6-1982

Distributions, Densities, and Relative Abundances of Grasshoppers (Orthoptera: Acrididae) in a Nebraska Sandhills Prairie

Anthony Joern
University of Nebraska - Lincoln

Distributions, Densities, and Relative Abundances of Grasshoppers (Orthoptera: Acrididae) in a Nebraska Sandhills Prairie

Anthony Joern
School of Life Sciences
The University of Nebraska
Lincoln, Nebraska 68588

Grasshoppers (Orthoptera: Acrididae) represent a conspicuous and often important component of grassland systems (Odum et al. 1962, Smalley 1960, Sinclair 1975, Van Hook 1971, Wiegert 1965). Often, assemblages of grasshoppers are quite diverse and may, on occasion, consume a large fraction of the available vegetation (Hewitt 1977, Hewitt et al. 1976, Mitchell and Pfadt 1974). As such, grasshoppers have the potential of being very important in the nutrient and energy flow in grassland ecosystems. However, to understand the impact of grasshoppers at the ecosystem level requires that the densities and fluctuations of populations as well as the species composition of entire assemblages be understood. The present study presents such background for an assemblage of grasshoppers located in the sandhills prairie of Nebraska. These results were obtained during a period when grasshopper abundances in the region were high enough for extensive chemical control efforts and the years just following this peak; the present study area was not sprayed, however.

The grasshopper fauna at Arapaho Prairie is diverse and includes species from four subfamilies. These species exhibit a wide range of feeding behaviors and life history traits (Joern, unpublished). Data on the abundances of these grasshoppers permit the evaluation of several specific questions including: 1) What trends are seen in the densities and the relative abundances of particular species shortly after periods of high densities when no chemical control is employed? 2) Are different sites in a sandhills prairie, each dominated by different species of plants, inhabited by the same or different species of grasshoppers? 3) What are the patterns of relative abundances of species? and 4) What is the effect of disturbance of the habitat on the composition of the specific taxa and abundances of grasshoppers?

STUDY SITE

Arapho Prairie is a representative dry sandhills site consisting of two sections (520 ha) in Arthur County, Nebraska. This site is owned by The Nature Conservancy and managed as a research tract by the School of Life Sciences at the University of Nebraska. Topographically, dune systems are typically composed of steep slopes at the ridges which grade into undulating dunes and finally broaden out into flat valleys (Barnes 1980, Keeler et al. 1980). Soil types vary from coarse textured sand (Valentine fine sand) on the dune ridges and slopes to finer textured soils (Doger-Dundy loamy fine sand) in the valleys (USDA Soil Conservation Service 1977).

Recent land use of Arapaho Prairie included cattle grazing until 1976 at which time the cattle were removed. Several old fields exist in the valley areas which had been abandoned in the 1930's or earlier (see Keeler et al. 1980 for a map). Because of recent heavy disturbance by cattle, some areas such as around windmills or in areas generally protected from the wind and water erosion subsequent to disturbance are common. With the removal of cattle, these areas have been undergoing secondary succession at a rapid rate.

Vegetation at Arapaho Prairie is typical of the sandhills grassland in Nebraska; a list of the flora is given in Keeler et al. (1980). Perennial tall grasses (both C_3 and C_4 species) are dominant while numerous species of forbs are also present. Nearly 200 species of plants have been recorded from Arapaho Prairie (Keeler et al. 1980). Three major community types typical of sandhills vegetation have been recognized at Arapaho Prairie (Barnes 1980, Keeler et al. 1980) including 1) ridge vegetation (*Bouteloua-Calamovilfa-Andropogon*), 2) slope vegetation (*Bouteloua-Calamovilfa*), and 3) valley vegetation (*Calamovilfa-Stipa-Bouteloua*). A fourth vegetation type consisting of pioneer, weedy plant species is unique to disturbed areas. These areas change greatly from year to year in terms of plant species composition and structure. Samples were taken in a disturbed area surrounding a windmill in this study.

