

**Description of Four New Genera of *Thraulius*  
Group Mayflies from the Eastern Hemisphere  
and Redescription of *Simothraulius*  
and *Chiusanophlebia* (Ephemeroptera:  
Leptophlebiidae: Atalophlebiinae)**

PETER M. GRANT

*Department of Biological Sciences  
Southwestern Oklahoma State University,  
Weatherford, OK 73096 USA*

and

WILLIAM L. PETERS

*Entomology, Agricultural Research Programs  
Florida A & M University  
Tallahassee, FL 32307 USA*

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## ABSTRACT

Four new genera of *Thraulius* group mayflies (Ephemeroptera: Leptophlebiidae: Atalophlebiinae) from Malaysia, Papua New Guinea, and the Philippines are established based on external morphological characters. All known life stages are described, diagnostic characters are illustrated, and keys to polytypic genera are provided. These four new genera comprise six species, four of which were previously assigned to *Thraulius* and two of which are new. The genera *Simothraulius* from Malaysia and *Chiusanophlebia* from Japan are also redescribed. *Thraulius* group mayflies possess three derived character states: an oblique cross vein is located in the fore wings between veins  $R^{4+5}$  and  $MA^1$ , just apical to the fork in vein  $MA$ ; vein  $MA$  of the fore wings is symmetrically forked; and the gills are fimbriate.

## INTRODUCTION

The mayfly family Leptophlebiidae (Ephemeroptera) is an extremely diverse group. In the Eastern Hemisphere alone over 60 genera are known from the collected works of Campbell and Suter (1988), Demoulin (1955, 1973), Peters and Edmunds (1970), Peters and Peters (1979-1980, 1981a, 1981b), Peters et al. (1978), Riek (1970), Towns (1978), Towns and Peters (1979a, 1979b), and Uèno (1969). Prior to 1970, research on Eastern Hemisphere leptophlebiid genera was hampered because the generic limits of most were poorly defined; sometimes it was impossible to even place a species in the proper genus (Peters and Edmunds, 1970). The redefinition of 12 Ethiopian genera (Peters and Edmunds, 1964; Peters et al., 1964) and a later, more comprehensive redefinition of an additional 18 Eastern Hemisphere genera (Peters and Edmunds, 1970) provided a solid basis for future leptophlebiid studies.

The leptophlebiid genus *Thraulius* is widespread throughout the Eastern Hemisphere, being found in Europe, southern Africa, Madagascar, Comoro Islands, India, southeastern Asia, Australia, and the Indo-West Pacific. Since Eaton established *Thraulius* in 1881, 45 species have been assigned to this genus at one time or another.

The purpose of our study was to revise *Thraulius* and the related genera *Simothraulius* and *Chiusanophlebia*, using external morphological characters. Our findings show that *Thraulius* is actually a group of closely related genera (the *Thraulius* group), which consists of *Thraulius* with its eight nominal species from

Europe, Africa, India, Malaysia and Thailand; the monotypic *Simothraulius* from Malaysia; *Chiusanophlebia* from Japan, which is also monotypic; and four new genera from Malaysia, Papua New Guinea and the Philippines, which include four species previously assigned to *Thraulius* and two new species.

Based on our studies, the following combination of derived character states defines the *Thraulius* group: an oblique cross vein is located in the fore wings between veins  $R^{4+5}$  and  $MA^1$ , just apical to the fork of vein  $MA$  (Figs. 1, 3, 5, 7, 9, 12); in the fore wings vein  $MA$  is symmetrically forked (Figs. 1, 3, 5, 7, 9, 12); and the abdominal gills of the nymphs are fimbriate (Figs. 74-79). Outgroups used to determine derived character states included representatives of Siphonuridae, Ephemerellidae, Ephemeroidea, and the leptophlebiid genera *Atalophlebiodes*, *Choroterpes* (*Euthraulius*), *Indialis*, *Megaglena*, *Nathanella*, *Notophlebia*, and *Paraleptophlebia*.

In this paper we describe four new genera and two new species of *Thraulius* group mayflies and redescribe *Chiusanophlebia* and *Simothraulius*. The revision of *Thraulius* (*sensu stricto*) and a phylogenetic analysis of the *Thraulius* group taxa will be examined in another paper.

#### METHODS AND TYPE DEPOSITION

All measurements are reported in millimeters. The range of values for any measurement of a specific character is followed by a number in parentheses, which indicates the number of specimens measured. When only one specimen was measured, a range of values may still be reported. In this case, paired structures were measured (e.g., both fore wings, both hind wings).

When measuring the length, width, or height of structures with non-parallel surfaces, the maximum dimension was measured.

Where greater accuracy is needed for identification, ratios are reported in decimals; otherwise they are reported as fractions.

Information on the labels associated with the holotype is reported exactly as it appeared on the labels: slashes ("/") separate each line of a label, and semicolons separate the information on individual labels. Information within brackets indicates our additions or comments that are not part of the original label.

In the "Type Data" section of a species description, a two digit number preceded by a "#" and enclosed in parentheses indicates the collection number.

All slides made by us were coded as follows: PMG-198X-THR00. "PMG" are the initials of the senior author, 198x is the year the slide was made, "THR" refers to this *Thraulius* group revision, and "00" indicates the individual slide number. Specimens, from which parts were dissected and mounted on slides, have associating labels identifying the part that is on a slide and the code number of that slide. All specimens discussed were examined by us unless otherwise stated.

The criteria of Peters and Edmunds (1970), for establishing new genera in the Ephemeroptera, are followed.

The following abbreviations are used to designate depositories of type specimens and specimens examined: BPBM, Bernice P. Bishop Museum, Honolulu, Hawaii, USA; FAMU, Florida A&M University, Tallahassee, Florida, USA; IRSN, Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium; USNM, United States National Museum, Washington, D. C., USA; UU, University of Utah, Salt Lake City, Utah, USA; ZIZM, Zoologisches Institut und Zoologisches Museum, Hamburg, Germany; and, ZMC, Zoologisk Museum, Copenhagen, Denmark.

## CHARACTERS AND TERMINOLOGY

This study was based on the examination of the external morphology of male and female adults (i.e., subimagos and imagos) and nymphs. The characters and terminology used in this revision were discussed in previous studies by Peters and Edmunds (1970), Tsui and Peters (1975) (especially thoracic morphology), Towns and Peters (1980), Pescador and Peters (1980), and Savage and Peters (1983). A discussion of selected characters follows.

*Adults*

The position of the fork of the longitudinal veins of the fore wings was calculated by determining the location of the fork in relation to the length of the longitudinal vein, as measured from the base of the longitudinal vein to the point on the wing margin midway between the apexes of the arms of the fork. This midpoint corresponded to the apex of vein IMA for the vein MA fork and vein IMP for the vein MP fork.

The strongly oblique cross vein between veins  $R^{4+5}$  and  $MA^1$  was quite apparent and its obliqueness was easily determined by comparison with adjacent cross veins in the same cell.

The position of the costal projection of the hind wings was calculated by determining the location of the apex of the costal projection, as measured from the base of the wings, in relation to the length of the hind wings.

The term pharate subimago refers to a subimago within a final nymphal instar cuticle; pharate imago refers to an imago within a subimaginal cuticle.

*Nymphs*

The nymphal descriptions provided here will work for nymphs of all ages, unless otherwise stated.

We recommend that a labrum, separated from the clypeus, be examined on a slide to properly view the anterior emargination and its denticles. Occasionally, when the labrum and clypeus were mounted attached to one other, the labrum did not flatten sufficiently for the anterior emargination to be viewed.

Terms for the surfaces of the legs of Ephemeroptera have not been formally established. The decision to identify a leg surface as dorsal/ventral or anterior/posterior may be obvious to the describer, but may not be so clear to the reader. To alleviate such a potential problem in this study, we provided Figs. 65-66 which show how we identified the dorsal and ventral surfaces, inner and outer margins, and the dorsal and ventral edges of the nymphal legs. These figures and their terms were provided solely to locate the nymphal setae referred to in our descriptions.

KEY TO GENERA FOR IMAGOS OF THE *THRAULUS* GROUP

1. Without hind wings ..... *Chiusanophlebia*  
 With hind wings ..... 2
2. Costal projection of hind wings bluntly rounded (Figs. 6, 13) ..... 3  
 Costal projection of hind wings acute or acutely rounded (Figs. 2, 4, 8, 10-11)  
 ..... 4

3. Costal projection of hind wings located near apex of wings (Fig. 6); upper portion of eyes contiguous mesally; segment 1 of genital forceps narrows abruptly apically (as in Fig. 26)..... *Simothraulus*  
 Costal projection of hind wings located 2/5-1/2 distance from base to apex of wings (Fig. 13); upper portion of eyes separated by ca. 1/2 times width of an upper portion; segment 1 of genital forceps narrows gradually apically (Fig. 29)..... *Thraulus* (in part)
4. Hind wings with a large costal projection and with 2 longitudinal veins posterior to vein C; apex of veins Sc and R of hind wings meet at same point on wing margin (Fig. 8)..... *Magnilobus* NEW GENUS  
 Hind wings with a small costal projection and with more than 2 longitudinal veins posterior to vein C; apex of veins Sc and R of hind wings do not meet apically at wing margin (Figs. 2, 4, 10-11)..... 5
5. Hind wings robust with apical and posterior areas expanded (Figs. 10-11); upper portion of male eyes subquadrate in dorsal view; lateral margin of apical 1/2 of penes divergent (Figs. 31-32); apex of penes expanded, with a large laterally projecting beak-like structure (Figs. 31-33).....  
 ..... *Sulu* NEW GENUS  
 Hind wings without apical and posterior areas expanded (Figs. 2, 4); upper portion of male eyes subcircular to oval in dorsal view; lateral margin of apical 1/2 of penes parallel or convergent (Figs. 18-21, 23, 25-26); apex of penes rounded or expanded but without large laterally projecting beak-like structure (Figs. 18-21, 23-27)..... 6
6. Segment 1 of genital forceps narrows abruptly at ca. 1/3 distance from base to apex (Fig. 22); major axis of upper portion of male eyes nearly perpendicular to longitudinal body axis; dorsal spine-like setae on penes restricted to apical area (Fig. 24)..... *Nonnullidens* NEW GENUS  
 Segment 1 of genital forceps narrows abruptly at ca. 1/2 distance from base to apex (Figs. 20, 26); major axis of upper portion of male eyes oblique to ca. parallel to longitudinal body axis; dorsal spine-like setae on penes variable (Figs. 18, 21)..... 7
7. Upper portion of male eyes subcircular; lateral ocelli with anteromesal area expanded; apex of sternum 9 of female truncate with shallowly rounded median emargination (Fig. 37); penes with dorsal spine-like setae scattered along lateral margin (Fig. 18)..... *Barba* NEW GENUS  
 Upper portion of male eyes oval-suboval; lateral ocelli without anteromesal area expanded; apex of sternum 9 of female rounded (Fig. 38); penes with dorsal spine-like setae in longitudinal rows (Fig. 21), scattered apically (as in Fig. 27), or absent..... *Thraulus* (in part)

Key to Genera for Nymphs of the *Thraulus* Group  
(Nymphs of *Chiusanophlebia*, *Magnilobus*, *Simothraulus*, and *Sulu* are unknown.)

1. Ventral lamella of abdominal gills 2-7 greatly reduced (Figs. 77-79); labrum with posterior margin strongly convex (labrum appears triangular) (Figs. 44, 46); labrum with 4 rows of dorsal setae; lateral margin of mandibles strongly rounded (Fig. 48); claws stout, with 4-5 denticles (Fig. 63) . . . . .  
 . . . . . *Nonnullidens* NEW GENUS  
 Ventral lamella of abdominal gills 2-7 subequal to slightly larger than dorsal lamella (Figs. 74-76); labrum with posterior margin slightly convex (labrum appears oval) (Figs. 39-42); labrum with 2-3 rows of dorsal setae; lateral margin of mandibles weakly rounded (Figs. 47, 49); claws narrow, more than 5 denticles (Figs. 62, 64) . . . . . 2
  
2. Abdominal gills 2-7 with margins of apical 1/3 fimbriate (Fig. 76); width of labrum greater than width of clypeus (Fig. 41); lateral margin of arms of superlingua without projections (Fig. 52); long fine setae in band on venter of labrum near anterior margin (as in Fig. 46); submentum with lateral and sublateral setae (Fig. 56) . . . . . *Barba* NEW GENUS  
 Abdominal gills 2-7 with entire margins fimbriate (Fig. 75) (in *T. turbinatus*, entire inner margin and apical 1/2 of outer margin fimbriate [Fig. 74]); width of labrum equal to or less than width of clypeus (Fig. 39); lateral margin of arms of superlingua with a projection (Fig. 50); 1-2 pairs of rows of short stout setae on venter of labrum near anterior margin (Fig. 40); submentum with lateral setae only (Fig. 55) . . . . . *Thraulus*

### SIMOTHRAULUS Ulmer, 1939

Figs. 5-6, 35-36

*Simothraulus* Ulmer, 1939:508-509; Peters and Edmunds, 1970:207-208. *nec Simothraulus* Ulmer; Demoulin 1969:236.

*Imago*.— Lengths of male: body, ca. 6.4; fore wings, 7.5. Female unknown.

**Head.** *Eyes*: Upper portion contiguous mesally. *Ocelli*: Lateral ocelli contiguous with upper portion of eyes laterally.

**Thorax.** *Fore wings* (Fig. 5) without narrow, dark transverse band at base; with oblique cross vein between veins R<sup>4+5</sup> and MA<sup>1</sup> just apical to MA fork; [the remaining fore wing characteristics were obtained from Ulmer's (1939) Fig. 74] vein Rs forked 0.3 distance from base of vein to apex; vein MA forked 0.6 distance from base of vein to apex; vein MP forked 0.3 distance from base of vein to apex, fork asymmetrical, base of vein MP<sup>2</sup> attached to MP<sup>1</sup> by cross vein; length of fore wings 3.0 times width. *Hind wings* (Fig. 6) [broken off and missing, the following description is based on Ulmer's (1939) description and his Fig. 75] base of wings darkly pigmented; costal projection rounded, located 0.9 distance from base to apex of wings; apex of wings bluntly rounded. *Legs*: [Broken off and missing].

**Genitalia.** *Forceps* segment 1 with basal 1/2 wide, apical 1/2 narrow; segment 3 smaller than segment 2. *Penes* (Figs. 35-36) long, straight, narrow; apex rounded and with a small ventral hook; not fused mesally; longitudinal ridge on dorsal surface of penes adjacent to mesal margin, ridge formed a rounded hump in median 1/3; 7 large spine-like setae formed a row on dorsal surface of hump, spines

projected laterally.

*Subimago*.— Unknown.

*Nymph*. Unknown.

*Type Species*. *Simothraululus seminiger* Ulmer, 1939 by original designation.

