

Life stage descriptions, taxonomic notes, and new records for the mayfly family Leptohiphidae (Ephemeroptera)

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Abstract

The larval stages of *Tricorythodes fictus* Traver, *T. cobbi* Alba-Tercedor and Flannagan, and *T. mosegus* Alba-Tercedor and Flannagan are described for the first time based upon reared specimens. The rarely reported *Asioplax dolani* (Allen) is newly documented from the Austroriparian ecological region of Texas. *Leptohiphes zalope* Traver, known from the southwestern United States and much of Central America, is newly documented from the Caribbean Islands of Grenada and Tobago. This represents only the second leptohiphid mayfly known from both Continental America and the Caribbean region. Additional Caribbean records of *Allenhiphes flinti* (Allen) are also given.

Key words: Ephemeroptera, Leptohiphidae, *Tricorythodes*, taxonomy, stage descriptions, new records

Introduction

The mayfly family Leptohiphidae (Ephemeroptera) is a new world family of mayflies endemic to the Western Hemisphere. Species of the family can be extremely abundant in streams and rivers throughout the southwestern United States and Central and South America. Although common and widely distributed, the taxonomy of this family suffers from many problems (Baumgardner and McCafferty 2000), one of the most significant being the lack of associated adult and larval stages. As part of a continuing effort to better document and describe species within the family Leptohiphidae, the larval stages of *Tric-*

orythodes fictus Traver, *T. cobbi* Alba-Tercedor and Flannagan and *T. mosegus* Alba-Tercedor and Flannagan are described for the first time based upon reared specimens. New distribution records for the rarely reported *Asioplax dolani* (Allen) are given, as well as new records of *Leptohyphes zalope* Traver and *Allenhyphes flinti* (Allen).

Collections (and their acronyms) housing materials used in this study include: The Academy of Natural Sciences of Philadelphia (ANSP); Cornell University Insect Collection, Ithaca, New York (CU); Florida A&M University, Tallahassee (FAMU); Northeastern Ephemeroptera Laboratory (NEL) at Southern Connecticut State University, New Haven; and Texas A & M University, College Station (TAMU). Larval collections are abbreviated by the letter "L" and sex of adult is abbreviated "M" for male imagos and "F" for female imagos. Larval and adult designations are preceded by the number of specimens examined.

Asioplax dolani (Allen)

Asioplax dolani was originally described in *Leptohyphes* by Allen (1967) based upon a small series of larvae from the Savannah River at the South Carolina-Georgia border. It was later reported from Texas (Allen and Roback, 1969) and Florida (Lager, 1985). Allen and Roback (1969) based these records upon specimens collected in 1962 by S.S. Roback from the Guadalupe River near Victoria, Texas, then a second time by Allen (1978) from specimens collected in 1950 and 1952 by T. Dolan IV from near the same locality. No other records of this species in Texas have been reported until now. New records given below document *A. dolani* from the Austroriparian ecological region of East Texas, where larvae occupied crevices on snags in moderate-sized, sandy-bottomed streams with dense riparian vegetation. Lager (1985) reported a similar microhabitat for this species in a Florida stream.

Study of the published holotype and paratypes of this species showed them to be undissected and in good condition, with clear indications of which specimen was designated the holotype, and which the paratypes. In addition to the type series listed in the literature, a third vial from ANSP contained three larvae of *A. dolani*, three associated slides, and a label indicating that they were paratypes. Because these specimens were collected many years before the species description, have the same style of labels as the published type series, and have associated slides from which the original figures appeared to have been drawn, it appears that Allen intended to publish them as part of the type series but inadvertently did not include them in the original publication. As such, they should be considered valid paratypes.

