Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454

Vol. 21 | No. 2 | pp. 563-570 | 2022

Original Research Paper

https://doi.org/10.46488/NEPT.2022.v21i02.014

Open Access Journal

Check List of Species Richness and Abundance of Orthoptera Fauna in Bharathi Park, Coimbatore, Tamil Nadu, India

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 29-05-2021
Revised: 09-08-2021
Accepted: 22-08-2021

Key Words:
Orthoptera
Species richness
Abundance
Acrididae
Oedipodinae

ABSTRACT

Order Orthoptera is one of the largest and most important invertebrate groups for environmental monitoring and assessment. Orthoptera faunal composition was carried out at Bharathi Park, Coimbatore, Tamil Nadu, India to evaluate the present status of various species. PAST software was used to perform various statistical analyses to estimate the Orthoptera composition. Overall, 334 individuals belonging to 22 species, 19 genera, 17 tribes under 10 subfamilies, and four families of Orthoptera were recorded. Species richness (59.09%) and species abundance (70.06%) were recorded highest in the Acrididae family followed by Pyrgomorphidae, Tettigoniidae, and Gryllidae. Oedipodinae was the most species-rich (27.27%) and the most abundant subfamily, accounting for 30.24% of the total collected individuals. During the study period, 10 dominant, five intermediate dominance, four incidental, and three rare species were observed. Among these, *Spathosternum prasiniferum* was found to be the most dominant species (D=18.26) and the least dominant (D = 0.6) species was *Euconocephalus pallidus*. Based on the principal component analysis, the distribution of species along with the first two PCs (PC1= 33.87% and PC2=28.68%) accounted for the highest variance of the total variances. Cluster analysis showed that *Acrotylus humbertianus* and *Teleogryllus mitratus*, *Conocephalus maculates* and *Gryllus bimaculatus* Orthopterans were similar to each other. The value of the Shannon diversity index (2.27), Simpson index (0.87), Margalef index (2.2), and α-diversity (5.75) were higher in Acrididae when compared with other families. Value of Evenness (0.93) was highest in Gryllidae. Statistical analysis infers that the richness and abundance percentage of Orthopterans significantly varied between species to species and family to family.

INTRODUCTION

Recording the distribution of species composition in the ecosystem is an important step for identifying biodiversity hotspots and designing effective conservation strategies (Mirzaei et al. 2017). Insects are the most diverse component of the ecosystem, and they play a critical role in many areas of ecological stability (Millar 1993). Insects from the order Orthoptera are important grassland species that fulfil key ecological niches (Gandar 1982, Belovski & Slade 1993, Ryszkowski et al. 1993). Grasshoppers, crickets, katydids, and locusts are hemimetabolous and phytophagous insects that come under the order of Orthoptera. It is one of the largest orders of insects belonging to the monophyletic suborders Caelifera called short-horned Orthopterans it includes the family Acrididae, Pyrgomorphidae, Tetrigidae, and Ensifera called long-horned Orthopterans it includes family Tettigoniidae, Gryllidae, Haglidae, and Gryllotalpidae. The number of known species of Orthoptera found throughout the world is 27,260 species (Eades et al. 2016). Shishodia et al. (2010) reported 1033 species/subspecies belonging to 400 genera and 21 families of Orthoptera from India.

Orthoptera has become one of the most important invertebrate groups for environmental monitoring and assessment (Jamison et al. 2002). This group also plays a significant role in terrestrial food webs and is known to be a good source of protein for many other animals such as amphibians, birds, small reptiles, and mammals; therefore, their scarcity may disturb the trophic structure in an ecosystem (Schmidt et al. 1991, Soliman et al. 2017). Orthopterans have also been successfully used in biomonitoring the effects of changes in land management regimes (Gardiner et al. 2002, O'Neill et al. 2003) and in identifying the grasslands state of conservation (Báldi & Kisbenedek 1997, Andersen et al. 2001).

Insect diversity research is important because a high number of species are on the verge of extinction, which is a sign of environmental change. The diversity of Orthoptera has been studied by various researchers throughout India but in Coimbatore, Orthoptera diversity is rarely studied (Chitra et al. 2000, Lena et al. 2012, Divya & Senthilkumar 2017, Suganya et al. 2020.) However, no previous record is available on the diversity, richness, and abundances of Orthoptera in Bharathi Park, Coimbatore. Keeping in view, the species composition

of "Orthopteran" fauna was carried out in the present investigation. We believe that the result would offer distinctive information of varieties of Orthoptera species from this park.

