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BIOLOGY, HABITAT PREFERENCE, AND LARVAL DESCRIPTION OF *Cicindela cursitans* LECONTE (COLEOPTERA: CARABIDAE: CICINDELINAE)

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Biology, Habitat Preference, and Larval Description of *Cicindela cursitans* LeConte (Coleoptera: Carabidae: Cicindelinae)

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Abstract

Cicindela cursitans LeConte is a small, flightless tiger beetle with a widely scattered distribution in the Great Plains, the Ohio Valley, and the north-central Gulf Coast region. Many aspects of the life history of *C. cursitans* are poorly known, and the larval stages have remained undescribed until now. We designed experiments to determine specific habitat preference, female oviposition preference, and daily activity cycles of the adults. In addition, we describe the entire pre-adult life history. Adults are most numerous on moist clay soils with sparse to patchy vegetation, but they may also occur in tall-grass prairies. Females oviposit strictly in moist soils consisting of fine particles. Adults are both diurnal and crepuscular, and presumably spend the nighttime hours hiding among vegetation. Larvae occur in the same habitats as the adults and are typically clustered near the bases of plants. The larvae are the smallest of any tiger beetle species described in North America (body length of first instars = 2.6–3.2 mm, second instars = 5.4–6.7 mm, third instars = 8.4–10.1 mm) and most similar in morphology to *Cicindela debilis* Bates. Knowledge of the life history and habitats used by this species will allow a better understanding of its distribution and abundance, and its association with prairie habitats. This information as well as low dispersal rates may make this species useful for assessment of habitat quality and restoration success.

Cicindela cursitans LeConte is a small flightless tiger beetle. At less than 1 cm in length, adults are among the smallest species in North America (Graves and Brzoska 1991). It is also among the more poorly known species, despite having been first described by LeConte in 1857 (LeConte 1857). The species is associated with bunchgrass prairies near rivers (Tinerella and Rider 2000; M. L. Brust, pers. obs.); however, its pre-adult life history remains very poorly known. It is a summer-active species in the adult stage and is most numerous in June and July (Graves and Pearson 1973; Knisley *et al.* 1987; Larochelle and Lariviere 2001). Because of its small size and general resemblance to ants it is easily overlooked (Graves and Brzoska 1991), and its North American distribution is probably underestimated (Graves and Pearson 1973; Graves and Brzoska 1991; Pearson *et al.* 1997).

Cicindela cursitans has been recorded from North Dakota (Boyd and Associates 1982), South Dakota (Gilbertson 1929; Backlund *et al.* 2000), Nebraska (Carter 1989), Minnesota (Tinerella and Rider 2000), Iowa (Eckhoff 1939), Indiana (Knisley *et al.* 1987), Ohio (Graves and Brzoska 1991; Will and Androw 1992), West Virginia (Kirchner and Kondratieff 1999), Arkansas, Louisiana, Mississippi (Graves and

Pearson 1973), Alabama, Illinois, Kentucky, and Tennessee (Bousquet and Larochelle 1993). Most of these records are from widely scattered locations within the states from which it has been recorded. There is a distributional gap of greater than 500 km between the eastern and Great Plains records, which some authors have suggested represents two disjunct forms and potentially two species (R. L. Huber, pers. comm.). A better characterization of the distribution of this species may be best accomplished by determining habitat associations of both adults and larvae. Some reported habitats for this species include river banks (Eckhoff 1939; Will and Androw 1992; Backlund *et al.* 2000), bare fields (Graves and Brzoska 1991), moist ditches (Carter 1989), damp areas near water (Graves and Pearson 1973; Knisley *et al.* 1987), and mesic and wet prairies (Tinerella and Rider 2000). The larval stages of *C. cursitans* were previously unknown (Valenti 1996), but *Cicindela cursitans* was suspected to have a one-year life cycle based on summer occurrence of adults and its small size.

The objectives of this study were to: 1) determine habitat preference and adult activity using pitfall traps; 2) determine the oviposition preference of *C. cursitans* in the laboratory; 3) describe all larval stages.

Material and Methods

Seasonal Occurrence and Habitat Associations. Information on adult habitat preference was obtained by barrier pitfall trapping and by direct observation. A total of 30 pitfall trap arrays were placed on three properties of the Whooping Crane Trust in the Platte River Valley of Buffalo and Hall Counties in Nebraska during the summer of 2003. The first site was located approximately 7.7 km SSE of Gibbon in Buffalo County, the second approximately 9.3 km south of Alda in Hall County, and the third approximately 11.7 km south of Grand Island. All of these sites are managed as grassland by the Whooping Crane Trust under a variety of rotational management methods. These methods include grazing, haying, idling, and occasional burns (Riggins 2004). The habitat at these sites is classified as wet meadow under the Nebraska National Heritage Inventory classification (Nebraska National Heritage Inventory List 1996).

