The Cixiid Planthopper *Haplaxius ovatus* (Ball) (Hemiptera: Fulgoroidea): Association with Switchgrass (*Panicum virgatum*; Poaceae) and New Distribution Records

Author(s): A. G. Wheeler, Jr. and Stephen W. Wilson
Source: Proceedings of the Entomological Society of Washington, 116(3):358-368. 2014.
Published By: Entomological Society of Washington
URL: http://www.bioone.org/doi/full/10.4289/0013-8797.116.3.358

PROC. ENTOMOL. SOC. WASH.
116(3), 2014, pp. 358–368

THE CIXIID PLANTHOPPER *HAPLAXIUS OVATUS* (BALL) (HEMIPTERA: FULGOROIDEA): ASSOCIATION WITH SWITCHGRASS (*PANICUM VIRGATUM*; POACEAE) AND NEW DISTRIBUTION RECORDS

A. G. Wheeler, Jr. and Stephen W. Wilson

(AGW) School of Agricultural, Forest, and Environmental Sciences, Clemson University, Clemson, South Carolina 29634-0310, U.S.A. urn:lsid:zoobank.org:author:D631EADE-004F-43EE-99A8-32F8C23A661F (e-mail: awhlr@clemson.edu); (SWW) Department of Biology and Agriculture, University of Central Missouri, Warrensburg, Missouri 64093, U.S.A. urn:lsid:zoobank.org:author:8D3AF965-5E83-46E4-8920-82BF3EC7BC2E (e-mail: swwilson@ucmo.edu)

Abstract.—*Haplaxius ovatus* (Ball) is a little-known cixiid planthopper whose host plants were unknown. During fieldwork in late May, late June–early July, and late August–early September from 2010 to 2013, we collected adults (n = 778) on switchgrass (*Panicum virgatum* L.; Poaceae: Panicoideae) at 59 sites in nine states: Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, Oklahoma, South Dakota, and Wisconsin. New state records are Illinois, Minnesota, Missouri, South Dakota, and Wisconsin. The cixiid was not encountered during less extensive collecting from other prairie grasses: big bluestem, *Andropogon gerardii* Vitman; little bluestem, *Schizachyrium scoparium* (Michx.) Nash; Indiangrass, *Sorghastrum nutans* (L.) Nash; and prairie cordgrass, *Spartina pectinata* Bosc ex Link. In Nebraska, where switchgrass surveys were most extensive, *H. ovatus* typically was found in the Tallgrass and Mixedgrass Prairie ecoregions (remnant prairies and roadsides), was uncommon in the Sandhills, and was present along the eastern edge (-102° W longitude) of Shortgrass Prairie. Cixiid nymphs are subterranean, and no attempt was made to detect nymphs of *H. ovatus*. Male-biased populations and presence of teneral adults (mostly females) in late May, however, suggest a recent emergence from *P. virgatum*. The few adults taken in late August–early September are assumed to represent those still persisting from the only complete generation (univoltinism). Characters are provided to facilitate the recognition of this switchgrass-associated cixiid. Additional study is needed to verify that *H. ovatus* overwinters as nymphs, develops on *P. virgatum*, and is univoltine, as well as determine if it might use related species of *Panicum*, other panicoid genera, or even non-panicoid grasses as hosts.

Key Words: planthoppers, Auchenorrhyncha, distribution, host plants, grassland ecosystems, tallgrass prairie, saline wetlands

DOI: 10.4289/0013-8797.116.3.358

urn:lsid:zoobank.org:pub:0C39BFB5-3170-47D7-A0C0-294EA67F6C1D

As currently construed, the planthopper genus *Haplaxius* comprises 34 species in North America north of Mexico and 31 species in the Neotropics (Bartlett 2012). North American species had been removed from *Haplaxius* Fowler 1904 (Caldwell 1946, Emeljanov 1989) and placed in *Myndus* (Ball 1933, Kramer 1979), but in revising the higher classification of the Cixiidae, Emeljanov (1989) placed the New World species of *Myndus* in *Haplaxius*, which has gained general acceptance (Holzinger et al. 2002, Ceotto and Bourgoin 2008, Ferreira et al. 2010, Bartlett 2012). Bionomic information on species of *Haplaxius* is scant, except for *H. crudus* (Van Duzee), whose nymphs develop on roots of grasses and sedges (Tsai and Kirsch 1978); nymphs of other Cixiidae are subterranean (O'Brien and Wilson 1985, Wilson et al. 1994, Holzinger et al. 2003, Nickel 2003). Adults of *H. crudus* transmit the phytoplasma that causes lethal yellowing of palms (Tsai and Kirsch 1978, Howard et al. 1983).

The little-known *H. ovatus* (Ball) was described in *Myndus* based on a female (holotype) and male (allotype) collected in 1894 at Ames, Iowa, on July 14 and June 28, respectively (Ball 1933). Ball (1902) previously had included the two Iowa specimens, used later to describe *H. ovatus*, as paratypes of *M. viridis* Ball (now *H. viridis*), which is known only from the western United States (Kramer 1979, Bartlett 2012). *Haplaxius ovatus* also has been recorded from Delaware, Georgia, Kansas, Maryland, Massachusetts, Nebraska, New Jersey, Oklahoma, and Virginia (Kramer 1979, Bartlett et al. 2011, Bartlett 2012). Osborn's (1938) record of *M. viridis* in Ohio might refer to *H. ovatus* (Kramer 1979). Florida (Hillsborough County) is an unpublished record based on images submitted in 2011 and 2012 to BugGuide (http://bugguide.net /node/view/600133).

