

A NEW SPECIES OF *THRAULUS* (EPHEMEROPTERA:
LEPTOPHLEBIIDAE: ATALOPHLEBIINAE) FROM
SOUTHERN INDIA

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ABSTRACT

Thraulus gopalani, n. sp., is described from specimens collected in southern India. Descriptions are provided for the male imago, female subimago, and nymph.

RESUMEN

Se describe *Thraulus gopalani*, n. sp., de especímenes colectados en el sur de la India. Se proveen descripciones del imago macho, del subimago hembra, y de la ninfa.

The genus *Thraulus* (Ephemeroptera: Leptophlebiidae) is widespread throughout the Eastern Hemisphere, being found in Europe, Africa, India, southeastern Asia, northern Australia and the Indo-West Pacific. Of its 11 described species only one, *T. semicastaneus* (Gillies), was previously known from India and was collected by Gillies (1951) near Pune, Maharashtra State.

One of us (KGS) recently collected specimens from southern India that represent a new species of *Thraulus*. The following is a description of the male imago, female subimago, and nymph of *Thraulus gopalani*, n. sp.

A number in parentheses after a measurement or count indicates the number of specimens examined. All measurements are in millimeters. For the holotype, we have given the information on all labels; we have separated the information given on different labels by a semicolon.

Thraulus gopalani Grant and Sivaramakrishnan, NEW SPECIES
Figs. 1-19

MALE IMAGO (in ethanol).—Length: body, 7.8 (1); fore wings, 6.8 (1).

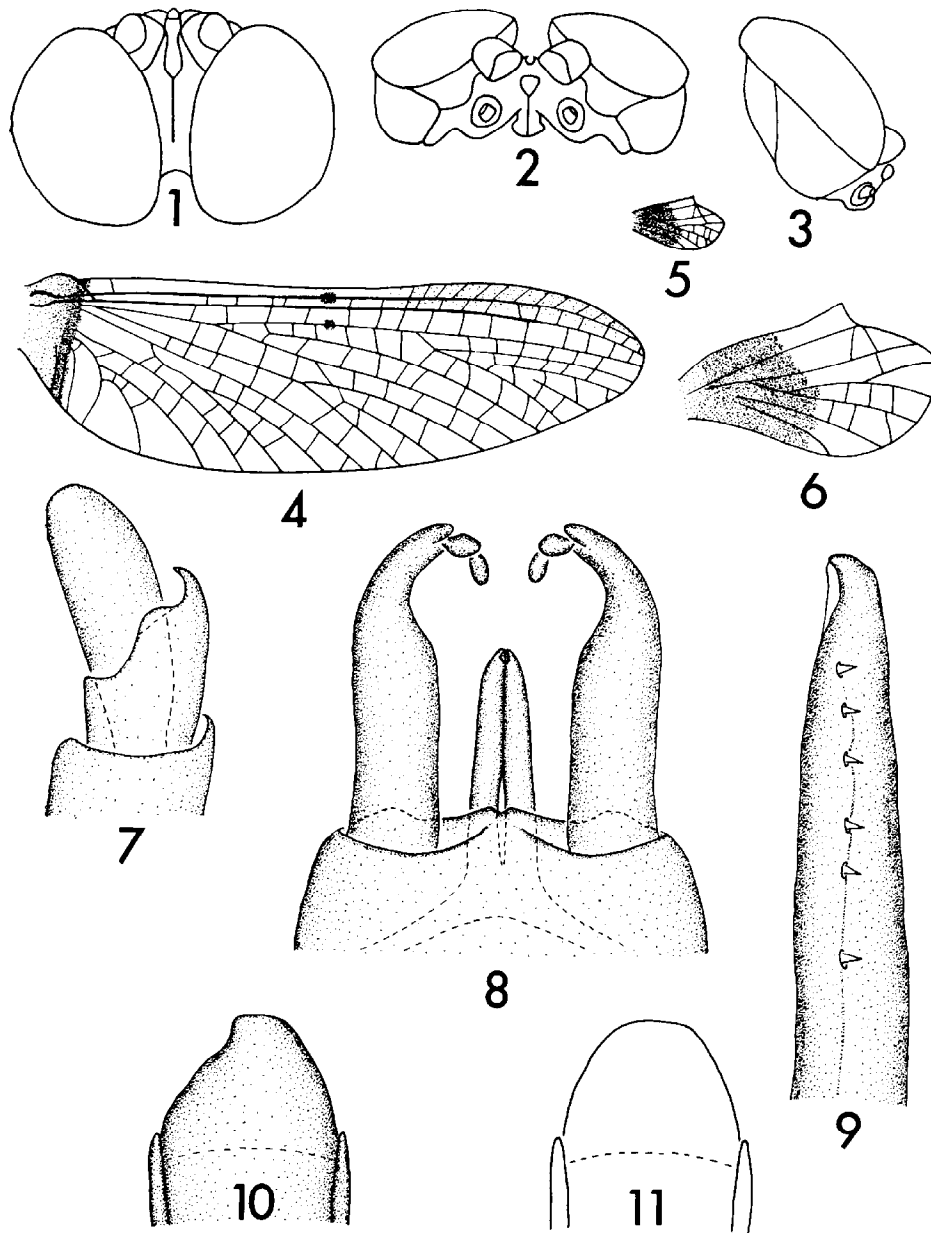
HEAD (Figs. 1-3); Brownish yellow, posterior half of dorsal surface washed evenly with dark brown, narrow dark brown bands outline antennal sockets; 2 narrow dark brown bands extend from dorsomedial margin of antennal socket: one extends to frontal longitudinal carina and the other to anteromesal base of lateral ocelli; frontal margin dark brown; dorsal longitudinal carina extends posteriorly from posteromesal corner of lateral ocelli to 2/3 distance to posterior margin of head (Fig. 1), anterior half

