Hindawi Publishing Corporation
Psyche
Volume 2014, Article ID 769021, 4 pages
http://dx.doi.org/10.1155/2014/769021

Research Article

Notes on the Biology of the Cixiid Planthopper *Cixius meridionalis* (Hemiptera: Fulgoroidea)

M. L. Bowser

U.S. Fish & Wildlife Service, Kenai National Wildlife Refuge, P.O. Box 2139, Soldotna, AK 99669, USA

Correspondence should be addressed to M. L. Bowser; matt_bowser@fws.gov

Received 24 October 2013; Accepted 27 November 2013; Published 3 February 2014

Academic Editor: Martin H. Villet

Copyright © 2014 M. L. Bowser. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

With the exception of a handful of economically important species, the biology of cixiid planthoppers (Hemiptera: Fulgoroidea: Cixiidae) is poorly known. The host plants and life history of *Cixius meridionalis* Beirne were investigated in a wetland in Soldotna, Alaska. Specimens were collected over the course of the growing season by hand, aspirator, Berlese funnel, and sweep net. A handful of live nymphs were placed in a terrarium containing potential host plants for direct observation of feeding. *C. meridionalis* was found to feed on roots of *Picea mariana* (Mill.) Britton, Sterns & Poggenb, *Empetrum nigrum* L., *Chamaedaphne calyculata* (L.) Moench, and *Vaccinium vitis-idaea* L. At least within the study area, *C. meridionalis* appears to require multiple years to reach adulthood, with overwintering in nymphal instars. *C. meridionalis* was occasionally tended by *Myrmica alaskensis* Wheeler.

1. Introduction

With the exception of a handful of economically important species that transmit phytoplasmas [1–4], the biology of cixiid planthoppers (Hemiptera: Fulgoroidea: Cixiidae) is largely unknown. Nymphs are subterranean, feeding on plant roots or fungi [3]. Adults generally live aboveground but have been collected underground [2, 3]. Some species have a completely cavernicolous life cycle, with adults feeding on roots along with nymphs [5, 6]. Cixiids are usually univoltine, with diapause in nymphal instars [3], although at least one species requires two years to complete its life cycle [7]. Cixiids are sometimes associated with ants [3, 8, 9], and at least one species appears to be an obligate guest of ants [10].

Cixius meridionalis Beirne is the most widespread and frequently collected cixiid in Alaska based on material in the collection of the University of Alaska Museum (Fairbanks, Alaska) and is broadly distributed in northern North America [11]. No biological data are available for this species other than localities and collection dates of adults [11]. Other *Cixius* species feed on roots of vascular plants (Table 1).

I first observed *C. meridionalis* as adults swept from low vegetation at Headquarters Lake, Soldotna, Alaska, on October 20, 2006. In 2008, I observed cixiid nymphs in a Berlese sample from a wetland near Headquarters Lake (KNWR:Ento:8917, http://dx.doi.org/10.7299/X72807QZ) and in a sample of *Hylocomium splendens* (Hedw.) Schimp. moss from a black spruce forest in the vicinity of the Chickaloon River near Chickaloon Flats. Over the summer of 2013, I sought to determine the host plants and life history of *C. meridionalis*.

2. Materials and Methods

2.1. Field Sampling. Adult and nymphal cixiids were sampled by hand, aspirator, and sweep net in the wetland around Headquarters Lake, Soldotna, Alaska (N 60°27′35″ W 151°03′58″), at least weekly from May 28, when soils in the muskeg were still partly frozen, until the first fall frost on September 20, 2013. Moss samples were collected at least weekly from July 31, 2013, to September 20, 2013, and cixiids were extracted with a BioQuip model 2831 Berlese funnel. Nymphs of *C. meridionalis* were mainly collected by carefully pulling apart moss and duff by hand and extracting nymphs with a BioQuip model 1135A aspirator. Feeding behavior was difficult to observe in the field because nymphs quickly hopped away or crept down into the substrate to avoid capture, but nymphs were occasionally found in dense moss or duff where they could not easily move away from their

Table 1: Known nymphal hosts of *Cixius* species.

