

**PRAIRIANA ORIZABA BALL AND REEVES (HEMIPTERA:
CICADOMORPHA: CICADELLIDAE), COLONIST OF THE INTRODUCED
AFRICAN BUNCHGRASS *ERAGROSTIS CURVULA* (POACEAE), WITH
NOTES ON THE USE OF LITTLE BLUESTEM, *SCHIZACHYRIUM
SCOPARIUM* (POACEAE), BY P. KANSANA (BALL)**

A. G. WHEELER, JR.

Department of Entomology, Soils, and Plant Sciences, Clemson University,
Clemson, SC 29634-0315, U.S.A. (e-mail: awhlr@clemson.edu)

Abstract.—Host plants of *Prairiana orizaba* Ball and Reeves, a scarine leafhopper described from Mexico and known in the United States only from Arizona and Texas, have remained unknown. It is reported new for Arkansas, New Mexico, and Oklahoma, with additional records given for Arizona and Texas. Nymphs and adults were beaten mainly from crowns of an introduced chloridoid bunchgrass, the African weeping lovegrass (*Eragrostis curvula* (Schr.) Nees; Poaceae), at 20 sites from late April to mid-June. Nymphs overwintered in the crowns, and adults were observed as early as late April in Arkansas and Oklahoma; at higher elevations in New Mexico, an adult was first found in late May and fifth instars were present as late as mid-June. Native grasses on which nymphs were collected (one site in Arizona) included *Aristida purpurea* Nutt., *Bothriochloa barbinodis* (Lag.) Herter, and *Bouteloua curtipendula* (Michx.) Torrey. *Prairiana kansana* Ball, reported new for Nebraska and South Carolina, developed on little bluestem (*Schizachyrium scoparium* (Michx.) Nash; Poaceae) on granite outcrops in South Carolina's upper Piedmont. Collections in Nebraska and Texas also were from little bluestem.

Key Words: Insecta, leafhoppers, weeping lovegrass, little bluestem, new records, host expansion, novel host

Cicadellids, or leafhoppers, have begun to be used in studies on grassland conservation and as indicators of habitat quality (e.g., Whitcomb 1987, Hamilton 1995, Biedermann et al. 2005, Hollier et al. 2005). Much of the work on grassland leafhoppers has involved species assemblages. Yet, as Biedermann et al. (2005) pointed out, rare leafhopper species also deserve attention from conservationists.

Prairiana Ball is a scarine (= gypso-nine) genus of medium-sized to large (5–12 mm) leafhoppers restricted to the New World. The nine species known

from North America north of Mexico (Oman 1949, Metcalf 1962) tend to be poorly represented in collections (Ball 1920). They typically are collected from grasslands (e.g., Ball 1920, Ball and Reeves 1927, Lowry 1933, Beirne 1956, Blocker et al. 1972, Blocker and Reed 1976, Kumar et al. 1976, Cwikla and Blocker 1981, Bess 1997). An association with prairies is suggested by the generic name; certain species are endemic to prairies (Hamilton 1995), and some might depend on prairie or savanna remnants (Panzer et al. 1995). Although

Prairiana species have been assumed to feed on grasses (Ball 1920), the host plants of these leafhoppers are largely unknown (Bess 1997). Ball (1920) suggested that the uniformly pale gray to brown coloration was an adaptation to their association with the dead grass blades on which they live, but he later predicted that the actual hosts would prove to be nongraminoid plants growing under grasses (Ball 1935). Since then, several of the species formerly placed in *Prairiana*, and that do not feed on grasses, have been transferred to related genera.

From studies on the hemipteran fauna associated with the crowns of bunchgrasses (Wheeler 1999, 2005; Wilson and Wheeler 2005), I report the colonization of the African *Eragrostis curvula* (Schrud.) Nees (Poaceae: Chloridoideae) by *P. orizaba* Ball and Reeves in the southwestern United States, record it from three native grasses, and give new distribution records and notes on its habitats and seasonal history. I also report little bluestem, *Schizachyrium scoparium* (Michx.) Nash (Poaceae: Panicoideae), as a host plant of *P. kansana* Ball and give notes on its seasonality in South Carolina.

MATERIALS AND METHODS

Prairiana species were collected periodically from crowns of native and non-native bunchgrasses from 1996 to 2005 by placing a white enamel pan at the base of a plant and striking the base two or three times to dislodge insects from the crown. Care was taken to avoid collecting from a grass species mixed with other grasses or forbs. Adults and nymphs were hand picked from the pan using plastic vials. Nymphs were preserved in 70% ethanol or, in the case of some fifth instars, reared to adults or mounted on points; other nymphs were replaced on host grasses. Nymphs are recorded under Distribution as early or late instars when