METHODS

Information on the distribution, densities, and relative abundances of grasshopper species in the various vegetation types was obtained by sampling repeatedly in sites representing each vegetation type. Construction of phenological patterns for adults was performed by combining collecting records into intervals of two weeks. During 1978 and 1979, absolute measures of density were not obtained and relative abundances were calculated based on the relative frequency of each species in intensive and standard collections. These collections were made for 1-2 hours in each site at approximately the same time of day. All grasshoppers were collected in the order in which they were observed. Fewer than 3% of the individuals were missed; missed individuals were not included in the analyses. An index of overall relative densities may also be obtained from these data by comparing the total number of grasshoppers collected per hour. However, problems arise at very high densities since it is not unusual to collect several individuals per sweep unlike collecting at low densities (which would inflate the index relative to low density sites). In addition, removing individuals from the net and processing them, rather than actually catching them, becomes a limiting step at high densities (which tends to lower the index relative to lower densities). Thus, I cannot assume that the index changes in a regular fashion as a function of density. The comparisons are useful, however, to rank sites for overall densities of grasshoppers.

Absolute densities were obtained in 1980 and 1981 using a technique modified from Pfadt (1977, Onsager and Henry 1978). A 0.1 m^2 ring was placed at randomly chosen points along a transect; the points were chosen with a random numbers table and marked with surveyors flags. Four transects with 50 points were located within each site. Densities for each species were determined by slowly walking along the transect and recording the numbers of individuals within each 0.1 m^2 area. Familiarity with the species at Arapaho Prairie minimized the error due to misidentification. Data were not collected until the day following the placement of rings to minimize the possibility of disturbance of the grasshoppers and data were typically collected in mid-morning when grasshoppers were most active. In one instance, data were collected on two successive days along the same transects and the density estimates between the two days did not differ in a statistical sense.

RESULTS AND DISCUSSION

Taxonomic Composition

Thirty-eight species of grasshoppers grouped into four subfamilies have been collected at Arapaho Prairie (Table 1). Typical phenological relationships of adults are shown in Figure 1. Most species are adults in the period from mid-July through August. A small number of species overwinter as nymphs and are adults in the spring and early summer, while another small group of species are adults only during the late portion of the season (mostly September and October). Some species were collected only during a restricted sample period (such as *Aulocara elliotti*, *Boopedon nubilum*, *Dactylotum bicolor*, *Melanoplus sanguinipes*). These data suggest either that established populations of these species do not exist at Arapaho Prairie during the period of this study and that these species are transients or that populations of these species were very small and not likely to be sampled. Small populations may be due to cycling of population densities with these particular species being in a low state (such as seen in Mulkern 1978, Pruess, pers. comm.) or that these are bona fide rare species. Data from sufficient years are not available to assess all of these possibilities. However, sampling was intense enough throughout each of these years to make it unlikely that the rare species hypothesis is true. Such trends need to be followed for a much longer period to obtain insight into the population fluctuations of these grasshopper species.

Clear differences in the taxonomic composition exist between the disturbed area and the other sites. In particular, there is an increase in the relative abundance of Melanoplines and a general decrease in the Gomphocerines. Few obvious differences exist among the other sites. The same groups of species are basically found in each although some quantitative differences are seen. Whether these differences are significant cannot be determined since long term data are needed to evaluate year-to-year changes relative to spatial differences. An exception to this rule is *Trimerotropis citrina* which has only been found in large blowouts and washouts with little vegetation. Once vegetation became common in these areas, this species disappeared from Arapaho Prairie.

Density Estimates

Overall estimates of density (or indices of density) for the total grasshopper abundance are given in Table 2. Much higher densities were observed in a dis-

Table. 1. Grasshopper species collected at Arapaho Prairie from September 1977 to November 1981.