*Species Included*.— *Simothraululus* is monotypic.

*Distribution*.— *Simothraululus* is known only from Sabah, Malaysia.

*Remarks*.— *Simothraululus* can be distinguished from all other genera of Leptophlebiidae by the following combination of characters. In the imago: 1) upper portion of eyes contiguous mesally; 2) costal projection of hind wings bluntly rounded and located 0.9 distance from base to apex of wings (Fig. 6); 3) segment 1 of forceps narrows abruptly apically.

The nymph of *Simothraululus* is unknown (see remarks section for *N. billhillii*), which made it impossible to determine its position in the *Thraululus* group phylogeny with any certainty. The row of spine-like setae on the dorsum of the penes suggested a close relationship with *Thraululus*. *Simothraululus* can be distinguished from *Thraululus* by the shape and position of the costal projection of the hind wings.

In Ulmer's (1939) Fig. 77, which is a dorsolateral view of the penes, the dorsal spines appear to be projecting dorsally. A fully dorsal view of the penes (our Fig. 35) showed the spines to be projecting laterally.

### ***Simothraululus seminiger* Ulmer, 1939**

Figs. 5-6, 35-36

*Simothraululus seminiger* Ulmer, 1939:509-511, Figs. 74-77 (original description); Peters and Edmunds, 1970:208 (mentioned as the type species of *Simothraululus*). *nec Simothraululus seminiger* Ulmer; Demoulin, 1969:239, Fig. 11 (not nymphs of *S. seminiger*).

*Male Imago* (in ethanol). Lengths: body, ca. 6.4 (1); fore wings, 7.5 (1).

**Head**. Light brown, mouthparts washed with black. *Eyes*: Upper portion light purplish brown. Lower portion black. *Ocelli*: Basal 1/2 dark brown, apical 1/2 white. *Antennae* light yellow.

**Thorax**. Light brownish yellow. Pronotum with posterolateral margins brown; rounded posterior emargination. Pleural carinae slightly darker. *Fore wings* (Fig. 5) hyaline, basal 1/3 of veins Sc and R<sup>1</sup> and membrane anterior to these veins brown, base of wings light brown. *Hind wings* (Fig. 6) [broken off and missing; the following hind wing description is based on Ulmer's (1939) description and his Fig. 75]: basal 2/3 blackish gray, apical 1/3 hyaline, apical margin of dark area obliquely slanted, hyaline oval area on anterior margin near midlength. *Legs*: Coxae and trochanters light brownish yellow. [Remaining portions of legs broken off and missing].

**Abdomen**. *Terga* 1-3 light brownish yellow; terga 2-3 light brown laterally and posteriorly; terga 4-10 light brown, lateral and posterior margins darker. *Sterna* light brownish yellow. *Caudal filaments* [broken off and missing].

**Genitalia**. *Styliger plate* brownish yellow, posterolateral corners dark brown. *Forceps* and *penes* (Figs. 35-36) brownish yellow.

*Female Imago*.— Unknown.

*Male Subimago*.— Unknown.

*Female Subimago*.— Unknown.

*Nymph*. Unknown.

*Remarks*.— Our description compared well with Ulmer's (1939) except for

coloration. Ulmer describes this specimen as being much darker, particularly the abdomen and the margins of the thorax. We saw no indication of dark thoracic margins, but the abdominal color described herein, although lighter than Ulmer's description, was patterned similarly.

The holotype, the only known specimen of *S. seminiger*, appeared to have been dried at one time. This condition made it impossible to describe and measure many of the characters used in the other *Thraulius* group species descriptions and may account for the discrepancy between Ulmer's (1939) Fig. 77 and our Fig. 35 of the dorsal penile spines.

*Distribution*.— *Simothraulius seminiger* is known only from northern Borneo in Sabah, near Sandakan, Malaysia.

*Biology*.— The holotype was collected in August.

*Type Data*.— Holotype male imago (in ethanol) with the following labels: *Simothraulius seminiger* Ulm./ Nord-Borneo, Bettotan [Malaysia]/ nr Sandakan, Aug. 1927. / Mus. Selangor, F. M. St. / Type [in box on right margin], [handwritten label]; Zool. Mus. Hamburg/ Coll. G. Ulmer/ Eing. Nr. 6-1963.

The holotype is in poor condition: missing left antennal flagellum, all legs, right pair of wings, left hind wing, and caudal filaments; upper portion of eyes, abdomen, and forceps are collapsed; left fore wing badly wrinkled and torn. The right penis is in a microvial.

This specimen is deposited at ZIZM.

### Chiusanophlebia Uèno, 1969

Figs. 12, 34

*Chiusanophlebia* Uèno 1969:230

[Note: The following description is based on Uèno (1969). See Remarks section of *C. asahinai*.]

*Imago*. Lengths of male: body, 6.5; fore wings, 6.0. Female imago unknown.

**Thorax.** *Fore wings* (Fig. 12) without narrow dark transverse band at base of wings; vein Rs forked 0.2 distance from base of vein to margin; vein MA forked 0.6 distance from base of vein to margin; vein MP forked 0.3 distance from base of vein to margin, fork asymmetrical, base of vein MP<sup>2</sup> connected to MP<sup>1</sup> with cross vein; with oblique cross vein between veins R<sup>4+5</sup> and MA<sup>1</sup> just apical to vein MA fork; length of fore wings 3.2 times width. *Hind wings* absent. *Legs*: Claws dissimilar, one blunt, pad-like; one apically hooked.

**Genitalia.** *Stylicher plate* (Fig. 34) with a rounded median emargination posteriorly. *Forceps* (Fig. 34) with 2 segments, segment 1 begins to narrow gradually ca. 1/3 distance from base to apex; basal 1/2 of segment 1 straight, apical 1/2 curved mesally; segment 2 very small. *Penes* (Fig. 34) long, straight, narrow; apex rounded.

*Subimago*. Unknown.

*Nymph*. Unknown.

*Type Species.* *Chiusanophlebia asahinai* Uèno, 1969.

*Species Included.* *Chiusanophlebia* is monotypic.

*Distribution*.— *Chiusanophlebia* is only known from three islands of the Nansei-shoto (Ryukyu Islands) of Japan.

*Remarks*.— *Chiusanophlebia* can be distinguished from all other genera of Leptophlebiidae by the following combination of characters. In the imago: 1) vein MA of fore wings symmetrically forked (Fig. 12), 2) oblique cross vein between veins R<sup>4+5</sup> and MP<sup>1</sup> just apical to vein MA fork, 3) hind wings absent, and 4) forceps



composed of a long basal segment and 1 short apical segment.

Without the nymphal stage the most closely related genus to *Chiusanophlebia* cannot be determined.

*Chiusanophlebia* is unique among the *Thraulius* group mayflies in that it lacks hind wings and has two-segmented forceps.

### **Chiusanophlebia asahinai** Uèno, 1969

Figs. 12, 34

*Chiusanophlebia asahinai* Uèno, 1969:231-232, Figs. 37-44 (original description).

[Note: The following description is based on Uèno (1969). See Remarks section.]

*Male Imago*.— (dried) Lengths: body, 6.5; fore wings, 6.0.

**Head.** Blackish brown. *Antennae* brown.

**Thorax.** Blackish brown. *Fore wings* (Fig. 12) grayish, subcostal area faint yellow; no cross veins before bulla. *Fore legs* with femora blackish brown. Tibiae and tarsi gray. *Middle and hind legs*: Femora blackish. Tibiae and tarsi gray.

**Abdomen.** Tergites and sternites blackish brown, with indistinct black markings which are a pair of longitudinal striae on segments 3-6.

**Genitalia.** *Forceps* (Fig. 34) gray.

*Female Imago*.— Unknown.

*Male Subimago*.— Unknown.

*Female Subimago*.— Unknown.

*Nymph*. Unknown.

**Remarks.**— We were unsuccessful in obtaining specimens of *C. asahinai* for examination. The generic and specific descriptions were based on Uèno's (1969) original description and illustrations.

**Distribution.**— *Chiusanophlebia asahinai* is known only from Nansei-shoto (Ryukyu Islands), Japan.

**Biology.**— Adults were collected in May, July, and October. One specimen was collected 200 m above sea level (Uèno, 1969).

**Type Data.**— Holotype male imago (dried), Yuwan-Ishara, 12-VII-1959, S. Asahina leg.

Paratype (dried): 1 defective specimen of unknown sex, Ishigaki-Jima, Mt. Omoto, at 200 m above sea level, 17-X-1963, G. A. Samuelson leg. The depository of type specimens remains unknown.

A third male specimen (dried) was collected at Yonabaru, Okinawa-Jima, 28-V-1963, by S. Asahina. The type status of this specimen was not reported by Uèno (1969).

Uèno (1969, Fig. 37) provides a full drawing of the fore wing (our Fig. 12) of the specimen from Okinawa-Jima. This illustration shows vein MP<sup>2</sup> as being connected to vein MP<sup>1</sup> by a cross vein at the base of MP<sup>2</sup>, and it also shows the oblique cross vein between veins R<sup>4+5</sup> and MA<sup>1</sup>. Uèno (1969) also provides a drawing of the anal area of the fore wing of the holotype (his Fig. 38). This illustration shows the vein MP fork as being symmetrical; the oblique cross vein is also present.

## NONNULLIDENS NEW GENUS

Figs. 3-4, 15, 22-25, 44-46, 48, 51, 53, 59-61, 63, 68-69, 71, 73, 77-79

*Thraulus*, sensu Peters and Tsui, 1972:5-7 (*partim*).*Imago*. Lengths of male: body, 5.2-5.9; fore wings, 5.4-5.8. Females unknown.**Head.** *Eyes*: Upper portion oval in dorsal view; major axes nearly perpendicular to longitudinal body axis; contiguous dorsally. *Ocelli*: Lateral ocelli with basal 1/2 contiguous with anterior surface of upper portion of eyes, apical 1/2 separated from edge of upper portion of eyes by ca. 1/2 width of a lateral ocellus.**Thorax.** *Fore wings* (Fig. 3) without dark, transverse band at base of wings; vein Rs forked 0.2 distance from base of vein to margin; vein MA forked 0.5 distance from base of vein to margin; vein MP forked 0.3-0.4 distance from base of vein to margin, fork asymmetrical, base of vein MP<sup>2</sup> connected to vein MP<sup>1</sup> by cross vein; with strongly to weakly oblique cross vein between veins R<sup>4+5</sup> and MA<sup>1</sup> just apical to vein MA fork, this cross vein not parallel to adjacent cross veins; length of fore wings 2.8-3.1 times width. *Hind wings* (Fig. 4) without color markings at base of wings; costal projection acute, apex of projection located 0.7 distance from base to apex of wings; apex of wings blunt. *Legs*: Ratio of segments in male fore legs: 0.5: 1.0 (1.8-2.0 mm): <0.1: 0.3: 0.2: 0.1: 0.1. *Claws* (Fig. 15) dissimilar: one blunt, pad-like; one apically hooked; hooked claw narrowed abruptly at apex.**Abdomen.** *Tergum* 10 with truncated apex.**Genitalia.** *Styliger plate* (Fig. 22) with a small median indentation on posterior margin. *Forceps* (Fig. 22): segment 1 begins to narrow gradually ca. 1/3 distance from base to apex; basal 1/2 of segment 1 straight, apical 1/2 curved mesally; 4-6 spines on mesal margin of segment 1 where it begins to narrow; segment 1 length 4.0-4.3 times segment 2 length, segment 3 length 0.8-0.9 times segment 2 length. *Penes* (Figs. 23-25) long, straight, narrow; inner margins straight, outer margins converging apically; apex projecting laterally; contiguous mesally to divergent apically, not fused; small spine-like setae scattered over ventral surface of apex and along outer margin; ca. 5 small spine-like setae on dorsal surface of lateral projection.*Subimago*. As in male imago except:**Head.** *Eyes*: Upper portion separated by ca. 1/6 of an upper portion.*Nymph*. Size range of specimens examined: head width, 0.7-1.1; body length, 2.6-5.2.**Head.** *Mouthparts*: Labrum (Figs. 44-46) triangular; 5 denticles in rounded anterior emargination; width of labrum 1.1-1.3 times width of clypeus; 4 subparallel closely spaced rows of dorsal setae near and ca. paralleling anterior margin; rows with long, thick, dense setae; venter of labrum with wide band of setae on anterolateral and anterior margins, setae in this band long laterally and gradually shorten mesally; a few scattered setae to a row of setae connecting submedian and anterolateral setae. Mandibles (Fig. 48) with lateral margin strongly rounded; regularly spaced setae on lateral margin from base of lateral incisor to midpoint of margin, setae shorten and thin out posteriorly from midpoint. Hypopharynx (Fig. 51) with blunt apexes on arms of superlingua. Maxillae (Fig. 53) with ca. 27-42 pectinate setae in subapical row; small beak-like protuberance mesally at end of subapical setal row; segment 1 length 1.2-1.4 times segment 2 length, segment 3 length 0.8-0.9 times segment 2 length. Labium (Figs. 59-61) with dorsal surface of glossae with short thick setae on lateral and anterior margins and oblique row of

thin setae across dorsum; segment 3 of palpi with row of short stubby setae on apex and ventral row of fine setae on lateral margin; dorsal surface of segment 3 with 1-3 large setae; segment 1 length 1.2-1.6 times segment 2 length, segment 3 length 0.8-0.9 times segment 2 length.

**Thorax.** *Fore legs:* Femora with 2 rows of long setae on outer margin. Tibiae (Figs. 68-69) with inner margin flattened towards apex and covered sparsely with short setae; with or without a row of long setae on dorsal edge of inner margin; long, thin setae scattered over remaining surfaces, denser on dorsal surface. Claws (Fig. 63) stout, narrowed apically to a curved tip; 4-5 denticles which increase in size apically. *Middle legs* as in fore legs except: tibiae (Fig. 71) with dorsal edge of inner margin lined with long setae, ventral edge lined sparsely with short setae; long, thin, dense setae on dorsal surface. *Hind legs* as in middle legs except: tibiae (Fig. 73) with dorsal edge of inner and outer margins lined with long setae, ventral edge of inner and outer margins lined sparsely with short setae; long, thin setae scattered over dorsal surface.

**Abdomen.** *Terga* 8-9 with posterolateral spines, spines on segment 9 larger. *Gills* (Figs. 77-79) 1-7 similar, composed of an oval to rectangular dorsal lamella with thick apical fimbriae; tracheae of dorsal lamella with oblique branches to fimbriae along its length; ventral lamella varied from being subulate to similar but smaller than dorsal lamella, projected posteromesally from base of gills.

*Type Species.*— *Nonnullidens hsui* (Peters and Tsui, 1972) NEW COMBINATION.

*Species Included.*— *Nonnullidens hsui* (Peters and Tsui) NEW COMBINATION, *N. billhilli* NEW SPECIES.

