PROC. ENTOMOL. SOC. WASH.
111(2), 2009, pp. 354–360

A PRELIMINARY SURVEY OF THE PLANTHOPPERS (HEMIPTERA: FULGOROIDEA) OF COASTAL ALABAMA

ELIZABETH P. BENTON AND JOHN W. MCCREADIE

Department of Biological Sciences, Life Sciences Building Rm. 124, University of South Alabama, 307 University Blvd., Mobile, AL 36688-0002, U.S.A. (e-mail: jmccread@jaguar1.usouthal.edu)

Abstract.—The two counties that encompass coastal Alabama were divided into 25 plots, approximately 18 × 16 kilometers in size and surveyed using a single ethanol supplied Malaise trap in each plot. Traps were operated for 1-week intervals once a month from February 2004 through January 2005. Selection of trapping stations was based on sampling as wide a variety of landscape types as possible. Sites ranged from relatively undisturbed secondary forests to agriculturally active lands. A total of 44 species from eight families of Fulgoroidea (Acanaloniidae, Achilidae, Cixiidae, Derbidae, Delphacidae, Dictyopharidae, Flatidae, and Issidae) were collected. Thirty-four of these species were new state records, indicating that the planthopper fauna of Alabama is poorly known.

Key Words: Planthoppers, bioinventory, Gulf Coast

Communities are diffuse sets of individuals that gradually blend into one another and are not discrete, spatially distinct entities (Austin 1990). One of the most basic questions that can be asked in community ecology is what species live where. To address the question, "How do species partition space and resources?" community ecologists must conduct species inventories. This paper presents results of our preliminary inventory of planthoppers of coastal Alabama, an area that has received little attention. This study is part of a larger long-term project aimed at producing a preliminary bioinventory of the insects of coastal Alabama.

Planthoppers consist of twenty families within the superfamily Fulgoroidea (Auchenorrhyncha) (Wilson 2005). They are a diverse and widespread group, being found in every major biome and on all continents (except Antarctica) and form a monophyletic group (Asche 1987, Emeljanov 1991). Of the limited number of studies concerning planthoppers in the wild, the bulk has been taxonomic in nature (O'Brien 1971; Wheeler and Wilson 1987, 1988; Bourgoin 1993; Remes-Lenicov and Virla 1993). Despite the lack of attention to this group, they are an ideal taxon for examining habitat structure and its effects on community structure, since so many species tend toward monophagy (Sogawa 1982, O'Brien and Wilson 1985, Wilson et al. 1994). The families of interest in the current study are the Acanaloniidae, Achilidae, Cixiidae, Derbidae, Delphacidae, Dictyopharidae, Flatidae, and Issidae.

MATERIALS AND METHODS

The study area included all lands in Mobile and Baldwin counties, in south-

* Accepted by David R. Smith

Table 1. Malaise trap sites from Baldwin and Mobile counties, Alabama.

Site	Site Name	County	GPS - N	GPS - W
1	Grand Bay Savannah	Mobile	30 23.342	88 18.438
2	Dauphin Island Sea Lab	Mobile	30 14.800	88 04.609
3	Fort Morgan Road	Baldwin	30 14.476	87 51.339
4	Bon Secour	Baldwin	30 18.254	87 44.642
5	Gulf State Park	Baldwin	30 16.030	87 39.643
6	County Road 11	Mobile	30 25.346	88 20.895
7	Bellefontaine	Mobile	30 26.792	88 06.779
8	Auburn Research Station	Baldwin	30 33.213	87 52.462
9	Silverhill	Baldwin	30 31.693	87 44.101
10	Johnson Road	Mobile	30 38.722	88 17.723
11	Brookley	Mobile	30 38.263	88 03.771
12	Bayfront Park	Baldwin	30 37.691	87 55.155
13	County Road 54	Baldwin	30 33.838	87 46.361
14	Styx River	Baldwin	30 37.570	87 35.241
15	Wilmer	Mobile	30 47.640	88 21.488
16	University of Mobile	Mobile	30 47.223	88 07.477
18	Stapleton	Baldwin	30 43.851	87 47.859
19	Mason Ferry Road	Mobile	30 58.276	88 23.248
20	Chunchula	Mobile	30 53.963	88 11.874
22	Camp Sid Edmonds	Baldwin	30 59.710	87 47.526
23	Citronelle	Mobile	31 06.872	88 13.857
24	Camp Scoutshire	Mobile	31 02.895	88 10.757
25	Big Lizard Creek	Baldwin	31 08.114	87 43.734
27	Tensaw	Baldwin	31 10.067	87 46.004
28	Lillian Swamp	Baldwin	30 25.794	87 25.776