of carina dark brown; posterior margin of head concave; mouthparts washed heavily with black. *Eyes* (Fig. 1-3); Upper portion light orange; suboval in dorsal view (Fig. 1), dorsal surface rounded (Figs. 2-3); separated dorsally by ca. $1/5$ width of upper portion of an eye (Figs. 1-2). Lower portion black. *Ocelli* (Figs. 1-2) with lens clear to opaque white, wide dark brown band outlines base of lens; lateral ocelli with dorsal surface basal to dark brown band brownish yellow; contiguous with upper portion of eyes laterally (Fig. 1); carina defines mesal edge of each ocellus, anterior end of carinae thickened slightly forming a small mesally projecting process; carinae intersect dorsal longitudinal carina at most anterior point (Fig. 1). *Antennae* yellow, scape with dark brown macula on anterior surface, basal $2/3$ of pedicel dark brown.

THORAX: *Pronotum* brownish yellow, brown macula in center of each lateral half, margins dark brown. *Mesonotum* light brown, carinae brown, posterior half of scutellum brown. *Metanotum* brownish yellow. *Pleura* and *sterna* light brown, washed unevenly with dark brown, carinae dark brown. *Fore wings* (Fig. 4) hyaline, narrow dark brown band between costal brace and apex of vein A_2 , membrane basal to band washed evenly with brown; small brown macula on bullae of veins Sc and R_2 ; oblique cross vein between veins R_{4+5} and MA_1 adjacent to vein MA fork; length 3.2 width (1). *Hind wings* (Figs. 5-6) with basal $1/2$ brown, apical $1/2$ hyaline, axillary area brownish yellow; apex of costal projection pointed, sides of projection almost orthogonal; apex of projection located 0.6-0.7 distance from base to apex of wings (1); apex of wings bluntly rounded; length 1.6 width (1). *Fore legs:* Coxae dark brown, carinae darker. Trochanters brownish yellow, mesal surface and apex dark brown. Femora brown. Tibiae with offset basal end light brown, apical $1/4$ dark brown, intervening portion white. Tarsi white. Claws white, dissimilar: one blunt, pad-like; one apically hooked. *Middle legs:* [broken off and missing]. *Hind legs* as in fore legs except for: Trochanters with lateral half dark brown, mesal half yellow. Femora dark brown, basal $3/10$ and apex yellow. Tibiae with apical $1/7$ dark brown, outer margin narrowly lined with dark brown, remaining portion and extreme apex white. Claws as in Fig. 7.

