

NEW SPECIES OF *THRAULUS* FROM ASIA (LEPTOPHLEBIIDAE : EPHEMEROPTERA)¹

By William L. Peters and Philip T.P. Tsui

Florida A and M University, Tallahassee 32307, USA.

ABSTRACT. Two new species of *Thraulius*, *T. mariae* and *T. hsui*, are described from NE. New Guinea. One new species, *T. maculatus*, is described from northern Thailand, and one new species, *T. bishopi*, is described from West Malaysia. The nymphs and adults are known for each species. A key is included for the nymphs and adults of all known species of *Thraulius*. The evolution of the abdominal gill types of nymphs from NE. New Guinea is discussed.

Peters and Edmunds (1970) revised the genus *Thraulius* thus making it a wide-ranging genus in the Eastern Hemisphere. They discussed three natural groups within the genus, separable only by the shape of the first abdominal gills in the nymphs. Among the specimens included in their study are those described herein as new species from NE. New Guinea and Thailand.

The following terms and procedures used in the species descriptions of the imagos and nymphs require further explanation. Venational terminology used is as given in Peters and Edmunds (1964). Each segment of the fore legs of the male imagos is compared to the length of the fore tibiae and expressed as a ratio, while the average length in millimeters of the fore tibiae is given in parenthesis.

We offer our sincere thanks to Dr. J. L. Gressitt for making the facilities of the B.P. Bishop Museum Field Station, Wau, Territory of Papua and New Guinea, available to the senior author and his wife, and to Mr. and Mrs. Josef Sedlacek of the station for making our trip both successful and enjoyable. Thanks are expressed to Mr. John E. Bishop, University of Malaya, for permission to study his material and for providing biological notes on the new species from West Malaysia. We thank Mrs. William L. Peters for preparation of the illustrations under our supervision.

The following keys will serve to distinguish the imagos and nymphs of all described species of *Thraulius*. In the key to the imagos, all characters are valid for both males and females unless otherwise stated.

1. This research was supported by a grant from the Florida A and M University. Specimens from NE. New Guinea were collected on a trip supported by a grant from the National Science Foundation to the University of Utah, G.F. Edmunds, Jr., Principal Investigator.

IMAGOS

1. Membrane of hind wings partially to entirely pigmented (Figs. 1-3). 2
 Membrane of hind wings hyaline except at base (Figs. 4, 7, 10, 13, 16). 4
2. Basal 0.66 of membrane of hind wings fuscous, color darker near middle of wings forming a median transverse band (Fig. 1); basal 0.33-1.5 of mesothoracic and metathoracic tibiae fuscous. Uganda, Tanzania **T. fasciatus** (Kimmins)
 Membrane of hind wings not marked as above (Figs. 2 and 3); color of mesothoracic and metathoracic tibiae not as above 3
3. Membrane of hind wings chestnut brown, except apex hyaline (Fig. 2); extreme apex and basal 0.66 of mesothoracic and metathoracic tibiae dark brown. Tanzania
 **T. torrentis** (Gillies)
 Basal 0.5 of membrane of hind wings of male yellowish-red (Fig. 3); mesothoracic and metathoracic tibiae of male uniformly yellowish-brown. Sarawak . **T. duliti** (Demoulin)
4. Femora of male uniformly yellowish-brown. Northern India
 **T. semicastaneus** (Gillies)
 Femora with 1 or 2 darker color transverse bands 5
5. Costal projection of hind wings rounded (Fig. 4); tarsi blackish. Europe
 **T. bellus** Eaton
 Costal projection of hind wings acute (Figs. 7, 10, 13, 16); tarsi paler 6
6. Tibiae uniformly black. Comora Islands **T. turbinatus** (Ulmer)
 Tibiae paler 7
7. Tibiae of mesothoracic and metathoracic legs unicolorous or faded only at base . . 8
 Tibiae of mesothoracic and metathoracic legs darker brown at base or at base and apex 9
8. Metathoracic tibiae dark brown, faded at apex; apex of each penis lobe of male genitalia rounded (Fig. 22). West Malaysia **T. bishopi***
 Metathoracic tibiae uniformly light brown; apex of each penis lobe of male genitalia blunt (Figs. 18, 20); NE. New Guinea. **T. hsui***
9. Apical 0.66 of tibiae of mesothoracic and metathoracic legs dark brown, remainder of legs pale; length of penes of male 0.6 length of forceps (Fig. 21). Northern Thailand **T. maculatus***
 Base of tibiae of mesothoracic and metathoracic legs dark brown, and with a narrow, transverse, dark brown, subapical band; length of penes of male a little more than 0.5 length of forceps (Fig. 17). NE. New Guinea **T. mariae***

MATURE NYMPHS

1. Abdominal gills 1-7 similar (Figs. 54-55). 2
 Abdominal gills 1-7 dissimilar (Figs. 53, 56-57, 60-61). 3

* New species.

2. Dorsal portion of lamellae of gills ovate with apical 0.5 of margin fringed, ventral portion of lamellae short, slender, lanceolate (Fig. 54). NE. New Guinea *T. hsui**
 Dorsal and ventral portions of lamellae of gills ovate with apex of margin fringed (Fig. 55). NE. New Guinea *T. mariae**
3. Ventral portion of abdominal gill 1 ovate with margin fringed, dorsal portion long, slender, lanceolate (Fig. 53). Tanzania *T. torrentis** Gillies
 Dorsal and ventral portions of abdominal gill 1 long, slender, lanceolate (Figs. 56, 60) 4
4. Apical 3 denticles on claws minute and set apart from larger more basal denticles (Fig. 52). West Malaysia *T. bishopi**
 Claws without minute, apical denticles (Figs. 49-51). 5
5. Tarsi black; sterna 8-9 entirely pale. Europe. *T. bellus* Eaton
 Tarsi pale; sterna 8-9 with a wide, dark brown, longitudinal, median band. Thailand *T. maculatus**

1. *Thraulus mariae*, sp. nov. (Fig. 5-7, 17, 23-27, 37, 41-42, 49, 55)