Cixius species	Nymphal host	Reference
C. pallipes Fieber	Roots (species unknown)	Vadell and Hoch [6]
C. pilosus (Olivier)	Grasses	China [12]
C. wagneri China	*Fragaria* × *ananassa* (Weston) Duchesne ex Rozier (pro sp.) (*chiloensis* × *virginiana*)	Salar et al. [4]

feeding sites. Roots were identified to species by excavating them back to the aboveground parts of the plants. Infested roots were brought to the laboratory and feeding sites were examined for evidence of feeding.

2.2. Rearing and Identification. Adults were reared from fifth-instar nymphs by placing nymphs in vials or plastic bags with damp *Sphagnum* moss, and then adults were identified using the key of Kramer [11].

To identify the nymphal instars of *C. meridionalis*, I developed a key through examination of the nymphs collected and by comparison with existing descriptions and keys [2, 13, 14].

2.3. Direct Observation of Feeding. In an attempt to observe feeding, several *C. meridionalis* nymphs were placed in a clear plastic terrarium (27 cm length × 17 cm width × 17 cm depth) filled with a correspondingly sized divot of moss and plants from the Headquarters Lake wetland including *Sphagnum* moss, a *Picea mariana* (Mill.) Britton, Sterns & Poggenb (Pinaceae) seedling, *Empetrum nigrum* L. (Ericaceae), *Ledum palustre* L. (Ericaceae), *Vaccinium vitis-idaea* L. (Ericaceae), *Andromeda polifolia* L. (Ericaceae), *Vaccinium oxycoccos* L., *Rubus chamaemorus* L. (Rosaceae), and *Drosera rotundifolia* L. (Droseraceae). The moss was kept moist. Roots visible on the sides and bottom of the terrarium were checked often for feeding activity.

2.4. Specimen Records and Specimen Deposition. Specimens were deposited in the entomology collection of the Kenai National Wildlife Refuge, Soldotna, Alaska (KNWR). Most specimens will be transferred to the entomology collection of the University of Alaska Museum (UAM), Fairbanks, Alaska. Specimen records for both collections are available via Arctos (http://arctos.database.museum/). Complete specimen records for specimens used in this study can be found in Supplementary Table 1 available online at http://dx.doi.org/10.1155/2014/769021.

3. Results

3.1. Habitat and Feeding Behavior. Nymphs were often closely associated with roots of *P. mariana*, but they also appeared to be on roots of *E. nigrum*, *V. vitis-idaea*, and *Chamaedaphne calyculata* (L.) Moench (Ericaceae) in black spruce muskeg. No nymphs were found farther than about 2 m from boles of black spruce trees, even where the microhabitat contained similar moss communities and ericaceous shrubs.

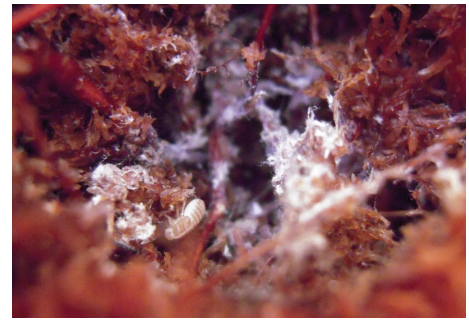

Figure 1: Fourth instar *C. meridionalis* nymph *in situ*, July 12, 2013. The disturbed nymph had moved from its feeding site on a root of *Chamaedaphne calyculata*.

Nymphs were found exclusively in loose, moist moss and duff, where they could move relatively freely through voids (Figure 1). In some places, there was evidence of abundant activity of *C. meridionalis* nymphs judging from the quantities of nymphs collected, copious amounts of waxy secretions, and nymphal exuviae, but it was often difficult to distinguish between feeding sites and waxy secretions of cixiids and other Hemiptera including eriosomatines (Aphididae) and ortheziids (Coccoidea). Feedings sites of cixiids were generally less conspicuous than those of eriosomatines and ortheziids, with sparser waxy secretions and imperceptible damage to roots.