ABDOMEN: Terga washed uniformly with brown, posterior margin of all terga dark brown; anterior margin of tergum 1 dark brown, undulating; terga 2-7 with a narrow light yellow median longitudinal streak extending posteriorly from anterior margin to $2/3$ segment length; terga 2-9 with shorter and wider submedian streaks; lateral folds dark brown; spiracular areas and anterolateral corners of each tergum immediately above lateral folds light brownish yellow. *Sternum* 1 brown; anterior, anterolateral, and posterior margins light brownish yellow; sterna 2-7 light brownish yellow, with large median and lateral maculae; maculae widen on posterior sterna and unite on sternum 7; sternum 8 brown, anterior margin light yellow; sternum 9 brown; posterolateral corners of sterna 1-8 dark brown. *Caudal filaments* white, articulations dark brown.

GENITALIA (Figs. 8-9): *Styliger plate* (Fig. 8) brown; rounded mesal emargination on posterior margin. *Forceps* (Fig. 8) with wide basal $1/2$ of segment 1 brown, apical $1/2$ and segments 2 and 3 washed evenly with dark brown; segment 1 apical width 0.3 basal width (1); mesal margin of basal $1/2$ of segment 1 without spine-like setae; mesal margin of apical half of segment 1 and segments 2 and 3 densely lined with small spine-like



Figs. 1-11, *Thraulius gopalani*, n. sp. Figs. 1-9, male imago. 1. Dorsal view of head. 2. Frontal view of head. 3. Lateral view of head. 4. Fore wing. 5. Hind wing drawn to scale of fore wing. 6. Hind wing, enlarged. 7. Hind claw. 8. Ventral view of genitalia. 9. Dorsal surface of left penis. Figs. 10-11, female subimago. 10. Teratological ninth sternum. 11. Probable normal shape of ninth sternum.

setae. *Penes* (Figs. 8-9) light brown; long, narrow, tapering to a mesally projecting beak-like apex (Fig. 9); mesal margin slightly concave in middle 1/3; basal 1/2 of lateral margins straight, apical 1/2 gradually converges mesally; contiguous along most of mesal length but not fused;

each penis with 6 spine-like dorsal setae (Fig. 9), setae arranged in a longitudinal row and project laterally.

MALE SUBIMAGO.—Unknown.

FEMALE IMAGO.—Unknown.

FEMALE SUBIMAGO (in ethanol).—Length: body, 8.3 (1); fore wings, 8.9-9.0 (1). Characters as in male imago except for the following.

HEAD: Light brownish yellow, washed unevenly with dark brown, carinae dark brown; a large dark brown macula on posterior margin mesal to each eye; dorsal longitudinal carina extends from center of head to posterior margin; posterior margin undulate, convexly rounded mesally. *Eyes* separated by ca. 5.5 width of an eye. *Lateral ocelli* with apical 1/2 clear to opaque white, basal 1/2 dark brown; 2 submedian parallel longitudinal carinae between ocelli, anterior ends of carinae bifurcate; 1 branch intersects edge of antennal socket and the other intersects base of median ocellus, posterior ends of carinae converge and intersect dorsal longitudinal carina at its most anterior point.

THORAX: *Mesonotum* light brownish yellow; anterior bulbous portion and scutal humps brown; long oval light brown area encompasses each inner parapsidal suture; notal furrow dark brown anterior to wing bases; outer parapsidal suture posterior to wing bases brown; posterior 1/2 of scutellum dark brown. *Fore wings* with membrane cloudy white; small dark brown macula on bulla of vein Sc, smaller macula on bulla of veins R₂ and R₄₊₅. *Fore legs*: Trochanters dark brown, anterior surface light brown; [remaining leg segments broken off and missing]. *Middle and hind legs*: Trochanters light brown, anterior and posterior surfaces dark brown; [remaining leg segments broken off and missing].

ABDOMEN (Figs. 10-11): *Tergal* coloration as in male imago but lighter brown; apex of spine on posterolateral corners of tergum 9 extends more posteriorly than posterior margin of tergum 9. *Sternum* 7 with straight posterior margin; posterolateral corners of sternum 8 converge posteriorly (Fig. 10); apex of sternum 9 rounded but asymmetrical (Fig. 10).

NYMPH (in alcohol).—Size range of specimens examined: head width, ca. 1.0-1.5 (4); body length, ca. 5.6-8.5 (4).