Male imago (in alcohol): *Length*: Body, 7.0-7.5 mm; fore wings, 8.3-8.8 mm. Upper portion of eyes purplish-brown, lower portion black. Head brown, anterior margin darker. Antennae light brown. Basal half of ocelli black, apical half white. *Thorax*: brown, carinae darker, sutures paler; lateral and posterior margins of pronotum black; small, paired submedian, black maculae near posterior margin of pronotum; large darker brown maculae on pronotum surrounding inner parapsidal sutures, and near posterolateral margin of scutum; mesoscutellum and metascutellum washed lightly with dark brown. *Wings* (Figs. 5-7): longitudinal and cross veins of fore and hind wings light brown; membrane of fore and hind wings pale yellowish-brown; base and membrane of cells C and Sc of fore wings and base of hind wings darker. *Legs*: ratios of segments in fore legs, 0.65: 1.00 (3.1 mm.): 0.03: 0.32: 0.24: 0.12: 0.07. Coxae dark brown, remainder of legs light brown; femora with wide, transverse, dark brown median and apical bands; base of tibiae dark brown, and with a narrow, transverse, dark brown, subapical band. *Abdomen*: segments 1-7 hyaline; washed with light brown; segments 8-10 light yellowish-brown; posterior margin of terga 1-10 brown as in figures 23-24; terga 1-9 with sublateral, wide, longitudinal, brown bars as in figure 24, bars faded on terga 8 and 9; spiracles and tracheae dark brown; ganglia of sterna 1-4 light brown. *Genitalia* (Fig. 17): penes divided, slender, and tubular, length of penes a little more than 0.5 length of forceps, apex of each penis lobe acute, rounded as in figure 17; genitalia brown, segments 2 and 3 of forceps and penes paler, lateral margins of styliger plate darker brown. Caudal filaments pale, annulations at articulations dark brown, fading in apical 0.33 of caudal filaments.

Female imago (in alcohol): *Length*: Body, 6.5 mm; fore wings, 9.0 mm. Eyes black. Head light brown, carinae washed with darker brown. Antennae

light brown. Basal half of ocelli dark brown, apical half white. *Thorax*: color and markings as in male imago, except pronotum and mesonotum brown, meso-scutellum washed with darker brown. *Wings*: longitudinal veins of fore and hind wings light brown, cross veins and membrane hyaline; apical 0.33 of cells C and Sc of fore wings translucent white. *Legs*: markings as in male imago; femora darker brown, and dark brown bands obscured; remainder of legs washed with brown except apex of tibiae and tarsi of prothoracic legs light brown. *Abdomen*: yellowish-brown; terga 1-10 with brown markings as in figures 25-26; spiracles and tracheae dark brown; sterna 1-7 with light brown color markings as in figure 27; sternum 9 brown. Caudal filaments pale, annulations at articulations dark brown, fading in apical 0.33 of caudal filaments.

Mature nymph (in alcohol): Head brown, washed with darker brown as in male and female imagos. Antennae light brown. Mouthparts (Figs. 37, 41, 42): light brown; dorsal hair on labrum as in figure 42; 5 small, equal sized denticles on anteromedian emargination of labrum (Fig. 41). Segment 2 of maxillary palpi equal to length of segment 1, segment 3 of palpi a little shorter than length of segment 2. Segment 2 of labial palpi equal to length of segment 1, segment 3 of palpi a little longer than 0.5 the length of segment 2. Thorax brown, darker brown markings on anterolateral margins of mesonotum. Legs (Fig. 49): light brown, darker brown markings as in male and female imagos; denticles on claws progressively larger apically, except apical denticle smaller. *Abdomen*: terga brown, sterna light brown; darker brown color markings as in male and female imagos. *Gills* (Fig. 55): gills 1-7 alike; dorsal and ventral portions of lamellae ovate with apex of margin fringed. Caudal filaments light brown.

Holotype ♂ imago, NE. NEW GUINEA: Bulolo Riv., E. of Wau, 2950', 15-27. x.64; *allotopotype* female imago; *paratypes*: 2 male imagos, 23 male subimagos, 2 female imagos, 37 female subimagos, 181 nymphs, same data as for holotype; 2 nymphs, NE. New Guinea: Bulolo Riv., at junc. with Karinga Creek, NW. of Wau, 300', 12.x.64; 23 nymphs, NE. New Guinea: Bulolo Riv., 0.8 mi. downstream from junc. of Bulolo Riv. and Karinga Creek, NW. of Wau, 2800', 12.x.64; 2 nymphs, NE. New Guinea: Hospital Creek, Wau, 3750', 20.x.64. All types are in alcohol, and collected by W. L. and J. G. Peters.

Association of the nymphs and imagos is by rearing. Holotype, allotype, 6 male subimaginal paratypes, 9 female subimaginal paratypes, and 52 nymphal paratypes are deposited in the collections of Florida A & M University. One male imaginal paratype, 1 female imaginal paratype, 6 male subimaginal paratypes, 10 female subimaginal paratypes, and 52 nymphal paratypes are each deposited in the collections of the University of Utah, Salt Lake City, and the B.P. Bishop Museum, Honolulu. Five male subimaginal paratypes, 8 female subimaginal paratypes, and 52 nymphal paratypes are deposited in the collections of the U.S. National Museum.

Thraulius mariae, sp.nov. appears to be most closely related to the other described species of *Thraulius* from NE. New Guinea but can be distinguished from them by the following combination of characters. In the imagos, (1) the length of the penes of the male is a little more than 0.5 the length of the forceps; apex of each penis lobe is acute and rounded (Fig. 17), (2) terga 1-9 of male possess sublateral, wide, longitudinal, brown bars as in figure 24, (3) tibiae of male and female possess a narrow, transverse, dark brown, subapical band, and (4) sterna 1-7 of female possess light brown markings as in figure 27. In the nymphs, (1) abdominal gills 1-7 are alike; dorsal and ventral portions of the lamellae are ovate with the apex of margin fringed (Fig. 55), (2) 5 small, equal sized denticles are present on the anteromedian emargination of the labrum (Fig. 41), and (3) segment 3 of labial palpi is a little longer than 0.5 the length of segment 2.

Etymology : This species is named in honor of Marie Sedlacek, who helped make the field trip of the senior author and his wife to NE. New Guinea both successful and enjoyable.

Biology : Nymphs of *T. mariae* live on the underneath of large flat rocks or on submerged logs in quiet side pools of large rivers to streams. The side pools possess a little water movement and are heavily silted. Nymphs emerge to subimagos after total darkness.

