REDESCRIPTION OF *CRICOTOPUS LEBETI*S (DIPTERA: CHIRONOMIDAE), A POTENTIAL BIOCONTROL AGENT OF THE AQUATIC WEED HYDRILLA (HYDROCHARITACEAE)

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ABSTRACT

The adult male and female of *Cricotopus lebetis* Sublette are redescribed and the pupa and larva described for the first time. Larvae of *C. lebetis* mine in the stems of the submersed aquatic weed hydrilla, *Hydrilla verticillata* (L.f. Royle), causing sufficient damage to the apical meristem to preclude further growth. The species is very similar to *C. tricinctus* (Meigen) but can be distinguished from that species in the adult male by the broader, more rounded inferior volsella; in the female by the lower number of sensilla chaetica on the mid and hind basitarsi; in the pupa by the fusiform thoracic horn; and in the larva by the simple S I and long setal tufts on abdominal segments I-VII.

Key Words: Chironomidae, *Cricotopus*, taxonomy, *Hydrilla verticillata*, aquatic weed, biocontrol

RESUMEN

Se redescriben el adulto macho y hembra de *Cricotopus lebetis* Sublette y se describen por primera vez la larva y pupa de esta especie. Las larvas de *C. lebetis* minan los tallos de la hierba acuática sumergida *Hydrilla verticillata* (L.f. Royle), causando suficiente daño al meristemo apical como para impedir su crecimiento. *C. lebetis* es muy similar a *C. tricinctus* (Meigen), pero se distingue de esta especie en que el macho adulto posee una volsella inferior más redondeada y ancha, mientras que la hembra

posee menos sénsulos tipo chaetica en los basitarsi medio e inferior. Asmísmo, la pupa de *C. lebetis* presenta un cuerno torácico fusiforme y la larva tiene un S I simple y largos pinceles de cerdas en los segmentos abdominales I-VII.

The chironomid genus *Cricotopus* van der Wulp is common, widespread and speciose. Hirvenoja (1973) revised the Palaearctic species but in the Nearctic the taxonomy of the genus remains in less than satisfactory condition. Many undescribed species exist and the conspecificity of some Nearctic taxa with species originally described from the Palaearctic is uncertain.

One such species is *Cricotopus lebetis* Sublette, a member of the *sylvestris* group of the subgenus *C. (Isocladius)*. Interest in the taxonomy of *C. lebetis* has been recently stimulated by the discovery of the larvae of this species feeding within the stems of hydrilla, *Hydrilla verticillata* (L.f. Royle) (Hydrocharitaceae), a well known pest aquatic plant that was introduced into Florida in the 1950's (Schmitz et al. 1991). Larvae of *C. lebetis* mine in the stems of hydrilla, causing sufficient damage to the plant's apical meristem to preclude further growth of the plant. This natural growth control may prevent hydrilla from reaching the water's surface, eliminating the dense surface mats which reduce biodiversity and interfere with navigation.

In this paper the adult male and female of *C. lebetis* are redescribed and the pupa and larva are described for the first time. Information on the midge's life history and potential use as a biocontrol agent for hydrilla is discussed in Cuda et al. (1999).

Materials and Methods

Morphological terminology and abbreviations follow Sæther (1980), Oliver & Dillon (1989), Epler (1988) and Sublette, et al. (1998). Measurements are in μm, unless otherwise stated, and consist of the range followed by the mean if three or more specimens were measured.

For the descriptions below, the majority of the adult male material and all of the adult female, pupal and larval material was from the F3 generation of laboratory reared midges originally collected from the Plantation Inn Canal, Crystal River in Citrus Co., Florida, on 23 September 1997 (see Cuda et al. 1999); data from two paratype males are included in the adult male description.

Systematics

Sublette (1964) described *Cricotopus lebetis* from adult male and female specimens collected in Louisiana in 1957-1959. He noted that this new species would key to *C. tricinctus* (Meigen) in Johannsen and Townes (1952) and that it was difficult to separate *C. lebetis* from Palaearctic material of *C. tricinctus* (Meigen) on the basis of color pattern. He also stated (1964: 118) that the "strong, almost right angled basal lobe [= inferior volsella of Sæther (1980) and Oliver & Dillon (1989)] on the basistyle [= gonocoxite] as well as the shape of the dististyle" [= gonostylus] seemed to be distinctive for *C. lebetis*.

