoanal region, which is flanked by about ten additional setae as figured. Ventral surface (except for coxae) striate. *Gnathosoma* with small brush and four setae apically. Chelicerae styliform. Gnathobase on either side with backwardly directed process above peritremes, which are as figured, the large lateral lobes being connected by an arch, which becomes finer medially. *Palpi:* Coxae fused into gnathobase; coxal setae simple. Trochanter indistinct. Femur and genu fused to form a single segment, bearing two plumose setae dorsally and three simple setae ventrolaterally; with retrorse basal spine externally. Tibia with two simple setae and retrorse basal spine internally. Tarsus much reduced and node-like, completely obscured dorsally by tibia; with three short simple setae. Tibial claw large, heavily sclerotized, and directed ventrally. *Legs:* Coxae in four groups of two, coxae I & II and III & IV being fused, but not meeting medially. Coxal setal formula 2.1.2.2. All femora with strong plumose seta dorsally, while some genual and tibial setae are also weakly barbed. Most setae on tibiae and tarsi simple and rod-like, of varying length. The setation of leg I is figured in detail, the number of setae on the segments being 3.0.2.2.6.8, including a short rod-like seta dorsally on coxa, tibia and tarsus. All tarsi with small rounded pretarsus bearing two claws, between which is a bifurcate pulvillus.



Figs. 1-2. *Nihelia calcarata* n.g., n. sp.

1, dorsal view of male; 2, dorsal view of female.



Figs. 3-6. *Nihelia calcarata* n.g., n. sp.

3, gnathosoma of male (dorsal view on left, ventral view on right); 4, gnathosoma of female (dorsal view on left, ventral view on right); 5, diagrammatic scheme of ventral setal pattern of female; 6, dorsal view of leg I of female.

Description of male.—Length of body to tip of gnathosoma 390μ; width not measurable due to fracture. *Dorsum* with two shields, which are weaker than in female. Anterodorsal shield with setae in anterolateral angles branched, but other setae simple, and arranged 2.4.4. Posterior border emarginate medially. Postdorsal shield concave laterally, with setae arranged 4.2 in addition to ten setae in semicircle around genital aperture. Aedeagus stronger in basal quarter, but recurved and very fine distally, exiting through a dorsal aperture, which is surrounded by six short spinose setae. *Venter* as in female, but lacking setae

around anal region. *Gnathosoma* with usual three anterior lobes, but without retrorse dorsal spines present in female. *Palpi:* Femur with plumose seta dorsally on blunt retrorse process, and with two simple setae ventrally, the more posterior of which is set on a small tubercle; distally with blunt internal forwardly directed process, and retrorse external spine. Genu discrete, with one branched and one simple seta. Tibia slender, with three simple setae. Tarsus with three short simple setae and minute nodule. Tibial claw much weaker than in female, and not strongly curved. *Legs:* Coxae and movable segments as in female.

Notes.—It would seem that the six slides of this species were made to compare various mounting media. Two are in Hoyer's medium, two in polyvinyl alcohol and two in methocellulose. The widely used formulas for these media are given in Baker & Wharton (1952). The two in Hoyer's medium are in good condition, and have been chosen as the holo- and allotype. This is an aqueous medium, and should crystallization or darkening occur later, remounting will be easy. The specimens in PVA are in reasonable condition, but much flattened, the buckling of the coverslip due to excessive contraction of the medium being quite evident. This medium tends to polymerize with time, rendering successful remounting without the loss of setae, etc., very difficult. The mounts in MC are in bad condition, as a result of overclearing and excessive drying-out. It would seem, then, that a gum-chloral medium, like Hoyer's, is preferable.

The recipes mentioned above all produce a fluid that is not very viscous and contains a large proportion of volatile matter. We would recommend that the amount of solvent be reduced as much as is practicable, and that the medium be used liberally, thus ensuring that as little contraction as possible takes place during drying. Warming the preparation almost to boiling point before applying the coverslip also helps to eliminate excess volatile matter.

SUMMARY

Nihelia calcarata, n. g., n. sp., is described from a mongoose of the genus *Herpestes* from Thailand. Of the two other cheyletid genera without modified palpal tarsal setae, the new genus appears closest to *Neocheyletiella* Baker.

REFERENCES

BAKER E. W. (1949). A review of the mites of the family Cheyletidae in the United States National Museum. *Proc. U.S. nat. Mus.*, *99* (3238), 267-320.

BAKER E. W. AND WHARTON G. W. (1952). *An Introduction to Acarology*. The Macmillan Company, New York.

MALAYSIAN PARASITES XLV

TWO NEW SPECIES OF CHIGGERS OF THE GENUS *LEPTOTROMBIDIUM* (ACARINA, TROMBICULIDAE)

BY

ROBERT TRAUB

United States Army Medical Research Unit (Malaya), Institute for Medical Research, Kuala Lumpur

During epidemiological investigations of scrub typhus in Malaya undertaken by the U.S. Army Medical Research Unit (Malaya), it was noted that the only *Leptotrombidium* chigger parasitizing rats in suspected foci along sandy beaches was an undescribed species related to *Leptotrombidium deliensis* (Walch)*, a well-known vector of the disease. This new species of *Leptotrombidium*, which is considered a probable vector of scrub typhus, as reported elsewhere (Institute for Medical Research, Malaya, 1960) is herein described. The second species described in this article is a *Leptotrombidium* collected in the mountains of North Borneo and which is highly unusual in two respects. It is the only known member of the genus which is characteristically intranasal in habit, and it possesses greatly modified dorsal setae, which bear a few stout spikes instead of many fine pinnae.

Leptotrombidium arenicola n. sp. (Figs. 2—11)

Diagnosis of Larva.—Unusual in the genus in that all the palpal setae are typically nude (excluding those on the palpal tarsus or "thumb"), and hence the palpal formula is N/N/NNN (rarely N/N/bNN)†, whereas the usual formula encountered in the "*akamushi* group" is N/N/BNN or N/N/BNB. Otherwise resembling *L. deliensis* (Brumpt), but further distinguishable as follows: (1) scutum significantly narrower and shorter, viz., about 60×24 microns, versus approximately 67×29 microns in Malayan *L. deliensis*; (2) with the palpal genual seta proportionately much longer, about three or more times the breadth of the segment, at times actually as long as entire tarsus, instead of only twice breadth of genu; (3) scutal setae definitely shorter, *i.e.*, AL about 34, AM 36 and PL 41 microns respectively, whereas in *L. deliensis* from Malaya the corresponding figures are 46, 50 and 53. The pinnae on the scutal and dorsal setae are stouter and longer in the new species.

Description of Larva.—Body: Ovate, 486×336 microns in engorged holotype. Eyes double; anterior eye in line with sensillae bases, and in cleared specimens, somewhat greater in diameter than these bases. *Gnathosoma:* Chelicerae with narrowed apical portion of blade about 3 times as long as broad at base; with apical tricuspid cap. Lateral and ventral margins of true base of chelicerae fairly angulate at point of junction. Seta on femur and on genu nude; all three tibial setae typically nude.† Galeal and palpal coxa (maxillary) seta each plumose. Palpal tarsus with 5 bristles, of which one is heavily plumed and two (or three) moderately plumose, the remaining two (or one) virtually nude; with a basal striated rod. Palpal claw three-pronged. *Scutum:* About 1 3/4 times as broad as long. Anterior margin shallowly concave mesad of ALs. Lateral margins fairly concave between insertion of ALs and PLs. Caudal margin slightly sinuate. With PLs inserted in rounded shoulders; somewhat beyond level of sensillae bases. Scutum lightly punctate except around base of AM. Scutal setae well barbed. Sensillae flagellate; apical half lightly branched.

---

* *L. deliensis* was formerly referred to as *Trombicula deliensis* or *Trombicula* (*Leptotrombidium*) *deliensis*.

† On an occasional specimen, the dorsal seta of the palpal tibia is frayed or, rarely, even slightly branched.

The Standard Measurements (in microns) for the holotype and the three series of paratypes from different localities are as follows:

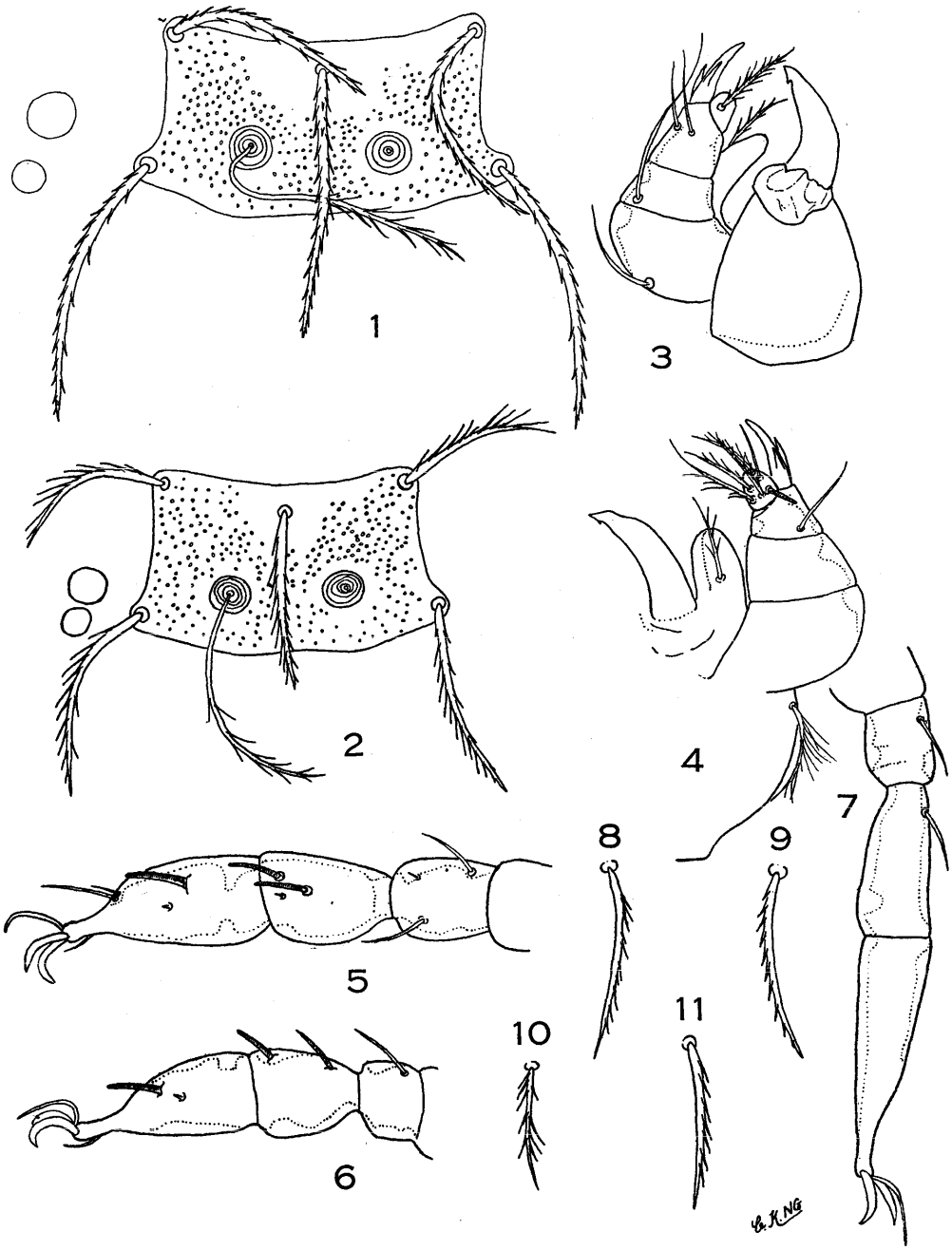
	AW	PW	SB	ASB	PSB	A-P	AL	AM	PL	DS	PW / Cox. II	PW / SD	PW / ASB
Holotype	51	59	23	22	13	27	34	38	42	40	1.12	1.69	2.68
Pangkor Series (15)													
Mean	51	60	23	21	13	26	34	37	41	41	1.12	1.76	2.86
Range (+ or −)	2	2	2	1	1	2	2	2	2	3	.08	.05	.07
Rumbia Series (10)													
Mean	52	60	23	22	13	26	35	37	41	41	1.15	1.71	2.73
Range (+ or −)	2	2	2	1	1	2	2	2	2	3	.08	04.	.07
E. Johore Series (10)													
Mean	49	59	23	23	12	25	34	37	40	41	1.13	1.72	2.60
Range (+ or −)	2	2	2	1	1	2	2	2	2	3	.08	.05	.08

Body Setae: Dorsal setae resemble those of scutum, generally 28 in number, arranged in rows as follows: 2-8-6-6-4-2. Two pairs of pectinate sternal setae. Ventral setae about 20 in number, of which 6 are postanals. True ventrals about 31 microns long; subpectinate. *Legs:* All coxae punctate and unisetose; on coxa I, seta submedian; on coxa II, caudomarginal, subapical; on coxa III, anteromarginal, subproximal. Sensory setae as typical in group, *viz:* Leg I with 2 genualae and a microgenuala; with 2 tibialae and a microtibiala; with a blunt striate tarsala (spur), an adjacent microtarsala, a well-developed subterminala and almost contiguous parasubterminala about 1/2-1/3 its length, a pretarsala. Leg II with a genuala; two tibialae, one of these stout and subapical; a tarsala, near to which a microtarsala, and a subterminala. Leg III with a genuala and a tibiala.

Type Material.—Holotype (B 50249-C) and a series of paratypes *ex Rattus jalorensis* ssp., Malaya, Perak, Pangkor Island, coll. in lallang (*Imperata cylindrica*) along the seashore by R. Traub and members of U.S. Army Medical Research Unit (Ben Ensoll and Phang Ong Wah), 2. iv. 59. Series of paratypes as follows: With same data, but from other specimens of rats; other paratypes *ibid.*, but *ex Rattus rattus diardi. Ex Rattus jalorensis* ssp., Pangkor Laut Island, otherwise as holotype. *Ex Rattus rattus rumbia* and *Rattus rattus diardi*, Rumbia Island in the Sembilan Islands, Perak, 3. iv. 59; otherwise as holotype. *Ex Rattus jalorensis* on seashore of E. Coast of Johore, Tanjang Siang on Pengarang Peninsula (R. Traub and USAMRU), 28-29. xii. 58.

Holotype and a series of paratypes deposited in U.S. National Museum, Washington Paratypes distributed among collections of Institute for Medical Research, Kuala Lumpur; the Rocky Mountain Laboratory of the U.S. Public Health Service, Hamilton, Montana; the British Museum; the South Australian Museum; the author's collection and elsewhere.

Comment.—This species is noteworthy in several respects. It is considered a probable vector of scrub typhus in Malaya for epidemiological reasons and because of the isolation of *Rickettsia tsutsugamushi* from laboratory mice inoculated with pools of chiggers apparently consisting wholly of *L. arenicola* n. sp. (Institute for Medical Research, Malaya, 1960). It has been collected only from rats inhabiting the sand-covered grassy borders of Malayan beaches. The specific status of this chigger was first recognized when the U.S. Army Medical Research Unit was investigating a limited outbreak of scrub typhus in Gurkha troops operating along the East Coast of Johore on the Pengarang Peninsula. Investigation soon showed it was also the predominant chigger, and only *Leptotrombidium*, on rats living in the sand on Pangkor Island and Pangkor Laut Island off the West Coast of Perak, and on Rumbia Island of the Sembilan group, further south. The probability that sand, and not salinity or brackish environs, is an important determining ecological factor in the known (Malayan) distribution of this mite is indicated by the fact that the rats of Jarak Island, in the Straits of Malacca, notorious for their great numbers and heavy infestation of chiggers, carry true *Leptotrombidium deliensis*, and not *L. arenicola.* Jarak Island has no sandy beaches and its shores are boulder-strewn; and the scrub and forest come right down to the water's edge. This predilection for sand suggested the name *arenicola.*



Figs. 1-11. *Leptotrombidium deliensis* (Walch) and *Leptotrombidium arenicola* n. sp.

L. deliensis.—1, scutum. *L. arenicola*.—2, scutum; 3, gnathosoma, dorsal; 4, gnathosoma, ventral; 5, 6, 7, legs I, II, III, distal segments; 8, humeral seta; 9, dorsal seta; 10, ventral seta; 11, caudal seta.

The relative consistency of the standard measurements noted in the populations of *L. arenicola* studied in any one area, as well as when compared to other localities, *i.e.* Pangkor and Rumbia, is quite unusual in trombiculid mites.

This species does not fit the strict concept of *Leptotrombidium* as defined by some authors, who tended to regard a palpal formula of N/N/BNB as being a critical feature. However, Audy (1954) in discussing this point, favored a more liberal interpretation of this critical character, which requires careful study under the oil-immersion lens to elucidate, and diagnosed the *akamushi*-group (as subgenus *Leptotrombidium s. str.*) as possessing the following palpal formula: N/N/B (N?) NN (B). Audy thus actually anticipated the discovery of a chigger like *L. arenicola*. As defined by Audy (1960) elsewhere, this new species is definitely a *Leptotrombidium*. Further, in certain specimens the dorsal tibial seta of the palpus is frayed or even slightly barbed, suggesting the genetic or morphological instability of the plumose feature in this case.

Leptotrombidium spicata n. sp. (Figs. 12—18)

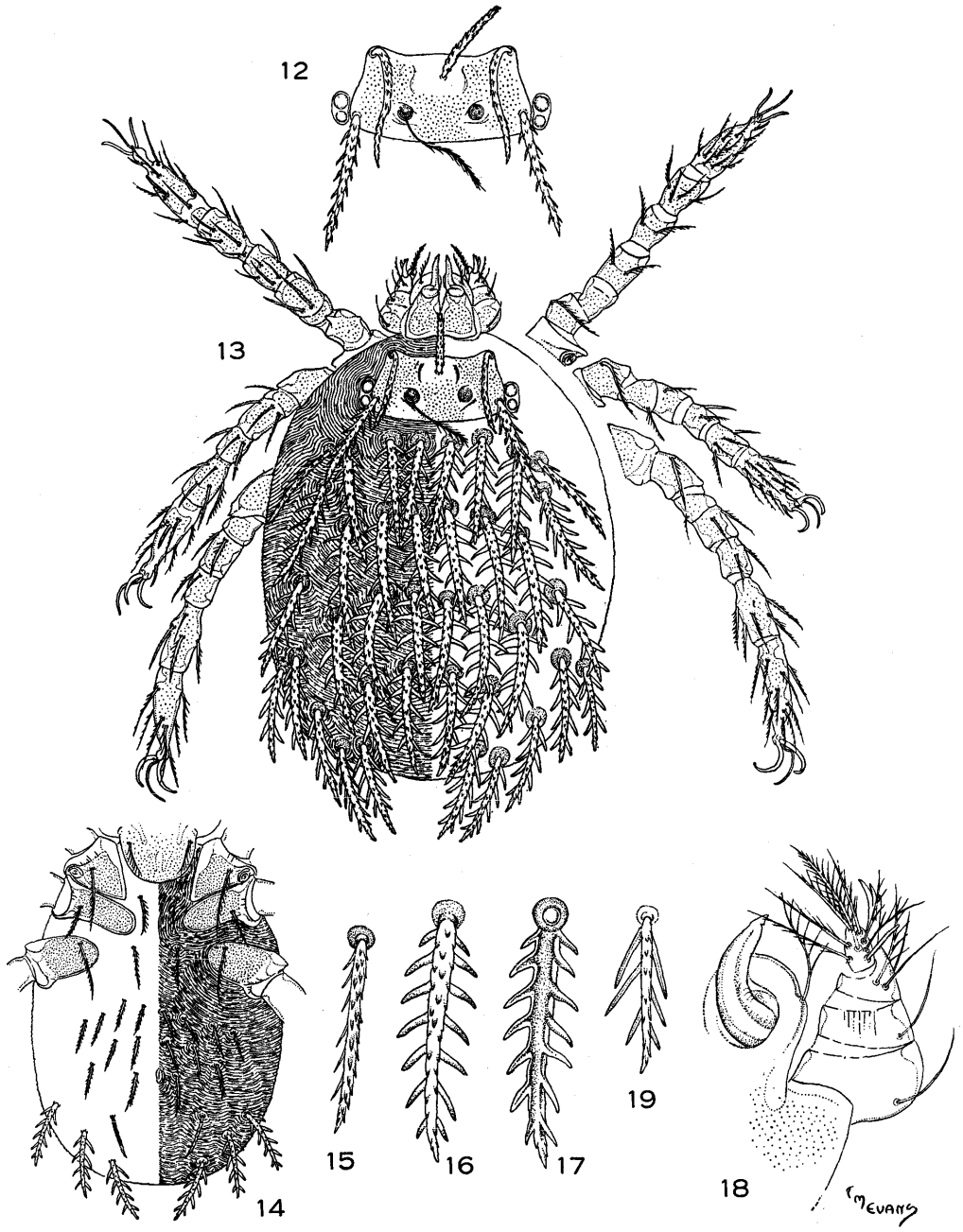
Diagnosis of Larva.—Unique in the bizarre modification of the dorsal setae, which are extremely stout, and spicate or racemose, the spikes widely separated and zygomorphic; the setal bases proportionately equally enlarged, exceeding the sensillary bases in diameter. Nearest to *Leptotrombidium baluensis* Traub and Audy 1954 (1954), with which it agrees in general morphology, and in which the dorsal setae possess blade-like processes instead of normal pinnae. In *L. baluensis*, the shaft of the dorsal setae is not much enlarged, its diameter being much less than that of the sensillary base; while the modified pinnae are relatively long, their lengths generally equal to three or four times the diameter of the shaft, and asymmetrical in position so that the bristle often appears subpectinate (fig. 19). In contrast, in *L. spicata* n. sp., the shaft of the dorsal setae is greatly enlarged, proximally being subequal to the diameter of the sensillary base, while the spikes are short, their length equalling only twice the diameter of the shaft, and they generally arise opposite each other (bilaterally symmetrical).