HEAD: Brownish yellow; washed evenly with brown between eyes and ocelli, around antennal sockets, and anterior margin of clypeus; posterior margin convexly rounded. *Eyes*: Upper portion (males) reddish brown, oval. Lower portion black; eyes of female separated by ca. 6 times width of an eye (1). *Antennae* with scape, pedicel, and base of flagellum light yellow, middle 1/3 of pedicel washed lightly with brown. *Mouthparts* (Figs. 12-16) brownish yellow, washed evenly with brown especially on lateral margins: Labrum (Figs. 12-13) with a rectangular mesal emargination anteriorly (Fig. 13); width 2.6 length (1); 2 rows of dorsal setae not parallel (Fig. 12); inner row almost straight, situated just anterior to center of labrum, ca. 0.5 width of labrum (2); outer row curved, 0.4 width of labrum (2); lateral margins with few setae. Mandibles (Fig. 14) with lateral margin smoothly rounded; lateral setae sparse, thin clump near middle of lateral margin, thinning posteriorly (Fig. 14). Maxillae with width of apical setal row 0.8-0.9 width of galealacinia (2); width of sub-apical setal row 0.4 width of galealacinia (2); 18-23 pectinate setae (2);

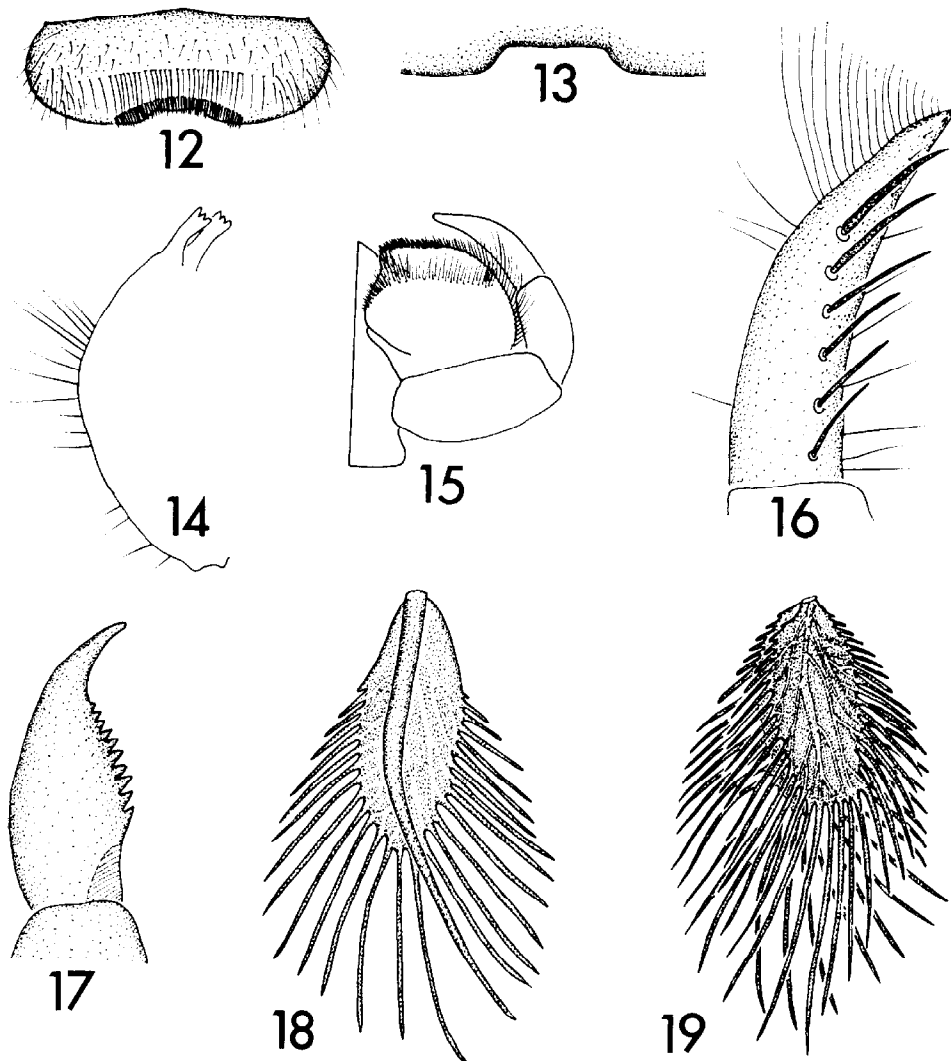
beak-like protuberance on mesal margin at end of subapical row. Labial palpi (Figs. 15-16) with inner and outer margins of segment 1 washed evenly with brown, a brown macula midway between base of palpi on ventral surface; ventrally paraglossae with long setae on mesal margin, row of setae extends laterally from mesal setal patch (Fig. 15); segment 3 with row of long thin lateral setae and 6-7 large dorsal setae (Fig. 16).

