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Geographical and seasonal variation effects on diversity and abundance of acridids fauna (Orthopetra: Acrididae) from Coimbatore, T.N., India

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ABSTRACT

Grasshoppers are highly diversified in grasslands and considered for both ecological and conservation importance. This study was evaluated to describe the geographical and seasonal variation of acridids community in Coimbatore, Tamil Nadu, India. Acridids were sampled using sweep net and handpicking method. Different diversity indices were calculated to estimate the acridids diversity and abundances in different environmental zone as well as different season using PAST software. A total of 2966 acridids belonging to 21 species, 15 genera and 12 tribes are under eight subfamilies were recorded. Among the 21 species of acridids, dominant species were *Spathosternum prasiniferum*, *Trilophidia annulata, Leva indica, Acrotylus patrulis, Oxya japonica japonica, Oedaleus abruptus* and *Phlaeoba infumata* found in all the zones as well as all the seasons. *Spathosternum prasiniferum* was found to be the most dominant species (D = 20.97) compared to other species of acridids. Oedipodinae was the most species rich subfamily, amounting 41.37% of total collected species. Species abundances and richness were higher in zone I (D = 41.34) compared to zone III (D = 30.45) and zone II (D= 28.22). Higher species diversity and composition of acridids were recorded in pre-monsoon season (D = 39.48). Principal component analysis also revealed that the most of the species studied were closer to zone I and pre-monsoon season. Shannon diversity index and *Margalef richness* were higher in zone 1 (2.67 and 3.07) during pre-monsoon and lowest in zone II (1.87 and 1.54) during summer. Renyi diversity shows that species were distributed more equitably in zone II (8.59) followed by zone III (7.39) and zone I (6.18) and α-diversity was recorded highest during pre-monsoon (8.82) compared to other seasons. Statistical analysis infers that the interaction between species, environmental zones and seasons have significant effect on abundance percentage of acridid populations.

Key words : *Acridids, Diversity indices, Abundances, Spathosternum prasiniferum, Pre-monsoon.*

Introduction

Understanding the distribution of species composition is a key step towards identifying biodiversity hotspots and designing conservation strategies (Mirzaei *et al.,* 2017). Biological diversity contributes an important role in various aspects of ecosystem stability (Peterson *et al.,* 1998). Insects are the most diverse component of the dynamice cosystem by providing multiple services (Miller, 1993). Grasshoppers and locusts are one of the most diverse and ecologically important insects found in the grasslands and considered to be of both ecological and conservation importance (Latchininsky *et al*., 2011). Acrididae is one of the family of grasshoppers as well as locusts in the superfamily Acridoidea which

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belongs to the order Orthoptera and suborder Caelifera. They are commonly known as the short-horned grasshopper, having antennae usually shorter than the body (Akhtar *et al.,* 2014). Super family Acridoidea is the largest and comprising 11,000 species worldwide and out of that 290 species belonging to 138 genera reported from India. Family Acrididae shows maximum diversity, comprising 8,000 species and out of that 285 species representing 135 genera are found in India (Shishodia *et al.,* 2010). Of which, 136 species and 28 genera of acridids are endemic to India (Chandra and Gupta, 2013).

As pests, grasshopper causes a serious damage to crops and rangelands (Lockwood and Lockwood, 2008). However, acridids are important in energy and nutrient cycling and they are most dominant group of herbivorous insects found in throughout the world (Saha and Haldar, 2013). Some species act as a biological control for weeds (Oberholzer and Hill, 2001). This group also plays a vital role in terrestrial food webs and is known to be a good source of protein for many amphibians, small reptiles, birds and small mam-mals and also facilitating their survival and reproductive efficiency. Therefore, their scarcity may disturb the trophic structure in an ecosystem (Schmidt *et al.,* 1991; Soliman *et al.,* 2017). Grass-hoppers are important bioindicators of threatened environments because of their specific microhabitat preferences, sensitivity to the modification of biotic and abiotic factors of their habitats, functional importance in ecosystems and the ease with which they can be sampled (Guido and Gianelle, 2001; Soliman *et al.,* 2017).

Previous studies conducted by Joshi *et al.,* (1999); Kandibane *et al.,* (2004), Mayya *et al.,* (2005); Saha and Haldar, (2008); Paulraj *et al.,* (2009); Senthilkumar,(2010); Saha and Haldar, (2013); Kumar and Usmani, (2015); Arya *et al.,* (2015); More and Nikam, 2016; Kumar *et al.,* (2018) and Raghavender and vastrad, (2017) have added information on grasshopper fauna of different regions of India. Studies regarding geographical and seasonal variation of acridids community in grasslands are very few. The present study was undertaken to record diversity and abundance of acridids fauna from different environmental zones and seasons of Coimbatore, Tamil Nadu, India. The result would offer distinctive information of acridids fauna for future taxonomic, ecological studies and designing effective conservation strategies.