MATERIALS AND METHODS

Study Area

Orthopteran diversity was conducted at Bharathi park. This place is located 4 km from the city of Coimbatore, Tamil Nadu, India. This place is the second-largest city in north-western Tamil Nadu located at 11°01'13.1"N 76°56'50.6"E in South India at 411 m (1349 ft) above sea level on the banks of the Noyyal river. To the west and north, it is surrounded by the western mountain range, with reserve forests of the Nilgiri Biosphere Reserve on the northern side. The mean maximum and minimum temperatures for Coimbatore city during summer and winter vary between 35°C to 18°C. The average annual rainfall is around 700 mm with the northeast and the southwest monsoons.

Collection of Grasshoppers

Using a sweep net and handpicking approach, Orthoptera fauna was collected twice a month from the study area in the morning (7 am to 9 am) and evening (4 pm to 6 pm) throughout the months of October 2019 to March 2020. In the morning and evening, Orthopterans were less active, and capturing was easy. The sweep net method generally provides an accurate estimation of grasshopper diversity on grasslands (Evans et al. 1983, Larson et al. 1999). Sweep net sampling is the most commonly used method to evaluate grasshopper species composition (Joshi et al. 1999).

Identification of Grasshoppers

Orthopterans were identified under a stereoscopic dissecting binocular microscope (MZ2000 Micros Austria) using the keys of Kirby (1914) and also referring to the Website (http://Orthoptera.SpeciesFile.org). After identification and counts of species were made, they were immediately released in the sampled site to avoid impoverishing the environment. A small number of the dominant and rare species were stored for further examination.

Data Analysis

The species richness was calculated as the total number of species present in the study site. Species abundance was calculated as a total number of individuals present in the study area according to a method by Buschini & Woiski (2008): D = (abundance of a species/total abundances recorded) × 100. If D was > 5%, the species was considered dominant; if 2.5% < D < 5%, the species was considered an intermediate abundance, and if D < 2.5%, the species was considered an incidental species. Rare species were the ones that had less than five individuals. The statistical analysis of the data was done using the data analysis tool pack available in MS Excel 2010. Principal Component Analysis (PCA) was performed to study the pattern of variation between the species among different families of Orthoptera. Furthermore, cluster analysis was used to investigate the similarity and dissimilarity of species composition among four different families. The different diversity indices such as Shannon index, Simpson index, Margalef index, Evenness, and Renyi index were calculated to describe and compare the diversity of species among different families using the statistical software PAST (Paleontological Statistical Software) version 2.02 (Hammer et al. 2001).

RESULTS

The families, subfamilies, tribes, genera, and species of the Orthopterans collected are shown in Table 1. A total of 334 individuals belonging to 22 species, 20 genera, 17 tribes, and 10 subfamilies under four families were sampled from the study area (Table 1).

Species Richness

In this study, Acrididae was the most species-rich family with 13 species, which accounted for 59.09% of the total species recorded with 11 genera and nine tribes under five subfamilies. The second dominant family was Pyrgomorphidae, which had four species, four genera, and four tribes under two subfamilies, which accounted for 18.18% of the total collected species. Family Tettigoniidae ranked third with three species under three genera, three tribes, and two subfamilies, which accounted for 13.64% of the total species collected while the Gryllidae family had the least with two species, under two genera, one tribe and one subfamily which accounted for 9.09% of the total recorded species (Fig. 1). Among the 10 subfamilies of Orthopterans, Oedipodinae was found to be the most dominant subfamily with six species accounting for 27.27% of the total collected species. Next in order of dominant families were Gomphocerinae and Pyrgomorphinae with three species constituting 13.4% (Fig. 2).

Species Dominance (D)

Among the four families, abundance was recorded highest in Acrididade, n = 234 (70.06%), followed by Pyrgomorphidae, n = 52 (15.57%) and Gryllidae, n = 31 (9.28%) while Tettigoniidae had the least individuals, n = 17 (5.09 %) (Fig. 1). Out of the 22 species of Orthoptera, 10 dominant species, five species with intermediate dominance, four incidental species,

Table 1: Checklist of Orthopterans from Study area.

