IMMATURE STAGES OF SOME EASTERN NEARCTIC TABANIDAE (DIPTERA). VIII. ADDITIONAL SPECIES OF *TABANUS* LINNAEUS AND *CHRYSOPS* MEIGEN

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ABSTRACT

Immature stages of *Tabanus colon, T. cymatophorus, T. lineola* subspecies *hinellus* and *Chrysops obsoletus* are described and illustrated. Additional comments are provided on the immature stages of *T. venustus*, previously described, and separation of the immatures of these 5 species from other known immatures of Nearctic Tabanidae is discussed. A key to *Tabanus* larvae with a stigmatal spine is provided as is a key to selected *Chrysops* larvae.

RESUMEN

Se describen e ilustran etapas inmaduras de *Tabanus colon, T. cymatophorus, T. lineola* subespecies *hinellus* y *Chrysops obsoletus*. Se proveen comentarios adicionales sobre las etapas inmaduras de *T. venestus* que han sido previamente descritas, y se discute la separación de los inmaduros de estas 5 especies de otros conocidos inmaduros de tabánidos neárticos. Se provee una clave de las larvas de *Tabanus* con una espina estigmatal, así como una clave de selectas larvas de *Chrysops*.

Since Teskey (1969) provided descriptions, figures, and keys for the larvae and pupae of 18 species of *Tabanus* and 36 species of *Chrysops*, several additional contributions to our knowledge of the immature stages of eastern North American Tabanidae have been forthcoming. I described the larvae and pupae of 5, the larva only of 1, and the pupa only of another species of *Chrysops* (Goodwin 1972, 1976a) and the larvae and pupae of 13 and the pupae only of 3 species of *Tabanus* (Goodwin 1973, 1976b). Tidwell (1973) presented descriptions of the larvae of 15 species of *Tabanus*, 4 described for the first time, and 12 species of *Chrysops*. The larvae and pupae of 5 additional species of *Tabanus* were described by Tidwell and Tidwell (1973). Descriptions of the larvae and pupae of another species of *Chrysops* and 2 of *Tabanus* were provided by Teskey and Burger (1976). The larvae and pupae of 2 species of *Tabanus* described in one or more of the above papers also were described by Burger (1977) based on specimens from New Mexico.

One of the species described by Teskey and Burger (1976) was *T. colon* Thunberg. Subsequently, comparisons of the larvae and pupae of *T. colon* from Texas with those described by Teskey and Berger (1976) suggested that 2 species were involved. Studies of adults from the northeastern United States, Texas and other areas led Dr. L. L. Pechuman (personal communication) to conclude that 2 species were involved, that the specimens from Texas are *T. colon* and that those from the northeast represent an undescribed species. Below I give the descriptions of the larvae and pupae of *T. colon* and 3 other species of *Tabanus* and 1 species of *Chrysops*. In addition, using the keys found in Teskey (1969) as a base reference, the points of separation of these larvae from those previously described are noted. To elucidate separation of 3 of the species a key is provided for all known Nearctic larvae of the subfamily Tabaninae which possess a stigmatal spine and couplet 8 of Teskey's key to larvae of *Chrysops* is modified.