We document a consistent association of *H. ovatus* with switchgrass (*Panicum virgatum* L.; Poaceae: Panicoideae); extend its known range to Illinois, Minnesota, Missouri, South Dakota, and Wisconsin; and provide the first specific records for Nebraska and additional records for Iowa, Kansas, and Oklahoma. Also provided are morphological features to facilitate recognition of this planthopper and notes on its seasonality.

Methods and Study Sites

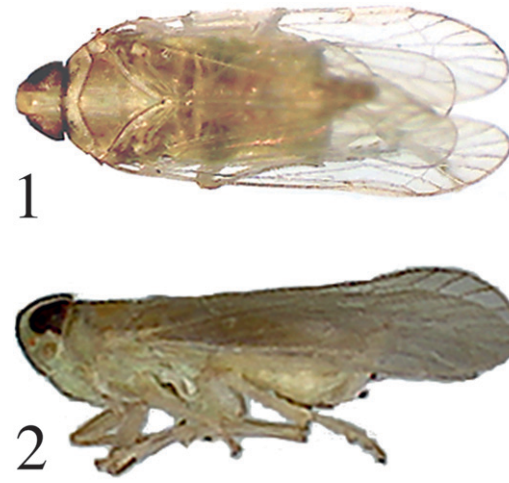
After adults of *H. ovatus* were collected from *P. virgatum* in western Nebraska in 2010, additional surveys of switchgrass were conducted from 2011 to 2013 to determine the consistency of the planthopper's presence on *P. virgatum* and obtain more information on its distribution and seasonality. Switchgrass, both bunch- (lowland) and sod-forming (upland) ecotypes (Vogel 2004), was sampled periodically in late May, late June to early July, and September by placing a beating net at the base of plants (ca. 45° angle to the ground) with a bunch-growth habit and using the flat end of an ax handle to beat crowns into the net. Rhizomatous (sod-forming) switchgrass was sampled similarly, but with more of the upper plant beaten into the net. Adult cixiids were collected into snap-cap plastic vials, point-mounted, and voucher material deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC, and S. W. Wilson Collection at the University of Central Missouri, Warrensburg. Geographic coordinates of collection sites were recorded. All collections listed under specimens examined were collected from switchgrass (by AGW), except one taken (by SWW) on a sedge in Cleveland County, Oklahoma, in 1988.

Although Nebraska was emphasized, switchgrass also was sampled in Illinois, Iowa, Kansas, Minnesota, Missouri, Oklahoma, South Dakota, and Wisconsin. Prairie grasses sampled less frequently for the possible presence of *H. ovatus* included big bluestem, *Andropogon gerardii* Vitman; little bluestem, *Schizachyrium scoparium* (Michx.) Nash; Indiangrass, *Sorghastrum nutans* (L.) Nash; and prairie cordgrass, *Spartina pectinata* Bosc ex Link. Also sampled were the Eurasian smooth brome (*Bromus inermis* Leyss.) and tall wheatgrass (*Thinopyrum ponticum* (Podp.) Z.-W. Liu & R.-C. Wang); the latter grass species was present in saline wetlands in Lincoln, Nebraska, where *H. ovatus* was found on *P. virgatum*.

Results

Diagnosis.—*Haplaxius ovatus* can be separated from other hemipterans on switchgrass by the location of the antennae ventral to the compound eyes; Y-shaped fused anal veins on the forewings; tibiae and first and second tarsomeres of metathoracic leg each with a row of stout spines at the apex; tibiae without lateral spines on the shaft (a feature of Oecleini) and without a terminal, movable spur; and the vertex of the head with a slightly concave posterior margin (Figs. 1, 2). Recent keys for identification of the families of planthoppers were provided by Wilson (2005) and Bartlett et al. (2014). Keys to the genera of Cixiidae are in Kramer (1983) and Bartlett et al. (2014), and a key for the identification of the species of *Haplaxius* (as *Myndus*), based on male genitalia, was provided by Kramer (1979).

Based on published distribution records (Bartlett et al. 2014), in addition to *H. ovatus*, the following species have been recorded for Nebraska or are likely to occur there: *H. fulvus* (Osborn), *H. pictifrons* (Stål), *H. radicis* (Osborn),



Figs. 1–2. *Haplaxius ovatus* (♂) habitus. 1, Dorsal view. 2, Lateral view.

H. slossonae (Ball), and *H. truncatus* (Metcalf). *Haplaxius pictifrons* and *H. truncatus* have two dark transverse markings on the frons, as do some specimens of *H. radicis*. The other species do not have these markings; specimens of *H. slossonae* usually have dark brown forewings with a pale "saddlelike" marking; *H. ovatus* ranges in color from tan to greenish, whereas *H. fulvus* is more orange. Kramer (1979) indicated that *H. radicis* is very variable in color and markings on the frons. To ensure accurate identification of species, the structures of the dissected male genitalia should be compared to the illustrations and descriptions in Kramer (1979).

Distribution.—Adults (n = 778) of *H. ovatus* were taken at 59 sites in nine states (Fig. 3). State totals (number of specimens: number of sites) are Illinois (4:1), Iowa (15:2), Kansas (22:4), Minnesota (188:8), Missouri (73:3), Nebraska (419:35), Oklahoma (2:1), South Dakota (4:4), and Wisconsin (51:1). Illinois, Minnesota, Missouri, South Dakota, and Wisconsin are new state records. Specific Nebraska records of the cixiid have not been published previously; the online

state record (Bartlett 2012) is based on examination of specimens rather than a literature reference (C. R. Bartlett, pers. comm.).