Family	Subfamily	Tribe	Species	(N)	(D)
Acrididae	Acridinae	Acridini	Acrida exaltata (Walker 1859)	7	2.1
		Phlaeobini	Phlaeoba infumata (Brunner von Wattenwyl 1893)	3	0.9
	Catantopinae	Catantopini	*Diabolocatantops pinguis* (Stal 1861)	12	3.59
	Gomphocerinae	Arcypterini	*Aulacobothrus luteipes* (Walker 1871)	15	4.49
			Crucinotacris decisa (Walker 1871)	8	2.4
	Oedipodinae	Dociostaurini	*Leva indica* (Bolívar 1902)	27	8.08
		Acrotylini	*Acrotylus longipes* (Charpentier 1845)	16	4.79
			Acrotylus humbertianus (Saussure 1884)	21	6.29
			Acrotylus insubricus (Scopoli 1786)	4	1.2
		Locustini	*Gsatrimargus africanus* (Saussure 1888)	9	2.69
			Oedaleus abruptus (Thunberg 1815)	19	5.69
		Trilophidiini	*Trilophidia annulata* (Thunberg 1815)	32	9.58
	Spathosterninae	Spathosternini	*Spathosternum prasiniferum* (Walker, 1871)	61	18.26
Pyrgomorphidae	Pyrgomorphinae	Atractomorphini	*Atractomorpha crenulata* (Fabricius 1793)	17	5.09
		Chrotogonini	*Chrotogonus oxypterus* (Blanchard 1836)	6	1.8
		Tagastini	*Tagsta indica* (Bolivar 1905)	11	3.29
	Orthacridinae	Orthacridini	*Orthacris maindroni* (Bolivar 1905)	18	5.39
Tettigoniidae	Conocephalinae	Conocephalini	*Conocephalus maculatus* (Le Guillou 1841)	10	2.99
		Copiphorini	*Euconocephalus pallidus* (Redtenbacher 1891)	2	0.6
	Phaneropterinae	Phaneropterini	*Phaneroptera* gracilis (Burmeister 1838)	5	1.5
Gryllidae	Gryllinae	Gryllini	*Teleogryllus mitratus* (Burmeister 1838)	21	6.29
			Gryllus bimaculatus (De Geer 1773)	10	2.99
Total				334	100

N - Number of individuals, D - Dominance

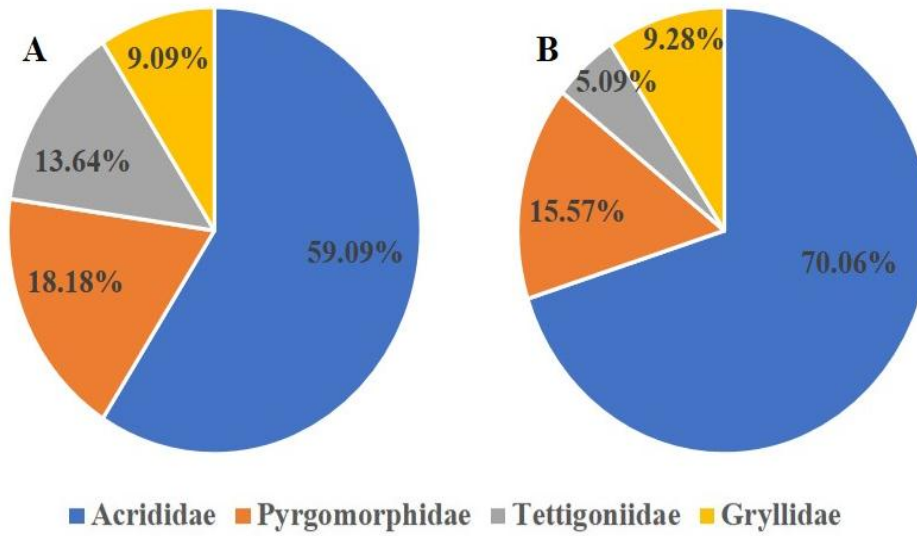

Fig. 1: A) Species richness and B) Species abundance families of Orthoptera from the study area.