*Etymology.*— *Nonnullus* (L., some, several), *dens* (L., m., tooth). This generic name refers to the nymphal claws, which characteristically have few denticles (Fig. 63).

*Distribution.*— Mainland Papua New Guinea and the island of New Britain.

*Remarks.*— *Nonnullidens* can be distinguished from all other genera of Leptophlebiidae by the following combination of characters. In the imago: 1) major axis of upper portion of male eyes nearly perpendicular to the longitudinal body axis; 2) hind wings with an acute costal projection and more than three longitudinal veins but without the apical and posterior areas expanded (Fig. 4); 3) segment 1 of forceps narrowed abruptly apically at ca. 1/3 distance from base to apex (Fig. 22); 4) apex of penes expanded but lacks a large laterally projecting beak-like structure (Figs. 23-25); and 5) dorsal spine-like setae restricted to the apical area of penes (Fig. 24). In the nymph: 1) labrum with a strongly convex posterior margin (labrum appears triangular) and 4 rows of dorsal setae (Figs. 44, 46); 2) width of labrum greater than width of clypeus (Fig. 44); 3) venter of labrum with a band of long, fine setae near anterior margin (Fig. 46); 4) lateral margin of mandibles strongly rounded (Fig. 48); 5) lateral arms of superlingua lack apical projections (Fig. 51); 6) claws stout with 4-5 denticles (Fig. 63); 7) ventral lamella of gills 2-7 greatly reduced (Figs. 77-79).

*Nonnullidens* is most closely related to *Barba* and can be distinguished from it by the following combination of characters. In the imago: 1) upper portion of eyes oval; 2) segment 1 of forceps narrows abruptly at ca. 1/3 distance from base to apex (Fig. 22); 3) dorsal spine-like setae restricted to the apical area of the penes (Fig. 24). In the nymph: 1) lateral margin of mandibles without dense row of setae at base of incisors (Fig. 48); 2) claws stout with 4-5 denticles (Fig. 63); 3) ventral lamella of gills 2-7 greatly reduced (Figs. 77-79).

The cross vein between veins  $R^{4+5}$  and  $MA^1$  in the fore wings, just apical to the vein  $MA$  fork, is usually noticeably oblique. On an occasional specimen, this cross

vein is weakly oblique. However, comparison with adjacent cross veins in the same cell will show that it is indeed oblique and not parallel to these cross veins.

KEY TO KNOWN NYMPHS OF *NONNULLIDENS*

1. Gills oval to obovate, apical 1/3-1/2 fimbriate (Figs. 77-78); male terga 1-9 with lateral 1/3 brown, middle 1/3 light brownish yellow; 38-42 pectinate setae in subapical row of maxillae; dorsal surface of third segment of labial palpi with 1 large seta (Fig. 60) . . . . . *N. hsui* NEW COMBINATION
- Gills rectangular, apex fimbriate (Fig. 79); male terga 1-9 dark brown with narrow longitudinal median brownish streak, terga 4-6 each with a median brownish yellow triangle; 27-30 pectinate setae in subapical row of maxillae; dorsal surface of third segment of labial palpi with 1-3 large setae (Fig. 61). . . . . *N. billhilli* NEW SPECIES

***Nonnullidens billhilli* NEW SPECIES**

Figs. 61, 69, 79

*Simothraululus seminiger*, sensu Demoulin, 1969:239, Fig. 11 *nec* Ulmer, 1939.

*Thraululus hsui* Peters and Tsui, 1972:5 (*partim*).

*Male Imago*.— Unknown.

*Female Imago*.— Unknown.

*Male Subimago*.— Unknown.

*Female Subimago*.— Unknown.

*Nymph* (in ethanol). Size range of specimens examined: head width, 0.7-0.8 (4); body length, 2.6-4.2 (4).

**Head.** Brown; areas between upper portion of eyes, lateral to lateral ocelli, and anterior to median ocellus brownish yellow; narrow dark brown line near mesal margin of each antennal socket, these lines converge anteriorly on clypeus. *Eyes:* Upper portion orangish brown. *Mouthparts:* Labrum dark brown, median area darker brown; width of labrum 1.1-1.2 times width of clypeus (2); venter of labrum with few setae between submedian and anterolateral setae. Maxillae with ca. 27-30 pectinate setae in subapical row (2). Labium (Fig. 61) with 1-3 large setae on dorsal surface of segment 3 of palpi.

**Thorax.** Pronotum brownish yellow to light brown, lateral areas dark brown; paired submedian brown maculae with narrow brown line from each macula to a brown macula on posteromesal margin. Mesonotum with lateral thirds brown, mesal 1/3 brownish yellow to light brown; median notal suture paralleled laterally in its anterior 1/2 by a pair of faint narrow brown lines which intersect suture ca. midlength; base of veins C and Sc of fore wing pads brown. Metanotum light brown; vein C basal to costal projection and base of wing pads dark brown. Pleura dark brown. *Sterna* brownish yellow, washed unevenly with brown; ganglia washed unevenly with dark brown. *Fore legs:* Light brownish yellow. Coxae brown laterally. Femora brown, base and lateral edge of dorsal surface brownish yellow. Tibiae (Fig. 69) without row of long setae on dorsal edge of inner margin. Claws with 4 denticles. *Middle legs* as in fore legs except: femora light brownish yellow with wide median and apical transverse brown bands, median band narrower than apical band. *Hind legs* as in middle legs except: femora with median transverse brown

band subequal to apical band.

**Abdomen.** *Terga* brown, dark brown laterally; terga 1-9 or 1-10 with narrow, longitudinal, median, brownish yellow streak; in males terga 4-6 with median brownish yellow triangle, apex of triangle projected posteriorly; in females posteromesal margin of anterior segments lighter brown. *Sterna* 1-7 light brownish yellow, *sterna* 8-9 brown; sternum 1 with large brown triangular macula in center, apex of triangle projected anteriorly; in males *sterna* 1-7 with lateral portions of posterior margin brown; in females wide, brown, paired, sublateral lines along *sterna* 2-7; ganglia outlined with dark brown. *Gills* (Fig. 79) dark brown; dorsal lamella long, narrow, rectangular, apex lined with fimbriae; ventral lamella similar to dorsal but smaller and with fewer fimbriae; tracheae unbranched.

**Remarks.**— Nymphs of *N. billhilli* can be distinguished from *N. hsui* by the following combination of characters: 1) 27-30 pectinate setae in the subapical row of the maxillae, 2) dorsum of third segment of labial palpi with 1-3 large setae (Fig. 61), 3) male abdominal terga 4-6 each with a brownish yellow triangular macula mesally, and 4) gill lamellae rectangular with a fimbriate apex (Fig. 79).

Four of the six labial palpi examined had two large setae on the dorsal surface of the third segment, one specimen had one large seta, and another had three large setae.

One small male nymph examined did not have the posteromesal macula on the pronotum, but it did exhibit the two submedian maculae.

Demoulin (1969) identified some nymphs, which were collected in the Bismarck Archipelago during the Noona Dan Expedition (Petersen, 1966) as being *S. seminiger* based on the veins, cross veins and coloration of the hind wing pads. Demoulin notes that the apex of the hind wing pads is more acute than that of the hind wings of *S. seminiger* illustrated by Ulmer (1939). Based upon the gills, the large dorsal setae on the third segment of the labial palpi, the shape of the claws, the shape of the developing hind wings, and the shape and position of the costal projection on the hind wing pad, we identified these specimens of Demoulin's as *Nonnullidens billhilli*.

**Distribution.**— *Nonnullidens billhilli* is known from mainland Papua New Guinea and the island of New Britain.

**Biology.**— Nymphs live on the underside of rocks in swift current (Peters and Tsui, 1972, for *T. hsui*). Nymphs were collected during middle and late October and the middle of May.

**Etymology.**— This species was named in honor and memory of Mr. William (Bill) K. Hill, a dear friend of the senior author, who pondered fame and immortality.

**Type Data.**— Holotype male nymph (in ethanol) with the following labels: N.E. NEW GUINEA [Papua New Guinea]: Bulolo/ Riv., E. of Wau. 2950' / 27-X-1964 W.L.&J.G. Peters / 37 [on left margin]; *Nonnullidens billhilli* NEW SPECIES Det. 1984 P. M. Grant [handwritten]; Holotype of *Nonnullidens billhilli* [handwritten]; *Thraulius hsui* Peters & Tsui, 1972 W. L. Peters Det. 19 [typed and handwritten]; Paratype of *Thraulius hsui* Peters & Tsui, 1972 [handwritten]; Mouthparts on slide PMG-1984-THR49; Claw on slide (fore) PMG-1984-THR50. This specimen is in fair condition: head separate from body, mouthparts mounted on slide, 5 legs loose in vial (one hind leg broken off and missing), some gills loose in vial.

Paratypes (in ethanol): 1 nymph, same data as holotype; 1 nymph, same data as holotype except collected 17-X-1964 (#21), mouthparts on slide PMG-1984-THR51; 1 nymph, N.E. NEW GUINEA: Bulolo Riv. 0.8 mi. downstream from junc. of Bulolo Riv. & Karinga Creek, N.W. of Wau. 2800' 12-X-1964 W.L.&J.G. Peters (#11). Each

paratype vial contains the following labels: *Nonnullidens billhilli* NEW SPECIES Det. 1984 P. M. Grant [handwritten]; Paratype of *Nonnullidens billhilli* [handwritten]; *Thraulus hsui* Peters & Tsui, 1972 W. L. Peters Det. 19 [typed and handwritten]; Paratype of *Thraulus hsui* Peters & Tsui, 1972 [handwritten].

The holotype and paratypes of *N. billhilli* are part of the original type series of *Nonnullidens hsui* (Peters and Tsui, 1972). (See discussion in Type Data section of *N. hsui*.)

The holotype (including slides of mouthparts: PMG-1984-THR49 and fore claw: PMG-1984-THR50) and 2 paratypes (#11, #37) are deposited at FAMU. One paratype (#21, including the slide of mouthparts: PMG-1984-THR51) is deposited at UU.

*Specimens Examined.* 2 nymphs, NEW GUINEA: New Britain, Komgi, 30 km SE Cape Lambert, St. 19, 14-V-1962, Noona Dan Expedition [parts on 7 slides]. Deposited at ZMC.

### *Nonnullidens hsui* (Peters and Tsui, 1972) NEW COMBINATION

Figs. 3-4, 15, 22-25, 44-46, 48, 51, 53, 59-60, 63, 68, 71, 73, 77-78

*Thraulus hsui* Peters and Tsui, 1972:5-7, Figs. 8-10, 18-20, 28-29, 38, 43-44, 50, 54 (original description).

*Male Imago* (in ethanol). Lengths: body, 5.2-5.9 (6); fore wings, 5.4-5.8 (4).

**Head.** Light brown, antennal sockets outlined in black, frontal margin and mouthparts black, labium white and washed evenly with black, frontal carina ventral to median ocellus white. *Eyes:* Upper portion light orange. Lower portion black. *Ocelli:* Apical 1/2 clear, basal 1/2 dark brown. *Antennae* light brownish yellow, washed unevenly with dark brown.

**Thorax.** Pronotum brownish yellow, washed evenly with dark brown; lateral margins and median notal suture dark brown; paired dark brown sublateral streaks. Mesonotum orangish brown, carinae brown, center of scutellum light brownish yellow, apex of scutellum washed evenly with dark brown. Metanotum brownish yellow, washed evenly with dark brown laterally. Pleura dark brown, carinae black. *Sterna* brownish yellow, ganglia washed unevenly with dark brown. *Fore wings* (Fig. 3) with membrane and cross veins hyaline, longitudinal veins light brownish yellow, base of wing light brown and washed lightly with dark brown; veins C, Sc, and R<sup>1</sup> basal to costal brace dark brown. *Hind wings* (Fig. 4) with membrane and cross veins hyaline, longitudinal veins light brownish yellow; vein C brown, fading to brownish yellow near costal projection; basal 1/3 of vein Sc brown, apical 2/3 brownish yellow with base of membrane between veins C and Sc washed lightly with brown. *Fore legs:* Brownish yellow. Coxae dark brown laterally. Femora with wide median and apical transverse brown bands. Claws as in Fig. 15. *Middle and hind legs* as in fore legs except: femora with darker brown transverse bands.

**Abdomen.** *Terga* 1-7 hyaline, terga 8-9 white, tergum 10 brown; terga 1-9 with paired, large, brown, subtriangular maculae laterally, maculae joined on posterior margin of tergum 9; area above lateral folds slightly lighter brown. *Sterna* 1-7 hyaline, *sterna* 8-9 white, sternum 9 brown laterally. *Caudal filaments* light brownish yellow, basal annulations brown, fading on apical segments.

**Genitalia.** Light brownish yellow. *Stylyger plate* (Fig. 22) with lateral margins

dark brown. *Forceps* (Fig. 22) with lateral margins of base of segment 1 washed lightly with dark brown. *Penes* (Figs. 23-25) with lateral margins of base brown.

*Female Imago*.— Unknown.

*Male subimago* (in ethanol). As in male imago except for the following characters.

**Thorax.** Mesonotum with anterior 1/2 of notal furrow brown; notum posterior to furrow washed unevenly with dark brown. *Wings* with membrane and longitudinal veins light brownish yellow.

*Female Subimago*.— Unknown.

*Nymph* (in ethanol). Size range of specimens examined: head width, 0.7-1.1 (23); body length, 2.6-5.2 (23).

**Head.** Dark brown, brownish yellow lateral to lateral ocelli and anterior to median ocellus; narrow dark brown line near mesal margin of each antennal socket, these lines converge anteriorly on clypeus. *Eyes*: Upper portion brownish orange to dark reddish brown. *Mouthparts*: Labrum (Figs. 44-46) dark brown, median area darker brown; width of labrum 1.3 times width of clypeus (2); venter of labrum with a row of setae connecting submedian and anterolateral setae. Mandibles (Fig. 48) dark brown. Hypopharynx as in Fig. 51. Maxillae (Fig. 53) with ca. 38-42 pectinate setae in subapical row (2). Labium (Figs. 59-60) with dorsal surface of segment 3 of palpi with 1 large seta.

**Thorax.** Pronotum brown, lateral areas darker brown, with paired submedian dark brown maculae; in females a narrow dark brown line from each macula to a dark brown macula on the posteromesal margin. Mesonotum with lateral thirds brown, mesal 1/3 brownish yellow; females with median notal suture brown and paralleled laterally in its anterior 1/2 by a pair of narrow brown lines which intersect suture ca. midlength; base of costal margin of wing pads with dark brown maculae. Metanotum brownish yellow, lateral areas dark brown, base of wing pads with a dark brown macula. Pleura brown. *Sterna* light brownish yellow, ganglia washed evenly with brown. *Fore legs*: Light brownish yellow. Coxae with brown lateral surface. Femora brown, base and lateral edge of dorsal surface brownish yellow. Tibiae (Fig. 68) with a row of long setae on dorsal edge of inner margin. Claws (Fig. 63) with 5 denticles. *Middle and hind legs* (Figs. 71, 73) as in fore legs except: femora light brownish yellow with wide median and apical transverse brown bands.

