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HABITAT ASSOCIATIONS OF FLORIDA GRASSHOPPERS (ORTHOPTERA: ACRIDIDAE)

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Abstract

A year-long survey was conducted to assess the grasshopper species assemblage in various natural and anthropogenic habitats in Florida. Distribution, density, and relative abundance data were collected, providing insight into habitat preference and resource utilization. Of the 70 species known to occur in Florida, 52 species were collected in one or more habitats. The number of different species found in each habitat, in descending order of species richness, were: sandhill, 34; freshwater marsh, 27; scrub, 26; roadside, 26; lakeside, 22; disturbed areas, 22; pasture, 19; pine plantation, 19; old fields, 18; flatwoods, 13; salt marshes, 11; oak hammock, 9; crops, 8; coastal scrub, 6; cutthroat seep; 5; and coastal strand, 5. Common species, and the number of habitats they were found to occupy, include *Schistocerca americana*, 12; *Aptenopedes sphenarioides*, 10; *Dichromorpha viridis*, 8; *Melanoplus propinquus*, 8; *Paroxya atlantica*, 8; *Achurum carinatum*, 7; *Amblytropidia mysteca*, 7; *Chortophaga australior*, 7; *Aptenopedes aptera* 6; *Melanoplus keeleri*, 5; *Melanoplus rotundipennis*, 5; *Orphulella pelidna*, 5; and *Spharagemon cristatum*, 5. Variation in habitat use within selected habitat types was demonstrated by (1) comparison of species richness and abundance on roadsides with grassy or weedy vegetation; weedy vegetation was inhabited by significantly more grasshoppers, and (2) comparison of species richness and abundance in pine plantations with pine trees of different ages; plantations with young trees had significantly more grasshoppers. In contrast, species richness was unaffected within these roadside and pine plantation sites.

Resumen

Se condujo una investigación durante un año para evaluar como están estructuradas las especies de saltamontes en varios hábitat naturales y antropogénicos en Florida. Se colectaron datos de distribución, densidad y abundancia relativa, proporcionando información en cuanto al hábitat de preferencia y la utilización de recursos. De las 70 especies reconocidas en Florida, 52 especies fueron colectadas en uno o más hábitat. El numero de especies diferentes encontradas en cada hábitat, en orden descendiente en cuanto a riqueza de especies, fue: cima arenosa, 34; pantanos de agua fresca, 27; arbustos, 26; bordes de caminos, 26; orillas de lagos, 22; áreas perturbadas, 22; pastizales, 19; plantación de pinos, 19; campos viejos, 18; bosques planos, 13; pantanos salinos, 11; plantación de robles en hamacas, 9; cultivos, 8; arbustos en la costa, 6; vegetación agresiva, 5; zonas costeras, 5. Las especies comunes, y el numero de hábitat en los que fueron encontrados, incluyen *Schistocerca americana,* 12; *Aptenopedes sphenarioides*, 10; *Dichromorphia viridis*, 8; *Melanoplus propinquus*, 8; *Paroxya atlántica*, 8; *Achurum carinatum*, 7; *Amblytropidia mysteca*, 7; *Chortophaga australior*, 7; *Aptenopedes aptera*, 6; *Melanoplus Keeleri*, 5: *Melanoplus rotundipennis*, 5; *Orphulella pelidna*, 5; y *Spharagemon cristatum*, 5. Variaciones en el uso de los hábitat, dentro de los tipos de hábitats seleccionados, se demostró por (1) comparación de la riqueza y abundancia de las especies en las orillas de los caminos con vegetación tipo pastos o maleza; la vegetación con maleza estaba habitada por un numero significativamente mayor de saltamontes, y (2) comparación de riquezas y abundancias de especies en plantaciones de pinos de diferentes edades; las plantaciones con los pinos mas jóvenes tuvieron significativamente mayor numero de saltamontes. En contraste, la riqueza de especies no fue afectada dentro de estos lugares a la orilla de los caminos y en las plantaciones de pinos.

An insect's habitat is the area of the environment that provides the resource requirements for a discrete phase of its life (Southwood 1987). Friauf (1953) noted that classification of orthopteran populations in relation to habitats has been a difficult problem, though it is apparent that assemblages of grasshoppers will vary in density and species composition in relation to differences in vegetation, soil, temperature and humidity of the habitat (Pfadt 1984). Friauf (1953) found it most satisfactory to associate orthopteran fauna with habitat classification based on the dominant flora.