2. *Thraulius hsui*, sp.nov. (Figs. 8-10, 18-20, 28-29, 38, 43-44, 50, 54)

Male imago (in alcohol): *Length* : body, 4.4-5.5 mm; fore wings, 5.5-6.0 mm. Upper portion of eyes purplish-brown, lower portion black. Head dark brown. Scape and pedicel of antennae brown, flagellum paler. Basal half of ocelli blackish-brown, apical half white. *Thorax* : light brown, carinae darker, sutures paler; median longitudinal suture and lateral sides of pronotum washed with dark brown; posterior mesoscutum and mesoscutellum darker, metascutellum and axillary regions of metathorax washed with dark brown. *Wings* (Figs. 8-10) : longitudinal veins of fore wings light brown, faded in cubital-anal area; cross veins and membrane of fore wings hyaline, except membrane of cells C and Sc translucent white and base darker brown; longitudinal veins, cross veins, and membrane of hind wings hyaline, except base dark brown. *Legs* : ratios of segments in fore legs, 0.53:1.00 (1.9 mm.) : 0.08 : 0.27 : 0.21 : 0.09 : 0.08. Coxae of prothoracic legs light brown, coxae of mesothoracic and metathoracic legs dark brown; remainder of legs light brown except femora with wide, transverse, dark brown median and apical bands. *Abdomen* : segments 1-7 hyaline, segments 8-10 yellowish-brown; posterolateral areas of terga 1-8 with a large, dark brown, triangular-shaped mark as in figures 28-29, tergum 9 washed with dark brown except on anteromedian margin, tergum 10 uniformly washed with dark brown; spiracles paler, tracheae darker. *Genitalia* (Figs. 18-20) : penes divided slender, and tubular, length of penes 0.75 the length of forceps, apex of each penis

lobe blunt as in figures 18, 20; genitalia pale except lateral margins of styliger plate washed with dark brown. Caudal filaments pale, annulations at articulations darker brown in basal 0.33 of caudal filaments.

Female imago : Unknown.

Mature nymph (in alcohol) : Head brown, washed with darker brown near ocelli and antennae. Antennae light brown. Mouthparts (Figs. 38, 43-44) : light brown; dorsal hair on labrum as in figure 44; anteromedian emargination of labrum without denticles as in figure 43. Segment 2 of maxillary palpi a little shorter than length of segment 1, segment 3 of palpi a little less than 0.5 the length of segment 2. Segment 2 of labial palpi a little shorter than length of segment 1; segment 3 of palpi 0.75 the length of segment 2. Thorax light brown, darker brown markings on dorsum as in male and female imagos. *Legs* (Fig. 50) : light brown; darker brown color markings as in male and female imagos; denticles on claws progressively larger apically. *Abdomen* : light brown; darker brown color markings as in male and female imagos. *Gills* (Fig. 54) : gills 1-7 alike; dorsal portion of lamellae ovate with apical 0.5 of margin fringed; ventral portion of lamellae short, slender, lanceolate. Caudal filaments light brown.

Holotype male imago, NE. NEW GUINEA : Bulolo Riv., E. of Wau, 2950', 15-27.x.64; *paratypes* : 16 male imagos, 4 male subimagos, 55 nymphs, same data as for holotype; 3 nymphs, NE. New Guinea : Bulolo Riv., at junc. with Karinga Creek, NW. of Wau, 3000', 12.x.64; 10 nymphs, NE. New Guinea: Bulolo Riv., 0.8 mi. downstream from junc. of Bulolo Riv. & Karinga Creek, NW. of Wau, 2800', 12.x.64. All types are in alcohol, and collected by W.L. & J.G. Peters.

Association of the nymphs and imagos is by the color markings on the legs and abdomen. Holotype, 4 male imaginal paratypes, 1 male subimaginal paratype, and 20 nymphal paratypes are deposited in the collection of Florida A & M University. Four male imaginal paratypes, 1 male subimaginal paratype, and 20 nymphal paratypes are each deposited in the collections of the University of Utah and B.P. Bishop Museum. Four male imaginal paratypes, 1 male subimaginal paratype, and 8 nymphal paratypes deposited in the collections of the U.S. National Museum.

Thraululus hsui, sp.nov. appears to be most closely related to the other described species of *Thraululus* from NE. New Guinea but can be distinguished from them by the following combination of characters. In the male imagos, (1) the length of the penes is 0.75 the length of the forceps (Figs. 18-20), (2) posterolateral areas of terga 1-8 possess a large, dark brown, triangular-shaped mark as in figures 28-29, and (3) tibiae are uniformly brown. In the nymphs, (1) abdominal gills 1-7 are alike; dorsal portion of lamellae is ovate with the apical 0.5 of the margin fringed; the ventral portion of the lamellae is short, slender, and lanceolate. (Fig. 54), (2) no denticles occur on the anteromedian emargi-

nation of the labrum (Figs. 43-44), and (3) segment 3 of the labial palpi is 0.75 the length of segment 2.

Etymology : This species is named in honor of Mr. King-Sun Hsu, father of the junior author, who has greatly encouraged the junior author's study of entomology.

Biology : Nymphs of *T. hsui* live on the underneath of rocks in the fastest portions of rivers. Nymphs emerge to subimagos after total darkness. The imagos swarm about five feet above the river in early morning.

3. *Thraulus maculatus*, sp.nov. (Figs. 11-13, 21, 30-32, 39, 45-47, 51, 59)

Male imago (in alcohol) : *Length* : Body, 4.0-4.5 mm., fore wings, 5.0-5.5 mm. Upper portion of eyes light brown, lower portion black. Head brown. Scape and pedicel of antennae light brown, flagellum paler. Basal half of ocelli dark brown, apical half white. *Thorax* : brown, carinae darker, sutures paler; mesoscutum and axillary regions of mesothorax dark brown, metascutellum washed with dark brown. *Wings* (Figs. 11-13) : longitudinal veins of fore and hind wings light brown; cross veins and membrane of fore and hind wings hyaline except base of wings dark brown, membrane of cells C and Sc of fore wings translucent white. *Legs* : ratios of segments in fore legs, 0.64 : 1.00 (1.9 mm.) : 0.04 : 0.36 : 0.28 : 0.16 : 0.08. Coxae and trochanters of legs brown; femora of prothoracic legs light brown, apex paler; basal 0.5 of tibiae of prothoracic legs dark brown, remainder of prothoracic legs pale; femora of mesothoracic and metathoracic legs pale, except for a wide, transverse, brown, median band and a narrow, transverse, brown apical band; apical 0.66 of tibiae of mesothoracic and metathoracic legs dark brown, remainder of legs pale. *Abdomen* : light brown, posterior half of tergum 1 dark brown, terga 2-9 with dark brown markings as in figures 30-31, and forming light brown, sublateral maculae, tergum 10 uniformly dark brown with a light brown posterior macula; spiracles paler, tracheae darker; sterna 2-7 with brown markings as in figure 32, sterna 8-9 with a wide, dark brown, longitudinal, median band, faded on posterior margin of sternum 9. *Genitalia* (Fig. 21) : penes divided, slender, and tubular, length of penes 0.6 length of forceps, apex of each penis lobe rounded as in figure 21; forceps and penes brown, apex paler. Caudal filaments broken off and missing.

Female imago : Unknown.