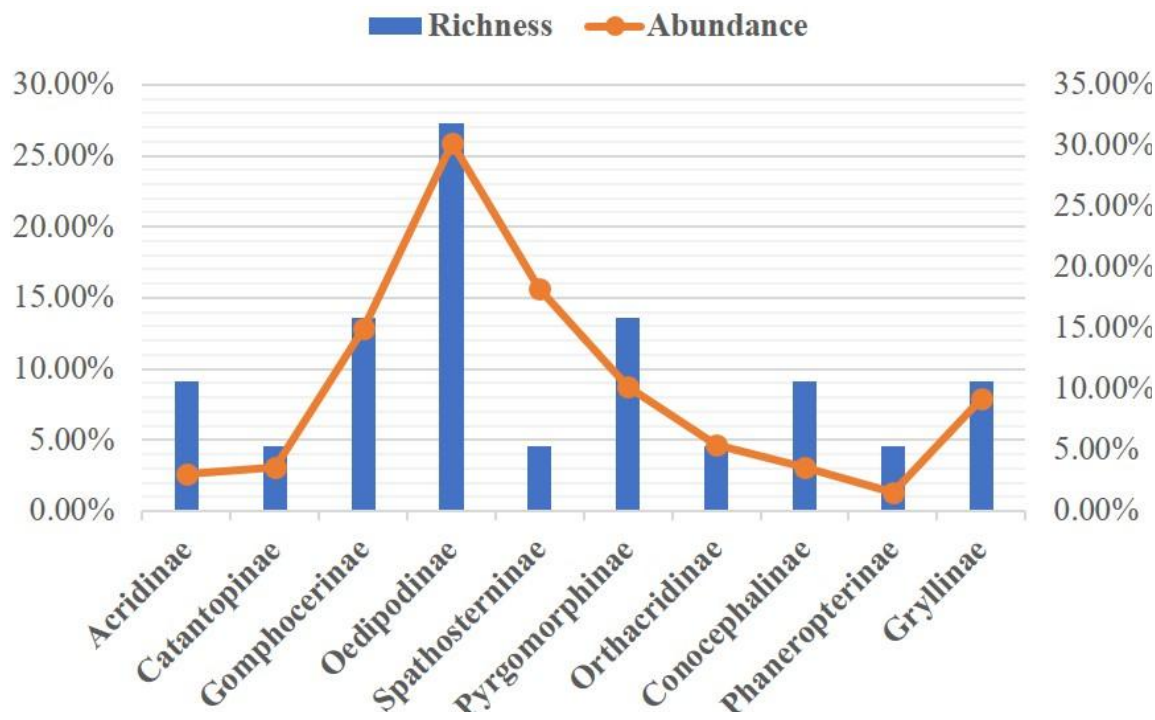

Fig. 2: Species richness and abundance subfamilies of Orthoptera.

and three rare species were observed during the study period (Table 1). In terms of the total number of individuals reported, the most dominant species were *Spathosternum prasiniferum* (D = 18.26) followed by *Trilophidia annulata* (D = 9.58) and *Leva indica* (D = 8.08) while *Euconocephalus pallidus* (D = 0.6), *Phlaeoba infumata* (D = 0.9) and *Acrotylus insubricus* (D = 1.2) were the least dominant species in the present study. For the Acrididae family, *S. prasiniferum* (D = 18.26) and *T.annulata* (D = 9.58) were the most dominant species. The abundant species in Pyrgomorphidae were *Orthacris maindroni* (D = 5.39) and *Tagasta indica* (D = 3.29). *Conocephalus maculatus* (D = 2.99) was observed maximum in the Tettigoniidae family. Gryllidae had only two species, *Teleogryllus mitratus* was the highest dominant (D = 6.29) and *Gryllus bimaculatus* was the least dominant (D = 2.99) (Table 1).

Subfamily Oedipodinae was found to be most abundant with 101 individuals (30.24%) followed by Spathosterninae with 61 individuals (18.26%) and Gomphocerinae with 50 individuals (14.97%). Less abundance was noted in Phaneropterninae with five individuals (1.50%) (Fig. 2). Some abundant species of Oedipodinae were *T. annulata* (D = 9.58), *Acrotylus humbertianus* (D = 6.29), and *Oedaleus abruptus* (D = 5.69) (Table 1).

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) was done for the family-wise representation of various Orthopteran taxa from the study area. A total of 22 species of Orthopterans were selected among four families for PCA. The percentage of variance and eigenvalues were explained by four PCs. The first two correlation matrices of PCA showed the highest variance and eigenvalue; other PCs had progressively less variances and eigenvalue. PC1 explained 33.87% of the variation in the parameters with an eigenvalue of 1.35511. PC2 explained 28.68% of the variation in the parameters with an eigenvalue of 1.14725. Principal component 1 analysis represents the higher species composition and family richness, and principal component 2 represents the lower species composition of Orthopterans. Among the four subfamilies of Orthoptera, Acrididae showed the highest PC score. Most of the acridids' fauna were clustered in the centre of the plot (Fig. 3).