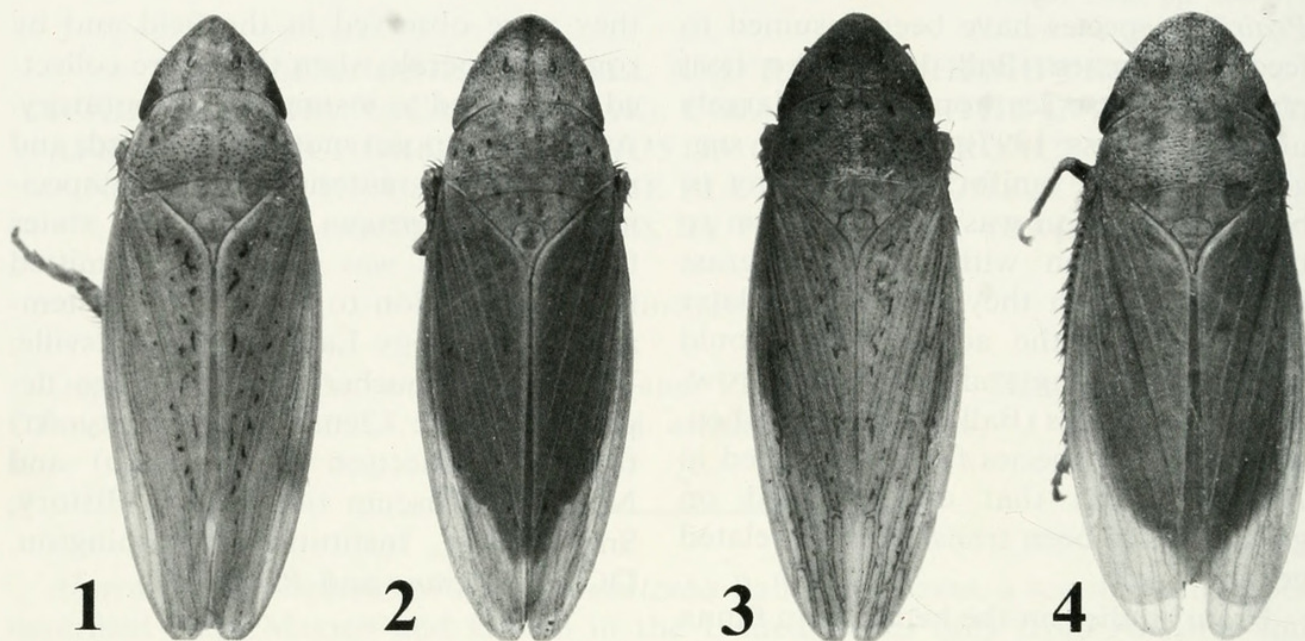
they were observed in the field and by roman numerals when they were collected and sorted to instar in the laboratory. Adults were point mounted, labeled, and representative material, including specimens of *P. orizaba* from all five states from which it was collected, submitted for identification to the USDA Systematic Entomology Laboratory, Beltsville, Maryland. Voucher specimens are deposited in the Clemson University Arthropod Collection (*P. kansana*) and National Museum of Natural History, Smithsonian Institution, Washington, DC (*P. kansana* and *P. orizaba*).

Prairiana orizaba Ball and Reeves (Figs. 1–2)

Prairiana orizaba was described as a variety of *P. cinerea* (Uhler) on the basis of a male collected at Orizaba, Veracruz, Mexico, in January 1892 by Ball and Reeves (1927). These authors suggested that it might be a rare form because it had not been included in the *Biologia Centrali-Americana*. Ball (1935), in reporting this leafhopper from Arizona and Texas, considered it a distinct species. The variety *rolenta*, described from Texas (DeLong 1942), was synonymized with *P. orizaba* by Oman (1949).

The body of *P. orizaba* is 9.0 to 9.5 mm long. As in other species of the genus (Oman 1949, DeLong and Freytag 1972), it has the head flattened in profile, as broad as the pronotum, anterior margin subfoliaceous, margins of the genae strongly sinuate, and surface of the crown coarsely rugose (Ball and Reeves 1927, DeLong 1942, Oman 1949). DeLong (1942) described the male and female genitalia of this pale brown or stramineous leafhopper and illustrated the male genitalia. An accurate identification of *Prairiana* species depends on examination of the male genitalia.

Distribution.—According to the most recent catalog of the group (Metcalf



Figs. 1–4. Dorsal habitus. 1, *Prairiana orizaba* male. 2, *P. orizaba* female. 3, *P. kansana* male. 4, *P. kansana* female.

1962), the previously known U.S. distribution is limited to Arizona and Texas. The inclusion of Arizona was based on Ball's (1935) records from Granite Dell and the Santa Rita Mountains. DeLong (1942) and DeLong and Knull (1945), however, listed Texas as the only state record. The male from Granite Dell, Arizona (Ball 1935), might have been designated as a paratype of *P. latens* DeLong, a species DeLong (1942) noted was similar to *P. orizaba* in form, general appearance, and structure of the male genitalia. DeLong (1942) apparently did not examine material from the Santa Rita Mountains in Arizona.