Mature nymph (in alcohol) : Head brown. Antennae light brown. Mouthparts (Figs. 39, 45-47) : light brown, dorsal and ventral hair on labrum as in figures 46-47; anteromedian emargination of labrum without denticles as in figure 45. Segment 2 of maxillary palpi a little shorter than length of segment 1, segment 3 of palpi a little shorter than length of segment 2. Segment 2 of labial palpi 0.8 the length of segment 1, segment 3 of palpi a little more than 0.75 the length of segment 2. *Thorax* light brown, darker brown markings as in male imago. Legs (Fig.

51) : light brown, darker brown markings as in male imago except bands on femora faded; denticles on claws about equal length. *Abdomen* : light brown; darker brown color markings as in male imago. *Gills* (Fig. 59) : gills 1-7 dissimilar; dorsal and ventral portions of gill 1 long, slender, lanceolate; dorsal and ventral portions of gills 2-7 ovate with entire margin fringed (Fig. 59). Caudal filaments light brown.

Holotype male imago, THAILAND : Chiangmai Prov., Doi Duang Chaing Dao, 15.xi.62, A. Dean Stock; *paratopotypes*, 2 male imagos, 1 nymph. All types are in alcohol. Association of the nymphs and imagos is by the color markings on the legs and abdomen. Holotype and 1 nymphal paratopotype are deposited in the collections of the University of Utah. One male paratopotype each is deposited in the collections of Florida A & M University and the B.P. Bishop Museum.

Thraululus maculatus, sp.nov. can be distinguished from all other described species of *Thraululus* by the following combination of characters. In the male imagos, (1) the length of the penes is 0.6 the length of the forceps (Fig. 21), (2) terga 2-9 possess light brown, sublateral maculae (Figs. 30-31), (3) the apical 0.66 of the tibiae of the mesothoracic and metathoracic legs are dark brown, while the remainder of the legs is pale, and (4) the membrane of the fore and hind wings is hyaline, except the base of the fore and hind wings is dark brown (Figs. 11-13). In the nymphs, (1) abdominal gills 1-7 are dissimilar; dorsal and ventral portions of gill 1 are long, slender, lanceolate (Fig. 59), (2) no denticles occur on the anteromedian emargination of the labrum (Fig. 45), and (3) segment 3 of the labial palpi is a little more than 3/4 length of segment 2.

Etymology : macula, L. meaning spot.

Biology : Unknown.

4. *Thraululus bishopi*, sp. nov. (Figs. 14-16, 22, 33-36, 40, 48, 52, 60-61)

Male imago (in alcohol): *Length*: body, 5.3 mm.; fore wings, 5.5 mm. Upper portion of eyes brown, lower portion black. Head dark brown. Antennae light brown. Basal half of ocelli dark brown, apical half white. *Thorax* : dark brown, sterna paler, carinae darker, sutures paler. *Wings* (Figs. 14-16) : longitudinal and cross veins of fore and hind wings light brown, cross veins hyaline; membrane of fore and hind wings hyaline light brown, membrane of cells C and Sc of fore wings translucent light brown, base of fore wings dark brown, base and basal 0.33 of cell C of hind wings dark brown. *Legs* : ratios of segments in fore legs, 0.76 : 1.00 (1.5 mm.) : 0.08 0.24 : 0.20 : 0.16 : 0.16. Mesothoracic legs broken off and missing. Coxae and trochanters of prothoracic and metathoracic legs brown; femora of prothoracic legs light brown, basal 0.5 of tibiae of prothoracic legs dark brown, remainder of prothoracic legs light brown; femora of metathoracic legs light brown, a wide, transverse, darker brown band near middle of femora, and a narrower,

transverse, darker brown band at apex of femora, tibiae dark brown, faded near apex, remainder of metathoracic legs light brown. *Abdomen* : segment 1-7 hyaline, washed with light brown; segments 8-10 light brown; terga 3-8 with a large, median, rectangular, dark brown mark as in figure 33; terga 8-9 with a wide, dark brown bar at lateral margins as in figure 34; median mark and lateral bar on tergum 9 fused to make a dark brown W-shape mark; spiracles and tracheae dark brown. *Genitalia* (Fig. 22) : penes divided, slender, and tubular, length of penes a little less than 0.75 the length of forceps, apex of each penis lobe rounded as in figure 22; forceps brown, styliger plate light brown, lateral margins dark brown, penes pale. Caudal filaments broken off and missing.

Female imago (in alcohol) : *Length* : body, 4.0 mm.; fore wings, 5.2 mm. Eyes black. Head brown, darker between lateral ocelli. Antennae light brown. Basal half of ocelli black, apical half white. *Thorax* : brown, carinae darker, sutures lighter. *Wings* : color of longitudinal veins, cross veins, and membrane of fore and hind wings as in male imago, except apical 1/3 of cell C of hind wings lighter brown. *Legs* : light brown, tibiae darker. *Abdomen* : terga brown; terga 2-8 with light brown markings as in figures 35-36; spiracles pale, tracheae brown; sterna light brown. Caudal filaments broken off and missing.

Mature nymph (in alcohol) : Head and antennae light brown. Mouthparts (Figs. 40, 48) : light brown; dorsal hair on labrum as in figure 48; no denticles on anteromedian emargination of labrum. Segment 2 of maxillary palpi a little shorter than length of segment 1, segment 3 of palpi 0.66 the length of segment 2. Segment 2 of labial palpi equal to length of segment 1, segment 3 of palpi a little shorter than length of segment 2. *Thorax* light brown. *Legs* (Fig. 52) : light brown, tibiae dark brown as in male and female imagos; denticles on claws about equal length, except apical 3 denticles minute and set apart from larger more basal denticles. *Abdomen* : light brown, darker brown color markings as in male and female imagos. *Gills* (Figs. 60-61) : gills 1-7 dissimilar; dorsal and ventral portions of gill 1 long, slender, lanceolate (Fig. 60); dorsal and ventral portions of gills 2-7 ovate with entire margin fringed (Fig. 61). Caudal filaments light brown.

Holotype male imago, WEST MALAYSIA : Gombak Riv., Univ. of Malaya Field Studies Center, 16 1/2 mi N. of Kuala Lumpur on Bentong road, v.68; *allotype* female imago, West Malaysia : Gombak Riv., 4 1/2 mi N. of Kuala Lumpur on Bentong road, 25.viii.69; *paratypes* : 1 male subimago, West Malaysia: Gombak Riv., 4 1/2 mi N. of Kuala Lumpur on Bentong road, 25.viii.69; 1 nymph, West Malaysia: Gombak Riv., 6 1/2 mi N. of Kuala Lumpur on Bentong road, 14.xi.68; 1 nymph, West Malaysia : Trib. of Gombak Riv., 21 mi. N. of Kuala Lumpur on Bentong road, 16.iii.70. All types are in alcohol, and collected by J.E. Bishop. Association of the nymphs and imagos is by the color markings on the legs and abdomen of specimens collected at the same locality. Holotype, allotype, and 1 nymphal paratype are deposited in the collections of Florida A & M University. One male subimaginal

paratype and 1 nymphal paratype are deposited in the collections of the University of Utah.

