https://doi.org/10.33451/florafauna.v28i2pp303-314
FLORA AND FAUNA ISSN 2456 - 9364 (Online)
2022 Vol. 28 No. 2 PP 303-314 ISSN 0971 - 6920 (Print)

Acridid (Orthoptera: Acrididae) diversity and distribution in the eastern plain of Rajasthan, India

Pooja Meena, Ramesh Prajapat, Neha Kumawat, Vinod Kumari and *Shashi Meena

Department of Zoology,
University of Rajasthan,
JAIPUR-302004 (RAJASTHAN) INDIA
*Corresponding Author
E-mail: drshashimeena15@gmail.com

Received **:** 20.09.2022; ***Revised*** **:** 25.09.2022; ***Accepted*** : 16.10.2022

ABSTRACT

Acridids are cosmopolitan, active, diurnal and voracious phytophagous insects in both larval and adult stages. These insects are generally known as a pest in agricultural farms and are accountable for locust attacks and outbreak situations. The current study reported on the distribution and diversity of acridids in the semiarid eastern plain, Rajasthan. The study area was surveyed from April 2021 to September 2021 and observed 17 acridids representing 14 genera, 7 subfamilies, and 10 tribes of the Acrididae family. The species abundance, distribution, and their relationship with abiotic factors (temperature, humidity, and rainfall) are also discussed. The subfamily Hemiacridinae was the most abundant, with the species *Hieroglyphus nigrorepletus* that was responsible for grasshopper outbreaks in agricultural farms. Subfamily Gomphocerinae was found to be the least abundant, whereas subfamily Oedipodinae had the highest species richness in the research area. Shannon Diversity Index (H'), Simpson's Diversity Index (D'), Dominance, and Evenness were calculated as, 1.294, 0.4951, 0.5049, and 0.2146, respectively, indicating that acridids are quite diverse in the surveyed area.

Figures : 08 References : 30 Tables : 03
KEY WORDS : Abiotic, Acrididae, Distribution, Diversity indices, Outbreak, Pest, Semiarid

Introduction

Orthoptera is one of the largest orders in the class Insecta, and it includes both short-horned (Suborder: Caelifera) and long-horned (Suborder: Ensifera) grasshoppers. They are an essential part of the ecosystem in food chains, nutrient cycling, and pollination. The majority of members of Caelifera is diurnal and some are nocturnal insects, so this group was previously well known in Rajasthan. Caelifera is classified into four families: the Acrididae, Pyrgomorphidae, Chorotypidae, and Tetrigidae. Out of the 20,000 orthopteran species worldwide, 1,750 have been documented in India[30]. The family : Acrididae has an important socioeconomic orthopteran pest. Acrididae is the most diverse group in the superfamily Acridoidea, with high species richness. In India, nearly 285 acridid species belonging to 135 genera have been reported[22]. This family includes all agriculturally important locusts and grasshoppers, which cause significant damage to crops, grasslands, and grazing land. The individuals of the orthoptera group are well distributed in Rajasthan[15, 16]. Grasshoppers belong to the second trophic level in the food web, are the first link in the terrestrial ecosystem's food chain. Most grasshoppers are economically significant insects; they are oligophagous and have a definite host, classified as forb-feeders (forbivorous), grass-feeders (graminivorous), or ambivorous. Among all orthopteran pest insects, locusts and grasshoppers are economically significant groups that attack a variety of cultivated and non-cultivated crops[16]. However, the geographical distribution of grasshoppers is constantly shifting due to the encroachment of grasslands and forests for agricultural and industrial purposes [9,19,30]. However, in the previous decades, Rajasthan and some neighboring states and countries had also been exposed to locust attacks[4,5].

ACKNOWLEDGEMENTS : The authors are thankful to Dr. R. Swaminathan, Emeritus Scientist (ICAR, New Delhi), Tatiana Swaminathan, and Dr. Ashok Kumar Meena, Division of Entomology, Jodhpur Agriculture University, Jodhpur, and Maharana Pratap University of Agriculture and Technology, Udaipur, India, for the expertise in species identification. The authors also like to thank Dr. Pankaj Salunkya, LWO, Jodhpur. The first author acknowledges CSIR, New Delhi for providing funding grants.