Tabanus colon Thunberg

Mature larva (Fig. 1): 34-40 mm long, whitish with contrasting brown pubescent pattern. Head capsule 5.8-6.1 mm long, greatest width 1.55-1.70 mm. Anal segment 3.5-3.7 mm long, ca. 1/3 greater than widest diameter. Respiratory siphon 1.48-1.62 mm long, ca. 1/2 greater than basal diameter; stigmatal spine present. Striations present laterally on all segments and also ventrally on anal segment, absent or inconspicuous and irregular elsewhere; spacings 0.05-0.06 mm on anal segment, elsewhere 0.020-0.035 mm. Anterior pubescence encircles thoracic and first 4 abdominal segments, absent from progressively wider areas midlaterally on abdominal segments 5-7, entirely absent from anal segment; prothoracic annulus with 2 lateral caudal projections, these relatively broad basally and tapered to pointed apices; meso- and metathoracic annuli each with 4 faint slender caudal lateral projections which cross 3/4 and 2/3, respectively, of the non-pubescent area of each segment. Pseudopodial pubescence forming complete annuli on all pseudopodial segments, united with anterior pubescence dorsolaterally on abdominal segments 1-2 and ventrolaterally on 1-3 or 4. Posterior pubescence absent from pro- and mesothorax, forming complete annuli elsewhere although these pale and indistinct except for posterior 4-5 segments; posterior annulus of preanal segment expanded laterally and having 4 short anterior projections. In addition to the posterior annulus, pubescence of anal segment covers anal ridges and lobes, forms on each side a mid-lateral anterior club-shaped projection from the posterior annulus that is united with the pubescence of the anal ridges by vertical band which is constricted near its union with the club-shaped projection, and either a single large irregular spot or 2 small spots located anterodorsally from the anterior margin of the club-shaped projection.

Pupa: 17.5-22 mm long, uniformly yellowish brown. Antennal ridges distinctly divided into median and lateral portions typically by a U-shaped notch and rarely by a shallow depression; median portions sharply ridged apically, crescentric in outline in ventral view, elevated 0.20-0.28 mm above general surface, separated medially, typically by a wide U-shaped gap and rarely by a more or less mushroom-shaped gap; lateral portions also sharply ridged, slightly less elevated than median portions. Frontal tubercle represented by a series of low ridges on each side of mid-line, height 0.04-0.08 mm. Callus tubercles unisetose, elevated 0.18-0.24 mm, skewed laterally. Antennal sheaths 0.60-0.80 mm long and wide, not attaining epicranial suture in male but attaining or slightly exceeding suture in female; apical 1/2 annulated, basal portion with an evident median tubercle which is more developed in female. Vertical and orbital tubercles evident, but small and generally rounded basally. Thoracic spiracles C-shaped, 0.86-0.98 mm long; spiracular prominence exceeding dorsal thoracic margin 0.06-0.10 mm. Setae of meso- and metathoracic segments not tuberculate. Dorsolateral setae of first abdominal segment not tuberculate, lateral setae tuberculate. Spinous fringes biseriate, present on all aspects of segments II-VII but greatly reduced in size ventrally, especially on II-V; fringe of tergite VII of 58-66 spines, the posterior series reduced to a submedian and 3-5 sublateral pairs. Dorsolateral, lateral, and ventrolateral or ventral preanal combs more or less well-developed (dorsolateral ones occasionally reduced), composed of 3-6, 5-8, 8-11 or 24-28 short spines respectively. Dorsal, lateral, and ventral tubercles

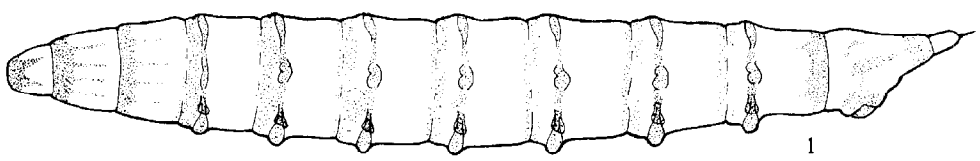

Fig. 1. Lateral view of the larva of *Tabanus colon*.

of aster 0.36-0.48, 0.48-0.58, and 0.26-0.42 mm long, respectively; tubercles gradually tapered from bases to pointed apices; dorsal and lateral tubercles on different planes; surface of aster rather smooth.

Collections: Eighteen larvae, 8 reared, were collected from wet organic mud at the margin or just below the water of Geronimo Creek about 19.5 km (ca 12 mi) west of San Antonio, Bexar Co., Texas. Larvae, all essentially full-grown, were collected in January, March, April, and August.