The traps used in this study were similar to those described by Durkis and Reeves (1982). Each barrier pitfall trap array consisted of two 0.94 liter (32 oz.) plastic cups dug into the soil with the top edge flush with the soil surface. These were placed approximately 0.4 m apart with a piece of lawn edging placed between and secured with large nails. No preservative was added to the cups so that the collected beetles could be either released or maintained alive. Trap arrays were placed in various habitats, included tall-grass prairie (>1 m), medium height grass areas (0.5–1 m), open medium grass (medium-height grass with some exposed soil areas), a wet clay-organic ditch, a clay ditch with some sandy patches, and a sandbar along the Platte River (at approximate high water mark). Five trap arrays were placed at the first site for a total of 55 trap days, 20 arrays were placed at the second site for a total of 217 trap days, and 5 traps were placed at the third site for a total of 55 trap days. Each trap was checked daily for an average of 10 days. In addition, visual surveys were conducted at the Alda site at least every 20 days in 2003 and 2004 to monitor adult seasonal activity. All species recorded during the study were identified under the classification system used in Larochelle and Lariviere (2001).

Diel Adult Activity. Because some tiger beetle species are active at night, traps were monitored during specific time periods. This survey was conducted for two nights at the site at which the highest density of adults was noted. Ten traps were checked during the day, covered from 17:00 to 22:00, and left uncovered from 22:00 to 05:00. They were checked immediately at 05:00. Visual surveys were also carried out on both nights from 23:00 to 00:30 to monitor potential nocturnal adult activity.

Oviposition Site Choice. The oviposition site preference of adult females for different soil particle size composition was tested in the laboratory using adults collected from the site south of Alda, Nebraska. In the laboratory, adults were maintained in 13.2 liter (3.5 gallon) aquaria and primarily fed freshly killed ants.

In the oviposition preference trials, three different soil particle size combinations were used: larger than 1 mm in diameter (very coarse sand), particles from 1 mm to 0.105 mm in diameter (medium sand), and particles smaller than 0.105 mm in diameter (very fine sand). Each of the three soil types was placed in a 13.2 liter (3.5 gallon) aquarium in a layer approximately 1.5 cm deep and covering about one-third of the aquarium bottom. Each aquarium contained all three soil categories placed side by side, and the orientation of each category to another was randomized. Three such aquaria were created, and the soil in all three sections was kept moist throughout the experiment by daily watering. Two adults of each sex were then placed in each aquarium and the aquaria were placed in a 25°C environmental chamber with a 12:12 light/dark cycle. In order to avoid potential effects of lighting, each aquarium was rotated 180° every 24 hours. Adults were fed freshly killed ants approximately every third day. Adults were left in the chambers to oviposit for 14 days, after which time oviposition holes were counted. The soil was then emptied into a tray and searched for individual eggs.

Larval Life History. Information on life history and development of larvae was obtained from both field observations and laboratory rearing of larvae. Larvae were reared from egg to third instar in the laboratory and additional larvae were obtained from the field. Field-collected larvae were detected by searching the soil for their characteristic burrow openings, which were easily distinguished from those of any other species because of their small size. Larvae were then dug up by placing a grass stem in the burrow and excavating with a hand trowel next to the burrow until the larva was found. As this species was by far the most abundant species at the site, there was little question on the identity of the collected larvae. Other species found at the site were a few *Cicindela punctulata punctulata* Olivier (adults and larvae), *Tetracha virginica* Linnaeus (larvae), and a single adult *Cicindela duodecimguttata* Dejean. In order to verify identification, field-collected larvae were compared with those reared from eggs collected in the laboratory.

Eggs recovered from adults in the laboratory were transferred to plastic medicine vials (approximately 60 ml) that were filled about three-quarters with soil from the habitat at the Alda site. The soil was watered every three to five days and larvae were fed apterous adult *Drosophila* about once per week. Because of the small size of the first instars, fruit flies were cut in half and each larva was fed one-half at a time. The latter two instars were fed with whole fruit flies.

Visual observations of larval burrows and associated microhabitats were obtained by surveying areas for larval burrows during the daytime. Habitat characteristics including general soil type, moisture, and association to vegetation was recorded. Any adults observed during these surveys were also noted.