TABLE-1: Sampling sites

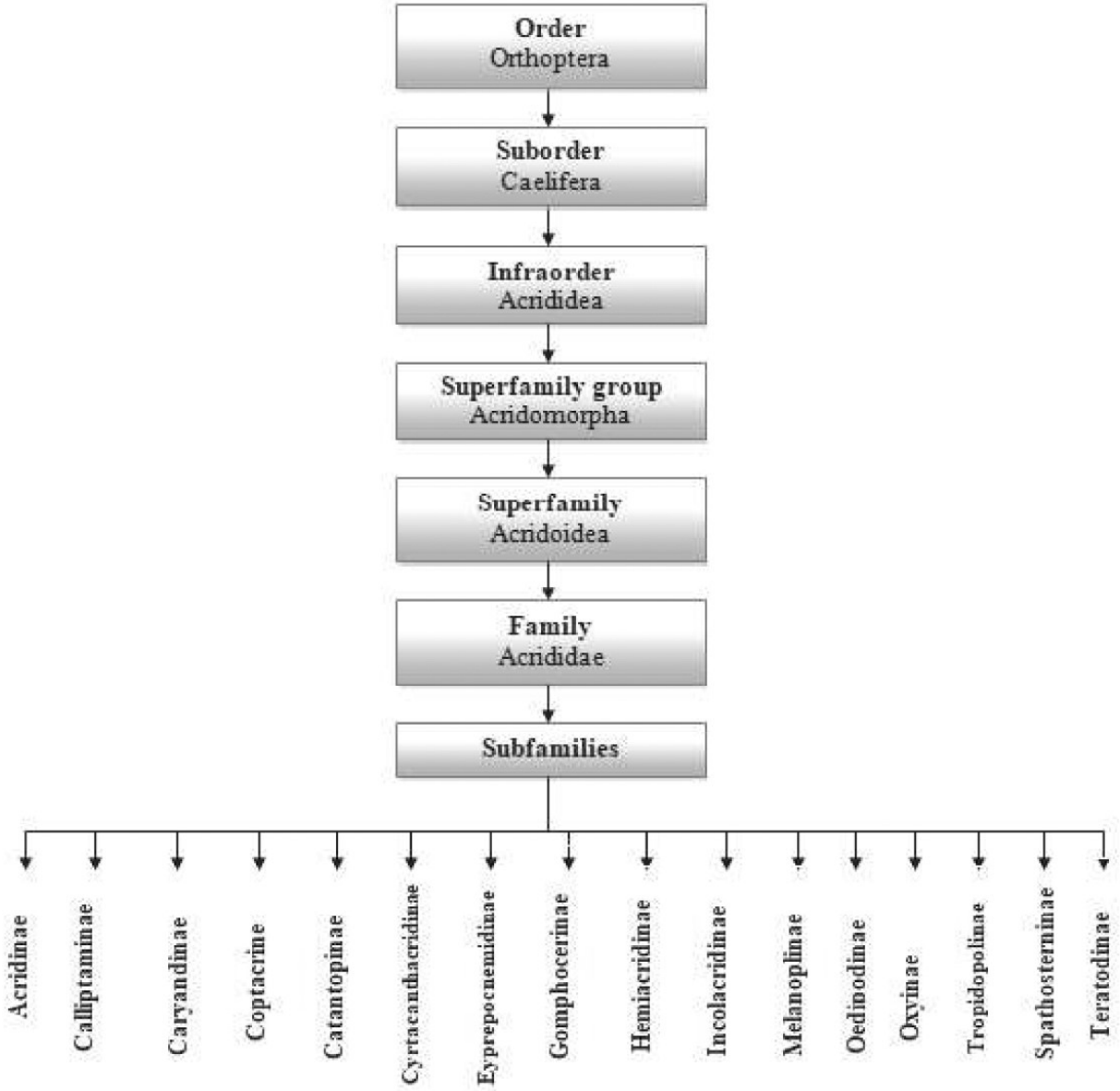
S.No.	District	Sampling sites	GPS Coordinates	Sampling habitat types
1.	Jaipur	Bassi	26.841542° N, 76.050413° E	Agriculture farms
		Phagi	26.577636° N, 75.568882° E	Open grasslands
		Jaipur city	26.930454° N, 75.837129° E	Gardens
		Viratnagar	27.429260° N, 76.193197° E	Hilly regions
2.	Ajmer	Kishangarh	26.585654° N, 74.858138° E	Urban gardens
		Beaware	26.101444° N, 74.320188° E	Hilly out cracks
		Sarwar	26.061778° N, 75.012929° E	Open grasslands
3.	Dausa	Dausa	26.910757° N, 76.325484° E	Agriculture farms
		Baswa	27.141272° N, 76.590283° E	Urban gardens
		Lalsot	26.560456° N, 76.330569° E	Agriculture farms
4.	Tonk	Malpura	26.299728° N, 75.370794° E	Agriculture farms
		Uniara	25.915568° N, 76.027558° E	Rocky regions
		Todaraisingh	26.022838° N, 75.485130° E	Rocky regions
		Niwai	26.361437° N, 75.930390° E	Urban gardens

Among acridid pests *Hieroglyphus nigrorepletus* was reported as a pest in Pakistan [10, 26], Rajasthan, and Gujarat[6] wreaking havoc on maize, rice, millets, wheat, fodder, and sugarcane crops. On the other hand, *Atractomorpha crenulata* and *Gastrimargus africanus sulphureus*, have been identified as minor maize pests[13,23,29]. Other acridids, such as *Spathsternum prasiniferum, Ailopus thalasisnus* from Pakistan[10], and *Acrida exaltata* from Rajasthan[14] and Pakistan[10] have been reported as paddy pests. Workers[1] reported *H. nigrorepletus,* and *A. exaltata* and observed feeding on rice crops causes drastic crop damage in later stages of growth, thus considered a major pest in Uttar Pradesh. Previous workers have contributed to the taxonomy and diversity of acridids in Rajasthan [3-5,9,11,15,17-19,25,27].

Rajasthan state has diversified topography and climatic conditions; the northeastern region of the state is occupied by a semiarid plain, which is part of the fringed area of the northern Ganges plain, drained by river Yamuna and its tributaries. The study on acridid diversity was conducted in various locations throughout the semiarid eastern plain (Rajasthan), from April 2021 to September 2021. The survey was conducted in the various semiarid habitats, including bushy vegetation with clusters of grassland, bushy areas, grasslands, cultivated areas, and floors.

Materials and Methods

Study area -Rajasthan (coordinates: 27.0238° N, 74.2179° E) is India's largest state, located in the country's northwest. The climate of the state is usually arid or semi-arid, with hot environment throughout the year and tremendous temperatures both in summer and winter, with the Tropic of Cancer passing through its southernmost tip. Rajasthan has several types of land



Fig, 1 : The taxonomic hierarchy of the Acrididae family and its subfamilies in India

diversity, including the Thar Desert, the Aravali range, the Eastern Plains and the Hadoti region.

The eastern plain is characterized by semiarid climatic conditions; it is formed by various seasonal and perennial rivers *viz*. Banganga, Chambal, Sabi, Banas. The river Banas and its tributaries drain this plain (sandy) and have 28% irrigation area. Four districts are included in the semiarid eastern plain: Jaipur, Ajmer, Tonk, and Dausa. It forms the majority of the Aravali mountain range and the eastern plateau (a physiographical division).