In the following list of localities where I observed *P. orizaba*, new state records are indicated by asterisks. Even though previous records of *P. orizaba* from Arizona might refer to *P. latens* or other species of the genus, Arizona is not considered a new state record.

ARIZONA: Gila Co., Rts. 60/77, 24 km N of Salt River, 33°55.8'N, 110°21.4'W, 19 June 2005, 1 ♂. Santa Cruz Co., Audubon Research Ranch, Cimarron Rd., S of Elgin, 31°33.5'N,

110°29.9'W, 13 May 2004, 7-V; 20 June 2005, 1 ♀. Yavapai Co., Rt. 89, Peeples Valley, 34°15.9'N, 112°43.6'W, 18 June 2005, 1 ♂. *ARKANSAS: Ashley Co., Rt. 82, 0.7 km E of Ouachita River, 13.5 km W of Crossett, 21 Apr. 2000, 1-V, 1 ♂; 19 May 2001, 1 ♂; 20 Apr. 2002, 1-V, 1 ♀; 26 May 2003, 4 early instars. *NEW MEXICO: Chaves Co., Rt. 82, 7.2 km E of Mayhill, 31 May 2003, 1-V; Rt. 82, 12 km E of Mayhill, 31 May 2003, 3-V, 1 ♂; Rt. 82, 16 km E of Mayhill, 32°55.2'N, 105°20.3'W, 14 June 2005, 1-V. Lea Co., Rt. 508, 28.5 km E of Crossroads, 26 Apr. 2002, 1-V. Roosevelt Co., Rt. 262, 13.5 km E of Milnesand, 26 Apr. 2002, 2 late instars. Sierra Co., Rt. 152, S of Kingston, 32°53.7'N, 107°44.4'W, 16 June 2005, 1-V, 1 ♂, 1 ♀. *OKLAHOMA: Atoka Co., Rt. 109A, 0.9 km S of Boehler Rd., 15.1 km N of Boswell, 22 Apr. 2000, 7 late instars, 1 ♂, 1 ♀; 1 May 2000, 5 ♂, 6 ♀; 20 Apr. 2002, 2-V, 1 ♀; 27 May 2003, 1-III, 1-V. Carter Co., Rt. 199, 0.3 km E of Sandy Branch, 2.2 km W of Dickson, 23 Apr. 2000, 1 late instar; Rt. 70, 6.5 km W of Dickson Rd., 2.0 km E

of Ardmore, 23 Apr. 2000, 2 late instars, 2 ♂, 2 ♀; Mary Niblack Rd., S of Rt. 199, E of Ardmore, 24 Apr. 2000, 1 late instar, 1 adult (sex unknown). Marshall Co., Rt. 70F, 0.8 km S of Rt. 70, 2.5 km SE of Madill, 1 May 2000, 1 adult (sex unknown). TEXAS: Callahan Co., jct. Frontage Rd. & CR-119 along I-20, ca. 7 km E of Clyde, 20 May 2004, 2 ♂, 13 ♀. Cottle Co., Rts. 62/83, 12.0 km N of Paducah, 25 Apr. 2002, 1 ♂. Culbertson Co., Rts. 62/180, nr entrance to Guadalupe Mountains National Park, 31°42.9'N, 104°51.8'W, 13 June 2005, 1 ♂. Gaines Co., Rt. 180, 2.9 km W of Dawson Co. line, 40.5 km E of Seminole, 8 May 2004, 2 ♀. Terry Co., ca. 11 km NE of Brownfield, 23 Apr. 2000, 2 late instars.

Host plants and habitats.—*Prairiana orizaba* was beaten almost exclusively from the crowns of weeping lovegrass, even though my sampling of grasses included other chloridoid species, as well as grasses of the subfamilies Aristoideae, Panicoideae, and Pooideae (Wheeler 2005, Wilson and Wheeler 2005). Nymphs and adults were found on weeping lovegrass in plantings at the edge of roads and those on highway embankments. Elevations ranged from about 45 m in Ashley County, Arkansas, to about 2,215 m in the Black Range in the mountains of southwestern New Mexico (Sierra County). In Terry County, Texas, nymphs were collected from a weeping lovegrass field that had been placed in the USDA's Conservation Reserve Program, which promotes the long-term, voluntary retirement of cropland (e.g., McIntyre 2003).

I found nymphs on native grasses only in southeastern Arizona at the Audubon Research Ranch, where weeping lovegrass also was a host. The native hosts were the aristoid *Aristida purpurea* Nutt., panicoid *Bothriochloa barbinodis* (Lag.) Herter, and chloridoid *Bouteloua curtipendula* (Michx.) Torrey.

Seasonality.—In Arkansas and Oklahoma, collections in late April consisted only of late instars or late instars and adults, suggesting that *P. orizaba* overwinters as nymphs. At higher elevations (>1,525 m) in Arizona and New Mexico, only fifth instars, presumably overwintered, were observed in mid-May 2004. In 2005, adults and fifth instars were present in mid-June. The collection of early instars in Arkansas in late May 2003 suggests the beginning of another generation; fifth instars and adults were observed in late April. Because weeping lovegrass and other grasses were sampled only from late April to mid-June, the number of annual generations is unknown.