Type Material Examined: HOLOTYPE: Savannah River, Dikes above Ellenton, S.C., Station 1, IX-2-1955, S.S. Roback (ANSP). PARATYPES: Savannah River, South Carolina-Georgia, Station 6A, SS Roback, VIII-21-55, 1L (ANSP). Savannah River, Ga-S.C., Station 5, T.Dolan IV, X-23-51, 1L (ANSP). Following specimens originally unpub-

lished - Savannah River, Georgia-South Carolina Station 1, Aiken Co., S.C., T. Dolan IV, VII-26-51, 3L (Survey SRP #1), 3 slides (ANSP).

Additional Material Examined: South Carolina: Newberry Co., Little River on Hwy. #56, 4-xiii-1955, Hynes, 1L (FAMU). Texas: Montgomery Co., Peach Creek, 16-vi-1998, D.E. Bowles, 3L (TAMU); San Jacinto Co., Winters Bayou, Sam Houston National Forest, ca. 5 mi. NW Cleveland, 03-x-1999, D.E. Baumgardner, 2F (reared) (TAMU).

Allenhyphes flinti (Allen)

Allenhyphes flinti was described in *Leptohyphes* by Allen (1973), based upon larvae from the island of Dominica in the West Indies. Hofmann et al. (1999) later reared this species, associated the adult, and listed new distributions records of the species from the island of Guadeloupe.

Molineri and Flowers (2001) recently discovered this species in Panama and Venezuela. Their report was the first known instance of a leptohyphid mayfly from both Continental America and the Caribbean Islands. Records given below extend the known range of this species in the Caribbean region to include the islands of Montserrat and St. Kitts.

On the island of Montserrat, *A. flinti* was collected from a very small stream on a steep slope at about 100 m elevation. Stream channel substrates included rocks and sand with some leaf debris. In Dominica *A. flinti* was collected from very small to medium-sized forested streams between 130 and 330 m elevation. Substrate in these streams included boulders, rocks, cobble, and sand with rooted aquatic vegetation along the shorelines and some leaf debris.

On the island of St. Kitts *A. flinti* was collected from a small permanently flowing stream in undisturbed forest with a bed composed mostly of rocks and sand, with some leaf debris. Regardless of site, larvae of *A. flinti* were collected from submerged leaf debris.

Material Examined: MONTSERRAT: Lawyers River, Woodlands, 22-vi-1996, D. Bass, 1L, 1 slide (TAMU); DOMINICA: Blenheim River, Blenheim Estate, 16-vi-1996, D. Bass, 3L (TAMU); same but, Check Hall River, Springfield Estate, 8-9-vi-1996, 6L (TAMU); same but, Banana Gutter Creek, Stonefield Estate, 11-vi-1996, 3L, 1 slide (TAMU); same but, L'Or River, Fond Melle, 2L (TAMU). ST. KITTS: West Farm Gut, West Farm Estate, 19-v-1997, D. Bass, 2L (TAMU).

Leptohyphes zalope Traver

Leptohyphes zalope is a common and wide-spread species, known from Arizona east to Texas and south to Costa Rica (Baumgardner and McCafferty, 2000). Records given below from Grenada and Tobago extend the known range of this species into the Caribbean

Islands, and make this only the second known species of leptohiphid known from both the Caribbean Islands and Continental America.

Leptohiphes zalope was collected from two different sites on the island of Grenada. The first (Grand Bras River) is a small river flowing mostly through a forest, and substrate composed primarily of large rocks and boulders, cobble and sand with abundant leaf debris. The second river (St. Mark's River) flows through mostly forest in the upper part of its drainage, and agricultural land at lower elevations. For most of its length, substrate consists primarily of large rocks and sand with little leaf debris. In both cases, larvae were collected from submerged leaf debris. On the island of Tobago, *L. zalope* was collected in submerged leaf debris from a small stream flowing through forest, with substrate consisting primarily of rocks, cobble, and sand with much leaf debris present.