**Abdomen.** *Terga* 1-9 (males) with lateral 1/3 dark brown, middle 1/3 light brownish yellow, tergum 10 dark brown; terga 1-10 (females) brown, dark brown laterally, terga 2-9 with median longitudinal brownish yellow streak, posteromesal margin of terga lighter brown. *Sterna* light brownish yellow, ganglia washed lightly with dark brown; sternum 9 with lateral 1/3 brown; in females *sterna* 1-8 with wide, brown, paired sublateral maculae, together these maculae formed 2 longitudinal bands ventrally. *Gills* (Figs. 77-78) dark brown; oval to obovate dorsal lamella, margin of apical 1/3-1/2 lined with fimbriae; ventral lamella varied from being small and slender ca. 1/4 to equal length of dorsal lamella to being similar to dorsal lamella but smaller and with fewer fimbriae.

*Remarks*.— Two species of *Nonnullidens* are known, *N. hsui* and *N. billhilli*, and *N. billhilli* is known only in the nymphal stage. Nymphs of *N. hsui* can be distinguished from *N. billhilli* by the following combination of characters: 1) 38-42 pectinate setae in subapical row of maxillae; 2) dorsum of third segment of labial palpi with 1 large seta (Fig. 60); 3) male abdominal terga 4-6 without median brownish yellow triangles; 4) dorsal gill lamella oval with margins of apical 1/3-1/2 fimbriate (Figs. 77-78).

The upper portion of the male imaginal eyes were typically contiguous dorsally but were slightly separated on a few specimens.

The abdominal gills were particularly variable in *N. hsui*. The shape of the dorsal lamella was fairly constant, being oval to obovate with the margins of the apical 1/3-1/2 fimbriate (Figs. 77-78). The dorsal lamella increased in size on posterior segments, being largest on segment four and then decreased in size on the following three segments. The ventral lamella is highly variable, occurring as: 1) short (ca. 1/4 length of dorsal lamella), narrow, and subulate on all segments; 2) short, narrow, and subulate on anterior gills, increasing in length on posterior gills, maximum length ca. equals length of dorsal lamella (Fig. 77); or 3) short, narrow, and subulate on anterior gills, increasing in width and developing apical fimbriae on posterior gills (Fig. 78). Considering all nymphs examined, there is continuous variation in the ventral lamella from the short, narrow, subulate shape to the larger fimbriate shape. Thus, we did not believe that more than one species was represented here. This variation in gill morphology was not correlated with geographic distribution, as all character states could be observed at one locality.

Final instar male nymphs exhibited coloration similar to that of male subimagos and imagos. The pharate subimago was observed in some final instar female nymphs, and the coloration of these pharate subimagos was similar to the female nymphs. Also, the posterior margin of the head of these pharate female subimagos had a bifid process.

*Distribution*.— *Nonnullidens hsui* is known only from mainland Papua New Guinea.

*Biology*.— Nymphs live on the underside of rocks in swift current and emerge after total darkness. Imagos swarm ca. 5 feet above the river in the early morning (Peters and Tsui, 1972). Nymphs and adults were collected during middle and late October.

*Type Data*.— Holotype male imago (in ethanol) with the following labels: N. E. NEW GUINEA [Papua New Guinea]: Bulolo Riv., / E. of Wau. 2950' at light/ 27-X-1964 W.L.&J.G. Peters/ 38 [in left margin]; HOLOTYPE/ William L. Peters; *Thraulus hsui*/ Peters & Tsui/ Det. 19/ W. L. Peters. This specimen was in good condition: both hind legs were loose in the vial and the terminal filament was broken off and missing.

Paratypes (in ethanol): 12 male imagos, 19-X-1964 (#25); 4 male imagos, 27-X-1964 (#36); 1 male subimago, 18-X-1964 (#23); 2 male subimagos, at light, 25-X-1964 (#33); 28 nymphs, 15-X-1964 (#18); 20 nymphs, 17-X-1964 (#21); 4 nymphs and 1 severed head, 27-X-1964 (#37); all of the previous paratypes were collected from the holotype locality. Sixteen nymphs, N. E. NEW GUINEA: Bulolo Riv. 0.8 mi. downstream from junc. of Bulolo Riv. & Karinga Creek, N.W. of Wau. 2800' 12-X-1964 W.L.&J.G. Peters (# 11).

The holotype, 4 male imaginal paratypes (#36, fore claw on slide: PMG-1984-THR44), 1 male subimaginal paratype (#33), and 17 nymphal paratypes (7 specimens from #37, 10 from #11, 2 slides of mouthparts: PMG-1984-THR47, PMG-1984-THR48) were deposited at FAMU. Four male imaginal paratypes (#25, genitalia on slide: PMG-1984-THR45), 1 male subimaginal paratype (#23), and 20 nymphal paratypes (#21, 1 slide of mouthparts: PMG-1984-THR46) were deposited at UU. Four male imaginal paratypes (#25) and 8 nymphal paratypes (#18) were deposited at USNM. Four male imaginal paratypes (#25), 1 male subimaginal paratype (#33), and 20 nymphal paratypes (#18) were deposited at BPBM.

The three nymphal paratypes (NE. New Guinea: Bulolo Riv., at junc. with



Karinga Creek, NW. of Wau, 3000', 12.x.64) deposited at FAMU and the male subimaginal paratype deposited at USNM could not be located for study.

Four *N. hsui* paratype slides (fore and hind wings, male genitalia, mouthparts, and nymphal fore claw), prepared for the original description of *N. hsui*, could not be positively correlated with any specimen. These slides were deposited at FAMU.

Four nymphal paratypes of *N. hsui* (1 specimen from #11, 2 specimens from #37 [FAMU]; 1 specimen from #21 [UU]) represented a new species of *Nonnullidens* (*N. billhilli*) and have been separated from the *N. hsui* type series. The original labels identifying these specimens as *N. hsui* paratypes remain in the vials along with labels appropriate for the new species designation.

Association of male nymphs and male imagos was by coloration of the legs and abdomen. Association of male and female nymphs was by similarity of mouthparts, setal patterns of the legs, and gill morphology. In addition, most specimens were collected at the same locality.

*Specimens Examined*: 1 nymph, N.E. New Guinea: Bulolo Riv., E. of Wau, 2950', 25-X-1964, W.L.&J.G. Peters (#32) (UU). This nymph is part of the original type series of *Barba mariae* (Peters and Tsui, 1972). (See discussion in Type Data section for *B. mariae*.)

#### BARBA NEW GENUS

Figs. 1-2, 14, 18-20, 37, 41-43, 47, 52, 54, 56-58, 62, 67, 70, 72, 76

*Thraululus*, *sensu* Peters and Tsui, 1972:3-5 (*partim*).

*Imago*. Lengths of male: body, 8.0-8.4; fore wings, 8.5-8.6. Lengths of female: body, 5.8-7.6; fore wings, 8.5.

**Head**. Posterior margin of female head shallowly undulate. *Eyes*: Upper portion subcircular in dorsal view; major axes parallel; contiguous mesally. Lower portion (female) separated by ca. 5.5-6.0 times width of an eye. *Ocelli*: Lateral ocelli with anteromesal area expanded; lateral ocelli separated from upper portion of eyes by less than 1/10 times width of a lateral ocellus.

**Thorax**. *Fore wings* (Fig. 1) without narrow dark transverse band at base of wings; vein Rs forked 0.2 distance from base of vein to margin; vein MA forked 0.5 distance from base of vein to margin; vein MP forked 0.3 distance from base of vein to margin, fork asymmetrical, base of vein MP<sup>2</sup> connected to MP<sup>1</sup> with cross vein; with oblique cross vein between veins R<sup>4+5</sup> and MA<sup>1</sup> just apical to vein MA fork; length of fore wings 2.7-3.0 times width. *Hind wings* (Fig. 2) without color markings at base of wings; costal projection acute, located 0.6 from base to margin of wings; apex of wings blunt. *Legs*: Ratio of segments in male fore legs: 0.6: 1.0 (2.9 mm): <0.1: 0.4: 0.2: 0.1: 0.1. Claws (Fig. 14) dissimilar: one blunt, pad-like; one apically hooked; hooked claw narrowed abruptly at apex.

**Abdomen**. *Tergum* 10 with truncate apex. *Sternum* 7 of female (Fig. 37) with small rounded median emargination on posterior margin; sternum 9 of female (Fig. 37) with truncate apex and shallowly rounded median emargination.

**Genitalia**. *Stylicher plate* (Fig. 20) with a rounded median emargination posteriorly. *Forceps* (Fig. 20) segment 1 begins to narrow abruptly ca. 1/2 distance from base to apex; basal 1/2 of segment 1 straight, apical 1/2 curved mesally; short spines scattered sparsely along mesal margin of basal 1/2 of segment 1, spines denser where segment begins to narrow; segment 1 length 4.8-5.2 times segment 2

length, segment 3 length 0.6-0.7 times segment 2 length. *Penes* (Figs. 18-20) long, straight, narrow; lateral margins converge apically; apex with a small rounded laterally projecting process; usually contiguous mesally but not fused; outer margins lined irregularly with small spine-like setae; ventral surface with large spine-like setae near apex and submesally; dorsal surface with few large spine-like setae near apex, many small spine-like setae sublaterally.

*Subimago*. As in imago except:

**Head.** Posterior margin of head in female strongly undulate. *Eyes*: Upper portion separated by ca. 1/7 width of an upper portion to contiguous mesally.

*Nymph*. Size range of specimens examined: head width, 1.1-1.5; body length, 3.6-9.0.

**Head.** *Mouthparts*: Labrum (Figs. 41-43) oval with rectangular anterior emargination; 5 large denticles in anterior emargination; width of labrum 1.1 times width of clypeus; 2 subparallel rows of dorsal setae near anterior margin: inner row composed of long dense setae, outer row composed of shorter setae; venter with a wide band of setae on anterolateral and anterior margins (as in Fig. 46), setae in this band long laterally and gradually shorten mesally; wide band of setae connects submedian and anterolateral setae. Mandibles (Fig. 47) with lateral margin rounded, slightly flattened area posterior to row of setae at base of incisors; lateral margin evenly lined with setae; short lobe of protheca on left mandible thick, outer margin serrate. Hypopharynx (Fig. 52) with blunt apexes on arms of superlingua. Maxillae (Fig. 54) with 16-25 pectinate setae in subapical setal row; small beak-like protuberance mesally at end of subapical setal row; segment 1 length 0.9-1.1 times segment 2 length, segment 3 length 0.7-1.0 times segment 2 length. Labium (Figs. 56-58) with short stubby setae on apex of third palpal segment, these setae extend posteriorly on ventral surface only a short distance, on dorsal surface these setae extend posteriorly along mesal margin to ca. midpoint of segment; segment 3 with ventral row of long fine setae on lateral margin and row of short setae near mesal margin; segment 3 with 4 large setae on dorsal surface and a tuft of long setae on apicolateral margin; segment 1 length 1.1 times segment 2 length, segment 3 length 0.6-0.7 times segment 2 length. Submentum (Fig. 56) with setae lining lateral margins and sublateral areas of ventral surface.

**Thorax.** *Fore legs*: Femora with 2 rows of long setae on outer margin. Tibiae (Fig. 67) with inner margin flattened, densely covered with short setae; outer margin with scattered long, thin setae. Claws (Fig. 62) long, narrow; apex pointed and curved mesally; 9-10 denticles which increase in size apically, apical denticle smaller. *Middle legs* as in fore legs except: tibiae (Fig. 70) with dorsal edge of inner margin lined sparsely with short, thick, setae; dense shorter setae covers inner margin, ventral edge and portion of ventral surface. *Hind legs* as in middle legs except: tibiae (Fig. 72) with dorsal edge of inner and outer margins lined with large setae, inner margin and ventral surface covered with short setae.

**Abdomen.** *Terga* 7-9 with posterolateral spines, spines increase in size on posterior segments. *Gills* (Fig. 76) 1-7 similar, composed of dorsal and ventral oblong lamellae with margins of apical 1/3 fimbriate; mesal margin of dorsal lamellae flattened to slightly concave; dorsal portion slightly larger; longitudinal tracheae with oblique branches.

*Type Species* *Barba mariae* (Peters and Tsui, 1972) NEW COMBINATION.

*Species Included.* *Barba* is monotypic.

*Etymology.*—*Barba* (L., f., beard). This generic name refers to the sublateral setae on the submentum (Fig. 56).

*Distribution.*— *Barba* is known only from Papua New Guinea.

*Remarks.*— *Barba* can be distinguished from all other genera of Leptophlebiidae based on the following combination of characters. In the imago: 1) upper portion of eyes subcircular; 2) lateral ocelli with expanded anteromesal area; 3) hind wings with acute costal projection and more than three longitudinal veins but without expanded apical and posterior areas (Fig. 2); 4) segment one of forceps narrows abruptly at ca. 1/2 distance from base to apex (Fig. 20); 5) penes with dorsal setae scattered along lateral margins (Fig. 18); 6) sternum 9 of female with a shallowly rounded median emargination (Fig. 37). In the nymph: 1) width of labrum greater than width of clypeus (Fig. 41); 2) venter of labrum with a band of long, fine setae near anterior margin (as in Fig. 46); 3) lateral arms of superlingua lack an apical projection (Fig. 52); 4) submentum with lateral and sublateral setae (Fig. 56); 5) claws with more than 5 denticles (Fig. 62); and 6) gills 2-7 lined with fimbriae on apical 1/3 and dorsal lamella slightly larger than ventral lamella (Fig. 76).

*Barba* is most closely related to *Nonnullidens* and can be distinguished from it by the following combinations of characters. In the imago: 1) upper portion of eyes subcircular; 2) segment one of forceps narrows abruptly at ca. 1/2 distance from base to apex (Fig. 20); and 3) dorsal spine-like setae scattered along lateral margins of the penes (Fig. 18). In the nymph: 1) lateral margin of mandibles with a dense row of setae at base of incisors (Fig. 47); 2) claws narrow with more than 5 denticles (Fig. 62); and 3) the dorsal lamella of gills 2-7 slightly larger than the ventral lamella (Fig. 76).

***Barba mariae* (Peters and Tsui, 1972) NEW COMBINATION**

Figs. 1-2, 14, 18-20, 37, 41-43, 47, 52, 54, 56-58, 62, 67, 70, 72, 76

*Thraulius mariae* Peters and Tsui, 1972:3-5, Figs. 5-7, 17, 23-27, 37, 41-42, 49, 55 (original description).

*Male Imago* (in ethanol). Lengths: body, 8.0-8.4 (2); fore wings, 8.5-8.6 (2).