In Nebraska, the only state surveyed extensively, the planthopper was found along roadsides and in remnant prairies of all four ecoregions (Schneider et al. 2011): Tallgrass Prairie, Mixedgrass Prairie, Sandhills, and Shortgrass Prairie. *Haplaxius ovatus* was most common in the Tallgrass and Mixedgrass Prairie ecoregions in the eastern half of the state, uncommon in the Sandhills, and appeared to reach its western limit (near –102° W) in Shortgrass Prairie (extreme southeastern Garden County). The planthopper was found at two sites (Keith and Lincoln counties) near the southern limit of the extensive Sandhills (ca. 50,000 km^2; Johnsgard 1995), but it was not encountered at interior sites in Arthur, Cherry, and Grant counties. The only site for *H. ovatus* in Cherry County was outside the Sandhills along a highway in mixedgrass prairie in the county's northeast corner. *Haplaxius ovatus* also was not found on switchgrass farther west in Nebraska's panhandle (Box Butte, Garden, Morrill, Sheridan, and Sioux counties). The planthopper was present at sites ranging in elevation from 335 m in the east (Cass Co.) to 1125 m in the west (Keith Co.).

In addition to our collections, we are able to provide records (not shown in Fig. 3) from other insect surveys of midwestern prairies, courtesy of the Wisconsin Department of Natural Resources, Bureau of Science Services. From 1997 to 2000, adults of *H. ovatus* were collected in Malaise traps or by sweep net in different types of native prairies. The cixiid was identified (by K.G.A. Hamilton) from the counties of Dane, Green, Kenosha, and Sauk in Wisconsin; Lee in Illinois; and Story in Iowa. Associated grasses in Wisconsin were little bluestem and prairie dropseed, *Sporobolus heterolepis* (A. Gray) A. Gray (R. A. Henderson and W. A. Smith, pers. comm).

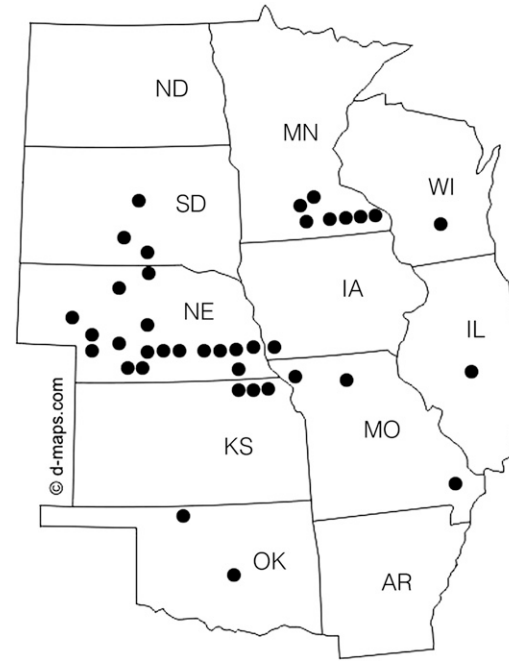


Fig. 3. Survey sites where *Haplaxius ovatus* was collected (2010–2013) in Illinois (IL), Iowa (IA), Kansas (KS), Minnesota (MN), Missouri (MO), Nebraska (NE), Oklahoma (OK), South Dakota (SD), and Wisconsin (WI). Note: the southernmost Oklahoma record is based on a 1988 collection.

Host plant and seasonality.—From 2010 to 2013, we collected adults of *H. ovatus* only from switchgrass. The cixiid was beaten from the crowns and stems of mature plants (ca. 1.5–1.8 m) and was common on regrowth of mowed plants along highways, especially in Nebraska during drought conditions in 2012. Adults were not found on other prairie grasses—big bluestem, Indiangrass, little bluestem, and prairie cordgrass—or on tall wheatgrass in saline wetlands of eastern Nebraska or smooth brome.

Adults were found in late May, late June–early July, and late August–early September. We observed two mating pairs in late June in Olmsted County, Minnesota. The presence of teneral adults (mainly females) and typically male-biased numbers in late May suggests that the planthopper had recently emerged from the roots of switchgrass. From late June to early July, the numbers of males and females were about equal or populations were female biased. Adults were found in late August and mid-September but were not encountered in late September.