Description of Larva.—Body: Subovate, about 305 × 187 microns in fairly engorged holotype. Eyes 2+2; well-developed, the posterior eye larger than sensillary bases yet somewhat smaller than anterior eye; contiguous with scutum at angles of PLs. *Gnathosoma:* Chelicerae about four times as long as broad at base; with a typical, apical tricuspid cap. Palpal setal formula N/N/BNN. Palpal tarsus with six plumed setae. Palpal claw 3-pronged, the middle prong the longest. *Scutum:* About twice as broad as long (82 × 42 microns at maxima—*i.e.* at shoulders). Anterior margin fairly straight except at rounded shoulders. Lateral margins slightly sinuate and somewhat inclined mesad towards ALs. Posterior margin very shallowly convex, almost straight. Uniformly micropunctate except for bare areas about AM and behind SB. AL setae at anterolateral angles of scutum; very stout, the pinnae short and broad, scale-like, somewhat imbricated. AM seta somewhat removed from margin; resembling ALs. PL setae longer and slightly stouter than ALs, approximating dorsal setae in size and structure but the proximal pinnae narrow in the form of spikes which form an acute angle with the main axis of the bristle; distal pinnae appearing as imbricated or adpressed scales. PLs in line with SB; removed from posterior margin by a distance equal to about thrice the diameter of setal pore. Distance between SB definitely greater than that between each base and lateral margin; with faint ridges behind the bases. Sensillae with proximal half nude; apical half plumose, the pinnae thin, delicate.

STANDARD MEASUREMENTS IN MICRONS

	AW	PW	SB	ASB	PSB	A-P	AL	AM	PL	DS	PW / Cox. II	PW / SD	PW / ASB
Holotype B 19519-9	65	80	34	34	16	31	56	46	72	70/81	1.25	1.60	2.35
Paratypes (11) Mean	66	80	35	34	15	31	60	48	75	70/93	1.26	1.62	2.34
Range + or −	2	6	3	2	1	3	7	5	6	—	.08	.07	.13

Body Setae: Dorsal setae lacking true pinnae; with shaft resembling a thick elongate cone, whose dorsal margin bears 3 irregular rows of short, pointed, separated, adpressed scales—one row median and the others submarginal; subventrally bearing 5 or 6 pairs of conspicuous zygomorphic, subparallel spikes, the processes making a 60-80° angle with the main axis. The shape of a dorsal seta suggesting a backbone with widely separated, long vertebral processes. Setal pore of these bristles surrounded by a distinct but lightly sclerotized base nearly twice diameter of seta. Dorsal setae about 34-38 in number; arranged approximately 2-8-8-8(10)-6-4. Ventral setae only about 24 in number, of which about 8 are



Figs. 12-19. *Leptotrombidium spicata* n. sp. and *Leptotrombidium baluensis* Traub and Audy

L. spicata.—12, scutum; 13, dorsal aspect of larva; 14, ventral aspect of larva; 15, humeral seta; 16, dorsal seta, dorsal view; 17, dorsal seta, ventral view; 18, gnathosoma. *L. baluensis.*—19, dorsal seta, dorsal view.

postanals, and of these last, about 6 are spicate and resemble the dorsal setae. True ventrals about 28 microns in length; thin, pinnatifid. *Legs:* Coxae each with one seta; in coxa III it is submarginal and near proximal third or fourth. Sternal setae 2-2. Sensory setae as follows (as in typical *Leptotrombidium*): Leg I with 2 genualae and a microgenuala; with 2 tibialae (one stout) and a microtibiala; with a blunt striate tarsala (spur), a microtarsala posterior and slightly distal to it; a well-developed subterminala and parasubterminala less than one-half its length, and a pretarsala. Leg II with a genuala; 2 tibialae, one of which is stout and subapical; a tarsala, anterior microtarsala and a well-developed subterminala. Leg III with a genuala and a tibiala.

Type Material.—Holotype and 10 paratypes (B 19519) coll. lying loose between the turbinated bones in the nasal passages of *Rattus whiteheadi* (Thomas), a small spiny rat; North Borneo, Mt. Kinabalu, Ranau, elev. 1,500 ft., 7 Sept. 1953; coll. R. Traub for the joint U.S. Army—British Colonial Office Medical Research Unit. All of the following paratypes were also collected by this Unit in the Ranau area: A. *Intranasal specimens*—Six (B 19506) with same data as holotype; but coll. 4 Sept.; five (B 19496) same as preceding; six (B 19495) ditto; four (B 19497) ditto; one *ex Rattus cremoriventer* (Miller), otherwise as holotype. (These specimens were collected by dissection of the nasal passages.) B. *Attachment Site Unknown*—One (B 19017) with same data as holotype but 13 July; four (B 19106) *ibid.*, but *ex Rattus sabanus* (Thomas), 23 July; eight (B 19034) *ex* pooled *R. cremoriventer* and *R. whiteheadi*, 14 July; two (B 20524) from another pool of these rats, 15 July. In addition, one (B 19039) *ex R. cremoriventer*, coll. 14 July by H. D. Newson and B. C. Walton, who also collected one (B 19091) *ex Rattus rajah* (Thomas), 21 July and one (B 20535) *ex Rattus* sp., 15 July 1953. (A modification of the detergent-washing method of Lipovsky (1951) was used to collect this series.)

Holotype deposited in U.S. National Museum. Paratypes in collections of U.S. National Museum, the British Museum, the South Australian Museum, the Rocky Mountain Laboratory of the U.S. Public Health Service, the Colonial Office Medical Research Unit, the Chicago Natural History Museum, that of the author, and distributed among various acarologists, including Doctors E. W. Jameson, Jr. and C. D. Radford.

Comment on Leptotrombidium spicata *and intranasal chiggers in North Borneo.*—The rats infested with *Leptotrombidium spicata* n. sp. inhabited terrain characterized by remnants of primary forests mixed with secondary jungle at the base of Mt. Kinabalu. These rats, namely *Rattus rajah, R. whiteheadi* and *R. cremoriventer*, were typical denizens of such a habitat, in contrast to *Rattus rattus* and *Rattus mulleri*, which lived in adjacent cultivated areas or in scrub terrain characterized by an abundance of grass and herbaceous shrubs. It is of interest that none of the 40 *Rattus rattus* or *R. mulleri* which were examined were parasitized by this species of chigger. Since it was on this expedition that the intranasal habitat of certain Borneo chiggers was first discovered, intensive efforts were made to collect chiggers of this type. It is therefore regarded as significant that no *L. spicata* was ever collected from the rats trapped in the relatively well studied Tenompak area of Mt. Kinabalu, higher on the mountain, at 4,300 feet elevation, and that the species was apparently absent from the true mountain forest of the upper reaches of Kinabalu. In all, over 125 specimens of *Rattus whiteheadi, R. cremoriventer* and other representative hosts from the higher elevations were examined very carefully for chiggers, but no *L. spicata* were found, although other intranasal forms were present.

At first glance *L. spicata* n. sp. seems to be morphologically distinct from any other species in the genus. However, except for the highly specialized dorsal setae, it is a typical *Leptotrombidium* larva. *L. baluensis* Traub and Audy 1954 apparently is intermediate between the new species and the "normal" *Leptotrombidium* with respect to the development of spikes or blade-like processes on the dorsal setae. In the absence of comparative studies of nymphal and adult stages of these chiggers, and because of our ignorance of the life history of intranasal trombiculids, it is felt best to avoid any subgeneric designation.

SUMMARY

Two new species of *Leptotrombidium* are described and illustrated. The first, *L. arenicola* n. sp., is considered a probable vector of scrub typhus, and is a parasite of *Rattus rattus* and *Rattus jalorensis* on the sandy beaches of Malaya. It is unique in the genus in that all the palpal setae are nude, but is otherwise close to *L. deliensis* (Walch). The second species, *L. spicata* n. sp. from North Borneo, is unique in that the dorsal setae are greatly modified, and are extremely stout and spicate or racemose, lacking true pinnae. It is an intranasal species, and was collected in the nasal cavities, between the turbinated bones, of *Rattus whiteheadi* and other jungle-inhabiting rats in the vicinity of Ranau, at the base of Mt. Kinabalu.

ACKNOWLEDGEMENTS

Various members of the staff of the Institute for Medical Research and of the U.S. Army Unit (Malaya) have been co-operating with me and with Dr J. R. Audy in our study of Malayan chiggers, and they too have assisted in various phases of the current paper, including collecting specimens. I am particularly indebted to Ben Ensoll, Phang Ong Wah, Ng Cheong Kee, Ang Whi Leng, M. Nadchatram and Lim Boo Liat. Major H. D. Newson and Captain Bryce Walton were very helpful during the field studies in North Borneo. Miss Mary Lou Morrow, formerly of the Walter Reed Army Institute of Research, assisted in measuring specimens of *L. spicata*. The drawings of *L. arenicola* were prepared by Ng Cheong Kee and those of *L. spicata* by Thomas M. Evans, to both of whom I am grateful.

REFERENCES

AUDY J. R. (1954). Malaysian Parasites, IX. Notes on the taxonomy of trombiculid mites with description of a new subgenus. *Stud. Inst. med. Res. Malaya, 26*, 123-170.

AUDY J. R. (1960). Trombiculid vectors of scrub-typhus: records and changes of names. I. Genus *Leptotrombidium* (Trombiculidae). *Med. J. Malaya*, (in press).

INSTITUTE FOR MEDICAL RESEARCH, MALAYA (1960). United States Army Medical Research Unit (Malaya). *Rep. Inst. med. Res. Malaya, 1959*, (in press).

LIPOVSKY L. J. (1951). A washing method of ectoparasite recovery, with particular reference to chiggers (Acarina, Trombiculidae). *J. Kans. ent. Soc., 24*, 151-156.

TRAUB R. AND AUDY J. R. (1954). Malaysian Parasites, IV. Species of *Trombicula* (Acarina Trombiculidae) from Borneo. *Stud. Inst. med. Res. Malaya, 26*, 45-76.

MALAYSIAN PARASITES XLVI

HYSTRICHONYSSUS TURNERI, N. SP., N. G., REPRESENTING A NEW SUBFAMILY OF DERMANYSSIDAE (ACARINA) FROM A MALAYAN PORCUPINE†

BY

HUGH L. KEEGAN

Army Medical Service School, Fort Sam Houston, Texas

CONRAD E. YUNKER

Department of Zoology, University of Maryland

AND

EDWARD W. BAKER

Entomology Research Division, U. S. Department of Agriculture, Washington, D. C.

Recently, each of us independently undertook description of a new genus and species of dermanyssid mite from Malaya. A subsequent meeting and comparison of material revealed that we were describing the same form. Our collated notes are presented herein. Two lots of mites totaling 13 specimens were collected from porcupines in 1948 and 1955 by Col. Robert Traub of the U.S. Army Scrub Typhus Team. The third lot, consisting of two specimens, was found between the scales of an elephant trunk snake in the Laboratory of Leslie H. Turner, M.B.E., M.D., recently virologist in the Division of Virus Research and Medical Zoology, Institute for Medical Research, Kuala Lumpur. In the following study the porcupine collections are chosen as type material, while the specimens from the snake are recorded as additional, non-type material in the event they should prove to be different.*

HYSTRICHONYSSINAE new subfamily

Dermanyssidae; similar to Dermanyssinae except as follows: hypostome and tectum forming an elongate, sheathlike cone; basal segment of chelicera long and attenuate; palpal trochanter without spur; tritosternal base partially divided.**

Type genus: *Hystrichonyssus*, new genus. Monotypic.

Hystrichonyssus new genus

Hypostome and tectum with elongate anterior projections; that of the tectum encircling the hypostomal processes laterally to form a sheathlike cone. Palpal trochanter without spur. Basal segments of chelicerae attenuate, extremely long and whiplike; basal segment ten times as long as distal segment; chelae minute but fully formed, chelate. Deutosternal teeth in two

† This investigation was aided by National Science Foundation Grant NSF-G 4561.

* In addition to Col. Traub and Dr Turner, the authors are grateful to Capt. Vernon J. Tipton, MSC, USA, and Dr J. R. Audy, formerly of the Institute for Medical Research, Kuala Lumpur, for making certain of the collections available to us.

** This and all subsequent descriptions are based solely on female specimens.

longitudinal rows, one on either side of deutosternal groove. Tritosternal base divided ventrally, each member connected by a dorsomedian membrane. Peritremal plate deeply subintegumental, posteriorly embracing coxa IV. Sternal plate rectangular; epigynial plate a short oval; anal plate situated on a posterior lobelike projection of the opisthosoma, large, subintegumental, with accessory setae. Dorsal plate entire, oval.

The name *Hystrichonyssus* is formed by combining the Greek words Hystrix (fem., porcupine) and nysso (to prick).

Type species: *Hystrichonyssus turneri* n. sp. Monotypic.

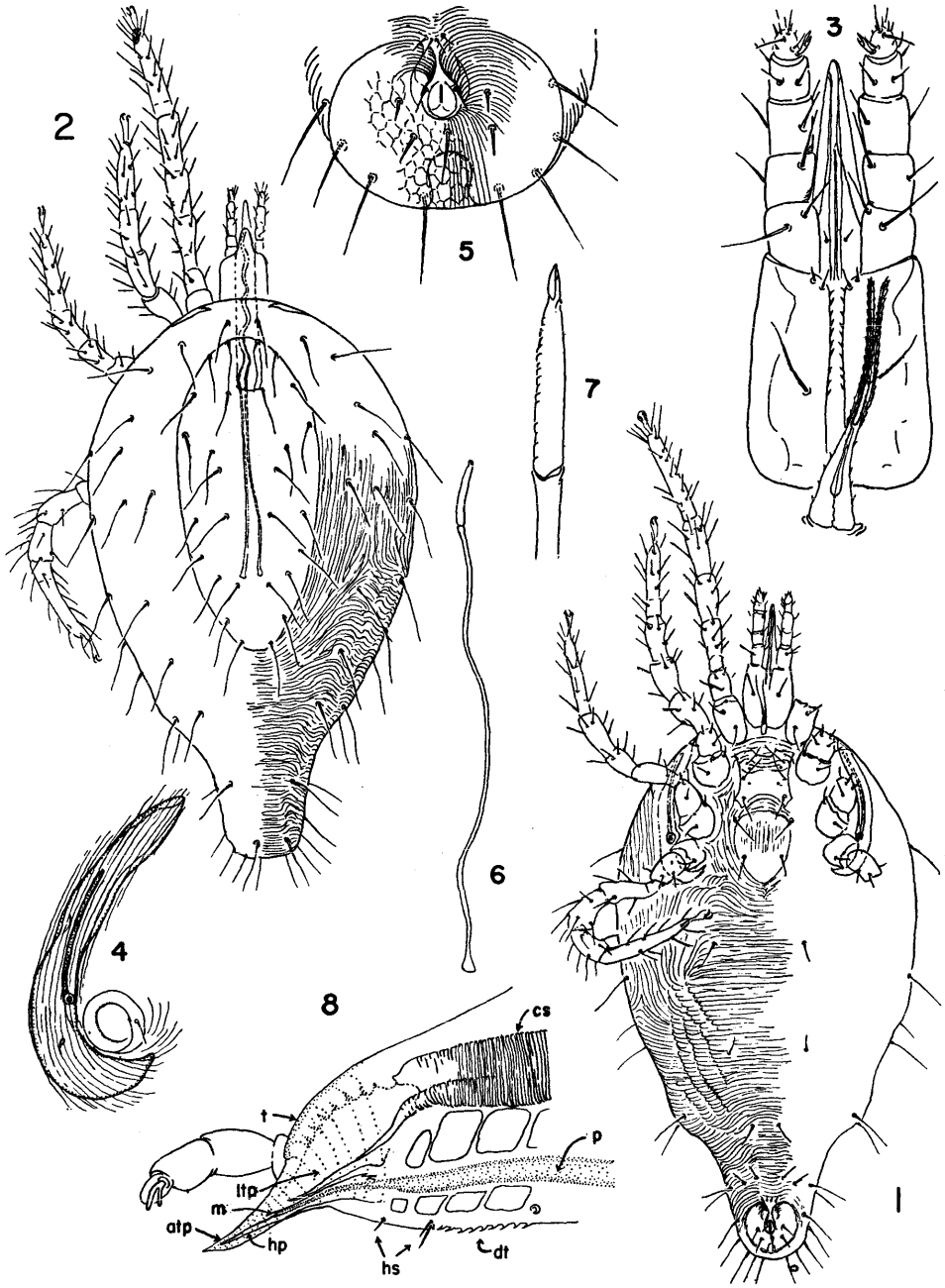
Hystrichonyssus turneri n. sp.

Adult female, holotype (figs. 1-7).—A large, oval mite, with a posterior lobelike projection of opisthosoma. All other gross facies typically dermanyssid. Total length, measured at dorsal surface exclusive of gnathosoma, 1573μ; width, measured at dorsal surface at level of legs III, 912μ.

Venter (fig. 1).—Tritosternum with two pilose lacinae originating at a base that is partially divided (fig. 3). Laterally, pilose structures begin on tritosternal base and proceed anteriorly to tip of lacinae as membranous lateral expansions. Sternal plate rectangular, longer than wide (157μ × 142μ); sculptured only at anterior margin and merging insensibly with sculptured presternal area; lateral margins straight; posterior margin slightly convex medially, posterolateral corners angular; with three pairs of setae and two pairs of circular pores, the first pair of setae slightly shorter (63μ) than second and third pairs (74μ). Metasternal setae on integument, lateral and adjacent to anterior margin of genital plate, equal in size to first pair of sternal setae. Genital plate small, oval (214μ long × 145μ wide); anterior end truncate; posterior end narrower, ending abruptly in a broad point; surface unsculptured; with a single pair of submarginal setae (46μ long) arising from a point two-thirds of the distance from anterior to posterior margins of the plate. Peritremal plate (fig. 4) large, entirely subintegumental, posteriorly embracing coxa IV, anteriorly continuing ventrally to anterior of idiosoma and proceeding dorsally for a short distance at level with coxa I. Peritreme 285μ long, arising posteriorly in stigma at level between coxae III and IV and terminating anteriorly at level of anterior margin of coxa II. Integument densely striated, bearing three pairs of setae between genital plate and beginning of opisthosomal projection, the first pair 57μ long, the second pair shorter (50μ), and the third pair longest (85μ). Opisthosomal lobelike projection (fig. 5) bearing two pairs of submedian setae equal in size to first sternal setae, a longer, submarginal pair (142μ), and two smaller pairs (34μ) immediately anterior to anal plate. Anal plate large (225μ long × 210μ wide), entirely subintegumental, deeply cleft on anteroventral margin; posterior margin rounded superficially but with an internal cleft resembling that of anterior margin; lateral margins rounded; surface sculptured with a roughly hexagonal pattern but this obscured by overlying integumental striations. Anal opening at base of anterior concavity of plate, closely associated with a single pair of short adanal setae (26μ). Two pairs of accessory adanal setae and a single, larger postanal seta (43μ) on anal plate. Lateral margins of body with eleven pairs of setae much longer than ventral setae (128μ-142μ).