**Head.** Brownish yellow, carinae dark brown, area between antennal sockets ventral to median ocellus dark brown; frontal carina ventral to median ocellus white; frontal margin dark brown; mouthparts black. *Eyes:* Upper portion light orange. *Ocelli:* Lateral ocelli with lens hyaline to white, wide dark brown band just basal to lens, mesal and posteromesal portions brownish yellow. Median ocellus with apex hyaline, base dark brown. *Antennae* with scape and pedicel light brownish yellow, washed lightly with brown; flagella [broken off and missing]; margin of sockets brown.

**Thorax.** Pronotum light brownish yellow, lateral margins dark brown, posterior margin brown, median notal suture dark brown; paired brown submedian streaks. Mesonotum light brownish yellow, area surrounding inner parapsidal sutures and scutellar humps light brown; area lateral to scutellar humps washed unevenly with brown; apex and sides of scutellum brown. Metanotum brownish yellow, washed evenly with dark brown. Pleura brownish yellow, washed evenly with dark brown, carinae black; meso- and metathoracic anepisterna with little or no washings. *Sterna* light brown, carinae dark brown; lateral margins of mesobasisternum dark brown adjacent to coxae. *Fore wings* (Fig. 1) with longitudinal and cross veins brownish yellow, membrane lighter; veins C, Sc and R dark brown basal to costal brace, intervening membrane brown. *Hind wings* (Fig. 2) with longitudinal and cross

veins light brownish yellow, membrane lighter; basal 1/3 of veins C and Sc and membrane between these veins brown. *Fore legs*: Brownish yellow. Coxae dark brown laterally. Femora dark brown, a narrow lighter brown transverse band just anterior to midlength. Tibiae with basal offset area brown and apex dark brown. Tarsi and claws (Fig. 14) light yellow. *Middle and hind legs*: As in fore legs except: femora with base light brownish yellow. Tibiae with narrow transverse dark brown subapical band.

**Abdomen.** *Terga* 1-10 white, wide brown band on posterior margins, median area washed lightly with brown; wide sublateral paired brown longitudinal bands on terga 1-9 or 1-10; terga 1-9 with lateral margins dark brown. *Sterna* 1-9 white; *sterna* 1-8 each with median light brown macula which fades on posterior segments; *sterna* 1-8 with brown washings on lateral margins, sternum 9 with larger washed area on lateral margins. *Caudal filaments* white, annulations brown.

**Genitalia.** *Stylyger plate* (Fig. 20) light brown, dark brown laterally. *Forceps* (Fig. 20) with segment 1 light brown, segments 2-3 white. *Penes* (Figs. 18-20) brownish yellow.

*Female Imago* (in ethanol). Lengths: body, 5.8-7.6 (3); fore wings 8.5 (1). As in male imago except for the following characters.

**Head.** Dark brown, area posterior to each ocellus and lateral to lateral ocelli light brownish yellow, carinae and frontal margin black; area between antennal sockets ventral to median ocellus light brownish yellow. *Antennae* with light brownish yellow flagella.

**Thorax.** Pronotum with lateral and anterior margins dark brown. Mesonotum orangish brown, lateral carinae darker brown. Prosternum with carinae on basisternum black, area between carinae evenly washed with dark brown. *Fore legs*: Femora dark brown. Tibiae with a narrow subapical dark brown band; portion of tibiae basal to band washed lightly with dark brown.

**Abdomen.** *Terga* 1-10 brown, posterior margins darker brown, tracheae light brownish yellow; terga 1-9 with lateral light brown areas and lateral margins dark brown. *Sterna* light brownish yellow; *sternal* maculae with brown lateral extensions; *sterna* 2-8 with brown lateral margins, lateral extensions of median maculae extend to these margins; sternum 9 (Fig. 37) with apical 1/2 brown. *Caudal filaments* [broken off and missing].

*Male Subimago*.— (in ethanol). As in male imago except for the following characters.

**Head.** Brown.

**Thorax.** Pronotum with anterior and lateral margins dark brown. Mesonotum with anterior 1/2 of notal furrow dark orangish brown. Wings with membrane cloudy white.

*Female Subimago*.— (in ethanol). As in female imago except for the following characters.

**Head.** Dark brown.

**Thorax.** Mesonotum with anterior 1/2 of notal furrow dark orangish brown; wide light brownish yellow band centered on mesonotal suture extending from anterior end of inner parapsidal sutures to near apex of scutellum, anterior end of this band with narrow lateral extensions to anterior end of inner parapsidal sutures.

*Nymph* (in ethanol). Size range of specimens examined: head width, 1.1-1.5 (210); body length, 3.6-9.0 (210).

**Head.** In male brown, lighter brown oval area anterior to median ocellus, area

lateral to lateral ocelli white; in female a large irregularly shaped brownish yellow macula on posterior margin, thin brown lines traverse macula. *Eyes*: Upper portion orangish brown. *Mouthparts*: Labrum (Figs. 41-43) and mandibles (Fig. 47) brown. Hypopharynx (Fig. 52) lightly washed with dark brown. Maxillae (Fig. 54) and labium (Figs. 56-58) brownish yellow.

**Thorax.** Pronotum light brown, lateral margins brown; in female posterior margin also brown; a pair of brown irregular submedian maculae, occasionally contiguous. Mesonotum with median 1/3 light brown, lateral thirds brown, fore wing pads light brown, costal margin of fore wing pads brown near base; brown band on margin of tergum adjacent to anal area of fore wing pads; in female median notal suture dark brown, a narrow brown line on either side of suture, these lines intersect suture near posterior end. Metanotum light brownish yellow, lateral and posterior margins brown; hind wing pads white, base dark brown. Pleura brown. Prosternum light brownish yellow, anterior 1/2 washed evenly with brown. Mesosternum light brownish yellow; posterior 1/2 of basisternum washed with brown, washings darker laterally, lateral margins dark brown, posterolateral corners brown; furcasternum occasionally with paired sublateral longitudinal parallel brown stripes. Metasternum light brownish yellow; in male lateral edges of posterior margin brown, in female lateral thirds brown. *Fore legs* (Figs. 62, 67): Brownish yellow. Coxae brown, margins darker. Femora dark brown, narrow longitudinal light brown streak on dorsal surface close to outer margin. Tibiae with dark brown apex, basal offset area brown. Claws as in Fig. 62. *Middle and hind legs* (Figs. 70, 72) as in fore legs except: femora brown, base and narrow transverse submedian band lighter.

**Abdomen.** Terga 1-9 light brown in male, brown in female; markings as in imagos. *Sterna* brownish yellow; in males *sterna* 1-8 with lateral portion of posterior margin brown, areas anterior to brown margins lightly washed with brown; sternum 9 with lateral margins brown; median maculae as in imagos but very faint. *Gills* (Fig. 76) dark brown.

*Remarks.*—Color variation among specimens was mostly due to slight differences in hue and intensity. This was particularly evident on the thorax and abdomen.

The hind femora of all stages typically had a light submedian band. Occasionally, the outer portion of this band was darkened so that it appeared as an irregular brownish yellow macula near the inner margin of the dorsal surface.

Very dark female nymphs had a narrow, longitudinal, brownish yellow median streak on posterior terga.

*Distribution.*—*Barba mariae* is known only from Papua New Guinea.

*Biology.*—The nymphs of *B. mariae* are found on the underside of large flat rocks or on submerged logs in quiet side pools of rivers and streams. These side pools have little current and are heavily silted. Nymphs emerge after total darkness (Peters and Tsui, 1972). Nymphs and adults were collected during middle and late October.

*Type Data.*—Holotype male imago (in ethanol) with the following labels: N.E. NEW GUINEA [Papua New Guinea]; Bulolo Riv.,/ E. of Wau. 2950' / 18-X-1964 W.L.&J.G. Peters / 23 [in left margin]; *Thraulius mariae*/ Peters & Tsui / Det. 19 / W. L. Peters; HOLOTYPE / William L. Peters. This specimen was in fair condition: upper portion of eyes collapsed in center; fore legs broken off and missing; remaining 4 legs, middle and right caudal filaments, and left fore wing loose in vial; claws of a middle or hind leg in a microvial.

Paratypes (in ethanol): 1 male imago, at light, 18-X-1964 (#24); 1 male imago, 27-

X-1964 (#37); 6 male subimagos, at light, 15-X-1964 (#20); 17 male subimagos, at light, 18-X-1964 (#24), 1 female imago (allotype), 18-X-1964 (#23); 2 female imagos, at light, 18-X-1964 (#24); 7 female subimagos, at light, 15-X-1964 (#20); 2 female subimagos, at light, 27-X-1964 (#38); 20 female subimagos, at light, 18-X-1964 (#24); 8 female subimagos, at light, 25-X-1964 (#33); 48 nymphs, 15-X-1964 (#18); 20 nymphs, 18-X-1964 (#23); 41 nymphs, at light [sic], 18-X-1964 (#24); 50 nymphs, 25-X-1964 (#32); 25 nymphs, 27-X-1964 (#37); all of the previous paratypes were collected from the same locality as the holotype. Eleven nymphs, N.E. NEW GUINEA: Bulolo Riv., 0.8 mi. downstream from junc. of Bulolo Riv. & Karinga Creek, N.W. of Wau., 2800', 12-X-1964, W.L.&J.G. Peters (#11). Forty-four nymphs, N.E. NEW GUINEA: Small side pool, Bulolo Riv., E. of Wau, 2950', 15-X-1964, W.L.&J.G. Peters (#19).

The holotype, 6 male subimaginal paratypes (#20), 1 female imaginal paratype (allotype) (#23 [fore claw on slide: PMG-1985-THR73]), 9 female subimaginal paratypes (7 from #20, 2 from #38 [4 abdomens of male subimagos in vial with female specimens]), and 76 nymphal paratypes (11 from #11, 20 from #18, 20 from #23 [in 3 vials; 2 slides of mouthparts: PMG-1984-THR53, PMG-1984-THR54; 2 slides of fore claw: PMG-1984-THR55, PMG-1984-THR56], 25 from #37 [in 2 vials]) are deposited at FAMU. One male imaginal paratype (#24 [genitalia on slide: PMG-1984-THR52]), 6 male subimaginal paratypes (#24), 1 female imaginal paratype (#24), 10 female subimaginal paratypes (#24), and 44 nymphal paratypes (#19) are deposited at BPBM. One male imaginal paratype (#37), 6 male subimaginal paratypes (#24), 1 female imaginal paratype (#24), 10 female subimaginal paratypes (#24), and 50 nymphal paratypes (#32 [2 vials]) are deposited at UU. Five male subimaginal paratypes (#24), 8 female subimaginal paratypes (#33), and 49 nymphal paratypes (41 from #24, 8 from #18) are deposited at USNM.

Six male imaginal paratype slides (fore wing; hind wing; fore, middle, and hind legs; genitalia), 1 female imaginal paratype slide (fore leg), and 8 nymphal paratype slides (3 mouthparts, 2 fore claw, first abdominal gill, 2 fourth abdominal gill) are deposited at FAMU. These slides were made for the original description of *B. mariae*. Unfortunately, none of these slides could be positively correlated with any of the paratype specimens.

Peters and Tsui (1972) report the date of collection for the holotype of *B. mariae* as "15-27.x.64," while the label in the holotype vial reads "18-X-1964." Peters and Tsui (1972) designated 2 nymphal paratypes from the Bulolo River at the junction with Karinga Creek and 2 nymphal paratypes from Hospital Creek; these 4 specimens could not be located. Twenty-three nymphal paratypes were reported (Peters and Tsui, 1972) from the Bulolo River, 0.8 mi. downstream from the junction of the Bulolo River and Karinga Creek (#11), but only 11 of these specimens could be located.

One nymph of *Nonnullidens hsui* was found among the *B. mariae* nymphal paratypes (#32) deposited at UU. This specimen remains as a part of the original type series of *B. mariae*. This nymph was placed in a separate vial and we added a label indicating its correct name.

Peters and Tsui (1972) associated nymphs and imagos of *B. mariae* by rearing. None of the type specimens available to us were identified as being reared, and nymphal exuviae were not observed among the type specimens. Some of the nymphal paratypes were final instars, and the characters of the pharate subimago were clearly evident. The coloration of male and female nymphs is very similar to their respective subimaginal and imaginal stages.

## SULU NEW GENUS

Figs. 9-11, 16, 30-33

*Thraulus*, sensu Peters and Edmunds, 1970:203 (*partim*).

*Imago*.—Lengths of male: body, 5.0; fore wings, 6.1-6.3. Female imago unknown.

**Head.** *Eyes*: Upper portion subquadrate in dorsal view with rounded corners; major axes diverge anteriorly; contiguous mesally. *Ocelli*: Lateral ocelli contiguous laterally with upper portion of eyes.

**Thorax.** *Fore wings* (Fig. 9) with narrow dark transverse band from apex of costal brace to apex of vein A<sup>2</sup>; vein R<sub>s</sub> forked 0.2 distance from base of vein to margin; vein MA forked 0.5 distance from base of vein to margin; vein MP forked 0.2 distance from base of vein to margin, fork asymmetrical, base of vein MP<sup>2</sup> connected to MP<sup>1</sup> by cross vein; with oblique cross vein between veins R<sup>4+5</sup> and MA<sup>1</sup> just apical to vein MA fork; length of fore wings 3.0 times width. *Hind wings* (Figs. 10-11) with basal 1/2 darkly pigmented, apical 1/2 hyaline to lightly pigmented; costal projection acutely rounded and located 0.6-0.7 distance from base to apex of wings; apex of vein Sc ends on cross vein or anterior margin of wings; hind wings robust in shape, apical and posterior areas expanded. *Fore legs* [broken off and missing]. *Middle and/or hind legs*: Claws (Fig. 16) dissimilar: one blunt, pad-like; one apically hooked; hooked claw narrows abruptly at apex.

**Abdomen.** *Tergum* 10 with apex truncate.

**Genitalia.** *Stylicher plate* (Figs. 30, 32) with rounded median emargination on posterior margin. *Forceps* (Figs. 30, 32) segment 1 begins to narrow gradually to abruptly ca. 1/2 distance from base to apex; basal 1/2 of segment 1 straight, apical 1/2 straight to curving mesally; segment 1 with 1-7 large spines on inner bend of each forceps; segment 1 length 6.0 times segment 2 length, segment 3 length 0.8 times segment 2 length. *Penes* (Figs. 31-33) long, straight, narrow; apex with pointed beak-like structure projecting laterally; penes not contiguous mesally; with or without spine-like setae on venter of apex.

*Subimago*. Unknown.

*Nymph*. Unknown.

*Type Species.* *Sulu duliti* (Demoulin, 1954) NEW COMBINATION.

*Species Included.* *Sulu duliti* (Demoulin) NEW COMBINATION, *S. pescadori* NEW SPECIES.