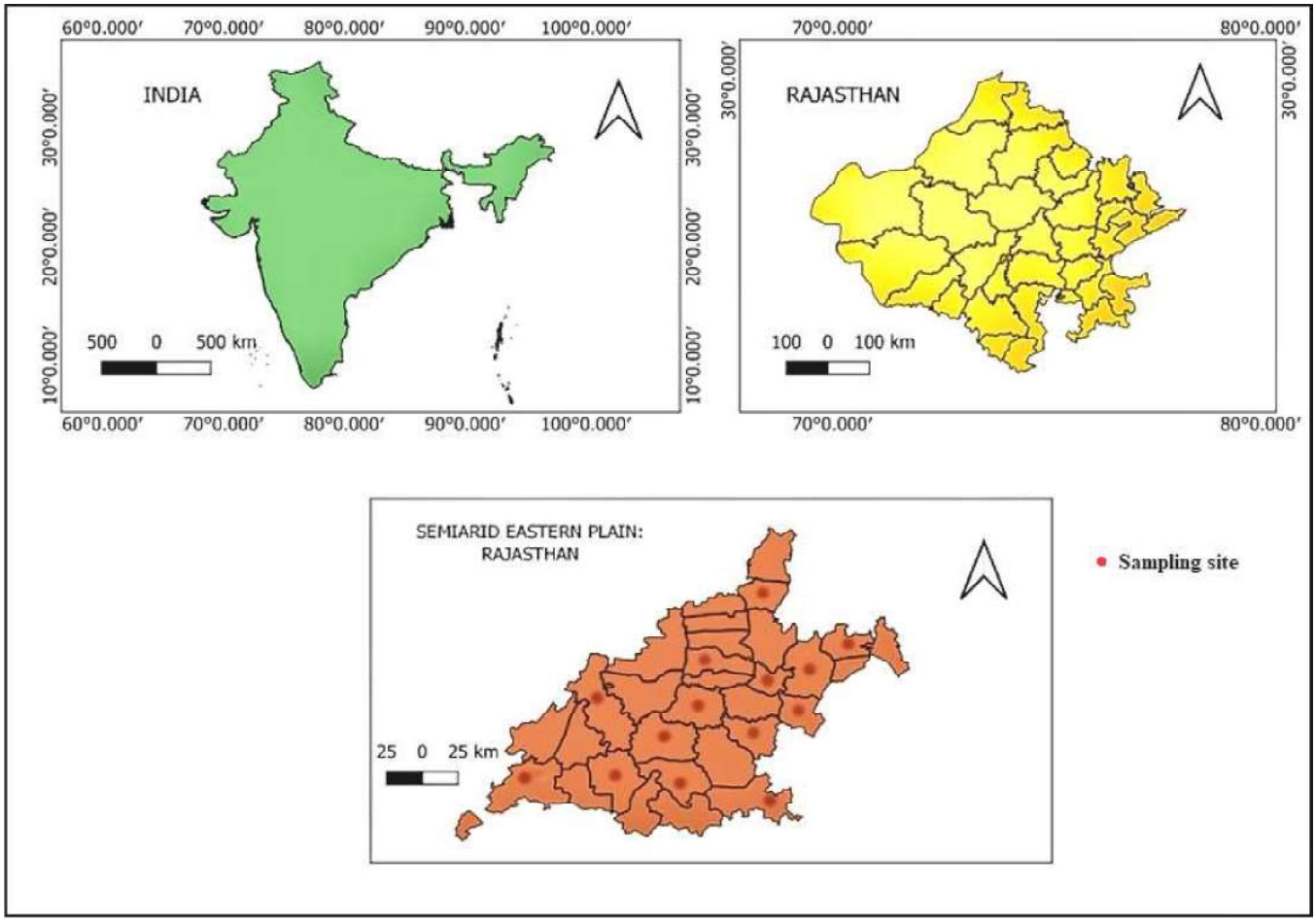
TABLE-2: Species diversity, richness, evenness and abundance of the acridid fauna of the selected sites in semiarid eastern plains of Rajasthan

Sea-son	Species richness	Abundance	Shannon-Wiener Diversity Index (H')	Dominance_D	Simpson_1-D	Evenness (H/S)
Pre-monsoon	12	159	2.295	0.112	0.888	0.827
Monsoon	17	8017	1.249	0.5219	0.4781	0.2051

TABLE-3 : Subfamily, genus and species of family Acrididae in the semiarid eastern plain of Rajasthan

S. No.	Subfamily	Genus	Tribe	Species	No. of Insects			Percent (%)
					Pre-monsoon	Monsoon	Total insects	
1.	**Hemiacridinae**	*Hieroglyphus*	Hieroglyphini	*Hieroglyphus nigrorepletus*	0	5725	5725	70.15
2.	**Spathosterninae**	*Spathosternum*	Spathosternini	*Spathosternum prasiniferum*	30	650	680	8.33
3.	**Gomphocerinae**	*Aulacobothrus*	Arcypterini	*Aulacobothrus sp.*	0	36	36	0.44
4.	**Catantopinae**	*Xenocatantops*	Catantopini	*Xenocatantops* sp.	4	37	41	0.50
		Diabolocatantops	Catantopini	*Diabolocatantops pinguis*	12	230	242	2.96
5.	**Oedipodinae**	*Gastrimargus*	Locustini	*Gastrimargus africanus*	6	122	128	1.56
		Oedaleus	Locustini	*Oedaleus abruptus*	13	85	98	1.20
		Acrotylus	Acrotylini	*Acrotylus longipes*	19	72	91	1.11
			Acrotylini	*Acrotylus humbertianus*	17	101	118	1.44