Beck & Beck (1966: 131) listed *Cricotopus lebetus* [sic] as a "recently substituted American name" for *C. tricinctus*, but did not give any references or reason for this placement.

Hirvenoja (1973: 304), in the section Ökologie und Verbreitung ("Ecology and Distribution") under *C. tricinctus*, mentioned Beck and Beck's (1966) listing of *C. lebetis* as a synonym of *C. tricinctus* with some doubt as indicated by a "?" before his listing; he did not list *C. lebetis* as a synonym of *C. tricinctus*.

Only Boesel (1983) formally listed *C. lebetis* as a new synonym of *C. tricinctus*, a concept followed by Oliver et al. (1990).

Placement of *C. lebetis* in the papers above was based only on characters of the adult stage. When characters from all life stages are considered, in particular the pupa and larva, it is readily apparent that *C. lebetis* is a taxon distinct from *C. tricinctus*.

Cricotopus (Isocladius) lebetis Sublette

Cricotopus lebetis Sublette, 1964: 118 (description of adult male and female).

Cricotopus tricinctus (Meigen, 1818) partim: Boesel 1983:81(synonymy; in key); Oliver et al. 1990: 24 (synonymy); and other North American authors.

Male imago (n = 10, unless otherwise noted)

Color: In life, pale green with blackish-brown markings; these colors fade to pale brown/stramineous with dark brown to brownish markings in alcohol preserved material. In alcohol preserved material, brown to dark brown on antennae, head, thoracic vittae (vittae sometimes joined posteriorly by diffuse brown area), scutellum, postnotum, median anepisternum, almost all to ventral ⅔ of preepisternum, ventral half of anterior anepisternum II and approximate ventral half of epimeron. Wings clear with light brown veins; halteres pale. Legs (Fig. 1) with fore and hind coxae light, mid coxa brown; all trochanters light; fore femur light brown basally, much darker in apical ⅓ to ½; mid and hind femora basally light with brown apical ⅓ to ¼; tibiae with brown basal and apical bands, fore tibia slightly darker in middle than mid and hind tibiae; fore tarsi brown, mid and hind tarsi light brown to stramineous. Abdomen (Fig. 2) with T I and IV stramineous; T II with posterior ½ brown; T III with posterior ⁴/₅ brown; T V mostly brown, with paler anterior and posterior margins; T VI with brown band across middle; T VII mostly stramineous, often with brown markings posterolaterally, sometimes almost completely dark; T VIII mostly brown, with narrow posterior stramineous band; T IX mostly brown; gonocoxites and gonostyli stramineous.

Length. Body (excluding head): 2.35-2.88, 2.55 mm (n = 5); thorax 0.70-0.85, 0.74 mm (n = 5); abdomen 1.65-2.05, 1.86 mm (n = 8).

Head. Temporal setae 6-8, 7; clypeal setae 4-8, 6; cibarial sensillae 2-9, 6. Lengths of palpomeres 2-5 (n = 8): 30-45, 37; 50-63, 56; 53-73, 63; 88-107, 97. AR 0.77-0.93, 0.83.

Thorax. Setae: lateral antepronotal (n = 8) 0-2, 1; acrostichal (n = 6) 10-13, 12; dorsocentral (n = 7) 8-14, 10; prealar (n = 9) 3-6, 4; scutellar (n = 9) 6-7, 6.

Wing. Length (n = 7) 1.08-1.30, 1.16 mm; width (n = 7) 310-380, 342. VR (n = 7) 1.14-1.23, 1.18. Costal extension (n = 6) 18-50, 31. Setae: brachiolum 1; squama (n = 9) 4-8, 6; R_1 (n = 8) 2-4, 3.