Prairiana kansana Ball
(Figs. 3–4)

Like *P. orizaba*, *P. kansana* was described as a variety of *cinerea* Uhler: as *Gypona (Prairiana) cinerea* var. *kansana* (Ball 1920). The original description was based on four specimens from Onaga, Kansas. Ball (1920) remarked that he also had collected the new variety in Colorado and Iowa. DeLong and Caldwell (1937) considered *P. kansana* a distinct species. *Prairiana kansana* var. *angustens*, described from Iowa, Nebraska, and South Dakota (DeLong 1942), was synonymized with *P. kansana* by Oman (1949).

Pale brown to brownish cinereous, *P. kansana* is 9.0 to 10.5 mm long. DeLong (1942) described and illustrated the male genitalia.

Distribution.—In addition to states mentioned in the original description and that of the variety *angustens* (now a synonym of *P. kansana*), the leafhopper is known from Connecticut (Ball and Reeves 1927), New Hampshire (Lowry 1933), North Carolina and Texas (DeLong 1942), Minnesota (Medler 1942), Illinois (DeLong 1948), Ohio (Cwikla

1987), Indiana (Panzer et al. 1995), and Kentucky (Bess 1997; as *P. angustens*). The record from South Carolina ("Southern Pines") given by DeLong (1942) and included in the catalog of Cicadellidae (Metcalf 1962) apparently represents a *lapsus* for North Carolina and is referred above to that state. In Canada, Maw et al. (2000) recorded *P. kansana* from Ontario and listed it provisionally from Manitoba based on Hamilton's (1995) record from that province as a *Prairiana* species "nr. *kansana*." Subsequently, however, Hamilton (2004) recorded *P. kansana* from Alberta, Manitoba, and Saskatchewan.

Nebraska and, as noted above, South Carolina should be considered new state records for *P. kansana*.

NEBRASKA: Keith Co., Cedar Point Biological Station, ca. 14 km N of Ogallala, 19 Aug. 1998, 1 ♀. SOUTH CAROLINA: Greenville Co., rock outcrop, Rt. 276, SW of Bald Rock, ca. 8 km S of Caesars Head, 35°04.9'N, 82°37.6'W, 12 Apr. 1998, 2-V; 23 Mar. 2003, 1-IV. Pickens Co., Glassy Mountain Heritage Preserve, 4.2 km NE of Pickens, 34°54.0'N, 82°39.5'W, 3 May 1996, 3 late instars; 16 June 1996, 1 adult (sex unknown); 4 July 1996, 1 adult (sex unknown); 7 Mar. 1997, 2 late instars; 13 Apr. 1997, 2-V, 1 adult (sex unknown); 31 Mar. 2002, 3 late instars; 12 May 2002, 2 ♂; 29 May 2002, 1 adult (sex unknown); 27 July 2002, 1 ♀; 23 July 2005, 3-III. Poe Creek outcrop, 10.3 km NE of Salem, 2 May 2003, 1-V (reared to adult ♂, 5 May 2003). TEXAS: Mills Co., Rt. 16, 9 km SW of Goldthwaite, 2 May 2002, 1 ♀.

Not included in the above records are an adult (subsequently lost) beaten from the crown of broom sedge, *Andropogon virginicus* L., on 6 May 1996 at Dixie Mountain serpentine barren in Columbia County, Georgia, and a fifth instar collected similarly on 19 May 1996 from big bluestem, *A. gerardii* Vitman, at the

Nottingham Park serpentine barren in Chester County, Pennsylvania, both putatively of *P. kansana*. The presence of *Prairiana* in Georgia and Pennsylvania fits only the known distribution of *P. kansana*.

Host plants and habitats.—In Canada, *P. kansana* is considered characteristic of the Northern Grasslands biome, including much of the Great Plains (Hamilton 2004). Although host relationships have remained unknown, collections at several sites suggest its association with bluestem grasses of the panicoid genera *Andropogon* and *Schizachyrium*. Lowry (1933) found adults in New Hampshire in a sandy area among pitch pine (*Pinus rigida* P. Mill.) where little bluestem, *S. scoparium*, was common. In Kansas, the leafhopper was collected from tallgrass prairie of the Flint Hills, an "essentially bluestem prairie" in which little bluestem and big bluestem, *A. gerardii*, are among the major grasses (Cwikla and Blocker 1981). Cwikla (1987) reported *P. kansana* in an Ohio fen in which both big and little bluestem were present, and Bess (1997) collected the leafhopper in *Andropogon*-dominated habitats in Kentucky.

I observed nymphs and adults in South Carolina in specialized communities of the upper Piedmont. All collections were from little bluestem except for a fifth instar taken in late March on weeping lovegrass growing near little bluestem on Glassy Mountain. On this monadnock, *P. kansana* was found on grasses near or on granite outcrops. Little bluestem also grew at the edge of granite outcrops at the other two South Carolina sites for the leafhopper. The collection in Nebraska was from little bluestem in mixed-grass prairie. In Texas, an adult was collected from little bluestem in a pasture of native grasses.