Species Similarity and Dissimilarity

The similarity of species composition among different families was performed based on cluster analysis as presented in Fig. 4. Clusters were numbered in ascending order based on abundance composition. The similarity matrix from the

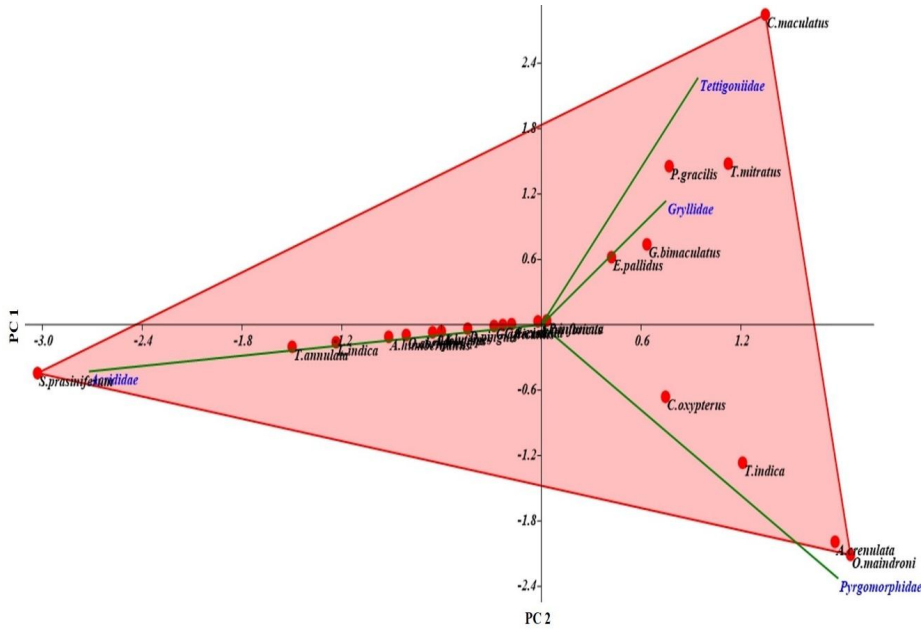

Fig. 3: Bi-plot of the first two axes of the principal component analysis of Orthoptera species.

quantitative data showed the composition of *A. humbertianus* (Acrididae), *T. mitratus* (Gryllidae), *C. maculatus* (Tettigoniidae), and *G. bimaculatus* (Gryllidae) Orthopterans were similar to each other. The only species that formed a single cluster was *S. prasiniferum* (Acrididae), and the species composition differed greatly from that of other Orthopteran

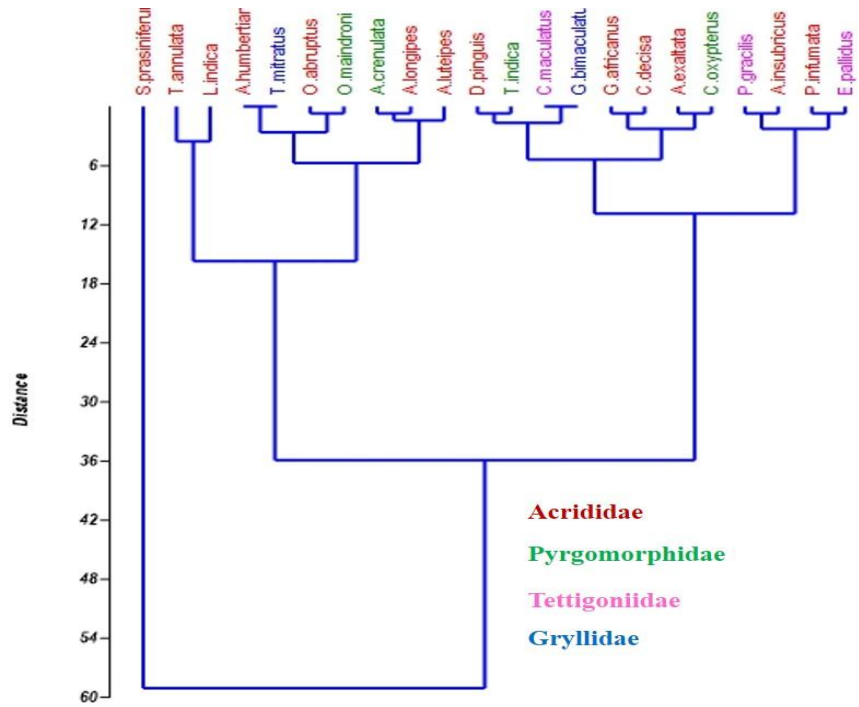

Fig. 4: Similarity and dissimilarity of species composition among different families using cluster analysis.