Dorsum (fig. 2).—With a single, elongated, oval shield (784μ long × 320μ wide), slightly narrower at posterior end. Surface of shield unsculptured; with fifteen pairs of setae, eight submedial and seven submarginal, increasing in size posteriorly (100μ-128μ long), and slightly smaller than lateral setae. Integument with twelve pairs of setae of approximately equal length.

Gnathosoma (fig. 3).—Palps five-segmented; tarsus bearing double-pronged claw; trochanter without ventral spurlike projection. Gnathosomal base elongate, one-half the total length of gnathosoma, bearing a single pair of pilose ventral setae (86μ long). Hypostome elongate, extending anteriorly as paired processes to a level of palpal trochanter, the anterior portion of these processes being encased by recurving, sheathlike processes originating on tectum. Hypostome bearing two small pairs of setae at base and a smaller anterior pair. Deutosternum with eight pairs of setiform teeth arranged in a single file, one file on each lateral side of deutosternal wall, beginning at level of gnathosomal base setae and ending anteriorly at level of second and third pair of hypostomal setae. Dorsally, the bulk of the tectum ends in a heavily sclerotized, rounded knob at level of palpal femur, but gives rise to an anterolateral projection that reaches anteriorly to level of palpal tarsus, encloses hypostomal projections laterally, and forms a sheathlike cone. This process can best be seen in lateral view (fig. 8). Chelicerae (figs. 6, 7) long and attenuate, overall length 1025μ, the basal segment being 935μ long. Terminal segment slightly broader than basal segment. Chelae chelate (fig. 7). [References to chelicerae are based on paratype specimens from which they were dissected for clarity. In these dissections and in whole mounts the chelae are closed and cryptic; their morphology could not be determined.]



Figs. 1-8. *Hystrichonyssus turneri* n. sp., n.g.—Female

1, ventral view; 2, dorsal view; 3, gnathosoma and tritosternum, ventral view; 4, peritremalia; 5, opisthosomal lobelike projection, ventral view, enlarged; 6, chelicera; 7, distal segment of chelicera, enlarged; 8, gnathosoma, lateral view, with one palp removed (diagrammatic)—atp=anterior projection of tectum, cs=cheliceral sheath, dt=deutosternal teeth, hp=hypostomal process, hs=hypostomal setae, ltp=lateral projection of tectum, m=mouth, p=pharynx, t=tectum.

Legs.—All tarsi with caruncles and paired claws. All segments with slender, slightly pilose setae, the dorsal ones generally longer than those that are lateral and ventral. Setation of each segment as follows (based on holotype):

Leg	Coxa	Trochanter	Femur (Basifemur, Telofemur)	Genu	Tibia	Tarsus (Basitarsus, Telotarsus)
I	2	6	11 (0, 11)	11	13	18 (0, 18)
II	2	5	9 (1, 8)	9	10	18 (4, 14)
III	2	5	5 (1, 4)	9	7	18 (4, 14)
IV	1	5	4 (0, 4)	10	9	18 (4, 14)

In addition, 15-18 setae are to be found in the specialized sensory area at tip of tarsus I. This area is basically similar to those of other *Dermanyssus* spp. All segments, including coxa II, are devoid of spines, spurs or other such modifications.

Type Specimens.—The holotype female, U.S. National Museum No. 2562, is deposited in the collection of the United States National Museum, Washington, D.C. It bears the following data: Ex: Porcupine; Loc.: Malaya: Selangor, Pahang Rd., 16 mi. N. Kuala Lumpur; Date: 12 July 1948; Coll: R. Traub; U.S. Army Scrub-Typhus Team, RT 8166. Twelve female paratypes, bearing the same data as the holotype will be distributed among the collections of the following institutions: U.S. National Museum, Washington, D.C.; British Museum (Natural History), London, England; Natal Museum, Pietermaritzburg, South Africa; South Australian Museum, Adelaide, South Australia; Instituto Butantan, Sao Paulo, Brazil; Musee National d'Histoire Naturelle, Paris, France; Institut Royal des Sciences Naturelle de Belgique, Brussels, Belgium; Institute for Medical Research, Kuala Lumpur, Malaya.

Type Host: Atherurus macrourus Linne, 1758, a Malayan porcupine.

Type Locality: Malaya, Selangor, Pahang Rd., 16 mi. N. Kuala Lumpur.

This new species is named in honor of Dr Turner, who has contributed so much to the field of medical research in Malaya.

Additional Material.—Two female specimens from *Atherurus macrourus*, Malaya, Selangor, Ulu Langat Forest Reserve, 25 November 1955, are deposited in the Institute of Acarology, Department of Zoology, University of Maryland, College Park, Maryland.

Two additional female specimens were found between the scales of an elephant-trunk snake, *Acrochordus javanicus* Hornst. Boulenger, 1912, at Kuala Lumpur, Malaya, 2. i. 59, by J. R. Audy. These are deposited in the U.S. National Museum. The snake from which specimens were taken was one of over 200 examined in the laboratory of Dr Turner in connection with evidence of heavy leptospiral infections of snakes of this species.

Remarks.—Classification of dermanyssid mites at the subfamily level is based mainly on cheliceral modifications. Thus, those forms in which the female has elongate, attenuate chelicerae are generally placed in the Dermanyssinae, while those in which the female has chelicerae of uniform diameter throughout are placed in the Macronyssinae. However, the elongate, attenuate chelicerae of *Hystrichonyssus*, while appearing to be of the dermanyssine type, are really the result of a different evolutionary trend. In *Dermanyssus* and *Allodermanyssus* the distal cheliceral segment has become elongate, while in *Hystrichonyssus* the basal segment is produced in a long, whiplike process, the distal segment appearing not much different than that of a macronyssine mite (fig. 6). This difference, along with the other characters of *Hystrichonyssus*, necessitates recognition of another subfamily to receive the new form.

MALAYSIAN PARASITES XLVII

NEMATODE PARASITES OF THREE COMMON HOUSE RAT SPECIES IN MALAYA, WITH NOTES ON *RICTULARIA TANI* HOEPPLI, 1929

BY

JOHN F. SCHACHER

Department of Tropical Medicine and Public Health, Tulane University, U.S.A.

AND

CHEONG CHEE-HOCK

Department of Parasitology, University of Malaya, Singapore

The nematodes with which this study is concerned form part of a collection of endoparasites from the Malaysian fauna at present deposited in the Department of Parasitology, University of Malaya (Faculty of Medicine), Singapore. Collection and fixation techniques have been described by Sandosham (1957) together with a tabulation showing percentage infection of hosts by the major helminth groups.

The host animals under consideration, *Rattus norvegicus*, *R. r. diardi*, and *R. exulans concolor*, are commonly found in commensal relationship with man in Malaya (Harrison, 1957). This study was thus initially intended to serve as an index to possible public health dangers resulting from this relationship, as well as to give a basis for comparison in proposed investigations on the nematode parasites of feral rats, with which Malaya is abundantly supplied both in numbers and species (Harrison 1948, 1957).

Methods of Study

Worms were in all cases examined unstained, either cleared in glycerine by slow evaporation or in beechwood creosote or lactophenol. *En face* mounts and dissections were mounted in pure glycerine, glycerine jelly, beechwood creosote or by the alginate-glycerine jelly method (Schacher, 1957). Fixation of preserved specimens was found adequate in most instances, but rather poor in some, particularly in the large forms in which cuticular swelling was often extreme.

Results

Of the rats examined, 180 and 34 were *R. norvegicus* trapped in Singapore and Kuala Lumpur (or towns nearby) respectively, 100 and 511 were *R. r. diardi*, and 128 and 164 *R. exulans concolor*, altogether 1,117. The sex distribution in the samples was roughly equivalent, and the parasite species were found equally distributed in the two sexes, with one exception—in Singapore *Gongylonema neoplasticum* infections were twice as common in male as in female *R. norvegicus* but in the other two species they were equally distributed.

At least 12 species of nematodes were found in one or more of the rats examined (Table I). The superfamily classification used below follows Chitwood and Chitwood (1950).

Trichuroidea

Trichosomoides crassicauda (Bellingham, 1846) Railliet, 1895

location: urinary bladder.

Eucoleus hepaticus (Bancroft, 1893) Lopez-Neyra, 1947

location: liver.

TRICHUROIDEA—(*cont.*)

Capillaria sp.
location: small intestine.

Trichuris muris (Schrank, 1788) Hall, 1916
location: caecum.

RHABDITOIDEA

Strongyloides ratti Sandground, 1925
location: duodenum and upper jejunum.

OXYUROIDEA

Syphacia sp.
location: caecum.

TRICHOSTRONGYLOIDEA

Nippostrongylus muris (Yokogawa, 1920) Lane, 1923
location: small intestine.

Hepatojarakus malayae Yeh, 1955
location: liver.

METASTRONGYLOIDEA

Angiostrongylus cantonensis (Chen, 1935) Dougherty, 1946
location: lung, liver, thoracic cavity.

SPIRUROIDEA

Gongylonema neoplasticum (Fibiger and Ditlevson, 1914) Ransom and Hall, 1916
location: stomach.

Rictularia tani Hoeppli, 1929
location: stomach and small intestine.

Protospirura—Mastophorus spp.
location: stomach and small intestine.

TABLE I

PERCENTAGE INCIDENCE OF NEMATODE PARASITES IN SINGAPORE AND KUALA LUMPUR HOUSE RATS BY HOST SPECIES

Parasite	*R. norvegicus* (214) S'pore (186)	K. L. (34)	*R. r. diardi* (611) S'pore (100)	K. L. (511)	*R. exulans concolor* (292) S'pore (128)	K. L. (164)
T. crassicauda	51.0	0.0	0.0	0.2	0.0	1.2
E. hepaticus	0.0	0.0	0.0	1.8	0 0	0.6
Capillaria sp.	0.6	0.0	0.0	0.0	0.0	0.0
T. muris	0.0	0.0	0.0	0.2	0.0	0.0
Str. ratti	1.1	0.0	0.0	0.0	0.0	0.0
Syphacia sp.	0.0	0.0	0.0	0.2	0.8	0.0
N. muris	6.1	0.0	0.0	1.2	0.8	1.2
H. malayae	0.0	0.0	0.0	0.0	0.0	0.6
A. cantonensis	0.0	0.0	1.0	1.8	0.0	1.2
*G. neoplasticum**	61.3	0.0	52.0	0.4	49.2	0.0
R. tani	1.1	5.9	0.0	7.2	0.0	0.0
Protospirura—Mastophorus spp.	1.1	8.8	2.0	6.6	0.8	5.5

*=59 males, 93%; 91 females, 41%; 30 without sex record not included

Discussion

Trichosomoides crassicauda

According to Hall (1916), this cosmopolitan rat parasite may be found in the ureters and pelvis of the kidneys as well as its more usual site in the bladder. An interesting feature of this helminth is the marked sexual dimorphism; the male is very much the smaller of the sexes, and lives within the vagina or uterus of the female. The life history is simple and direct (Thomas, 1924).

Although *T. crassicauda* was found in all three of the species of rats investigated, the overwhelming majority of infections were found in *R. norvegicus* in Singapore. Considering the life history of the parasite, this is not felt to reflect a difference in host susceptibility, but is believed to be linked with the habits of the rats in the different areas.

Eucoleus hepaticus

This parasite is represented by records of eggs found in "squash" preparations of liver from infected animals. Although this worm is chiefly known throughout the world as a rat parasite (usually as *Capillaria hepatica* or *Hepaticolus hepatica*), numerous cases of infections have been noted in other animals (Read, 1949), and six cases have been diagnosed in man, either ante- or post-mortem (Beaver, 1958). The very low incidence of infection in the present survey is astonishing, but it is felt to be at least partly due to faulty or inadequate sampling at the time of collection, as one of us (JFS) has found it on several occasions in Singapore rats caught in the Medical Faculty building.

Capillaria sp.

The presence of this species was shown by a single fragment consisting of the posterior one half of a female worm found in the intestine of *R. norvegicus*. Fortunately the portion recovered contained eggs *in utero*, from which (and because of the absence of a swollen posterior end) at least a generic evaluation could be made. These showed typical, prominent, opercular plugs, and measured 23-26 micra by 45-54 micra; mean size was 24 by 50 micra. Lopez-Neyra (1947) lists five capillarid species from *R. norvegicus*, none of which have egg sizes closely corresponding to those found here.

Trichuris muris

This parasite has a world-wide distribution, but infection percentages are generally of a low order. Tubangui (1931) examined 950 *R. norvegicus* in the Philippines, finding no infections. In the present survey, only a single specimen was recovered from *R. r. diardi* trapped in Kuala Lumpur.

Strongyloides ratti

Because of the small size of the parasitic females of this species, and because the duodenum of the host must be firmly scraped to effect removal of the worms, there is considerable doubt that all infections were found. Tubangui (*l. c.*) showed 74 per cent. of 950 *R. norvegicus* to be infected, while the work of Enigk (1952), wherein prenatal infection was shown possible in at least two species of this genus, makes it very probable that the true incidence is higher than reflected here.

Syphacia sp.

This parasite was found once in *R. r. diardi* in Kuala Lumpur and once in *R. exulans concolor* in Singapore. No males were found and it was not possible to determine if they belonged to *S. muris* or *S. obvelata*. Hussey (1957) records differences in the size of eggs in

these species and judging by that (average size of eggs 81$\mu \times 33\mu$) these worms should be identified as *S. muris*. Adams (1933) has recorded it from rats (species undesignated) from Taiping and Pahang (Malaya) and Tubangui (*l. c.*) failed to find it in the Philippine survey.

Nippostrongylus muris

The incidence of this parasite is apparently low in both survey areas, the highest being 6 per cent. in *R. norvegicus* in Singapore. This is usually a parasite of younger, non-immune animals.

Hepatojarakus malayae

This worm was first described by Yeh (1955) from the liver of *Rattus r. jarak* from Pulau Jarak, Malaya. In his generic description, the author, apparently with some reluctance, placed this worm in the family Trichostrongylidae Leiper, 1912. Its location in the host would possibly be more suited to a metastrongyloid worm than to a trichostrongyloid. However, the writers agree with the placement of this worm in Trichostrongylidae, as anatomically it most resembles members of this superfamily. The specimens examined by the writers were too few in number to justify dissections for *en face* mounting, but we cannot wholly agree with Yeh (*l. c.*) in his description of a corona radiata surrounding the oral opening. Final elucidation of this point must await additional material.

Angiostrongylus cantonensis

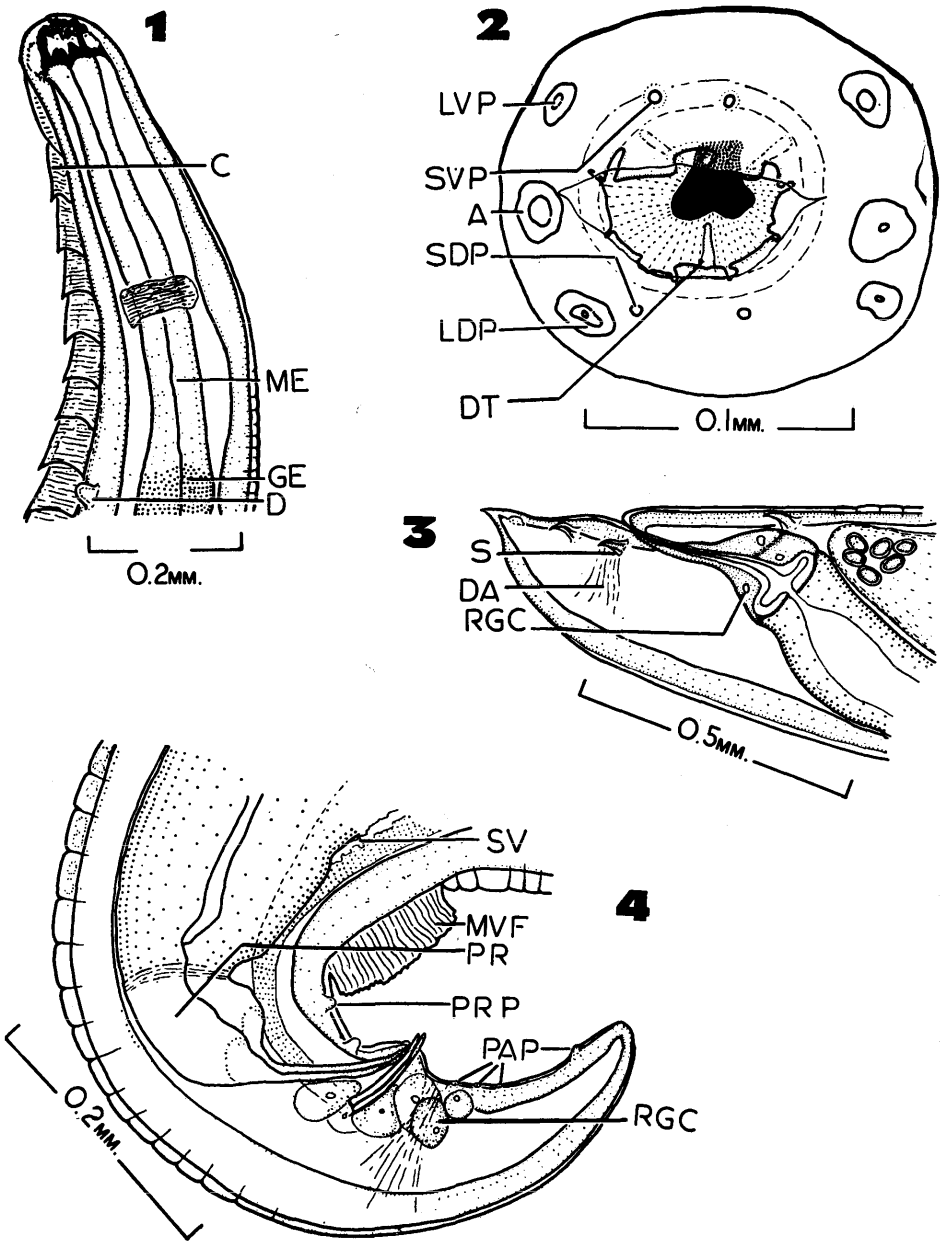
This parasite was originally described by Chen (1935) in Canton under the name *Pulmonema cantonensis*, and subsequently by Yokogawa (1937) in Formosa as *Haemostrongylus ratti*. Dougherty (1946), in a review of certain metastrongyloid genera, placed it in the genus *Angiostrongylus* Kamenskii, 1905. In this survey, worms were most commonly found in the lung and liver in that order, possibly reflecting a predeliction on the part of the parasite for the former organ. One specimen was recorded as having been found in the thoracic cavity. The overall incidence was low, but, in general, this worm appears to be slightly more common in Kuala Lumpur than in Singapore. It was not found in *R. norvegicus* at either location.

Gongylonema neoplasticum

This was the major parasite of Singapore rats regardless of species. The life-cycle according to Hall (1916) involves an intermediate host in the form of cockroaches, meal beetles or similar habitually or occasionally coprophagous insects. It is doubtful that differences in the infection rate in rats from the two survey areas reflect either a difference in food habits or the frequency of occurrence of suitable intermediate hosts. It would be more logical to assume that this parasite has been at some time in the past imported into Singapore in *R. norvegicus* where, with excellent opportunities for its propagation, it has spread to its present proportions on the island. Its outward geographic radiation has apparently been slow. Tubangui (1931) found a 44 per cent. infection with this parasite in the Philippines.