Seasonality.—Bess (1997) noted that in Kentucky *P. kansana* (as *P. angustens*) overwinters as an adult at the only site

where it is known. My collection of only late instars on Glassy Mountain from early March to early May in most years (an adult was found with two fifth instars on 13 April 1997) suggests that in northwestern South Carolina the leafhopper overwinters as nymphs. Adults typically were not observed until early to mid-May. The third instars found in late July 2005 likely belonged to another generation. Nymphs of that generation might overwinter, but more regular sampling of little bluestem on Glassy Mountain is needed to determine voltinism of *P. kansana*.

DISCUSSION

An emphasis on host-plant relationships of North American grassland Cicadellidae, rather than their habitat and community relationships, characterized studies by H. H. Ross in the 1960s and 1970s (Whitcomb et al. 1987a, 1994). Leafhopper-grass relationships have continued to be emphasized for North America, particularly by R. F. Whitcomb and colleagues (e.g., Whitcomb et al. 1987a, b, 1994; Whitcomb and Hicks 1988; Hicks and Whitcomb 1993, 1996) and K.G.A. Hamilton (e.g., Hamilton 1994, 1995, 2002, 2004, 2005). In many studies of temperate grasslands, the distributions of leafhopper species are correlated with the composition of local plant assemblages (e.g., Whitcomb et al. 1987a, b; Bess et al. 2004). Such patterns generally reflect the host specificity of grassland leafhoppers (Whitcomb et al. 1986, 1987b, 1994).

Despite recent attention given to the host relationships of North American grassland leafhoppers, biological data on members of the scarine genus *Prairiana*, though long suspected to be grass feeders (Ball 1920), have remained scant. For example, *Prairiana* species were not included among Cicadellidae (>300 species) associated with grasses in western U.S. rangelands (Thomas and Werner

1981). Many leafhoppers of this genus might be among the rare plant and animal components comprising about 80% of species in grasslands and other ecosystems (Hammond 1995), a pattern that conforms to a “hollow-curve” frequency distribution (e.g., Kempton 1979). The cryptic habits of *Prairiana* species—they are considered partly nocturnal and subterranean (Bess 1997)—might contribute to the infrequency of their collection by conventional methods, such as sweep-netting.

Grasses serve as hosts of both *P. kansana* and *P. orizaba*. Not all *Prairiana* males collected during the study were verified through genitalic examination and, in a few cases, only females, which cannot be identified with certainty, were present at a locality. Additional *Prairiana* species might be involved, but the determination of numerous males, comparison of single females with those from sites where males were found, and rearing of fifth instars suggests that only *P. orizaba* has colonized the introduced weeping lovegrass and that a single species, *P. kansana*, was associated with the native little bluestem.

Nymphs of *P. kansana* (third to fifth instars) were collected from the crowns of little bluestem at three sites in South Carolina and were observed at Glassy Mountain during four seasons over a nine-year period of irregular sampling. Nymphs of *P. orizaba*, either early or late instars, were found on the introduced weeping lovegrass at 14 sites in southwestern states, and at 3 sites were recollected on this grass in subsequent years. Adults were collected from weeping lovegrass at six additional sites. Other native leafhoppers that have colonized the chloridoid weeping lovegrass are the oligophagous deltocephalines *Flexamia atlantica* (DeLong), *F. inflata* (Osborn and Ball), and *Laevicephalus unicoloratus* (Gillette and Ball). All three of these widespread species have colo-

nized another non-native chloridoid, bermudagrass, *Cynodon dactylon* (L.) Pers., but are capable of transferring between grass subfamilies (Whitcomb et al. 1987a, b; Whitcomb and Hicks 1988; Hicks and Whitcomb 1993; Dietrich et al. 1997; Hamilton 2005). *Prairiana orizaba*, however, is a rarely collected, poorly known native insect that has incorporated weeping lovegrass into its host range. Other rare, unusual, or little-known native insects that have undergone this expansion of host range include a podopine pentatomid (Wheeler 1999), two blissids (Wheeler 2005), and a dictyopharid and three fulgorid planthoppers (Wilson and Wheeler 2005). Although grasses have a simple architecture compared to dicotyledonous plants (Tschardt and Greiler 1995), the greater architectural complexity of weeping lovegrass relative to many other grasses is thought to have played a role in its colonization by native insects (Wheeler 1999, Wilson and Wheeler 2005).

The presence of a fifth instar of *P. kansana* on weeping lovegrass in South Carolina (Glassy Mountain) might have been incidental, reflecting the plant's proximity (<25 m) to little bluestem; or it might represent the incipient stages of a colonization of *Eragrostis curvula* that will be either ephemeral or long term. Brief (several-year) colonizations of exotic grasses by native leafhoppers have been observed (Whitcomb et al. 1987a). On Glassy Mountain in South Carolina, a rarely collected native fulgorid, *Amyle vernalis* Manee, also develops mainly on little bluestem, with a few nymphs having been found on nearby weeping lovegrass (Wilson and Wheeler 2005).