Vegetation seems to be the key requisite in determining the presence of grasshoppers. For example, Anderson (1964) concluded that vegetation had a definite influence upon grasshopper distribution because grasshoppers were never found in areas that were lacking their preferred hosts, and the occupation of the habitat was also influenced by the physical structure of the vegetation. Also,

Fielding & Brusven (1992) confirmed through food and habitat preferences that host plants and their characteristics influence the distribution of grasshoppers. Joern (1979) indicated that plant species may influence aspects of the grasshopper's life to include microhabitat choice and life history in relation to plant phenology. Grasshopper presence and species richness are positively correlated to the number of plant species in different types of habitats (Kemp et al. 1990, Otte & Joern 1977). Crypsis can also affect habitat selection because coloration and texture of the background affect the ability of grasshoppers to evade predators (Joern 1980). Although many authors have suggested that habitats affect grasshopper populations, there are few data available for southeastern species. Only Rehn and Hebard (1916), Blatchley (1920), and Friauf (1942, 1953) have provided detailed information on habitat of Florida grasshoppers, although the work of Dakin and Hays (1970) in nearby Alabama provides relevant information. In this report the association of grasshoppers with some of Florida's distinctive habitats was determined.

Materials and Methods

Several habitats that can be positively identified by the presence of key plant species were identified, and grasshoppers were collected from representative sites. Habitats included coastal strand, coastal scrub, salt marsh, freshwater marsh, lakeside, cutthroat seep, flatwoods, oak hammock, scrub, sandhill, roadside, crops, pine plantations, pasture, disturbed areas (formerly sandhill), and old fields (formerly crops or pastures). The classification systems of the Florida Natural Areas Inventory (1990) and the Soil and Water Conservation Society (1989) were used to define the natural habitats.

The habitat sites included in this study were sampled about twice per month for local sites (sandhill, lakeside, roadsides, pine plantations and pastures), about once per month for more distant locations (salt marsh, freshwater marsh, flatwoods, oak hammocks, scrub, crops, disturbed areas and old fields), and some habitats were rarely accessed (2 visits to an east and west coast coastal strand, 1 visit to coastal scrub and 1 visit to a cutthroat seep). The counties sampled and the number of habitat samples were: sandhill (Clay 4, Highlands 2, Hernando 2, Levy 12, Leon 1, Marion 1, St. Johns 1); freshwater marsh (Alachua 3, Clay 2, Levy 1, Marion 2, Orange 1); scrub (Highlands 2, Lake 1, Levy 4, Marion 4, Polk 1); roadside (Alachua 30, Levy 1); lakeside (Alachua 14, Clay 1, Leon 1); disturbed (Alachua 11, Marion 1); pasture (Alachua 23, Clay 1); pine plantations (Alachua 31); old field (Alachua 10, Levy 1); flatwoods (Alachua 11, Highlands 1); salt marsh (Levy 12); oak hammock (Alachua 10); crops (Alachua 10); coastal scrub (Flagler 1); cutthroat seep (Highlands 1); coastal strand (Flagler 1, Pinellas 1). More complete description of sample sites is provided by Squitier (1999). The crops sampled were corn, wheat, tomato, tobacco, cotton, beans and sugar cane. The collecting occurred over a one-year period (April 1997 to April 1998) to ensure that all species that occur could be collected. The grasshoppers were identified and abundance recorded immediately in the case of adults, but nymphs were reared in the laboratory until they were adults and could be positively identified.

The sites were sampled by collecting at each site for 50 minutes with a sweep net (by JMS), use of a collecting time period similar to that used by Joern (1979). Grasshoppers were sighted as they dispersed away from the collector, and collected with the net. Sweep net sampling is the most commonly used method to estimate grasshopper species composition (Capinera & Sechrist 1982, Evans 1989, Thompson 1987, Kemp et al. 1990). Densities at each site were estimated by walking a 100 m transect and counting the grasshoppers that moved as they were disturbed. The proportional data obtained from sweep net samples and the abundance data from the 100 m transect were combined to estimate the abundance of each species at each sampling interval. Such sampling is imperfect due to different densities of vegetation and grasshoppers, and different behaviors displayed by grasshoppers. However, it is the most practical and widely used approach to grasshopper population estimation.

Species determinations and density data were used not only to determine habitat associations, but also to make comparisons between different forms of the same habitat. Two such comparisons were made between roadsides with a uniform stand of grass versus roadsides with mixtures of grass and forbs, and also among pine plantations of different ages. One roadside plot of each roadside type was sampled in spring (3 dates in March) and summer (August, September, October) with dates treated as replicates. The density sampling periods for the roadside habitats were with repeated measures ANOVA. Also, a linear regression was conducted to determine if there was a relationship between the number of species found in a habitat and the number of collections from that habitat. Statistical analyses were performed using Instat (Graph Pad Software, San Diego CA).