Material Examined: GRENADA, Grand Bras River, Mount Horne Estate, 02-v-1996, D. Bass, 6L, 1 slide (TAMU); same but, St. Mark's River, Bocage Estate, 01-v-1996, 5L, 1 slide (TAMU). TOBAGO, Argyle River Tributary, Forest Reserve, 28-iv-1996, D. Bass, 1L (TAMU).

Tricorythodes fictus Traver

Tricorythodes fictus Traver, 1935:635.

Tricorythodes fictus was described by Traver (1935) from Murry County, Oklahoma based upon male and female imagos. The exact type location of the species is unknown, but was likely the Turner Falls area through which Honey Creek flows. This stream has long been known to aquatic collectors for its diverse fauna and minimally disturbed habitat.

Larvae of *Tricorythodes fictus* were collected and reared from Honey Creek and several locations in the Hill Country of Central Texas. Larvae appear to prefer small to moderate sized streams with limestone outcrops. Small bits of limestone and other debris can often be found attached to hairs on the thorax and abdomen of this species. Mature larvae were collected during the winter and early spring months, indicating an early season emergence for this species. *Tricorythodes fictus* is currently known from south-central Oklahoma throughout the Hill Country of Central Texas, south to Chihuahua, Mexico (Randolph and McCafferty, 2000). Additional larval material from south-central Mexico seems to belong to this species, but cannot be determined with certainty at this time because adults are unknown.

Larvae: Body length 3.5–6.0 mm; caudal filaments 2.5–3.0 mm. General color pale yellowish-brown with underlying gray maculation; immature larvae pale with limited gray maculation.

Head: Pale yellow with limited gray maculation; compound eyes remote, widely separated; ocelli clear; antennae approximately 2 to 3 times length of head capsule. **Mouthparts:** Labrum (Fig. 1) dorsally with long, fine simple setae along lateral margin; row of

short, branched setae recessed from anterior margin; ventrally with vertical row of simple, fine setae near mid-line; branched setae along anterior margin. Right mandible (Fig. 2) with outer incisors three-lobed; inner incisor two-lobed; prosthema and molar region as in figure 2; scattered setae on dorsal surface. Left mandible (Fig. 3) with outer incisors four-lobed, mostly fused; inner incisor two-lobed; prosthema arising at base of inner incisor, with thicker base and more setae than on right incisor, but not appearing fused with inner incisor; molar region as in figure 3; scattered setae on dorsal surface. Hypopharynx with long, fine simple setae on anterior surface (Fig. 4); inner basal edge of superlinguae with row of setae. Maxilla (Fig. 5) with one-segmented palp and terminal setae; apex of galealacinia with cluster of fused spines and row of heavy setae. Labium (Fig. 6) with moderately-expanded mentum; numerous long, simple setae along outer margins; glossae and paraglossae subequal in length with numerous long, simple setae; edges of glossae and paraglossae jagged; notch between glossae deeper with bottom more rounded than notches between glossae and paraglossae; labial palp three-segmented with long, simple apical setae.