Comments: As noted above in the introduction, Teskey and Burger (1976) described larvae and pupae designated as *T. colon* but subsequent comparison of these larval and pupal specimens with those described herein, plus comparisons made by Dr. L. L. Pechuman of the adults obtained from all these juvenile stages revealed the presence of 2 distinct species, the one treated herein being *T. colon* and that treated by Teskey and Burger (1976) being as yet unnamed. In addition to the larval and pupal descriptions, Teskey and Burger (1976) provided a key for the identification of all North American *Tabanus* larvae then known to possess a stigmatal spine, except *T. trijunctus* Walker for which no details were then available except for the presence of a stigmatal spine. I subsequently provided descriptions of *T. trijunctus, T. birdiei* Whitney, and *Whitneyomyia beatifica* var. *atricorpus* Philip, all of which have stigmatal spines. In addition a partial description of the larva of *T. cymatophorus*, also possessing a stigmatal spine, is given in this paper. I agree with Teskey and Burger (1976) that the best way of indicating the relationship of the species of *Tabanus* with a stigmatal spine is to provide a key. I have prepared the key below by making the necessary modifications of the key presented by Teskey and Burger (1976). No attempt has been made to prepare a pupal key, or to discuss pupal separation, because as pointed out by Teskey and Burger, "This was found to be impractical since the general similarity in pupae of the group was such that differences between the majority of the species were less than the variation within each species." Although, as noted above, larvae of *Whitneyomyia beatifica* var. *atricorpus* also possess a stigmatal spine, the key is limited to species of *Tabanus*. Larvae of *W. b. atricorpus* are superficially similar to those of *Tabanus* with a stigmatal spine, but they can be readily recognized because in larvae of this species the club-shaped midlateral transverse pubescent band of the anal segment is clearly separated from both the posterior annulus and the pubescence of the anal ridges whereas in the larvae of all *Tabanus* species included in the key this band is clearly united at least with the posterior annulus.

Key to *Tabanus* Larvae with a Stigmatal Spine

1. Anterior pubescence encircling the thoracic segments and present on all or most of the 1st 7 abdominal segments 3
   Anterior pubescence absent on dorsum and venter of thoracic segments and restricted to no more than 1st 2 or 3 abdominal segments 2
2. Posterior projections from the prothoracic annulus relatively broad and coalescing basally. Striations present laterally on all segments .... *wiedemanni* Osten Sacken
   Posterior projections from prothoracic annulus narrow and rather widely separated at their base. Striations absent except for a few broken lines laterally on meso- and metathorax ..... undecribed species
   (This species was treated as *T. colon* by Teskey and Burger 1976).
3. Prothoracic annulus with a single broad fan-shaped posterior projection laterally 4
   Prothoracic annulus laterally with paired posterior projections 7

4. Anal segment on each side with a narrow but distinct pubescent band extending dorsally from pubscence of anal ridges to midpoint where it arches anterodorsally and continues as a moderately distinct band that attains the anterior margin dorsolaterally ..... *trzjunctus* Walker

   Isolated pubescent spots typically present dorsolaterally on anal segment, these sometimes attaining anterior margin (*T. stygius*) but never united with midlateral pubescence 5

5. Posterior pubescence present on all abdominal segments and metathorax. Lateral anterior club-shaped pubescent extensions of posterior annulus of anal segment connected to pubescence on anal ridges. Pseudopodial annuli each with a dorsolateral and a ventrolateral posterior pubescent extension which face anteriorly directed extensions from posterior annuli on at least abdominal segments V-VII ..... *stygius* Say

   Not agreeing entirely with the foregoing 6

6. Lateral club-shaped anterior projections from posterior annulus of anal segment widely and clearly separated from pubescence of anal ridges ..... *proximus* Walker

   Lateral club-shaped anterior projections of posterior annulus of anal segment down-curved near middle of segment and if not uniting with pubescence of anal ridges, only narrowly and indistinctly separated from this pubescence ..... *cymatophorus* Osten Sacken

7. Anal segment with a broad pubescent band extending dorsally from anal ridges to anterior dorsal margin with a narrow lateral band connecting with posterior annulus. Posterior pubescent annulus on preanal segment narrowly connected to pseudopodial pubescence dorso- and ventrolaterally ..... *fumipennis* Wiedemann