Legs. Lengths of tibial spurs: fore 30-40, 34; mid 12-17, 14 (n = 9); 15-18, 17; hind 14-20, 18; 35-44, 38. Sensilla chaetica: mid 8-15, 12 (n = 9); hind 18-29, 23. Hind tibial comb with 8-10, 9 setae (n = 8), setal length 27-43, 35. Pulvilli developed, about ½ length of claw. Lengths and proportions of legs:

	P1	P2	P3
fe	440-600, 510	475-605, 535	430-640, 535
ti	560-735, 627	480-650, 551	510-730, 604
ta1	260-375, 304	190-275, 226	260-375, 305 (n = 9)
ta2	140-210, 164	100-160, 124	125-185, 151 (n = 9)
ta3	110-150, 126	85-115, 96	120-160, 134 (n = 9)
ta4	80-95, 83	55-70, 63	65-85, 73 (n = 9)
ta5	65-80, 73	60-70, 65	60-80, 68 (n = 9)
LR	0.46-0.51, 0.48	0.39-0.42, 0.41	0.48-0.55, 0.50
BV	3.09-3.42, 3.24	3.53-3.96, 3.78	3.15-3.49, 3.34 (n = 9)
SV	3.50-3.94, 3.75	4.47-5.07, 4.82	3.50-3.89, 3.74

Abdomen (n = 9). T III with 2-4, 3 median setae and 2-4, 3 lateral setae; T IV with 2-5, 3 median setae and 3-5, 4 lateral setae.

Hypopygium (Fig. 3). T IX with 5-10, 7 setae; laterosternite IX with 3-5, 4 setae. Transverse sternapodeme width 83-155, 100 (n = 9); phallapodeme length 63-78, 70 (n = 9). Virga absent. Superior volsella well developed; inferior volsella (Figs. 4-6) linguiform to triangular. Gonocoxite length 163-205, 179; gonostylus length 80-98, 86, with well developed crista dorsalis (Fig. 7); GC/GS 1.99-2.13, 2.07. Megaseta length 14-16, 15 (n = 5).

Female imago (n = 5, unless otherwise noted)

Color. Mostly as in male, except thoracic vittae sometimes joined by diffuse brown coloration, so that dorsum of thorax appears mostly brown (in fluid preserved specimens). Legs light brown, with weaker vittate pattern than in male (pale areas not as pale as in male). Abdominal tergites similar to male, except T IX and gonocoxite IX brown.

Length. Body (excluding head) 2.23-2.65, 2.51 (n = 3); thorax 0.68-0.77, 0.74; abdomen 1.55-1.90, 1.78 (n = 3).

Head. Temporal setae 2-7, 5; clypeal setae 7-9, 8; cibarial sensillae 3-10, 6. Lengths of palpomeres 2-5 (n = 4): 30-40, 34; 43-53, 49; 48-55, 52; 88-103, 95. Antenna with 5 flagellomeres; AR 0.40-0.55, 0.47.

Thorax**.** Setae: lateral antepronotal 1-2, 2; acrostichal 9-12, 11; humeral 2-3, 2; dorsocentral 7-10, 9; prealar 3-4, 3; scutellar 5-8, 7.

Wing. Length (n = 4) 1.08-1.20, 1.00 mm; width (n = 4) 380-420, 395. VR (n = 4) 1.18-1.22, 1.20. Costal extension (n = 3) 40-60, 50. Setae: brachiolum 1; squama 4-11, 7; R (n = 4) 4-5, 4; R_1 (n = 4) 0-3, 2; R_{4+5} (n = 4) 1-3, 2.

Legs. Lengths of tibial spurs: fore 21-25, 23; mid 10-13, 12; 12-15, 14; hind 11-15, 13; 33-38, 36. Sensilla chaetica: mid 18-21, 20; hind 22-34, 27. Hind tibial comb with 9-12, 10 setae, setal length 35-37, 36 (n = 3). Pulvilli developed, about ½ length of claw. Lengths and proportions of legs (n = 4):

	P1	P2	P3
fe	370-430, 406	420-490, 458	420-490, 461
ti	465-520, 500	430-480, 468	490-530, 520
ta1	210-245, 226	175-200, 190	245-280, 268
ta2	95-120, 106	80-90, 86	100-125, 113
ta3	60-90, 76	60-75, 65	90-110, 101
ta4	45-60, 50	40-50, 44	45-50, 49
ta5	50-60, 55	55	50-60, 58
LR	0.44-0.47, 0.45	0.40-0.42, 0.41	0.50-0.53, 0.51
BV	3.82-4.18, 3.95	4.33-4.67, 4.46	3.75-4.02, 3.91
SV	3.88-4.11, 4.01	4.85-4.89, 4.87	3.57-3.71, 3.67

Abdomen (n = 3). T III with 2-3, 2 median setae and 2 lateral setae; T IV with 2 median setae and 2-3, 2 lateral setae.

