

## SPECIES RICHNESS, DENSITY AND DIVERSITY INDICES OF GRASSHOPPERS FAUNA (ORTHOPTERA: PYRGOMORPHIDAE) IN MAIZE-WHEAT CROPPING SYSTEM OF SOUTH-WESTERN RAJASTHAN (INDIA)

by

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### Abstract

Survey conducted in the five districts of Rajasthan viz., Banswara, Dungarpur, Rajsamand, Sirohi and Udaipur during 2005-06 and 2006-07 yielded four different species *Chrotogonus trachypterus* (Blanchard), *Chrotogonus oxypterus* (Blanchard), *Atractomorpha crenulata* Fabricius and *Pyrgomorpha bispinosa* Walker. Based on the mean density data recorded during the investigation, the two species of *Chrotogonus* (*C. trachypterus* and *C. oxypterus*) had the highest mean density in the month of February with (12.88 & 12.13/ 180 ft<sup>2</sup>) at Udaipur and lowest mean density in the month of October with (2.30 & 1.88/ ft<sup>2</sup>) at Rajsamand, respectively. In the south-western regions of Rajasthan, the maximum mean density was during February in maize-wheat cropping system. The relative density of *C. trachypterus* and *C. oxypterus* was the maximum during the month of May (50.56 & 48.41 % respectively) at Dungarpur district. Due to sparse vegetation during May in most parts of Rajasthan the geophilus species, *Chrotogonus* had relatively the highest relative density as compared to the other pyrgomorphids. The mean density for *Atractomorpha crenulata* happened to be the maximum during the month of August with 4.38 per ft<sup>2</sup> and relative density was the highest in September (31.10 %) at Banswara. The grasshopper, *Pyrgomorpha bispinosa* had the maximum mean density (3.88/ ft<sup>2</sup>) during the month of August at Banswara. The relative density (28.39 %) was the highest during September at Banswara. The Simpson Diversity Index and Shannon Weiner Diversity Index values were the maximum in August during both the years. This conspicuously indicates the fact that the monsoon season (August-September) happened to comprise greater diversity of the Pyrgomorphids than the spring season (February-March). Based on the habitat preference and their behaviour, the Pyrgomorphids could be grouped as the geophilus and arboreal types. A comparison within the geophilus species showed that the relative density was nearly equal depicting a 1: 1 ratio at all districts and the diversity indices were 1.915 to 2.00 during both the year. Similarly, comparison between the arborea species indicated that their relative density was also nearly equal depicting a similar 1: 1 ratio and the diversity indices were 1.00 to 1.997 during both years.

### Introduction

A central problem in ecology is to identify and understand patterns in the distribution and abundance of species. Widespread species are generally locally abundant, and have populations that fluctuate than scarce, geographically restricted species. Predicted effects of body size are less well supported, although common, widespread, widely fluctuating species tend to be small (Gaston and Lawton, 1988). The Orthoptera are a group of large and easily recognized insects that include the grasshoppers, locusts, ground hoppers, crickets, bush crickets, mole crickets

and camel crickets as well as some lesser groups. Members of the orthopteran families Acridiidae and Pyrgomorphidae (earlier considered as a sub-family, Pyrgomorphinae, under the family Acridiidae), grasshoppers and surface grasshoppers, are important pests of forage and crop plants. Of the nearly five thousand known species of grasshoppers in the world, only nine are categorized as locusts on account of their capability to devastatingly plague large geographical areas. Surface grasshoppers are widely distributed in the orient and Africa. In India, *C. trachypteros* is common in the north, whereas

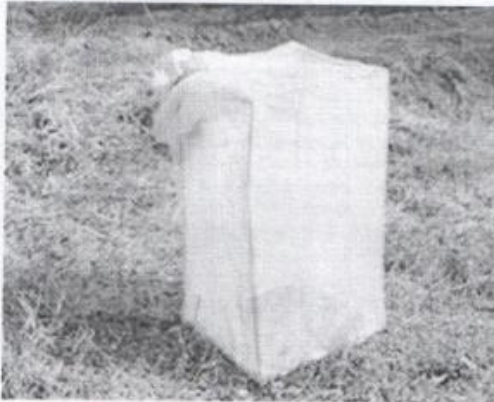
*C. oxyptrous* occurs in the southern regions. Short horned grasshoppers are belonging to the family Pyrgomorphidae, characterized by the presence of *fastigial furrow* and the apical *areolae*, besides having the lower basal lobe of the hind femora longer than the upper lobe. Misari and Raheja (1976) reported that the most abundant species of pyrgomorphids were *Chrotogonus senegalensis* and *Pyrgomorpha vignaudi*. Khaemba (1979) recorded *Acrotylus patruelis*, *Chrotogonus hemipterous*, *Gastrimargus africanus*, *Morpharis fasciata*, *Ornithaeris* sp. and *Zonocerus elegans*, as pests of sunflower before the flowering stage. Losses of vegetation due to grasshopper have also been evaluated thoroughly in some other parts of the globe; an estimated 6 to