S. No.	Subfamily	Genus	Tribe	Species	No. of Insects			Percent (%)
					Pre-monsoon	Monsoon	Total insects	
		Aiolopus	Epacromiini	*Aiolopus simulatrix*	2	7	9	0.11
		Trilophidia	Trilophidiini	*Trilophidia annulata*	25	445	454	5.56
6.	**Acridinae**	*Acrida*	Acridini	*Acrida exaltata*	16	171	187	2.29
			Acridini	*Acrida turrita*	13	126	139	1.70
		Truxalis	Truxalini	*Truxalis indica*	0	53	53	0.64
			Truxalini	*Truxalis eximia*	0	54	54	0.66
7.	**Coptacrinae**	*Eucoptacra*	-	*Eucoptacra praemorsa*	2	80	82	1.004
		Epistaurus	-	*Epistaurus* sp.	0	23	23	0.28



Fig, 2 : Study area map of semiarid eastern plain, Rajasthan

Tropical thorny scrubby forest dominates the region, with *Acacia senegal*, *Anogeissus pendula, Acacia arabica, Acacia nilotica,* and invasive plant species such as *Prosopis juliflora* and *Lantana camera*. The experimental area is bounded by Aravalli hills and gets 30-60 mm of rainfall on average; temperature ranges between 25-30ºC during sowing, 2-5ºC - January, and 42-45ºC - May-June, and has a relative humidity of 60-90% throughout the year.

Survey and collection

The study area was surveyed on fortnight during the pre-monsoon and monsoon seasons (April 2021 to September 2021). The insects were gathered using the "*Line Transect Method*"[2]. Selected habitat portions of the localities were marked as sampling sites. The sampling locations included grassland, agricultural lands, natural areas, hilly regions, rocky areas, home gardens and some others. The sampling took place between 8 to 10 a.m. and 4 to 6 p.m. The insects were collected and counted using a sweep net and handpicking while walking in a straight line.

Preservation and Identification

The collected orthopteran insects were placed in killing jars containing cotton soaked in ethyl acetate. Grasshoppers were pinned slightly to the right side of the midline through the posterior part of the pronotum. Each specimen was labelled with the location, date of collection, and collector's name. The insects were stretched, spreaded, and pinned, and then the killing jars were brought to the laboratory. To preserve the insects, they were oven-dried for 72 hours at 60ºC before being placed in wooden boxes and labeled according to their systematic position.

Identification was accomplished with the guidance of the departmental museum, the Department of Entomology, the Rajasthan College of Agriculture (MPUAT, Udaipur), and the Locust Warning Organization (LWO), Jodhpur, using taxonomic expertise knowledge and keys, illustration and the department's collected specimens. References were consulted from relevant literature and comparisons were made with the Department's recognized reference collection. For the Orthopterans, the modern and updated classification system Orthoptera

Fig. 3: Sampling habitat types in the study area: A & F; Agriculture farm area B; Hilly area C; Aquatic habitat D; Grassland E; Rocky area

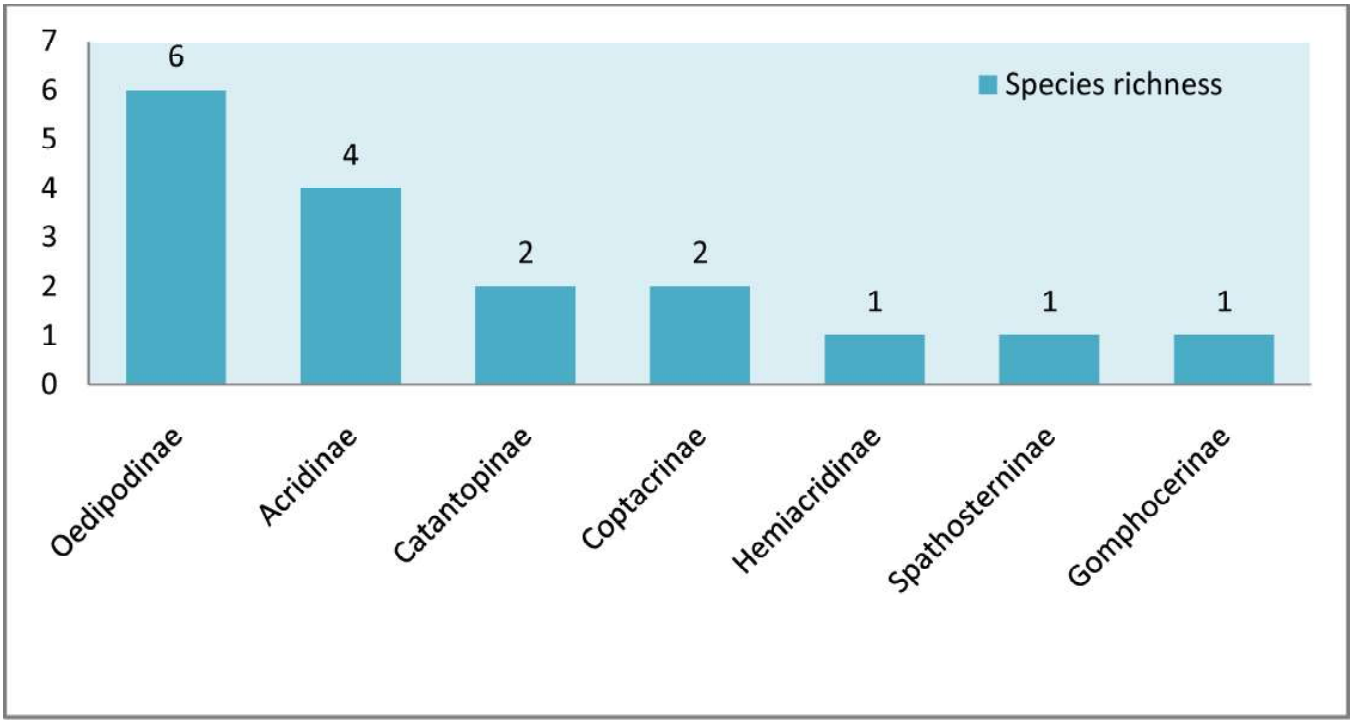


Fig. 4: Species richness in semiarid eastern plain, Rajasthan (Year 2021)