Specimens examined.—ILLINOIS: *Macon Co.,* Rt. 33, 1.3 km E of Shumway, 39°10.492′N 88°38.638′W, 23 June 2012, 3♂, 2♀. IOWA: *Fremont Co*., Rt. 275 NE of Sidney, 40°45.465′N 95°38.348′W, 28 May 2012, 4♂, 1♀; Rt. 275 SE of Sydney, 40°44.222′N 95°37.914′W, 28 May 2012, 6♂, 4♀. KANSAS: *Brown Co*., Rt. 36, 1.5 km S of Hiawatha, 39°50.497′N 95°31.774′W, 28 May 2012, 1♂; jct. rts. 36 & 75 W of Fairview, 39°50.479′N 95°44.264′W, 28 May 2012, 1♂, 1♀. *Marshall Co*., Rt. 77, 2.4 km NW of Marysville, 39°51.394′N 96°40.003′W, 28 May 2012, 7♂, 4♀. *Nemaha Co*., Rt. 136, 13 km E of Seneca, 39°50.467′N 95°54.435′W, 28 May 2012, 4♂, 4♀. MINNESOTA: *Blue Earth Co*., Rt. 14, 3.7 km E of Eagle Rock, 44°09.332′N 93°50.140′W, 25 June 2012, 9♂, 6♀. *Dodge Co*., Rt. 14, 3 km W of Dodge Center, 44°01.704′N 92°53.645′W, 25 June 2012, 11♂, 10♀. *Le Sueur Co*., jct. Rt. 22 & Co. Rd. 45 N of Kasota, 44°18.233′N 93°57.435′W, 25 June 2012, 6♂, 4♀; jct. Rt. 22 & Co. Rd. 45 E of St. Peter, 44°19.346′N 93°56.833′W, 25 June 2012, 1♂, 2♀. *Nicollet Co*., Rt. 22 SE of St. Peter, 44°18.594′N 93°57.754′W, 25 June 2012, 6♂, 4♀. *Olmsted Co*., Rt. 14, 3.7 km W of St. Charles, 43°58.243′N 92°06.753′W, 24 June 2012, 50♂, 52♀. *Steele Co*., Rt. 14, 1.5 km W of Owatonna, 44°03.617′N 93°13.608′W, 25 June 2012, 8♂, 4♀. *Winona Co*., I-90, Dresbach Information Center nr Upper Mississippi River NWR, 43°51.491′N 91°18.261′W, 24 June 2012, 11♂, 5♀. MISSOURI: *Holt Co*., Rt. 136 nr Big Lake, 3.7 km W of Fortescue, 40°03.088′N 95°21.702′W, 28 May 2012, 33♂, 38♀. *Linn Co*., Rt. 36, 5.6 km SE of Brookfield, 39°45.763′N 93°00.788′W, 10 Sep. 2013, 1♀. *Stoddard Co*., Rt. 60, 8 km W of Dudley, 36°47.020′N 90°10.917′W, 6 July 2012, 1♂. NEBRASKA: *Buffalo Co*., Rt. 183, 1.4 km S of Elm Creek, 40°42.321′N 99°22.765′W, 2 July 2012, 3♂, 4♀; Rt. 30, 8.5 km W of Gibbon, 40°43.607′N 98°56.523′W, 2 July 2012, 1♂, 1♀. *Cass Co*., Rt. 34 W of jct. Rt. 1, S of Elmwood, 40°48.758′N 96°17.804′W, 28 May 2012, 2♂; Rt. 34, 1.3 km W of jct. Rt. 67 SW of Nehawka, 40°48.783′N 96°01.343′W, 28 May 2012, 1♀. *Cherry Co*., Rt. 12, 14 km NE of Valentine, 42°56.422′N 100°26.540′W, 27 June 2012, 9♂, 11♀. *Custer Co*., Rt. 2, 7.2 km SE of Berwyn, 41°18.921′N 99°25.534′W, 29 June 2013, 1♀. *Dawson Co*., Rt. 30, 2.6 km E of Gothenburg, 40°54.876′N 100°08.111′W, 2 July 2012, 8♂, 4♀; Rt. 22, 20 km S of Cozad, 40°46.920′N 99°59.725′W, 2 July 2012, 3♂, 3♀. *Frontier Co*., Rt. 83, 8 km S of jct. Rt. 23, 1.5 km W of Maywood, 40°35.230′N 100°37.768′W, 30 June 2011, 8♂, 13♀ & 30 June 2013, 14♂, 13♀; Rt. 21, 1.5 km N of jct. Rt. 23 NE of Eustis, 40°40.973′N 100°00.048′W, 2 July 2012, 4♂, 2♀. *Gage Co*., Rt. 77, 10 km S of Wymore, 40°02.042′N 96°39.140′W, 28 May 2012, 1♂, 1♀. *Garden Co*., Rt. 26, 8.8 km SE of Lewellen, 41°15.579′N 102°06.426′W, 2 July 2011, 1♂, 1♀. *Gosper Co*., Rt.

23, 1.9 km NW of Elwood, 40°36.153′N 99°52.600′W, 2 July 2012, 4♀. *Hall Co*., Rt. 30, 0.5 km E of Wood River, 40°49.410′N 98°35.337′W, 2 July 2012, 4♂, 1♀. *Keith Co*., Ogallala, 41°06.967′N 101°42.656′W, 1 July 2011, 2♂, 3♀ & 2 July 2012, 4♂; Rt. 61, sandhills, 16 km S of Arthur Co. line, 38 km N of Ogallala, 41°27.1′N 101°43.3′W, 1 July 2011, 1♂; Rt. 26, 1.8 km E of jct. Eagle Canyon Rd., 9.5 km E of Garden Co. line, 41°12.376′N 101°57.343′W, 2 July 2011, 9♂, 8♀; I-80, Paxton exit, 41°06.548′N 101°21.388′W, 2 July 2012, 4♂. *Keya Paha Co*., Rt. 183, 10.3 km N of Springview, 42°54.701′N 99°46.074′W, 27 June 2012, 4♂, 4♀; Rt. 12, 4.7 km E of Norden, 42°52.069′N 100°01.049′W, 27 June 2012, 9♂, 7♀. *Lancaster Co*., Lincoln Saline Wetlands Nature Center, E of Capitol Beach Lake, Lincoln, 40°49.400′N 96°43.849′W, 25 May 2012, 2♂, 1♀ & 4 July 2012, 2♂; Pfizer Saline Wetlands, jct. W Cornhusker Hwy. & N 1st St., Lincoln, 40°50.051′N 96°43.352′W, 26–27 May 2012, 46♂, 23♀ & 3 July 2012, 2♂, 7♀ & 27 June 2013, 1♂; Whitehead Saline Wetlands, S of I-80 E of N 27th St., Lincoln, 40°52.933′N 96°44.812′W, 26 May 2012, 2♂, 1♀ & 28 June 2013, 1♂; NW 27th St. S of Raymond Rd., ESE of Raymond, 40°57.094′N 96°45.480′W, 26 May 2012, 5♂, 4♀. *Lincoln Co*., Wellfleet, 40°45.118′N 100°43.526′W, 30 June 2011, 8♂, 17♀; Rt. 23, 3.5 km W of jct. Rt. 83, NNW of Wellfleet, 40°49.768′N 100°47.070′W, 4 July 2010, 25♂, 34♀; Rt. 23, 19 km E of Dickens, 1.3 km W of jct. Rt. 83, 40°49.72′N 100°46.21′W, 30 June 2013, 3♂; Rt. 83, ca. 15 km S of North Platte, 40°59.518′N 100°45.243′W, 5 July 2010, 6♂, 4♀; Rt. 83, 18 km S of North Platte, 40°57.885′N 100°45.224′W, 30 June 2011, 6♂, 8♀; Rt. 97, 20 km NNW of North Platte, 41°18.437′N 100°51.011′W, 1 July 2011, 9♂, 4♀. *Perkins Co*., Rt. 23, 5 km E of Grant, 40°50.447′N 101°40.010′W, 30 June 2013,1♀; Rt. 23, 7.5 km W of Elsie, 40°51.032′N 101°28.802′W, 30 June 2013,1♂. *Seward Co*., Rt. 34, 4.0 km E of Utica, 40°54.115′N 97°17.852′W, 2 July 2012, 3♂, 3♀; Rt. L80G, 5.6 km N of Goehner, 40°53.171′N 97°12.948′W, 2 July 2012, 1♂, 2♀. *York Co*., Rt. 34, 9 km W of York, 40°53.224′N 97°41.803′W, 2 July 2012, 7♂, 7♀. OKLAHOMA: *Alfalfa Co*., Rt. 38, 1 km N of Jet, 36°40.567′N 98°10.910′W, 29 Aug. 2013, 1♂, 1♀. *Cleveland Co*., Norman, 30 May 1988, S.W. Wilson, 1♂ ex *Carex frankii*. SOUTH DAKOTA: *Mellette Co*., Rt. 83, 17 km N of White River, 43°42.429′N 100°41.314′W, 27 June 2012, 1♀. *Sully Co*., Rt. 83, 3.5 km N of Agar, 44°52.303′N 100°04.907′W, 26 June 2012, 1♂; Rt. 83, 2.9 km N of Hughes Co. line S of Onida, 44°34.472′N 100°04.870′W, 26 June 2012, 1♂. *Tripp Co*., Rt. 183, 1.1 km N of Keya Paha River, 2.4 km N of Wewela, 43°02.218′N 99°46.841′W, 27 June 2012, 1♀. WISCONSIN: *Columbia Co*., Rt. 60, 1 km E of Prairie du Sac, 43°17.728′N 89°43.091′W, 24 June 2012, 20♂, 31♀.