12 percent of the available forage is consumed by them in U.S.A. (Cowan, 1958). Anderson (1961) reported 25.9 % to 62.1 % loss of forage due to grasshopper in Montana range lands of U.S.A.

**Materials and Methods:** Surveys to assess the relative incidence of the pyrgomorphids will be conducted in Udaipur, Dungarpur, Banswara, Rajsamand and Sirohi districts of South Western Rajasthan.

**Estimation of grasshopper density:** The 18ft<sup>2</sup> sample method at each survey site was employed randomly picking a spot on the ground about 10 paces. The following mathematical/ statistical analyses were made towards estimating the species richness and diversity indices.

#### Density method in Maize growing field



#### Density method in Wheat field



#### (i) Mean Density:

$$\text{Mean Density} = \frac{\sum X_i}{n}$$

Where,

$X_i$  = Number of grasshopper in  $i^{\text{th}}$  quadrates  
 $n$  = Total number of quadrates sampled.

#### (ii) Relative Density (RD %):

$$\text{Relative Density (\%)} = \frac{\text{Number of individual of one species}}{\text{Number of individual of all species}} \times 100$$

#### (iii) Diversity indices:

$$(a) \text{ Shannon's index (H')} = \sum_{i=1}^s (P_i \ln P_i)$$

$$i = 1$$

Where,

- S = Total number of species  
 P = is the proportional abundance of the  $i^{\text{th}}$  species  
 $\ln$  = Natural logarithm of n (Log with base e)

$$(b) \text{ Simpson index } (\lambda) = \sum_{i=1}^S (P_i^2)$$

$$P_i = \frac{n_i}{N} \quad i = 1, 2, 3, \dots, S$$

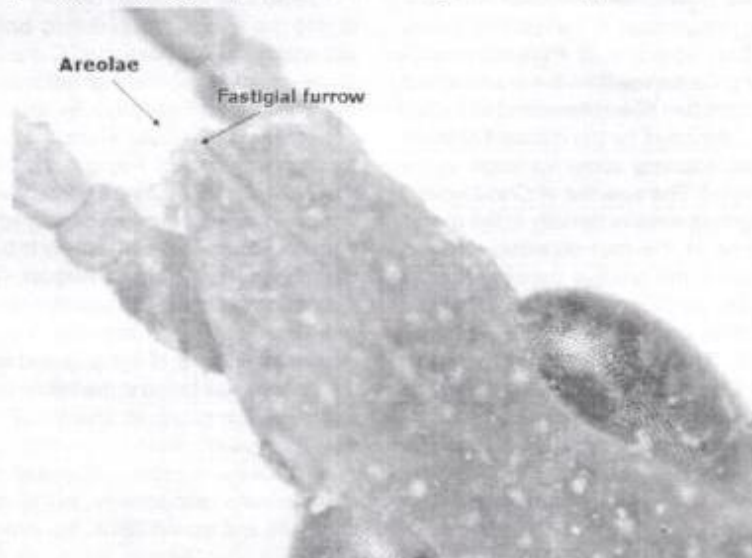
Where,

- S = Total number of species  
 N = Total number of individual  
 $n_i$  = Number of individual

### RESULTS

Survey conducted in the five districts of Rajasthan viz., Banswara, Dungarpur, Rajsamand, Sirohi and Udaipur during 2005-06 and 2006-07 yielded four different species of short

homed grasshoppers belonging to the family Pyrgomorphidae, characterized by the presence of *fastigial furrow* and the apical *areolae*, besides having the lower basal lobe of the hind femora longer than the upper lobe.