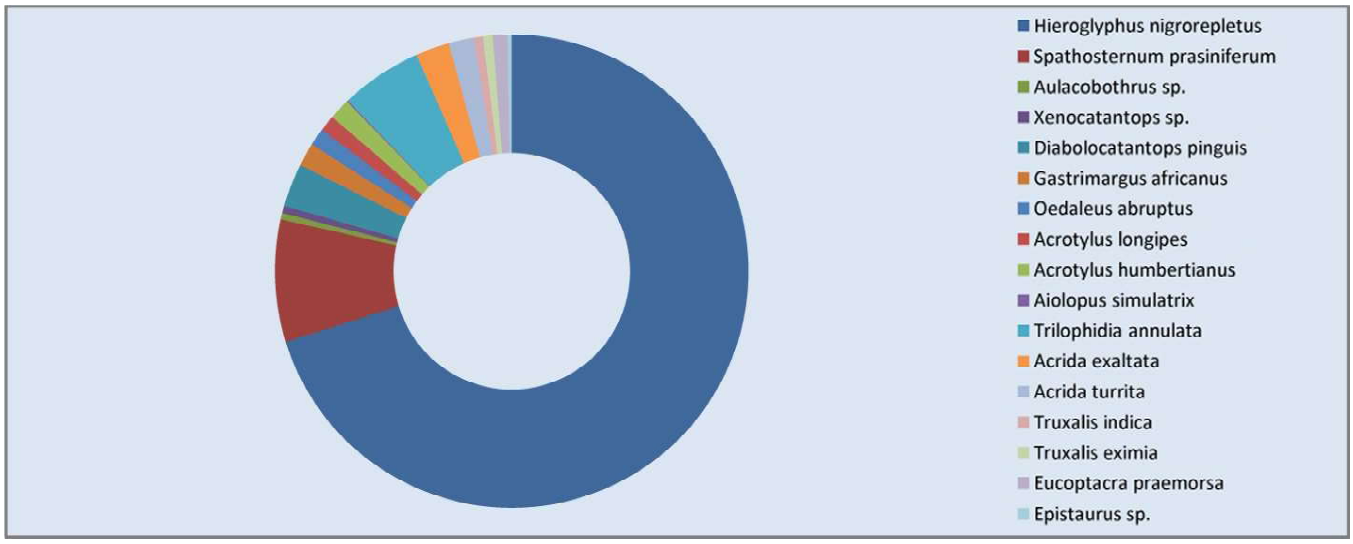


Fig. 5 : Species composition in semiarid eastern plain, Rajasthan (Year 2021)

Species File (OSF) (online version 5.0/5.0) as proposed was used[7].

Data Analysis

Species diversity, as well as associated parameters such as diversity indices, species richness, abundance and distribution status, were measured. The diversity indices were a numerical evaluation of the diversity of acridid species found in the semiarid eastern plain, Rajasthan. Species abundance is the total number of reported individuals per species by survey time and sampling unit; occurrence is the presence or absence of a species in the target site; distribution status defines spatial and temporal changes in population and species composition, and species richness is the total number of species that occur in the defined community or habitat. The relationship between acridid abundance and distribution and abiotic factors such as temperature, rainfall and humidity were also studied. The data observed at the study sites are presented (Table-2).

The Shannon Weiner diversity index[21], Simpson's index[24], and Evenness Index[20] were calculated using standard formulas using the PAST Ver. 4.03 tool.

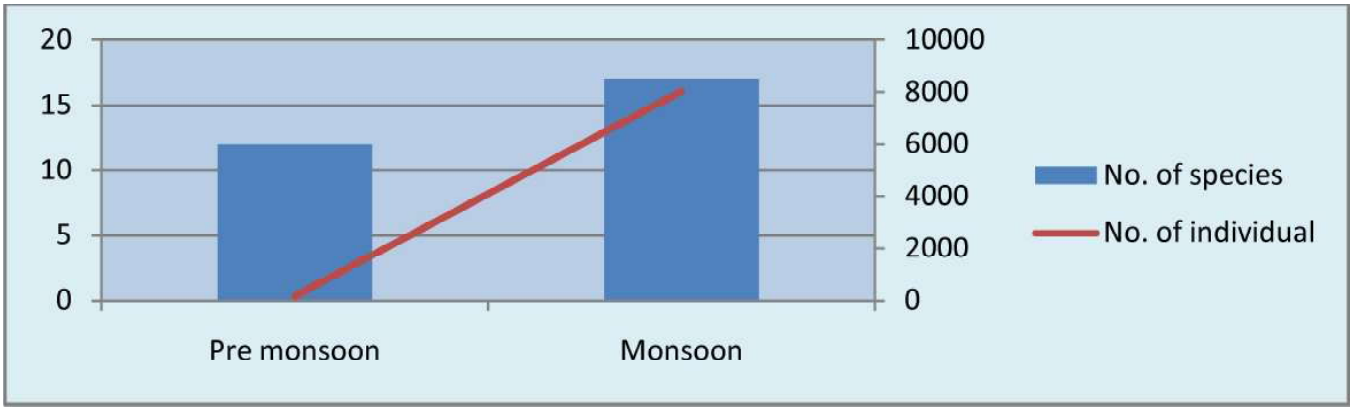


Fig. 6: Seasonal variation in number of species and individuals of the Acridids in semiarid eastern plain, Rajasthan (Year 2021)