Discussion

Since its description more than 80 years ago, *H. ovatus* has remained an infrequently collected species. Thirty-eight specimens were examined in a revision of the genus (as *Myndus*) by Kramer (1979); the recent listing of Delaware as a new state record was based on four specimens (Bartlett et al. 2011). In southeastern Nebraska, cixiids were not among hemipterans identified during a two-year survey of switchgrass in managed stands and patches in a tallgrass prairie (Schaeffer et al. 2011). *Haplaxius ovatus* was not among the 15 planthopper taxa recorded from tallgrass

prairies along the Platte River in central Nebraska despite the collection of a leafhopper that specializes on switchgrass (Nemec 2003, Nemec and Bragg 2008). The cixiid also was not found in a survey of planthoppers in a Missouri tallgrass prairie in which switchgrass was present but not a dominant grass species (Wilson et al. 1993).

Previously published plant relationships for *H. ovatus* have been limited to "grasses" (Kramer 1979). Knowledge of specific hosts in the large family Poaceae, however, can facilitate bionomic studies of little-known, rarely collected grass-feeding insects. Many leafhoppers and planthoppers are host restricted, specializing on one grass species or genus (Wilson et al. 1994; Holzinger et al. 2002, 2003; Nickel 2003; Hamilton and Whitcomb 2010).

Our consistent collection of adults from switchgrass represents the first documented host-plant association for *H. ovatus*. A previous, but unpublished, record is K. G. A. Hamilton's comment (2011) in BugGuide that the planthopper is a "common species on switch grass" (http://bugguide.net/node/view/ 539353/ bgpage?printable = 1). A characteristic C_4 perennial graminoid of tallgrass prairies (Weaver 1968, Hartnett 1993, Whiles and Charlton 2006), switchgrass occurs widely in North American prairie remnants. Native stands of switchgrass in North America were most abundant east of -100° W longitude (Vogel 2004). We collected *H. ovatus* mostly east of the 100th meridian but found it west to -102° longitude in Nebraska. Though common in tallgrass prairie, the planthopper should not be considered a strict tallgrass specialist. We did not attempt to detect the presumably subterranean nymphs, but the often large numbers of adults, including teneral females (cixiid females, as in many other insects, develop later than males; Nickel 2003) in late May in Lincoln, Nebraska, suggest that nymphs develop on switchgrass. Moreover, mating pairs were found on *P. virgatum*.

Haplaxius ovatus might specialize on switchgrass, as do several leafhopper species (Hamilton and Whitcomb 2010, Hamilton 2012), although collections of adults from two additional grass species in Wisconsin prairies where switchgrass might not be present (R. A. Henderson, pers. comm.) suggest associations with other Poaceae. The presence of an adult on sedge in Oklahoma (see specimens examined) is considered incidental. The planthopper could live on switchgrass outside midwestern prairies because the grass is found nearly throughout the continental United States (USDA NRCS 2013), including coastal salt marshes and inland grasslands from Long Island, New York, to New England (Wherry 1920, Miller and Egler 1950, Hamilton 2012). Populations of *P. virgatum* are disjunct between midwestern prairies and the Atlantic coast (Hamilton 2012). *Haplaxius ovatus* is known from coastal areas of the eastern United States, such as Woods Hole, Massachusetts, and Deal Island, Maryland (Kramer 1979). A potential host of *H. ovatus* along the Atlantic and Gulf coasts is the sometimes syntopic (Palmer 1975) bitter beachgrass, *P. amarum* Elliott. *Panicum amarum* hybridizes with *P. virgatum*; both species are placed in the same section (*Virgata*) of *Panicum* sensu stricto (Palmer 1975, Triplett et al. 2012).