Genitalia (Figs. 8-10). Notum 105-143, 124 long (measured to bifurcation); seminal capsule diameter 50-60, 57 (n = 3), cercus length 85-103, 97 (n = 4) (measured from ventral aspect). Spermathecal ducts with at least one loop. Coxosternapodeme as in Fig. 10. T IX with 3-5, 4 setae; gonocoxite IX with 8-12, 11 setae.

Pupa (n = 10, unless otherwise noted)

Color. Exuviae pale yellow with narrow, light brown bands at posterior of T II (over hooklet row) and T III; T IV entirely pale; T V with posterior 2/3 light brown; T VI with median light brown area; lateral margins of T VI-VIII and anal lobes light brown.

Length. Total 2.50-3.18, 2.79 mm (n = 8); cephalothorax 0.75-0.95, 0.81 mm (n = 7); abdomen 1,70-2.30, 1.99 mm (n = 9).

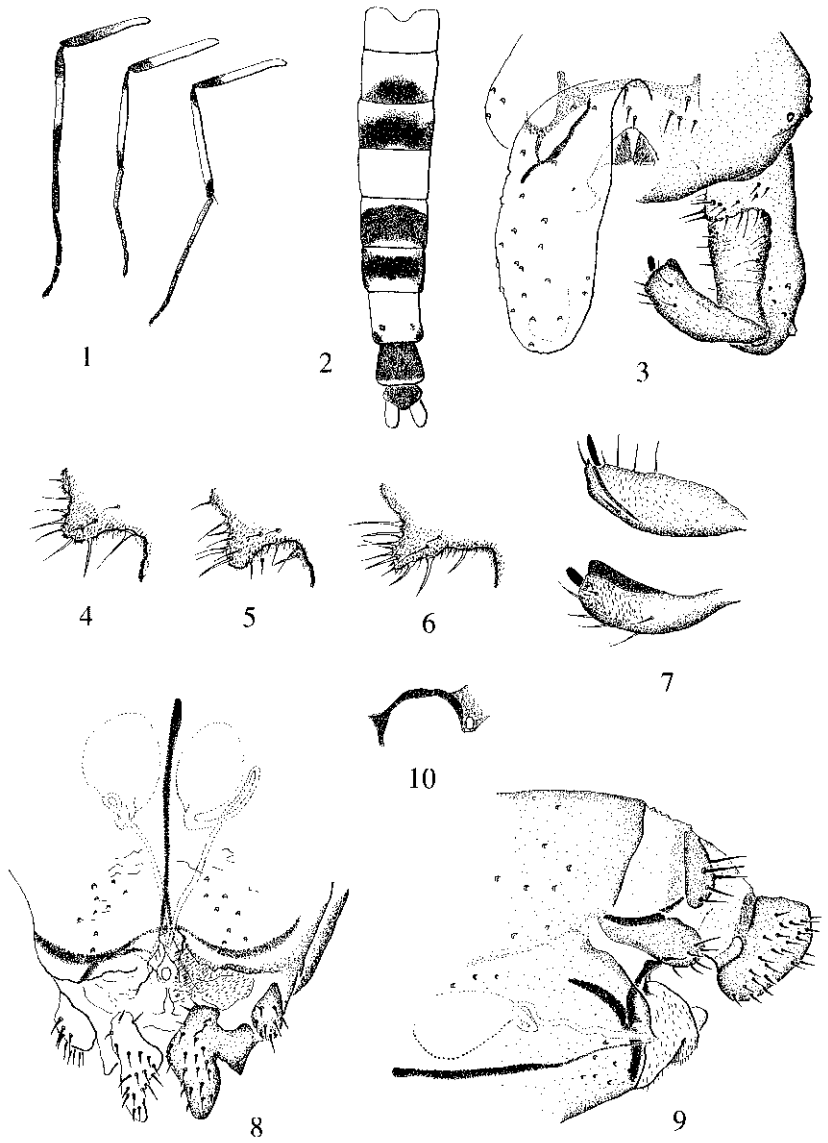
Cephalothorax. Frontal setae 60-88, 73 (n = 6) long, 2 wide; dorsal median antepronotal seta 58-73, 64 (n = 6) long; ventral median antepronotal seta 83-155, 96 (n = 8) long; lateral antepronotal seta 25-40, 33 (n = 8) long. Median suture area smooth. Thoracic horn (Fig. 11) fusiform with sparsely scattered minute spinules; 50-83, 67 long; 15-20, 17 (n = 9) maximum width. Precorneal setae lengths: PC_1 88-105, 101 (n = 9); PC_2 65-93, 77 (n = 8); PC_3 63-100, 82 (n = 7). Dorsocentral setae lengths: DC_1 33-48, 39; DC_2 25-60, 36 (n = 9); DC_3 30-40, 36 (n = 8); DC_4 35-48, 39 (n = 9); DC_1 stouter than DC_2. Wing sheath without bacatiform papillae or nasiform tubercles.