The categories assigned for the pine plantations (one plantation in each category) were based on tree diameter: small (mean of 3.2 cm), medium (mean of 15.3 cm), and large (mean of 21.0 cm). The pine plantations were sampled on five dates in 1997 (June, August, October (2), November) with dates treated as replicates. The densities of grasshoppers among the different aged pine plantation plots were analyzed by repeated measures

ANOVA. A linear regression analysis was conducted to assess the relationship between tree diameter and grasshopper population density. Where appropriate, means were separated with a Tukey-Kramer multiple comparison test (P = 0.05). Statistical analysis was performed using Instat (Graph Pad Software, San Diego CA).

Results and Discussion

In the course of this year-long study, 52 of the 70 species known to occur in Florida were collected, and a total of 9,049 grasshoppers were collected from the various habitats. The actual number and percentage of the total catch for each species is displayed in Table 1. Through repeated collecting from various habitats it was possible to compile a list of the grasshopper species typically found in each natural habitat type (Table 2) and anthropogenic (created by humans) habitat type (Table 3). The number of different species found in each habitat follow, in descending order of species richness: sandhill, 34; freshwater marsh, 27; scrub, 26; roadside, 26; lakeside, 22; disturbed areas, 22; pasture, 19; pine plantation, 19; old fields, 18; flatwoods, 13; salt marshes, 11; oak hammock, 9; crops, 8; coastal scrub, 6; cutthroat seep; 5; and coastal strand, 5. In a study of orthopteran populations in habitats found in the Welaka area (Putnam County), Friauf (1953) also found that sandhill habitat had the largest assemblage of species. Nevertheless, most habitats contained a large assemblage of grasshopper species. There was a strong positive correlation between the number of times a habitat was sampled and the number of grasshopper species collected (r = 0.653; P = 0.006). The correlation probably would not have been significant if a greater number of samples had been taken from the coastal scrub, cutthroat seep and coastal strand—habitats that were undersampled due to distance. When habitats with less than 10 samples were deleted from the correlation analysis, there was no significant relationship between sample frequency and species richness (r = 0.41; F = 2.2; P = 0.16), supporting the concept that many Florida habitats contain a robust assemblage of grasshopper species.

The dominant (at least 2% of the assemblage) grasshopper species in sandhill habitats, and the proportion of each in the total sample were: *Achurum carinatum* 12%, *Amblytropidia mysteca* 8%, *Aptenopedes aptera* 4%, *Aptenopedes sphenarioides* 9%, *Arphia granulata* 4%, *Eritettix obscurus* 25%, *Melanoplus keeleri* 4%, *Melanoplus rotundipennis* 10%, *Schistocerca americana* 4%, and *Syrbula admirabilis* 5%.

The dominant grasshopper species in freshwater marsh habitats, and the proportion of each in the total sample were: *Aptenopedes sphenarioides* 10%, *Dichromorpha elegans* 11%, *Dichromorpha viridis* 2%, *Eotettix signatus* 7%, *Gymnoscirtetes pusillus* 27%, *Leptysma marginicollis* 7%, *Mermiria intertexta* 4%, *Paroxya atlantica* 7%, *Paroxya clavuliger* 12%, and *Stenacris vitreipennis* 6%.

The dominant grasshopper species in scrub habitats, and the proportion of each in the total sample were: *Achurum carinatum* 7%, *Aptenopedes aptera* 15%, *Aptenopedes sphenarioides* 10%, *Melanoplus forcipatus* 7%, *Melanoplus rotundipennis* 9%, *Melanoplus tequestae* 8%, *Orphulella pelidna* 3%, *Schistocerca alutacea* 20%, *Spharagemon crepitans* 7%, and *Spharagemon marmorata* 4%.

The dominant grasshopper species in roadside habitats, and the proportion of each in the total sample were: *Aptenopedes sphenarioides* 4%, *Arphia granulata* 5%, *Chortophaga australior* 23%, *Dichromorpha viridis* 7%, *Melanoplus keeleri* 5%, *Melanoplus propinquus* 9%, *Mermiria intertexta* 7%, *Orphulella pelidna* 7%, *Paroxya atlantica* 5%, and *Schistocerca americana* 19%.

The dominant grasshopper species in lakeside habitats, and the proportion of each in the total sample were: *Aptenopedes sphenarioides* 4%, *Chortophaga australior* 2%, *Dichromorpha elegans* 2%, *Dichromorpha viridis* 7%, *Gymnoscirtetes pusillus* 9%, *Leptysma marginicollis* 3%, *Paroxya atlantica* 5%, *Paroxya clavuliger* 5%, *Schistocerca americana* 2%, and *Stenacris vitreipennis* 50%.

The dominant grasshopper species in disturbed habitats, and the proportion of each in the total sample were: *Achurum carinatum* 17%, *Amblytropidia mysteca* 6%, *Aptenopedes aptera* 7%, *Arphia granulata* 3%, *Melanoplus keeleri* 5%, *Melanoplus propinquus* 3%, *Melanoplus rotundipennis* 9%, *Orphulella pelidna* 3%, *Schistocerca alutacea* 2%, *Schistocerca americana* 5%, *Schistocerca damnifica* 10%, *Spharagemon crepitans* 2%, *Spharagemon cristatum* 2%, and *Spharagemon marmorata* 5%.