The adult Pyrgomorphids, determined on the basis of their morphological features belonged to three genera (*Chrotogonus*, *Atractomorpha* and *Pyrgomorpha*) and four species i.e., *Chrotogonus trachypterus* (Blanchard), *Chrotogonus oxypterus*

(Blanchard), *Atractomorpha crenulata* Fabricius and *Pyrgomorpha bispinosa* Walker.

Data on mean density for the 4 grasshopper species encountered in the maize-wheat cropping system in the 5 districts surveyed have been

presented district wise in the Tables 1. During both the years, the species *Chrotogonus trachypterus* had the maximum population density during February that ranged from 10.08 to 12.88 grasshoppers per 180 sq. ft. in the different districts surveyed with however the maximum (12.88/ 180 ft<sup>2</sup>) at Udaipur. The mean density (12.13/ ft<sup>2</sup>) of species *C. oxypterus* was maximum during the month of February at Udaipur and minimum mean density (1.88/ ft<sup>2</sup>) was found in September at Banswara. The mean density for *Atractomorpha crenulata* was the maximum during the month of August and ranged from 2.5 to 4.38 grasshoppers per 180 s. ft. in the different districts observed with the maximum (4.38/ ft<sup>2</sup>) being recorded from district Banswara during 2005-06 and 2006-07. The grasshopper, *Pyrgomorpha bispinosa* also had the maximum mean density in the month of August with a population range from 2.18 to 3.88 grasshoppers per 180 sq. ft. in the districts surveyed and the maximum (3.88/ ft<sup>2</sup>) was recorded from Banswara. A district-wise comparison of the relative density among the four species of Pyrgomorphids collected during the survey from the maize-wheat cropping systems has been presented in Tables 2. The relative densities for the different species of grasshopper showed some variation in the districts surveyed. The species of *Chrotogonus* had their maximum relative density in the month of May in three of the four districts, while in district Dungarpur the relative density was the maximum in May for *C. oxypterus* (48.41 %) and in May (50.56%) and June (50.68 %) for *C. trachypterus*. The relative density for *A. crenulata* was the maximum (31.10 %) in the month of September during the two year study at Banswara. Similarly, the relative density for *P. bispinosa* was the maximum (28.39) in the month of September in the Banswara district surveyed.

A year wise comparison of the Pyrgomorphid diversity in the 5 districts has been presented in the Tables 3. During both the year, in all the 5 districts, the maximum pyrgomorphid diversity as given by Simpson Diversity Index was during August being 3.840, 3.750, 3.975, 3.840 and 3.985 for the districts Udaipur, Sirohi, Rajsamand,

Dungarpur and Banswara, respectively. Similarly, on the basis of Shannon Weiner Diversity Index the maximum Pyrgomorphid diversity was in the month of August with the index values being 1.366, 1.352, 1.383, 1.366 and 1.384 for the districts Udaipur, Sirohi, Rajsamand, Dungarpur and Banswara, respectively. Based on the habitat preference and their behaviour, the Pyrgomorphids could be grouped as the geophilus and arboreal types (Table 4). A comparison within the geophilus species showed that the relative density was nearly equal depicting a 1: 1 ratio at all districts and the diversity indices were 1.915 to 2.00 during both the year. Similarly, comparison between the arborea species indicated that their relative density was also nearly equal depicting a similar 1: 1 ratio and the diversity indices were 1.00 to 1.997 during both years.

#### DISCUSSION

Based on the mean density data recorded during the investigation during both years, the two species of *Chrotogonus* (*C. trachypterus* and *C. oxypterus*) had the highest mean density in the month of February in all the districts observed. Our results show that in the south-western regions of Rajasthan, the maximum mean density was during February in the cropped areas. However, the mean density when recorded from non-cropped areas is likely to be high during the monsoon period i.e., August – September. According to population counts made by Grewal and Atwal (1968) in the month of August the maximum number of nymphs and adults (73 per unit space) was found in the fallow fields of sandy soil under low grass, as against 27, 24 and 19 in sandy loam fields under *Cyamopsis tetragonoloba*, *Arachis hypogea* and *Saccharum spontaneum*, respectively. In the case of fallow clay soils and gravel fields, the average number of insects counted over the same distance was as low as 18 and 9, respectively. Much before, Kevan (1954) observed that taller vegetation provide unsuitable habitat for *Chrotogonus* species. *C. trachypterus* was found most abundant in fallow sandy soils covered with grasses and was the least abundant in fallow

**Table 1.** Mean Density of Common Pyrgomorphids in Maize-Wheat Cropping System for Districts of South-Western Rajasthan during 2005-06 and 2006-07