The illustration of gill 1 (Fig. 60) was made from a young nymph and is probably not typical. Gill 1 is very slender, and longer than gill 4, in most described species.

Thraulius bishopi, sp. nov. can be distinguished from all other described species of *Thraulius* by the following combination of characters. In the imagos, (1) the length of the penes of the male is a little less than 0.75 the length of the forceps; apex of each penis lobe is rounded (Fig. 22), (2) the basal 0.33 of cell C of the hind wings of the male and female is dark brown to brown (Figs. 15-16), (3) terga 3-8 of the male possess a large, median, rectangular, dark brown mark as in figures 33-34, and (4) terga of the female are brown; terga 2-8 of the female possess light brown markings as in figures 35-36. In the nymphs, (1) abdominal gills 1-7 are dissimilar, dorsal and ventral portions of gill 1 are long, slender, lanceolate (Fig. 60), (2) no denticles occur on the anteromedian emargination of the labrum (Fig. 48), and (3) segment 3 of the labial palpi is equal to length of segment 2.

Etymology: This species is named in honor of Mr. John E. Bishop, University of Malaya, who collected the specimens.

Biology: The nymphs of *Thraulius bishopi* are found in the upland jungle areas (water temperature range 21-24°C) and lowland reaches (water temperature range 24-31°C) of the Gombak River. The species is restricted to sandy-gravel areas around the bases of boulders and rooted banks in the shaded forest reaches where current effects (1-2 m/sec) on the stability of the substrate are minimal. Grain size in these areas range from 1-4 mm, but coarser gravels and organic detritus may also occur. In the lowland open areas, more silt and organic matter is found among the slightly smaller sand particles (0.5-2.0 mm). that make up the common habitat along slow reaches (<1 m/sec) of the river. There are no emergent aquatics in either area and nymphs seem to avoid the root habitat, adjacent to the sand, at the higher stations. O₂ saturations are ≈95 % in the upper reaches and rarely drop below 75 % in the slightly polluted areas lower down. Nymphs appear to be present throughout the year. All subimagos and imagos were collected in an emergence trap.

EVOLUTION OF GILL TYPES AMONG THE NE. NEW GUINEA SPECIES

Peters and Edmunds (1970) noted three natural groups within the genus, separable only in the nymphs by the shape of the first abdominal gills. The function of the three types of gill is unknown. Nymphs of the various groups live in a variety of habitats from lakes to torrential streams. No correlation appears to exist between type of first abdominal gill and habitat. In fact Verrier (1948, 1953) reported *T. bellus* to occur in lakes and fairly fast flowing streams, both with extremely different oxygen levels.

Peters and Edmunds (1970) indicated that abdominal gills 2-7 were similar in the three natural groups. However, closer examination of the NE. New Guinea species, some of which are described herein, revealed three types of gills.

The nymphs of *T. hsui* possess gills 2-7 with the dorsal portion of the lamellae ovate and the ventral portion short, slender, and lanceolate (Fig. 54). The ovate dorsal portion has the apical 0.5 of the margin fringed. Gills 1-7 are alike. Nymphs of *T. hsui* live in the fastest portions of rivers.

The nymphs of *T. mariae* possess gills 2-7 with the dorsal and ventral portions of the lamellae ovate with the apex of the margin fringed (Fig. 55). The ventral portion is a little smaller than the dorsal portion. Gills 1-7 are alike. Nymphs of *T. mariae* occur in quiet side pools of large rivers and streams. These pools possess a little water movement and are heavily silted.

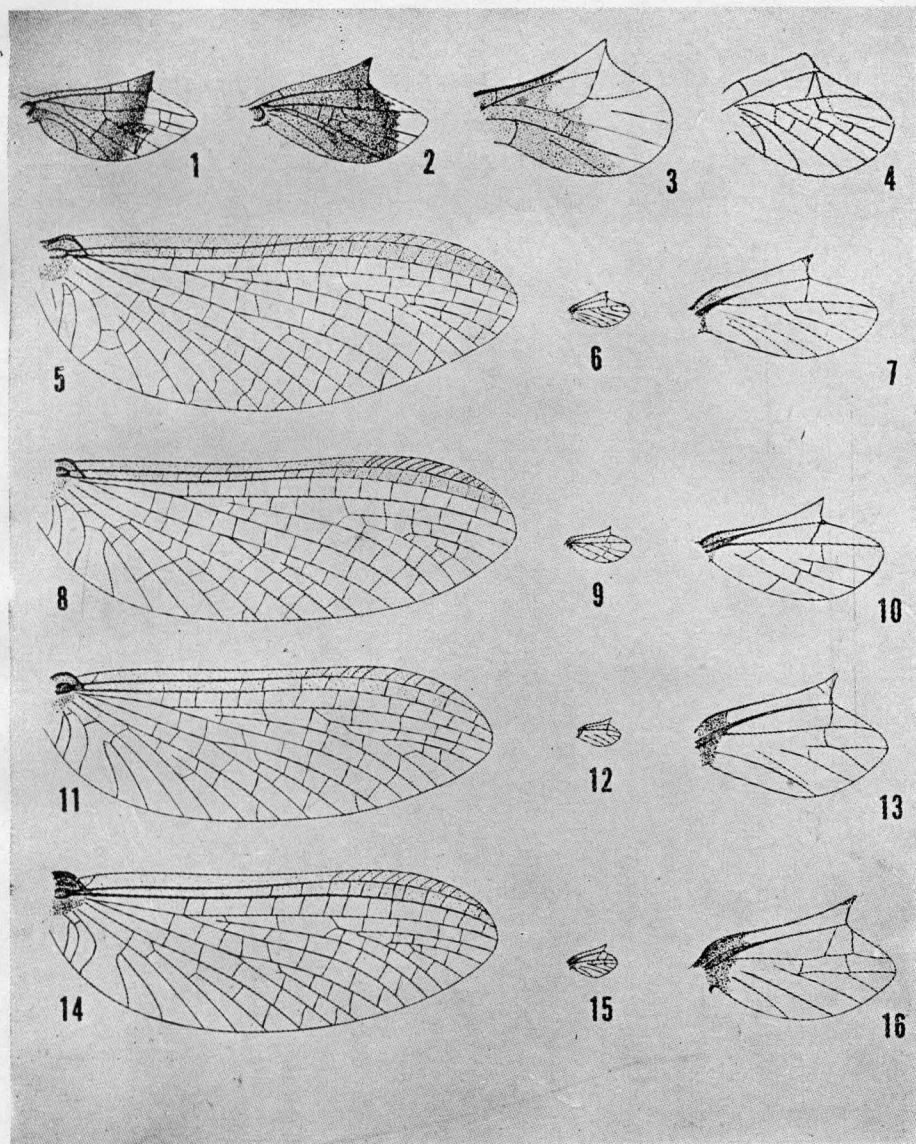
The nymphs of two undescribed species of *Thraulius* from NE. New Guinea possess gills 2-7 with the dorsal and ventral portions of the lamellae ovate and with the entire margin fringed (Fig. 57). Gills 1-7 of one species are alike while gills 1-7 of the other species are dissimilar. The first gills of the latter species possess dorsal and ventral lamellae that are long and slender (Fig. 56). Nymphs of both species occur in quiet side pools of large rivers and streams where there is no water movement. The habitat is heavily silted.