Rictularia tani

The description of this worm by Hoeppli (1929) was based on five female specimens from the intestine of *R. norvegicus* in Amoy, China. Tubangui (1931) subsequently reported a very similar species, *R. whartoni*, from the same host in the Philippines; again only females were found. Chen (1936) described the male of *R. tani* for the first time, giving additional notes on the female, and compared Hoeppli's species with *R. whartoni* Tubangui. He concluded that the two might be the same, but did not definitely state that they were synonymous. Thus, Cuckler (1939), in his key, differentiated the two on the basis of the presence or absence of



Figs. 1-4. *Rictularia tani* Hoeppli

1, anterior end, male specimen—C=combs, ME=muscular oesophagus, GE=glandular oesophagus, D=deirid; 2, anterior end, female specimen, mounted *en face*—LVP=lateroventral papilla, SVP=subventral papilla, A=amphid (lateral organ), SDP=subdorsal papilla, LDP=laterodorsal papilla, DT=dorsal tooth at base of buccal capsule; 3, female tail—S=spine, DA=*depressor ani* muscle, RGC=rectal gland cell; 4, male tail—SV=seminal vesicle, MVF=median ventral fan, PR=proctodeum, PRP=pre-cloacal papillae, PAP=post-cloacal papillae, RGC=rectal gland cells.

spines posterior to the anus in the female, and gave no opinion on their status. Dollfus and Desportes (1945) gave a very good synopsis of the species in this genus and stated that *R. tani* and *R. whartoni* were probably in reality conspecific. Presumably they had no material for comparison, and thus did not pursue the matter conclusively.

The finding of a reasonably large number of these worms in the present survey has allowed observations on both males (6) and females (numerous), and, in the writers' opinion, tends to show *R. whartoni* Tubangui 1931 to be a definite synonym of *R. tani* Hoeppli 1929.

Description of male.—The body is strongly curved ventrally at the posterior end, less strongly at the anterior. Length 6.54-7.38 mm.; maximal width at the junction of the middle and posterior thirds of the body of 390-504 micra. Width at the oesophageo-intestinal junction from 270-363 micra. Oesophagus 2.13-2.29 mm. long, divided into an anterior muscular portion 490-580 micra long and a thicker, posterior glandular portion. Nerve ring 280-390 micra from the anterior tip, slightly post-midline of the muscular oesophagus. The buccal cavity is dorsally inclined, guarded externally by a series of circumoral labial lobes, and measures 34×34 to 42×55 micra. Two subventral and a single dorsal tooth at the base of the buccal capsule surround the entrance into the oesophagus. The buccal capsule is thick and chitinous, the ventral wall thicker than the dorsal. Cuticular striations are irregular in width throughout the body, becoming apparent at the extremities. A series of 55-64 cuticular processes called "combs" or "spines" line the subventral body margins from 70-125 micra behind the anterior tip to 1.3-1.8 mm. from the posterior end. The last 6-8 cuticular processes are widely spaced and thorn-like, the next 6-10 (proceeding anteriorly) are transitional; the most anterior 41-54 are comb-like, with a posteriorly-directed sharp point at the outer margin. An inconspicuous cervical papilla may be found at or slightly behind the level of the junction of the muscular and glandular oesophageal portions. The two spicules are very nearly equal, 68-86 micra in length, and are surrounded by 6-8 very large rectal-gland cells. There is no accessory piece. The vas deferens is prominent, 540-710 micra long by 80-128 micra in maximal width, apparently muscular throughout, and passes posteriorly to one side of the strongly chitinized rectum. The seminal vesicle is large; the testis is generally confined to the posterior 2/3 of the body; in one specimen, it reaches slightly anterior to the oesophago-intestinal junction. Two small but readily visible caudal papillae can be seen 36-44 micra from the tip of the tail. Three subventral papillae are found on each side immediately behind the cloacal aperture, 99-143 micra from the end of the body; there are two large pre-cloacal papillae on each side, 30-90 micra in front of the cloaca and immediately posterior to the large, single, ventrally placed caudal-fan. The dorsal subcuticular outgrowths described by Chen (1936) in the caudal region were noted in these specimens as well; one of the six had an exaggerated thickening of the cuticle in this region. *See* figs. 1 and 4.

Description of female.—The body is curved dorsally, 24-26 mm. (from *R. r. diardi*) to 28-34 mm. (ex. *R. norvegicus*) long, with a maximal width at mid-body of .658-.882 mm. Cuticular striations are variable in width dependant in part on the strength of body curvature; striae tend to disappear at the extremities. The buccal cavity measures 53×56 micra to 64×71 micra, wider than deep; guarded at the stoma by an irregularly spaced series of circumoral labial lobes. Around the dorsally directed oral aperture can be found two latero-ventral and two latero-dorsal papillae in the outer circle, flanking the prominent amphids on either side; in the inner circle, sometimes difficult to resolve, can be found two sub-ventral and two sub-dorsal papillae. There is no distinguishable sharp line of demarcation in the female between muscular and glandular oesophagus parts; the oesophagus is 3.72-5.0 mm. long; the nerve ring is 214-302 micra from the anterior body tip. A cephalic papilla (deirid) is present at the level of the first and second fifths of the oesophagus. The vulva is situated 220-280 micra in front of the oesophago-intestinal junction; the vagina is short and muscular. Two sub-ventral rows of cuticular processes—"combs" and "spines"—are present from immediately behind the posterior limit of the buccal capsule to the region of the anus. The pre-vulvar rows consist of an average of 40 (range 41-43) such cuticular processes and the post-vulvar rows average 42 (range 35-51). The presence or absence of post-anal spines was variable; some specimens showed the last spine anterior to the anus, others had a spine at the anal margins with none, one, two or three post-anal spines. One specimen showed a spine at the anal margin, two post-anal and a small ventral comb near the tip of the tail. The tail is 231-285 micra long, conical, and ends in a sharp point; the uterus extends beyond the level of the anus in less than half the specimens. 25 uterine eggs cleared in glycerine measured 31-35 micra by 42-48 micra; mean 33×44 micra. The rectum is heavily chitinized and is surrounded by at least three rectal gland or sphincter muscle cells. *See* figs. 2 and 3.

Comparison of the original descriptions of *R. tani* Hoeppli 1929 and *R. whartoni* Tubangui 1931 shows the only differential feature to be the presence of spines posterior to the anus in the female of *R. whartoni*. Excluding this structure from consideration, the specimens described in the present study would fit either species. Since this feature has been shown to be more variable than previously thought, *R. whartoni* Tubangui 1931 must be regarded as a synonym of *R. tani* Hoeppli 1929.

Protospirura—Mastophorus spp.

These stout spirurids were sometimes present in astonishing numbers in infected animals, and were found in all of the three species of rats examined in both survey areas. 511 worms were found in an infected *R. norvegicus* from Singapore; 87 in an animal of the same species from Kuala Lumpur.

The difficulties facing one in an attempt to separate specimens of these two genera are manifold, particularly in animals showing such heavy worm-burdens, wherein many may be stunted. Chitwood (1938) in a review of these two genera has shown that the most important anatomical structure for generic and specific differentiation is the anterior end, split and mounted *en face*. Examination of selected specimens from the present collection has shown some to correspond closely to either *Protospirura bonnei* Ortlepp, 1924, or *P. muricola* Gedoelst, 1916, while others, judging from the number of pseudo-labiata, appear to compare well with varieties of *Mastophorus muris* (Gmelin, 1790) Chitwood, 1938. A comprehensive study of these specimens will be necessary before exact classification (and infection rates) can be determined.

SUMMARY

1. From the Malayan house rats *Rattus norvegicus*, *R. r. diardi* and *R. exulans concolor*, surveyed for nematode parasites in Singapore and Kuala Lumpur, the following parasites were identified: *Trichosomoides crassicauda*, *Eucoleus hepaticus*, *Capillaria* sp., *Trichuris muris*, *Strongyloides ratti*, *Syphacia* sp., *Nippostrongylus muris*, *Hepatojarakus malayae*, *Gongylonema neoplasticum*, *Rictularia tani*, *Protospirura-Mastophorus* spp., and *Angiostrongylus cantonensis*. In Singapore, *T. crassicauda* was found in about half of the *R. norvegicus*, and *G. neoplasticum* was equally as common in all three host species. Otherwise, infections in the various rat species in the different localities were relatively uncommon or lacking.

2. A redescription of *Rictularia tani*, based on six male and numerous female specimens, showed that *R. whartoni* Tubangui 1931 is definitely a synonym of *R. tani* Hoeppli 1929.

ACKNOWLEDGEMENTS

The writers wish to acknowledge the kindness of Professor A. A. Sandosham of the University of Malaya, Singapore in allowing access to the preserved material, for laboratory facilities and for his encouragement and suggestions. They are grateful to Professor R. J. C. Hoeppli for his suggestions and for the loan of otherwise unobtainable reprints, and to Professor P. C. Beaver for his suggestions.

This study was conducted in part under the sponsorship of the Commission on Parasitic Diseases, United States Armed Forces Epidemiological Board, and supported in part by the Office of the Surgeon General, Department of the Army.

REFERENCES

ADAMS A. R. D. (1933). Report on a collection of nematodes from the Federated Malay States. *Ann. trop. Med. Parasit., 27,* 1-13.

BEAVER P. C. (1958). Animal parasites and human diseases. *J. Pediat., 22,* 380-384.

CHEN H. T. (1935). Un nouveau nematode pulmonaire, *Pulmonema cantonensis*, N.G., N.Sp. des rats de Canton. *Ann. Parasit. hum. comp., 13,* 312-317.

CHEN H. T. (1936). *Rictularia tani* Hoeppli from rats in Canton (Nematoda: Rictulariidae). *Lingnan Sci. J., 15,* 283-286.

CHITWOOD B. G. (1938). The status of Protospirura vs. Mastophorus with a consideration of the species of these genera. *Livro Jub. Travassos, 3,* 115-118.

CHITWOOD B. G. AND CHITWOOD M. B. (1950). *An Introduction to Nematology* (Revised 1950). Monumental Printing Co., Baltimore.

CUCKLER A. G. (1939). *Rictularia onychomis* n. sp. (Nematoda: Thelaziidae) from the grasshopper mouse, *Onychomys leucogaster* (Weid). *J. Parasit.*, *25*, 431-435.

DOLLFUS R. Ph. AND DESPORTES C. (1945). Sur le genre *Rictularia* Froelich, 1802 (Nematodes, Spiruroidea). *Ann. Parasit. hum. comp.*, *20*, 6-34.

DOUGHERTY E. C. (1946). The genus *Aelurostrongylus* Cameron 1927 (Nematoda: Metastrongylidae), and its relatives; with descriptions of *Parafilaroides*, gen. nov., and *Angiostrongylus gubernaculatus*, sp. nov. *Proc. helm. Soc. Wash.*, *13*, 16-26.

ENIGK K. (1952). Zur Biologie von *Strongyloides*. *Z. Tropenmed. u. Parasit.*, *3*, 358-367.

HALL M. C. (1916). Nematode parasites of mammals of the orders Rodentia, Lagomorpha, and Hyracoidea. *Proc. U. S. nat. Mus.*, *50*, 1-258.

HARRISON J. L. (1948). A key to the rats of Malaya. *Malay. Nat. J.*, *3*, 130-141.

HARRISON J. L. (1957). Malaysian Parasites, XXXIII. The hosts. *Stud. Inst. med. Res. Malaya*, *28*, 409-426.

HOEPPLI R. J. C. (1929). *Rictularia tani* n. sp., ein Parasit des Rattendarms. *Zbl. Bakt.*, (1), *110*, 75-78.

HUSSEY K. L. (1957). *Syphacia muris* vs. *S. obvelata* in laboratory rats and mice. *J. Parasit.*, *43*, 555-559.

LOPEZ-NEYRA C. R. (1947). Los Capillarinae, *Mem. R. Acad. Madr.* (*Ser. Cien. Nat.*), *12*, 1-240.

READ C. P. (1949). Studies on North American helminths of the genus *Capillaria* Zeder 1800 (Nematoda): I. Capillarids from mammals. *J. Parasit.*, *35*, 223-229.

SANDOSHAM A. A. (1957). Malaysian Parasites, XXXII. Infection of animals by major groups of helminths: an interim tabulation. *Stud. Inst. med. Res. Malaya*, *28*, 403-408.

SCHACHER J. F. (1957). A contribution to the life history and larval morphology of *Toxocara canis*. *J. Parasit.*, *43*, 599-612.

THOMAS L. J. (1924). Studies of the life-history of *Trichosomoides crassicauda* (Bellingham). *J. Parasit.*, *10*, 105-136.

TUBANGUI M. A. (1931). Worm parasites of the brown rat (*Mus norvegicus*) in the Philippine Islands, with special reference to those forms which may be transferred to human beings. *Philipp. J. Sci.*, *46*, 537-591.

YEH LIANG-SHENG (1955). A new bursate nematode *Hepatojarakus malayae* gen. et sp. nov. from the liver of *Rattus rattus jarak* (Bonhote) on Pulau Jarak, Straits of Malacca. *J. Helminth.*, *29*, 44-48.

YOKOGAWA S. (1937). A new species of nematode found in the lungs of rats *Hemostrongylus ratti*. *Trans. nat. Hist. Soc. Formosa*, *27*, 347-350.

MALAYSIAN PARASITES XLVIII

NOTES ON REARING MALAYAN IXODID TICKS (ACARINA, IXODIDAE) WITH SPECIAL REFERENCE TO *IXODES GRANULATUS* SUPINO AND *AMBLYOMMA GEOEMYDAE* (CANTOR)

BY

M. NADCHATRAM

Institute for Medical Research, Kuala Lumpur

In Malaya 28 species of Ixodid ticks belonging to 7 genera have now been recorded (Kohls, 1957; Audy *et al*, 1960, this *Study*). All the available records of the hosts of these species are presented elsewhere (Audy *et al*, l.c.), but little is known of their habits or life-histories. This paper is therefore only concerned with an investigation carried out to establish a reliable technique for breeding Malayan ticks from the larval to the adult stage, mainly in order that the immature stages could be correlated with their adults. At the same time laboratory colonies of two species, *Ixodes granulatus* and *Amblyomma geoemydae*, were established, and since the life-histories of these two species have not previously been investigated, their main features will be described.

The species *Ixodes granulatus* is of particular interest, since from a pool of 25 specimens collected from the forest rats *Rattus mulleri* and *R. sabanus* an unidentified virus, TP21, was isolated. This isolate has been described elsewhere (Smith, 1956). A second isolate, TP39, which is probably identical with TP21 was also isolated from *Ix. granulatus* (Institute for Medical Research, Malaya, 1959) and a third, TP19, which is unidentified, came from a pool of *Amblyomma cordiferum* collected from a python (Institute for Medical Research, Malaya, 1957, 1958).

Rearing Methods

The life-history of a tick consists of four stages—egg, larva, nymph, and adult. The eggs are laid on the soil, and the larvae, nymphs and adults are parasitic on cold- or warm-blooded vertebrates; at some time during each of the larval, nymphal and adult stages the ticks require a blood-meal before further development can proceed. Usually three different host-animals subscribe to the life-cycle of the tick, one for each stage which requires a blood-meal, but some ticks pass all three stages—larval, nymphal and adult—on the same animal. Generally the larvae and nymphs are found on small animals while the adults feed on larger animals. However, most ticks spend the major part of their existence on the ground.

To collect ticks, the procedure has been as follows. Small vertebrates which are trapped in the field are brought to the laboratory where they can be examined carefully for parasites. Animals with attached ticks are suspended in a small cage over a tray of water. The ticks then detach themselves naturally within several days, or weeks, and fall to the water, from which they are easily collected. (If the ticks are removed with forceps from the animal there is a grave risk of damaging them; the mouth-parts, in particular, are easily damaged.) Since ticks will not live for long periods in water, engorged specimens from the wild-caught animals must be removed from the tray several times a day. After identification, selected ticks are transferred to breeding-pots for rearing to the adult stage, or, if the specimen is already adult, for egg-laying.

Larval and nymphal ticks are best reared in soil in order to simulate as much as possible the natural conditions under which they live. The soil is best collected from areas where there is a high population of acarines. After being broken up into small particles the soil must be sterilized in a hot-air oven; then it should be washed several times in distilled water, with a final wash in alkaline water in order to raise the pH and so discourage the growth of fungi.

The soil, on which the ticks will be introduced, is placed in breeding-pots of unglazed clay. These pots are about $1\frac{1}{2}''$ in height and $1\frac{3}{4}''$ wide at the opening, and before being used they are boiled several times in water, for an hour at a time, to remove soluble minerals. Before the soil and ticks are introduced, the pot is allowed to soak in distilled water for about an hour.

The breeding-pots stand on an aluminium platform which rests in a tray of water. Strips of filter paper are placed with one end under each pot and the other end submerged in the water; this keeps the pot and its contents moist. The whole unit is kept at room temperature, which under the conditions in these laboratories varied between 75° and 84°F. The pots are covered with a glass plate, and to ensure a good seal it is advisable to spread a thin film of water round the rim of the pot; this will serve as an adhesive to the glass cover.

The ticks which are being reared are usually fed on laboratory rats or guinea-pigs. The animals are enclosed for a day or two in a cylinder of fine-meshed wire netting which limits their movements and prevents disturbance to the ticks which may crawl about for some time before attaching. When the ticks have become established the host animal is transferred to a small cage. At all times the enclosed animals rest on a metal stand over a tray of water. After the ticks have fed on the rat or guinea-pig they detach and fall into the tray of water, from which they can be easily removed at frequent intervals. As a precautionary measure, a thin layer of vaseline should be applied round the rim of the tray to prevent any ticks crawling free.

The above method is suitable for feeding and maintaining larvae or nymphs, but sometimes fully-engorged nymphs are found on wild-caught animals, and the following alternative method can be used to keep such nymphs until the adults emerge.

Each engorged nymph is retained in a small, round, pill-box, 1-2 ins. in diameter, the interior of the box being padded with several layers of filter paper which has been moistened with a little distilled water. The nymphs usually become inactive 3 or 4 days later, and several tiny drops of a sticky exudate appear on the body surface. These droplets seem to serve as a glue, holding the nymph firmly to the filter paper. After an interval of usually 2-4 weeks the nymphal skin is split from side to side, and the adult emerges. After identification, the adult may be preserved in 70% alcohol or kept in the pill-box for further observations. Unengorged adults may remain alive for long periods, in some cases for more than a year, if optimum temperatures and humidities are maintained.

The duration of the nymphal stage of several Malayan species is shown in Table I.

TABLE I

THE DURATION OF THE NYMPHAL STAGE OF MALAYAN TICKS

Species	Number of observations	Duration of nymphal stage (in days)	Average duration (in days)
Amblyomma cordiferum	4	27, 30, 34, 42	33
Amblyomma helvolum	2	20, 26	23
Amblyomma testudinarium ...	1	22	22
Dermacentor sp.	9	12, 14, 15, 17, 17, 18, 20, 28, 31 ...	19
Haemaphysalis bispinosa	4	13, 13, 15, 20	15
Haemaphysalis cornigera ...	1	20	20
Haemaphysalis hystricis	5	14, 15, 15, 20, 22	17

THE LIFE-CYCLE OF *Ixodes granulatus*

Ixodes granulatus is a one-host tick. The larvae, nymphs and adults are found typically on forest rodents, particularly on the giant rats (*see* Kohls, 1957; Audy *et al*, 1960, this *Study*), but it is interesting to note that, with the exception of *Ix. granulatus*, Malayan rats only harbour the immature stages of ixodid ticks. Adults of *granulatus* were easily obtained from wild-caught rats by the methods mentioned earlier; individual ticks were kept in breeding-pots with sterilized soil, and from those the young, immature stages were reared.

The eggs

Egg-laying began about 12-14 days after the blood-meal, and it continued for some 16-20 days, the eggs being laid in a small heap, which increased in size day by day. A total of about 1,500 eggs may be laid by a single mother after one meal. The eggs themselves were yellowish-brown in colour, round, shiny, and little bigger than the head of a pin.

Some 14-15 days after the eggs were laid, small white spots appeared over the surface and during the following 14-17 days the larvae continued development and finally hatched.

The larvae

The larval stage was the most difficult stage to maintain and handle in the laboratory. The newly-hatched larvae, with six legs, were about 1 mm. in length, light brown in colour, and ovoid in shape. As they grew older, the larvae darkened in colour and the exoskeleton hardened.

Some 10-15 days after the larvae emerged, a considerable amount of a white excretory deposit was seen on the cover glass of the breeding-pot and on the soil; at this stage the larvae were usually fed. Great care was required in handling the very active, unfed larvae since they accumulated on the under surface of the glass cover and accidental displacement of the cover would damage some and allow others to escape. It is therefore advisable to work always over a dish of water.