THORAX: *Pronotum* brownish yellow, margins dark brown, 2 dark brown submedian maculae in center and 1 dark brown median macula on posterior margin. *Mesonotum* brownish yellow, lateral and posterior margins washed unevenly with dark brown; fore wing pads with basal transverse dark brown band. *Metanotum* brownish yellow, washed unevenly with dark brown; basal half of hind wing pads dark brown. *Pleura and sterna* brownish yellow, washed unevenly with brown. *Fore legs*: Coxae brownish yellow, washed evenly with dark brown; lateral margin lined with setae. Trochanters with anterior and posterior surfaces dark brown, lateral and mesal surfaces brownish yellow; with an apical row and a shorter sub-apical row of setae. Femora with basal 1/2 white, apical 1/2 washed evenly with dark brown. Tibiae light brownish yellow, apex washed evenly with dark brown; inner margin flattened, densely covered with short setae. Tarsi light brownish yellow. Claws (Fig. 17) with 10-13 denticles; denticles decrease in size apically. *Middle legs* as in fore legs except: Trochanters with apical row of setae only. Tibiae with inner margin covered sparsely with very short, tiny setae. *Hind legs* as in middle legs except: Tibiae densely covered with short setae, base and lateral margin with few setae.

ABDOMEN: *Terga* brownish yellow, washed evenly with dark brown, washings heavier laterally and on posterior margins; terga 2-9 with a brownish yellow longitudinal mesal stripe; terga 2-8 with 2 submedian brownish yellow spots on anterior margins; spiracular areas white. *Sterna* light yellow; sterna 1-8 with paired sublateral maculae; posterior margin of sternum 8 and all of sternum 9 washed evenly with dark brown; mesal margin of posterolateral spines on segments 8 and 9 dark brown; lateral portions of posterior margins narrowly dark brown. *Gills* (Figs. 18-19) washed evenly with dark brown: gills on abdominal segment 1 with a long lanceolate dorsal lamella and an oval ventral lamella (Fig. 18); margin of apical 2/3 of lamella lined with fimbriae; lamellar length ca. 3 times width; lengths of fimbriae increase apically. Gills on abdominal segments 2-7 with oval dorsal and ventral lamellae; lamellae as in gills on abdominal segment 1 except fimbriae cover all margins except extreme basal portion (Fig. 19). *Caudal filaments* brown basally, fading to light brown towards apex.

REMARKS.—Imagos of *T. gopalani* can be distinguished from all other described species of *Thraulius* by the following combination of characters: (1) the upper portion of the male eyes are separated (Figs. 1-2); (2) fore wings have a narrow dark brown band between the costal brace and vein A_2 (Fig. 4); (3) the bullae of veins Sc and R_2 have a small dark brown macula (Fig. 4); (4) the basal 1/2 of the hind wings is brown and the apex is bluntly rounded (Fig. 6); and (5) each penis has a single longitudinal row of spine-like setae on its dorsal surface (Fig. 9).

Nymphs of *T. gopalani* can be distinguished from all other described species of *Thraulius* (with known nymphal stage) by the following com-



Figs. 12-19, *Thraulius gopalani*, n. sp., nymph. 12. Dorsal view of labrum. 13. Anterior emargination of labrum, enlarged. 14. Mandible, lateral setal pattern. 15. Left paraglossal setal pattern, ventral view. 16. Third segment of labial palp, dorsal surface. 17. Fore claw. 18. First abdominal gill. 19. Fourth abdominal gill.

bination of characters: (1) the labrum has a rectangular mesal emargination anteriorly (Fig. 13); (2) the inner row of the dorsal setae is located just anterior to the middle of the labrum (Fig. 12); (3) the outer margin of the mandibles lacks a tuft of setae at the base of the incisors (Fig. 14); (4) the denticles on the claws decrease in size apically (Fig. 17); and (5) the abdominal gills on segment 1 have a dorsal lanceolate portion and a ventral fimbriate lamellar portion (Fig. 18), and the abdominal gills on segments 2-7 have dorsal and ventral fimbriate lamellar portions (Fig. 19).