In addition to its presence on switchgrass in prairie remnants, *H. ovatus* was taken in the critically imperiled saline wetlands (S1 conservation status; Rolfsmeier and Steinauer 2010) of eastern Nebraska. The cixiid also was common on switchgrass in highway plantings. The grass is used in Nebraska's roadside seed mixtures (NDOR 2009), as well as

those of certain other midwestern states (Harper-Lore and Wilson 2000). The salt-tolerant *P. virgatum* can withstand the use of de-icing salts on roads (Jull 2009). Restoring native plants along roadsides can help maintain prairie vegetation and associated prairie animals (Noss 2000). Roads, however, can act as barriers to the movement of vertebrate animals (Shepard et al. 2008) and restrict the movement of insects such as carabid beetles (Noordijk et al. 2006) and mosquitoes (Mahabir et al. 2012). In the case of *H. ovatus*, roadside colonies of switchgrass might provide corridors for its dispersal. The planthopper is on the list of rare hemipterans (S1S2 conservation rank) in Wisconsin (WDNR 2012), but it was abundant at the only southwestern Wisconsin site (Columbia Co.) where we found switchgrass along roadsides. *Haplaxius ovatus* can be considered an apparent disturbance-tolerant, rather than remnant-dependent, prairie insect (sensu Panzer et al. 2010).

This cixiid previously had been taken as late as 30 August (Kramer 1979). In 2013, we collected a male in late August (Oklahoma) and a female on 10 September (Missouri). Our fieldwork suggests that nymphs overwinter, adults begin to appear in the latter half of May, and persist until August or early September. Univoltinism with a nymphal diapause, while uncommon in Heteroptera (Saulich and Musolin 1996), apparently is typical for cixiid planthoppers of temperate regions (Wilson et al. 1993, Sforza et al. 1999, Holzinger et al. 2003, Nickel 2003, Bressan 2009, Bressan et al. 2010). In Florida, however, *H. crudus* is multivoltine (Tsai and Kirsch 1978).

Host-plant relationships of Cixiidae more often are based on the presence of adults rather than nymphs (Wilson et al. 1994, Attie et al. 2008). Future work should determine if nymphs of *H. ovatus* overwinter and develop on switchgrass. Studies also are needed to determine whether related grasses serve as hosts and verify that the cixiid is univoltine. *Panicum virgatum* has been used as an ornamental, in conservation plantings, for roadside stabilization, and in livestock production (Oakes 1990, Vogel 2004, Shaw 2008), and recently has been planted as a sustainable bioenergy crop (Parrish and Fike 2005, Sanderson et al. 2006). The cixiid's feeding is not expected to become problematic on switchgrass. A congener, *H. crudus*, does not produce symptoms of injury on host grasses (Tsai and Kirsch 1978) but is economically important as a vector of the phytoplasma that causes lethal yellowing of palms (Howard et al. 1983). Most diseases of switchgrass are caused by fungi (Vogel 2004), but *H. ovatus* potentially could become involved in emerging phytoplasma diseases.

Acknowledgments

We are grateful to Richard Henderson and William Smith (Wisconsin Department of Natural Resources, Bureau of Science Services, Madison) for generously sharing records of *H. ovatus* from prairie surveys in their state (and records from Illinois and Iowa) and allowing us to refer to them.

Literature Cited

Attie, M., T. Bourgoin, J. Veslot, and A. Soulier-Perkins. 2008. Patterns of trophic relationships between planthoppers (Hemiptera: Fulgoromorpha) and their host plants on the Mascarene Islands. Journal of Natural History 42: 1591–1638. doi:10.1080/00222930802106963

Ball, E. D. 1902. Some new North American Fulgoridae. Canadian Entomologist 34: 147–157. doi:10.4039/Ent34147-6

Ball, E. D. 1933. The genus *Myndus* Stal [sic] in North America (Homoptera Fulgoridae). Journal of the Washington Academy of Sciences 23: 478–484.

Bartlett, C. R. 2012. Planthoppers of North America. Genus *Haplaxius* Fowler, 1904. Available at http://ag.udel.edu/enwc/research/planthoppers/families/species/Haplaxius.htm. Accessed 21 November 2012.

Bartlett, C. R., E. R. Adams, and A. T. Gonzon, Jr. 2011. Planthoppers of Delaware (Hemiptera, Fulgoroidea), excluding Delphacidae, with species incidence from adjacent states. ZooKeys 83: 1–42. doi:10.3897/zookeys.83.1176

Bartlett, C. R., L. B. O'Brien, and S. W. Wilson. 2014. A review of the planthoppers (Hemiptera: Fulgoroidea) of the United States. Memoirs of the American Entomological Society 50: 1–287.

Bressan, A. 2009. Agronomic practices as potential sustainable options for the management of *Pentastiridius leporinus* (Hemiptera: Cixiidae) in sugar beet crops. Journal of Applied Entomology 133: 760–766. doi:10.1111/j.1439-0418.2009.01407.x

Bressan, A., F. J. Moral García, O. Sémétey, and E. Boudon-Padieu. 2010. Spatio-temporal pattern of *Pentastiridius leporinus* migration in an ephemeral cropping system. Agricultural and Forest Entomology 12: 59–68. doi:10.1111/j.1461-9563.2009.00450.x

Caldwell, J. S. 1946. Notes on *Haplaxius* Fowler with descriptions of new species (Homoptera, Cixiidae). Proceedings of the Entomological Society of Washington 48: 203–206.