The dominant grasshopper species in pasture habitats, and the proportion of each in the total sample were: *Amblytropidia mysteca* 2%, *Chortophaga australior* 21%, *Dichromorpha viridis* 32%, *Melanoplus bispinosus* 5%, *Melanoplus propinquus* 10%, *Melanoplus sanguinipes* 2%, *Orphulella pelidna* 9%, *Paroxya atlantica* 6%, and *Schistocerca americana* 11%.

The dominant grasshopper species in pine plantation habitats, and the proportion of each in the total sample were: *Achurum carinatum* 10%, *Amblytropidia mysteca* 27%, *Aptenopedes sphenarioides* 5%, *Dichromorpha viridis* 8%, *Melanoplus keeleri* 4%, *Melanoplus propinquus* 11%, *Paroxya atlantica* 11%, *Schistocerca americana* 15%, *Schistocerca damnifica* 5%, and *Spharagemon cristatum* 2%.

The dominant grasshopper species in old field habitats, and the proportion of each in the total sample were: *Amblytropidia mysteca* 5%, *Aptenopedes sphenarioides* 3%, *Chortophaga australior*

TABLE 1. SPECIES OF GRASSHOPPERS COLLECTED IN THE STUDY AND THEIR ABUNDANCE.

Species	Number collected	Percent of total collected
Achurum carinatum (F. Walker)	418	4.62
Amblytropidia mysteca (Saussure)	613	6.77
Aptenopedes aptera Scudder	365	4.03
Aptenopedes sphenarioides Scudder	454	5.02
Arphia granulata (Saussure)	144	1.59
Arphia xanthoptera (Burmeister)	1	0.01
Chortophaga australior (Rehn & Hebard)	647	7.15
Dichromorpha elegans (Morse)	193	2.13
Dichromorpha viridis (Scudder)	582	6.43
Dissosteira carolina (Linnaeus)	1	0.01
Eotettix signatus Scudder	24	0.27
Eritettix obscurus(Scudder)	251	2.77
Gymnoscirtetes pusillus Scudder	257	2.84
Hesperotettix floridensis Morse	7	0.08
Hesperotettix osceola Hebard	9	0.10
Hippiscus ocelote (Saussure)	7	0.08
Leptysma marginicollis (Serville)	56	0.62
Melanoplus apalachicolae Hubbell	13	0.14
M. bispinosis Scudder	85	0.94
M. davisi (Hebard)	1	0.01
M. forcipatus Hubbell	26	0.29
M. impudicus Scudder	1	0.01
M. keeleri (Thomas)	240	2.65
M. ordwayae Deyrup	5	0.06
M. propinquus Scudder	727	8.03
M. puer (Scudder)	9	0.10
M. querneus Rehn & Hebard	4	0.04
M. rotundipennis Scudder	208	2.30
M. sanguinipes (Fabricius)	117	1.29
M. strumosus Morse	1	0.01
M. tequestae Hubbell	31	0.34
M. withlacoocheensis Squitier & Deyrup	9	0.10
Mermiria intertexta Scudder	94	1.04
Mermiria picta (F. Walker)	10	0.11
Metaleptea brevicornis (Johannson)	8	0.09
Orphulella pelidna (Burmeister)	329	3.64
Pardalophora phoenicoptera (Burmeister)	55	0.61
Paroxya atlantica Scudder	597	6.60
Paroxya clavuliger (Serville)	105	1.16
Psinidia fenestralis (Serville)	36	0.40
Romalea microptera (Beauvois)	136	1.50
Schistocerca alutacea (Harris)	149	1.65
S. americana (Drury)	1062	11.74
S. ceratiola Hubbell & Walker	3	0.03
S. damnifica (Saussure)	259	2.86
S. obscura (Fabricius)	10	0.11
Spharagemon crepitans (Saussure)	51	0.56
Spharagemon cristatum (Scudder)	176	1.94
Spharagemon marmorata (Scudder)	54	0.60
Stenacris vitreipennis (Marschall)	315	3.48
Syrbula admirabilis (Uhler)	90	0.99
Trimerotropis maritima (Harris)	4	0.04

3%, *Dichromorpha viridis* 4%, *Melanoplus propinquus* 33%, *Paroxya atlantica* 9%, *Schistocerca americana* 25%, and *Schistocerca damnifica* 4%.