One nymph kept in the terrarium fed on a root of *E. nigrum* (Figure 2). No other feeding was observed in the terrarium.

3.2. Life History. Sampling by all methods yielded 288 specimens of *C. meridionalis* (Figure 3).

Despite targeted searching, only one egg was found that was thought to belong to *C. meridionalis*. This had been in moss inadvertently taken with nymphs on September 4. Nymphs were collected at Headquarters Lake over the entire sampling season. Only three first-instar nymphs were found between June 7 and August 7. Second-instar nymphs were found from June 7 to September 12 and third-instar nymphs were found from June 5 to September 20. Fourth-instar and fifth-instar nymphs were found for the entire portion of the season sampled (May 28 to September 20). My sampling methods appeared to be biased, yielding more large, late-instar nymphs than early instars.

Adult males appeared by July 8 and were observed until September 4. Adult females were found from July 12 to August 27.

Figure 2: Fifth instar *C. meridionalis* nymph feeding on a root of *Empetrum nigrum* in a terrarium.

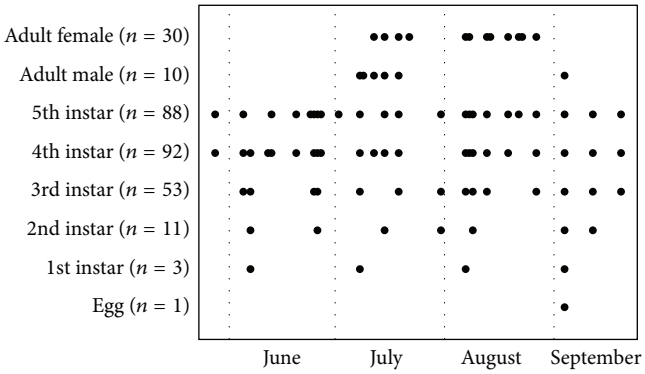

Figure 3: Distribution of life history stages of 288 specimens of *C. meridionalis* collected at Headquarters Lake from May 28 through September 20, 2013.

3.3. Key to the Nymphal Instars of Cixius meridionalis

(1) Metatarsi 3-segmented: mesonotum with a longitudinal row of 2–4 pits near anteromedial corner (2);

Metatarsi 2-segmented: mesonotum with 0-1 pits in anteromedial corner (3);

(2) Mesonotal wingpads extending nearly to apex of metanotal wingpads; mesonotum with a longitudinal row of 2–4 (usually 3-4) pits near anteromedial corner (fifth instar);

Mesonotal wingpads not approaching apex of metanotal wingpads; mesonotum with a longitudinal row of 1-2 (usually 2) pits near anteromedial corner (fourth instar);

(3) Mesonotum with 0-1 (usually 1) pits in anteromedial corner, length 2.1-2.2 mm (third instar);

Mesonotum with no pits in anteromedial corner, length 1.7 mm or less (4);

(4) Abdominal wax plates clearly evident, length 1.6-1.7 mm (second instar);

Abdominal wax plates not apparent, length about 1.2 mm (first instar).

3.4. Additional Observations. None of the nymphs collected were obviously parasitized.

C. meridionalis nymphs, although seldom associated with ants, were not averse to close proximity. When a large colony of *Formica aserva* Forel (including slaves of *Formica neorufibarbis* Emery) in a peaty hummock was excavated, *C. meridionalis* nymphs were found within 2-3 cm of ant tunnels. There was no obvious communication between the ants' tunnels and the feeding places of the nymphs. In one case, a *Myrmica alaskensis* Wheeler worker appeared to be attending a *C. meridionalis* nymph. In another case, *M. alaskensis* workers were found in the same wax-lined cavity with *C. meridionalis* nymphs.

When disturbed, the nymphs would forcibly squirt honeydew from their posterior ends, sending a narrow stream up to about 1 cm away. This was not obvious in the field but was observed when handling live nymphs under magnification.