ern Alabama, from 30.22° to 31.31° N and from 87.37° to 88.44° W. These two counties comprise the coastline of Alabama and belong to the Coastal Plain Ecoregion (Omnermik 1995). This area consists of nearly level lowlands and low ridges with slopes generally less than two percent (Myers et al. 1986). The two counties were subdivided into 25 plots, each approximately 18 × 16 kilometers in size. Sites and GPS coordinates are listed in Table 1. Sites where no planthoppers were collected were not included in the table. Insects were sampled by placing a single ethanol supplied Malaise trap in each plot. Each trap operated for 1-week intervals once a month from February 2004 through January 2005. Selection of trapping stations was based on sampling as wide a variety of landscape types as possible, ranging from relatively undisturbed secondary forests to agriculturally active lands. Samples from Malaise traps were sorted in the laboratory for the families of interest. Taxonomic keys and resources used to identify specimens included Metcalf (1923, 1938), Doering (1938), Beamer (1946, 1951, 1955), Fennah (1950), McDermont (1952), BuBose (1960), Kramer (1977,1979, 1981, 1983, 1986), Wilson and McPherson (1980), Mead and Kramer (1982), Wilson (1982), Flynn and Kramer (1983), Caldwell and Martorell (1950), Asche and Wilson (1990), Freund and Wilson (1995) and Bartlettt and Dietz (2000). Most species identifications are based on male genitalia (O'Brien and Wilson 1985) with female identifications, when possible, used to augment the faunal list. Due to taxonomic difficulty, immatures were not identified. Males were identified by dissecting the genitalia, placing them in a 10% potassium hydroxide solution to dissolve the soft tissues, and viewing

them under a dissecting scope. Species identifications were confirmed by S. W. Wilson, University of Central Missouri, and voucher specimens are deposited in the University of South Alabama Arthropod Depository.

A species accumulation curve (rarefaction) was used to assess the effectiveness of the sampling protocol (Krebs 1999). Since the order of addition of a sample can influence the shape of the curve, a randomization procedure was used to produce a smooth curve. Curves were constructed by averaging 1000 random re-orderings of the data at each increasing unit of sampling effort. A single sample effort for this analysis was considered to be all species of planthoppers collected at a single site over the course of the study. The sampling effort was thus measured on a range from one to twenty-five. Ordinary Least Squares Regression was used to produce the equation and final form of the accumulation curve. The shape of the curve indicates the degree of taxonomic completeness of the sampling protocol. A curve that approaches a distinct asymptote, would be interpreted as an indicator that few additional species would be found with additional sampling. In contrast, a steep, rising curve, with little indication of 'leveling off' near or at the maximum number of samples indicates that additional samples would result in the capture of many additional species. The intent of the regression analysis was to determine whether the second order term (i.e., curvature toward an asymptote) was significant.

Results

Over the course of this study 44 species were collected in Mobile and Baldwin counties of which 34 were new state records (Table 2). The Delphacidae exhibited the highest diversity; thirteen species were identified. This group was followed by the Cixiidae (10), Derbidae (9), Achilidae (4), Flatidae (3), Issidae (2), Acanaloniidae (2), and Dictyopharidae (1). Only three species were present at more than 25% of the sites sampled, while 65% of all species collected were obtained from only one or two sites. Most species appeared restricted in both frequency and spatial distribution.