Description of Larval Stages. Larval descriptions follow Knisley and Pearson (1984). Eggs and pupae were described from material collected in the laboratory. The three instars were described from both reared and field-collected larvae. Descriptions were based on a total of 3–5 for each of the developmental stages: eggs, three larval instars, and pupae. All larvae were killed by dropping them into boiling in water and were then transferred to 95% ethanol, where they were stored until they could be examined.

Results

Seasonal Occurrence and Habitat Associations. Habitat sampling from May until September in 2003 revealed that adults become active in early July and were numerous

Table 1. Oviposition site choice by *Cicindela cursitans* based on soil particle diameter. Results are totals for 3 replicates, 2 females per replicate, 14 days.

Soil particle size (mm)	Oviposition holes	Eggs
>1.00	0	0
1.00 to 0.105	0	0
<0.105	57	34

between July 10 and August 1. However, visits to the Alda site in 2004 revealed adults emerged in early and mid-June. A few adults were still seen on moist soil patches on August 7, 2004.

The results of pitfall trapping suggest that adult *C. cursitans* occur primarily in areas of moist clay soils, especially in grassy areas with patches of soil exposed or in areas of sparse vegetation. The beetles were also common in low moist areas. Over the course of 203 trapping days, only two adults were collected in areas with heavy vegetation. This is not likely the result of chance (Chi-square Goodness of Fit; $P = <0.01$). During the same period, 20 were collected over the course of 73 trapping days in areas of sparse vegetation. Within a clay ditch area with sparse vegetation, adults were most numerous near the bottom of the ditch and least numerous near the top edge. The number of beetles collected near the bottom of the ditch was significantly different from both the upper (Chi-square Goodness of Fit; $P = 0.04$) and middle areas (Chi-square Goodness of Fit; $P = 0.03$), but the upper and middle areas were similar to each other (Chi-square Goodness of Fit; $P = 0.19$). Along the bottom of the ditch the average capture rate was 0.588 beetles/trap day.

The soils in the area where *C. cursitans* was common are classified in the Gibbon-Gothenburg-Platte group. The wet meadows in this region have high water tables, poorly drained soils, and are rich in organic content (Jelinski and Currier 1996). The elevation and moisture gradients formed by the ridge and swale topography result in substantial abiotic changes over short distances (Riggins 2004). Overall, the soils in areas occupied by *C. cursitans* appeared to most closely fit the description of the Gibbon soil type (fluvaquentic haplaquolls).

Adult Behavior and Activity. Field observations indicated that adults run rapidly when alarmed and will run continuously until they find cover in which to hide. Suitable cover included the bases of grass clumps or cracks and crevices in the ground. Though their movement is interspersed with pauses when foraging, as is seen in most other tiger beetles, movement when alarmed is continuous.

No adults were collected in pitfall traps between 2200 hours and the next morning. This may be the result of chance because of a limited amount of night trapping (Chi-square Goodness of Fit; $P = 0.14$). However, visual surveys conducted within known habitat also failed to reveal any nocturnal adult movement. A single individual was collected at a lantern near grassland habitat at a separate site at about 2230 hours. It is unknown whether all collections in pitfall traps occurred during the day because traps were normally checked only once daily.

Oviposition Site Choice. The results of the oviposition preference tests indicated that female *C. cursitans* oviposited only in soils with a particle size of less than 0.105 mm (Table 1). This is not likely a result of chance (Chi-square Goodness of Fit; $P = <0.01$). The absence of oviposition holes in the two coarse soil combinations suggests that no attempts were made to oviposit in those soils. Eggs were found in approximately 60% of the oviposition holes, which were approximately 3 to 5 mm deep and about 1.2 mm in diameter. We found no indication that holes were covered as has been reported for some *cicindela* species (Pearson 1988; Knisley and Schultz 1997).

Larval Life History. Field observations indicated that larval burrows were most numerous in the same moist clay ditch areas in which the adults were most often encountered. Only a few widely scattered larval burrows were noted in the more dense grassy areas. Larval burrows were mostly located around the bases of plants, such as clumps of grass or white sweetclover (*Melilotus alba* Medikus). Though the various species of grass were not determined, species known to occur on the slopes and within the swales of the wet meadows include big bluestem (*Andropogon gerardi* Vitman), indiangrass (*Sorgastrum nutans* (L.) Nash), prairie cordgrass (*Spartina pectinata* Link), various sedges (*Carex* ssp.), and spikerush (*Eleocharis obtusa* (Willde.) J. A. Schultes) (Nagel and Harding 1987). In one case, 23 second and third instars were counted around a single clump of grass, and in several other cases over 12 were noted around individual plants. Larval burrows were generally from about 10 to 30 cm from the base of each plant or grass clump. In some localized areas, larval burrow densities were estimated to be as high as 35 per square meter. Only one case of larval feeding was noted in the field. This occurred when we were digging a first instar out of its burrow and found it feeding on a small orangish ant (species undetermined, length = 4.5 mm) that was nearly twice the size of the larva.