ACRIDIDAE

Gomphocerinae

Acrolophitus hirtipes (Say)
Ageneotettix deorum (Scudder)
Amphitornus coloradus (Thomas)
Aulocara elliotti (Thomas)
Boopedon nubilum (Say)
Chorthippus curtipennis (Harris)
Cordillacris occipitalis (Thomas)
Eritettix simples (Scudder)
Mermiria bivittata (Serville)
Opeia obscura (Thomas)
Parapomala wyomingensis (Thomas)
Phlibostroma quadrimaculatum (Thomas)
Psoloessa delicatula (Scudder)

Melanoplinae

Aeoloplides turnbulli (Caudell)
Dactylotum bicolor (Thomas)
Hesperotettix speciosus (Scudder)
Hesperotettix viridis (Thomas)
Hypochlora alba (Dodge)
Melanoplus angustipennis (Dodge)
Melanoplus bivittatus (Say)
Melanoplus confusus Scudder
Melanoplus differentialis (Thomas)
Melanoplus discolor (Scudder)
Melanoplus femurrubrum (DeGeer)
Melanoplus flavidus (Scudder)
Melanoplus foedus Scudder
Melanoplus gladstoni Scudder
Melanoplus sanguinipes (Fabricius)
Phoetaliotes nebrascensis (Thomas)

Oedipodinae

Arphia pseudonietana (Thomas)
Derotmema haydeni (Thomas)
Dissosteira carolina (Linnaeus)
Hadrotettix trifasciatus (Say)
Hippiscus ocelote (Scudder)
Pardalophora haldemani (Scudder)
Spharagemon collare (Say)
Trachyrhachys kiowa (Thomas)
Trimerotropis citrina (Scudder)
Xanthippus montanus (Thomas)

Cyrtacanthacridinae

Schistocerca lineata Scudder

TETTIGONIIDAE

Conocephalus saltans (Scudder)
Neoconocephalus ensiger (Harris)
Scudderia texansis Saussure & Pickett

turbed area around the stock tank rather than in "typical" sandhills vegetation sites. No significant difference in overall densities of grasshoppers was seen between the ridge and slope sites which had the lowest overall densities. Intermediate densities of grasshoppers were seen in the valley vegetation. Although it is not evident from Table 2, grasshoppers were definitely more numerous in 1978 and 1979 than in 1980 and 1981 (Joern, personal observation); the actual