The nymphs of another undescribed species of *Thraulius* from NE. New Guinea possess dissimilar gills 1-7 like those of the second undescribed species discussed above (Fig. 58). Nymphs of this third species were collected from a high altitude pond. None of the three undescribed species discussed are named and described in this paper as all three species are known only from the nymphs.

The amount of water movement in the habitat appears to correlate with the type of abdominal gills 2-7. *Thraulius hsui*, *T. mariae*, and the first undescribed species discussed are all probably closely related. The undescribed species possesses well developed, plesiomorphic gills 2-7 for standing water, while *T. mariae* has more reduced and apomorphic gills 2-7 for slowly moving water. *Thraulius hsui* possesses the most reduced and apomorphic gills 2-7 for fast moving water. The two undescribed species with gills 1-7 dissimilar probably represent a separate line of evolution from the other species discussed, but both possess well developed gills 2-7 and live in quiet water. The correlation of movement of water and the type of gills 2-7 is probably explained by the amount of oxygen in the habitat. In habitats with an abundance of oxygen less gill surface is required for oxygen uptake, while in still water habitats a greater amount of gill surface is required for oxygen uptake. No morphological protective device for the gills was observed among species of *Thraulius* living in quiet and silted habitats. These protective devices are common among other groups of mayflies.

REFERENCES

- PETERS, W.L. and G. F. EDMUNDS, Jr. 1964. A revision of the generic classification of the Ethiopian Leptophlebiidae (Ephemeroptera). *Trans. Roy. Ent. Soc. London* **116** : 225-253, 141 figs.
- PETERS, W.L. and G.F. EDMUNDS, Jr. 1970. A revision of the generic classification of the Eastern Hemisphere Leptophlebiidae (Ephemeroptera). *Pacific Ins.* **12** (1) : 157-240, 357 figs.
- VERRIER, M.L. 1948. Note écologique sur *Thraulius bellus* Etn. (Ephemeroptera). *Feuille Natur., N.S.* **3** : 59.
- VERRIER, M.L. 1953. Note biogéographique sur *Thraulius bellus* Etn. (Ephemeroptera). *Bull. Soc. Ent. France* **58** : 54-55.



Figs. 1-4, hind wings enlarged : 1, *Thraulius fasciatus*; 2, *T. torrentis*; 3, *T. duliti* (redrawn from Demoulin, 1954); 4, *T. bellus* (after Edmunds, 1950). Figs. 5-7, *T. mariae* : 5, fore wing; 6, hind wing; 7, hind wing enlarged. Figs. 8-10, *T. hsui* : 8, fore wing; 9, hind wing; 10, hind wing enlarged. Figs. 11-13, *T. maculatus* : 11, fore wing; 12, hind wing; 13, hind wing enlarged. Figs. 14-16, *T. bishopi* : 14, fore wing; 15, hind wing; 16, hind wing enlarged.