Ceotto, P. and T. Bourgoin. 2008. Insights into the phylogenetic relationships within Cixiidae (Hemiptera: Fulgoromorpha): cladistic analysis of a morphological dataset. Systematic Entomology 33: 484–500. doi:10.1111/j.1365-3113.2008.00426.x

Emeljanov, A. F. 1989. To the problem of division of the family Cixiidae (Homoptera, Cicadina). Entomologicheskoe Obozrenie 68(1): 93–106 (in Russian; English translation in Entomological Review 68(4): 54–67).

Ferreira, M., S. H. McKamey, and R. T. Martinez. 2010. New records of *Haplaxius* (Hemiptera: Cixiidae) in the Dominican Republic, with description of a new species. Zootaxa 2614: 65–68.

Hamilton, K. G. A. 2012. Unraveling the enigma of an Atlantic prairie. Northeastern Naturalist 19(Spec. Issue 6): 13–42.

Hamilton, K. G. A. and R. F. Whitcomb. 2010. Leafhoppers (Homoptera: Cicadellidae): a major family adapted to grassland habitats, pp. 169–197. *In* J. D. Shorthouse and K. D. Floate, eds. Arthropods of Canadian Grasslands. Vol. 1. Ecology and Interactions in Grassland Habitats. Biological Survey of Canada (Terrestrial Arthropods) [Ottawa]. 358 pp.

Harper-Lore B. L. and M. Wilson, eds. 2000. Roadside Use of Native Plants. Island Press, Washington, DC. 665 pp.

Hartnett, D. C. 1993. Regulation of clonal growth and dynamics of *Panicum virgatum* (Poaceae) in tallgrass prairie: effects of neighbor removal and nutrient addition. American Journal of Botany 80: 1114–1120. doi:10.2307/2445538

Holzinger, W. E., A. F. Emeljanov, and I. Kammerlander. 2002. The family Cixiidae Spinola 1839 (Hemiptera: Fulgoromorpha) – a review. Denisia 4: 113–137.

Holzinger, W. E., I. Kammerlander, and H. Nickel. 2003. The Auchenorrhyncha of Central Europe. Vol. 1. Fulgoromorpha, Cicadomorpha excl. Cicadellidae. Brill, Leiden. 673 pp.

Howard, F. W., R. C. Norris, and D. L. Thomas. 1983. Evidence of transmission of palm lethal yellowing agent by a planthopper, *Myndus crudus* (Homoptera: Cixiidae). Tropical Agriculture (Trinidad) 60: 168–171.

Johnsgard, P. A. 1995. This Fragile Land: a Natural History of the Nebraska Sandhills. University of Nebraska Press, Lincoln. 256 pp.

Jull, L. G. 2009. Winter salt injury and salt tolerant landscape plants. University of Wisconsin Extension Bulletin A3877. 12 pp.

Kramer, J. P. 1979. Taxonomic study of the planthopper genus *Myndus* in the Americas (Homoptera: Fulgoroidea: Cixiidae). Transactions of the American Entomological Society 105: 301–389.

Kramer, J. P. 1983. Taxonomic study of the planthopper family Cixiidae in the United States (Homoptera: Fulgoroidea). Transactions of the American Entomological Society 109: 1–58.

Mahabir, R. S., D. W. Severson, and D. D. Chadee. 2012. Impact of road networks on the distribution of dengue fever cases in Trinidad, West Indies. Acta Tropica 123: 178–183. doi:10.1016/j.actatropica.2012.05.001

Miller, W. R. and F. E. Egler. 1950. Vegetation of the Wequetequock-Pawcatuck tidal-marshes, Connecticut. Ecological Monographs 20: 143–172. doi:10.2307/1943548

NDOR (Nebraska Department of Roads). 2009. Discover Nebraska's roadside flowers and

grasses. Nebraska Department of Roads, Lincoln. Available at http://www.dor.state.ne.us/docs/flowers/brochure/Wildflower2009.pdf. Accessed 21 November 2012.

Nemec, K. T. 2003. Insect communities of native and restored wet-mesic tallgrass prairies in central Nebraska: leafhoppers, planthoppers, treehoppers, and ants. M.A. thesis, University of Nebraska at Omaha. 138 pp.

Nemec, K. T. and T. B. Bragg. 2008. Plant-feeding Hemiptera and Orthoptera communities in native and restored mesic tallgrass prairies. Restoration Ecology 16: 324–335. doi:10.1111/j.1526-100X.2007.00306.x

Nickel, H. 2003. The Leafhoppers and Planthoppers of Germany (Hemiptera, Auchenorrhyncha): Patterns and Strategies in a Highly Diverse Group of Phytophagous Insects. Pensoft Publishers. Goecke & Evers, Keltern, Sofia, Moscow. 460 pp.

Noordijk, J., D. Prins, M. de Jonge, and R. Vermeulen. 2006. Impact of a road on the movements of two ground beetle species (Coleoptera: Carabidae). Entomologica Fennica 17: 276–283.

Noss, R. F. 2000. Restoring grassland ecosystems: an opportunity to save the pieces, pp. 36–37. *In* B. L. Harper-Lore and M. Wilson, eds. Roadside Use of Native Plants. Island Press, Washington, DC. 665 pp.

Oakes, A. J. 1990. Ornamental Grasses and Grasslike Plants. Van Nostrand Reinhold, New York. 614 pp.

O'Brien, L. B. and S. W. Wilson. 1985. Planthopper systematics and external morphology, pp. 61–102. *In* L. R. Nault and J. G. Rodiguez, eds. The Leafhoppers and Planthoppers. Wiley, New York. 500 pp.