Before feeding the larvae, an exact number were counted and transferred from the breeding-pot to a watch-glass of water; usually 100 larvae were fed together. The larvae formed a clump in the watch-glass and were easily removed with a fine-pointed stick and dropped on a white rat. The rat was enclosed in wire-mesh for several hours, or overnight, over water. When the larvae found themselves on the fur of the rat, they wandered freely all over the body. Many fell off into the water below and these were picked up and placed on the rat again: this continued for about an hour. Finally, about two hours after the start of feeding, nearly all the larvae had attached to the host animal, and from the following day onwards the tray of water was examined morning and evening for engorged larvae. On the day after feeding began, a few detached unfed larvae were found in the water, but these were killed, for generally their mouthparts had been damaged or they were not mature enough for feeding. Engorged larvae began detaching from the host on the 4th day after feeding commenced and the last larva had usually detached by the 6th day. In these experiments only about 70 per cent of the original 100 larvae were recovered fully-fed. Of the remaining 30 per cent, some larvae failed to become attached and were discarded, but most cannot be accounted for, and it is probable that the host animal killed a number, mainly by scratching.

After feeding, the larvae were much enlarged and elongated, dark-grey in colour, and slow-moving. Six to eight days after detaching from the host animal, the larvae became quiescent, and 14-18 days after this the nymphs emerged.

The nymphs

Unfed nymphs are ovoid, brownish in colour, and under a low-power lens they resemble the adult males. Nymphs are 8-legged and asexual; and being slow-moving they are much

easier to handle than unfed larvae. The mouthparts take about 10-14 days to harden, and the nymphs are then ready to feed; they are fed in the same manner as the larvae. After feeding, most nymphs detached on the 6th or 7th day but a few remained attached for two or three days longer. The recovery rate of fully-fed nymphs was only about 50 per cent., and the nymphs then measured 2-3 mm in length. They moulted 6 days after detaching from the host, and the mature adult ticks emerged 16-20 days later.

The adults

The unfed adults were kept in a breeding-pot until they were strong enough to be fed. Two wild-caught males were introduced into the pot as no mates were available among the laboratory-reared ticks, and on the following morning both those males were seen coupled to 2 unengorged females. Usually adults were fed on the laboratory rat when they were 4-8 weeks old. On one occasion 6 females, two of which had males coupled to them, were placed on a white rat to feed; three of the females detached on the 10th day of engorgement, the other three detached between the 12th and 14th days. On detachment the male ticks were found coupled to 2 engorged females, but it is not known if the engorged females were the same as those to which the males were attached before engorgement. Four of the females oviposited, and the larvae hatched from their eggs were reared through to the adult stage.

On a single occasion 2 semi-engorged females remained attached on the host for 26 and 33 days respectively.

A tabulation of the life-cycle of *Ixodes granulatus* reared in the laboratory is given in Table II. The life-cycle can be completed in 174-272 days. The completion of the life-cycle in nature may of course take longer: much will depend upon temperature and humidity conditions, and on the availability of suitable host animals.

TABLE II

THE LIFE-CYCLE OF THE PROGENY OF 3 FEMALE *Ixodes granulatus* REARED IN THE LABORATORY ON WHITE RATS

	Period in days
Females detached from host	0
Females oviposited after	12 - 14
Females continued oviposition for	16 - 20
Larvae hatched out after	28 - 32
Larvae were fed after	15 - 25
Larvae fed for	4 - 6
Engorged larvae quiescent after	6 - 8
Nymphs emerged after	14 - 18
Nymphs were fed after	14 - 42
Nymphs fed for	6 - 10
Engorged nymphs quiescent after	5 - 7
Adults emerged after	16 - 20
Adults were fed after	28 - 56
Adults fed for	10 - 14
Total duration to complete life-cycle ...	174 - 272

THE LIFE-CYCLE OF *Amblyomma geoemydae*

A specimen of *Amblyomma geoemydae* was collected in the first instance from a land tortoise, *Testudo emys*. The tick was found attached near the base of the tail of the tortoise, on the underside, and it detached itself naturally, fully-fed, some five days after its collection. Fully engorged, *Amb. geoemydae* measured about 25×19 mm., and was yellowish-brown in colour.

Amb. geoemydae is a reptile tick, the principal host being the land tortoise; in addition, a monitor lizard, *Varanus* sp., has been recorded as an occasional host (Kohls, 1957). In laboratory experiments, a land tortoise (*Testudo emys*), a box tortoise (*Cuora amboinensis*), and a guinea-pig were offered to different groups of larvae, nymphs, and adults to record the reactions of the ticks and, in particular, to assess the suitability of the guinea-pig as a laboratory host; and also to correlate the early stages with their adults.

The feeding methods and general procedure were as described earlier.

The eggs

The fully-fed *Amb. geoemydae* was kept in a breeding-pot, and oviposition commenced on the fifth day and ended 26 days later. During this period a total of 10,800 eggs were laid, an average of 415 each day. The highest number laid on a single day, the tenth, was 950, and the peak period was between the 7th and 11th days inclusive when 4,050 eggs were laid. Four days after oviposition ended the parent tick died, and the eggs hatched 20 days after being laid.

The larvae

The larvae were small, 0.8×0.7 mm, globose, and dark-brown in colour, with relatively long legs. They congregated on the underside of the glass cover of the breeding-pot, often covering its entire surface; but when a light was shone on them they dropped into the pot and became very active. When the larvae were more than 3 weeks old they were selected for feeding on *Testudo emys*, *Cuora amboinensis*, and a guinea-pig.

Five hundred were placed on the land tortoise, and from the 8th to the 20th day engorged larvae detached. In all, 455 engorged larvae, or 91 per cent, were recovered, the bulk of those detaching between the 8th and 11th days. The larvae were observed to attach principally near the base of the neck, in the axillae of the legs, and round the anal region and base of the tail.

Two hundred larvae were placed on the box tortoise, and the fully-fed larvae detached between the 9th and 18th days. Only 95, or 47.5 per cent, were recovered. Unfortunately, the tortoise died four days after the larvae had fed: the cause of death was not established.

Some of the larvae failed to attach when they were placed on the tortoises, but all those larvae which succeeded in becoming attached did engorge. Both tortoises were reasonably quiet and placid both when the larvae were attaching and when they were feeding. They were, however, very restless when the larval ticks were detaching themselves, often rearing up on their hind legs and moving sideways round the cage with the fore legs resting on the bars. This contrasts with the behaviour of rats and guinea-pigs which become restless when the ticks first attach and feed.

One hundred and fifty unfed larvae were placed on a guinea-pig, but many of those fell off, unfed, although the animal was quite still. The larvae were replaced when they fell, and on the 3rd day the guinea-pig became restless, perhaps a sign that the larvae were beginning to feed. However, many larvae were still unattached on the 10th day. On the 5th, 6th and 7th days, 20 partially-engorged and 14 fully-engorged larvae were recovered; only these 34 larvae, or 22.7 per cent, were recovered fed, and none of the partially-engorged larvae developed to become nymphs.

The preferred site for attachment seemed to be on the dorsal part of the neck region.

Thus the larvae of *Amb. geomydae* attach and feed readily on *T. emys*, less readily on *C. amboinensis*, and hardly at all on guinea-pig.

The engorged larvae had a glossy appearance when first they detached, but after a day or two the skin became more coarse, and about three days after detachment the larvae moved away from the source of light and lay quiescent. About a week later the ornate scutum of the nymph became apparent and after a few more days the nymph emerged.

The nymphs

Newly-emerged nymphs were pale brown in colour with light yellow legs, but three or four days later the body and legs darkened. At this stage the nymphs measured about 3 × 2 mm., and they were quite active.

When they were nearly 3 weeks old, 210 nymphs were placed on a land tortoise, and within an hour many of them had become attached. From the 12th day onwards fully-engorged nymphs detached and for 28 days small numbers were recovered, by which time 138, or 65.7 per cent, had detached, an average of about 5 each day.

Fifty unfed nymphs were placed on a guinea-pig, but, as in the case of the larvae, this animal proved an unsatisfactory host. It seemed that many of the nymphs were killed or damaged by the guinea-pig, and those which did survive would not attach.

Engorged nymphs measured 6 × 5 mm., and both in colour and in habits they resembled engorged larvae. Five days after their meal they became quiescent, and a further 25 days later the mature adults emerged. In all, 9 males and 120 females emerged within five days of one another.

TABLE III

THE LIFE-CYCLE OF THE PROGENY OF A FEMALE *Amblyomma geoemydae* REARED IN THE LABORATORY ON *Testudo emys*

	Period in days
Female detached from host	0
Female oviposited after	5
Female continued oviposition for	21
Larvae hatched out after	20 - 32
Larvae were fed after	24
Larvae fed for	8 - 20
Engorged larvae quiescent after	3 - 5
Nymphs emerged after	10 - 14
Nymphs were fed after	20
Nymphs fed for	12 - 28
Engorged nymphs quiescent after	5 - 10
Adults emerged after	25 - 30
Adults were fed after	14
Adults fed for	18 - 48
Total duration to complete life-cycle	185 - 271

The adults

The newly-emerged adults were light brown in colour and they darkened during the following 6-7 days. Both males and females measured about 7×6 mm.

When the ticks were 2 weeks old, 3 males and 27 females were placed on a land tortoise (*T. emys*). The adults, however, did not attach as readily as did the larvae and nymphs, and although one female attached after 6 hours, the remainder were walking or resting on the back of the tortoise. By the 5th day nearly all had attached to the sides of the neck or base of the tail. There were, however, still 5 females apparently resting near the posterior end of the shell, and there they remained for almost a week. Then it was noticed that one of these females was swelling, and on closer examination it became apparent that each of the ticks was attached along one of the sutures of the thick shell.

Those ticks attached to the skin were fully-engorged after 18 days, but of the 5 on the shell, 3 engorged in 31 days, and the remaining 2 in 48 days.

After engorgement the female ticks measured up to 27×21 mm., and they oviposited 4 to 7 days later. The males were not seen to feed, but a blood-meal was not easily detected in their case without disturbance. They may have taken blood at the same time as the females, but owing to the large scutum on the dorsum engorgement was not apparent. The males remained unattached on the tortoise long after the females had fed and detached. Eventually, 84 days after being placed on the host, they were removed.

Robinson (1926) records parthenogenesis in the genus *Amblyomma*, but it was not established whether this could take place in *Amb. geoemydae*. In the present experiments copulation was observed between males and engorged as well as unfed females.

A summary tabulation of the life-cycle of *Amb. geoemydae* as observed in the laboratory is given in Table III.

SURVIVAL OF TICKS IN THE UNFED STATE

A number of larvae, nymphs, and adults of both *Ix. granulatus* and *Amb. geoemydae* were kept unfed to determine how long they could survive without a blood-meal. The following maximum survival times (in days) were obtained:

	larvae	nymphs	adults
Ixodes granulatus	95	160	180
Amblyomma geoemydae	190	240	315

It is clear from the figures that *Amb. geoemydae* is much more resistant than *Ix. granulatus* in the unfed state. The conditions to which the ticks are exposed will of course greatly influence the survival times, and the results from laboratory experiments may not apply in nature. Very long survival periods have been recorded for some species in the laboratory; for example, Nuttal (1911: 301) kept adult *Ix. ricinus* unfed for as long as 15 to 27 months, and Robinson (1926) recorded unfed adults of *Amb. americanum* surviving 393 and 430 days.

SUMMARY

1. Methods and techniques for handling and rearing Malayan ticks have been described.

2. *Ixodes granulatus* was reared satisfactorily in the laboratory using a white rat as the host animal for the larval, the nymphal, and for the adult stages; but the mortality of both larvae and nymphs was high. The average survival rates of larvae and nymphs were only 70 and 50 per cent respectively. Improvements in technique are therefore required to increase these rates.

3. In the case of *Amblyomma geoemydae* a guinea-pig proved an unsatisfactory host animal, and probably the same will be true of white rats. The natural host, the land tortoise (*Testudo emys*), was the most satisfactory in the laboratory, and a box tortoise (*Cuora amboinensis*) was a little less suitable.

4. The duration in the laboratory of the different stages of the life-cycles of both *Ix. granulatus* and *Amb. geoemydae* have been summarized in tabular form.

ACKNOWLEDGEMENTS

I am grateful to Dr J. R. Audy and Mr W. W. Macdonald for their help and encouragement, and to the latter I am also indebted for a critical review of the manuscript.

REFERENCES

AUDY J. R., NADCHATRAM M. AND LIM B. L. (1960). Malaysian Parasites, XLIX. Host distribution of Malayan ticks (Ixodoidea). *Stud. Inst. med. Res. Malaya, 29*, 225–246 (this *Study*).

INSTITUTE FOR MEDICAL RESEARCH, MALAYA. (1957). Division of virus research and medical zoology. *Rep. Inst. med. Res. Malaya, 1956*, 61-73.

INSTITUTE FOR MEDICAL RESEARCH, MALAYA. (1958). Division of virus research and medical zoology. *Rep. Inst. med. Res. Malaya, 1957*, 54-65.

INSTITUTE FOR MEDICAL RESEARCH, MALAYA. (1959). Division of virus research and medical zoology. *Rep. Inst. med. Res. Malaya, 1958*, 52-64.

KOHLS G. M. (1957). Malaysian Parasites, XVIII. Ticks (Ixodoidea) of Borneo and Malaya. *Stud. Inst. med. Res. Malaya, 28*, 65-94.

NUTTALL G. H. F. (1911). Notes on the biology of *Ixodes*. *In* Nuttall G. H. F., Warburton C., Cooper W. F., and Robinson L. E. *Ticks: a monograph of the Ixodoidea*. Cambridge University Press.

ROBINSON L. E. (1926). Notes on the biology of *Amblyomma*. *In* Nuttal G. H. F., Warburton C., Cooper W. F., and Robinson L. E. *Ticks: a monograph of the Ixodoidea*. Cambridge University Press.

SMITH C. E. G. (1956). A virus resembling Russian spring-summer encephalitis virus from an ixodid tick in Malaya. *Nature, Lond., 178*, 581-582.

MALAYSIAN PARASITES XLIX

HOST DISTRIBUTION OF MALAYAN TICKS (IXODOIDEA)

BY

J. R. AUDY*

M. NADCHATRAM AND LIM BOO-LIAT

Institute for Medical Research, Kuala Lumpur

CONTENTS

INTRODUCTION

In reports of arthropod parasite surveys, it is customary to record only the details of hosts found infested, without recording the numbers examined or the host species found *un*infested. This makes it impossible, for example, to judge the frequency of distribution of various stages of ticks on all available hosts, or to get an impression, among the various possible hosts, of the infestation "patterns", to which we attach some importance (Audy, 1954, 1958).

The present paper summarizes complete infestation data of 17,683 animals examined for ticks in Malaya from 1952 to 1959 by the Medical Zoology Laboratory of the Institute for Medical Research. It also includes data gained by rearing ticks in the laboratory, details of which are given elsewhere in this *Study* (Nadchatram, 1960).

The ticks of Malaya and Borneo were reviewed by Kohls (1957), who discussed 23 species from Malaya. The main bulk of the collections he studied were made in 1948-1953 by the U.S. Army Medical Research Unit (Lt.-Col. Robert Traub and his colleagues) and the Colonial Office Scrub Typhus Research Unit (since incorporated into the Medical Zoology Laboratory), both units being based at the Institute for Medical Research. The present paper deals with additional collections not previously reported.

Rodents, insectivores, and lizards are most completely represented in the collection of hosts. A classified host-list was given by Kohls (*loc. cit.*). We can see no useful purpose in repeating that list but have replaced it by another, which shows the infested and uninfested hosts examined, along the same lines as a previous list showing trombiculid infestation (Audy, 1956*b:* 66-72). This complete list of hosts examined can be used in conjunction with the infested host data which we have tabulated under each species of tick.

* Now Director, The Hooper Foundation, University of California Medical Center, San Francisco.

Our individual contributions to the work have been complementary: collecting, identifying, and recording the vertebrate hosts by Lim; routine handling, rearing, and recording of the tick material by Nadchatram; and initiation, supervision, and collation of the work by Audy. We are greatly indebted to Dr Glen M. Kohls for his previous studies and for checking identifications and giving ready advice.

List of Malayan Ticks Recorded in this Paper

In the following list, species which are new records since the review by Kohls (1957) are indicated by an asterisk. The species are here arranged in the same order as in Kohls' Table I (*l. c.*), but in the tabulation which follows they are arranged in alphabetical order, Argasids followed by Ixodids.

The following species, recorded by Kohls (*l. c.*) on the Malayan list, have not yet been collected by us: *Amblyomma crenatum* Neumann, *Haemaphysalis papuana* Thorell, *H. vidua* Warb. & Nuttall, and *Ixodes werneri* Kohls. In addition, *Amb. c. cyprium*, recorded as possibly occurring in Malaya in spite of the absence of a sure record, has not been found in Malaya in the extensive post-war collections—reasons for suspecting that this species is not a member of the true Malayan fauna are given below.

**Argas pusillus* Kohls
Ornithodoros batuensis Hirst
Ixodes granulatus Supino
**Haemaphysalis birmaniae* Supino
Haemaphysalis bispinosa Neumann
Haemaphysalis centropi Kohls
Haemaphysalis cornigera Neumann
Haemaphysalis dentipalpis Warburton & Nuttall
Haemaphysalis doenitzi Warburton & Nuttall
**Haemaphysalis hylobatis* Schulze
Haemaphysalis hystricis Supino
Haemaphysalis koningsbergeri Warburton & Nuttall
**Haemaphysalis traguli* Oudemans
Haemaphysalis wellingtoni Nuttall & Warburton
Rhipicephalus sanguineus (Latreille)
**Rhipicephalus h. haemaphysaloides* Supino
Boophilus microplus (Canestrini)
Dermacentor spp.
**Amblyomma cordiferum* Neumann
Amblyomma cyprium cyprium Neumann (?)
Amblyomma geoemydae (Cantor)
Amblyomma helvolum Koch
Amblyomma javanense (Supino)
**Amblyomma nitidum* Hirst and Hirst
Amblyomma testudinarium Koch
Aponomma lucasi Warburton

NEW RECORDS AND OTHER NOTES

Argas pusillus Kohls

8 specimens (4 ♂, 4 ♀) from a dwelling-house, Butterworth (mainland opposite Penang), Province Wellesley, Malaya, vii. 1954 (Health Officer, Butterworth). Collected from the ceiling space. It is suspected that the hosts are bats.

Ornithodoros batuensis Hirst

Until recently the only records of post-larval stages of this species were three adults, collected on two separate occasions, from Batu Caves, about 7 miles north of Kuala Lumpur. In April and May, 1959, however, very large numbers of nymphs and adults were seen in the caves, rapidly crawling about on a small group of damp rocks immediately below a cluster of cave fruit-bats (*Eonycteris spelaea*). This sudden appearance of large numbers of these ticks coincided with what appeared to be an epizootic among the bats (under investigation). Dead and dying bats were first found by Dr Elliott McClure and Mr Lim Boo-Liat who are carrying out a survey of the cave fauna. The population of post-larval ticks dropped considerably 3-4 weeks after its first discovery.

Ornithodoros batuensis, distinct form: 1 specimen (1 ♂), T1143, was collected by one of us (*M. N.*) from the cave wall of Bukit Che Yatim in the King George V National Park, Pahang, 27. iii. 1956. The mammillae of this specimen are somewhat finer and the 9-10 large buttons situated near the periphery of the dorsal posterior half are more evident than in *O. batuensis* (*G. M. K.*)

Amblyomma cordiferum Neumann

13 specimens, 12 ♀, T1887, from *Python reticulatus*, Kuala Lumpur, 13 iii. 1956; and 1 ♀, T1146, from the same species of snake, R49248, Sentul, Kuala Lumpur, 10. i. 1958. In addition, 17 nymphs and 68 larvae off 19 *Rattus jalorensis* from Rantau Panjang are almost certainly the same species: 10 nymphs were reared to the adult stage and their identification confirmed. It is interesting that 19/21 infested *Rattus jalorensis* trapped in this area were infested by this species; the other 2 had 1 nymph and 6 larvae of a *Haemaphysalis* sp. A tick (1N), probably of this species, was found attached to man.

Rantau Panjang is on the West Coast about 5 miles northwest of Klang and the trapping area was originally all mangrove swamp.