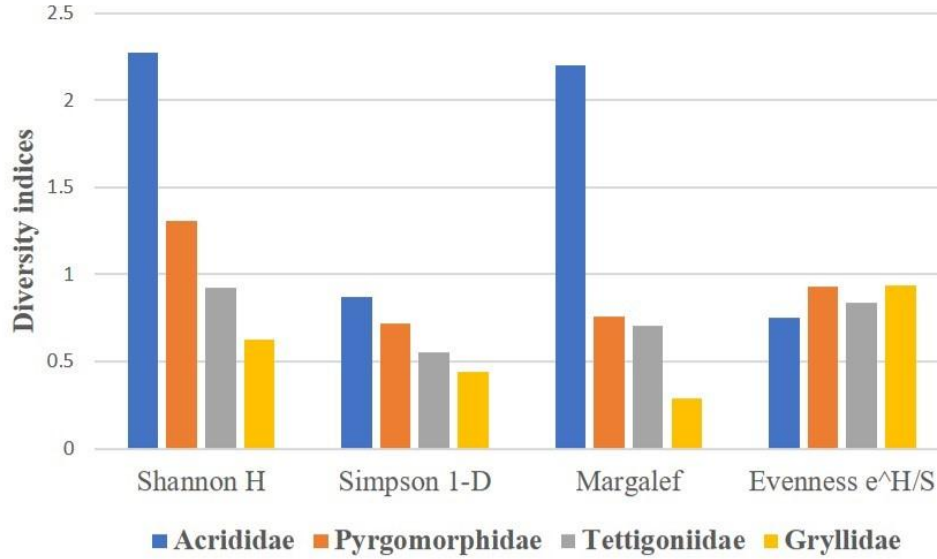

Fig. 5: Comparison of different diversity indexes among different families of Orthoptera.

species. Acrididae species, on the other hand, were grouped at the highest level of similarity (Fig. 4).

Diversity Indices

In the present study, the Shannon index varied from 0.62 to 2.27. The Simpson index ranged from 0.43 to 0.87. The Margalef index fluctuated between 0.29 and 2.2. Shannon, Simpson, and Margalef's diversity index values were lowest in Gryllidae and highest in Acrididae, while evenness index values showed difference; it was highest in Gryllidae and lowest in Acrididae. The species evenness index varied from 0.74 to 0.93. Among these diversity indices, the Shannon index showed the highest diversity value (Fig. 5).

As illustrated in Fig. 6, the Renyi indices of diversity plot clearly demonstrate the species diversity pattern in four groups. The number of species and individuals in the Acrididae family was not only higher but the individuals were also distributed more evenly in the Acrididae family. Renyi

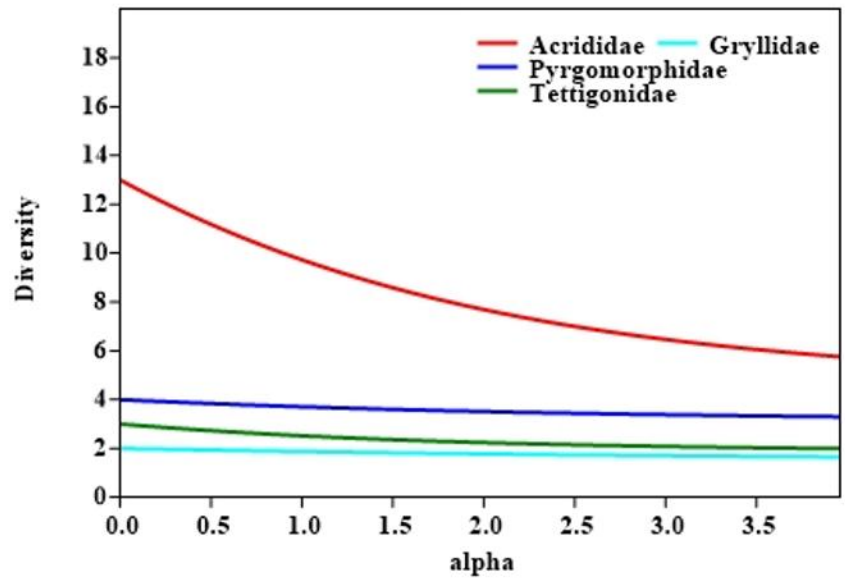

Fig. 6: Species accumulation curve among different families of Orthoptera.