Thraulius gopalani does not appear to be closely allied with any one of the other described species of *Thraulius*. In the imagos it shares the character of separated male eyes with *T. bellus* Eaton and *T. turbinatus*

(Ulmer), claw shape with *T. fasciatus* (Kimmings), dorsal spine-like penile setae with *T. turbinatus* and *T. semicastaneus*, and hind wing shape and coloration with *T. duliti* (Demoulin). In the nymphs it shares the character of mandibular setal pattern with *T. bellus*, claw shape with *T. torrentis* (Gillies), and shape of the first pair of abdominal gills with *T. torrentis* and *T. fasciatus*. Phylogenetic relationships among the species of *Thraulius* are presently being studied as part of a systematic revision of the *Thraulius*-group genera by the senior author.

Imagos of *T. gopalani* key to couplet 3 (*T. torrentis* and *T. duliti*) in Peters and Tsui (1972) but can be distinguished from those 2 species by: (1) the metathoracic tibiae being dark brown on the apical 1/7 with the remaining portion and extreme apex white and (2) the upper portion of the eyes are not contiguous dorsally (Figs. 1-2). Nymphs of *T. gopalani* key to *T. torrentis* in Peters and Tsui (1972) but can be separated from *T. torrentis* by: (1) the labrum having a rectangular emargination anteriorly (Fig. 13) and (2) the outer margin of the mandibles lacks a tuft of setae at the base of the incisors (Fig. 14).

The only male imaginal fore claw available for examination is damaged. Comparison of the fore and hind claws indicates that at least the shape of the outer margin of the hooked claw and the hook itself are similar.

On the genitalia slide of the male imago the forceps and styliger plate are mounted with the dorsal surface up. The penes are not attached to the rest of the genitalia but are mounted superimposed over the styliger plate. As the genitalia are oriented on the slide, the spine-like setae of the penes appear to be on the ventral surface. Examination of the penes of *T. semicastaneus* from India, *T. bishopi* Peters and Tsui from Malaysia, and *T. demoulini* Peters and Tsui from Thailand indicates that all 3 species have a row of spine-like setae only on the dorsal surface. We believe that the penes of *T. gopalani* were inadvertently rotated during mounting and that the spine-like setae do indeed occur on the dorsal surface.

The penes are divergent from one another on the slide, but a photograph taken before the genitalia were permanently mounted shows that the penes are naturally contiguous along most of their mesal length.

The setation of the middle and hind nymphal tibiae are unique to this species. The setae lining the inner margin of the middle tibiae are extremely reduced in length. The hind tibiae are densely covered with setae except for the extreme base and the outer margin.

The ninth sternal apex of the female subimago and its final nymphal instar exuviae is asymmetrical (Fig. 10). Two female nymphs from the same locality were examined, and both had symmetrical ninth sterna. This asymmetry is most likely a teratology; the typical shape is probably symmetrical, resembling Fig. 11.

The number of pectinate setae forming the subapical row on the maxillae vary with a large female nymph having more (23) than a smaller male (18-19). Larger nymphs of both sexes also have more denticles on the claws.

There was only a slight indication that denticles were present on the labrum.

Thraulius gopalani differs from the generic description given for *Thraulius* by Peters and Edmunds (1970) in 3 respects: (1) the male imaginal eyes are not contiguous, (2) the setal tuft on the outer mandibular margin

just basal to the incisors is lacking (cf. Peters and Edmunds 1970, their Fig. 232), and (3) the denticles on the claws become progressively smaller apically. This is the first time that spine-like setae on the dorsal surface of the penes have been described for any species of *Thraulius*.

GEOGRAPHIC DISTRIBUTION.—*Thraulius gopalani* is known only from southern Tamil Nadu State, India.

BIOLOGY.—Nymphs have been collected in March and December; adults were reared from final instar nymphs collected in March. Nymphs inhabit the underside of rocks in heavily silted side pools with a slow current.

ETYMOLOGY.—This species is named in honor of Prof. G. Gopalan, Madura College, Madurai, for having been of great assistance to the junior author on his field trips.