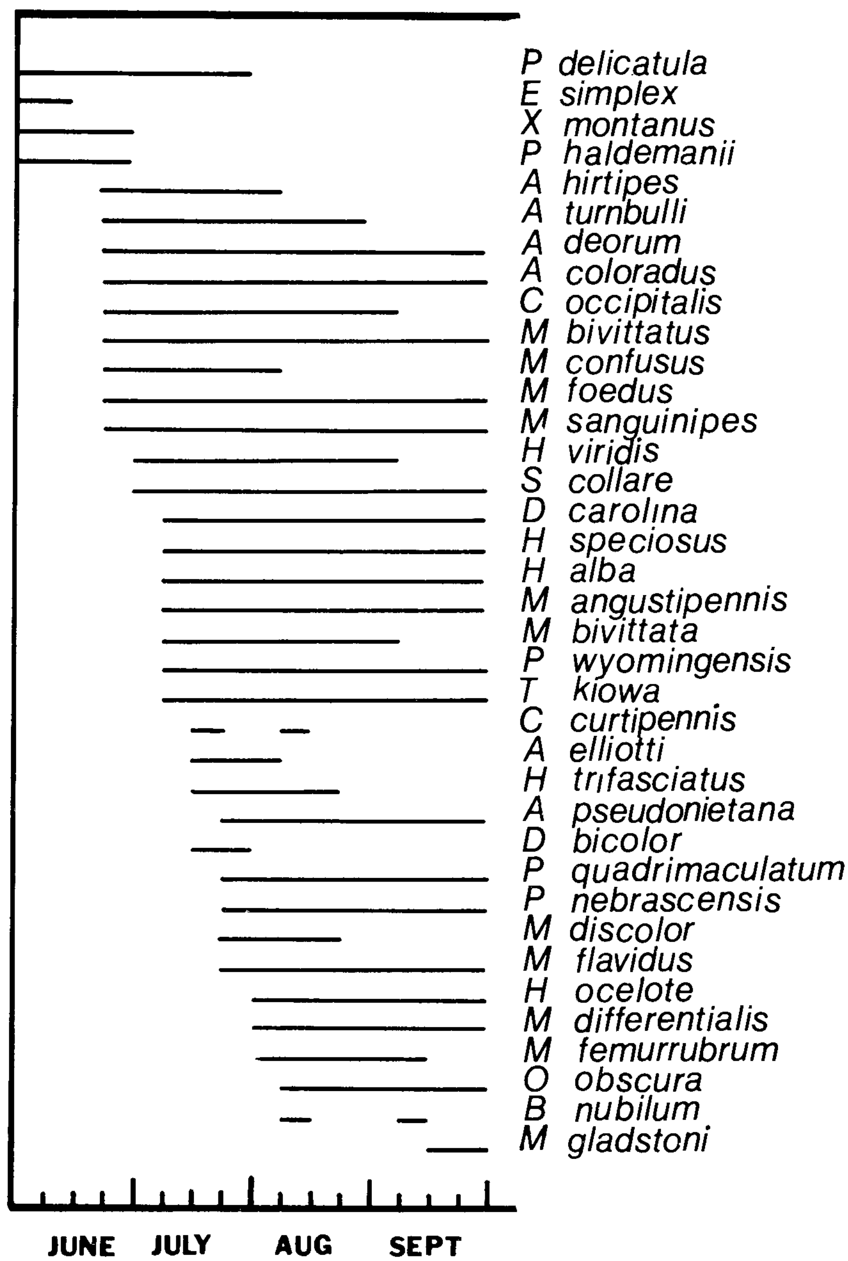

Figure 1. Typical phenology of adult grasshoppers at Arapaho Prairie (1980). Many species exist past September but accurate samplings do not exist for October or later.

Table 2. Relative and absolute densities of grasshoppers in available vegetation types at Arapaho Prairie. Quantitative estimates of absolute densities are only available for 1980 and 1981. See Methods for differences in sampling between the first two and latter two years. Units are in individuals collected per hour (ICPH) in 1978 and 1979 and number of individuals per square meter in 1980 and 1981. Means and 95% confidence intervals are given for estimates of 1980 and 1981.

YEAR	RIDGE	SLOPE	VALLEY	DISTURBED
ICPH				
1978	151	228	396	–
1979	179	243	256	954
No. Per Square Meter				
1980				
$\bar{x}$	2.28	2.92	6.58	10.69
2 S.E.	0.99	0.83	1.56	
1981				
$\bar{x}$	1.62	3.23	6.60	–
2 S.E.	0.50	0.71	1.07	–

magnitude of the differences was not quantified. Much concern about the high densities by ranchers and government officials existed during this period, particularly in 1978 and 1979, in Arthur and surrounding counties. Many of these problems were associated with disturbed land due to cultivation or periodic heavy grazing as expected, based on the data presented here.

Although the grasshopper densities were high during 1978 and 1979, they dropped significantly in the latter two years of this study without active control. Unfortunately, these highest densities were not quantified although from a collecting viewpoint the drop was very noticeable. Such changes occurred very rapidly over a 1-2 year period. Reasons to explain such a drop cannot be given until at least several more years of data are obtained. Predation on adults may be important. Joern and Rudd (in press) have demonstrated that one species of robber fly (*Proctacanthus milbertii*) took approximately 20-25% of the adult grasshoppers over a 30-day period in 1980 (valley site). This would reduce egg production and possibly affect population size the next year. It is not known if the impact of predation is of this magnitude on a yearly basis or not. The importance of weather is not yet understood. Also, since this study was performed on an ungrazed grassland, some differences may be expected when compared with grazed areas.

Relative Abundances

Relative abundances observed in August for all species in each vegetation type are presented in Table 3. Most species are relatively uncommon and a small number very common.

