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DIVERSITY OF CICADELLIDAE AND CERCOPIDAE (HEMIPTERA) ON SAND PRAIRIES OF NEWAYGO COUNTY, MICHIGAN

James P. Dunn¹, Holly A. Hereau¹, and Adam J. Klomp¹

ABSTRACT

Sand prairies in the Great Lakes region occur as small sites dispersed throughout a heavily disturbed landscape. These unique natural areas are dominated by dry prairie grasses and are inhabited by a diversity of insects of which Cicadellidae and Cercopidae are among the most diverse groups. Their species compositions have been implicated as being potential indicators of ecological quality that could be used to rank the quality of prairie vegetation. In Newaygo Co., Michigan, 12 sand prairies were surveyed for Cicadellidae and Cercopidae and these data were then used to estimate species diversity for each site by the Simpson's Dominance and the Brillouin Diversity indices. A ranking of ecological quality of each site was also done by using an inferential analysis. Results from these indices indicated that the Big Finger prairie and the Michigan Nature Association's North prairie ranked the highest in diversity. Other highly ranked sites were the Cottonwood Street prairie and the Newaygo Prairie Study Area. The Locust Street prairie, although ranking low in diversity as determined by the Brillouin index, was dominated by *Philaenarcys bilineata* (Say) (Hemiptera: Cercopidae) a "Threatened" species, and *Flexamia delongi* Ross and Cooley (Hemiptera: Cicadellidae) a species of "Special Concern", indicating the importance of preserving this site even though its species richness and biodiversity rankings were low. Seven species of Cercopidae were collected including *Lepyronia gibbosa* Ball a state "Threatened" species, and *P. bilineata* and *Prosapia ignipecta* (Fitch), state species of "Special Concern".

Twenty species of Cicadellidae were identified of which *F. delongi*, a species of "Special Concern", was collected from all sites. Several prairie obligate species from both families were collected from each site. Eight Michigan state "Special Concern" or "Threatened" species, four new state records, and two new county records were collected. These results indicate the biological uniqueness of these sand prairies with evidence that all of these sites warrant conservation oriented management.

Cicadellidae and Cercopidae (Hemiptera) are diverse taxa in grassland ecosystems and their community composition allows their use as an index of the ecological quality of prairie vegetation. Nymphs and adults of these insects are herbivorous. Many species have close associations with their food plants and are easily sampled and determined (Hamilton 1995, 2005). Key species and community composition of these insects may help delimit the pre-settlement distribution of the sand prairie that now occurs as small patches in a mosaic of human development, abandoned agricultural fields, conifer plantations, oak openings and pine-barrens (Hauser 1953, Chapman and Crispin 1984, Hamilton 2005).

There are 208 species of Cicadellidae (Taboada 1964) and 19 species of Cercopidae in Michigan (Hanna and Moore 1966, Hanna 1970). Several species are designated by the state as "Special Concern" or "Threatened" in Michigan's sand prairies and pine-barrens including *Lepyronia gibbosa* Ball (Cercopidae) (Dunn et al. 2002). Although species lists for these two families exist for Michigan (Taboada 1964, Hanna and Moore 1966, Hanna 1970) there have been no recent or comprehensive surveys of the species on Michigan sand prairies.

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Sand prairies were once common in Muskegon, Newaygo, and Oceana Counties of west Michigan on old lake plains that are characterized by Sparta sandy loam (Hauser 1953, Chapman and Crispin 1984, Dunn et al. 2002). During the 19th century, the prairies were damaged first by agriculture, which failed due to dry and infertile soils, and later planted to conifers to reduce erosion. A survey of the region concluded that most of the remaining patches of prairie vegetation have been disturbed; few, if any, escaped cultivation (Chapman and Crispin 1984).