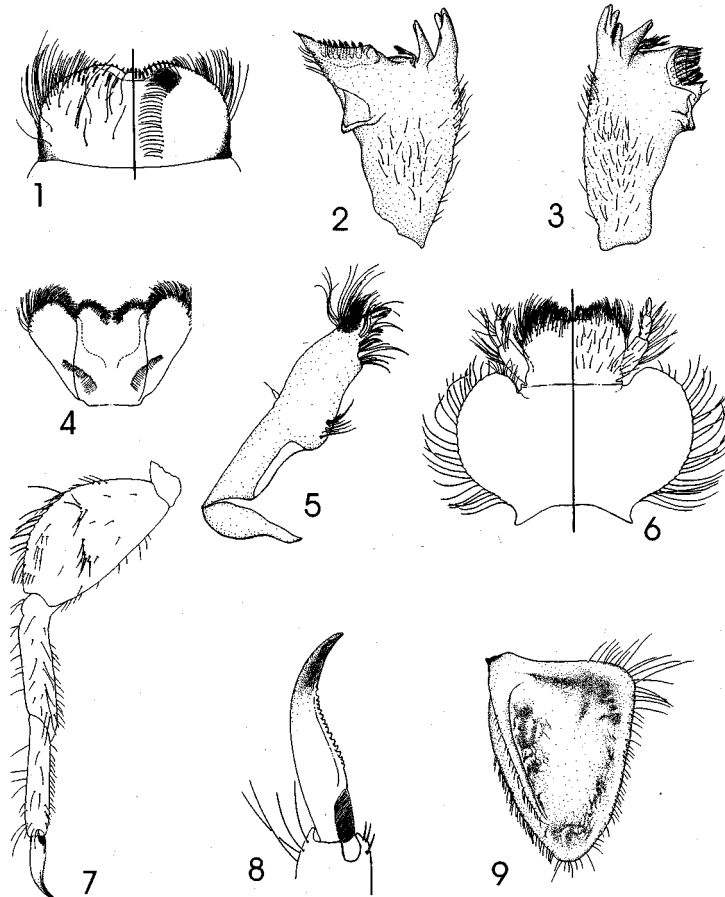
Thorax: Pale-yellowish brown, with hairs along lateral margins. Pronotum with gray maculation along margins and mid-dorsal line; long, simple setae along lateral margins and median transverse ridge. Dorsal surface of forefemur with median transverse row of long setae, inner margin with small setae anteriorly, and outer margin with row of long setae, becoming shorter apically (Fig. 7). Tarsal claws (Fig. 8) with single row of uniform, small, apically flattened denticles numbering 14–16 (with minute apical denticle, slightly separated from primary row, only visible at high magnification). Meso- and metafemora with few, scattered setae on dorsal surface not forming a distinct row as in forefemur. Meso- and metac claws with approximately 10 and 14 denticles, respectively; denticles sometimes flattened.

Abdomen: Terga 2–9 with transverse, anterior gray maculation (much reduced in early instars); scattered hairlike setae present on terga. Dorsal lamella of gill two (operculate gill) subtriangular brownish-yellow with areas near margins shaded grayish-black (Fig. 9) and hairs along most of margin; outer margin with longitudinal ridge and scattered small setae along edge of ridge; inner apex with numerous, long setae. Cerci with row of setae at each annulation. Body frequently covered by thick periphyton biofilm, composed of diatoms, bacteria, fungi, and detritus.

Type Material Examined: *Tricorythodes fictus*: HOLOTYPE: Murry Co., Oklahoma, 20 March 1932, A. Sandoz, male imago (genitalia removed and slide mounted) (CU).

Other Material Examined: OKLAHOMA: Murry Co., Honey Ck. at Turner Falls Pk., above Falls, 30-iv-1995, DE Baumgardner, 3M, 2F, 1F reared (TAMU). Same but, 21-iii-1995, 25L (TAMU). Same but, 16-ii-1995, 4M, 3L (TAMU). Same but, 07-ii-1994, 3L, 1M reared (TAMU). TEXAS: Bandera Co., Medina R. @ Hwy. 16, 1 mi. NW Medina, 08-iii-1997, DE Baumgardner & DE Bowles, 1M (reared), 4F (reared) (TAMU). Montgomery Co., New Caney, Peach Creek at FM 1485, 05-i-1997, NA Wiersema, 2M. Hays Co., San

Marcos R. @ Cape Rd., San Marcos, 22-ii-1997, DE Baumgardner, 11L (TAMU). Kerr Co., Fessenden Ck. @ Hwy. 41, 19-iv-1997, DE Baumgardner and DE Bowles, 1F (reared), 6L (TAMU). Comal Co., Guadalupe R @ Hwy. 311, 20-vi-1993, JL Cook, 3L (TAMU). Val Verde Co., Devils River at Devils River State Park, 22-xii-1992, DE Baumgardner, 2L, 2M (TAMU). Val Verde Co., Devils River at Dolan Creek Preserve (TNC), 08-xi-1998, DE Baumgardner, numerous larvae, reared adults (TAMU).