*Etymology*.—*Sulu* is taken from the Sulu Sea which is situated between the type locality of *S. duliti* in Malaysia and that of *S. pescadori* in the Philippines. *Sulu* is to be considered masculine.

*Distribution*.—*Sulu* is known from Sarawak, Malaysia and the island of Mindanao, Republic of the Philippines.

*Remarks*.—*Sulu* can be distinguished from all other genera of Leptophlebiidae by the following combination of characters. In the imago: 1) upper portion of eyes subquadrate in dorsal view; 2) fore wings with a narrow dark band extending from apex of costal brace to apex of vein A<sub>2</sub> (Fig. 9); 3) hind wings robust with apical and posterior areas expanded, acute costal projection, more than three longitudinal veins, and basal 1/2 of wings darkly pigmented (Figs. 10-11); and 4) apex of penes expanded forming a large laterally projecting beak-like structure (Figs. 31-33).

Two characteristics of the fore wings, the presence of the oblique cross vein between veins R<sup>4+5</sup> and MA<sup>1</sup> just apical to the vein MA fork and the symmetrical vein MA fork (Fig. 9) place *Sulu* in the *Thraulus* group, but its exact placement

cannot be made with certainty without knowledge of its nymphal stage. At this time the most closely related genus to *Sulu* remains unknown.

### Key To Known Male Imagos Of *Sulu*

1. Femora unicolorous; *sterna* 2-7 with brown median longitudinal streaks on posterior 1/2 of each segment; apex of vein Sc of hind wings ends on cross vein (Fig. 10); inner margin of segment 1 of forceps narrows gradually apically (Fig. 30); without spine-like setae on venter of apex of penes; segment 1 of forceps without large spines on dorsal surface . . . . .  
 . . . . . *S. duliti* NEW COMBINATION

Femora with a wide transverse submedian band; *sterna* without median longitudinal streaks; apex of vein Sc of hind wings ends on anterior margin of wings (Fig. 11) inner margin of segment 1 of forceps narrows abruptly apically (Fig. 32); with spine-like setae on venter of apex of penes (Fig. 33); segment 1 of forceps with large spines scattered sparsely over dorsal surface on apical 1/2 of wide basal portion . . . . . *S. pescadori* NEW SPECIES

#### *Sulu duliti* (Demoulin, 1954) NEW COMBINATION

Figs. 9-10, 30-31

*Hagenulus* (?) *duliti* Demoulin, 1954:124-125, Fig. 1 (original description).

*Masharikella duliti* (Demoulin), Peters et al. 1964:120 (transferred from *Hagenulus*).

*nec Masharikella duliti* (Demoulin), Peters et al. 1964:120, Figs. 5-9, 11-12; Demoulin 1969:233, Fig. 8.

*Thraululus duliti* (Demoulin), Peters and Edmunds 1970:203 (transferred from *Masharikella*).

*Thraululus duliti* (Demoulin), Peters and Tsui 1972:2 (in key to imagos).

*Male Imago* (on slide). Lengths: body, 5.0 (from Demoulin, 1954); fore wings, 6.1 (1).

**Head.** Dark orange, dorsal longitudinal carina dark brown, frontal margin dark brown adjacent to frontal longitudinal carina, mouthparts black. *Eyes:* Upper portion dark orange. Lower portion black. *Ocelli:* Apical 1/2 clear, basal 1/2 dark brown. *Antennae* brownish yellow, antennal sockets outlined with dark brown.

**Thorax.** Brownish orange. Pronotum with lateral margins washed evenly with dark brown, median notal suture dark brown. Mesoscutellum washed evenly with dark brown. Pleural carinae dark brown. Metasternum with brown washings. *Fore wings* (Fig. 9) with membrane and cross veins light brownish yellow, longitudinal veins darker; basal transverse band light brown, purplish brown adjacent to vein A<sup>2</sup>; membrane basal to band light brown. *Hind wings* (Fig. 10) with apical 1/2 light brownish yellow; basal 1/2 brown at base, changing to purplish brown at center of wings; longitudinal veins darker; apical margin of colored area oblique; apex of vein Sc ends on cross vein; costal projection located 0.6 distance from base to apex of wings (1). *Fore legs:* [broken off and missing]. *Middle and/or hind legs:* Femora orange. Tibiae, tarsi, and claws lighter.

**Abdomen.** *Terga* 1-7 light brown with dark brown washings on posterior margins and dark brown lateral margins; terga 3-7 each with light brown washings



forming a pair of lateral oblique bands. *Sterna* 1-7 reddish orange, anterior and posterior margins brownish yellow; *sterna* 2-7 with median longitudinal brown streak from ca. middle of sternum to posterior margin. *Caudal filaments* [broken off and missing].

**Genitalia** light brownish yellow. *Styliger plate* as in Fig. 30. *Forceps* (Fig. 30) segment 1 narrows gradually apically; segment 1 with 1-2 large spines on inner margin where segment narrows, small spines line inner and outer margin of segment 1, spines lacking on dorsal surface. *Penes* (Fig. 31) without spine-like setae on venter of apex.

*Female Imago*.— Unknown.

*Male Subimago*.— Unknown.

*Female Subimago*.— Unknown.

*Nymph*. Unknown.

**Remarks**.— Imagos of *S. duliti* can be distinguished from the other described species of *Sulu* by the following combination of characters. In the imago: 1) apex of vein Sc of hind wings ends on cross vein (Fig. 10); 2) femora unicolorous; 3) *sterna* 2-7 with a brown median longitudinal streak on posterior 1/2 of each segment; 4) inner margin of segment 1 of forceps narrows gradually (Fig. 30); 5) segment 1 of forceps without large spines on dorsal surface; 6) and without spine-like setae on venter of apex of penes.

The holotype, the only known specimen of *S. duliti*, was dried before being slide mounted (Demoulin, 1954), and this probably explains the condition of some of the body parts (e.g., styliger plate in Fig. 30). The fact that the entire specimen was dissected and slide mounted makes examination of certain characters difficult or impossible.

Demoulin (1954) describes the third segment of the forceps as being very small, but its small size may be due, in part, to the dried condition of the holotype.

Peters et al. (1964) identified a number of pinned subimagos and imagos from New Guinea and New Ireland as *S. duliti*. We have examined these specimens and they are not *S. duliti*. In fact, they appeared to represent a new species. However, their condition precluded a formal description. These specimens differed from *S. duliti* by the following: 1) base of fore wings without narrow transverse band; 2) hind wings hyaline, basal 1/2 not colored, narrow, not robust; 3) fore femora dark brown, middle and hind femora light brownish yellow with narrow dark brown median and apical transverse bands; 4) abdomen dark brown; and 5) apex of penes without pointed beak-like structure projecting laterally. These specimens are deposited at BPBM.

Demoulin (1969) identified some subimagos and nymphs from the Bismarck Archipelago as *S. duliti*. We have examined these subimagos and nymphs and they are not *S. duliti*. These subimagos appeared to be a new species and differed from *S. duliti* as the above mentioned specimens of Peters et al. (1964), and in addition: 1) vein MP of the fore wings forked 0.4 distance from base to margin, 2) femora not banded, and 3) femora and basal 1/2 of tibiae pink.

The nymphs that Demoulin (1969) identified as *S. duliti* actually represent two species. One species has characters similar to those illustrated in Demoulin's (1969) Fig. 8 (identified as *Masharikella duliti*): 1) labrum with a single row of stout setae curving mesally on venter near apical margin; 2) more than 20 pectinate setae in the subapical row of the maxillae; 3) gill 1 with dorsal lamella subulate, ventral lamella oval and fimbriate; and 4) gills 2-7 with dorsal and ventral lamella oval with fimbriate margins. The second species has 1) a band of fine setae on the venter of

the labrum, 2) 6-7 pectinate setae in the subapical row of the maxillae, and 3) gills 1-7 with dorsal and ventral portions oblong with three long apical projections.

Demoulin (1969) correlated these nymphs with the subimagos based on similar collecting sites and dates. The generally poor condition of the above specimens and the lack of strongly correlated life history stages, precluded describing them as new species. The above specimens, described by Demoulin (1969), were collected during the Noona Dan Expedition (Petersen, 1966) and are deposited at IRSN and ZMC.

*Distribution.*— *Sulu duliti* is known only from Sarawak, Indonesia.

*Biology.*— The male imaginal holotype was collected at 3,000 ft. in January.

*Type Data.*— Holotype male imago (on 3 slides) with the following labels: R. Mus. Hist. Nat. Belg./ I. G. 14.976/ Sarawak/ Mt. Dulit/ 3.000 ft./ Jan./ Dr. E. Mjöberg; G. Demoulin det., 1954/ Hagenulus duliti Dem./ ♂ imago/ HOLOTYPE/ Genitalia; cf. B. A. Soc.,/ Ent. B., XC,/ 1954, fasc. V.VI,/ p. 124, fig. 1 [this label, on back of slide, refers to Demoulin's published figures] [slide contains styliger plate, forceps (left forceps missing segments 2 and 3), penes and a portion of integument; position of genitalia on slide indicated by a red circle]. The second slide is identical to the first except it is labeled: Corps, Tête [contains head, thorax, abdomen (missing apical 1/2 of segment 8 and segments 9 and 10), and base of fore wing]. The third slide is identical to the first except it is labeled: Ailes, Pattes [contains fore wing; 2 hind wings: 1 entire, 1 torn in half; base of a fore wing; 2 legs (middle and/or hind): 1 with femur, tibia, tarsus, claws; 1 with femur and tibia].

The holotype is deposited at IRSN.

### *Sulu pescadori* NEW SPECIES

Figs. 11, 16, 32-33

*Male Imago.*— (in ethanol). Lengths: body, 6.3 (without head and prothorax) (1); wings, 6.3 (1).

**Head.** [Broken off and missing.]

**Thorax.** Brownish yellow, carinae brown. Pronotum [broken off and missing]; apex of mesoscutellum white. Pleurae with membrane around coxae pinkish. *Sterna* light brown, carinae brown; metasternum with brown washings forming a narrow transverse band across center. *Fore wings* with membranes and cross veins hyaline, longitudinal veins light yellow; basal transverse band light brown, purplish brown adjacent to vein A<sub>2</sub>; membrane basal to band light brown. *Hind wings* (Fig. 11) with apical 1/2 of wings hyaline, basal 1/2 brown; longitudinal veins darker brown in basal 1/2; apical margin of colored area oblique and darker than base; apex of vein Sc ends on anterior margin of wings; costal projection acutely rounded, located 0.6-0.7 from base to apex of wings (1). *Fore legs*: [Broken off and missing.] *Middle and hind legs*: Light brownish yellow. Coxae brown. Femora with wide light brown submedian transverse band, this band ca. 1/2 length of femora. Claws as in Fig. 16.

**Abdomen.** *Terga* brownish orange, spiracles darker; tergum 1 with anterior margin darker brown; terga 1-8 with posterior margin lighter; tergum 9 with posterolateral spines. *Sternum* 1 light brownish yellow, anterior and lateral margins brown; *Sterna* 2-7 light brownish yellow, anterior and posterior margins of each segment lighter; sternum 7 washed lightly with brown; sternum 8 white with a large brown "U", opening of "U" directed anteriorly; lateral margins washed lightly with brown; sternum 9 white. *Caudal filaments* [broken off and missing].

**Genitalia.** *Styliger plate* (Fig. 32) white. *Forceps* (Fig. 32) brown; segment 1 narrows abruptly; ca. 5-7 long spines on mesal margin of segment 1 where segment narrows; large spines scattered sparsely over dorsal surface of segment 1 on apical 1/2 of wide base. *Penes* (Figs. 32-33) brownish yellow; with small spine-like setae on venter of apex.

*Female Imago.*— Unknown.

*Male Subimago.*— Unknown.

*Female Subimago.*— Unknown.

*Nymph.* Unknown.

*Remarks.*— *Sulu pescadori* can be distinguished from the other known species of *Sulu* by the following combination of characters. In the imago: 1) apex of vein Sc of hind wings ends on anterior margin of wings (Fig. 11); 2) femora with a wide transverse submedian band; 3) *sterna* without median longitudinal streaks; 4) segment 1 of forceps narrows abruptly (Fig. 32); 5) segment 1 of forceps with large spines scattered sparsely over dorsal surface on apical 1/2 of wide basal portion; and 6) spine-like setae on venter of apex of penes (Fig. 33).

Although the head and prothorax were missing, we believed that *S. pescadori* was congeneric with *S. duliti* based on the coloration of the fore and hind wings, the shape of the hind wings, and the shape of the penes.

This specimen was originally dried and mounted on a card point. It was soaked for 24 h in a glycerine-acetic acid-water solution to soften the structures, and then transferred to 80% ethanol.

*Distribution.*— *Sulu pescadori* is known only from the island of Mindanao, Republic of the Philippines.

*Biology.*— The male imaginal holotype was collected between late March and early April at an altitude of 1050 m.

*Etymology.*— It is a great privilege for us to name this species for Dr. Manuel L. Pescador, a friend and scientist, who has made significant contributions to the study of Ephemeroptera.

*Type Data.*— Holotype male imago (in ethanol) with the following labels: PHILIPPINES: Mindanao, Misamis Or.,/ Minalwang, 1050m/ 24.III.-4.IV.1961/ H. Torrevillas [we added this label]; P. I., MISAMIS OR. / Minalwang, 1050m/ 24.III.-4.IV.'61 [original label]; H. Torrevillas/ Collector; *Thraulius*/ W. L. Peters/ Det. 19; HOLOTYPE of/ *Sulu pescadori*/ det. 1985/ P. M. Grant [handwritten]; middle or hind tarsus on slide/ PMG-1985-THR57 [handwritten]. The holotype was in fair condition: head, prothorax, fore legs, 3 middle and hind legs, and all caudal filaments missing; fore wings torn, mesothorax laterally compressed; both fore wings, one hind wing, and 3 legs broken off and loose in vial; 1 forceps and 1 penis broken off. All genitalic parts were in a microvial.

The holotype is deposited at BPBM.

## MAGNILOBUS NEW GENUS

Figs. 7-8, 17

*Thraulius*, *sensu* Demoulin, 1969:234 (*partim*).

*Imago.*— Unknown.

*Subimago.*— Male unknown. Lengths of female: body, 3.9; fore wings, 4.9.

**Head.** Posterior margin of head with wide truncate mesal projection.

**Thorax.** *Fore wings* (Fig. 7) without narrow dark transverse band at base; vein Rs

forked 0.2 distance from base of vein to margin; vein MA forked 0.5 distance from base of vein to margin; vein MP forked 0.4 distance from base of vein to margin, fork asymmetrical, base of vein MP<sup>2</sup> attached to MP<sup>1</sup> with cross vein; with oblique cross vein between veins R<sup>4+5</sup> and MA<sup>1</sup> just apical to MA fork; length of fore wings 2.9 times width. *Hind wings* (Fig. 8) without basal coloration; only 2 longitudinal veins posterior to vein C, both veins end at same point at base of costal projection; vein R curved; without cross veins; costal projection long, acute, located 0.8 distance from base to apex of wings; apex of wings bluntly rounded. *Legs*: Claws (Fig. 17) dissimilar: one blunt, pad-like; one apically hooked.