Results of the species accumulation curve/regression analysis showed both first-order (x) and second-order (x^2) terms were significant ($P < 0.001$) with an asymptotic leveling off of species richness with increased sampling effort (Fig. 1).

Discussion

Faunal surveys can be conducted following one of two broad methodologies (Stohlgren et al. 1995). High intensity sampling protocols usually focus on a particular group of insects at a small number of sites, and often relies on the investigators' knowledge of the taxa of interest. This methodology often lacks repeatable selection protocols and is subject to bias. When collecting the Auchenorrhyncha sweep nets have been a standard sampling method (Payne 1982). Ecologically designed inventories employ the systematic use of repeatable sampling protocols. These methods can provide community characterizations, such as species abundance and diversity (e.g., Longino and Colwell 1997). These low intensity protocols, which are often employed in survey work, increase the number of sites sampled and use a repeatable sampling method. The latter was used in the current study, with the advantage that the majority of species in a landscape are apt to be collected (e.g., Allsopp 1997). This is supported by our species accumulation curve, which indicated that few other species would have been collected with increased sampling effort, given the sampling methodology. Accordingly, most of the planthopper

Table 2. Planthopper species collected in Malaise traps from Baldwin and Mobile counties, Alabama, from March to December, 2004. Species with an asterisk are new state records. Site information is given in Table 1.

Family	Species	Sites
Acanaloniidae	*Acanalonia conica* Say	3, 4,15
Acanaloniidae	*Acanalonia servillei* Spinola*	6, 7, 9,10
Achilidae	*Catonia bicinctura* Van Duzee*	9, 23,24, 27
Achilidae	*Catonia carolina* Metcalf*	18
Achilidae	*Catonia pumila* Van Duzee	23,24,26,27,28
Achilidae	*Epiptera variegata* (Van Duzee)*	16
Cixiidae	*Bothriocera datuna* Kramer	13,20,26
Cixiidae	*Bothriocera maculata* Caldwell*	1,5
Cixiidae	*Haplaxius neopusillus* Kramer*	9
Cixiidae	*Oecleus productus* Metcalf*	19
Cixiidae	*Oliarus chuliotus* Ball*	3,11
Cixiidae	*Oliarus placitus* Van Duzee	4,7,9,14,20,22,26,28
Cixiidae	*Oliarus quinquelinaetus* (Say)	10
Cixiidae	*Pintalia delicata* (Fowler)*	9,11
Cixiidae	*Pintalia gurneyi* Kramer*	18
Cixiidae	*Pintalia vibex* Kramer	17,26
Delphacidae	*Delphacodes idonea* Beamer*	12
Delphacidae	*Delphacodes puella* (Van Duzee)*	2,11
Delphacidae	*Delphacodes sp* near *magna* (Van Duzee)	11
Delphacidae	*Liburniella ornata* (Stal)	24,27
Delphacidae	*Megamelus lobatus* Beamer*	7
Delphacidae	*Megamelus trifidus* Beamer*	7
Delphacidae	*Pissonotus aquilonius* Morgan & Beamer*	1
Delphacidae	*Pissonotus piceus* (Van Duzee)*	2,6
Delphacidae	*Prokelisia dolus* Wilson*	1
Delphacidae	*Pygospina spinata* (Caldwell)*	2
Delphacidae	*Sogatella molina* (Fennah)*	14,23
Delphacidae	*Stenocranus ramosus* Beamer*	26
Delphacidae	*Toya propinqua* (Fieber)*	1
Derbidae	*Anotia uhleri* (Van Duzee)*	16,19
Derbidae	*Apache degeerii* (Kirkaldy)*	6,19
Derbidae	*Cedusa carolinensis* Flynn & Kramer*	9,10,16,24,27
Derbidae	*Cedusa hedusa* McAtee*	1,9
Derbidae	*Cedusa shawi* Flynn & Kramer*	20
Derbidae	*Cedusa sp* near *xenga* (Kramer)	4,5,12
Derbidae	*Omolicna uhleri* (Ball)*	3
Derbidae	*Patara vanduzei* Ball*	4
Derbidae	*Sayiana sayi* (Ball)*	19
Dictyopharidae	*Nersia florens* Stal*	1
Flatidae	*Anormenis chloris* (Melichar)*	8,16,27
Flatidae	*Metcalfa pruinosa* (Say)*	3,7,10,12,16,23,28
Flatidae	*Ormenoides venusta* (Melichar)*	7,11,22,23
Issidae	*Thionia bullata* (Say)	4,17,19,25
Issidae	*Thionia elliptica* (Germar)*	3,10,16,18,22,23