Sand prairies typically have low plant canopy coverage with spots of bare soil and abundant clumps of encrusted lichens (*Cladonia* spp.; Cladoniaceae). The dominant native grass is *Schizachyrium scoparium* (Michaux) Nash (Poaceae) with scattered patches of *Andropogon gerardi* Vitman (Poaceae) growing along more mesic edges. Other grasses or sedges include *Danthonia spicata* (L.) R. & S. (Poaceae), *Panicum* spp. (Poaceae), and often dense stands of *Carex pensylvanica* Lam. (Cyperaceae), the dominance of which has greatly increased in recent years (Winn and Kapp 1987, Dunn et al. 2002). These sites are also home to diverse native forbs including *Liatris* spp. (Asteraceae), *Asclepias* spp. (Asclepiadaceae), *Euphorbia corollata* L. (Euphorbiaceae), and *Viola pedata* L. (Violaceae) (see Winn and Kapp 1987). Several state "Threatened" plant species also occur on some of these sites including *Geum triflorum* Pursh. (Rosaceae), *Aster sericeus* Vent. (Asteraceae), and *Bouteloua curtipendula* (Michaux) Torrex. (Poaceae). Rare insects known to be on these sites include the state "Threatened" species, *L. gibbosa*, (Winn and Kapp 1987, Dunn et al. 2002), *Hesperia ottoe* W. H. Edwards (Hesperiidae) and *Speyeria idalia* (Drury) (Nymphalidae) (Nielsen 1999).

Knowledge of the species that inhabit a habitat may be important in ecosystem management. Several important ecological functions are related to species richness (Tilman and Downing 1994, Kinzig et al. 2001). Our objectives were to survey the sand prairies of Newaygo Co. for Cicadellidae and Cercopidae and to add to the known species for the area. It was not our intent to do a complete inventory of species, but to rank the quality of the remaining sites by comparing species richness and ecological indices and to add to a growing species list. Species composition of Cicadellidae and Cercopidae can also be used in determining which sites should be preserved, restored, or be assigned management priority (Hamilton 2005).

MATERIALS AND METHODS

We conducted a one sweep survey for Cicadellidae and Cercopidae on each of 12 sand prairies in Newaygo Co., MI, that were first described by Chapman and Crispin (1984) (Table 1). Each site still had a dominant cover of *S. scoparium* and a cover of diverse native forbs. Sampling occurred on 19, 20 or 24 July 2000. All days were warm and sunny. Collections were done between 1000-1500 hours. Diversity of these taxa is generally highest here in July when both early and late season species are present (Taboada 1964, Hanna 1970, Hamilton 1995). Importantly, most species are adults by mid-July which facilitates their determination. Insects were collected by sweeping (38 cm diam. net) through the plant canopy along meandering transects that were walked throughout the entire site for 15 minutes. Sweeping distances were recorded by a pace-calibrated pedometer and counts expressed per 500 m of linear vegetation. Heights of plants in these ecosystems are typically less than 40 cm.

Cercopidae were determined to species using the keys of Hanna and Moore (1966) and Hamilton (1975, 1982). Cicadellidae were identified first to genera by the regional key of Hamilton (unpublished), then to species by the keys of Beirne (1956), Ross and Hamilton (1972), Oman (1985), Whitcomb and Hicks (1988), Hamilton (1994, 1995, 1998, 1999) and Sinada and Blocker (1994). Voucher

Table 1. Sand prairies of Newaygo Co., MI, surveyed for Cicadellidae and Cercopidae in July 2000.

Site letter code, name of preserve, managing agency, township, and USGS coordinates
A Ore-Ida Preserve, Brooks Twp. (T12 N, R12 W, Sec 4, S1/2 of SE ¼).
B 40th at Locust St. prairie, Manistee National Forest, Croton Twp. (T13N R11W Sec 30 N1/2 of SE ¼).
C Cottonwood Road - Stearns prairie relict, Manistee National Forest, Croton Twp. (T12N R11 W Sec 10 E ½).
D Big Finger prairie - Little Scherrar prairie relict, Manistee National Forest, Brooks Twp. (T12N R12W Sec 35 SW ¼).
E Research Natural Area at Oak and 48th - Merengo relict, Manistee National Forest, Brooks Twp. (T12NR12W Sec 2).
F Oak and Poplar - Merengo prairie relict, Manistee National Forest, Brooks Twp. (T12NR12W Sec 2 W ½).
G Newaygo Prairie Preserve, Popular Rd, Michigan Nature Association, Brooks Twp. (T12N R12W Sec 2 SW ¼).
H Pine St. powerline - Big prairie relict, Consumers Power, Big Prairie Twp. (T13N R11W Sec 19 W ½).
I Newaygo bowl prairie - Michigan Nature Association, Brooks Twp. (T12N R12W Sec11 SW1/4).
J Newaygo Prairie Study Area - Little Scherrar relict, Manistee National Forest, Brooks Twp. (T12N R12W Sec35 NE ¼).
K Oak St. powerline - Little Scherrar prairie relict, Consumers Power, Brooks Twp. (T12NR12WSec26 SE ¼).
L Rollways prairie, Manistee National Forest, Brooks Twp. (T12NR12W Sec 27 S1/2).