**Abdomen.** *Sternum* 7 with truncate posterior margin.

*Nymph.* Unknown.

*Type Species.*— *Magnilobus pacificolus* (Demoulin, 1969) NEW COMBINATION.

*Species Included.*— *Magnilobus* is monotypic.

*Etymology.*— *Magnus* (L., large), *lobus* (L., m., projection). The generic name refers to the large costal projection of the hind wings (Fig. 8).

*Distribution.*— *Magnilobus* is known only from the island of Manus, Papua New Guinea.

*Remarks.*— *Magnilobus* can be distinguished from all other genera of Leptophlebiidae by the following combination of characters. In the female subimago: 1) hind wings with a large costal projection located 0.8 from base to apex of wings (Fig. 8); and 2) hind wings with two longitudinal veins posterior to vein C, apex of both veins meet on wing margin (Fig. 8).

The occurrence of the oblique cross vein and the symmetrical fork of vein MA of the fore wings (Fig. 7) suggests that *Magnilobus* belongs to the *Thraulus* group lineage. As the male imago and nymph are unknown for this genus, we could not determine its exact phylogenetic position or the most closely related genus.

We believe that establishing this new genus was justified based on the unique characteristics of the hind wings.

### ***Magnilobus pacificolus* (Demoulin, 1969) NEW COMBINATION**

Figs. 7-8, 17

*Thraulus pacificola* Demoulin, 1969:234, Fig. 9 (original description).

*Male Imago.*— Unknown.

*Female Imago.*— Unknown.

*Male Subimago.*— Unknown.

*Female Subimago.*— (in ethanol). Lengths: body, 3.9 (1); fore wings, 4.9 (1).

**Head.** Light brown, surface between antennal sockets ventral to median ocellus light brownish yellow, frontal margin brown, antennal sockets outlined with brown, mouthparts brown. *Eyes*: Lower portion black. *Ocelli*: Apical 1/2 white, basal 1/2 brown. *Antennae* light yellow.

**Thorax.** Pronotum brown. Remaining portions of thorax light yellow; carinae light brown on nota and pleura. *Fore wings* (Fig. 7) hyaline. *Hind wings* (Fig. 8) hyaline; base of veins C and Sc and intervening membrane washed lightly with brown. *Fore legs*: Light yellow. Coxae brownish yellow. Femora reddish brown, base and apex brownish yellow. Tibiae with brownish yellow base and a reddish brown subapical transverse band. *Middle legs* as in fore legs except: femora light yellow, with narrow median and subapical transverse reddish brown bands, apex brownish yellow. Tibiae with subapical band very faint. *Hind legs* as in middle legs except: tibiae with

basal reddish brown washings. Claws as in Fig. 17.

**Abdomen.** *Terga* light brown, tergum 9 brown; terga 1-6 with narrow transverse brown band on posterior margin; terga 7-8 with narrow transverse brownish yellow band on posterior margin. *Sterna* brownish yellow, *sterna* 1-2 with narrow transverse brown band on posterior margin; *sterna* 3-8 with lateral ends of posterior margin brown. *Caudal filaments* [broken off and missing].

*Nymph.* Unknown.

*Remarks.*— The holotype female subimago is the only known specimen of *M. pacificola*. It was in poor condition and thus many of its characters could not be described.

Our description compared well with Demoulin's (1969), but we described the holotype as being much lighter and also described the subapical bands on the tibiae.

*Distribution.*— *Magnilobus pacificolus* is known only from the island of Manus, Papua New Guinea.

*Biology.*— The holotype female subimago was collected in early June.

*Type Data.*— Holotype female subimago (in ethanol) with the following labels: Arch. Bismarck, Manus [Papua New Guinea]/ Lorengau, 7-VI-1962/ Noona Dan Exp.; G. Demoulin det., 1968/ *Neohagenulus pacificola*/ ♀ sp. n.; Pr.m.no:68.0325/12./a.b.; HT [embossed on red plastic tape]. We added the following label to the holotype vial: *Magnilobus pacificolus*/ (Demoulin, 1969)/ Det. 1985 P. M. Grant. Slide of legs: R. I. Sc. Nat. Belg./ I. G./ Arch. Bismarck/ Manus/ Lorengau/ 7-VI-1962/ Noona Dan Exp.; G. Demoulin det., 1968/ *Neohagenulus? pacificola*/ Demoulin/ H.T [printed in red]/ Pattes 1 -, - 2, 3 3 [numbers correspond to pro-, meso-, and metathoracic legs on slide]/ Pr.no:68.0325/12.a. Slide of fore and hind wings with same information as on leg slide except: Ailes. I.II. H.T. [printed in red]/ ♀ sub./ Pr.no.68.0325/12.b.

The holotype and the 2 slides are deposited at ZMC.

The holotype is in poor condition: head and apex of abdomen damaged; abdomen broken off (apical 7 segments) and loose in vial; missing right antennal flagellum, 2 legs, and *Caudal filaments*.

Demoulin (1969) reports the date of collection for the holotype as "7.IV.1962," but the date on the vial and slide labels was "7-VI-1962."

This specimen was collected during the Noona Dan Expedition (Petersen, 1966).

#### ACKNOWLEDGEMENTS

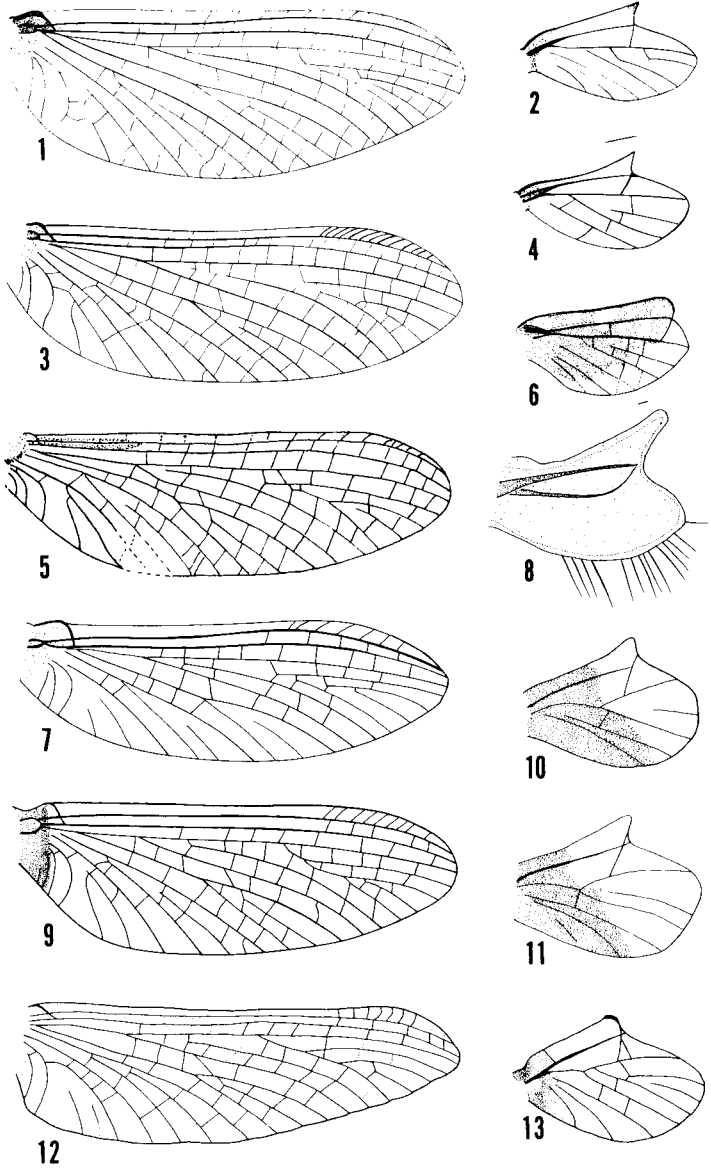
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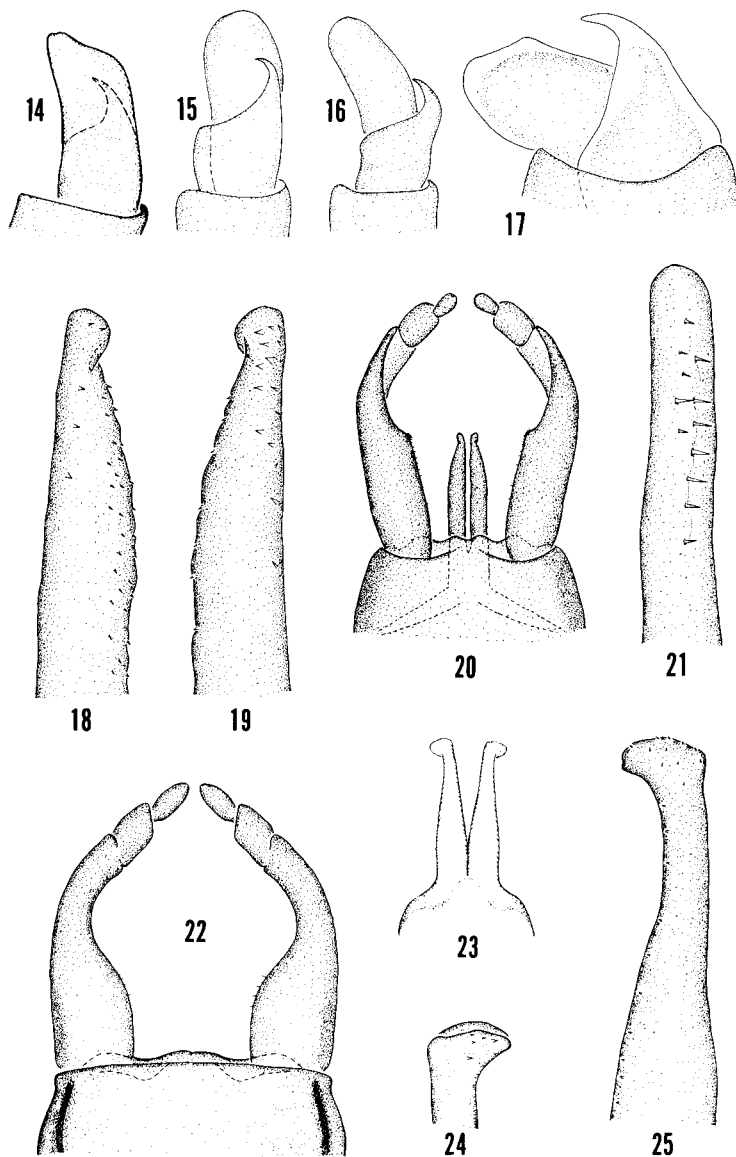
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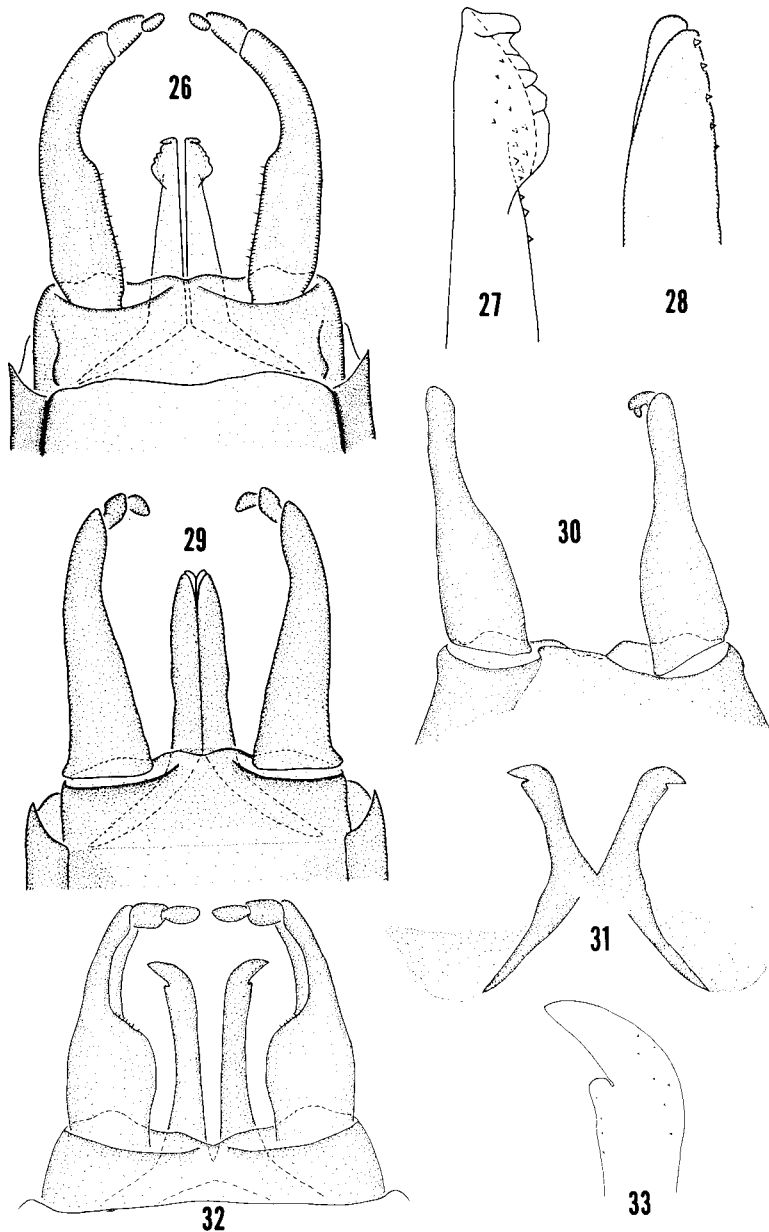


Figs. 1-13. Fore wing and enlarged hind wing of male imago (unless stated otherwise). 1-2, *Barba mariae* (from Peters and Tsui, 1972). 3-4, *Nonnullidens hsui* (from Peters and Tsui, 1972). 5-6, *Simothraululus seminiger* (Figs. 5-6 from Ulmer, 1939) 7-8, *Magnilobus pacificolus*, female subimago. 9-10, *Sulu duliti*. 11, *Sulu pescadori* (hind wing only). 12, *Chiusanophlebia asahinai* (fore wing only; from Ueno, 1969). 13, *Thraululus bellus* (hind wing only).