species that could be collected in Malaise traps were most likely collected.

The planthopper fauna of Alabama is poorly known, as indicated by the fact that 34 out of the 44 species collected were new state records. Since most planthoppers do not cause significant economic impact in North America, few studies have addressed this group (O'Brien and Wilson 1985). Given that we used only one sampling protocol, the list of records for planthoppers for coastal Alabama

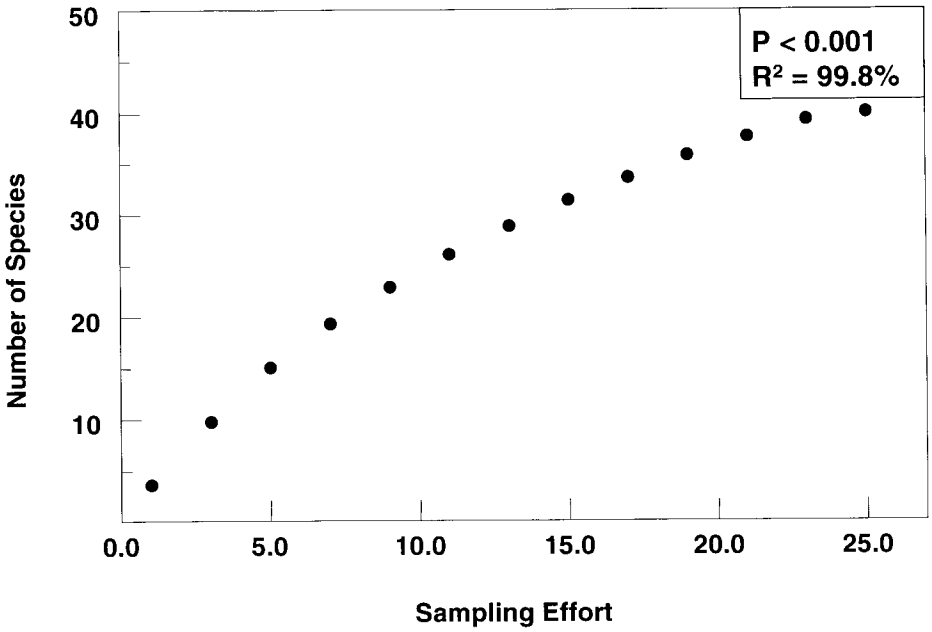

Fig. 1. Species accumulation curve for planthopper species collected in 25 Malaise traps in Mobile and Baldwin Counties, Alabama, from February 2004 through January 2005. The response variable is richness and the predictor variables are sampling effort and sampling effort squared. Coefficients for both first-order (x) and second-order (x^2) predictor terms were significant as well as the overall regression.

will no doubt increase as other collecting methods are employed. For example, 97 species have been recorded only from Great Smokey National Park (Gonzon et al. 2007). Over the entire southeastern US a total of 196 species from 11 species have thus far been recorded (Wilson 2005). Clearly, the results of this study suggest that further surveys of the planthopper fauna of Alabama are warranted and should yield a rich fauna.