   Disagreeing with above. If pubescence of anal segment extends from anal ridges to anterior dorsal margin, the band is narrow and is not united with posterior annulus by a lateral band 8

8. Anal segment with a narrow pubescent band extending from anal ridges to anterior dorsal margin, this band having 2 posteriorly directed pubescent extensions, 1 lateral and 1 dorsolateral, neither attaining posterior annulus ..... *birdiei* Whitney

   Anal segment with pubescence forming a club-shaped anterior projection of posterior annulus that may be narrowly connected to pubescence on anal ridges and sometimes forming 1 or more isolated dorsolateral spots 9

9. Anterior club-shaped projection from posterior annulus on anal segment narrowly connected with pubescence on anal ridges, or lateral pair of posterior pubescent projections from prothoracic annulus widely separated 10

   Anterior club-shaped projections of posterior annulus on anal segment not connected to pubescence on anal ridges. Lateral pair of posterior pubescent projections from prothoracic annulus broad basally and separated by much less than the width of each ..... *aranti* Hays

10. Anterior pubescence encircling abdominal segments 1 to 6 or 7. Faint irregular dorso- and ventrolateral anterior pubescent patches present on anal segment. Posterior pubescence present on segments 3-11. Living larvae greenish ..... *maculipennis* Wiedemann

    Anterior pubescence encircling no more than lst 4 abdominal segments. Anterior pubescence absent from anal segment. Posterior pubescence variable. Living larvae whitish 11

11. Posterior pubescence present on segments 3-11, faint on 3-5. Pseudopodial pubescence moderately extensive, at least extending to fill gaps above and

below lateral pseudopodia. Anterior pubescent projections from posterior annulus of preanal segment short, widely separated from pseudopodial annulus. Pubescent connection between club-shaped anterior projection from posterior annulus of anal segment and pubescence of anal ridge typically constricted near middle, or at least with reduction in density of pubescence ..... *colon* Thunberg

Posterior pubescence present on no more than segments 6-11. If pubescence present in gaps above and below lateral pseudopodia, anterior extensions from posterior annulus of preanal segment elongate, the dorsolateral one uniting or nearly uniting with pseudopodial pubescence. If anterior pubescent extensions from preanal posterior annulus short, pubescence absent from gaps above and below lateral pseudopodia. No constriction or reduction of pubescence connecting anterior club-shaped extension from posterior annulus of anal segment and pubescence of anal ridge 12

12. Pseudopodial pubescence extensive, bordering pseudopodia posteriorly and extending between pseudopodia, particularly the gap above and below lateral pseudopodia. Posterior pubescent annulus on preanal segment with 4 rather long anterior projections laterally, the dorsolateral projection connected to, or almost to, adjacent pseudopodial pubescent annulus ..... *gladiator* Stone

Pseudopodial pubescence narrowly bordering only the pseudopodia and not extending between pseudopodia. Dorsolateral projection anteriorly from posterior pubescent annulus on preanal segment well separated from adjacent pseudopodial pubescent annulus ..... *nigrescens* Palisot

Tabanus cymatophorus Osten Sacken

Only a partial description of the larval stage is given. This description is based upon a fragmented, incomplete larval exuvium in which the 1st 4 segments and the anal segment and respiratory siphon are reasonably intact. However, since the larva possesses a stigmatal spine of the typical form found in species of *Tabanus* and *Chrysops*, it can be separated with reasonable certainty from other known Nearctic larvae based on characters noted below.