α-diversity varied from1.65 to 5.75. The lowest diversity index was observed in Gryllidae and the highest index was recorded in Acrididae; however, the interaction between Tettigoniidae (1.99) and Gryllidae (1.65) indicates similar α-diversity (Fig. 6).

DISCUSSION

All the collected grasshoppers were classified under four families viz., Acrididae, Pyrgomorphidae, Tettigoniidae, and Gryllidae. Among these, Acrididae showed the richest family (13 species). This perception was in parallel with the observations of Divya and Senthilkumar (2017) who also observed four families of Orthoptera and 13 species of acridids in Coimbatore. The present study's findings showing the Acrididae family had the most dominating numerical distribution are similar to those of Paulraj et al. (2009), who found that the Acrididae family had the most dominant numerical distribution. Other studies such as Akhtar et al. (2012), Thakkar et al. (2015), Arya et al. (2015), and Suganya et al. (2020) also found maximum diversity being shown by the Acrididae family. Acridids are graminivorous in nature and the grasslands found in the ecosystem provide a wide variety of food as well as a breeding site for acridids.

The subfamily Oedipodinae had the highest species diversity and population composition in the research area during the study period. This observation was similar to Kumar & Usmani (2015), Shishodia et al. (2010), and Suganya et al. (2020) who found members of the subfamily Oedipodinae were more diverse and abundant. Growth rate and reproduction efficiency influenced the distribution of dominant species in the ecosystem.

Among the collected species, *S. prasiniferum* was found to be the most dominant in the study area. These species have greater ecological plasticity as they can reproduce and increase their population in different conditions of ecosystems. Kumar & Usmani (2015) and Raghavender & Vastrad (2017) also reported that *S. prasiniferum prasiniferum* was found to be most abundant. According to Bhusnar (2015), *S. prasiniferum prasiniferum* is found throughout the year and is dominant in the Solapur region.

Based on the PCA bi-plot results, the Orthoptera composition showed significant differences among species and families. The distribution of individuals along the first two PCs showed the highest variances. The first two correlation matrix PCs accounted together for 62.55% (PC1= 33.87% + PC2=28.68%) of the total variances and other PCs showed less variances.

A cluster analysis (or classification) is helpful in finding the natural groupings of samples, such that samples within a group are more similar to each other than the samples in different groups. It is also used to define species assemblages and groups of species that tend to occur in a parallel manner across sites (Balakrishnan et al. 2014). In our study, cluster analysis clearly revealed the similarity and dissimilarity of species concentration among different families of Orthoptera from the study area. Habitat complexity and host plant might act as drivers and determinants of the variation among species composition in the park.

In the present study, Family-wise diversity: Shannon, Simpson, Margalef, and Renyi index values were highest in Acrididae and Evenness was the highest in Gryllidae. Thakkar et al. (2015) also observed that Family-wise diversity, Shannon-Wiener diversity index, and Evenness were elevated for Acrididae followed by Tettigoniidae, Gryllidae, and Pyrgomorphidae in South Gujarat. Generally, the Shannon diversity index and Simpson diversity index are commonly used to evaluate the diversity richness of organisms present in an area. Typical values of H are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4 (Shannon & Weiner 1949). Simpson's diversity index (λ) was calculated since it is well accepted that all species are at a site. The value ranges between 0 and 1 (Simpson 1949).

CONCLUSION

Statistical analysis infers that the quantitative concentration of Orthoptera fauna varies from species to species as well as family to family. A small change in species composition from a healthy stable state can adversely affect the trophic complexity of the food web and species interaction. The promotion of biodiversity conservation is an important step for maintaining overall environmental health and stability of various kinds of ecosystems. The present study provides distinctive information on the present status of dominant, subdominant, incidental and rare species of Orthoptera from the study area and this result would help to assess appropriate and possible strategies to Orthopteran conservation as well as habitat management in the future. A long-term study is needed to record the species composition from this area, to get better and more comprehensive information.

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