Result and Discussion

Acridid faunal survey of the semiarid eastern plain that includes Jaipur, Ajmer, Tonk, and Dausa districts of Rajasthan were carried out for 6 months from April to September 2021 in various habitats such as hilly areas, grasslands, shrubby areas, grasslands plus shrubby areas, and agricultural farms. In Jaipur, Dausa, Ajmer, and Tonk districts, 8160 individuals of acridids belonging to 17 acridid species 10 tribes, 14 genera, and from 7 subfamilies *i.e.* Hemiacridinae, Acridinae, Spathosterninae, Coptacrinae, Oedipodinae, Catantopinae and Gomphocerinae were observed. The diversity of acridid fauna in pre-monsoon and monsoon was measured and quantified in the form of diversity indices *viz.* Shannon Diversity Index (H'), Simpson's Diversity Index (D'), Dominance & Evenness (E) were calculated as 2.295, 1.249; 0.888, 0.4781; 0.112, 0.5219; and 0.827, 0.2051 subsequently. The study revealed the presence of *Hieroglyphus nigrorepletus*, *Spathosternum prasiniferum*, *Aulacobothrus sp.*, *Xenocatantops* sp., *Diabolocatantops pinguis*, *Gastrimargus africanus*, *Oedaleus abruptus*, *Acrotylus longipes*, *Acrotylus humbertianus*, *Aiolopus simulatrix*, *Trilophidia annulata*, *Acrida exaltata*, *Acrida turrita*, *Truxalis indica*, *Truxalis eximia*, *Eucoptacra praemorsa* and *Epistaurus* sp. from the study area. The least number of acridid individuals were reported from the Tonk while Jaipur and Dausa had much abundance. The Hemiacridinae subfamily was found dominant in agricultural farms, with 5725 individuals of *Hieroglyphus nigrorepletus* species. The total number of members of each species and their percentile contribution to the entire Acrididae family are represented in Table-3. Subfamily Oedipodinae had the maximum number of species, followed by Catantopinae, Acridinae, and Coptacrinae. *Hieroglyphus nigrorepletus* was accounting for 70.15 % of the overall individuals followed by 8.33 %