Mature larva (Fig. 2): Length estimated to be ca. 30 mm, living ground color unknown, pubescence brown. Head capsule 4.73 mm long, greatest width 1.08 mm. Anal segment 2.2 mm long, ca.1/4 greater than widest diameter. Respiratory siphon 1.2 mm long, ca. 3/4 greater than basal diameter; stigmatal spine present. Striations present only laterally, spacings 0.024-0.032 mm. Anterior pubescence forming complete annuli on 1st 4 segments, absent from anal segment; prothoracic annulus with a single broad lateral caudal projection; meso- and metathoracic annuli each with 4 lateral caudal projections crossing 2/3 and 3/4 of the nonpubescent areas of the respective segments. Pseudopodial pubescence a complete annulus on abdominal segment 1, united dorso- and ventrolaterally with anterior pubescence. Posterior annuli complete on at least

Fig. 2. Lateral view of the larva of *Tabanus cymatophorus*.

preanal and anal segments; preanal annulus slightly expanded laterally but lacking anterior projections. In addition to the posterior annulus, pubescence of anal segment covers anal ridges and lobes, and forms on each side a mid-lateral anterior club-shaped projection from the posterior annulus that is united with pubescence of the anal ridges by a relatively broad vertical band of more or less uniform width.

Female Pupa: ca. 22.5 mm long, yellowish brown. Antennal ridges large, sharply ridged apically, divided into median and lateral portions by a narrow U-shaped notch; median portions elevated ca. 0.24 mm, not noticeably skewed; lateral portions about 2/3 as high as medians. Callus tubercles unisetose, elevated ca. 0.20 mm, highest at lateral extreme, roughly circular in outline, periphery of apex a more or less continuous dark ridge; seta located in ventrolateral depression of apical surface. Paired frontal tubercles large, elevated ca. 0.12 mm in middle, separated by a V-shaped depressed area on midline. Antennal sheaths ca. 0.66 mm long and wide, nearly attaining epicranial suture, with an evident midbasal tubercle. Vertical and orbital setae distinctly tuberculate, orbital setae not noticeably compressed obliquely. Thoracic spiracle comma-shaped, ca. 0.96 mm long; spiracular prominence low, anteriorly truncate, not exceeding anterior thoracic margin. Abdominal segments 2-7 with biseriate fringes, those of anterior series less than 1/2 the length of posterior on same segment, reduced in size ventrally; fringe of tergite VII of 49 spines, the posterior series reduced to a submedian and 3-4 sublateral pairs. Lateral preanal combs absent; dorsolaterals and ventrolaterals well developed, composed of 5-6 short spines each. Dorsal, lateral, and ventral tubercles of aster 0.36, 0.30, 0.26 mm long, respectively; all tubercles with pointed apices, moderately broad basally, tapering rapidly from base to apex.

Collections: As reported by Thompson (1979) the larva was taken "from the marginal mud of a woodland pond" in the Navasota River bottom land in Grimes Co., Texas.

Comments: Separation of larvae and pupae of this species from other larvae possessing a stigmatal spine is discussed above in the comments on *T. colon*.

Tabanus lineola subspecies *hinellus* Philip

Mature larva (Fig. 3): 23-26 mm long, whitish with contrasting brown pubescent pattern. Head capsule 3.6-3.8 mm long, greatest width 0.76-0.80 mm. Anal segment 2.20-2.32 mm long, ca. 1/4 greater than maximum width. Respiratory siphon 0.72-0.80 mm long and wide basally; stigmatal spine absent. Striations present on non-pubescent areas of anal segment, elsewhere only laterally, spacings 0.021-0.029 mm on thoracic segments, 0.014-0.021 on abdominal segments, 0.024-0.045 on anal segment. Anterior pubescence absent from anal segment, restricted to dorsal and ventral transverse straps on abdominal segments 6 and 7, elsewhere forming complete annuli; prothoracic annulus with 2 lateral caudal projections, these considerably expanded posteriorly so that gap between them is relatively broad near annulus but narrow near apices of projections; meso- and metathoracic annuli with 4 lateral caudal projections which cross about 3/4 of non-pubescent area on each segment, those of mesothorax inflated posteriorly. Pseudopodial pubescence forming complete annuli on all pseudopodial segments, united