Laboratory rearing and field observations strongly suggest that *C. cursitans* has a one-year life cycle in Nebraska. All larvae reared from eggs laid in July reached the third instar by mid-September in the laboratory. Field observations showed that about 80% of larvae reach the third instar by September 4, and nearly 100% had reached in the third instar by early May of the following year (2004). No larval burrows were noted from July 5 to July 25 in 2003, or from June 5 to June 25 in 2004. Attempts to rear larvae beyond the third instar in the laboratory failed, but third instars collected in late April pupated in May and emerged as adults in June.

Cicindela cursitans Leconte

Measurements given below are the means (in mm) and range of 3–5 individuals for each instar.

Third Instar
(Figs. 2, 5–7)

Description. *Measurements*. TL 9.2(8.4–10.1); W3 0.9(0.8–1.0); PNW 1.88(1.8–2.0). *Pronotal length*. PNL 1.2(1.1–1.5); FW 0.97(0.9–1.0); FL 0.67(0.6–0.7); PNL/PNW = 0.59. *Color*. Head and labrum dark brown to blackish; pronotal disk and cephalolateral angles dark brown to blackish with slight purplish reflections. Antennae and labium dark brown to blackish. Mandibles reddish brown, darker distally. Maxillae light brown to pale yellowish brown. Dorsal cephalic and pronotal setae transparent or whitish; other body setae brown. *Head*. Dorsal setae prominent; U-shaped ridge on frons with 4 setae. Antennal segment1 with 5 setae, segment 2 with 7 setae. *Pronotum*. Pronotal setae prominent, 10–14 pairs; 4 to 6 setae on cephalolateral portion of disk; carina on disk close to the margin (Fig. 2). 11–16 pairs of cephalomarginal setae. *Abdomen*. Sclerotized areas not distinct (Fig. 5). Third tergites with 8–12 setae (Fig. 5). Median hooks with 3 setae, distal seta is short and stout, inner hooks with 2 stout setae, spine minute to very small (Fig. 6). Fifth caudal tergites with 24–30 setae, 10–11 very stout; epipleura with 5–7 setae. Ninth eusternum with 2 groups of 4 setae on caudal margin, inner pair about half the length of other 3 pairs (Fig. 7); pygopod with 7 setae, 5 very stout, on each side.

Second Instar
(Fig. 3)

Description. *Measurements*. TL 6.13(5.4–6.7); W3 0.57(0.5–0.7); PNW 1.18(1.1–1.3); PNL 0.73(0.6–0.8); FW 0.57(0.5–0.6); FL 0.4(0.4); PNL/PNW = 0.62. *Color*. Head and labrum dark brown to blackish; pronotal disk and cephalolateral angles dark brown to blackish with slight