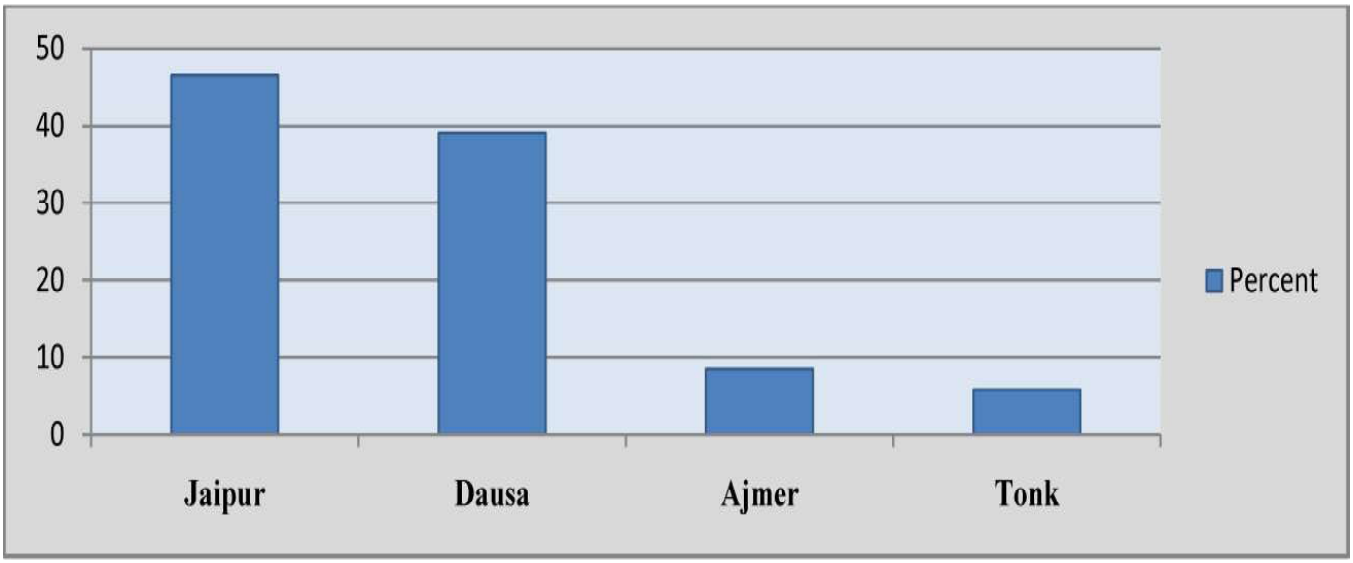


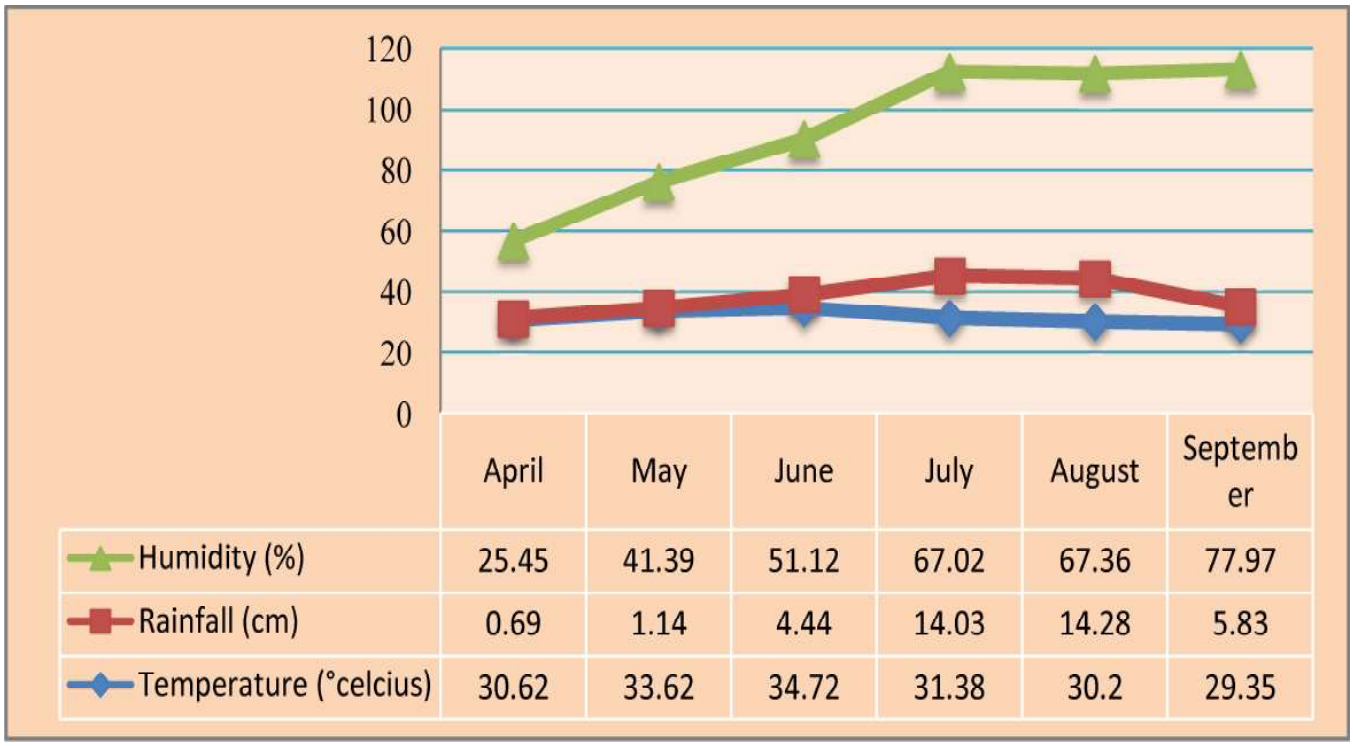
Fig. 7 : Abundance of Acridid fauna in four study sites of semiarid eastern plain, Rajasthan (Year 2021)

Spathosternum prasiniferum, 5.56 % *Trilophidia annulata* 2.96 % *Diabolocatantops pinguis* and 0.11 % *Aiolopus simulatrix*, respectively. The number of acridid species and individuals recorded during the research period varied seasonally and the highest number of acridid individuals was recorded during the monsoon period (8017 individuals) having 17 species, followed by the pre-monsoon period (159 individuals) with 12 species as determined by the Shannon Weiner Diversity Index (Figs. 6 and 7 & Table-2). According to observations made during the research period, the highest acridid abundance and distribution were recorded in the monsoon period due to favorable environmental conditions, temperature 29 to 32 C, rainfall of 5 to 14 cm, and relative humidity 67 to 77 % (Fig. 7).

According to previous reports, *Hieroglyphus nigrorepletus* causes significant crop damage when compared to *Atractomorpha crenulata, Gastrimargus africanus*, and other acridids. *Hieroglyphus nigrorepletus* is one of the acridid pests, and it has been reported as a pest in Pakistan[10], Rajasthan[26], and Gujarat[6], where it destroys crops of maize, rice, millets, wheat, fodder, and sugarcane. In contrast, *Gastrimargus africanus sulphureus* and *Atractomorpha crenulata*, have been identified as minor maize pests[13,23,29]. There have also been reports of other acridids as paddy pests, including *Ailopus thalasisnus, Spathsternum prasiniferum* from Pakistan[10], *Acrida exaltata* from Pakistan[10] and Rajasthan[14]. A study in Udaipur revealed that the relative density of the family Acrididae was highest among all orthopterans for the genus *Hieroglyphus*, followed by *Oxya* and *Spathosternum* having 16.47, 13.18, and 12.61 % respectively[9]. There were pointed out 37 species of grasshoppers and locusts, in which 25 genera and 11 subfamilies of the Acrididae family, have been found in various locations throughout Rajasthan[15]. 1484 desert locust occurrence areas were observed in Rajasthan, India[11].

Conclusion

Acridids are the clear indicators of environmental and economic welfare and because of their crucial role in ecosystem conservation, their conservation has been acknowledged as essential for a sustainable world. Acridids assist plant decay and re-growth, balancing the types of plants that thrive and provide benefits to both people and the environment. By giving spiders, birds, and lizard's food, they support the environment by enabling these animals to live and continue to play their respective roles in preserving a thriving, healthy ecosystem. Grasshoppers act as a natural counterbalance, eating any excess weed plants that may disrupt an ecosystem's foliage balance[8]. Acridids are the most commonly consumed by humans. However, in some regions of Rajasthan and for some years, a few acridid species, notably *H. nigrorepletus* and *Oxya* spp., have economically harmed crops. Therefore, this research would undoubtedly add to the already existing knowledge



	April	May	June	July	August	September
Humidity (%)	25.45	41.39	51.12	67.02	67.36	77.97
Rainfall (cm)	0.69	1.14	4.44	14.03	14.28	5.83
Temperature (°celcius)	30.62	33.62	34.72	31.38	30.2	29.35

Fig. 8: Meteorological parameters of semiarid eastern plain, Rajasthan (The year 2021)

among entomologists in Rajasthan and India. It is hoped that additional studies on the biodiversity and taxonomy of acridids would be conducted in this region to record better and more information on those topics for future use.