Amblyomma cyprium cyprium Neumann

There are no records of this species either from Malaya or from Borneo. Neumann (1911: 88) noted this species as "Sur Chelonia (?). Iles Philippines, iles Mariannes, Nouvelle-Guinee, Peninsule Malaise", and for this reason Kohls (*l. c.*) included it, with reservations, in his list of Malayan ticks. This species occurs on common domiciliated animals such as cattle and pig from the Celebes through New Guinea to some Pacific islands (the subspecies *aeratipes* Schulze is from the Philippines). In addition, we have recently (November 1957) received 2 females of this species from Thailand, through the courtesy of the entomologist at the Pak Chong Veterinary Laboratory, Thailand (specimens probably from a deer). Appearances suggest that this is perhaps one of a number of species which are known to occur north of Malaya but which disappear from the mainland south of a zoogeographical boundary ("Kedawi") running roughly through Kedah and the Langkawi islands, and which reappear in Indonesia (*see* Zeuner 1941; Reid 1950). An example is the trombiculid mite *Ascoschongastia soekaboemiensis* (Takekawa), which is common in south Burma and parts of Java but absent from our collections in Malaya (Audy 1956*a:* 13).

It is therefore our opinion that *A. cyprium* is probably absent from the body of Malaya but may be expected to occur in the northern States such as Kedah and possibly even Trengganu. For this reason, we continue to retain the species as "possibly" on the Malayan list. Kohls (*in litt.*) queries whether the existence of the "Kedawi" barrier explains the apparent scarcity of *Rh. haemaphysaloides* in southern Malaya: he has several records of this species from Thailand.

Amblyomma nitidum Hirst and Hirst (=**laticaudae** Warburton, new synonym, Kohls *in litt.*)

2 specimens (2N; T1401), from the sea-snake *Laticauda colubrina* (2091), coral reef with scattered mangrove, near Raffles Lighthouse, Singapore, vi. 1952 (*J. R. Hendrickson*); in addition, 1 ♀ and 1N (T1796) (*J. R. A.*, 27. vii. 1959) and 4N, 11L (T1885 and T1886) (*M. N.*, 18. x. 1959) from the same host and locality. Kohls has compared these specimens of ticks with the descriptions of *Amb. nitidum* and of *Amb. laticaudae*, and considers that the specimens are *nitidum* and that *laticaudae* is a synonym. The only point of difference of any consequence appears to be 3/3 hypostomal dentition of the male of *laticaudae* against 4/4 for the male of *nitidum*. This purported difference could be due either to variation or to error in observation of *laticaudae*. Warburton (1933) stated that *nitidum* has very distinct eyes yet both Hirst & Hirst (1910) and Robinson (1926) described the eyes as almost invisible. The latter is true of our specimens. Kohls (1957) did not include this species in his list because he was uncertain whether it was actually established in Malaya. We can now confirm *Amb. nitidum* as a member of the Malayan tick fauna.

It is of interest that this nocturnal sea-snake spends the daytime resting, often in tightly-packed groups, in mangrove tree-holes or in rock-crevices out of the water. Furthermore, the genus *Laticauda* appears to have evolved from an elapid stem much later than the other sea-snakes. This would explain not only the infestation by *Amblyomma*, but also the infestation of the air-sacs by larvae of a peculiar trombiculid mite, *Vatacarus ipoides* Southcott. This mite is also found in the related species *L. laticaudata*, which ranges from the Ryukyu islands to the South Pacific. Larvae reared (by M. N.) in August, 1959, bypassed the nymphal stage and emerged as adults—this is not known to obtain with any other trombiculids, and is an extremely interesting adaptation. It will be interesting to discover how *Amb. nitidum* is adapted to parasitizing this sea-snake.

Haemaphysalis birmaniae Supino

5 specimens (5 ♀), T1219, from an *Atherurus macrourus* (Brush-tailed Porcupine), R43859, Ulu Langat F. R., Selangor, 25. xi. 1955; and 1 ♀, T1571, and 4 ♂ and 1 ♀, T1551, from the same species of host from Kepong F. R., Selangor, 22. x. 1954 and 30. x. 1953 respectively.

Haemaphysalis hylobatis Schulze

1 specimen (1N; T1836) from *Rattus rajah surifer*, 37 A.R. Ampang Reservoir, Selangor, 23. ix. 1959. An adult female was reared from the nymph and identified by Dr Glen M. Kohls. One nymph from *Tragulus javanicus* (Smaller Mousedeer), T1843, Bukit Lagong F. R., 5. x. 1959, may also be this species.

Haemaphysalis traguli Oudemans

4 specimens, 1 ♂, 2 ♀, T1777, from *Tragulus javanicus* (Smaller Mousedeer), R41261, Bukit Lagong F. R., 15. vi. 1955; and 1 ♀, T1337, from the same species of host, R53179, Sungei Buloh Estate, Selangor, 5. vi. 1958.

Dermacentor sp. or spp. nr. **auratus** Supino

Two forms of *Dermacentor* are known to occur in Malaya. They can be separated on the basis of the spurs on coxa I in the adults. In one form the spurs are rather short and widely separated, in the other they are long and close together. The one with short, separated spurs appears to be indistinguishable from *D. auratus* from Burma, the source of Supino's material on which the species was based (*see* also Kohls, 1957: 84). Both forms may occur together on the same host. A study of some reared adults correlated with larval skins has confused the situation further (Kohls, *in litt.*) and it is not possible to decide if the form with long contiguous spurs is a variant of *auratus* or another species.

Rhipicephalus haemaphysaloides haemaphysaloides Supino

1 specimen (1 ♂), T1211, from *Cervus unicolor* ("Rusa", Sambar deer), Seremban, Negri Sembilan, 17. ix. 1957.

Records of Ticks Collected from Islands

The following are records of ticks from islands off the Malayan coast. The special interest of these records is that most islands in the Malacca Straits apparently have an oceanic rather than a continental type of fauna, possibly because life on them was destroyed by ash following the gigantic volcanic explosion of Toba in North Sumatra (*see* Audy *et al.*, 1950; Tweedie, 1950; Wyatt-Smith, 1953).

The abbreviations used in the following summary of the data are explained in the next section.

Pulau Jarak, Malacca Straits

Mabuia multifasciata: 15 examined, 1 infested with 1 ♀ and 1N of *Amblyomma helvolum.*

Rattus r. jarak: 650 examined, 2 infested—one with 1N *Haemaphysalis*, the other with 1N *Dermacentor.*

Pulau Nipis, Sembilan Islands

One female *Amblyomma helvolum* was collected from dried leaves on the ground.

Pulau Rumbia, Sembilan Islands

Mabuia multifasciata: 20 examined, 5 infested—1♀/1 *Amb. helvolum;* 8L/3, 11N/5 *Amb.* prob. *helvolum.*

Varanus salvator: 1 examined and infested with 12 ♀, 7 ♂ *Amb. helvolum* and 1 ♀, 7 ♂ *Aponomma lucasi.*

Pulau Lalang, Sembilan Islands

"Skink" (prob. *Mabuia multifasciata):* 1 examined and infested with 1N, 5L *Amblyomma* prob. *helvolum.*

Tabulated Infestation Data

The following tabulations give infestation details by species of tick, grouped broadly into species infesting reptiles, birds, bats, and other mammals. The first three groups include relatively host-specific ticks. The names of the Argasid and Ixodid ticks are alphabetically arranged. Under the name of each tick, the infested hosts are listed in an order which is firstly taxonomic, following the order of Kohls' classified list (1957: 67-72), except that species within a genus are listed alphabetically. The infestation details given for each host in five columns relate to (i) the number of animals examined, of which only some may have been

infested; (ii) infestation by larvae (L); (iii) by nymphs (N); (iv) by adult females (♀); and (v) by adult males (♂). The infestation details are shown for each stage as (a) the number of ticks in that stage, and (b) the number of hosts infested by that stage, the two numbers being separated by a stroke (/). For example, under *Amblyomma helvolum*, among the ticks infesting reptiles, is the following entry:

Mabuia multifasciata ... ... (Common Skink+ 3 "skinks")	85	14L/4	14N/7	2♀/1	—

This signifies that 82 *M. multifasciata* plus 3 "skinks" (almost certainly the same species, making a total of 85) were examined. Of these, four skinks had 14 larvae, seven had 14 nymphs, one had 2 females, and none had any male adults of *Amb. helvolum*.

Ticks infesting reptiles

Ticks which infest reptiles in Malaya all belong to the genera *Amblyomma* and *Aponomma*. *Amb. helvolum* is probably the most common species, except in the case of the Testudinids which are infested with *Amb. geoemydae*. An unidentified virus has been recovered from *Amb. cordiferum*, specimens of which were taken from a python (*P. reticulatus*) (Institute for Medical Research, Malaya, 1957).

Amblyomma cordiferum Neumann					
Python reticulatus ... ... (Reticulated Python)	33	—	—	13♀/2	—
Amblyomma geoemydae (Cantor)					
Testudo emys ... ... (Burmese Brown Tortoise)	2	9L/1	—	2♀/2	3♂/1
Varanus dumerilii ... ... (Dumeril's Monitor)	3	—	2N/1	—	—
Amblyomma helvolum Koch					
Varanus dumerilii ... ... (Dumeril's Monitor)	3	—	12N/1	1♀/1	3♂/1
Varanus rudicollis ... ... (Harlequin Monitor)	7	—	2N/1	—	1♂/1
Varanus salvator ... ... (Water Monitor)	16	3L/1	2N/1	17♀/4	7♂/1
Mabuia multifasciata ... ... (Common Skink+ 3 "skinks")	85	14L/4	14N/7	2♀/1	—
Python reticulatus ... ... (Reticulated Python)	33	3L/1	9N/1	6♀/2	5♂/1
Elaphe flavolineata ... ... (Common Malayan Racer)	18	—	1N/1	3♀/1	1♂/1
Zaocys fuscus ... ... (White-bellied Rat Snake)	9	4L/1	5N/1	4♀/2	—
Macropisthodon flaviceps ... ... (Orange-necked Keelback)	11	—	1N/1	—	—
Natrix trianguligera ... ... (Triangle Keelback)	12	—	—	1♀/1	—
Naja naja ... ... (Cobra)	18	—	—	5♀/2	—
"Snake"	1	—	—	1♀/1	2♂/1
Amblyomma nitidum Hirst & Hirst					
Laticauda colubrina ... ... (Amphibious Sea Snake)	18	11L/5	7N/4	1♀/1	—
Amblyomma spp.					
Ptyas korros ... ... (Indo-Chinese Rat Snake)	21	9L/1	1N/1	2♀/1	—

Natrix maculata ... ... (Spotted Keelback)	2	—	1N/1	—	—
Ahaetulla caudolineata ... ... (Striped Bronze Back)	8	—	2N/1	—	—
Oligodon octolineatus ... ... (Striped Kukri Snake)	4	1L/1	—	—	—
Bungarus candidus ... ... (Malayan Krait)	10	—	1N/1	—	—
Aponomma lucasi Warburton					
Varanus rudicollis ... ... (Harlequin Monitor)	7	—	10N/1	—	1♂/1
Varanus salvator ... ... (Water Monitor)	16	—	—	1♀/1	7♂/1
Python reticulatus ... ... (Reticulated Python)	33	—	2N/1	—	7♂/1

Ticks infesting birds

Species of ticks found in all stages on birds (and only on birds) are *Haemaphysalis centropi*, *H. doenitzi*, and *H. wellingtoni*. Immature *Amblyomma* and *Dermacentor* are also found on birds in small numbers.

Amblyomma spp. (immature)					
Rallus striatus gularis ... ... (Slaty-breasted Rail)	11	—	2N/2	—	—
Rollulus roulroul ... ... (Crested Green Wood Partridge)	3	—	1N/1	—	—
Dermacentor sp. (immature)					
Centropus bengalensis javanicus ... (Lesser Crow-Pheasant)	5	—	3N/1	—	—
Haemaphysalis centropi Kohls					
Centropus sinensis eurycercus ... (Large Crow-Pheasant)	2	—	—	—	4♂/1
Centropus bengalensis javanicus ... (Lesser Crow-Pheasant)	5	—	2N/2	4♀/2	6♂/4
Haemaphysalis doenitzi Warburton & Nuttall					
Gallus g. gallus ... ... (Red Jungle-Fowl)	2	—	—	3♀/1	8♂/2
Centropus bengalensis javanicus ... (Lesser Crow-Pheasant)	5	—	—	—	1♂/1
Haemaphysalis wellingtoni Nuttall & Warburton					
Gallus g. gallus ... ... (Red Jungle-Fowl)	2	—	—	—	1♂/1
Haemaphysalis spp.					
Excalfactoria c. chinensis ... ... (Blue-breasted Button-Quail+3 "Quail")	24	1L/1	3N/1	—	—
Rallus striatus gularis ... ... (Slaty-breasted Rail)	11	—	1N/1	—	—
Otus bakkamoena lempiji ... ... (Collared Scops Owl)	4	—	1N/1	—	—
Centropus bengalensis javanicus ... (Lesser Crow-Pheasant)	5	16L/1	—	—	—
"Bird"	ca. 10	2L/1	—	—	—

Ticks infesting bats

Only the larvae of *O. batuensis* have been found on bats. The nymphs and adults are probably nest-dwellers, having short diurnal feeds. The four bats listed as hosts of *O. batuensis* are all new records; previously *batuensis* has been known with certainty only from free-living adults. The undetermined form or species "near *batuensis*" was discussed above. *Argas pusillus* is a new record for Malaya, and the collection was also discussed above.

Argas pusillus Kohls						
Dwelling house, ?ex Bats	—	—	—	4♀/1	3♂/1
Ornithodoros batuensis Hirst						
Eonycteris spelaea ... ... (Cave Fruit Bat)	258	450L/30	—	—	—
Cynopterus (*Penthetor*) *lucasi*... ... (Dusky Fruit Bat)	205	2L/1	—	—	—
Nyctalus stenopterus ... ... (Noctule Bat)	11	60L/1	—	—	—
Scotophilus temminckii ... ... (Yellow Bat)	125	271L/5	—	—	—
Bats (unidentified, prob. *E. spelaea*)	—	43L/3	—	—	—
Batu Caves floor	—	—	ca. 50N	ca. 150A	
Ornithodoros, form nr. **batuensis**						
Cave wall, K.G.V. Nat. Park ...	—	—	—	—	1♂/1

Ticks infesting other mammals

Mammals are by far the richest source of ixodid ticks. *Amblyomma javanense* is host-specific on *Manis javanicus* (Scaly Ant-eater), *Rhipicephalus sanguineus* on dogs, and *Boophilus microplus* on cattle and deer. Casual collections of ticks either attached to, or crawling on, man were sent to us from time to time for determination. Altogether 36 collections have been recorded (11 attached to, and 25 crawling on, man). The six species found so attached are mostly *Amblyomma testudinarium*, and also *Haemaphysalis koningsbergeri* and *H. hystricis*. Nymphs and larvae of *Dermacentor* are by far the commonest ticks on rodents, the adults being largely parasitic on wild-pig. *Haemaphysalis* spp. and *Amblyomma* spp. take second and third place after *Dermacentor* on rodents. No adults were recorded on small mammals excepting *Ixodes granulatus* which is parasitic on rodents in all stages: the giant forest rats *Rattus mulleri* and *Rattus sabanus* are the chief hosts. (Kohls has recorded *Ix. werneri* Kohls parasitic on rodents in the adult stage.) Adults of *Haemaphysalis* spp. are parasites of the carnivora—immature stages are also found on carnivores, but the giant forest rats are their favourite hosts.

A virus (TP21) closely related to that of Russian spring-summer encephalitis has been recovered from *Ix. granulatus* in Malaya (Smith, 1956), and later recoveries (unpublished) are probable.

Amblyomma cordiferum Neumann					
Man (attached to)	11+	—	1N/1	—	—
Rattus jalorensis ... ... (Malaysian Wood Rat)	2789	68L/11	17N/12	—	—
Amblyomma helvolum Koch					
Man (crawling on)	25+	—	3N/3	2♀/2	—
Amblyomma javanense (Supino)					
Manis javanicus ... ... (Scaly Ant-Eater)	7	17L/1	31N/3	28♀/4	109♂/3

Amblyomma testudinarium Koch						
Man (attached to)	11+	ca. 25L/2	—	1♀/1	—
Man (crawling on)	25+	—	1N/1	1♀/1	—
Sus scrofa ... ... (Wild Pig)	3	—	—	—	4♂/2
Cervus unicolor ... ... (Rusa; Sambar Deer)	2	—	—	—	1♂/1
Amblyomma spp. (immature)						
Tupaia glis ... ... (Greater Tree Shrew)	155	—	4N/4	—	—
Man (attached to)	11+	26L/3	2N/2	—	—
Man (crawling on)	25+	ca. 220L/3	2N/1	—	—
Hystrix brachyurus ... ... (Common Porcupine)	2	—	5N/1	—	—
"Porcupine" (unidentified)	2	12L/1	2N/2	—	—
Viverra zibetha ... ... (Large Indian Civet)	2	90L/1	2N/2	—	—
Paguma larvata ... . (Masked Palm Civet)	2	75L/1	—	—	—
Panthera pardus ... ... (Leopard)	2	—	2N/2	—	—
Panthera tigris ... ... (Tiger)	2	50L/1	—	—	—
Tragulus javanicus ... ... (Smaller Mouse-Deer)	16	1L/1	1N/1	—	—
Callosciurus tenuis ... ... (Slender Tree Squirrel)	64	—	1N/1	—	—
Rattus argentiventer ... ... (Malaysian Ricefield Rat)	288	—	3N/1	—	—
Rattus jalorensis ... ... (Malaysian Wood Rat)	2789	70L/12	24N/14	—	—
Rattus mulleri ... ... (Müller Giant Rat)	639	2L/1	1N/1	—	—
Rattus sabanus... ... ... (Long-tailed Giant Rat)	1246	3L/2	1N/1	—	—
Boophilus microplus (Canestrini)						
Cervus unicolor ... ... (Rusa; Sambar Deer)	2	—	25N/1	ca. 200♀/1	7♂/2
"Buffalo"	10	—	4N/2	15♀/5	5♂/3
Cattle (domestic)	14	ca. 50L/4	ca. 200N/8	ca. 400♀/12	ca. 70♂/7
Dermacentor spp.						
Tupaia glis ... ... (Greater Tree-Shrew)	155	2L/1	39N/5	—	—
Tupaia minor ... ... (Lesser Tree-Shrew)	38	2L/1	3N/2	—	—
Ptilocercus lowii ... ... (Pen-tail Tree Shrew)	12	—	11N/2	—	—
Man (attached to)	11+	—	1N/1	—	1♂/1
Man (crawling on)	25+	—	—	3♀/3	3♂/3
Lutra sumatrana ... ... (Hairy-nosed Otter)	2	—	1N/1	—	—
Viverra tangalunga ... ... (Malay Civet)	2	—	2N/1	—	—
Arctogalidia trivirgata ... ... (Three-striped Palm Civet)	4	3L/1	—	—	—
Felis bengalensis ... ... (Leopard Cat)	4	—	23N/1	—	—
Flying squirrel	13	—	1N/1	—	—

Callosciurus caniceps ... ... (Grey-bellied Squirrel)	12	3L/1	9N/3	—	—
Callosciurus lowii ... ... (Low's Little Squirrel)	12	—	1N/1	—	—
Callosciurus nigrovittatus ... ... (Black-banded Squirrel)	231	1L/1	49N/10	—	—
Callosciurus notatus ... ... (Red-bellied Squirrel)	344	5L/2	80N/12	—	—
Callosciurus prevostii ... ... (Prevost Squirrel)	4	—	4N/1	—	—
Callosciurus tenuis ... ... (Slender Little Squirrel)	64	7L/1	29N/6	—	—
Dremomys rufigenis ... ... (Red-cheeked Squirrel)	12	1L/1	—	—	—
Rhinosciurus laticaudatus ... ... (Shrew-faced Ground Squirrel)	21	—	6N/2	—	—
Rattus argentiventer ... ... (Malaysian Ricefield Rat)	288	20L/4	4N/4	—	—
Rattus bowersi ... ... (Bower Giant Rat)	296	30L/7	52N/19	—	—
Rattus canus ... ... (Grey Tree-Rat)	115	3L/2	8N/2	—	—
Rattus cremoriventer ... ... (Pencil-tailed Tree-Rat)	225	2L/1	7N/4	—	—
Rattus exulans ... ... (Burmese House-rat)	745	3L/3	9N/4	—	—
Rattus jalorensis ... ... (Malaysian Wood Rat)	2789	44L/14	43N/23	—	—
Rattus mulleri ... ... (Müller Giant Rat)	639	177L/19	171N/55	—	—
*Rattus rajah pellax** ... ... (Rajah Spiny-Rat)	42	—	5N/3	—	—
*Rattus rajah surifer** ... ... (Rajah Spiny-Rat)	641	23L/10	71N/35	—	—
Rattus rattus jarak ... ... (Jarak Rat)	650	—	1N/1	—	—
Rattus sabanus... ... ... (Long-tailed Giant Rat)	1246	320L/49	272N/72	—	—
Rattus whiteheadi ... ... (Whitehead Spiny-Rat)	667	—	4N/4	—	—
Chiropodomys gliroides ... ... (Tree Mouse)	84	7L/3	—	—	—
Sus scrofa ... ... (Wild Pig)	3	—	—	5♀/2	42♂/3
Haemaphysalis birmaniae Supino					
Atherurus macrourus ... ... (Brush-tailed Porcupine)	7	—	—	7♀/3	4♂/1
Haemaphysalis bispinosa Neumann					
Man (crawling on)	25+	—	—	2♀/2	1♂/1
Dog	8	—	—	1♀/1	4♂/1
Sus scrofa ... ... (Wild Pig)	3	—	—	4♀/1	—
Cervus univolor ... ... (Rusa; Sambar Deer)	2	—	—	2♀/2	—
Buffalo (domestic)	10	—	—	1♀/1	—
Cattle (domestic)	14	—	2N/1	5♀/1	1♂/1

* These are considered to be two colour forms of *R. rajah* by Harrison (1957*a*) though some workers regard them as two species: they are here shown as subspecies.