specimens were deposited in the biological collections of Grand Valley State University. Plant nomenclature follows Gleason and Cronquist (1991).

Standard ecological diversity indices as described in Magurran (1988) and Krebs (1989) including the Simpson's Dominance Index (I) and the Brillouin Diversity Index (HB) were analyzed by EcoStat Software (Trinity Software Inc.) and results compared among all sites. Simpson's Dominance Index is best used to identify the ecological importance of a common species which occurs within a community that has a large number of rarer species (Magurran 1988, Krebs 1989), with higher calculated values indicating single species dominance. The Brillouin Diversity Index is best used when samples are drawn from a community in which few species are known (Pielou 1966) which was the case in this study. Higher values indicate higher species diversity. Individual prairies were ranked by species richness and abundance using the formula from Bomar (2001)

$$\sum 1/ (p/ N)$$

where p represents the total number of prairies inhabited by a given species and N is the total number of prairies (N = 12). This formula minimizes the importance of common species and favors those species that were less common. By summing the species present at a given site, a score was generated (Table 2). The highest score represents the highest quality for species diversity and inferentially the highest quality prairie. Bomar (2001) used this analysis with Acrididae to assess prairie quality in Wisconsin.

Relationships between prairie area and species richness (Table 2) were analyzed by Pearson correlations and then by Spearman rank order correlation test (Lehmann 1975) by comparing the four largest prairies (> 3 ha) to the eight smallest prairies (<3 ha) using Statistix (Analytical Software 2003).

Table 2. Species diversity rank, score and richness of Cicadellidae and Cercopidae from 12 sand prairies of Newaygo Co., MI, July 2000.

Prairie	Site code	Rank	Score	No. of species	Area (ha)
Big Finger	D	1	50.2	15	3.2
MNA – north	G	2	48.3	14	4.6
Rollways	L	3	36.1	13	.2
Cottonwood	C	4	27.0	17	3.6
MNA – south bowl	I	5	25.4	12	34.0
Pine St. power line	H	6	25.2	10	1.2
Newaygo Prairie Study Area	J	7	20.8	12	32.0
Ore-Ida	A	8	17.5	10	5.3
Oak St. power line	K	9	14.4	9	1.2
Oak and Poplar	F	10	14.1	9	1.7
Research Natural Area	E	11	13.3	9	8.2
Locust St.	B	12	10.9	7	4.2

RESULTS AND DISCUSSION

Seven species of Cercopidae (Table 3) were collected including a Michigan “Threatened” species, *L. gibbosa*, which was collected at nine sites. Two Cercopidae species of “Special Concern” in Michigan were collected including *Philaenarcys bilineata* (Say) at all sites and *Prosapia ignipectus* (Fitch) at two sites (Table 3). Two of the seven species are considered to be prairie specialists including *L. gibbosa* (Hamilton 1995, Panzer et al. 1995, Dunn et al. 2002) and *P. ignipectus*, considered a moderate prairie remnant dependant species (Panzer et al. 1995). The remaining four species are highly polyphagous upon prairie plants and also feed upon several species of woody plants and, so, are not prairie obligates (Hanna and Moore 1966; Hamilton 1982, 1995; Reed 1996). *P. ignipectus* is a new record for Newaygo Co. (Taboada 1964, Hamilton 1995).

Twenty species of Cicadellidae were collected (Table 3) with the dominant species being *Flexamia delongi* (Ross and Cooley), a prairie specialist (Panzer et al. 1995, Reed 1996) and a Michigan species of “Special Concern”. It was collected from all sites, with the highest counts of 66 individuals per 500 meter of swept vegetation on the bowl-prairie preserved by the Michigan Nature Association.