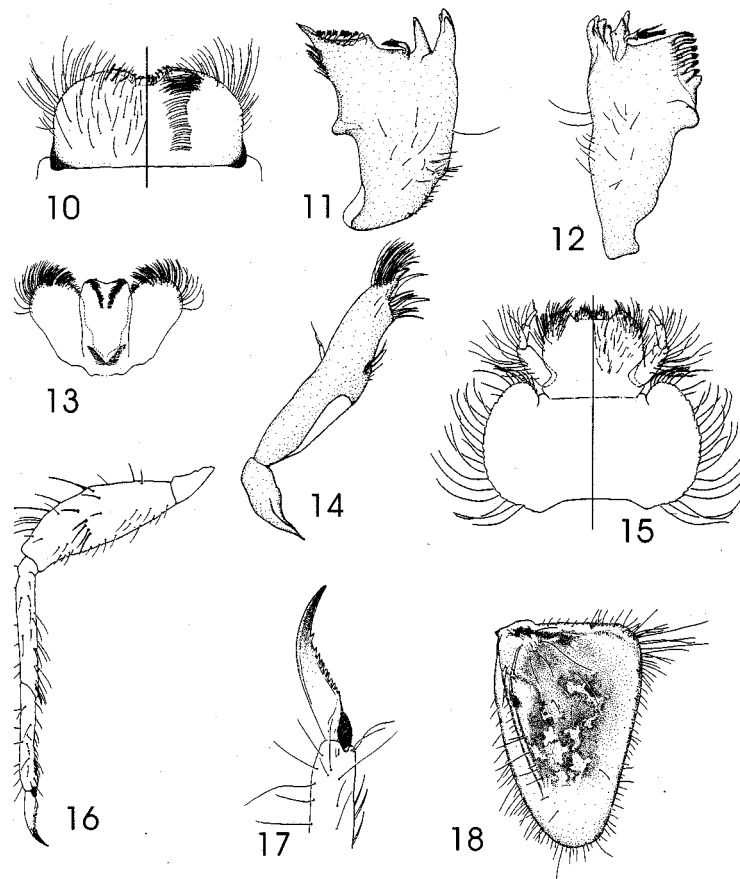
FIGURES 1-9. *Tricorythodes fictus* Traver, larva. 1. Labrum (left: dorsal; right: ventral); 2. Right mandible; 3. Left mandible; 4. Hypopharynx; 5. Maxilla; 6. Labium (left: dorsal; right: ventral); 7. Foreleg . 8. Foreclaw. 9. Operculate Gill 2.

***Tricorythodes cobbi* Alba-Tercedor and Flannagan**

Tricorythodes cobbi Alba-Tercedor and Flannagan, 1995:1592.

This species was described based upon male and female imagoes from Manitoba, Canada. The larval stage is described here for the first time based upon reared specimens from

Connecticut, USA, which are also the first records of this species from Connecticut and the United States.



FIGURES 10–18. *Tricorythodes cobbi* Alba-Tercedor and Flannagan, larva. 10. Labrum (left: dorsal; right: ventral); 11. Right mandible; 12. Left mandible; 13. Hypopharynx; 14. Maxilla; 15. Labium (left: dorsal; right: ventral); 16. Foreleg. 17. Foreclaw. 18. Operculate Gill 2.

Larva: Body length 3.5–5.0 mm; caudal filaments 2–3.5 mm. General color pale reddish-brown; immature larvae much paler with limited gray maculation.