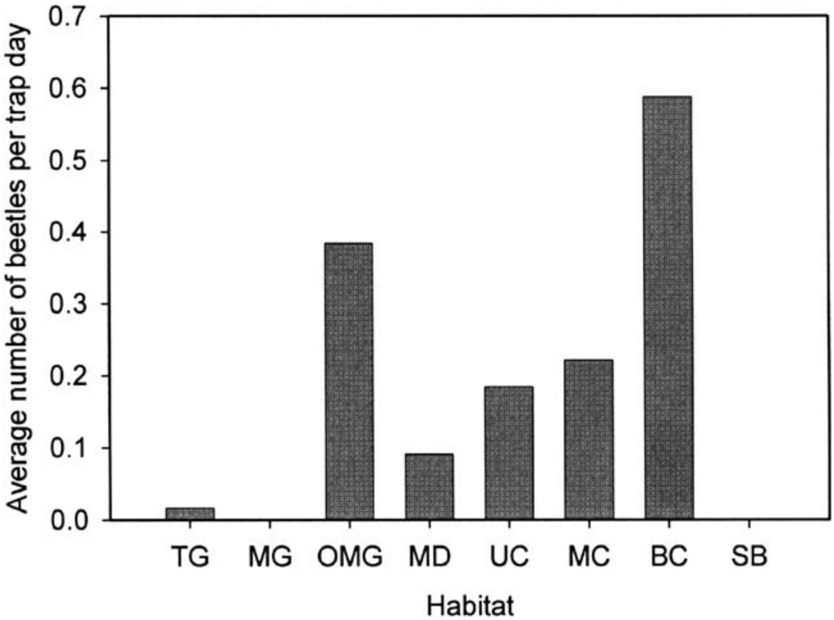
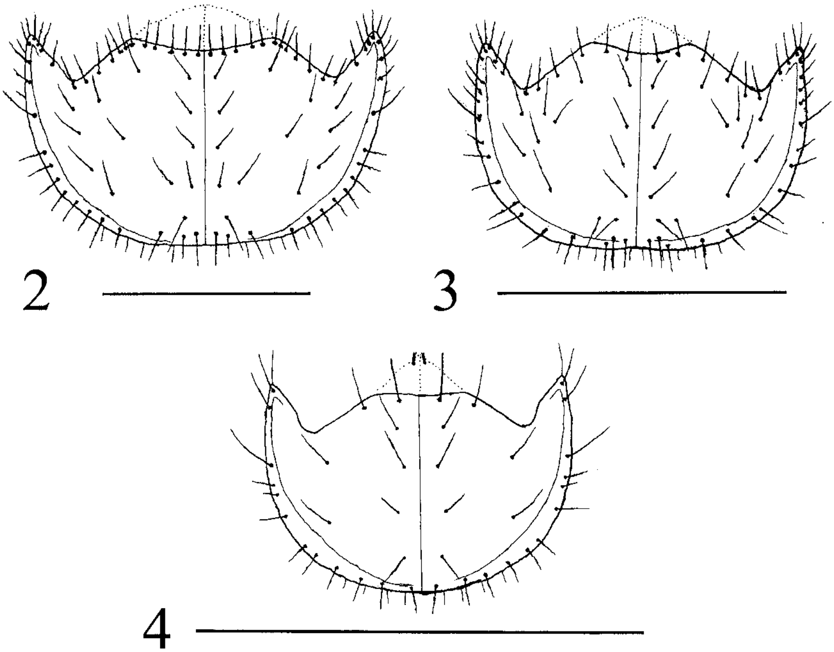


Fig. 1. Average number of adult *C. cursitans* collected per trap day by habitat type; tall-grass prairie (TG), medium height grass (MG) open medium height grass (OMG), muddy ditch (MD), upper slope of clay ditch (UC), middle slope of clay ditch (MC), bottom of clay ditch (BC), river sandbar (SB).

purplish reflections. Antennae and labium dark brown. Mandibles reddish brown, darker distally. Maxillae light brown to pale yellowish brown. Dorsal cephalic and pronotal setae transparent or whitish; other body setae brown. *Head*. Dorsal setae prominent; U-shaped ridge on frons with 4–6 setae. Antennal segment 1 with 5 setae, segment 2 with 7 setae. *Pronotum*. Pronotal setae prominent, 9 to 14 pairs; 4 setae on cephalolateral portion of disk (Fig. 3). 7–11 pairs of cephalomarginal setae. *Abdomen*. Sclerotized areas only somewhat distinct. Third tergites with 4–6 setae. Median hooks with 3 setae, distal seta is short and stout, inner hooks with 2 stout setae, spine about one-fifth total hook length. Fifth caudal tergites with 20–28 setae, 9–11 very stout; epipleura with 4–6 setae. Ninth eusternum with 2 groups of 4 setae on caudal margin, inner pair about half the length of other 3 pairs; pygopod with 7 setae, 5 very stout, on each side.

First Instar
(Fig. 4)

Description. *Measurements*. TL 2.83(2.6–3.2); W3 0.33(0.3–0.4); PNW 0.73(0.7–0.8); PNL 0.43(0.4–0.5); FW 0.36(0.3–0.4); FL 0.2(0.2); PNL/PNW = 0.59. *Color*. Head and labrum dark brown to blackish; pronotal disk and cephalolateral angles brown. Antennae and labium dark brown. Mandibles light reddish brown, darker distally. Maxillae light brown to pale yellowish brown. Dorsal cephalic and pronotal setae transparent or whitish; other body setae brown. *Head*. Dorsal setae prominent; U-shaped ridge on frons with 2 setae. Antennal segment 1 with 5 setae, segment 2 with 6 setae. *Pronotum*. Pronotal setae prominent, 6–8 pairs; 2–3 pairs of cephalomarginal setae. 2–4 setae on cephalolateral portion of disk (Fig. 4). *Abdomen*. Sclerotized areas moderately distinct. Third tergites with 2 setae. Median hooks with 2–3 setae, inner hooks with stout 2 setae, spine about one-half total hook length. Fifth caudal tergites lacking setae



Figs. 2–4. *Cicindela cursitans*. Scale bars equal 1.0 mm. **2)** Third instar pronotum, dorsal aspect; **3)** second instar pronotum, dorsal aspect; **4)** first instar pronotum, dorsal aspect.

entirely; epipleura with 4–5 setae. Ninth eusternum with 2 groups of 4 setae on caudal margin, inner pair about half the length of other 3 pairs; pygopod with 7 setae, 5 very stout, on each side.