Table 3. Relative abundances of grasshopper species in available vegetation types over a four year period. Sampling of grasshoppers during 1978 and 1979 differed from 1980 and 1981 as explained in the methods section. A "P" denotes that the species was present but accounted for less than .01 of the total sample. All samples are indicative of relationships in August.

	RELATIVE ABUNDANCE															
	Ridge				Slope				Valley				Disturbed		1980 & 1981 Average (S.D.)	
Species	1978	1979	1980	1981	1978	1979	1980	1981	1978	1979	1980	1981	1979	1980		
Gomphocerinae																
Acrolophitus hirtipes			P	P	P	P	P	P		P	P	P		P	P	
Ageneotettix deorum	.18	.39	.42	.38	.17	.44	.27	.31	.22	.15	.22	.14	.21	.25	.28	(.10)
Amphitornus coloradus	.01	.05	P	.07	.02	.03	.05	.06	.02	.09	.09	.11	.01	.04	.06	(.03)
Cordillacris occipitalis	.02	.01	.02	P	P	P	P	P	P	P	P	.02	P	.04	.01	(.01)
Mermiria bivittata	.06	.13	.14	.07	.02	.14	.05	.11	.01	.05	.17	.10	P	.03	.10	(.05)
Opeia obscura	P	.02	P	P	.01	.05	.18	.08	.02	.22	.16	.08		.01	.07	(.07)
Parapomala wyomingensis	.03	.03	.04	.07	.03		P								.02	(.03)
Phlibostroma quadrimaculatum	P	P	P	P	.02	.02	.15	.01	.03	.04	.04	.02	.01	P	.03	(.05)
Oedipodinae																
Arphia pseudonietana			P	P	.03	.05	.02	P	.02	.02	P	.01		P		
Dissosteira carolina													P	P	.01	(.01)
Hippiscus ocelote		P				.01						P			P	
Spharagemon collare	.04	.08	.04	P	.04	.04	P	P	.08	.01	P	P	.05	.02	.01	(.01)
Trachyrhachys kiowa				P				P	P	.01	P	.01	P	P	P	
Melanoplinae																
Aeoloplides turnbulli								P				P	.02	.03	P	
Dactylotum bicolor				P				P	P		P	P			P	
Hesperotettix speciosus			P	P	P	P	P	P	P	P	P	.01	.01	.03	P	
Hesperotettix viridis	P	.01	P	P	.01	P	P	P				P		P	P	
Hypochlora alba	P	P	P	P	.01	P		.01	.03	.10	P	.02		.03	.01	(.01)
Melanoplus angustipennis	.36	.19	.10	.10	.35	.09	.05	P	.33	.08	.06	.04	.41	.16	.07	(.05)
Melanoplus bivittatus			P	P			P	P	P	P	P	P	.02	.03	P	
Melanoplus confusus			.04	.05			P	.01		P	P	.01		P	.02	(.02)
Melanoplus differentialis				P				P				P	.02	.03	P	
Melanoplus discolor								.01							P	
Melanoplus femurrubrum									P	P			.03	P	P	
Melanoplus flavidus	.23	P	.04		.21	.04		P	.02			P	.04		P	
Melanoplus foedus	.05	.07	.04	.20	.03		.05	.01	.05	.04	.05	.06	.05	.08	.07	(.06)
Melanoplus gladstoni					.01								.02		P	
Melanoplus sanguinipes		.01	.06	P	.01	.01	.02	P	.06	.04	.03	.07	.05	.06	.04	(.03)
Phoetaliotes nebrascensis	P	P	.04	.10	.01	.05	.13	.19	.09	.12	.17	.29	.04	.14	.15	(.08)
Cyrtacanthacridinae																
Schistocerca lineata	.02			P				P	P			P			P	

Ageneotetti deorum was clearly the most abundant species at Arapaho Prairie during the four years of this study. This species was important if not most abundant at all sites for each year. It was most abundant in a relative sense, in the ridge sites and to a lesser degree in the slope. Other species which tended to be relatively abundant include: *Phoetaliotes nebrascensis*, *Mermiria bivittata*, *Opeia obscura*, *Amphitornus coloradus*, *Melanopus angustipennis* and *Melanoplus foedus*.