Abdomen (Fig. 12). T II with 49-68, 56 hooklets arranged in double row. Pedes spurii B weakly developed on T II; pedes spurii A present on S IV-VI. Tergite I with one anterolateral seta, T II-VIII with 3 lateral setae (2 dorsal and one ventral). Dorsal shagreen on T I sparse, scattered minute spinules in weak, longitudinal lateral bands; T II with scattered weak spinules over most of surface; T III with fine spinules over most of surface; T IV-VI with larger spinules over most of surface, with coarser spinules at center of tergites; T VII-VIII with anterior band of fine spinules; anal disc with small anteromedian area of fine spinules. Conjunctiva III-IV, IV-V and V-VI with spinules. Ventral shagreen consists of small posterolateral groups of minute spinules on S I; S II-V with weak longitudinal bands of minute spinules; S VI-VII with small anterolateral groups of minute spinules. Anal lobes with 3 macrosetae; anal lobe length 200-218, 208 (n = 7). Lengths of anal lobe macrosetae (n = 9): seta 1 (anteriormost seta) 78-88, 82; seta 2 (middle seta) 73-95, 85; seta 3 80-102, 91. The anal lobe ratio (ALR) varies depending on which macroseta is measured and compared to the anal lobe length, thus ALR1 (using anteriormost seta) 0.39-0.43, 0.40; ALR2 0.38-0.45, 0.42; ALR3 0.40-0.47, 0.43 (all ALR n = 7).

Fourth instar larva (n = 11, unless otherwise noted)

Color. In life, the body is green with blue bands on the second and third thoracic segment; the blue color is bleached on alcohol preserved specimens but the thorax remains darker than the remainder of the body in such material. Head capsule pale yellow-brown, premandibles light brown, mentum and apical ⅓ to ½ of mandible dark brown to black. Claws of parapods translucent to pale brown.

Head. Postmentum length 170-205, 186 (n = 9). Labrum (Fig. 13) with simple S I. Total antennal length 61-73, 64 (Fig. 14). Length of antennal segments 1-5: 31-43, 37; 13-18, 16; 9-13, 11; 3-4, 4; 3-4, 4; 2. Ring organ 8-10, 9 (n = 5) from base of basal segment; sensory pits slightly above to around same level as ring organ. Lauterborn organs extend to apex of antennal segment 3. AR 1.11-1.60, 1.34. Premandible (Fig. 15) apically bifid; length 69-80, 74. Mandible (Fig. 16) length 120 = 137, 127; with 3 inner



Figs. 1-10. *Cricotopus lebetis* adult structures. 1. Male fore, mid and hind legs; 2. Male abdomen; 3. Hypopygium; 4-5. Inferior volsella variation in Florida material; 6. Inferior volsella, Louisiana specimen; 7. Variation of gonostylus due to angle of observation; 8. Female genitalia, ventral; 9. Female genitalia, lateral; 10. Female coxosternapodeme.

teeth; apical tooth length 13-16, 14 (n = 5); width of inner teeth 23-27, 25 (n = 5). Outer margin of mandible mostly smooth; inner margin of mandible without spines; mandibular margin at base of seta subdentalis without minute teeth. Seta interna present, usually with 6 branches. Mentum (Fig. 17) with 13 teeth; second lateral tooth small and fused to first. Maxilla as in Fig. 18.