The dominant grasshopper species in flatwoods habitats, and the proportion of each in the total sample were: *Achurum carinatum* 5%, *Aptenopedes*

TABLE 2. SPECIES PRESENCE IN ASSOCIATION WITH NATURAL HABITATS. SH IS SANDHILL, FM IS FRESHWATER MARSH, S IS SCRUB, LS IS LAKESIDE, F IS FLATWOODS, SM IS SALTMARSH, OH IS OAK HAMMOCK, CS IS COASTAL STRAND, CSC IS COASTAL SCRUB, AND CSP IS CUTTHROAT SEEP.

Species	SH	FM	S	LS	F	SM	OH	CS	CSc	CSp
Achurum carinatum	X	X	X	X	X	X				X
Amblytropidia mysteca	X	X			X	X	X			
Aptenopedes aptera	X	X	X	X	X		X		X	
Aptenopedes sphenarioides	X	X	X	X	X	X	X			
Arphia granulata	X	X	X	X						
Arphia xanthoptera	X									
Chortophaga australior	X	X	X	X	X	X		X		
Dichromorpha elegans		X	X	X		X				X
Dichromorpha viridis	X	X		X			X			
Eotettix signatus		X								
Eritettix obscurus	X		X	X						
Gymnoscirtetes pusillus	X	X		X	X					X
Hesperotettix floridensis		X	X							
Hesperotettix osceola	X		X							
Leptysma marginicollis	X	X		X						
Melanoplus apalachicolae	X									
M. bispinosis		X	X							
M. davisi	X									
M. forcipatus			X							
M. impudicus	X									
M. keeleri	X		X		X				X	
M. ordwayae	X									
M. propinquus	X	X	X					X	X	
M. puer	X		X							
M. querneus							X			
M. rotundipennis	X		X	X	X		X			
M. sanguinipes				X						
M. strumosus	X									
M. tequestae			X							
M. withlacoochensis	X									
Mermiria intertexta		X		X		X		X		X
Mermiria picta	X									
Metaleptea brevicornis		X		X						
Orphulella pelidna	X	X	X	X		X				
Pardalophora phoenicoptera	X	X								
Paroxya atlantica		X		X		X				
Paroxya clavuliger		X		X						
Psinidia fenestralis	X	X	X	X						
Schistocerca alutacea	X	X	X	X	X				X	
S. americana	X	X	X	X	X	X	X	X		
S. ceratiola	X		X							
S. damnifica	X	X	X	X	X	X	X			
S. obscura		X				X				
Spharagemon crepitans	X		X				X			
Spharagemon cristatum	X		X						X	
Spharagemon marmorata	X		X						X	
Stenacris vitreipennis		X		X	X					
Syrbula admirabilis	X	X	X		X					X
Trimerotropis maritima								X		

aptera 45%, *Aptenopedes sphenarioides* 15%, *Gymnoscirtetes pusillus* 10%, *Melanoplus rotundipennis* 3%, *Schistocerca alutacea* 7%, *Schistocerca americana* 3%, and *Schistocerca damnifica* 4%.

The dominant grasshopper species in saltmarsh habitats, and the proportion of each in the total sample were: *Aptenopedes sphenarioides* 2%, *Dichromorpha elegans* 24%, *Mermiria inter-*

TABLE 3. SPECIES PRESENCE IN ASSOCIATION WITH ANTHROPOGENIC SITES. RS IS ROADSIDE, DA IS DISTURBED AREA, P IS PASTURE, PP IS PINE PLANTATION, OF IS OLD FIELD AND C IS CROPS.

Species	RS	DA	P	PP	OF	C
Achurum carinatum	X	X		X	X	
Amblytropidia mysteca	X	X	X	X	X	
Aptenopedes aptera	X	X		X		
Aptenopedes sphenarioides	X	X	X	X	X	
Arphia granulata	X	X	X	X		
Chortophaga australior	X	X	X	X	X	X
Dichromorpha elegans			X	X		
Dichromorpha viridis	X		X	X	X	X
Dissosteria carolina	X					
Eotettix signatus		X				
Eritettix obscurus		X				
Hesperotettix floridensis	X				X	
Hippiscus ocelote	X		X			
M. bispinosis	X	X	X	X	X	X
M. keeleri	X	X	X	X	X	
M. propinquus	X	X	X	X	X	X
M. rotundipennis	X	X	X			
M. sanguinipes	X		X		X	X
Mermiria intertexta	X			X	X	
Orphulella pelidna	X	X	X	X	X	
Pardalophora phoenicoptera	X	X	X			
Paroxya atlantica	X		X	X	X	X
Psinidia fenestralis	X	X		X		
Romalea microptera	X					
Schistocerca alutacea		X	X			
S. americana	X	X	X	X	X	X
S. damnifica	X	X	X	X	X	
S. obscura					X	
Spharagemon crepitans		X				
Spharagemon cristatum	X	X	X	X	X	X
Spharagemon marmorata		X				
Syrbula admirabilis	X	X		X		
Trimerotropis maritima	X				X	

texta 3%, *Orphulella pelidna* 25%, *Paroxya atlantica* 44%, and *Schistocerca americana* 2%.