Additional field studies are needed to determine whether *P. orizaba* continues to use *E. curvula* as a host and if *P. kansana* includes this African grass in its host range. Field sampling that would elucidate voltinism in both species

should be supplemented by laboratory studies to determine if weeping lovegrass and little bluestem are hosts of *P. orizaba* and *P. kansana*, respectively, in the sense of plants on which eggs are laid and that support nymphal growth and development (e.g., Oman 1949). Host-range expansion involves not only the acceptance of a novel plant for feeding or oviposition but also the physiological capability of completing development on the new plant. If physiological performance relative to the normal host is poor, a preference for the novel host likely will be removed by selection (e.g., Pilson 1999). Also needed is work on basic aspects of the leafhoppers' bionomics, such as fecundity and longevity.

Although Ball (1935) reported for *P. sidana* that a prostrate species of *Sida* (Malvaceae) definitely is its host in Arizona, he did not indicate if nymphs had been found on the plant. Bess (1997) commented that K.G.A. Hamilton suspects that species of *Artemisia* (Asteraceae) are hosts of certain other western *Prairiana* species. Future research will determine whether other *Prairiana* species are grass feeders, or whether some use dicotyledonous hosts.

ACKNOWLEDGMENTS

I am grateful to Linda Kennedy (National Audubon Society Appleton-Whittell Research Ranch, Elgin, AZ) for hospitality and assistance during my visits to the Audubon Research Ranch, issuing an insect collecting permit, and identifying grasses; Mary Batterson (formerly Associate Director, Cedar Point Biological Station) for her hospitality and permission to collect insects at the station; Robert Whitcomb (USDA, ARS, Beltsville, MD, retired) for accompanying me in the field at the Audubon Research Ranch in 2004 and sharing his knowledge of grassland leafhoppers; Stuart McKamey (USDA, ARS, System-

atic Entomology Laboratory, Washington, DC) for identifying *Prairiana* species; Thomas Henry and Michele Touchet (USDA, ARS, SEL, Washington, DC) for providing the illustrations and otherwise facilitating completion of the manuscript; Stephen Bennett (South Carolina Department of Natural Resources, Columbia) for allowing me to collect insects at Glassy Mountain Heritage Preserve; Donald Gibbons (USDA, Natural Resources Conservation Service, Brownfield, TX) and James Williams (USDA, NRCS, Ardmore, OK) for accompanying me in the field and directing me to plantings of weeping lovegrass, respectively; Peter Adler (Department of Entomology, Soils, and Plant Sciences, Clemson University) for suggestions that improved an earlier draft of the manuscript; and two anonymous reviewers for their useful comments.