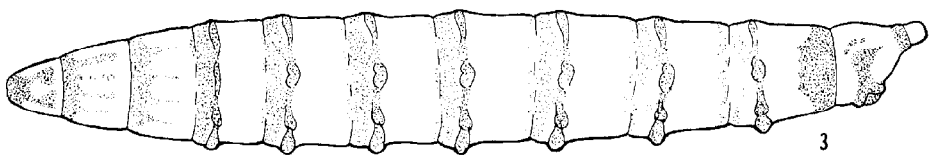

Fig. 3. Lateral view of the larva of *Tabanus lineola hinellus*.

with anterior pubescence dorsolaterally on all, ventrolaterally on abdominal segments 1-5. Posterior pubescence absent from pro- and mesothorax, restricted to a small dorsolateral patch on metathorax, elsewhere forming complete annuli, these progressively more distinct caudally; preanal annulus expanded laterally and bearing at least hints of 4 pointed anterior projections. Anal segment with pubescence covering anal ridges and lobes and extending dorsally to middle of segment where it bends rearward to form an attenuated projection that does not unite with the posterior annulus; anterodorsally are 3 small pubescent spots, these sometimes united into 2 or even a single large spot.

Pupa: 13-16.5 mm long, yellowish brown. Antennal ridges divided into median and lateral portions by a shallow notch, the separation more evident by difference in elevation; median portions sharply ridged apically, not noticeably skewed, elevated 0.11-0.13 mm; lateral portions with rounded apices, 1/2-2/3 as high as median portions. Callus tubercles unisetose, elevated 0.16-0.20 mm, irregularly circular or triangular in basal outline, highest in middle, seta near middle at apex of a transverse ridge. Frontal tubercles represented by a pair of low rounded mounds, elevated only ca. 0.02 mm in middle. Antennal sheaths 0.36-0.48 mm long and wide, not attaining epicranial suture in male, tip slightly exceeding epicranial suture in female, lacking a distinct midbasal tubercle. Vertical and orbital setae of head tuberculate, none obliquely compressed. Lateral mesothoracic setae and setae of lst abdominal segment tuberculate, other setae of meso- and metathorax sessile. Thoracic spiracle 0.72-0.76 mm long, C-shaped; spiracular prominence exceeds dorsal thoracic margin 0.18-0.21 mm. Abdominal segments 2-7 encircled by biseriate fringes, those of anterior series about 1/3 length of posterior on same segment; fringes reduced in size ventrally, posterior series scarcely evident on anterior segments; fringe of tergite 7 with 36-44 spines, the posterior series reduced to a submedian and 3-4 sublateral pairs. Dorsal preanal combs absent; lateral, ventrolateral, or ventral combs with 2-5, 7-8, or 18-22 spines, respectively. Dorsal, lateral, and ventral tubercles of aster 0.30-0.32, 0.38-0.40, 0.22-0.24 mm long respectively; dorsal tubercles arise from bases of laterals; dorsal and lateral tubercles in side view on same plane basally, but at least tips (generally apical 1/4) of dorsal tubercles clearly visible in lateral view; all tubercles with pointed apices.

Collections: 12 essentially full-grown larvae, 6 reared, were collected in February from wet mud and grass roots at the margin of water-filled depression on South Padre Island, Cameron Co., Texas. The water in this depression was brackish, and the entire area was periodically inundated by sea water.

Comments: Larvae of *T. lineola hinellus* would key to *T. similis* Macquart in Teskey (1969). Larvae of *T. subsimilis* are very similar to *T. similis*. Separtation of these 2 species is discussed by Burger (1977). Both of these species can be separated from *T. lineola hinellus* by the difference in the pubescent pattern of the prothorax as follows: in both *T. similis* and *T. subsimilis* the posterior projections from the anterior annulus are slender and pointed, whereas in *T. lineola hinellus* they are greatly inflated toward the truncate apex. Except for the flask-shaped non-pubescent area on the lateral midline, the pubescent pattern of the pro-thorax of *T. lineola hinellus* gives the general appearance of the single broad fan-shaped projection typical in larvae of many *Tabanus* species, including typical *T. lineola*. However, the differences between the larvae of typical *T. lineola* and those of *T. lineola hinellus* suggest that they might be distinct, but further study, including examination of specimens from other parts of the range of both subspecies is needed. Fairchild (1983) has discussed the situation in detail based on an analysis of adult characters and has also noted that further study is needed.