Other suspected prairie specialists as designated by Hamilton (1995) and Panzer et al. (1995) included *Laevicephalus unicoloratus* (Gillette and Baker) (Cicadellidae), which was collected from all sites and, *Auridius helvus* (Delong) (Cicadellidae), a new Michigan record that is listed as a species of “Greatest Need of Conservation” in Illinois suggesting that this species should be considered for listing in Michigan. Other new Michigan cicadellid records include *Athysanella longicauda* Beirne, *Acinopterus viridus* Ball, and *Limotettix osborni* (Ball). A new record for Newaygo Co., was *Diplocolenus configuratus* (Uhler) (Cicadellidae) (Hamilton 1995). Invasive species of leafhoppers were collected, including *Athysantus argentarius* Metcalf (Cicadellidae) at three sites and *Doratura stylata* (Boheman) (Cicadellidae) at four sites, especially at the Michigan Nature Association (MNA) bowl prairie (Table 3).

Species richness of Cercopidae and Cicadellidae among the sites ranged from 17 species at the Cottonwood Road prairie to just six species at the Locust St. prairie (Table 2). Other prairies with high species richness were the Big Finger prairie with 15 species and the MNA - North prairie preserve with 14 species. Counts per 500 m also varied among sites and ranged from 189 at the

Table 3. Number of each species per 500 meters of native vegetation as collected by sweep net sampling from 12 remnant dry sand prairies in Newaygo County, Michigan, July, 2000. Site letter codes: A = Ore-Ida Preserve, B = Locust St. prairie, C = Cottonwood Rd., D = Big Finger prairie, E = Research Natural Area at Oak and 48th, F = Oak and Poplar, G = Newaygo Prairie Preserve - Michigan Nature Association, H = Pine St. powerline - Big prairie relict, I = Newaygo bowl prairie - Michigan Nature Association, J = Newaygo Prairie Study Area, K = Oak St. powerline - Little Scherrar prairie relict, L = Rollways prairie.

Species	Prairies ^a												
	A	B	C	D	E	F	G	H	I	J	K	L	
a. Cicadellidae													
<i>Flexamia delongi</i> (Ross & Cooley) *+	11	8	20	1	12	16	66	9	13	18	15	28	
<i>Laevicephalus unicoloratus</i> (Gillette & Baker) *+	6	5	9	21	31	15	10	4	2	20	14	2	
<i>Latalus sayi</i> (Fitch)	3	0	10	3	5	2	16	0	3	6	9	4	
<i>Chlorotettix unicolor</i> (Fitch)	11	1	5	8	1	1	10	4	2	20	14	2	
<i>Athysanus argentatus</i> Metcalf	11	0	1	0	1	0	0	0	0	0	0	0	
<i>Diplocolenus configuratus</i> (Uhler)	11	0	6	3	3	0	7	0	0	2	1	1	
<i>Aceratagallia sanguinolenta</i> (Provancher)	0	1	0	6	0	0	10	2	18	4	2	2	
<i>Empoasca fabae</i> (Harris)	0	0	2	13	0	1	4	24	0	0	0	0	
<i>Doratura stylata</i> (Boheman)	0	0	1	1	0	0	0	0	44	1	0	0	
<i>Macrostelus fascifrons</i> (Stal)	0	0	1	2	0	1	0	0	1	1	0	0	
<i>Scaphytopius frontalis</i> (Van Duzee)	0	0	1	1	0	0	1	1	0	0	0	0	
<i>Athysanella longicauda</i> Beir. #	1	0	0	0	0	0	3	0	3	0	0	0	
<i>Draeculaecephala antica</i> (Walker)	0	0	0	1	0	0	1	0	0	0	0	1	
<i>Polyamia apicata</i> (Osborn)	0	0	0	0	0	0	1	0	0	0	0	0	
<i>Auridius helvus</i> (Delong) #	0	0	0	0	0	0	1	1	1	0	0	1	
<i>Acinopterus viridus</i> Ball #	0	0	0	0	0	0	0	1	0	0	0	0	
<i>Vestocephellus</i> sp.	0	0	1	0	0	0	0	0	0	0	0	0	
<i>Tinobregmus</i> sp.	0	0	1	0	0	0	0	0	0	0	0	0	
<i>Scleroracrus osborni</i> (Ball) #	0	0	0	1	0	0	0	0	0	0	0	0	
<i>Laevicephalus sylvestris</i> (Osborn and Ball)	0	0	0	0	0	0	0	0	0	1	0	0	

Table 3. Continued.