LITERATURE CITED

- Ball, E. D. 1920. A review of the species of the genus *Gypona* occurring in North America north of Mexico (Homoptera). *Annals of the Entomological Society of America* 13: 83–100.
- . 1935. Some new *Gyponas* with notes on others. *Journal of the Washington Academy of Sciences* 25: 497–503.
- Ball, E. D. and J. A. Reeves. 1927. Further studies on the genus *Gypona* and its allies (Rhynchotha, Homoptera). *Annals of the Entomological Society of America* 20: 488–500.
- Beirne, B. P. 1956. Leafhoppers (Homoptera: Cicadellidae) of Canada and Alaska. *Canadian Entomologist* 88(suppl. 2): 1–180.
- Bess, J. A. 1997. The leafhopper species assemblages associated with native and replanted grasslands in southwest Montana, M.S. Thesis, Montana State University, Bozeman, 94 pp.
- Bess, J. A., K. M. O'Neill, and W. P. Kemp. 2004. Leafhopper assemblages on native and reseeded grasslands in southwestern Montana. *Western North American Naturalist* 64: 518–531.
- Biedermann, R., R. Achtziger, H. Nickel, and A. J. A. Stewart. 2005. Conservation of grassland leafhoppers: A brief review. *Journal of Insect Conservation* 9: 229–243.
- Blocker, H. D. and R. Reed. 1976. Leafhopper populations of a tallgrass prairie (Homoptera: Cicadellidae): Collecting procedures and population estimates. *Journal of the Kansas Entomological Society* 49: 145–154.
- Blocker, H. D., T. L. Harvey, and J. L. Launchbaugh. 1972. Grassland leafhoppers. 1. Leafhopper populations of upland seeded pastures in Kansas. *Annals of the Entomological Society of America* 65: 166–172.
- Cwikla, P. S. 1987. Annotated list of leafhoppers (Homoptera: Cicadellidae) from two Ohio fens with a description of a new *Chlorotettix*. *Ohio Journal of Science* 87: 134–137.
- Cwikla, P. S. and H. D. Blocker. 1981. An annotated list of the leafhoppers (Homoptera: Cicadellidae) from Tallgrass Prairie of Kansas and Oklahoma. *Transactions of the Kansas Academy of Sciences* 84: 89–97.
- DeLong, D. M. 1942. A monographic study of the North American species of the subfamily Gyponinae (Homoptera-Cicadellidae) exclusive of *Xerophloea*. Graduate School Studies, Contributions in Zoology and Entomology No. 5. Ohio State University, Columbus, 187 pp.
- . 1948. The leafhoppers, or Cicadellidae, of Illinois (Eurymelinae-Balcluthinae). *Illinois Natural History Survey Bulletin* 24(2): 93–376.
- DeLong, D. M. and J. S. Caldwell. 1937. Check list of the Cicadellidae (Homoptera) of America, north of Mexico. Ohio State University, Columbus, 93 pp.
- DeLong, D. M. and P. H. Freytag. 1972. Studies of the Gyponinae: A key to the known genera and descriptions of five new genera. *Journal of the Kansas Entomological Society* 45: 218–235.
- DeLong, D. M. and D. J. Knull. 1945. Check list of the Cicadellidae (Homoptera) of America, north of Mexico. Ohio State University Press, Columbus, 102 pp.
- Dietrich, C. H., R. F. Whitcomb, and W. C. Black IV. 1997. Phylogeny of the grassland leafhopper genus *Flexamia* (Homoptera: Cicadellidae) based on mitochondrial DNA sequences. *Molecular Phylogenetics and Evolution* 8: 139–149.
- Hamilton, K. G. A. 1994. Leafhopper evidence for origins of northeastern relict prairies (Insecta: Homoptera: Cicadellidae), pp. 61–70. In Wickett, R. G. et al., eds. *Proceedings of the 13th North American Prairie Conference: Spirit of the Land, our Prairie Legacy*, 6–9 Aug. 1992, Windsor, Ont. Preney, Windsor.
- . 1995. Evaluation of leafhoppers and their relatives (Insecta: Homoptera: Auchenorrhyncha) as indicators of prairie preserve

- quality, pp. 211–226. In Hartnett, D. C., ed. Proceedings of the 14th Annual North American Prairie Conference: 12–16 July 1994, Manhattan, Kansas. Kansas State University, Manhattan.
- . 2002. Homoptera (Insecta) in Pacific Northwest grasslands. Part 1—New and revised taxa of leafhoppers and planthoppers (Cicadellidae and Delphacidae). Journal of the Entomological Society of British Columbia 99: 3–31.
- . 2004. Leafhoppers and their relatives (Homoptera, Auchenorrhyncha) from the Canadian Great Plains. Arthropods of Canadian Grasslands. [http://www.biology.ualberta.ca/bsc/pdf/grasslands_10.pdf; accessed 3 September 2005]. 10: 16–24.
- . 2005. Bugs reveal an extensive, long-lost northern tallgrass prairie. BioScience 55: 49–59.
- Hammond, P. C. 1995. Conservation of biodiversity in native prairie communities in the United States. Journal of the Kansas Entomological Society 68: 1–6.
- Hicks, A. L. and R. F. Whitcomb. 1993. The genus *Laevicephalus* (Homoptera: Cicadellidae): Hosts, biogeography, and three new species. Proceedings of the Entomological Society of Washington 95: 481–487.
- . 1996. Diversity of the leafhopper (Homoptera: Cicadellidae) fauna of northern Chihuahuan grasslands, with emphasis on gypsum grasslands and description of a new species of *Athysanella* (Cicadellidae: Deltocephalinae). Proceedings of the Entomological Society of Washington 98: 145–157.
- Hollier, J. A., N. Maczey, G. J. Masters, and S. R. Mortimer. 2005. Grassland leafhoppers (Hemiptera: Auchenorrhyncha) as indicators of habitat condition—A comparison of between-site and between-year differences in assemblage composition. Journal of Insect Conservation 9: 299–307.
- Kempton, R. A. 1979. The structure of species abundance and measurement of diversity. Biometrics 35: 307–321.
- Kumar, R., R. J. Lavigne, J. E. Lloyd, and R. E. Pfadt. 1976. Insects of the Central Plains Experiment Range, Pawnee National Grassland. University of Wyoming Agricultural Experiment Station Science Monograph 32, 76 pp.
- Lowry, P. R. 1933. Cicadellidae leafhoppers of New Hampshire. Ohio Journal of Science 33: 59–80.
- Maw, H. E. L., R. G. Foottit, K. G. A. Hamilton, and G. G. E. Scudder. 2000. Checklist of the Hemiptera of Canada and Alaska. NRC Research Press, Ottawa, 220 pp.
- McIntyre, N. E. 2003. Effects of Conservation Reserve Program seeding regime on harvester ants (*Pogonomyrmex*), with implications for the threatened Texas horned lizard (*Phrynosoma cornutum*). Southwestern Naturalist 48: 274–313.
- Medler, J. T. 1942. The leafhoppers of Minnesota (Homoptera: Cicadellidae). University of Minnesota Agricultural Experiment Station Technical Bulletin 155, 196 pp.
- Metcalf, Z. P. 1962. General Catalogue of the Homoptera. Fascicle VI Cicadelloidea, Part 3 Gyponidae. Agricultural Research Service, United States Department of Agriculture, Washington, DC, 229 pp.
- Oman, P. W. 1949. The Nearctic leafhoppers (Homoptera: Cicadellidae): A generic classification and check list. Memoirs of the Entomological Society of Washington 3: 1–253.
- Panzer, R., D. Stillwaugh, R. Gnaedinger, and G. Derkovitz. 1995. Prevalence of remnant dependence among prairie- and savanna-inhabiting insects of the Chicago region. Natural Areas Journal 15: 101–116.
- Pilson, D. 1999. Plant hybrid zones and insect host range expansion. Ecology 80: 407–415.
- Thomas, D. B. and F. G. Werner. 1981. Grass feeding insects of the western ranges: An annotated checklist. University of Arizona Agricultural Experiment Station Technical Bulletin 243, 50 pp.
- Tscharntke, T. and H. J. Greiler. 1995. Insect communities, grasses, and grasslands. Annual Review of Entomology 40: 535–558.
- Wheeler, A. G., Jr. 1999. *Oncozygia clavicornis* Stål and *Allopodops mississippiensis* Harris and Johnston: Association of rarely collected Nearctic turtle bugs (Heteroptera: Pentatomidae: Podopinae) with an introduced African grass. Proceedings of the Entomological Society of Washington 101: 714–721.
- . 2005. *Blissus minutus* (Blatchley) and *Toonglasia umbrata* (Distant): Seldom-collected native chinch bugs (Hemiptera: Lygaeoidea: Blissidae) as colonists of the African bunchgrass *Eragrostis curvula*, and their association with other grasses in the southern United States. Proceedings of the Entomological Society of Washington 107: 336–345.
- Whitcomb, R. F. 1987. North American forests and grasslands: Biotic conservation, pp. 163–176. In Saunders, D. A., G. W. Arnold, A. A. Burbidge, and A. J. M. Hopkins, eds. Nature Conservation: The Role of Remnants of Native Vegetation. Surrey Beatty & Sons, Sydney.
- Whitcomb, R. F. and A. L. Hicks. 1988. Genus *Flexamia*: New species, phylogeny, and ecology. Great Basin Naturalist Memoirs 12: 224–323.