Months	Number of adult grasshoppers/ 180 ft <sup>2</sup>																													
	Udaipur						Sirohi						Rajsamand						Dungarpur						Banswara					
	CT	CO	AC	PB	CT	CO	AC	PB	CT	CO	AC	PB	CT	CO	AC	PB	CT	CO	AC	PB	CT	CO	AC	PB	CT	CO	AC	PB		
Nov.	6.63	5.88	1.88	1.38	5.38	5.13	1.13	0.63	5.38	4.88	1.13	0.88	5.13	4.88	0.88	0.63	4.88	4.50	2.00	1.38	4.88	4.50	2.00	1.38	4.88	4.50	2.00	1.38		
Dec.	7.13	6.38	1.38	1.13	6.13	5.88	1.38	1.13	5.88	5.25	1.13	0.63	5.88	5.38	1.13	0.75	5.38	5.13	1.63	1.13	5.38	5.13	1.63	1.13	5.38	5.13	1.63	1.13		
Jan.	10.25	9.13	2.88	2.38	8.75	8.63	1.88	1.63	7.63	7.13	2.38	1.88	8.88	8.63	1.88	1.63	8.63	7.88	2.88	2.38	8.25	7.88	2.88	2.38	8.25	7.88	2.88	2.38		
Feb.	12.88	12.13	3.00	2.63	11.75	11.38	2.38	2.63	11.13	10.50	2.63	2.38	11.25	10.75	2.25	1.38	10.88	9.75	3.13	2.88	10.88	9.75	3.13	2.88	10.88	9.75	3.13	2.88		
March	11.38	10.38	2.88	2.38	9.75	9.50	2.00	1.63	9.00	8.63	2.63	2.13	10.25	9.38	2.00	1.63	9.13	8.63	2.88	2.25	9.13	8.63	2.88	2.25	9.13	8.63	2.88	2.25		
April	9.38	9.13	1.88	1.38	8.38	8.00	1.38	1.13	7.88	7.38	2.38	1.38	7.63	7.13	1.13	0.88	7.25	6.88	2.38	1.88	7.25	6.88	2.38	1.88	7.25	6.88	2.38	1.88		
May	8.88	7.88	0.88	0.38	7.75	7.25	0.38	0.00	7.13	6.38	0.63	0.38	5.88	5.63	0.13	0.00	6.38	6.13	1.38	1.13	6.38	6.13	1.38	1.13	6.38	6.13	1.38	1.13		
June	6.88	6.38	1.38	1.13	6.13	5.88	1.00	0.50	5.75	4.88	0.88	0.63	4.88	4.38	0.25	0.13	4.88	4.63	1.88	1.63	4.88	4.63	1.88	1.63	4.88	4.63	1.88	1.63		
July	5.38	4.88	2.38	1.88	5.38	4.88	1.88	1.38	4.88	4.50	1.88	1.38	3.88	3.63	1.38	1.13	4.88	4.63	2.88	2.63	4.88	4.63	2.88	2.63	4.88	4.63	2.88	2.63		
Aug.	5.13	4.13	3.75	2.88	4.63	4.38	2.88	2.50	3.13	2.88	2.88	2.50	3.63	3.13	2.50	2.13	4.25	3.75	4.38	3.88	4.25	3.75	4.38	3.88	4.25	3.75	4.38	3.88		
Sept.	3.88	3.38	2.88	2.13	3.50	2.88	1.88	1.63	2.75	2.38	2.63	1.63	2.88	1.88	1.88	1.63	1.88	1.88	2.88	2.63	1.88	1.88	1.88	2.88	2.63	1.88	1.88	2.88	2.63	
Oct.	3.88	3.13	1.88	1.63	3.88	3.63	1.38	1.25	2.38	1.88	2.38	1.63	2.88	2.63	1.13	0.88	3.13	2.63	3.13	2.88	3.13	2.63	3.13	2.88	3.13	2.63	3.13	2.88	2.63	

\* CT=C. trachipterus, CO=C. oxypterus, AC=A. crenulata, PB=P. bispinosa

**Table 2.** Relative Density (%) of Common Pyrgomorphids in Maize-Wheat Cropping System for Districts of South-Western Rajasthan during 2005-06 and 2006-07