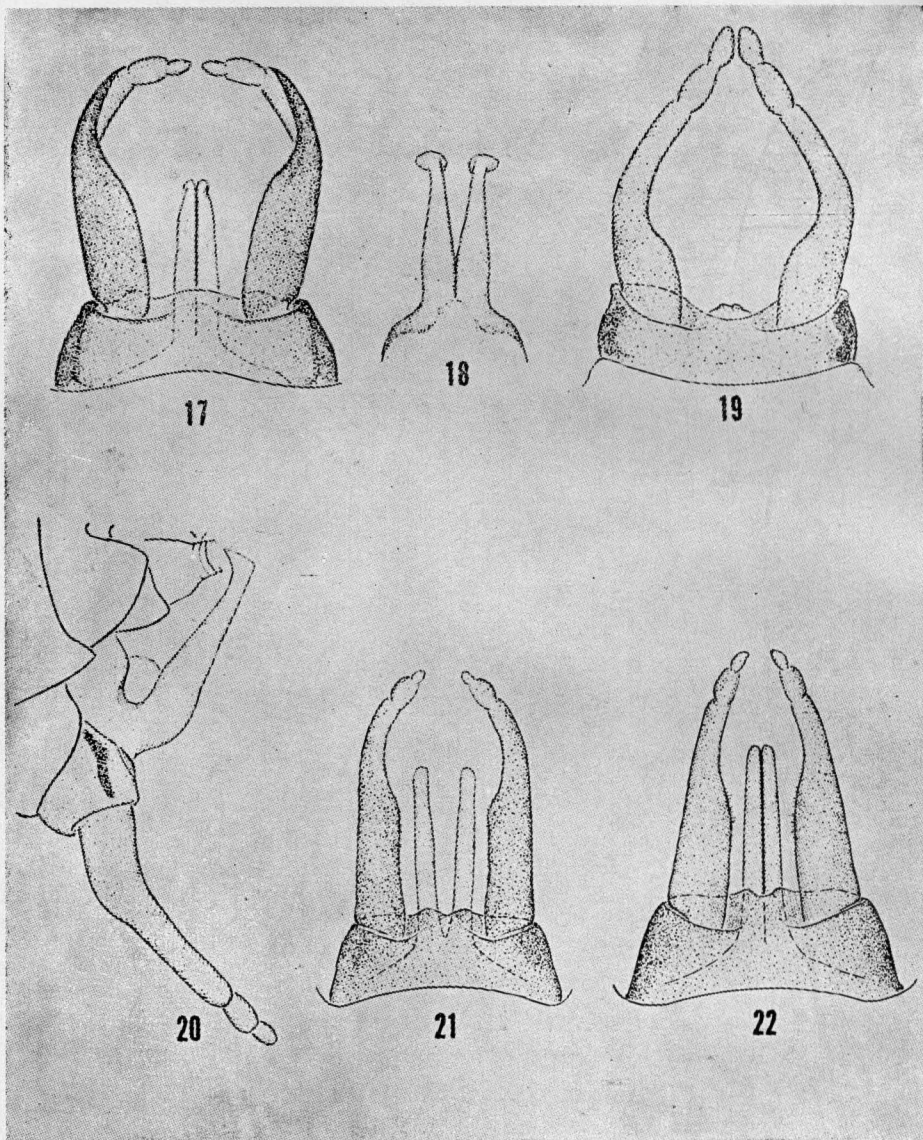
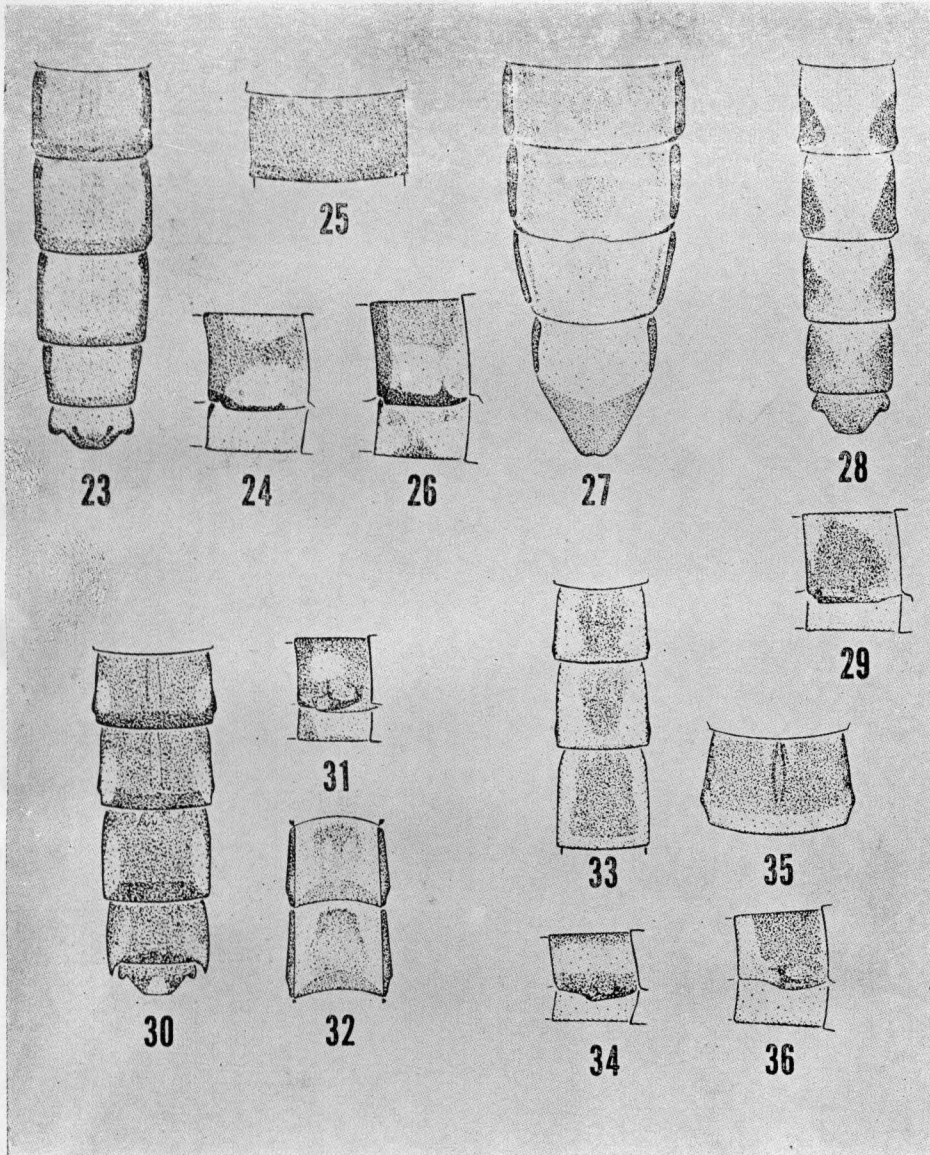
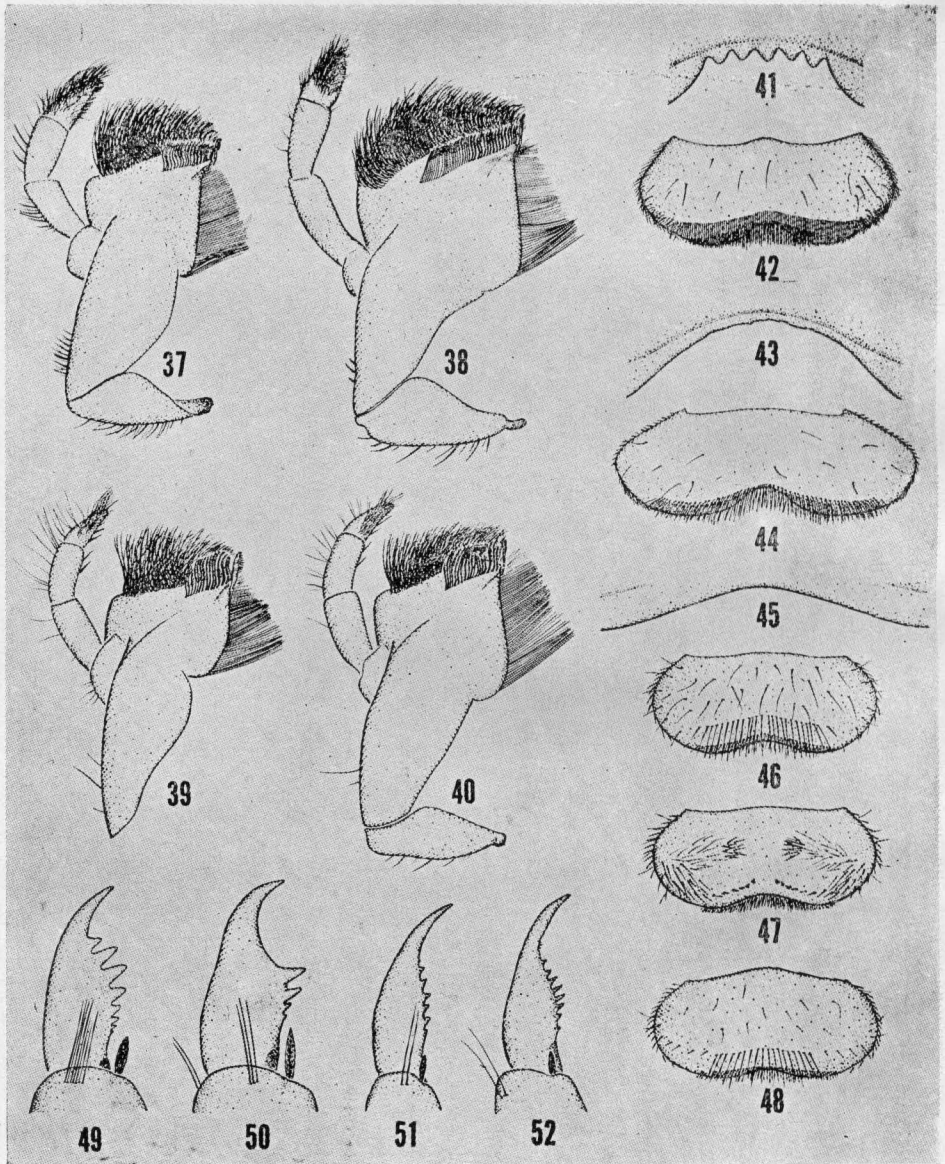