References

1. Akhtar MH, Usmani MK, Nayeem MR, Kumar H. Species diversity and abundance of Grasshopper fauna (Orthoptera) in rice ecosystem. *Ann. Biol. Res.* 2012; **3**(5) : 2190-2193.
2. Bagaturov MF, Mahmood M, Tariq G, Faiz LZ. Insect Diversity and Association with Plants: A Case Study in Rural Areas of Dhirkot, Azad Kashmir Pakistan. *J. bioresour. manag.* 2020; **7**(1) : 3.
3. Chandra S, Sinha PP, Singh RP. The desert locust build-up in western Rajasthan during monsoon season of 1986. *Plant Prot. Bull.* (Faridabad). 1988; **40**(1): 21-28.
4. Chandra S. Population dynamics of the desert locust (*Schistocerca gregaria* F.) in relation to summermonsoon rainfall in western Rajasthan Desert - a long term study. *Plant Prot. Bull. (Faridabad*). 1990; **42**(1-2):1-6.
5. Chandra S. Some field observations on the plant association of solitary living desert locust hoppers in western Rajasthan. *Plant Prot. Bull.* (Faridabad). 1985; **37**(1) : 25-26.
6. Charan Singh. *Plant Prot. Bull.*, India. 1972; **22**: 38.
7. Cigliano MM, H Braun, DC Eades, D Otte. *Orthoptera Species File*. Version 5.0/5.0.
8. Cullen DA, Cease AJ, Latchininsky AV, Ayali A, Berry K, Buhl J, Rogers SM. From molecules to management: mechanisms and consequences of locust phase polyphenism. In *Adv In Insect Phys.* 2017; **53** : 167-285). Academic Press.
9. Dhakad DEVENDRA, NAGAR R, MAL J, Rathore PS, Swaminathan R. Diversity of Orthopteran fauna in sugarcane at Udaipur. *The Bioscan*. 2014; **9**(1): 207-210.
10. Irshad M, Mazhar RA, Ghani MA. *Agriculture Pakistan*. 1977; **28** : 55- 64.
11. Jhiknaria H. Distribution of Desert Locust Schistocerca gregaria in Rajasthan, India and Establishing an Early Warning System for Locust Control in India. 2021.
12. K Chandra, MS Shishodia, SK Gupta. Diversity of Orthoptera (Insecta) In India: State of Our Knowledge. In Advancement in Invertebrate Taxonomy and Biodiversity. 2010 : 43-80.
13. Karimullah MAM, Ahmad S. Insect pests of maize crop in different localities of Kalam. *Sarhad J. Agric*. 1992; **8**:513- 518.
14. Khan RM, Vyas HK, Vaish OP. *Rice News Teller.* 1963; **11**(1) : 15-17.
15. Kumar H, Usmani MK. Taxonomic studies on Acrididae (Orthoptera: Acridoidea) from Rajasthan (India). *J. Entomol. Zool. Stud.* 2014; **2**(3) : 131-146.
16. Kumar H, Usmani MK. A checklist of Acrididae (Orthoptera: Acridoidea) from Haryana, India. *Acta Zool. Mex.* (n. s.). 2015; **31**(2): 234-238.
17. Meena NK, Lal G, Kant K, Meena RS, Meena SR. Pest scenario of cumin *(Cuminum cyminum* L.) and population dynamics in semi-arid region of Rajasthan. *Int. j. seed spices.* 2018; **8**(1) : 80-83.
18. Pareek A, Lekha Rathore PS. Species Diversity and Density of Acridids in Paddy Ecosystem in Southern Rajasthan. *Period. res.* 2014; **3**(2) : RNI No. UPBIL/2012/55438.
19. Pareek A, Sharma US, Lekha KR. Species richness, density and diversity of Acrididae in maize ecosystem in southern Rajasthan. *J. Entomol. Zool. Stud*. 2017; **5**(2) : 746-749.
20. Pielou EC. Ecological diversity. *Wiley Interdiscip Rev, New York*. 1966.
21. Shannon CE, W Wiener's. The mathematical theory of communication. Urbana, IL: University of Illinois Press. 1949.

22. Shishodia MS, Chandra Kailash Gupta, Sunil Kumar. An Annotated Checklist of Orthoptera (Insecta) from India. *ZSI*. 2010; **314** : 1-366.

23. Shishodia MS. Swarming of *Hieroglyphus nigrorepletus* in Western U. P. with a new record of *H. concolor* (Orthoptera: Acrididae). *Bionotes*. 2009; **11**:14.

24. Simpson E. Measurement of Diversity. *Nature.* 1949; 163 : 688. https://doi.org/10.1038/163688a0.

25. Sinha PP, Chandra S. Observations on plant complex of some important locust habitats in western Rajasthan. *Plant Prot. Bull.* (Faridabad). 1987; **39**(4) : 13- 15.

26. Suhail A, Arif MJ. Suhail G. *Int J Agric Biol*. 1999; **1**(3): 142-144.

27. Swaminathan R, Swaminathan T. Taxonomy of Orthoptera with Emphasis on Acrididae. In *Indian Insects*. 2019; (pp. 57-68). CRC Press.

28. Tandon SK, Hazra AK. Faunal diversity in India: Orthoptera. ENVIS Center, *ZSI*. 1998; 183-188.

29. Uvarov BP. Rice grasshoppers of the genus *Hieroglyphus* and their nearest allies. *Bull. Entomol. Res*. 1922; **13** : 225- 41.

30. Waghmare S, Waghmare D, Bhatnagar PS. Species Diversity of Short Horned Grasshopper (Orthoptera: Acrididae) in Selected Grasslands of Solapur District, Maharashtra, India. *J Biodivers Endanger Species.* 2013; **1**:110. doi:10.4172/2332-2543.1000110