Body. Small claws of anterior parapods (Fig. 19) with apical tooth much larger than inner teeth. Abdominal segments I-VII with long setal tufts (Fig. 20); setal tufts with about 25-50 setae, longest setae about 385 long; tuft on VII with smaller and fewer (about 11-20) setae. Anal tubules elongate-ovoid.

Discussion

The color pattern of adults can be variable in many species of *Cricotopus*; *C. lebetis* is no exception. In males, tergite VII is apparently most susceptible to color variation; it may be almost totally unmarked with brown or, as in the majority of the Florida material examined, marked with brown in the posterolateral corners. Sublette (pers. comm.) has seen material of *C. lebetis* from Baton Rouge, Louisiana, in which T VII is almost completely infuscate.

In general, the type series is darker than the Florida material examined. Sublette (1964) stated that the female pronotum (= antepronotum) was infuscate; in the Florida material examined the antepronotum is stramineous, similar to other unmarked body areas.

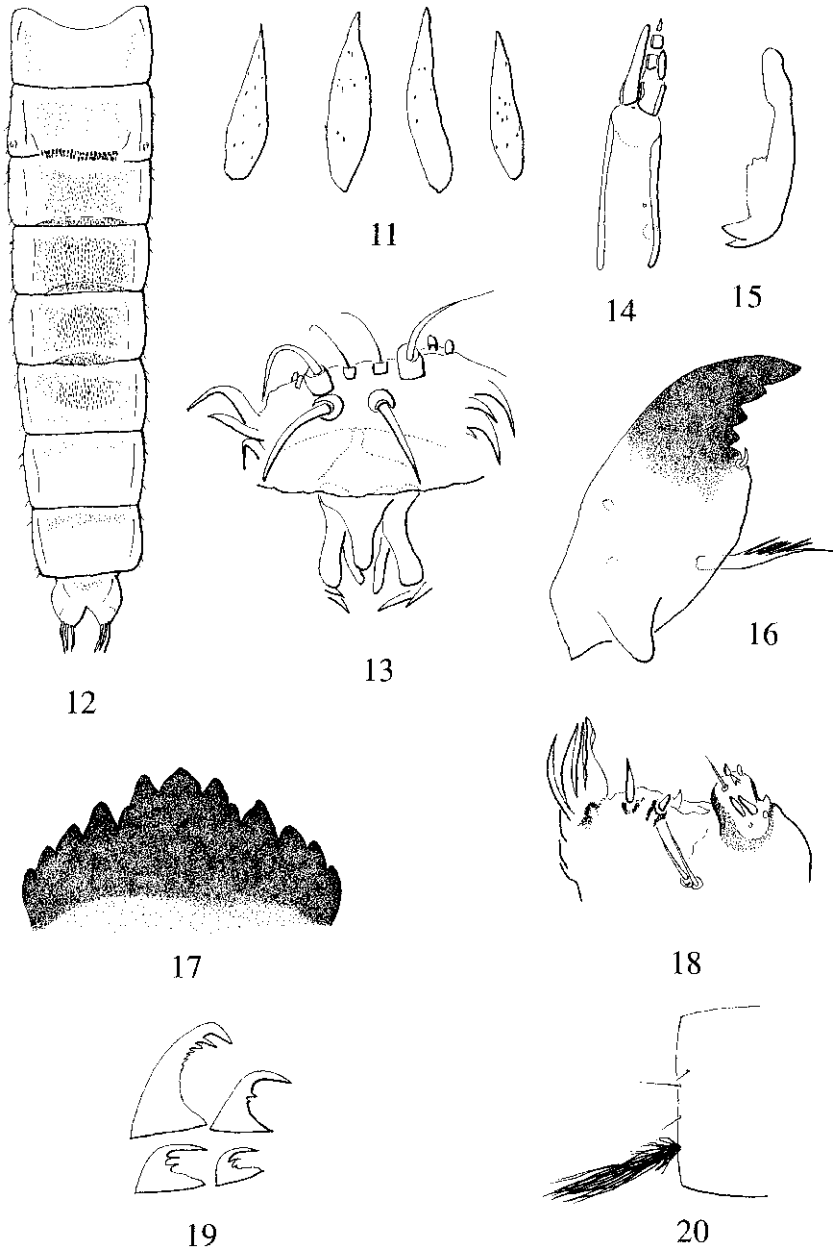
Adults of *C. lebetis* are most likely to be confused with *C. tricinctus*, as originally noted by Sublette (1964). In males, the inferior volsella of *C. tricinctus* is generally narrower and more triangular than that of *C. lebetis*. There is variation in the shape of this lobe; figure 6 is from a Louisiana paratype and is similar to, but still shorter and broader than, the volsella of some European *C. tricinctus* (see Hirvenoja 1973: Fig. 189(3) and 189(5)).