Species	Prairies ^a											
	A	B	C	D	E	F	G	H	I	J	K	L
b. Cercopidae												
<i>Lepyronia gibbosa</i> Ball ** +	8	0	60	22	0	0	2	2	15	5	4	8
<i>Philaenarcys bilineata</i> Say *	11	20	59	53	32	9	12	19	24	14	4	6
<i>Philaenus spumarius</i> L.	5	0	9	19	0	6	0	0	0	4	1	5
<i>Philaenus lineatus</i> L.	0	1	2	0	4	1	0	0	0	0	0	1
<i>Prosapia ignipectus</i> (Fitch) * +	0	0	1	0	0	0	0	0	2	0	0	0
<i>Aphophora parallela</i> (Say)	0	0	0	0	0	0	0	0	0	0	0	7
<i>Clastoptera obtuse</i> (Say)	0	0	0	0	1	0	0	0	0	0	0	0

* Michigan species of "Special Concern"

** Michigan "Threatened" species

+ prairie specialist (Hamilton 1995, Panzer et al. 1995)

New Michigan state record

Cottonwood prairie to 36 at the 40th and Locust St. prairie. Other prairies with high abundances of these taxa included the Big Finger prairie with 158 individuals and the MNA North prairie with 144 individuals collected.

Species dominance varied among sites with the highest Simpson's Dominance Index (I) values at the Locust St. prairie (B) with a value of 0.36, dominated by *P. bilineata*, Michigan "Threatened" species and, *F. delongi*, a Michigan species of "Special Concern" (Fig. 1). The dominance by these two species at this site may indicate its ecological importance even though its overall species diversity was the lowest (Table 2). The lowest dominance value of 0.14 was measured at the 42 ha. Newaygo Prairie Study Area (J) which had an even distribution of 12 species within the second largest site (Fig. 1 A).

Analysis of species diversity by the Brillouin index indicated that diversity of these taxa was highest at Big Finger (D), Newaygo Prairie Preserve (J) and the Cottonwood Rd. (C) (Fig. 1 B). The Big Finger and the Newaygo Prairie Preserve area are currently managed as prairie but the Cottonwood Rd. site is currently a general management unit of the Manistee National Forest. Our data indicate the importance for this site to be managed as prairie.

Inferential analysis of prairie quality using a species richness index (Bomar 2001) indicated that the two highest quality prairies were the Big Finger (D) with a score of 50.2 and the MNA - North prairie (G) with a score of 48.3. Both of these sites had the second and third highest number of species at 15 and 14, respectively. The Cottonwood Rd. prairie had the greatest number of species with 19 but ranked fourth in quality with a score of 27 (Table 2). Another prairie of high quality according to this index was the Rollways prairie (L). The lowest scoring prairies were the Research Natural Area (E) with a score of 13.3 and the Locust St. prairie with a score of 10.9 which indicated both low species richness and abundance.

The sites varied in area from 1.2 ha to 34 ha (Table 2). There was a positive correlation between area and number of species by Pearson correlation ($P = 0.053$) and the Spearman rank order correlation test for sites larger than 3 ha ($n = 4$) when compared to those less than 3 ha ($n = 8$) ($P < 0.001$). The three sites with the most species were seventh, fifth, and eighth in size, respectively (Table 2) The biodiversity-inferential score of the two largest sites (32 and 34 ha) ranked fifth and seventh among the 12 sites sampled (Table 2).