Months	Relative density (%)																			
	Udaipur				Sirohi				Rajsamand				Dungarpur				Banswara			
	CT	CO	AC	PB	CT	CO	AC	PB	CT	CO	AC	PB	CT	CO	AC	PB	CT	CO	AC	PB
Nov.	42.08	37.31	11.90	8.72	43.88	41.88	9.17	5.09	43.91	39.83	9.16	7.11	44.60	42.43	7.58	5.40	38.26	35.27	15.71	10.76
Dec.	44.55	39.86	8.58	7.02	42.27	40.54	9.47	7.74	45.69	40.78	8.71	4.82	44.82	41.00	8.55	5.64	40.59	38.70	12.25	8.47
Jan.	41.63	37.07	11.67	9.64	41.92	41.34	8.97	7.78	40.14	37.51	12.49	9.86	42.27	41.08	8.92	7.73	38.60	36.86	13.45	11.10
Feb.	42.05	39.60	9.80	8.57	41.78	40.46	8.44	9.33	41.80	39.44	9.86	8.91	43.92	41.97	8.76	5.36	40.86	36.62	11.74	10.80
March	42.14	38.43	10.65	8.79	42.65	41.55	8.71	7.10	40.24	38.55	11.73	9.49	42.31	38.72	12.26	6.73	39.91	37.72	12.57	9.82
April	43.12	41.96	8.62	6.31	44.40	42.39	7.27	5.95	41.46	38.83	12.49	7.23	45.54	42.56	6.70	5.21	39.46	37.44	12.92	10.20
May	49.33	43.77	4.85	2.07	50.43	47.17	2.41	0.00	49.17	43.99	4.29	2.56	50.56	48.41	1.04	0.00	42.52	40.85	9.15	7.48
June	43.67	40.49	8.72	7.13	45.37	43.52	7.41	3.71	47.45	40.26	7.18	5.12	50.68	45.48	2.60	1.25	37.52	35.60	14.41	12.48
July	37.09	33.63	16.37	12.92	39.84	36.13	13.88	10.17	38.62	35.68	14.84	10.87	38.79	36.28	13.73	2	32.50	30.86	19.16	17.49
Aug.	32.29	25.98	23.64	18.10	32.20	30.46	20.00	17.35	27.47	25.27	25.27	22.01	31.87	27.47	22.01	7	26.14	23.06	26.95	23.86
Sept.	31.64	27.56	23.47	17.34	35.45	29.14	18.98	16.44	29.29	25.36	28.04	17.32	37.15	24.19	20.95	1	20.26	20.26	31.10	28.39
Oct.	36.90	29.81	17.84	15.46	38.28	35.81	13.56	12.36	28.79	22.73	28.79	19.70	38.40	35.05	14.96	1	31.30	26.24	23.74	18.73

\* CT=C. trachypterus, CO=C. oxypterus, AC=A. crenulata, PB=P. bispinosa

**Table: 3.** Simpson and Shannon Weiner Diversity Indices for Districts of South-Western Rajasthan during 2005-06 and 2006-07

Months	Simpson index					Shannon's index				
	Udaipur	Sirohi	Rajsamand	Dungarpur	Banswara	Udaipur	Sirohi	Rajsamand	Dungarpur	Banswara
Nov.	3.005	2.635	2.740	2.580	3.255	1.092	1.095	1.134	1.076	1.266
Dec.	2.705	2.795	2.600	2.640	2.970	1.124	1.249	1.082	1.095	1.091
Jan.	2.995	2.775	3.055	2.770	3.170	1.209	1.144	1.223	1.143	1.249
Feb.	2.850	2.825	2.875	2.635	3.065	1.169	1.161	1.175	1.095	1.225
March	2.870	2.725	3.000	2.860	3.055	1.184	1.128	1.208	1.163	1.222
April	2.680	2.595	2.910	2.525	3.100	1.113	1.082	1.182	1.057	1.515
May	2.285	2.095	2.285	2.040	2.765	0.936	0.788	0.937	0.736	1.137
June	2.725	2.490	2.435	2.150	3.295	1.128	1.194	1.061	0.844	1.274
July	3.400	3.140	3.220	3.190	3.725	1.295	1.236	1.259	1.252	1.349
Aug.	3.840	3.750	3.975	3.840	3.985	1.366	1.352	1.383	1.366	1.384
Sept.	3.830	3.650	3.860	3.680	3.855	1.363	1.338	1.368	1.345	1.368
Oct.	3.555	3.240	3.890	3.270	3.865	1.324	1.264	1.372	1.269	1.369