Head: Reddish-brown; compound eyes remote, widely separated; ocelli clear. Antennae approximately 2–3x length of head capsule. **Mouthparts:** Labrum (Fig. 10) dorsally with long, fine simple setae along lateral margin; row of short, branched setae recessed from anterior margin; ventrally with vertical row of simple, fine setae near mid-line; short row of branched setae along anterior margin. Right mandible (Fig. 11) strongly curved towards base, with outer incisors three-lobed; inner incisor two-lobed; prosthema and molar region as in figure 11; scattered setae on dorsal surface. Left mandible (Fig. 12) with

outer incisors four-lobed, fused for most of their distance; inner incisors two-lobed; protheca visible at base of inner incisor, not appearing fused to side of incisor; base of inner incisor closely associated with base of outer incisor, appearing as a single unit. Hypopharynx with long, fine simple setae on anterior margin (Fig. 13); inner basal edge of superlinguae with row of setae. Maxilla (Fig. 14) with elongate two-segmented palp, segment two with faint annuli (visible only at 400x magnification) and elongate apical seta that is broad at base and tapers to sharp point; apex of galea-lacinia with pair of large fused spines and row of smaller separate spines. Labium (Fig. 15) with moderately-expanded mentum with regularly-spaced long, simple setae along outer margins; glossae and paraglossae subequal with numerous long, simple setae and smooth outer margins; notch between glossae equal in depth and appearance to notch between glossae and paraglossae; labial palp three-segmented with long, simple setae. **Thorax:** Reddish-brown, with hairs and setae scattered along lateral margins and median transverse ridge. Dorsal surface of forefemur with median transverse row of heavy setae, inner margin with numerous, small setae, and outer margin with few, long setae, setae shorter apically (Fig. 16). Tarsal claws (Fig. 17) with single row of uniform, small, pointed denticles numbering 10–12, apical denticle separated from previous denticles. Meso- and metafemora with few, scattered setae on dorsal surface not forming a distinct row as in forefemur; meso- and metac claws with approximately 10 and 12 denticles, respectively; denticles sometimes flattened.

Abdomen: Terga 2–9 pale to dark reddish-brown; scattered hairlike setae present on terga. Dorsal lamella of gill 2 (operculate gill) subtriangular with more or less uniform black shading (Fig. 18); outer margin with longitudinal ridge and scattered small setae along edge of ridge; inner apex with numerous, long setae. Cerci with row of setae at each annulation. Body frequently covered by thick periphyton biofilm and detritus.

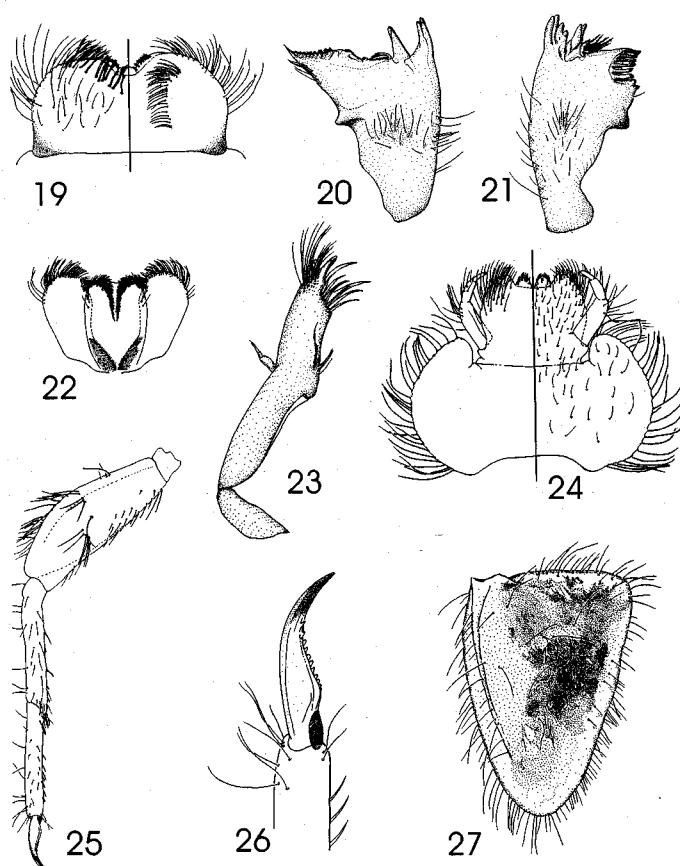
Type Material Examined: Paratypes: CANADA: Manitoba, Assiniboine River, St. Francois Xavier, Lido Plage Rd., 49°52'24"N; 97°30'35"W, 23-vii-1993, 14F (FSCA (FAMU) E2052).