Tabanus venustus Osten *Sacken*

I described the pupa of this species (Goodwin 1976). In the same paper I described

under the name 'Genus A', a larva and malformed pupa which had died. In that paper I stated that the unique structure of the respiratory siphon of the larva of 'Genus A' and the reduction of the posterior fringe spines on all tergites of the pupa to a median and several sublateral pairs suggested it represented an unreared genus of Tabanidae. Through the courtesy of Dr. Patrick H. Thompson, I now have a larval exuvium of *T. venustus*. The larval exuvium is essentially identical with the specimen I termed 'Genus A', except it is smaller being only 25 mm long. The structure of the respiratory siphon is still unique among known larvae of Tabanidae, but as a single character does not seem sufficient to place *T. venustus* in a separate genus. The "uniqueness" of the pupa of 'Genus A', noted above and in my earlier paper (Goodwin 1976) is not in evidence in the specimen of *T. venustus* provided by Dr. Thompson or the specimen of *T. venustus* I described previously (Goodwin 1976). I suspect the "uniqueness" of the pupa that died was a manifestation of the conditions causing the general malformation and subsequent death of the specimen.

Collections: As noted by Thompson (1978) the larva he provided "was found in March at the margin of a small pond near College Station", in Grimes Co., Texas.

Chrysops obsoletus Wiedemann

Mature larva (Fig. 4): 12 mm long, yellowish-white with contrasting brown pubescent markings. Head capsule 2.06 mm long, greatest width 0.64 mm. Anal segment 1.1 mm long, a little greater than maximum diameter. Respiratory siphon 0.6 mm long, about 1/3 greater than basal diameter; stigmatal spine present. Striations present on all aspects of every segment; spacings 0.22-0.27 dorsally and ventrally and on anal segment, 0.015-0.021 laterally. Anterior pubescence absent from anal segment, restricted to well-developed dorsal and small ventral transverse bands on preanal segment, elsewhere forming complete annuli, that on abdominal segment 6 very narrow midlaterally; prothoracic annulus with a single broad fan-shaped caudal projection laterally; mesothoracic annulus with 4 slender attenuated lateral caudal projections which reach to about midpoint of segment; metathoracic annulus with only 2 short lateral caudal projections on line with upper and lower projections of mesothorax. Pseudopodial pubescence forming complete annuli on all psuedopodial segments, united with anterior pubescence dorsolaterally on all and ventrolaterally on all except abdominal segment 7. Posterior pubescence present only on preanal and anal segments; preanal annulus broad, expanded midlaterally to form a single anterior projection; posterior annulus of anal segment covering more or less posterior 2/3 of segment including anal ridges and lobes, but anterior margin lies only slightly anterior to midpoint of segment dorsally; laterally this margin sinuous with 3 anterior rounded projections; 2 small isolated pubescent spots anterior to annulus in ventral half.

Male Pupa: 11.5 mm long, pale yellowish brown except for dark brown of head and thorax as follows: except for ventrolateral thirds posterior to antennal sheaths and an oval area near middle of each eye region, entire head dark brown, darker near midline, especially dorsally; on thorax a dark brown dorsal triangular area, broad at anterior margin and extending to pointed apex at caudal end of mesothorax. Antennal ridges

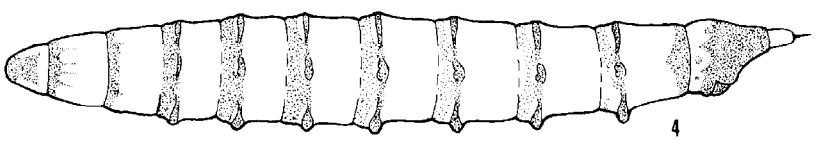

Fig. 4. Lateral view of the larva of *Chrysops obsoletus*.