Egg

Description. *Measurements*. TL 1.13(1.1–1.2); TW 0.65(0.6–0.7). *Color*. Pale yellow.

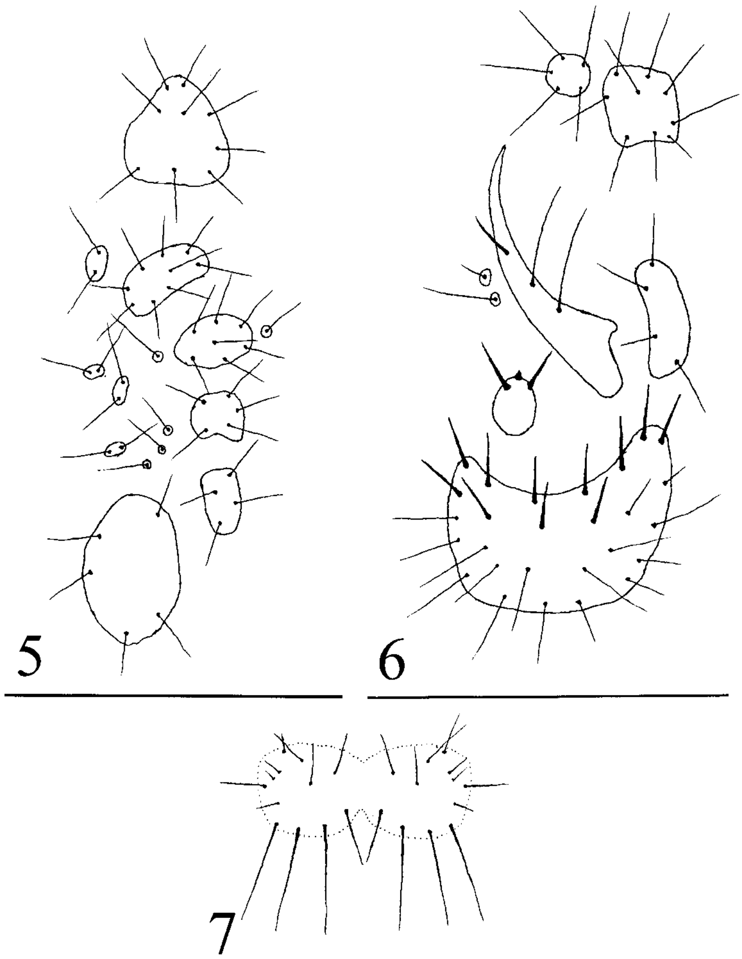
Pupa

Description. *Measurements*. TL 7.0(6.4–7.5); Length of spine on fifth abdominal segment 0.57(0.5–0.6). *Color*. Pale cream to yellowish.

Discussion

Because the largest concentrations of both adults and larvae of *C. cursitans* were noted in the bottom areas of the ditch, we believe that ditch and swale formations in grasslands and wet meadows represent the primary areas of reproduction. Adults found among tall grasses most likely represent dispersing individuals. Though there may be some limited reproduction among more dense vegetation, these areas probably only represent marginal or temporary populations, which are partially maintained by larger populations in the nearby ditch and swale formations.

Surprisingly, other tiger beetle species were uncommon in areas where *C. cursitans* was found. The habitat dominated by larval burrows of *C. cursitans* had only very widely scattered larval burrows of *C. punctulata* and even fewer burrows of *Tetracha virginica*.



Figs. 5–7. *Cicindela cursitans*. Scale bars equal 1.0 mm. **5)** Third abdominal segment, third instar, lateral aspect; **6)** fifth abdominal segment, third instar, dorsal aspect; **7)** ninth eusternum, third instar, ventral aspect.

At one site where the soil was somewhat sandier, *Cicindela tranquebarica* Herbst was abundant throughout the swale areas, but larval burrows of *C. cursitans* were mostly restricted to the top edge of these swales where the soil contained more clay.