Other Material Examined: USA: Connecticut, Hartford County, Connecticut River at Kings Island boat ramp, Enfield (41°57'50"N; 72°36'30"W); 14-viii-1997, S.K. Burian, 1F (TAMU); same but, 15-viii-1999, 1F, 2F (reared) (NEL, TAMU); same but, 30-vi-1998, 1F (reared) (TAMU); same but, 21-vii-1998, 1F (reared) (TAMU); same but, 20-vii-1997, M and F (TAMU); 14-viii-1997, 3M (1 reared), 2F (reared) (NEL, TAMU); same but, 30-vii-1998, 3F, 2F (reared) (NEL); same but, 02-ix-1999, 1M, 3F (reared) (TAMU, NEL); USA: Connecticut, Hartford County, Connecticut River at Kings Island boat ramp, sandy area at end of path (41°54'59"N; 72°36'30"W), 20-vii-1997, S.K. Burian, 1M, 2F (NEL); USA: Connecticut, Hartford County, Connecticut River at Kings Island boat ramp, Enfield, upstr. Side of near island (41°57'46"N; 72°36'28"W), 24-vii-2000, S.K. Burian, 1M, 2F (reared) (TAMU); USA: Connecticut, New Haven County, Mill River, below broken dam, Sleeping Giant S.P., Hamden, vii-1996, S.K. Burian, 1F (reared) (TAMU).

***Tricorythodes mosegus* Alba-Tercedor and Flannagan**

Tricorythodes mosegus Alba-Tercedor and Flannagan, 1995:1589.

Tricorythodes mosegus was described by Alba-Tercedor and Flannagan (1995) based upon male and female imagoes from Manitoba, Canada. The larval stage is described here for the first time based upon reared specimens from Connecticut, USA. *Tricorythodes mosegus* is also documented here for the first time from the state of Maine. Previous records of this species in the United States are from Indiana and Michigan (Randolph and McCafferty, 1998).



FIGURES 19–27. *Tricorythodes mosegus* Alba-Tercedor and Flannagan, larva. 19. Labrum (left: dorsal; right: ventral); 20. Right mandible; 21. Left mandible; 22. Hypopharynx; 23. Maxilla; 24. Labium (left: dorsal; right: ventral); 25. Foreleg 2. 26. Foreclaw. 27. Operculate Gill 2.

Larvae examined for this study were all reared. As such, it is not possible to provide details on the coloration of the species, because the coloration is not retained in the larval cast skin.

Larva: Body length 4.5–5.5 mm; caudal filaments 2.5–3.5 mm.

Head: Compound eyes remote, widely separated; ocelli clear. Antennae approximately 2x length of head capsule. **Mouthparts:** Labrum (Fig. 19) dorsally with long, fine simple setae along lateral margin; row of elongate, branched setae recessed from anterior margin; ventrally with vertical row of simple, fine setae near mid-line, and row of short, branched setae along anterior margin. Right mandible (Fig. 20) with outer incisors three-lobed; inner incisor two-lobed; prosthema and molar region as in Fig. 20; scattered setae on dorsal surface. Left mandible (Fig. 21) with outer incisors four-lobed, mostly fused; inner incisor with two denticles; prosthema arising at base of inner incisor, appearing fused with side of outer incisor; molar region as in Fig. 21; scattered setae on dorsal surface. Hypopharynx with long, fine simple setae on anterior surface (Fig. 22); inner basal edge of superlinguae with row of setae. Maxilla (Fig. 23) with three-segmented palp and short, terminal setae; apex of galea-lacinia with fused two large fused apical spines row of heavy setae Labium (Fig. 24) with moderately-expanded mentum with numerous long, simple setae along outer margins and ventrally; glossae and paraglossae subequal in length with smooth margins; glossae with small fine, simple setae; paraglossae with numerous long, simple setae; notch between glossae slightly deeper and more rounded than notches between glossae and paraglossae; labial palp three-segmented with long, simple setae.