The dominant grasshopper species in oak hammock habitats, and the proportion of each in the total sample were: *Amblytropidia mysteca* 3%, *Aptenopedes aptera* 27%, *Aptenopedes sphenarioides* 6%, *Dichromorpha viridis* 2%, *Melanoplus querneus* 4%, *Melanoplus rotundipennis* 23%, *Schistocerca americana* 17%, *Schistocerca damnifica* 12%, and *Spharagemon crepitans* 7%.

The dominant grasshopper species in crop habitats, and the proportion of each in the total sample were: *Chortophaga australior* 2%, *Melanoplus propinquus* 9%, *Melanoplus sanguinipes* 29%, *Schistocerca americana* 23%, and *Spharagemon cristatum* 37%.

The dominant grasshopper species in coastal scrub habitats, and the proportion of each in the total sample were: *Aptenopedes aptera* 36%, *Melanoplus keeleri* 20%, *Melanoplus propinquus* 15%, *Schistocerca americana* 22%, *Spharagemon cristatum* 2% and *Spharagemon marmorata* 3%.

The dominant grasshopper species in cutthroat seep habitats, and the proportion of each in the total sample were: *Achurum carinatum* 14%, *Dichromorpha elegans* 62%, *Gynoscirtetes pusillus* 16%, *Mermiria intertexta* 3%, and *Syrbula admirablis* 5%.

The dominant grasshopper species in coastal strand habitats, and the proportion of each in the total sample were: *Chortophaga australior* 17%, *Melanoplus propinquus* 10%, *Mermiria intertexta* 19%, *Schistocerca americana* 49%, and *Trimerotropis maritima* 5%.

Some species of grasshoppers are capable of occupying many habitats while others apparently occur in one or two habitats. Among the dominant species (arbitrarily set at 2% or greater of the species assemblage), *Schistocerca americana and Aptenopedes sphenarioides* were found inhabiting the largest number of habitats, 12 and 10, respectively. Other common species, and the number of habitats they were found to occupy, include *Dichromorpha viridis*, 8; *Melanoplus propinquus*,

8; *Paroxya atlantica*, 8; *Achurum carinatum*, 7; *Amblytropidia mysteca*, 7; *Chortophaga australior*, 7; *Aptenopedes aptera*, 6; *Melanoplus keeleri*, 5; *Melanoplus rotundipennis*, 5; *Orphulella pelidna*, 5; and *Spharagemon cristatum*, 5. Nevertheless, nearly all habitats have a robust species assemblage. Other than the few habitats sampled infrequently, we typically recovered 10-30 species from each habitat. Salt marsh habitat is a possible exception, however. Interestingly, the species that were most commonly encountered in anthropogenic habitats (*Chortophaga australior*, *Dichromorpha viridis*, *Melanoplus propinquus*, *Paroxya atlantica*, and *Schistocerca americana*) generally were not the species most frequently encountered in native habitats. The exception is *Schistocerca americana*, which apparently adapts to nearly all Florida habitats. Another obvious pattern is that some species tend to attain greatest abundance in wet habitats: *Achurum carinatum*, *Dichromorpha elegans*, *Gymnoscirtetes pusillus, Mermiria intertexta*, and *Paroxya atlantica*. *Romalea microptera* also is commonly found in hydric habitats (Friauf 1942) though it was infrequent in these studies.

Species assemblages are not completely consistent within habitat types. For example, sampling of sandhill habitats from around the state showed the absence or presence of some grasshopper species that are restricted to particular locations, though most of the other species present were the same from location to location. Similarly, grasshopper assemblages in cropland apparently varied according to weed management practices, with weedy fields typically having more species present. Fertilizing and grazing of areas such as pastures can also affect grasshopper numbers (Wingerden et al. 1992, Capinera and Sechrist 1982). To demonstrate the nature of variability among sites of the same habitat type, but with varying floral components, we analyzed the species assemblage of roadside and pine plantation habitats.

Comparison of Roadsides

Comparison of roadside grasshopper populations showed that significantly ($F = 9.31$, $df = 1,5$; $P = 0.028$) more grasshoppers occurred in the plots containing weedy plant populations (forbs) than in stands of pure grass, 61.2 per transect and 33.8 per transect, respectively.