These results indicate the biological uniqueness of these sand prairies of Newaygo Co., as a total of nine sites with the state "Threatened" species and three species of "Special Concern", four sites with new state records, and two sites with new county records, were collected. An immediate concern is that the ecological quality of these sites is in decline due to woody plant encroachment, itself due to the elimination of natural fire, and in some cases by off-road vehicle use. The invasion of exotic species such as *Centaurea maculosa* Lam. (Asteraceae) and *Hypericum perforatum* L. (Clusiaceae) and the native species *C. pensylvanica*, which is more typical of the forest understorey, are competing with prairie plants (Dunn et al. 2002). These 12 sites in Newaygo Co. are some of the last remaining habitats for these rare species in Michigan, and if not soon preserved and more suitably managed, could be extirpated from Michigan. Similar sites have occurred in surrounding counties but most have been developed, indicating the overall importance of saving the Newaygo area prairies.

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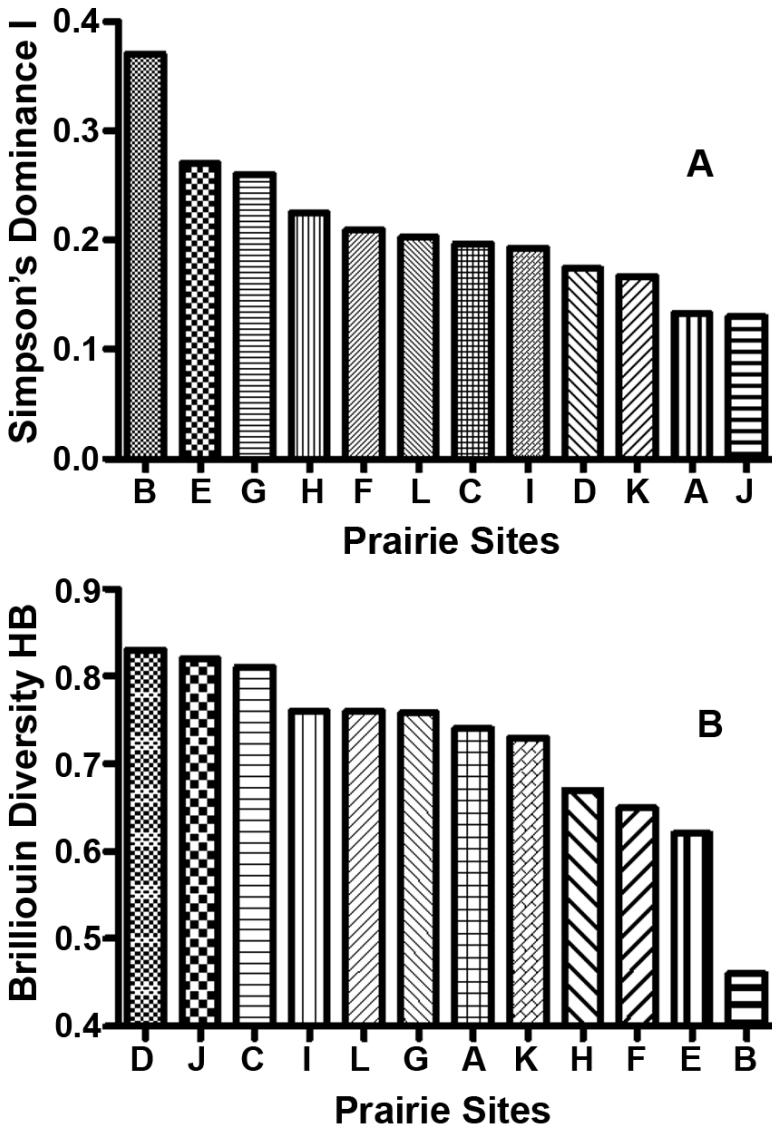


Figure 1. A comparison of Cicadellidae and Cercopidae species dominance and richness among 12 sand prairies in Newaygo Co., MI., July 2000 by A. the Simpson's Dominance Index (I) and B. the Brillouin (HB) Index. Site letter codes: A = Ore-Ida Preserve, B = Locust St. prairie, C = Cottonwood Rd. prairie, D = Big Finger prairie, E = Research Natural Area, F = Oak and Poplar, G = Newaygo Prairie Preserve - Michigan Nature Association, H = Pine St. powerline - Big Prairie relict, I = Newaygo south bowl prairie - Michigan Nature Association, J = Newaygo Prairie Study Area- Forest Service, K = Oak St. powerline - Little Scherrar prairie relict, L = Rollways prairie.

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