Females of *C. lebetis* are also similar to *C. tricinctus*; lower counts of sensilla chaetica on the mid and hind basitarsi (means of 22 and 27) will separate the Florida *C. lebetis* females examined from those of *C. tricinctus* (means of 48 for both legs), following the data from Hirvenoja (1973). It must be noted that the descriptions above (for all life stages of *C. lebetis*, with the exception of the two males from Louisiana) are for individuals from one population in Florida. These individuals may be smaller than populations of this species from other areas; setal counts and other measurements may also show a wider range once more material is examined.

Pupae of the two species are also similar, but the thoracic horn of *C. lebetis* is fusiform compared to the elongate digitiform horn of *C. tricinctus* (see Hirvenoja 1973: Fig. 190(2)).

Larvae of *C. lebetis* are similar to other members of the *C. sylvestris* group, but differ in bearing setal tufts on abdominal segments I-VII; in *C. tricinctus* larvae, only abdominal segments I-VI possess setal tufts. All larvae of *C. lebetis* examined had simple S I; the S I of related species are bifid (but note that the bifurcation of some of these other species may be unequal, with one branch much larger than the other; see Hirvenoja 1973: Fig. 191(3)).

An unresolved problem is that of the origin of North American *Cricotopus lebetis*. Is this a species that was introduced with hydrilla, or is it native to North America and has seized upon introduced hydrilla as a suitable host plant? Is *C. lebetis* a facultative miner of hydrilla or does it attack other plants? Hirvenoja (1973) noted that European *C. tricinctus* larvae mine in the leaves of *Potamogeton*, and that other aquatic plant species may also be attacked.



Figs. 11-20. *Cricotopus lebetis* pupal structures; 13-20, larval structures. 11. Variation in thoracic horn; 12. Abdomen, dorsal; 13. Labrum; 14. Antenna; 15. Premandible; 16. Mandible; 17. Mentum; 18. Maxilla; 19. Small claws of anterior parapod; 20. Lateral setae of abdominal segment II.

As seen above, *C. tricinctus* and *C. lebetis* have been confused in North America; Sublette (pers. comm.) has seen true *C. tricinctus* specimens from the north central U.S. and compared them with Palaearctic material from the British Museum (Natural History) and from Hirvenoja's collection; thus both species occur in the Nearctic. The Crystal River specimens constitute the first record of *C. lebetis* from Florida. The possibility exists that *C. lebetis* has been misidentified as *C. tricinctus* or other species in other countries where hydrilla occurs (i.e., Japan). *Cricotopus nitens* (Kieffer, 1921) and *C. taiwanus* Tokunaga, 1940, both described from Taiwan, have a similar color pattern; if not distinct species, either may be a senior synonym. The best way to solve this riddle would be to rear all life stages of hydrilla-associated *Cricotopus* throughout the range of the plant.

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