- Whitcomb, R. F., J. Kramer, M. E. Coan, and A. L. Hicks. 1987a. Ecology and evolution of leafhopper-grass relationships in North American grasslands. *Current Topics in Vector Research* 4: 121-178.
- Whitcomb, R. F., A. L. Hicks, D. E. Lynn, K. Allred, and H. D. Blocker. 1987b. Geographic variation in host relationships of leafhoppers (Homoptera: Cicadellidae) in North American grasslands, pp. 293-325. *In* Wilson, M. R. and L. R. Nault, eds. *Proceedings of the 2nd International Workshop on Leafhoppers and Planthoppers of Economic Importance*, 28 July-1 Aug. 1986. Commonwealth Institute of Entomology, London.
- Whitcomb, R. F., A. L. Hicks, H. D. Blocker, and D. E. Lynn. 1994. Biogeography of leafhopper specialists of the shortgrass prairie: Evidence for the roles of phenology and phylogeny in determination of biological diversity. *American Entomologist* 40: 19-35.
- Wilson, S. W. and A. G. Wheeler, Jr. 2005. An African grass, *Eragrostis curvula* (Poaceae), planted in the southern United States recruits rarely collected native planthoppers (Hemiptera: Fulgoroidea: Dictyopharidae, Fulgoridae). *Journal of the New York Entomological Society* 113: 174-204.



Wheeler, A. G. 2006. "Prairiana orizaba ball and reeves (Hemiptera: Cicadomorpha: Cicadellidae), colonist of the introduced African bunchgrass *Eragrostis curvula* (Poaceae), with notes on the use of little bluestem, *Schizachyrium scoparium* (Poaceae), by *P. kansana* (Ball)." *Proceedings of the Entomological Society of Washington* 108, 868–877.

View This Item Online: <https://www.biodiversitylibrary.org/item/95531>

Permalink: <https://www.biodiversitylibrary.org/partpdf/69186>

Holding Institution

Smithsonian Libraries and Archives

Sponsored by

Smithsonian

Copyright & Reuse

Copyright Status: In copyright. Digitized with the permission of the rights holder.

Rights Holder: Entomological Society of Washington

License: <http://creativecommons.org/licenses/by-nc-sa/3.0/>

Rights: <https://biodiversitylibrary.org/permissions>

This document was created from content at the **Biodiversity Heritage Library**, the world's largest open access digital library for biodiversity literature and archives. Visit BHL at <https://www.biodiversitylibrary.org>.