Because adults were encountered during virtually all times of the day from about 0800 hours to 1900 hours (sunrise = circa 0530 hours, sunset = circa 2050 hours), they appear to be both diurnal and crepuscular. Though none were caught in pitfall traps at night, one was attracted to a lantern at a different site at about 2230 hours. Thus, it is likely that there may be some limited nocturnal activity if temperatures are warm enough. It is expected that *C. cursitans* should be active and attracted to lights at night, as are many other summer-active species in the United States (Larochelle and Lariviere 2001). Adults observed during the early morning hours were never found to have soil adhering to the body, and thus it is thought that they do not burrow into the ground at night, but instead probably spend the night in the bases of plants, especially grasses. It is common to see soil adhering to the pronotum during the morning hours in tiger beetle species that burrow at night, particularly spring-fall species such as *Cicindela repanda* Dejean and *Cicindela splendida* Hentz (M. L. Brust, pers. obs.).

The results of oviposition site choice show that female *C. cursitans* select soils dominated by small particles. This is not surprising, because first instars average only 3 mm in length, and large soil particles would likely be difficult for a larva of that size to dig through. It is unknown whether soil pH or salinity plays a role, but scattered salt deposits at the primary study site suggests that they can tolerate at least a moderate level of salinity. Although most larvae and adults were associated with clay and sandy clay soils, a few adults were found in muddy areas with significant amounts of organic material. Thus, it is possible that *C. cursitans* may use clayey, silty, or rich organic soils. Other studies have shown that tiger beetles select oviposition sites based on soil type (Shelford 1911) and that the shape of the female ovipositor is related to the particle size of the preferred substrate (Leffler 1979).

The clustering of larval burrows near the bases of plants suggests that *C. cursitans* females select oviposition sites with scattered to sparse vegetation, rather than areas completely devoid of vegetation or that are overgrown. Thus, areas invaded by spreading grasses are not expected to support larvae. It has not been determined whether the oviposition sites are related to shade, moisture, or other environmental factors. It is likely that oviposition near plants is unrelated to the plant species, but perhaps does relate to plant morphology. Microhabitat selection occurs for other species, and the use of shade as an oviposition cue has been previously recorded in salt flat species (Hoback *et al.* 2000).

The swales at the Alda site were an attempt to replicate the ridge and swale habitat that once occurred in the wet meadows of the Platte River floodplain (Riggins 2004). This site had previously been cornfield and the swales were completed in 1999 (C. A. Davis, pers. comm.). This suggests that although *C. cursitans* is flightless, it is capable of rapidly colonizing recently disturbed sites. It might be expected, however, that nearby populations must be present as a beetle of this size would be unlikely to travel more than a few km to new habitat. The grasslands surrounding these swales were apparently burned in the spring of both 2004 and 2005, as evidenced by charred vegetation in April. Thus, fire may have no negative effect on this tiger beetle during the larval or pupal stages.

Attempts to rear larvae to adulthood failed because third instars became dormant for a long period and most died after seven to ten months of dormancy. This dormancy may represent a naturally occuring diapause period that is common to many summer occurring species in temperate regions (Knisley and Schultz 1997). However, the development from egg to third instar in less than 10 weeks, coupled with field observations of larval development, support the conclusion that *C. cursitans* has a one-year life cycle.

Because of the morphological similarity of many species, size and geographic distribution are important for identifying the larvae of tiger beetle species, especially the smaller and larger species. The most useful size character is pronotal width of third instars (Knisley and Pearson 1984). Although *C. cursitans* is similar in pronotal width to *Cicindela lemniscata* LeConte, *Cicindela viridisticta* Bates, *Cicindela wickhami* W. Horn, *C. abdominalis* Fabricius, *C. scabrosa* Schaupp, and *C. highlandensis* Chaote, *C. cursitans* has a different geographic distribution from all of these except for a slight overlap with *C. abdominalis* in southern Mississippi. However, *C. abdominalis* is found in habitats with deep sandy soils and would not co-occur with *C. cursitans*. *Cicindela cursitans* would overlap closely in size and somewhat in geographic range with *C. celeripes* LeConte, but the larvae of this species have not been described.