Haemaphysalis cornigera Neumann					
Rattus sabanus... ... ... (Long-tailed Giant Rat)	1246	—	1N/1	—	—
Haemaphysalis dentipalpis Warburton & Nuttall					
Panthera pardus ... ... (Leopard)	2	—	—	—	2♂/1
Haemaphysalis hylobatis Schulze					
Rattus rajah surifer ... ... (Rajah Spiny-Rat)	641	—	1N/1	—	—
Haemaphysalis hystricis Supino					
Man (attached to)	11+	—	—	2♀/2	—
Man (crawling on)	25+	—	—	5♀/5	2♂/2
Dog	8	—	—	1♀/1	—
Panthera pardus ... ... (Leopard)	2	—	—	2♀/2	6♂/2
Panthera tigris ... ... (Tiger)	2	—	—	20♀/4	71♂/4
Felis nebulosa ... ... (Clouded Leopard)	1	—	—	—	3♂/1
Rattus whiteheadi ... ... (Whitehead Spiny-Rat)	667	—	2N/2	—	—
Haemaphysalis koningsbergeri Warburton & Nuttall					
Man (prob. crawling on)	25+	—	—	3♀/2	2♂/2
Paguma larvata ... ... (Masked Palm Civet)	2	—	—	—	2♂/2
Arctogalidia trivirgata ... ... (Three-striped Palm Civet)	4	—	—	1♀/1	1♂/1
Arctictis binturong ... ... (Binturong)	1	—	—	—	5♂/1
Panthera pardus ... ... (Leopard)	2	—	—	5♀/2	40♂/1
Panthera tigris... ... ... (Tiger)	2	—	—	—	1♂/1
Felis nebulosa ... ... (Clouded Leopard)	1	—	—	—	12♂/1
Felis marmorata ... ... (Marbled cat)	1	—	—	—	1♂/1
Haemaphysalis traguli Oudemans					
Tragulus javanicus ... ... (Smaller Mouse-Deer)	16	—	—	3♀/2	1♂/1
Haemaphysalis spp. (immature)					
Tupaia glis ... ... (Greater Tree-Shrew)	155	4L/1	2N/1	—	—
Man (crawling on)	25+	—	1N/1	—	—
Viverra tangalunga ... ... (Malay Civet)	2	3L/1	—	—	—
Paradoxurus hermaphroditus ... ... (Common Palm Civet)	26	7L/2	19N/2	—	—
Paguma larvata ... ... (Masked Palm Civet)	2	—	1N/1	—	—
Felis bengalensis ... ... (Leopard Cat)	4	26L/2	1N/1	—	—
Felis marmorata ... ... (Marbled Cat)	1	—	1N/1	—	—
Callosciurus nigrovittatus ... ... (Black-banded Squirrel)	231	—	1N/1	—	—
Callosciurus notatus ... ... (Common Red-bellied Squirrel)	344	1L/1	1N/1	—	—

Callosciurus tenuis (Slender Little Squirrel)	64	—	6N/1	—	—
Rhinosciurus laticaudatus (Shrew-faced Ground Squirrel)	21	1L/1	—	—	—
Rattus alticola (Mountain Rat)	—	2L/1	—	—	—
Rattus bowersi (Bower Giant Rat)	296	3L/1	13N/11	—	—
Rattus exulans (Burmese House Rat)	745	—	1N/1	—	—
Rattus jalorensis (Malaysian Wood Rat)	2789	7L/4	4N/4	—	—
Rattus mulleri (Müller Giant Rat)	639	22L/5	54N/13	—	—
Rattus rajah pellax (Rajah Spiny-Rat)	42	1L/1	7N/4	—	—
Rattus rajah surifer (Rajah Spiny-Rat)	641	4L/3	53N/17	—	—
Rattus rajah group (Rajah Spiny-Rat)	683	—	38N/4	—	—
Rattus rattus diardi (Malaysian House-Rat)	2059	—	1N/1	—	—
Rattus rattus jarak (Jarak Rat)	650	—	1N/1	—	—
Rattus sabanus Long-tailed Giant Rat)	1246	46L/15	48N/19	—	—
Chiropodomys gliroides (Tree Mouse)	84	1L/1	—	—	—
Atherurus macrourus (Brush-tailed Porcupine)	7	—	2N/1	—	—
Tragulus javanicus (Smaller Mouse-Deer)	16	—	3N/2	—	—
Ixodes granulatus Supino					
Tupaia glis (Greater Tree Shrew)	155	—	—	3♀/2	—
Echinosorex gymnurus (Moon-Rat)	7	6L/1	—	3♀/2	—
Crocidura malayana (White-toothed Shrew)	26	—	3N/2	—	—
Man (attached to)	11+	—	—	1♀/1	—
Callosciurus caniceps (Grey-bellied Squirrel)	12	—	—	1♀/1	—
Callosciurus nigrovittatus (Black-banded Squirrel)	231	—	6N/1	—	—
Rattus argentiventer (Malaysian Ricefield Rat)	288	—	—	1♀/1	—
Rattus bowersi (Bower Giant Rat)	296	—	—	5♀/1	—
Rattus jalorensis (Malaysian Wood Rat)	2789	—	—	26♀/12	2♂/1
Rattus mulleri (Müller Giant Rat)	639	16L/1	—	327♀/61	45♂/15
Rattus rajah pellax (Rajah Spiny-Rat)	42	—	—	5♀/1	—
Rattus rajah surifer (Rajah Spiny-Rat)	641	—	—	43♀/15	2♂/2
Rattus sabanus (Long-tailed Giant Rat)	1246	—	5N/3	86♀/39	5♂/4
Ixodes sp. prob. **granulatus**					
Rattus canus (Grey Tree-Rat)	115	—	2N/1	—	—

Rhipicephalus h. haemaphysaloides Supino					
Cervus unicolor (Rusa; Sambar Deer)	2	—	—	—	1♂/1
Rhipicephalus sanguineus (Latreille)					
Man (crawling on)	25+	—	—	14♀/3	8♂/3
Dog	8	16L/1	14N/1	36♀/12	76♂/7
Rhipicephalus sp. prob. **sanguineus**					
Man (attached to)	11+	2L/2	—	—	—

List of Infested and Uninfested Hosts

The following hosts (2,187 reptiles, 1,202 birds, and 14,294 mammals, of over 413 species) have been examined for ticks for the purposes of the present study. The authorities taken for the scientific and popular names of hosts are: Tweedie (1953) for snakes; Smith (1930) for lizards; Gibson-Hill (1949) for birds (his serial numbers are quoted here and also by Glenister, 1951); and Chasen (1940) amended by Ellerman and Morrison-Scott (1955) for the mammals.

This list follows that of Audy (1956*b*:65-72) for trombiculid infestation, and the latter list gives some further details of the species of birds. The purpose of the present list is to show at a glance what species are and what species are not infested by particular ticks, details of infestation being given in the tabulation. We may note the following: the absence of ticks from Flying Lizards and Rhinolophid Bats, although these are important hosts of trombiculids; the host-specific ticks on tortoises and the sea-snake *Laticauda;* considerable infestation of the Reticulated Python but not of the Short Python; and the restriction of tick infestation to only a few birds. These peculiarities are related to the habits of both the hosts and the ticks: a study of host-distribution throws light on the ecology of both hosts and their parasites. The list is however here presented without discussion: discussion is reserved until further and more representative data have been collected and when a comparison can be made at the same time with trombiculid mite infestation. Reference should be made to Harrison (1957*a*, *b*) for ecological data on Malayan hosts of interest to the parasitologist.

A few species of hosts, examined in negligible numbers but not found infested, have been omitted. Some uninfested hosts have been pooled, usually by species but in the case of the birds often by genera. Pooling of species in one genus may be indicated by giving the name of the commonest species followed by "&c" and the number of species examined.

Reptiles (Reptilia)

Total examined: 2,187, of over 103 species

Order Testudinata

Testudinidae: Tortoises &c (6, of 2 species)
- 4 *Geoemys spinosa* (Spiny Hill Tortoise)
- 2 *Testudo emys* (Burmese Brown Tortoise)

Amb. geoemydae

Order Squamata

Suborder **Sauria** (Lizards)

Gekkonidae: Geckoes (102, of 9 species)
- 5 *Gekko gecko* (Tuck-too or Tokay; from Jarak Island)
- 41 *Gekko stentor* &c.; 2 spp. (Giant & House Geckoes)
- 27 *Gymnodactylus consobrinus* &c.; 2 spp. (Forest Geckoes)
- 20 *Hemidactylus frenatus* &c.; 2 spp. (House Gecko or "chickak")
- 9 *Ptychozoon kuhli* (Flying Gecko)

AGAMIDAE (811, of 10 species)
- 32 *Calotes cristatellus* &c.; 2 spp. (Crested Lizards)
- 412 *Draco melanopogon* &c.; 6 spp. (Flying Lizards)
- 367 *Gonocephalus borneensis* &c.; 2 spp. (Forest Crested Lizards)

VARANIDAE: Monitors (40, of 4 species)
- 3 *Varanus dumerilii* (Dumeril's Monitor)
  Amb. geoemydae, Amb. helvolum
- 14 *Varanus nebulosus* (Clouded Monitor)
- 7 *Varanus rudicollis* (Harlequin Monitor)
  Amb. helvolum, Apo. lucasi
- 16 *Varanus salvator* (Water Monitor)
  Amb. helvolum, Apo. lucasi

SCINCIDAE: Skinks (119, of 5 species)
- 10 *Lygosoma atrocostatum* (from islands in Malacca Straits)
- 24 *Lygosoma olivaceum* &c.; 3 spp.
- 85 *Mabuia multifasciata* (Common Skink)
  Amb. helvolum, Amblyomma sp.

Suborder **Serpentes** (Snakes)

TYPHLOPIDAE, Anilidae, Xenopeltidae (29, of 4 species)
- 2 *Typhlops*, 2 spp. (Common & Striped Blind Snakes)
- 8 *Cylindrophis rufus* (Red-tailed Pipe Snake)
- 19 *Xenopeltis unicolor* (Iridescent Earth Snake)

BOIDAE: Pythons (45, of 2 species)
- 12 *Python curtus* (Short Python)
- 33 *Python reticulatus* (Reticulated python)
  Amb. cordiferum, Amb. helvolum, Apo. lucasi

COLUBRIDAE (900, of 44 species)
- 370 *Acrochordus javanicus* (Elephant's Trunk Snake, aquatic)
- 22 *Ahaetulla ahaetulla* &c. (Painted & Elegant Bronze Backs)
- 8 *Ahaetulla caudolineata* (Striped Bronze Back)
  Amblyomma sp.
- 37 *Boiga dendrophila* &c.; 5 spp. (Cat Snakes)
- 17 *Calamaria vermiformis* &c.; 3 spp. (Reed Snakes)
- 2 *Cerberus rhynchops* (Dog-faced Water-Snake)
- 21 *Chysopelea paradisi* &c.; 3 spp. (Tree Snakes)
- 6 *Dryophiops rubescens* (Keel-bellied Whip Snake)
- 59 *Dryophis prasinus* &c.; 3 spp. (Whip Snakes)
- 18 *Elaphe flavolineata* (Common Malayan Racer)
  Amb. helvolum
- 18 *Elaphe oxycephala* (Red-tailed Racer)
- 2 *Enhydris punctata*
- 11 *Haplopeltura boa* (Blunt-headed Tree Snake)
- 207 *Homalopsis buccata* (Puff-faced Water-Snake)
- 6 *Lycodon*, 4 spp. (Wolf Snakes)
- 11 *Macropisthodon flaviceps* (Orange-necked Keelback)
  Amb. helvolum
- 10 *Natrix chrysarga* (Speckle-bellied Keelback)
- 2 *Natrix maculata* (Spotted Keelback)
  Amblyomma sp.
- 1 *Natrix sanguinea* (Smedley's Keelback)
- 12 *Natrix trianguligera* (Triangle Keelback)
  Amb. helvolum
- 4 *Oligodon octolineatus* (Striped Kukri Snake)
  Amblyomma sp.
- 5 *Oligodon purpurascens* (Brown Kukri Snake)

6 *Pareas vertebralis* &c.; 2 spp. (Mountain & Smooth Slug Snakes)
7 *Psammodynastes pulverulentus* (Mock Viper)
2 *Pseudorhabdion longiceps* (Dwarf Reed Snake)
21 *Ptyas korros* (Indo-Chinese Rat Snake)
Amblyomma sp.
5 *Sibynophis melanocephalus*
10 *Zaocys fuscus* &c.; 2 spp. (White-bellied Rat Snake &c.)
Amb. helvolum

ELAPIDAE (71, of 7 species)
10 *Bungarus candidus* (Malayan Krait)
Amblyomma sp.
6 *Bungarus*, 2 spp. (Banded & Red-headed Kraits)
31 *Maticora intestinalis* &c.; 2 spp. (Malaysian Coral Snakes)
6 *Naja hannah* (King Cobra, Hamadryad)
18 *Naja naja* (Common Cobra)
Amb. helvolum.

HYDROPHIIDAE: Sea-snakes (18, of 1 species)
18 *Laticauda colubrina* (Amphibious Sea-Snake)
Amb. nitidum

VIPERIDAE: Vipers (46, of 5 species)
46 *Trimeresurus wagleri* &c.; 5 spp. (Wagler's Pit Viper &c.)

Birds (Aves)

Total examined: 1,202, of over 141 species

Order ACCIPITRES

ACCIPITRIDAE (Hawks, Eagles, Vultures) (8, of 6 species)
8 in 6 genera (42, 43, 45, 52, 56, 59)*

Order GALLINAE

PHASIANIDAE: Pheasants, Partridges, &c. (38, of 7 species)
4 in 3 genera (76, 83, 89)
21 *Excalfactoria c. chinensis* (78, Blue-breasted Button Quail)
Haemaphysalis spp.
3 *Rollulus roulroul* (82, Crested Green Wood-Partridge)
Amblyomma sp.
2 *Gallus g. gallus* (85, Red Jungle-Fowl)
H. doenitzi, H. wellingtoni
8 *Gallus gallus domesticus* (Domestic Fowl)

Order HEMIPODII

TURNICIDAE: Bustard-Quail (26, of 1 species)
26 *Turnix suscitator atrogularis* (91, Barred Bustard-Quail)

Order GRALLAE

RALLIDAE: Rails (32, of 6 species)
4 in 3 genera (94, 99, 101)
11 *Rallus striatus gularis* (93, Slaty-breasted Rail)
Amblyomma sp., **Haemaphysalis** spp.
10 *Porzana f. fusca* (97, Ruddy Crake)
7 *Amaurornis phoenicurus chinensis* (100, White-breasted Water-Hen)

CHARADRIDAE: Plovers (2, of 2 species)
2 in 2 genera (110, 115)

SCOLOPACIDAE: Sandpipers, Snipes, &c. (32, of 1 species)
32 *Capella stenura* (132, Pintail Snipe)

* The numbers are cross-references to species of birds in the lists of Gibson-Hill and Glenister.

Order COLUMBAE

COLUMBIDAE: Pigeons, Doves (10, of 7 species)
10 in 7 genera (163, 168, 171, 173 175, 176, 177)

Order CORACIFORMES

CUCULIDAE: Cuckoos, Malkohas (24, of 10 species)
17 in 7 genera (182, 188, 197, 198, 199, 201, 202, 203)
2 *Centropus sinensis eurycercus* (205, Large Crow-Pheasant)
H. centropi
5 *Centropus bengalensis javanensis* (206, Lesser Crow-Pheasant)
Dermacentor sp., **H. centropi, H. doenitzi, Haemaphysalis** spp.

STRIGIDAE, TYTONIDAE, & PODARGIDAE: Owls, Barn-Owls, Frogmouths (10, of 7 species)
5 in 5 genera (208, 214, 217, 221, 224)
1 *Otus scops malayanus* (212, Lesser Scops Owl)
4 *Otus bakkamoena lempiji* (213, Collared Scops Owl)
Haemaphysalis spp.