TYPE DATA.—Holotype male imago (in ethanol) with the following labels: INDIA: Tamil Nadu State, Kottum Thalam, nr. Papanasam, Tamraparany River, 54 km S Tenkasi, 250m, 20 III 1978, K. G. Sivaramakrishnan; *Thraulius gopalani*, Grant and Sivaramakrishnan; holotype, Grant and Sivaramakrishnan; wings on slide, KGS: 82#11:82-18; claw on slide (fore), KGS:82#11:82-19; male genitalia on slide, KGS:82#11:82-20. This specimen is in fair condition: the upper portion of the eyes are collapsed; the head, 2 caudal filaments, and a portion of the left mesopleuron are loose in the microvial with the imago; and only 3 legs are present (1 fore leg). Three microvials are in the holotype vial: one contains the imago, one the left hind claw, and one the final nymphal instar and subimaginal exuviae.

Paratypes (in ethanol): Female subimago (with its associated final nymphal instar exuviae), same data as holotype. Three nymphs, same data as holotype; mouthparts on slide: PMG-1984-THR33. One nymph, same data as holotype but collected 10 XII 1982; mouthparts on slide: PMG-1984-THR32, fore claw on slide: PMG-1984-THR31.

The holotype (with wings, fore claw, and male genitalia slides) and 3 nymphal paratypes (with mouthparts slides) are deposited in the collection of the Entomology Institute, Loyola College, Madras, India. The female subimaginal and 1 nymphal paratypes (with mouthparts and fore claw slides of nymph) are deposited in the collection of Florida A&M University.

Adult and nymphal stages are associated by rearing.

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REFERENCES CITED

- GILLIES, M. T. 1951. Further notes on Ephemeroptera from India and South East Asia. Proc. R. Ent. Soc. London, (B) 20: 121-130.

PETERS, W. L. AND G. F. EDMUNDS, JR. 1970. Revision of the generic classification of the Eastern Hemisphere Leptophlebiidae (Ephemeroptera). Pac. Ins. 12: 157-240.

PETERS, W. L. AND P. T. P. TSUI. 1972. New species of *Thraulius* from Asia (Leptophlebiidae: Ephemeroptera). Orient. Ins. 6: 1-17.

SYSTEMATICS OF THE NEARCTIC GENUS *PSEUDIRON* (EPHEMEROPTERA: HEPTAGENIIDAE: PSEUDIRONINAE)

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ABSTRACT

The genus *Pseudiron* is redescribed and the subimagos are described for the first time. *Pseudiron meridionalis* Traver is synonymized with *P. centralis* McDunnough leaving *Pseudiron* a monotypic genus. *Pseudiron centralis* is redefined, and its biology, ecology, distribution, and geographic variation in the Central United States and Canada is discussed.

RESUMEN

Se redescrive el género *Pseudiron meridionalis* Traver y los subimagos son descritos por primera vez. Se sinonimiza *Pseudiron meridionalis* Traver con *P. centralis* McDunnough, lo que deja a *Pseudiron* como género monotípico. Se redefine *Pseudiron centralis* y se discute su biología, ecología, distribución, y variación geográfica en las partes centrales de Estados Unidos, y en Canadá.

McDunnough (1931) established the genus *Pseudiron* for *P. centralis* based on female imagos. The nymph was first described and tentatively referred to *Pseudiron* by Spieth (1938), and with additional specimens available, Burks (1953) subsequently complemented the nymphal description and accepted Spieth's generic assignment of the nymph. The genus has been assigned to various subfamilies and/or families. McDunnough (1931) originally noted that the genus had typical heptageniid venation and was close to *Siphloplecton*. Traver (*in* Needham, Traver and Hsu, 1935) assigned *Pseudiron*, along with *Metretopus* and *Siphloplecton*, to the subfamily Metretopinae, while Lestage (1938) included *Pseudiron* and *Siphloplecton* in Siphloplectonidae. Burks (1953) assigned *Pseudiron* to the family Ametropidae (sic), in which he also included *Metretopus* and *Siphloplecton*. Edmunds and Traver (1954) established the subfamily Pseudironinae in Heptageniidae for *Pseudiron*. This arrangement has been uniformly followed in subsequent classifications (Demoulin, 1958; Edmunds, et al., 1963; Koss and Edmunds, 1974; Edmunds et al., 1976; Berner, 1978; and McCafferty and Edmunds, 1979) and is based upon internal and external morphology, and studies on the eggs.

Except for generic descriptions of the adult and nymph of *Pseudiron*