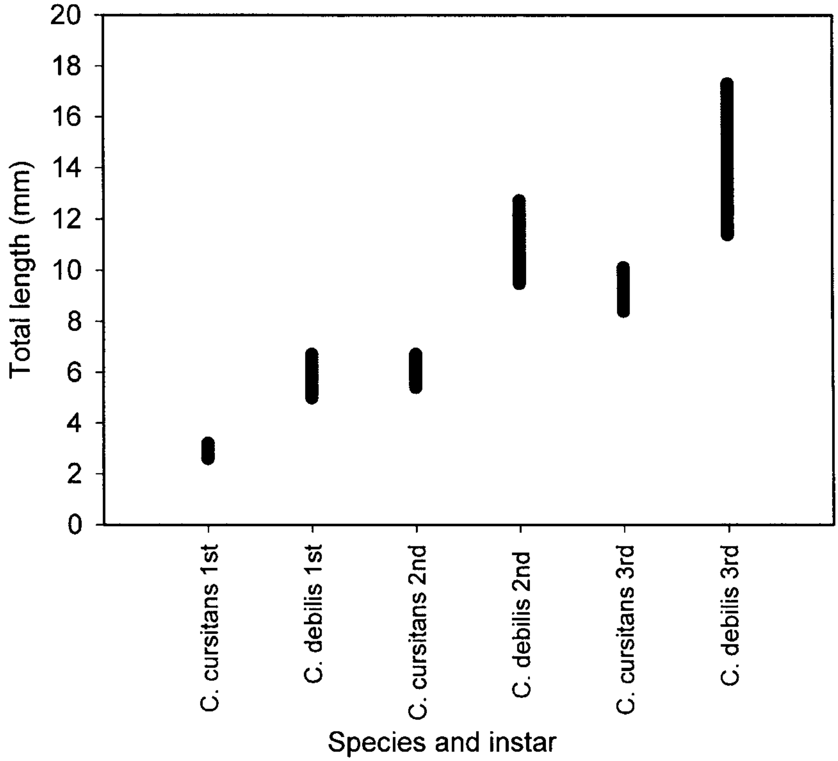


Fig. 8. Comparison of total length of instars of *C. cursitans* and *C. debilis* (*C. debilis* data from Knisley and Pearson (1984)).

Compared to species described in Hamilton (1925), Willis (1967), and Knisley and Pearson (1984), *C. cursitans* is morphologically most similar to *Cicindela debilis* Bates, but is smaller as a third instar (pronotal width of 1.88 mm and range of 1.8–2.0 mm, compared to 2.3 mm, range of 2.2–2.5 mm for *C. debilis*). Both *C. debilis* and *C. cursitans* have the distal spine-like median hook setae, a minute inner hook spine (in the latter two instars), indistinct abdominal sclerites, and a large number of setae on the cephalolateral portions of the pronotum. However, there are differences. *Cicindela cursitans* has at least four setae on the U-shaped ridge on the frons and 30 or fewer setae on the fifth caudal tergites, eleven of which are normally stout. In addition, the median hooks consistently have three setae, two of which are nearly half the length of the hook, and the most distal seta is stout and spine-like. The ninth eusternum consistently has four prominent setae along the caudal margin, with the most innermost pair being about half the length of the others.

Because of the small number of larvae examined, there is likely some overlap in characters within a large sample. Thus, larvae of these two species are probably best differentiated by size. Based on measurements of *C. debilis*, *C. cursitans* does not overlap in size at any instar, but third instars of *C. cursitans* are similar in size to second instar *C. debilis* (Fig. 8). The similarity of the adults of *C. cursitans* and *C. debilis* might be expected since they are both in the subgenus *Cylindera* which includes many of the other small United States tiger beetle species (*C. lemniscata*, *C. viridisticta*, *C. celeripes*, and *C. debilis*), it is not unexpected that their larvae are likewise similar. The habitats used by these two species are also quite similar. The primary population of *C. cursitans* studied occurred in a clay ditch, which had been artificially created to duplicate the swale formations that naturally occurred in the Platte River Valley. Several *C. debilis* were collected in a drainage swale in the study by Knisley and Pearson (1984), and this suggests that despite different geographic distributions, these two species occupy similar ecological niches.

This study revealed that despite its flightless nature, *C. cursitans* can rapidly colonize newly opened habitat. This is evident by the large population found near Alda at a site that had been converted from cornfield to grassland and wet meadow less than a decade ago. Colonization has likely been facilitated by two factors: a one-year life cycle which allows this species to increase its numbers more rapidly than in tiger beetle species with two-year life cycles, and the occurrence of remnant wet meadow habitat in adjacent areas from which adults could colonize. The occurrence of *C. cursitans* at several sites in the Platte River Valley suggests that despite the historic proliferation of agriculture in the area, this tiger beetle likely survived in fragmented tracts of wet meadow and has more recently spread into restored wet meadows. Thus, *C. cursitans* may serve as a useful indicator of wet meadow restoration success. In addition, its flightless nature may allow historic assessment of regional land use. Finally, using information from this study, future studies should attempt to delineate the actual distribution of *C. cursitans* and determine if eastern and western populations share the same life history patterns and habitat requirements.

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