Acknowledgments

We thank S. W. Wilson for his help with the taxonomy of this group. We also express our thanks G. Richard, S. Vojvodich, M. Caldwell, S. Sweetser, D. Benton, A. Pate, T. Rice, S. Major, J. Borden, A. Penney, P. McCarty, D. McCarty, and J. McCarty for their assistance in the field. Funding was provided by the National Oceanic and Atmospheric Administration and the Alabama State Lands Department.

Literature Cited

Allsopp, P. G. 1997. Probability of describing an Australian scarab beetle: influence of body size and distribution. Journal of Biogeography 24(6): 717–724.

Asche, M. 1987. Preliminary thoughts in the phylogeny of Fulgoromorpha (Homoptera: Auchenorrhyncha). Proceedings 6th International Auchenorrhyncha Meeting. University of Turin Press, Turin, Italy. pp. 47–53.

Asche, M. and M. R. Wilson. 1990. The delphacid genus *Sogatella* and related groups: a revision with special reverence to rice-associated species (Homoptera: Fulgoroidea). Systematic Entomology 15: 1–42.

Austin, M. P. 1990. Community theory and competition in vegetation, pp. 215–233. *In* J. B. Graceand and D. Tillman, eds. Perspectives in Plant Competition. Academic Press, New York.

Bartlett, C. and L. L. Deitz. 2000. Revision of the New World delphacid planthopper genus *Pissonotus* (Hemiptera: Fulgoroidea). Thomas Say Publications Entomological Monographs 234.

Beamer, R. H. 1946. The genus Stenocranus in America north of Mexico (Homoptera: Delphacinae). Journal of the Kansas Entomological Society 19: 1–11.

———. 1951. A review of the genus Kelisia in America north of Mexico with four new species (Homoptera: Fulgoridae: Delphacinae). Journal of the Kansas Entomological Society 24: 117–121.

———. 1955. A revision of the genus Megamelus in America north of Mexico (Homoptera: Fulgoridae: Delphacinae). Journal of the Kansas Entomological Society 28: 29–46.

Bourgoin, T. 1993. Female genitalia in Fulgoromorpha (Insecta, Hemiptera): morphological and phylogenetical data. Annals of the Society of Entomology of France 29: 225–244.

Caldwell, J. S. and L. F. Martorell. 1950. Review of the auchenorrhynchous Homoptera of Puerto Rico. Part II. The Fulgoroidea except Kinnaridae. Journal of Agriculture University Puerto Rico 4: 133–269.

Doering, K. C. 1938. A contribution to the taxonomy of the subfamily Issinae in America north of Mexico (Fulgoridae: Homoptera). Part II. University of Kansas Scientific Bulletin 25: 447–575.

DuBose, W. P. 1960. The genus *Delphacodes* Fieber in North Carolina (Homoptera: Delphacidae). Journal of the Elisha Mitchell Scientific Society 76: 36–63.

Emeljanov, A. F. 1991. An attempt to construct a phylogenetic tree for planthoppers (Homoptera: Cicadina). Entomology Review 70: 24–28.

Fennah, R. G. 1950. A generic revision of the Achilidae (Homoptera: Fulgoroidea) with descriptions of new species. Bulletin of the British Museum of Natural History, Entomology Series 1: 1–169.

Flynn, J. E. and J. P. Kramer. 1983. Taxonomic study of the planthopper genus *Cedusa* in the Americas (Homoptera: Fulgoroidea: Derbidae). Entomography 2: 121–260.

Freund, R. and S. W. Wilson. 1995. The planthopper genus *Acanalonia* in the United States (Homoptera: Issidae): morphology of male and female external genitalia. Insecta Mundi 9: 195–215.

Gorzon, A. T., C. R. Bartlett, and J. L. Bowman. 2007. Planthoppers (Hemiptera: Fulgoroidea) diversity in the Great Smokey Mountains National Park. Transactions of the American Entomological Society 132: 243–260.

Kramer, J. P. 1977. Taxonomic study of the planthopper genus *Oecleus* in the United States (Homoptera: Fulgoroidea: Cixiidae). Transactions of the American Entomological Society 103: 379–449.