The number of species present did not differ greatly between weedy and grassy roadsides. Weedy plant plots had 16 species present, only one more than the grassy plots. Comparison of the abundance of the most abundant grasshopper species collected in the two roadside plots is shown in Figure 1. The weedy plots differed from the grassy plots by the presence of *Achurum carinatum*, *Arphia granulata*, *Mermeria intertexta* and *Schistocerca damnifica* and the absence of *Hippiscus ocelote*, *Melanoplus sanguinipes* and *Psindia fenestrailis*. The increased cover and variety of food provided by the plants of the weedy plots may allow larger populations of grasshoppers. The grassy plots seem to be a place for the nymphs to develop due to the high percentage of nymphs in the grass (62%), whereas in the weedy plots it was 14%. In Florida, Capinera et al. (1997) reported higher densities of grasshoppers in weedy areas than in grass pastures, and also noted a skewed population distribution, with a high percentage of nymphs in grass areas. They suggested that avian predation might account for the disappearance of grasshoppers before they achieved the adult stage.

In some cases, there are practical implications associated with roadside plant management. Olfert et al. (1994), Bird and Romanow (1966) and Davis (1949) all reported that weedy roadsides contained more grasshoppers, including crop-feeding species. These authors observed that planting roadsides and field margins with grass, or eliminating weeds from such areas, reduced the number of grasshoppers in crop fields. In the case of roadside grasshopper populations in Florida, at least one important crop-feeding species, *Schistocerca americana*, was more abundant in weedy roadsides. Thus, the benefits of weed reduction for protection from crop-feeding grasshoppers reported elsewhere also extends to Florida.

Comparison of Pine Plantations

Pine plantations were examined for the relative difference in species composition and abundance among stands of different ages. The plantations were separated based upon average tree diameter in a plot, which is positively related to tree age and height. The different ages of the plots supplied various sized canopies that allowed various levels of sunlight penetration, promoting weedy undergrowth in younger plots whereas the more dense canopies of the large trees restricted the sunlight and allowed an understory consisting of only 1 or 2 grass species. Thinner canopies allowed more sunlight to reach the ground, encouraging weedy undergrowth that supported many more grasshoppers. This is illustrated in the high grasshopper densities in the small tree (young) plots and in the presence of forb-feeders such as *Melanoplus propinquus* and *Spharagemon cristatum* (Fig. 2). The ratio of grasshoppers among the plots of small, medium, and large trees was 8:1.2:1.0. A repeated measures ANOVA was performed to analyze the differences between grasshopper densities in the small, medium and large tree plots. There was a statistically significant difference, $F = 35.03$; $df = 2,4$; $P = 0.0001$. A Tukey-Kramer multiple comparisons test was conducted to identify the specific differences. The small tree-containing groves (80.3 grasshoppers

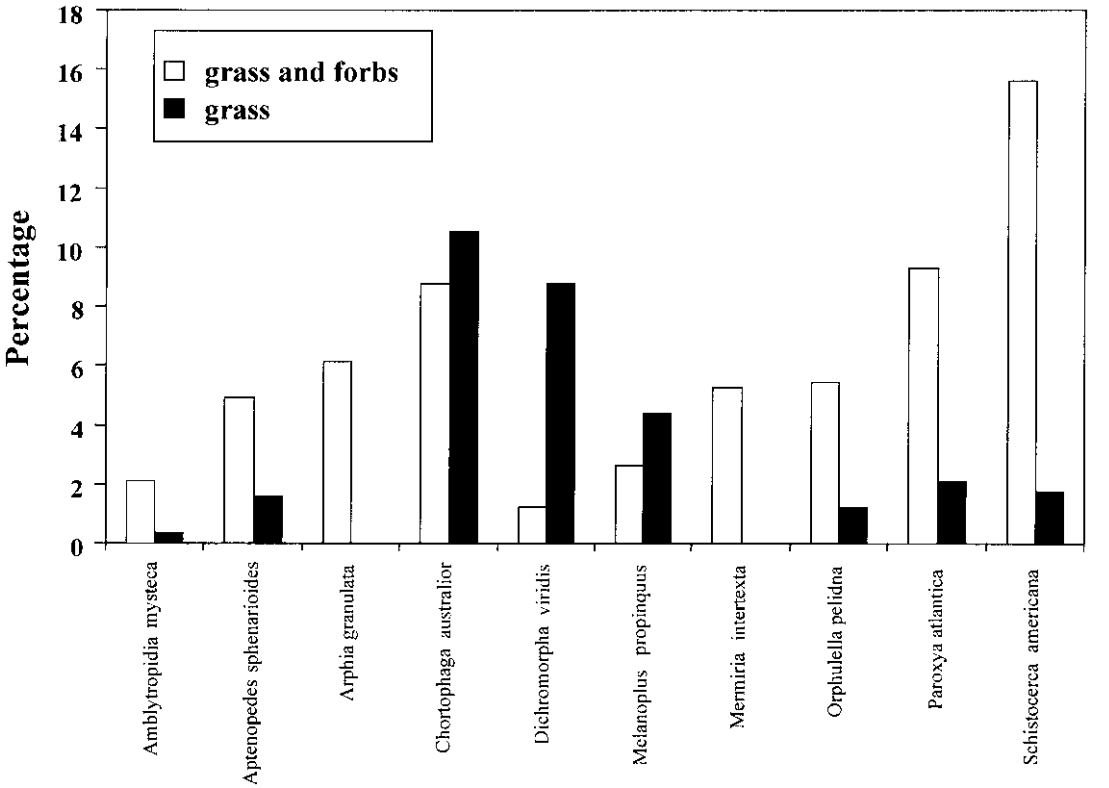

Fig. 1. Proportions of common grasshopper species associated with weedy and grassy roadside habitats.