with median portions hemispherical with rounded apical ridge, elevated ca. 0.04 mm; lateral portions hardly indicated. Callus tubercles bisetate, irregularly ovoid basally, apical margins rather sharply ridged, long axes dorsally divergent, elevated ca. 0.05 mm. Antennal sheaths ca. 0.50 mm long, 0.36 mm wide, exceeding epicranial suture. Setae of head very slightly tuberculate. Thoracic spiracle C-shaped, ca. 0.50 mm long; spiracular prominence exceeds dorsal thoracic margin ca. 0.13 mm. Spinous fringes of abdominal segments 2-7 uniseriate, attenuate, reduced only in size ventrally; fringe of tergite 7 composed of 30 spines, 3 of which have paired apices. Ventral comb of 22 spines, a few with paired apices. Dorsal, lateral, and ventral tubercles of aster ca. 0.26, 0.36, 0.22 mm long, respectively; all tubercles slender with pointed apices.

Collection: A single full-grown larva was collected in May from wet mud at the margin of a water-filled borrow pit alongside the railroad right of way on the University of Florida, Gainesville, campus (Alachua Co.).

Comments: The larva of this species keys to couplet 8 in Teskey (1969). This couplet separates *C. atlanticus* Pechuman and *C. univittatus* Macquart. These 3 species can be separated by the following modification of Teskey's key:

8. Anterior pubescence encircles 1st 5 or 6 abdominal segments. Either posterior pubescent projections from meso- and metathoracic annuli very short or apparently absent, or posterior annulus of preanal segment broadly expanded to form a single anterior projection on lateral midline 8a

   Anterior pubescence encircles 1st 3 or 4 abdominal segments. Posterior pubescent projections from meso- and metathoracic annuli extend approximately 1/2 and 1/3 length of the segments respectively. Posterior annulus of preanal segment lacking anterior projection on lateral midline ..... *atlanticus* Pechuman

8a. Posterior pubescent projections of mesothorax slender, pointed, crossing approximately 1/3 of length of segment; on metathorax these projections represented only by very short dorsolateral and ventrolateral points. Posterior annulus of preanal segment broadly expanded to form a single anterior projection on lateral midline ..... *obsoletus* Wiedemann

   Posterior pubescent projections from meso- and metathoracic annuli very short or apparently absent. Posterior annulus of preanal segment broadly expanded laterally with hints of dorso- and ventrolateral anterior extensions but lacking a midlateral anterior extension ..... *univittatus* Macquart

The pupa of *C. obsoletus* keys to couplet 7 in Teskey (1969). Separation beyond this point is not possible based on a single male specimen.

Endnote

Approved for publication as TA 21880 by the Texas Agricultural Experiment Station.

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BIOMAGNETISM: AN ORIENTATION MECHANISM IN MIGRATING INSECTS?

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ABSTRACT

The ability of short lived insects to migrate seasonally over long distances requires the use of some heritable, direction-finding mechanism. Biologically synthesized magnetic particles, functioning like a built-in compass, may serve as one such mechanism by enabling orientation in the earth's magnetic field. Biomagnetism has been a leading candidate to explain geomagnetic orientation in animals.

Except for 2 species, insects have not been examined for evidence of magnetic particles. In this study 9 insect species were tested. Five migratory (moths and butterflies) and 4 non-migratory (crickets) species were compared to reveal any correlation between the presence of magnetic particles and migratory behavior.

Only 1 migrant, the monarch butterfly (*Danaus plexippus* L.), displayed evidence of biomagnetism. All non-migrants possessed significant levels of magnetism, the function of which if any, is not known.

RESUMEN

La abilidad de insectos de vida corta a migrar temporalmente sobre distancias largas, requiere el uso de algún mecanismo de orientación hereditaria. Particulas magnéticas biologicamente investigadas, funcionando como un compás interno, pudieran servir como tal mecanismo, facilitando la orientación en el campo magnético de la tierra. El biomagnetismo ha sido un candidato principal en la explicación de la orientación geomagnética en los animales.