Materials and Methods

Study area

The survey work was conducted from different ecological zones of Coimbatore from January, 2019 to December, 2019. Coimbatore is located at the biodiversity hotspot of the Western Ghats; the city is rich in fauna and flora. This place is the second largest city in Tamil Nadu after Chennai. Coimbatore lies at 11°1′6″N 76°58′21″E in south India at 411 m above sea level on the banks of the Noyyal River, in north western part of Tamil Nadu. The mean maximum and minimum temperature in summer and winter various between 35°C to 18°C. The average annual rainfall is around 700 mm (27.6 in) with the northeast and the southwest monsoons contributing to 47% and 28% respectively to the total rainfall. The zones were selected and classified into three categories (Less disturbed, moderately disturbed and highly disturbed) according to the characteristics of vegetation structure and degrees of human disturbances.

Zone I: Marudhamalai (11°02′33.1"N 76°52′ 10.1"E) is located in the foot hills about 12 km west from the city of Coimbatore. This area was covered higher region of vegetation structure and lesser human disturbance. ZoneII: Saibaba colony (11°01′15.2"N 76°56′55.4"E) is situated just 4 km north of the city of Coimbatore. This zone contains little region of vegetation and high human disturbance. Zone III: Thudiyalur (11°04′32.3"N 76°56′ 00.8" E) is within the Coimbatore, about 10 km north of the city centre. This area contains moderate region of vegetation structure and human interference. Climatically study area was classified as four distinct seasons: Post-monsoon (January to March) comprised lower temperature and moderate precipitation. Summer (April to June) is dry season with higher temperature, Pre-monsoon (July to September) comprised high rainfall and moderate temperature. Monsoon (October to December) comprised heavy rainfall and lower temperature based on the northeast monsoon, which is prevalent in the study area.

Sampling procedure

Acridids species were sampled from three different environmental zones of Coimbatore using sweep nets and handpicking method. Sweep net method generally provide accurate estimation of grasshop-

per 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). Acridids were surveyed inside a 10 m² area, thus, with the 5 plots, sampling a total area of 50 m² for each zone. Sampling was conducted twice a month during January to December, 2019 from 7 am to 11 am. In morning time, acridids were less active and capturing was easy.

Identification

Acridids were identified under stereoscopic dissecting binocular microscope using the keys of kirby, (1914) and description available on the ''Website (http://www.orthoptera.org) Orthoptera Species File Online''. After identification and counts of species were made in all the zones, acridids caught were immediately released in the sampled site in order to avoid impoverishing the environment. A small number of the dominant and rare species were collected for further examination.

Data analysis

Dominance (D) of different species in acridid community was determined according to the method by Buschini and Woiski, (2008). D = (abundance of a species/total abundances recorded) × 100. If D was > 5%, the species regardedas dominants if 2.5% < D < 5%, the species was considered as sub dominant and if D was < 2.5%, the species considered as rare species. Principal Component Analysis (PCA) was performed in order to study the pattern of variation in the populations among different zones as well as seasons. The most common diversity indices such as Shannon-Wiener index, Margalef richness, Evenness and Renyi index were calculated to describe and compare the diversity and population of acridids from different zones and across seasons using the statistical software PAST (Paleontological Statistical Software) version 2.02 (Hammer *et al.*, 2001).

Results

Over the study period, 2966 acridids belonging to 21 species of acridids, 15 genera and 13 tribes are classified under eight subfamilies namely, Acridinae, Catantopinae, Cyrtacanthacridinae, Eyprepocnemidinae, Gomphocerinae, Oedipodinae, Oxyinae, Spathosterninae were collected from three different localities of Coimbatore. In zone I (Marudhamalai), a total of 1250 individuals belonging to 20 species, 12 genera and 13 tribes under eight subfamilies were recorded. Totally, 821 individuals belonging to 14 species, 13 genera and 12 tribes under seven subfamilies were recorded in zone II (Saibaba colony). A total of 895 individuals belonging to 16 species, 13 genera and 12 tribes under eight subfamilies were recorded in zone III (Thudiyalur) (Table 1). Totally, 625 idividuals in post monsoon, 322 individuals in summer, 1171 individuals in pre-monsoon and 848 individuals in monsoon were recorded during the study period (Table 2). Different acridids species varied in population among the zones and seasons.