Thorax: Scattered small hairs and setae present. Dorsal surface of forefemur with median transverse row of long setae, inner margin with smaller setae basally and outer margin with row of long setae apically (Fig. 25). Tarsal claws (Fig. 26) with single row of uniform, small flattened denticles numbering 10–12. Meso- and metafemora with few, scattered setae on dorsal surface not forming a distinct row as in forefemur; meso- and metac claws with approximately 10 and 12 denticles, respectively; denticles sometimes flattened and appear as a single structure.

Abdomen: Scattered hairlike setae present on terga. Dorsal lamella of gill 2 (operculate gill) subtriangular, brownish-yellow with scattered patches of black shading (Fig. 27); outer margin with longitudinal ridge and scattered small setae along edge of ridge; numerous long and short setae along margin of gill. Cerci with row of setae at each annulation.

Type Material Examined: Paratype: CANADA: Manitoba, Assiniboine River, St. Francois Xavier, Lido Plage Rd., 49°52'24"N; 97°30'35"W, 09-vii-1993, 1M (FSCA (FAMU) E2051).

Other Material Examined: USA: Connecticut, New Haven Co.; Bladdens Brk., Seymour @ jct. of Rt. 67 and Sokarat Rd., 22-vii-1996, S.K. Burian, 2M (reared) (NEL, TAMU); USA: Connecticut, Hartford County, Connecticut River at Kings Island boat ramp, sandy area at end of path (41°54'59"N; 72°36'30"W), 20-vii-1997, S.K. Burian, 1M (reared), 1F (reared) (TAMU).

Discussion

At this point, it is not possible to reliably separate species of *Tricorythodes* in the larval stage, because many species have not been associated in both life stages, and because characters have not been studied carefully enough to determine which characters are reliable and which are not. For example, there seems to be much variation on the structure of maxillary palps. *Tricorythodes fictus* has single segmented maxillary palps that terminate with a slender apical setae compared to *T. cobbi*, which has 2 segmented maxillary palps that terminate with a setae that is broad at the base and tapers to a point. Also, the second segments are slender and appear weakly annulated. Both of these forms are quite different from the condition observed in *T. mosegus* where 3 distinct segments occur. Until the more larvae are known the significance of this variation can not be determined. Currently, characters which appear to hold promise in differentiating species include arrangement of spines on the fore-femur and presence or absence of branched setae on the labrum.

Studies of eastern North American species of *Tricorythodes* are continuing, with particular emphasis on rearing and associating stages and detailed examination of morphological features. A subsequent paper will include detailed descriptions of additional eastern North American species of *Tricorythodes* and taxonomic keys to species of larvae.

Acknowledgments

We would like to thank Rick Hoebek (Cornell University) and Don Azuma (Academy of Natural Sciences of Philadelphia) for providing type specimens of *Tricorythodes fictus* and *Asioplax dolani*, respectively, and Janice Peters (Florida A&M University, Tallahassee) for providing paratypes of *T. cobbi* and *T. mosegus* in addition to other leptohiphid specimens included in this study. The first author especially thanks David Bowles (Texas Parks and Wildlife) for assistance in collecting many of the specimens, and David Risking (Texas Parks and Wildlife) for allowing access to Texas State Parks, and The Nature Conservancy for access to Dolan Creek Preserve.

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