4. Discussion

Within the area sampled, *C. meridionalis* nymphs appear to be polyphagous on roots of *P. mariana* and ericaceous dwarf shrubs in moist moss and duff. However, the species' consistent proximity to *P. mariana* suggests that it is either dependent on *P. mariana* at some stage in its life history or the two species share similar microhabitat requirements. In addition to the wetland habitat at Headquarters Lake, *C. meridionalis* has been collected from moist *Sphagnum* moss in well-drained black spruce forest in Kasilof, Alaska (KNWR:Ento:8918, http://dx.doi.org/10.7299/X7XG9R8K).

Phytoplasmas were recently reported from Poland in *Picea abies* (L.) Karst. and the two imported Nearctic species *Picea glauca* (Moench) Voss and *Picea pungens* Engelm. [15]; none are currently known from *P. mariana*. As potential vectors, it would be interesting to check for the presence of phytoplasmas in cixiids associated with *Picea* spp., especially *Cixius beieri* Wagner, whose adult hosts include *Picea* in central Europe [16].

Based on the observed phenology at Headquarters Lake, the life history of *C. meridionalis* is suggested to be as follows. Eggs are deposited in the late summer, hatching in the fall or spring. The nymphs appear to take multiple years to reach adulthood, overwintering in place as nymphs. Adults emerge in early July and are active until late September. However, adults can be found over a longer season. The University of Alaska Museum has adults collected as early as June 23 from interior Alaska (UAM:Ento:176723) and I have observed adults at Headquarters Lake as late as October 20.

The unusually long nymphal stage of *C. meridionalis* at Headquarters Lake as compared to most other cixiids may be due to the cold soil temperature of this wetland, a protracted

life cycle being a common adaptation of insects to cold climates [17].

As with some other cixiids, *C. meridionalis* is at least occasionally tended by ants, but the association is facultative and infrequent, fitting best into the "opportunistic and occasional" category of ant attendance defined by Bourgoin [18].

This species' lack of spines on the fore tibiae, common on many cixiid nymphs, may be an adaptation to the loose, mossy microhabitat in which it lives, where such spines would not be necessary for digging.

Conflict of Interests

The author declares that there is no conflict of interests regarding publication of this paper.

Acknowledgments

Shanice Bailey assisted with field work. Dr. André Francoeur provided identifications for ant specimens. Charles Bartlett, Lois O'Brien, Stephen Wilson, Andy Hamilton, Elizabeth Bella, and two anonymous reviewers provided helpful comments on this paper.

References

[1] S. W. Wilson and L. B. O'Brien, "A survey of planthopper pests of economically important plants (Homoptera: Fulgoroidea)," in *Proceedings of the 2nd International Workshop on Leafhoppers and Planthoppers of Economic Importance*, M. R. Wilson and L. R. Nault, Eds., pp. 343–360, Brigham Young University, CAB International Institute of Entomology, Provo, Utah, USA, July-August 1986.

[2] R. Sforza, T. Bourgoin, S. W. Wilson, and E. Boudon-Padieu, "Field observations, laboratory rearing and descriptions of immatures of the planthopper *Hyalesthes obsoletus* (Hemiptera: Cixiidae)," *European Journal of Entomology*, vol. 96, no. 4, pp. 409–418, 1999.

[3] W. E. Holzinger, A. F. Emeljanov, and I. Kammerlander, "The family Cixiidae Spinola 1839 (Hemiptera: Fulgoromorpha)—a review," in *Zikaden: Leafhoppers, Planthoppers, and Cicadas (Insecta: Hemiptera: Auchenorrhyncha)*, W. Holzinger, Ed., vol. 4 of *Denisia 4 (Zugleich Kataloge des Oberösterreichischen Landesmuseums)*, pp. 113–118, 2002.

[4] P. Salar, J. L. Danet, J. J. Pommier, and X. Foissac, "The biology of Cixius wagneri, the planthopper vector of 'Candidatus *Phlomobacter fragariae*' in strawberry production tunnels and its consequence for the epidemiology of strawberry marginal chlorosis," *Julius-Kühn-Archiv*, vol. 427, pp. 24–26, 2010.