Osborn, H. 1938. The Fulgoridae of Ohio. Ohio Biological Survey Bulletin 35: 283–357 (Vol. 6, No. 6). Ohio State University, Columbus.

Palmer, P. G. 1975. A biosystematic study of the *Panicum amarum–P. amarulum* complex (Graminiae). Brittonia 27: 142–150. doi:10.2307/2805475

Panzer, R., K. Gnaedinger, and G. Derkovitz. 2010. The prevalence and status of conservative prairie and sand savanna insects in the Chicago Wilderness Region. Natural Areas Journal 30: 73–81. doi:10.3375/043.030.0108

Parrish, D. J. and J. H. Fike. 2005. The biology and agronomy of switchgrass for biofuels. Critical Reviews in Plant Sciences 24: 423–459. doi:10.1080/07352680500316433

Rolfsmeier, S. B. and G. Steinauer. 2010. Terrestrial ecological systems and natural communities of Nebraska (Version IV). Nebraska Game and Parks Commission, Lincoln. 223 pp. Available at http://outdoornebraska.ne.gov/wildlife/programs/legacy/pdfs/Terrestrial%20 Ecological%20Systems.pdf. Accessed 27 September 2013.

Sanderson, M. A., P. R. Adler, A. A. Boateng, M. D. Casler, and G. Sarath. 2006. Switchgrass as a biofuels feedstock in the USA. Canadian Journal of Plant Science 86: 1315–1325. doi:10.4141/P06-136

Saulich, A. K. and D. L. Musolin. 1996. Univoltinism and its regulation in some temperate true bugs (Heteroptera). European Journal of Entomology 93: 507–518.

Schaeffer, S., F. Baxendale, T. Heng-Moss, R. Sitz, G. Sarath, R. B. Mitchell, and R. Shearman. 2011. Characterization of the arthropod community associated with switchgrass (Poales: Poaceae) in Nebraska. Journal of the Kansas Entomological Society 84: 87–104. doi:10.2317/JKES100329.1

Schneider, R., K. Stoner, G. Steinauer, M. Panella, and M. Humpert, eds. 2011. The Nebraska Natural Legacy Project: State Wildlife Action Plan, 2nd ed. Nebraska Game and Parks Commission, Lincoln. 344 pp. Available at http://outdoornebraska. ne.gov/wildlife/ programs/legacy/pdfs/NE%20Natural%20Legacy%20Project%20-%202nd % 20 edition.pdf. Accessed 21 November 2012.

Sforza, R., T. Bourgoin, S. W. Wilson, and E. Boudon-Padieu. 1999. Field observations, laboratory rearing and descriptions of immatures of the planthopper *Hyalesthes obsoletus* (Hemiptera: Cixiidae). European Journal of Entomology 96: 409–418.

Shaw, R. B. 2008. Grasses of Colorado. University of Colorado Press, Boulder. 650 pp.

Shepard, D. B., A. R. Kuhns, M. J. Dreslik, and C. A. Phillips. 2008. Roads as barriers to animal movement in fragmented landscapes. Animal Conservation 11: 288–296. doi:10.1111/j.1469-1795.2008.00183.x

Triplett, J. K., Y. Wang, J. Zhong, and E. A. Kellogg. 2012. Five nuclear loci resolve the polyploid history of switchgrass (*Panicum virgatum* L.) and relatives. PLoS ONE 7(6): 1–19. doi:10.1371/journal.pone.0038702

Tsai, J. H. and O. H. Kirsch. 1978. Bionomics of *Haplaxius crudus* (Homoptera: Cixiidae). Environmental Entomology 7: 305–308.

USDA NRCS (United States Department of Agriculture Natural Resources Conservation Service). 2013. The PLANTS Database. National Plant Data Team, Greensboro, NC. http://plants.usda.gov. Accessed 10 June 2013.

Vogel, K. P. 2004. Switchgrass, pp. 561–588. *In* L. E. Moser, B. L. Burson, and L. E. Sollenberger, eds. Warm-season (C_4) Grasses. American Society of Agronomy; Crop Science Society of America. Soil Science Society of America, Madison, WI. 1171 pp.

WDNR (Wisconsin Department of Natural Resources). 2012. Wisconsin's rare leafhoppers and true bugs. Available at http://dnr.wi.gov/topic/endangeredresources/Animals. asp?mode=list&Grp=15. Accessed 20 November 2012.

Weaver, J. E. 1968. Prairie Plants and their Environment: a Fifty-Year Study in the Midwest. University of Nebraska Press, Lincoln. 276 pp.

Wherry, E. T. 1920. Plant distribution around salt marshes in relation to soil acidity. Ecology 1: 42–48. doi:10.2307/1929256

Whiles, M. R. and R. E. Charlton. 2006. The ecological significance of tallgrass prairie arthropods. Annual Review of Entomology 51: 387–412. doi:10.1146/annurev.ento.51.110104.151136

Wilson, S. W. 2005. Keys to the families of Fulgoromorpha with emphasis on planthoppers of potential economic importance in the southeastern United States (Hemiptera: Auchenorrhyncha). Florida Entomologist 88: 464–481. doi:10.1653/0015-4040(2005)88[464:KTTFOF]2.0.CO;2

Wilson, S. W., J. L. Smith, and P. D. Calvert. 1993. Planthoppers of a Missouri tallgrass prairie (Homoptera: Fulgoroidea). Journal of the Kansas Entomological Society 66: 75–80.

Wilson, S. W., C. Mitter, R. F. Denno, and M. R. Wilson. 1994. Evolutionary patterns of host plant use by delphacid planthoppers and their relatives, pp. 7–113. *In* R. F. Denno and T. J. Perfect, eds. Planthoppers: their Ecology and Management. Chapman & Hall, New York. 799 pp.