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

———. 1981. Taxonomic study of the planthopper genus *Cixius* in the United States and Mexico (Homoptera: Fulgoroidea: Cixiidae). Transactions of the American Entomological Society 107: 1–68.

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

———. 1986. Supplement to a taxonomic study of the planthopper genus *Cedusa* in the Americas (Homoptera: Fulgoroidea: Derbidae). Entomography 4: 245–314.

Krebs, C. J. 1999. Ecological Methodology. 2nd ed. Addison Wesley Longman, New York.

Longino, J. T. and R. T. Colwell. 1997. Biodiversity assessment using structured inventory: capturing the ant fauna of a tropical rain forest. Ecological Applications, 1263–1277.

McDermott, B. T. 1952. A revision of the genus *Megamelanus* and its allies (Homoptera: Fulgoridae: Delphacinae). Journal of the Kansas Entomological Society 25: 41–49.

Mead, F. W. and J. P. Kramer. 1982. Taxonomic study of the planthopper genus *Oliarus* in the United States (Homoptera: Fulgoroidea: Cixiidae). Transactions of the American Entomological Society 107: 381–569.

Metcalf, Z. P. 1923. A key to the Fulgoridae of eastern North America. Journal of the Elisha Mitchell Scientific Society 38: 139–230.

———. 1938. The Fulgorina of Barro Colorado and other parts of Panama. Bulletin of the Museum of Comparative Zoology 82: 276–433, plates 1–23.

Myers, R. K., R. Zahner, and S. M. Jones. 1986. Forest habitat regions of South Carolina from Landsat Imagery. Department of Forestry. Forest Research Series 42: 1–31.

O'Brien, L. B. 1971. The systematics of the tribe Plectoderini in America north of Mexico (Homoptera: Fulgoroidea: Achilidae). University of California Publications in Entomology 64: 1–79.

O'Brien, L. B. and S. W. Wilson. 1985. Planthopper systematics and external morphology. *In* Nault, L. R. and J. G. Rodriguez, eds. The Leafhoppers and Planthoppers. John Wiley and Sons, New York.

Omernik, J. M. 1995. Ecoregions: a spatial framework for environmental managements, pp. 49–62. *In* Davis, W. S. and T. P. Simon, eds. Biological Assessment and Criteria. Boca Raton, Florida.

Payne, K. 1982. A comparison of the catches of Auchenorrhyncha (Homoptera) obtained from sweep-sampling and pitfall trapping. Entomological Monographs Magazine 117: 215–223.

Remes Lenicov, A. and E. Virla. 1993. Homopteros auquenorrincos asociados al cultiro de maiz en la Republica Argentina I. Familia Delphacidae. Proc. V. Congreso Nacionals II. Reunin Suramericana Maiz 92: 34–55.

Sogawa, K. 1982. The brown rice planthopper: Feeding physiology and host plant interactions. Annual Reviews in Entomology 27: 49–73.

Stohlgren, T. J., J. F. Quinn, M. Ruggiero, and G. S. Wagoner. 1995. Status of inventories in USnational parks. Biological Conservation 71: 97–106.

Wheeler, A. G. Jr. and S. W. Wilson. 1987. Life history of the issid planthopper *Thionia elliptica* (Homoptera: Fulgoroidea) with description of a new *Thionia* species from Texas. Journal of the New York Entomological Society 95: 440–451.

———. 1988. Notes on the biology and immatures of the issid planthoppers *Thionia bullata* and *T. simplex* (Homoptera: Fulgoroidea). Journal of the NewYork Entomological Society 96: 266–273.

Wilson, S. W. 1982. The planthopper genus Prokelisia in the United States (Homoptera: Fulgoroidea: Delphacidae). Journal of the Kansas Entomological Society 55: 532–546.

———. 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.

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

Wilson, S. W. and J. E. McPherson. 1980. Keys to the planthoppers, or Fulgoroidea, of Illinois (Homoptera). Transactions of the Illinois Academy of Science 73(2): 1–61.