[5] G. S. Taylor and P. Weinstein, "Confirmation of host plant of cave-dwelling Cixiid Planthoppers (Hemiptera: Cixiidae) by histological sectioning of fig roots," *Australian Journal of Entomology*, vol. 35, no. 2, pp. 115–118, 1996.

[6] M. Vadell and H. Hoch, "*Cixius* (*Ceratoxicius*) *pallipes* Fieber, 1876 (Hemiptera: Auchenorrhyncha: Fulgoromorpha: Cixiidae): first record for Spain," *Bolleti de la Societat d'Historia Natural de les Balears*, vol. 52, pp. 123–128.

[7] R. A. Cumber, "Studies on *Oliarus atkinsoni* Myers (Hem.: Cixiidae), vector of the 'Yellow-leaf' disease of *Phormium tenax* Forst. II.—the nymphal instars and seasonal changes in the composition of nymphal populations," *New Zealand Journal of Science and Technology B*, vol. 34, pp. 160–165, 1952.

[8] J. G. Myers, "Observations on the biology of two remarkable cixiid plant-hoppers (Homoptera) from Cuba," *Psyche*, vol. 36, pp. 283–292, 1929.

[9] C. R. Thompson, J. C. Nickerson, and F. W. Mead, "Nymphal Habitat of *Oliarus vicarius* (Homoptera: Cixiidae), and Possible Association with *Aphaenogaster* and *Paratrechina* (Hymenoptera: Formicidae)," *Psyche*, vol. 86, pp. 321–326, 1979.

[10] C. R. Thompson, "Association of *Paratrechina arenivaga* (Hymenoptera: Formicidae), with Nymphs of *Oecleus borealis* (Homoptera: Cixiidae)," *Journal of the New York Entomological Society*, vol. 92, no. 1, pp. 35–41, 1984.

[11] J. P. Kramer, "Taxonomic study of the planthopper genus *Cixius* in the United States and Mexico (Homoptera: Fulgoroidea: Cixiidae)," *Transactions of the American Entomological Society*, vol. 107, pp. 1–68, 1981.

[12] W. E. China, "A revision of the British species of *Cixius* Latr. (Homoptera), including the description of a new species from Scotland," *Transactions of the Society For British Entomology*, vol. 8, pp. 79–110, 1942.

[13] S. W. Wilson and J. H. Tsai, "Descriptions of the immature stages of *Myndus crudus* (Homoptera: Fulgoroidea: Cixiidae)," *Journal of the New York Entomological Society*, vol. 90, pp. 166–175, 1982.

[14] S. W. Wilson, J. H. Tsai, and C. R. Thompson, "Descriptions of the nymphal instars of *Oecleus borealis* (Homoptera: Fulgoroidea: Cixiidae)," *Journal of the New York Entomolgical Society*, vol. 91, no. 4, pp. 418–423, 1983.

[15] M. Kamińska and H. Berniak, "Detection and identification of three 'Candidatus phytoplasma' species in *Picea* spp. trees in Poland," *Journal of Phytopathology*, vol. 159, no. 11-12, pp. 796–798, 2011.

[16] H. Nickel, *The Leafhoppers and Planthoppers of Germany: Patterns and Strategies in a Highly Diverse Group of Phytophagous Insects*, Pensoft Publishers, Sofia, Bulgaria, 2003.

[17] S. F. MacLean Jr., "Ecological adaptations of tundra invertebrates," in *Physiological Adaptation to the Environment*, J. Vernberg, Ed., pp. 269–300, Intext Educational Publishers, New York, NY, USA, 1975.

[18] T. Bourgoin, "Habitat and ant-attendance in Hemiptera: a phylogenetic test with emphasis on trophobiosis in Fulgoromorpha," in *The Origin of Biodiversity in Insects: Phylogenetics Tests of Evolutionary Scenarios*, P. Grandcolas, Ed., vol. 173, pp. 109–124, Mémoires du Muséum National d'Histoire Naturelle, 1997.