**Table 4.** Comparative Simpson Diversity Indices for the Grasshopper Groups in South-Western Rajasthan during 2005-06 and 2006-07

Months	<i>C. trachypterus</i> and <i>C. oxypterus</i> (geophilus species)					<i>P. bispinosa</i> and <i>A. crenulata</i> (arboreal species)				
	Udaipur	Sirohi	Rajsamand	Dungarpur	Banswara	Udaipur	Sirohi	Rajsamand	Dungarpur	Banswara
Nov.	1.993	1.998	1.995	1.999	1.997	1.953	1.841	1.968	1.942	1.930
Dec.	1.994	1.999	1.993	1.996	1.999	1.980	1.980	1.841	1.986	1.935
Jan.	1.992	2.000	1.998	2.000	1.999	1.982	1.990	1.973	1.990	1.982
Feb.	1.998	2.000	1.999	1.999	1.994	1.990	1.995	1.995	1.891	1.997
March	1.996	2.000	1.988	1.996	1.998	1.982	1.979	1.978	1.991	1.968
April	2.000	1.999	1.998	1.998	1.999	1.953	1.980	1.866	1.968	1.973
May	1.993	1.998	1.994	1.999	1.999	1.700	1.000	1.862	1.000	1.980
June	1.997	1.999	1.987	1.994	1.999	1.980	1.800	1.942	1.500	1.990
July	1.995	1.995	1.997	1.998	1.997	1.923	1.953	1.953	1.980	1.996
Aug.	1.977	1.998	1.997	1.989	1.992	1.915	1.988	1.990	1.985	1.993
Sept.	1.991	1.990	1.993	1.915	2.000	1.955	1.990	1.903	1.991	1.996
Oct.	1.975	1.998	1.980	1.996	1.983	1.990	1.991	1.943	1.968	1.973



hard clay and gravel soils or in the fields under tall vegetation. Long back, Cotes (1894) reported that the grasshoppers appear in June in Punjab and die in September; while, Uvarov (1927) and Bei-Bienko and Mish (1951) reported that *Chrotogonus trachypterus* hibernated in the nymphal stage during winters that does not hold true anymore.

During the present investigations the relative density of *C. trachypterus* and *C. oxypterus* was the maximum during the month of May in all the districts. In literature, records of relative density for *Chrotogonus* are wanting. The exact determining factors for the fluctuation in numbers are much more complex and the conditions obtained from year to year would indicate the expected levels of population. Due to sparse vegetation during May in most parts of Rajasthan the geophilus species, *Chrotogonus* had relatively the highest Relative Density as compared to the other Pyrgomorphids.

The mean density for *Atractomorpha crenulata* happened to be the maximum during the month of August in all the districts during 2005-06 and 2006-07. The relative density was the highest in August and September for this species. Similar works on bio-ecological studies in the literature are scanty, hence would be difficult to compare. The grasshopper, *Pyrgomorpha bispinosa* had the maximum mean density during the month of August in most districts. However, it was observed to have two peaks for mean density in district Sirohi (during February and August). The relative density was the highest during August in all the districts. Parihar (1983) recorded two generations in a year for *Pyrgomorpha bispinosa deserti* (Bei-Bienko), based on whether the egg-hatch from the egg-pod was in January or July. Peak hopper population was observed in August whereas adults in September.

The Simpson Diversity Index and Shannon Weiner Diversity Index values were the maximum during August during both the years. This conspicuously indicates the fact that the monsoon season (August-September) happened

to comprise greater diversity of the Pyrgomorphids than the spring season (February-March). Based on the data on Mean Density and Relative Density in the surveyed area, comprising south west plains of Rajasthan and Aravalli hills, the Pyrgomorphid population could be classified into two groups – the spring breeders (*Chrotogonus*) and the monsoon breeders (*Pyrgomorpha* and *Atractomorpha*). Grass feeders (gomphocerines and most locustines) made up 85% of the total density. The dominant species was *Ageneotettix deorum* (Scud.), which contributed 52% of the grasshopper density in 1981 and 37% in 1982. The grasshopper population was at outbreak density in both years (60 and 36/m<sup>2</sup>, respectively). The pasture had never been treated with insecticide or herbicide. The Shannon-Wiener index of about 2.00 indicated high grasshopper diversity (Pfadt, 1984).

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