All of these species feed primarily on grasses and sedges at Arapaho Prairie (Joern, unpublished); *M. angustipennis* also feeds on forbs. *Melanoplus flavidus* and *M. foedus* were important in 1978 when populations were quite high; *M. foedus* and *M. flavidus* are forb feeders (Joern, unpublished). Of course, the absolute densities of grasshoppers within the ridge and slope sites were lower than the valley sites so relative importance does not necessarily indicate overall numerical importance when comparing among all sites. *Phoetaliotes nebrascensis* was often as or more abundant than *A. deorum* in the valley sites.

Potential Applied Significance

Disturbed habitats in the sandhills grassland resulted in increased overall densities and a different group of species. In particular, the relative abundances of *Melanoplus* species increased. From the standpoint of grazing, such increases in this group of grasshopper species are not particularly important and may be beneficial since they are largely forbivorous. However, with the increase of irrigated agriculture in the sandhills, as well as periodic abandonment of fields after erosion, it is conceivable that sporadic but dramatic increases in the densities may be seen. These same species are also likely to move into cultivated areas and feed on crops whereas typical abundant rangeland species are not likely to do this.

Results of this study also demonstrate that high populations will decrease naturally without intensive control in a relatively short period of time. Of course, this study was performed primarily on little disturbed sandhills grassland and the rules may change when grazing or other land use practices are employed.

ACKNOWLEDGMENTS

Funds from the University of Nebraska Research Council, the Center for Great Plains Studies, and NSF SER 77-06931 RIAS grant supported portions of this study. Logistic support from the Cedar Point Biological Station is also gratefully acknowledged. Drs. D. Otte and I. Cantrall aided in identifications for which I extend hearty thanks.

LITERATURE CITED

Barnes, P. W. 1980. Water relations and distributions of several dominant grasses in a Nebraska Sandhills Prairie. M.S. Thesis. University of Nebraska, Lincoln.

Hewitt, G. B. 1977. Review of forage losses caused by rangeland grasshoppers. USDA Misc. Publ. No. 1348.

Hewitt, G. B., W. H. Burleson and J. A. Onsager. 1976. Forage loss caused by the grasshopper *Aulocara elliotti* on shortgrass rangeland. J. Range Manage. 29:376-380.

Joern, A. and N. T. Rudd. In press. Impact of predation by the robber fly *Proctacanthus milbertii* on grasshopper populations. Oecologia.

Keeler, K. H., A. T. Harrison and L. S. Vescio, 1980. The flora and sandhills prairie communities of Arapaho Prairie, Arthur County, Nebraska. Prairie Nat. 12:65-78.

Mitchell, J. E. and R. E. Pfadt. 1974. A role of grasshoppers in shortgrass prairie ecosystem. Env. Ent. 3:358-360.

Mulkern, G. B. 1980. Population fluctuations and competition relationships of grasshopper species (Orthoptera: Acrididae). Trans. Amer. Ent. Soc. 106:1-41.

Odum, E. P., C. E. Connell, and L. P. Davenport. 1962. Population energy flow of three primary consumer components of old field ecosystems. Ecology 43:88-96.

Onsager, J. A. and J. E. Henry. 1978. A method for estimating the density of rangeland grasshoppers (Orthoptera: Acrididae) in experimental plots. Acrida 6:231-237.

Pfadt, R. E. 1977. Some aspects of the ecology of grasshopper populations inhabiting the shortgrass plains. U. Minn. Agr. Exp. Sta. Bull. 310:73-79.

Smalley, A. E. 1960. Energy flow of a salt marsh grasshopper population. Ecology 41:672-677.

Van Hook, R. I., Jr. 1971. Energy and nutrient dynamics of spider and Orthoptran populations in a grassland ecosystem. Ecol. Monogr. 41:1-26.

Wiegert, R. G. 1965. Energy dynamics of the grasshopper populations in old fields and alfalfa field ecosystems. Oikos 16:161-176.