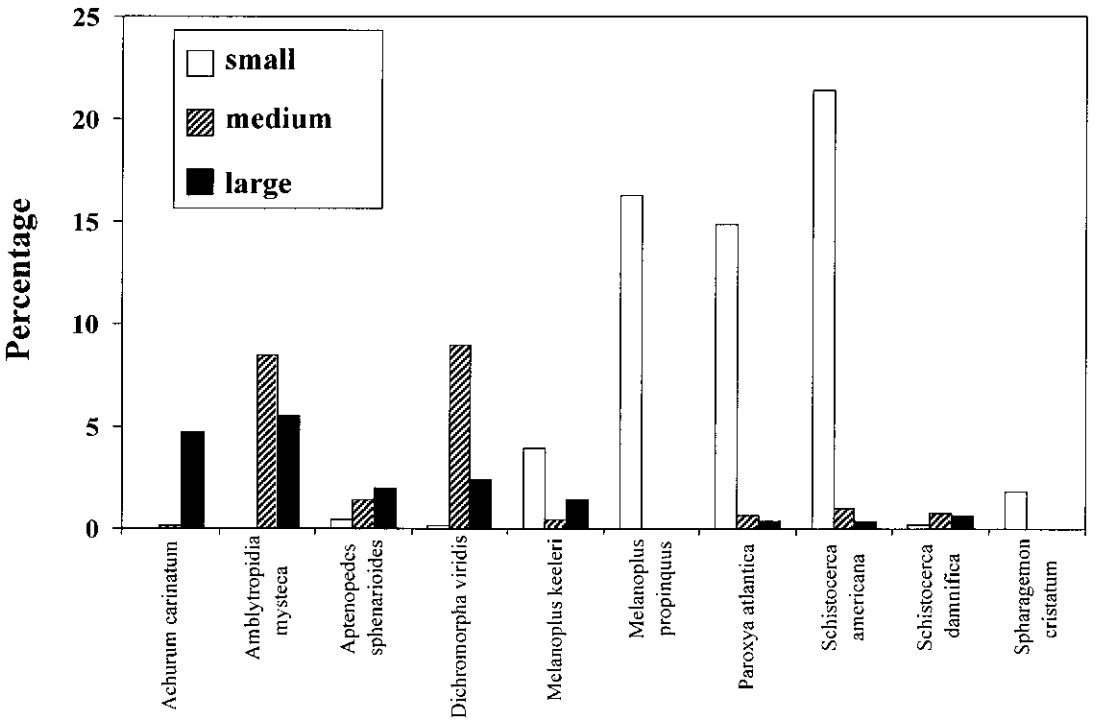

Fig. 2. Proportions of common grasshoppers associated with pine plantations containing small, medium, and large pine trees.

per transect) contained significantly more grasshoppers than the medium and large tree-containing groves (12.3 and 9.3 per transect, respectively). A regression analysis of the tree diameter and grasshopper densities revealed a significant negative regression ($Y = 89.9\text{-}4.24x$; $r = -0.954$; $F = 70.8$; $P = 0.0001$). Anderson (1964), working with rangeland in Montana, also reported grasshopper populations to be inversely proportional to plant height and the amount of shading provided.

The grasshopper species assemblage was slightly affected by tree size. The plot with small trees contained 12 species of grasshoppers with 4 species unique to it: *Aptenopedes aptera*, *Melanoplus propinquus*, *Mermeria intertexta* and *Spharagemon cristatum*. Plots with intermediate sized trees contained 10 species with *Syrbula admirabilis* the only species unique to this habitat. Plots with large trees contained 11 species with *Arphia granulata* and *Dichromorpha elegans* unique. Most grasshoppers do not normally feed on pine but when weeds and grasses are mowed from under the trees some grasshoppers will feed on pine needles (Feaver 1985). Cultural practices such as herbicide application and mowing can have beneficial or damaging results depending upon when they are implemented.

This survey provides an overview of grasshopper species assemblage structure in relation to natural and anthropogenic habitats in Florida. Distribution, density, and relative abundance data are presented, providing insight into resource utilization. A note of caution is warranted, however, because relative abundance may change among and within habitats. Thus, although feeding patterns were not assessed, the aforementioned data allow formation of testable hypotheses relative to feeding behavior.

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