CAPRIMULGIDAE: Nightjars (9, of 2 species)
9 *Caprimulgus*, 2 spp. (228, 229)

APODIDAE: Swifts, Swiftlets (59, of 2 species)
24 *Collocalia esculenta cyanoptila* (235, White-bellied Swiftlet)
35 *Apus affinis subfurcatus* (240, House-Swift)

TROGONIDAE: Trogons (3, of 2 species)
3 *Harpectes* 2 spp. (245, 247)

ALCEDINIDAE: Kingfishers (14, of 4 species)
4 *Ceyx r. rufidorsum* (254, Red-backed Kingfisher)
10 *Halcyon*, 3 spp. (259, 258, 262)

MEROPIDAE: Bee-eaters (44, of 2 species)
44 *Merops v. viridis* (265, Blue-throated Bee-eater)

CORACIIDAE: Rollers (4, of 1 species)
4 *Eurystomus o. orientalis* (268, Broad-billed Roller)

BUCEROTIDAE: Hornbills (6, of 3 species)
6 in 3 genera (270, 271, 275)

CAPITONIDAE: Barbets (8, of 3 species)
8 in 3 genera (281, 283, 289)

PICIDAE: Woodpeckers (15, of 9 species)
15 in 7 genera (295, 297, 300, 303, 304, 308, 309, 313, 316)

Order PASSERES

EURYLAIMIDAE: Broadbills (6, of 3 species)
6 in 2 genera (318, 322, 323)

CAMPEPHAGIDAE: Cuckoo-Shrikes, Minivets (5, of 5 species)
5 in 3 genera (340, 341, 342, 343, 345)

PITTIDAE, DICRURIDAE, ORIOLIDAE, CORVIDAE, PARIDAE, SITTIDAE (9, of 6 species)
9 in 6 genera (328, 346, 353, 358, 363, 364)

TIMALIIDAE: Babblers (62, of 17 species)
28 in 9 genera (366, 368, 370, 374, 380, 388, 389, 399, 401, 410, 412)
11 *Malacopteron*, 3 spp. (375, 376, 377)
23 *Stachyris*, 3 spp. (391, 394, 395)

AEGITHINIDAE: Ioras, Leaf-Birds (12, of 3 species)
12 in 3 genera (414, 418, 420)

PYCNONOTIDAE: Bulbuls (486, of over 15 species)
77 *Pycnonotus*, over 4 spp. (incl. 422, 424, 425, 426)
23 *Pycnonotus a. atriceps* (423, Black-headed Bulbul)
150 *Pycnonotus b. brunneus* (434, Red-eyed Brown Bulbul)
74 *Pycnonotus e. erythrophthalmos* (436, Lesser Olive-brown Bulbul)
81 *Pycnonotus goiaver personatus* (431, Yellow-vented Bulbul)
18 *Pycnonotus s. simplex* (435, White-eyed Brown Bulbul)
22 *Criniger*, 2 spp. (437, 439)
35 *Tricholestes c. criniger* (441, Hairy-backed Bulbul)
6 *Microscelis*, 3 spp. (443, 444, 445)

TURDIDAE: Thrushes, Robins, &c. (11, of 3 species)
11 in 2 genera (450, 451, 453)

SYLVIIDAE: Warblers, Tailor-Birds (8, of 3 species)
8 in 2 genera (467, 468, 482)

MUSCICAPIDAE: Flycatchers (11, of 5 species)
11 in 5 genera (486, 500, 512, 514, 515)

MOTACILLIDAE, LANIIDAE, STURNIDAE (6, of 4 species)
6 in 4 genera (518, 524, 527, 530)

NECTARINIIDAE: Sunbirds, Spider-Hunters (58, of 6 species)
18 *Anthreptes*, 4 spp. (534, 535, 537, 538)
9 *Leptocoma jugularis microleuca* (541, Yellow-breasted Sunbird)
31 *Arachnothera l. longirostra* (545, Little Spider- Hunter)

DICAEIDAE: Flower-Peckers (17, of 6 species)
9 *Dicaeum*, 5 spp. (552, 553, 554, 555, 556)
8 *Piprisoma agile sordidum* (561, Thick-billed Flower-Pecker)

PLOCEIDAE: Sparrows, Munias (167, of 7 species)
7 in 2 genera (565, 573)
27 *Passer montanus malaccensis* (563, Tree-Sparrow)
133 *Munia*, 4 spp. (566, 567, 568, 569)

Mammals (Mammalia)

Total examined: 14,294, of over 139 species

Order CHIROPTERA

Total examined: 2,553, of over 30 species

PTEROPODIDAE: Fruit Bats (650, of 8 species)
18 *Pteropus vampyrus* (Flying Fox)
64 *Cynopterus brachyotis* (Common Dog-faced Fruit Bat)
49 *Cynopterus horsfieldi* (Large Dog-faced Fruit Bat)
205 *Cynopterus* (*Penthetor*) *lucasi* (Dusky Fruit Bat)
O. batuensis
19 *Cynopterus* (*Chironax*) *melanocephalus* (Black-capped Fruit Bat)
30 *Balionycteris maculata* (Spotted-winged Fruit Bat)
258 *Eonycteris spelaea* (Cave Fruit Bat)
O. batuensis
7 *Macroglossus lagochilus* (Long-tongued Fruit Bat)

EMBALLONURIDAE: Sheath-tailed & Tomb Bat (59, of 3 species)
36 *Emballonura monticola* (Sheath-tailed Bat)
23 *Taphozous* &c.; 2 spp. (Tomb Bats)

MEGADERMATIDAE: False-Vampires (8, of 1 species)
8 *Megaderma spasma* (False Vampire)

RHINOLOPHIDAE: Horseshoe Bats (325, of several species)*
36 *Rhinolophus* spp. (Leaf-nosed Bats)
289 *Hipposideros* spp. (Horseshoe Bats)

VESPERTILIONIDAE: Flittermice (1,468, of over 10 species)
798 *Myotis* spp. (Mouse-eared Bats)
22 *Pipistrellus* spp. (Pipistrelles)
5 *Glischropus tylopus* (Thick-thumbed Pipistrelles)
483 *Tylonycteris*, 3 spp. (Club-footed Bats)
11 *Nyctalus stenopterus* (Noctule Bat)
O. batuensis
24 *Kerivoula* spp. (Forest Bats)
125 *Scotophilus temminckii* (Brown Bat)
O. batuensis

MOLOSSIDAE: Free-tailed Bats (43, of 2 species)
16 *Chaerephon* sp. (Wrinkled-lipped Bat)
27 *Cheiromeles torquatus* (Naked Bull-dog Bat)

Order INSECTIVORA

TUPAIIDAE†: Tree-Shrews (205, of 3 species)
155 *Tupaia glis* (Greater Tree Shrew)
Amblyomma spp., **Dermacentor** sp., **Haemaphysalis** spp., **I. granulatus**
38 *Tupaia minor* (Lesser Tree Shrew)
Dermacentor sp.
12 *Ptilocercus lowii* (Pen-tail Tree Shrew)
Dermacentor sp.

ERINACEIDAE: "Shrews" (19, of 2 species)
7 *Echinosorex gymnurus* (Moon Rat)
I. granulatus
12 *Hylomys suillus* (Short-tailed Shrew)

SORICIDAE: Shrews 87, of 3 species)
26 *Crocidura malayana* (White-toothed Shrew)
Dermacentor sp., **I. granulatus**
3 *Chimarrogale hantu* (Water Shrew)
58 *Suncus murinus* (House Shrew)

Order PRIMATES

HOMINIDAE: Man (36 reported)
11 Man (attached to)
Amb. prob. **cordiferum, Amb. testudinarium, Amblyomma** spp., **Dermacentor** sp., **H. hystricis, I. granulatus, R.** prob. **sanguineus**
25 Man (crawling on)
Amb. helvolum, Amb. testudinarium, Amblyomma sp., **Dermacentor** sp., **H. bispinosa, H. hystricis, H. koningsbergeri, Haemaphysalis** spp., **R. sanguineus**

CERCOPITHECIDAE: Macaques &c. (21, of 1 species)
21 *Macaca irus* (Long-tailed Macaque)

COLOBIDAE: Leaf-Monkeys &c. (8, of 2 species)
8 *Presbytis*, 2 spp. (Banded & Dusky Leaf Monkeys)

LORISIDAE: Lorises (2, of 1 species)
2 *Nycticebus coucang* (Slow Loris)

* The Rhinolophidae are very rich in Malayan species, and the identifications of the present series are incomplete.

† These are usually considered as primitive primates with the habits, and, in general, the parasites, of small insectivores.

Order CARNIVORA

MUSTELIDAE: Otters, Weasels (3, of 2 species)
1 *Mustela nudipes* (Malay Weasel)
2 *Lutra sumatrana* (Hairy-nosed Otter)

CANIDAE: Dogs &c. (8, of 1 species)
8 *Canis domesticus* (Domestic Dog)
H. bispinosa, H. hystricis, R. sanguineus

VIVERRIDAE: Civets (42, of 8 species)
2 *Viverra tangalunga* (Malay Civet)
Dermacentor sp., **Haemaphysalis** spp.
2 *Viverra zibetha* (Large Indian Civet)
Amblyomma sp.
1 *Viverricula malaccensis* (Little Civet)
26 *Paradoxurus hermaphroditus* (Common Palm Civet)
Haemaphysalis sp.
2 *Paguma larvata* (Masked Palm Civet)
Amblyomma sp., **H. koningsbergeri, Haemaphysalis** spp.
4 *Arctogalidia trivirgata* (Small-toothed Palm Civet)
Dermacentor sp., **H. koningsbergeri**
1 *Arctictis binturong* (Bear Cat)
H. koningsbergeri
4 *Prionodon linsang* (Linsang)

FELIDAE: Cats &c. (14, of 6 species)
4 *Felis bengalensis* (Leopard Cat)
Dermacentor sp., **Haemaphysalis** spp.
4 *Felis cattus* (Domestic Cat)
1 *Felis marmorata* (Marbled Cat)
H. koningsbergeri, Haemaphysalis spp.
1 *Felis nebulosa* (Clouded Leopard)
H. hystricis, H. koningsbergeri
2 *Panthera pardus* (Leopard)
Amblyomma sp., **H. dentipalpis, H. hystricis, H. koningsbergeri**
2 *Panthera tigris* (Tiger)
Amblyomma sp., **H. hystricis, H. koningsbergeri**

Order PHOLIDOTA (EDENTATA)

MANIDAE: Scaly Anteater (7, of 1 species)
7 *Manis javanicus* (Scaly Anteater)
Amb. javanense

Order RODENTIA

SCIURIDAE: Squirrels (732, of 17 species)
13 *Petaurista* &c.; 5 spp. in 5 genera (Flying Squirrels)
Dermacentor sp.*
5 *Ratufa*, 2 spp. (Giant Squirrels)
12 *Callosciurus caniceps* (Grey-bellied Squirrel)
Dermacentor sp., **I. granulatus**
4 *Callosciurus hippurus* (Horse-tailed Squirrel)
12 *Callosciurus lowii* (Low's Little Squirrel)
Dermacentor sp.
231 *Callosciurus nigrovittatus* (Black-banded Squirrel)
Dermacentor sp., **Haemaphysalis** spp., **I. granulatus**

* Out of 13 Flying Squirrels listed as examined, one was infested with 1N *Dermacentor*. Unfortunately the identification of this host is unknown.

344 *Callosciurus notatus* (Common Red-bellied Squirrel)
Dermacentor sp., **Haemaphysalis** spp.
4 *Callosciurus prevostii* (Prevost Squirrel)
Dermacentor sp.
64 *Callosciurus tenuis* (Slender Little Squirrel)
Amblyomma sp., **Dermacentor** sp., **Haemaphysalis** spp.
10 *Lariscus insignis* (Three-striped Ground Squirrel)
12 *Dremomys rufigenis* (Red-cheeked Squirrel)
Dermacentor sp.
21 *Rhinosciurus laticaudatus* (Shrew-faced Ground Squirrel)

SPALACIDAE: Bamboo Rats (13, of 1 species)
13 *Rhizomys sumatrensis* (Bamboo Rat)
Dermacentor sp.

MURIDAE: Rats, Mice (10,489, of 14 species)
3 *Rattus alticola* (Mountain Rat)
Haemaphysalis spp.
288 *Rattus argentiventer* (Malaysian Ricefield Rat)
Amblyomma sp., **Dermacentor** sp., **I. granulatus**
296 *Rattus bowersi* (Bower Giant Rat)
115 *Rattus canus* (Grey Tree Rat)
Dermacentor sp., I. prob. **granulatus.**
225 *Rattus cremoriventer* (Pencil-tailed Tree Rat)
Dermacentor sp.
745 *Rattus exulans* (Little Burmese House Rat)
Dermacentor sp., **Haemaphysalis** spp.
2789 *Rattus jalorensis* (Malaysian Wood Rat)
Amblyomma sp., **Dermacentor** sp., **Haemaphysalis** spp., **I. granulatus**
639 *Rattus mulleri* (Müller Giant Rat)
Amblyomma sp., **Dermacentor** sp., **Haemaphysalis** spp., **I. granulatus**
42 *Rattus rajah pellax* (Rajah Spiny-Rat)
Dermacentor sp., **Haemaphysalis** spp., **I. granulatus**
641 *Rattus rajah surifer* (Rajah Spiny-Rat)
Dermacentor sp., **H. hylobatis, Haemaphysalis** sp., **I. granulatus**
2059 *Rattus rattus diardi* (Malaysian House Rat)
Haemaphysalis spp.
650 *Rattus rattus jarak* (Jarak Rat)
Dermacentor sp., **Haemaphysalis** spp.
1246 *Rattus sabanus* (Long-tailed Giant Rat)
Amblyomma sp., **Dermacentor** sp., **H. cornigera , Haemaphysalis** spp., **I. granulatus**
667 *Rattus whiteheadi* (Whitehead's Spiny Rat)
Dermacentor sp., **H. hystricis**
84 *Chiropodomys gliroides* (Tree Mouse)
Dermacentor sp., **Haemaphysalis** spp.

HYSTRICIDAE: Porcupines (9, of 2 species)
2 *Hystrix brachyurus* (Common Porcupine)
Amb. testudinarium
7 *Atherurus macrourus* (Brush-tailed Porcupine)
H. birmaniae, Haemaphysalis spp.

Order ARTIODACTYLA

SUIDAE: Pigs (3, of 1 species)
3 *Sus scrofa* (Wild Pig)
Amb. testudinarium, Dermacentor sp., **H. bispinosa**

TRAGULIDAE: Mouse-Deer (17, of 2 species)
16 *Tragulus javanicus* (Smaller Mouse-Deer)
Amblyomma sp., **H. traguli, Haemaphysalis** spp.
1 *Tragulus napu* (Larger Mouse-Deer)

CERVIDAE: Deer (2, of 1 species)
2 *Cervus unicolor* (Rusa; Sambar Deer)
Amb. testudinarium, B. microplus, H. bispinosa, R. h. haemaphysaloides

BOVIDAE: Oxen (24, of 2 species)
10 *Bubalus bubalis* (Buffalo)
B. microplus, H. bispinosa
14 *Bos taurus* (Domestic Cattle)
B. microplus, H. bispinosa

SUMMARY

1. Details are tabulated of tick-infestation, by larvae, nymphs, and adults, of 17,683 reptilian, avian, and mammalian hosts examined in 1952-1959 by the Medical Zoology Laboratory of the Institute for Medical Research in Kuala Lumpur.

2. The following new records are added to the ticks recorded for Malaya by Kohls in 1957: *Argas pusillus*, from a dwelling-house roofspace, presumably from bats; *Haemaphysalis birmaniae* from two porcupines; *H. hylobatis* from a forest rat; *H. traguli* from a mouse-deer; *Rhipicephalus h. haemaphysaloides* from a deer; *Amblyomma cordiferum* from a python and wood-rats. A distinct form of *Ornithodoros*, presumably of *O. batuensis*, was collected from a cave. In addition, *Amblyomma nitidum* (=*laticaudae*, new synonym) from sea-snakes, is confirmed as a member of the Malayan fauna. The species *Amb. c. cyprium*, tentatively listed by Kohls, is considered possibly present in north Malaya but not a true member of the Malayan fauna.

3. Reptiles: 2,187 individuals, of 50 genera and over 103 species, were examined. Of these, 36/277 of 17 species were infested by species of *Amblyomma* and *Aponomma*: *Amb. helvolum* is common on snakes and lizards, and *Amb. geoemydae* is restricted to the testudinids. The nymphs of *Amb. cordiferum* were commonly found on *Rattus jalorensis*; the adults have so far been recorded only on *Python reticulatus*.

4. Birds: 1,202 birds of 114 genera and over 141 species were examined. Of these, 18/48 individuals of 7 species were found infested, particularly by three species of *Haemaphysalis* which are specific to birds, together with some immature stages of *Amblyomma* and *Dermacentor*. The infested birds were mostly rallids, phasianids, and a cuculid (*Centropus*)—ground- and to some extent swamp-frequenting— which we have found also to be infested by trombiculid mites.

5. Bats: 2,553 bats of 19 genera and over 30 species were examined. Of these, 40/599 of 4 species were infested by larvae of *Ornithodoros batuensis*. *Argas pusillus* was newly recorded, presumably from bats. Only argasid ticks have been found on bats.

6. Other mammals: 11,741 mammals, other than bats, of 44 genera and 109 species were examined. Of these, 547/11,277 of 49 species were infested by ticks of 6 genera and at least 13 species. Carnivores are particularly infested by species of *Haemaphysalis*, and rodents by immature stages of *Dermacentor* (adult *Dermacentor* feed on wild pig). *Ixodes granulatus* is one of the few species which remain parasitic on rodents in the adult stage. The only species showing some apparent host-specificity were *Amb. javanense* (scaly anteater), *Rhipicephalus sanguineus* (dogs in towns and villages), and *Boophilus microplus* (cattle and deer).

7. The following species were recorded as feeding on man (9 species have been recorded as crawling on man, but these records are relatively insignificant): *Amblyomma testudinarium*

(the commonest), immature *Amblyomma* (probably the preceding species), *Amblyomma* sp. probably *Amb. cordiferum*, *Dermacentor* sp., *Haemaphysalis hystricis*, *Ixodes granulatus*, *Rhipicephalus* sp. probably *R. sanguineus*.

8. A list is given of the numbers of each host-species examined (sometimes pooled), both infested and uninfested. The importance is stressed of giving such data, instead of only details of individual hosts found infested.

9. Two viruses have been recovered from ticks in this collection. One (TP21), from *Ixodes granulatus*, is a member of the Russian-spring-summer-encephalitis/louping-ill group, and probably infects man. The other (TP19), from *Amb. cordiferum*, is not yet characterized.

REFERENCES

AUDY J. R. (1954). A biological approach to medical geography. *Brit. med. J.*, *i*, 960-962.

AUDY J. R. (1956*a*). *Laurentella*, a new subgenus of trombiculid mites, with notes on biology and medical importance. *Bull. Raffles Mus.*, *28*, 5-26.

AUDY J. R. (1956*b*). Trombiculid mites infesting birds, reptiles and arthropods in Malaya, with a taxonomic revision, and descriptions of a new genus, two new subgenera, and six new species, *Bull. Raffles Mus.*, *28*, 27-80.

AUDY J. R. (1958). The localization of disease with special reference to the zoonoses. *Trans. R. Soc. trop. Med. Hyg.*, *52*, 308-334.

AUDY J. R., HARRISON J. L. AND WYATT-SMITH J. (1950). A survey of Jarak Island, Straits of Malacca. *Bull. Raffles Mus.*, *23*, 230-261.

CHASEN F. N. (1940). A handlist of Malayan mammals. *Bull. Raffles Mus.*, *15*, 1-209. (Amended & indexed by Ellerman & Morrison-Scott, 1955).

ELLERMAN J. R. AND MORRISON-SCOTT T. C. S. (1955). *Supplement to Chasen (1940). A handlist of Malaysian mammals*. London: British Museum.

GIBSON-HILL C. A. (1949). An annotated checklist of the birds of Malaya. *Bull. Raffles Mus.*, *20*, 1-299.

GLENISTER A. G. (1951). *The Birds of the Malay Peninsula Singapore and Penang*. London: Oxford University Press.

HARRISON J. L. (1957*a*). Malaysian Parasites, XXXIII. The hosts. *Stud. Inst. med. Res. Malaya*, *28*, 409-426.

HARRISON J. L. (1957*b*). Habitat of some Malayan rats. *Proc. zool. Soc. Lond.*, *128*, 1-21.

INSTITUTE FOR MEDICAL RESEARCH, MALAYA (1957). Division of virus research and medical zoology. *Rep. Inst. med. Res. Malaya*, *1956*, 61-73.

KOHLS G. M. (1957). Malaysian Parasites, XVIII. Ticks (Ixodoidea) of Borneo and Malaya. *Stud. Inst. med. Res. Malaya*, *28*, 65-94.

NADCHATRAM M. (1960). Malaysian Parasites, XLVIII. Notes on rearing Malayan Ixodid ticks (Acarina, Ixodidae) with special reference to *Ixodes granulatus* Supino and *Amblyomma geoemydae* (Cantor). *Stud. Inst. med. Res. Malaya*, *29*, 217-224. (This *Study*).

NEUMANN L. G. (1911). Acarina. Ixodidae. *Das Tierreich*, *26*, xvi+1-169.

REID J. A. (1950). Some new records of mosquitoes from the Malay Peninsula with remarks on geographical distribution. *Bull. Raffles Mus.*, *21*, 48-58.

ROBINSON L. E. (1926). The genus *Amblyomma*. *In* Nuttall G. H. F., Warburton C., Cooper W. F., and Robinson L. E. *Ticks: a monograph of the Ixodoidea*. Cambridge University Press.

SMITH C. E. G. (1956). A virus resembling Russian spring-summer encephalitis virus from an ixodid tick in Malaya. *Nature, Lond.*, *178*, 581-582.

SMITH M. A. (1930). The Reptilia and Amphibia of the Malay Peninsula. *Bull. Raffles Mus.*, *3*, 1-149.

TWEEDIE M. W. F. (1950). A note on Pulau Jarak considered as an oceanic island. *Bull. Raffles Mus.*, *23*, 262.

TWEEDIE M. W. F. (1953). *The Snakes of Malaya*. Singapore: Govt. Printing Office.

WARBURTON C. (1933). On five new species of ticks (Arachnida, Ixodoidea). *Ixodes petauristae*, *I. ampullaceus*, *Dermacentor imitans*, *Amblyomma laticaudae* and *Aponomma draconis*, with notes on three previously described species, *Ornithodorus franchinii* Tonelli-Rondelli, *Haemaphysalis cooleyi* Bedford and *Rhipicephalus maculatus* Neumann. *Parasitology*, *24*, 558-568.

WYATT-SMITH J. (1953). The vegetation of Jarak Island, Straits of Malacca. *J. Ecol.*, *41*, 207-225.

ZEUNER F. G. (1941). Geology, climate and faunal distribution in the Malay archipelago. *Proc. R. ent. Soc. Lond.*, (A) *16*, 117-123.

INDEX

Pages with systematic descriptions are shown in bold type; pages with figures are shown in italics. Where a species is mentioned several times in a single paper only the more important references are indexed.

7373—1,000—17-8-60.