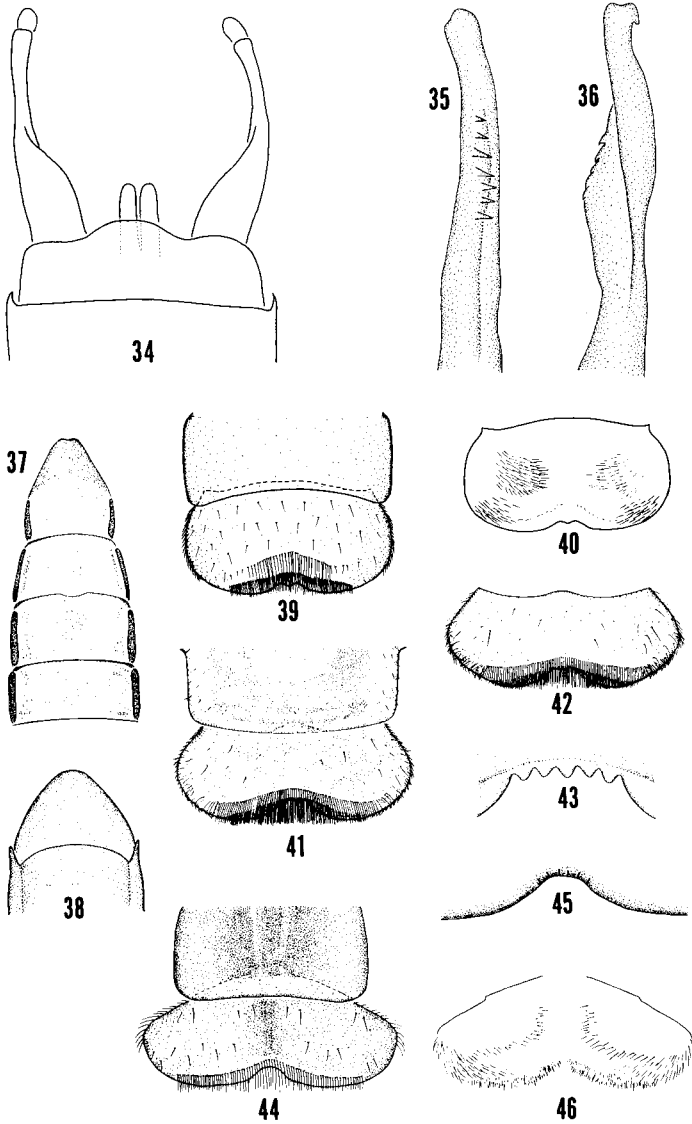




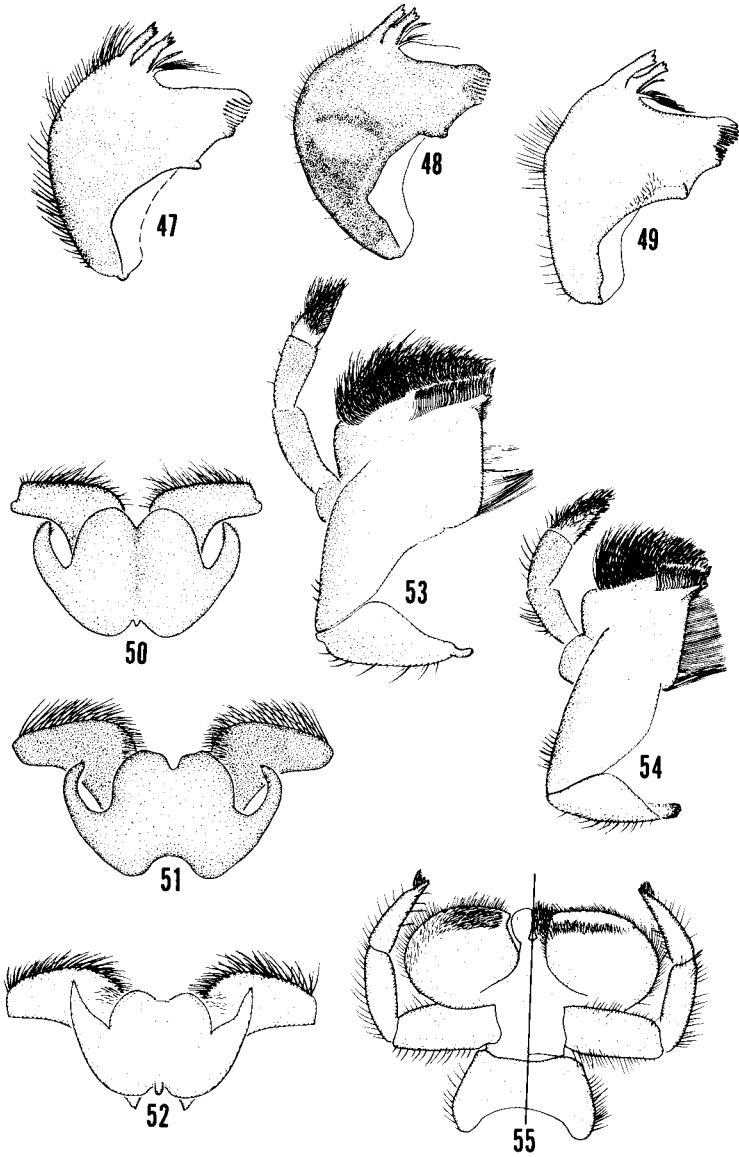
Figs. 14-25. Figs. 14-17. Male imaginal claws (unless stated otherwise). 14, *Barba mariae*, composite drawing of male and female imaginal fore claws. 15, *Nonnullidens hsui*, fore claws. 16, *Sulu pescadori*, middle or hind claws. 17, *Magnilobus pacificolus*, female subimaginal hind claws. Figs. 18-25. Male imaginal genitalia (ventral view) and penes. 18-20, *Barba mariae*: 18, left penis, dorsal view; 19, left penis, ventral view. 21, *Thraululus demoulini*, left penis, dorsal view. 22-25, *Nonnullidens hsui*: 23, penes, ventral view (from Peters and Tsui, 1972); 24, apex of left penis, dorsal view; 25, left penis, ventral view.



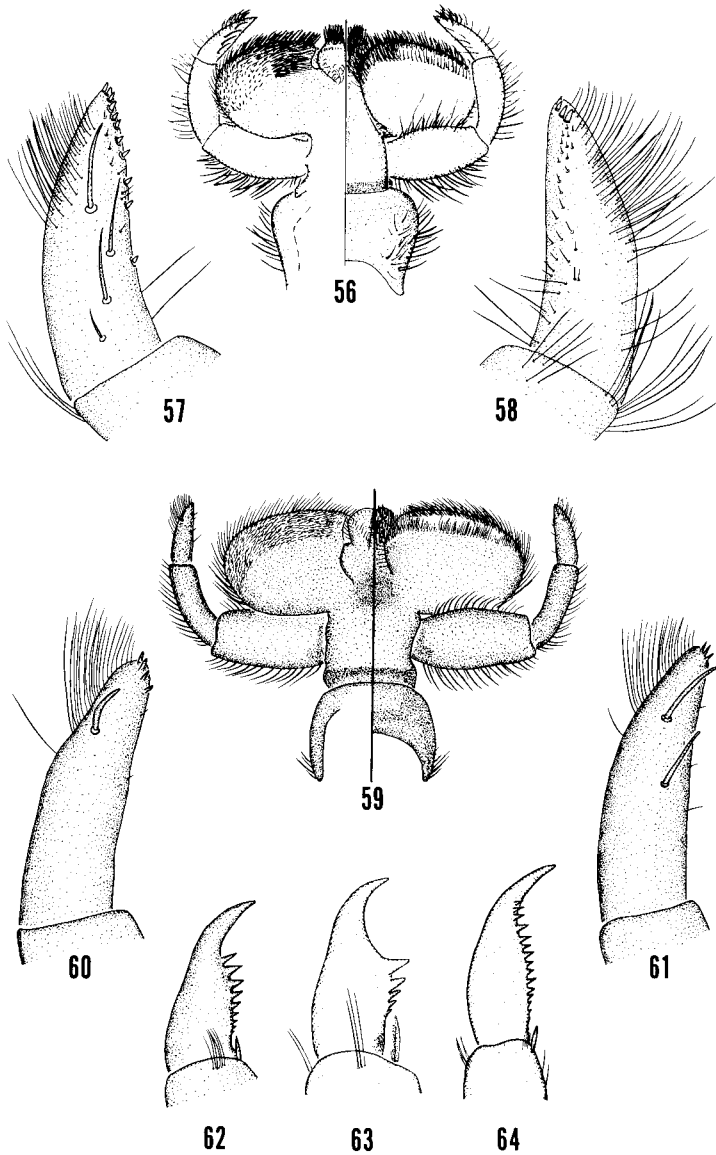
Figs. 26-33. Male imaginal genitalia (ventral view) and penes. 26-27, *Thraululus fasciatus*: 27, apex of right penis, ventral view. 28-29, *Thraululus bellus*: 28, apex of right penis, ventral view. 30-31, *Sulu duliti*: 31, penes, ventral view. 32-33, *Sulu pescadori*: 33, apex of left penis, ventral view.



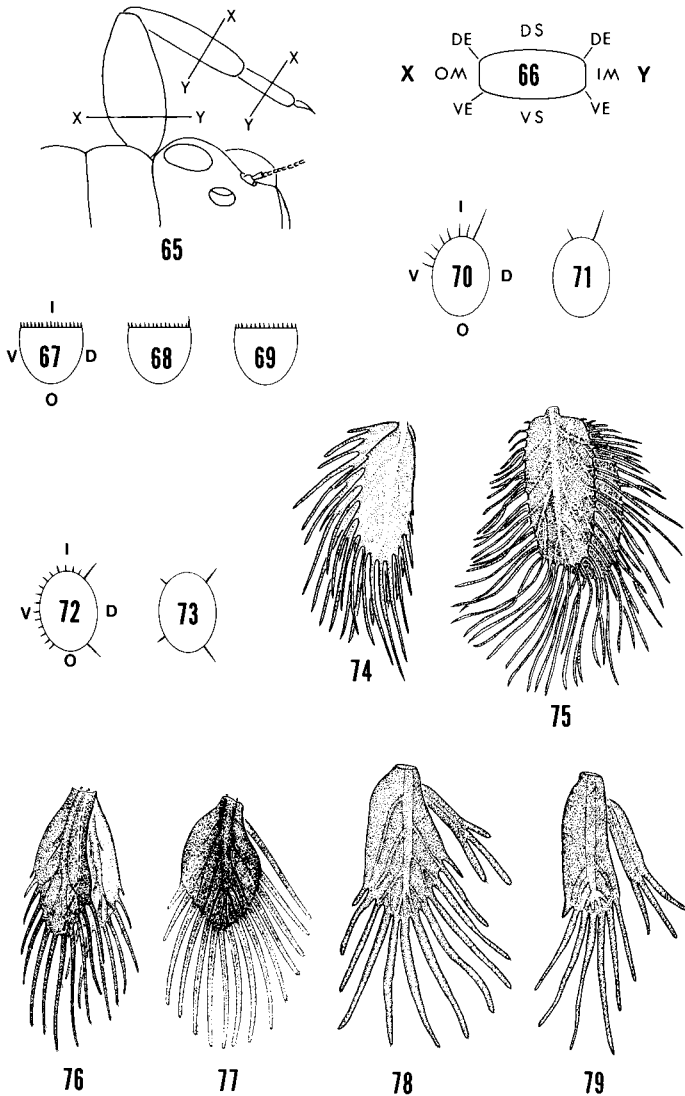
Figs. 34-46. Figs. 34-36. Male imaginal genitalia (ventral view) and penes. 34, *Chiusanophlebia asahinai* (from Uèno, 1969). 35-36, *Simothraulius seminiger*, left penis: 35, dorsal view; 36, lateral view. Figs. 37-38. *sterna* of female imago. Fig. 37. *Barba mariaae*, *sterna* 6-9 (from Peters and Tsui, 1972). 38, *Thraulius torrentis*, *sterna* 8-9 (from Peters and Edmunds, 1970). Figs. 39-46. Clypeus and labrum (dorsal view unless otherwise stated). 39-40, *Thraulius bellus*: 40 ventral setal pattern of labrum. 41-43, *Barba mariaae*: 42, labrum showing hind margin (from Peters and Tsui, 1972); 43, anterior emargination of labrum, enlarged (from Peters and Tsui, 1972). 44-46, *Nonnullidens hsui*: 45, anterior emargination of labrum, enlarged; 46, ventral setal pattern of labrum.



Figs. 47-55. Figs. 47-49: Left mandible (dorsal view). 47, *Barba mariae*. 48, *Nonnullidens hsui*. 49, *Thraulus bellus*. Figs. 50-52. Hypopharynx (ventral view). 50, *Thraulus torrentis* (from Peters and Edmunds, 1970). 51, *Nonnullidens hsui*. 52, *Barba mariae*. Figs. 53-54: Right maxilla (ventral view) 53, *Nonnullidens hsui* (from Peters and Tsui, 1972). 54, *Barba mariae* (from Peters and Tsui, 1972). Fig. 55. Labium (dorsal surface illustrated on left of vertical line, ventral surface illustrated on right). 55, *Thraulus bellus*.



Figs. 56-64. Figs. 56-61: Labium (dorsal surface illustrated on left of vertical line, ventral surface illustrated on right) and third palpal segment. 56-58: *Barba mariae*: 57, third palpal segment, dorsal view; 58, third palpal segment, ventral view. 59-60: *Nonnullidens hsui*: 60, third palpal segment, dorsal view. 61, *N. bilhilli*, third palpal segment, dorsal view. Figs. 62-64: Nymphal fore claw. 62, *Barba mariae*. 63, *Nonnullidens hsui* (from Peters and Tsui, 1972). 64, *Thraululus bellus*.



Figs. 65-79. Figs. 65-66: Schematics identifying surfaces of nymphal leg as used in this study. 65, Dorsal view of left side of head and prothorax and left fore leg of nymph showing orientation of cross sections x-y. 66, Lateral view of a cross section x-y of nymphal leg in Fig. 65. This cross section and its terms are the same for the femora, tibiae, and tarsi of all nymphal legs (de, dorsal edge; ds, dorsal surface; im, inner margin; om, outer margin; ve, ventral edge; vs, ventral surface). Figs. 67-73: Schematic cross section of nymphal tibiae showing distribution of setae (d, dorsal; i, inner, o, outer, v, ventral). Figs. 67-69: Fore tibiae. 67, *Barba mariae*. 68, *Nonnullidens hsui*. 69, *N. billhilli*. Figs. 70-71. Middle tibiae. 70, *Barba mariae*. 71, *Nonnullidens hsui* (long dorsal setae not shown). Figs. 72-73: Hind tibiae. 72, *Barba mariae*. 73, *Nonnullidens hsui* (long dorsal setae not shown). Figs. 74-79: Abdominal gill 4. 74, *Thraululus turbinatus*. 75, *Thraululus bellus*. 76, *Barba mariae* (from Peters and Tsui, 1972). 77-78: *Nonnullidens hsui* (from Peters and Tsui, 1972). 79, *Nonnullidens billhilli*.