Fig. 17, genitalia of ♂ of *Thraulius mariae*, ventral view. Figs. 18-20, genitalia of ♂ of *T. hsui*: 18, penes, ventral view; 19, forceps, ventral view; 20, lateral view. Fig. 21, genitalia of ♂ of *T. maculatus*, ventral view. Fig. 22, genitalia of ♂ of *T. bishopi*, ventral view.



Figs. 23-27, *Thraulius mariae* : 23, segments 6-10 of ♂, dorsal view; 24, segment 6 of ♀, lateral view; 25, segment 6 of ♀, dorsal view; 26, segment 6 of ♀, lateral view; 27, segments 6-9 of ♀, ventral view. Figs. 28-29, *T. hsui*, ♂ : 28, segments 6-10, dorsal view; 29, segment 6, lateral view. Figs. 30-32, *T. maculatus*, ♂ : 30, segments 6-10, dorsal view; 31, segment 6, lateral view; 32, segments 5-6, ventral view. Figs. 33-36, *T. bishopi*; 33, segments 5-7 of ♂, dorsal view; 34, segment 6 of ♂, lateral view; 35, segment 6 of ♀, dorsal view; 36, segment 6 of ♀, lateral view.



Figs. 37-40, ventral view of right maxilla of nymph : 37, *Thraulius mariae*; 38, *T. hsui*; 39, *T. maculatus*; 40, *T. bishopi*. Figs. 41-42, *T. mariae*, nymph : 41, anteromedian emargination of labrum enlarged; 42, labrum. Figs. 43-44, *T. hsui*, nymph : 43, anteromedian emargination of labrum enlarged; 44, labrum. Figs. 45-47, *T. maculatus*, nymph : 45, anteromedian emargination of labrum enlarged; 46, labrum, dorsal view; 47, ventral view. Fig. 48, labrum of nymph of *T. bishopi* (anteromedian emargination and ventral surface similar to *T. maculatus*). Figs. 49-52, tarsal claw of nymph : 49, *T. mariae*; 50, *T. hsui*; 51, *T. maculatus*; 52, *T. bishopi*.

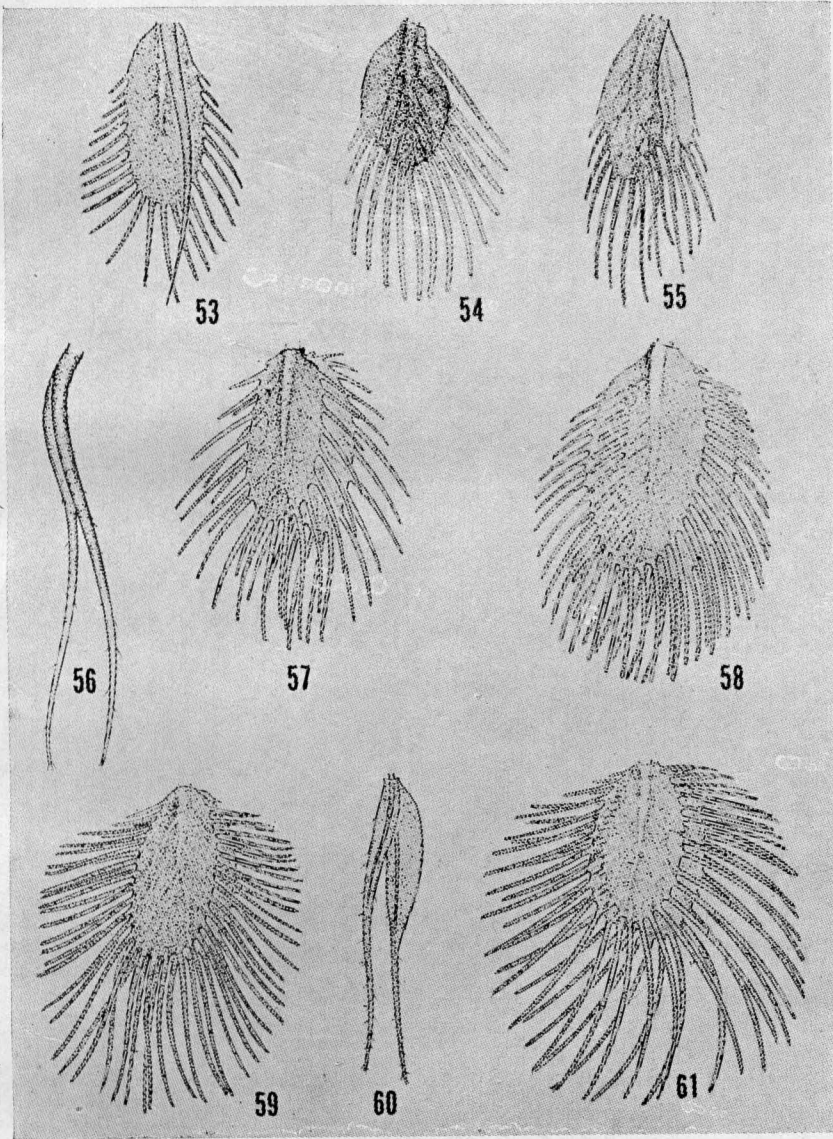


Fig. 53, *Thraulius torrentis*, gill 1 of nymph. Fig. 54, *T. hsui*, gill 4 of nymph. Fig. 55, *T. mariae*, gill 4 of nymph. Figs. 56-57, *Thraulius* sp. from side pool of Bulolo River, Wau, NE. New Guinea, nymph : 56, gill 1; 57, gill 4. Fig. 58, *Thraulius* sp. from pond at Edie Creek Camp, NE. New Guinea, gill 4 of nymph. Fig. 59, *T. maculatus*, gill 4 of nymph. Figs. 60-61, *T. bishopi*, nymph : 60, gill 1; 61, gill 4.