Oedipodinae was found to be the most dominant subfamily with 10 species under six genera and four tribes amounting to 41.37% of total individuals recorded. Next in order of dominant families were Spathosterninae (21.27%)and Gomphocerinae (15.44%) (Figure 1). Some abundant species of Oedipodinae were *Trilophidia annulata* (D = 11.83), *Acrotylus patruelis* (D = 10.28) and *Oedaleus abruptus* (D = 5.7) which was also highly dominant and distributed in all the zones (Tabe 1) and all the seasons (Table 2).

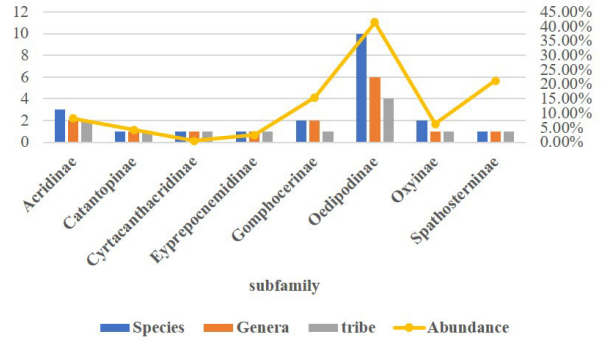

Fig. 1. Relative proportion of species composition in the subfamilies of acridids in study area.

During the study period, *Spathosternum prasiniferum*, *T. annulata*, *Leva indica*, *A. patrulis*, *Oxya japonica japonica*, *O. abruptus* and *Phlaeobainfumata* were dominant and found in all the zones (Table 1) as well as all the seasons (Table 2). Among the 21 species of acridids, *S.prasiniferum* was the most dominant species (D = 21.27) which was also highly distributed in three zones followed by *T. annulata* (D = 11.83), *L. indica* (D = 11.73), *A. patruelis* (D = 10.28). Acridids *S. prasiniferum*(D = 24.64) and *L. indica* (D = 13.12) were the dominant species in zone I. The most

Table 1. List of acridids diversity and abundance from different zones of Coimbatore.

Subfamily	Tribe	Species	Zone I	Zone II	Zone III	Total	(D)
Acridinae	Acridini	*Acrida exaltata*	29	20	25	74	2.49
	Acridini	*Acrida gigantea*	0	0	19	19	0.64
	Phlaeobini	*Phlaeoba infumata*	33	45	73	151	5.09
Catantopinae	Catantopini	*Diabolocatantops pinguis*	56	33	39	128	4.32
Cyrtacanthacridinae	Cyrtacanthacridini	*Cyrtacanthacris tatarica*	4	0	11	15	0.51
Eyprepocnemidinae	Eyprepocnemidini	*Eyprepocnemisalacris alacirs*	9	46	20	75	2.53
Gomphocerinae	Dociostaurini	*Leva indica*	164	93	91	348	11.73
	Arcypterini	*Aulacobothrus luteipes*	48	29	33	110	3.71
Oedipodinae	Acrotylini	*Acrotylus patruelis*	108	90	107	305	10.28
	Acrotylini	*Acrotylus humbertianus*	22	0	39	61	2.06
	Acrotylini	*Acrotylus insubricus*	29	0	0	29	0.98
	Locustini	*Gastrimargus africanus*	27	0	6	33	1.11
	Locustini	*Gastrimargus marmoratus*	17	23	0	40	1.35
	Locustini	*Oedaleus abruptus*	63	45	61	169	5.7
	Locustini	*Oedaleusi nfernalis*	41	53	39	133	4.48
	Sphingonotini	*Sphingonotus longipennis*	40	37	0	77	2.6
	Trilophidiini	*Trilophidia annulata*	152	124	75	351	11.83
	-	*Morphacris fasciata*	29	0	0	29	0.98
Oxyinae	Oxyini	*Oxy avelox*	12	0	0	12	0.4
	Oxyini	*Oxya japonica japonica*	59	50	67	176	5.93
Spathosterninae	Spathosternini	*Spathosternum prasiniferum*	308	133	190	631	21.27
		Total	1250	821	895	2966	100

Table 2. Distribution of acridid population in different seasons of Coimbatore.

S.No.	Species	Post monsoon	Summer	Pre-monsoon	Monsoon
1	*A. exaltata*	14	0	47	13
2	*A. giantea*	4	0	11	4
3	*P. infumata*	36	16	72	27
4	*D. pinguis*	43	0	52	33
5	*C. tatarica*	5	0	10	0
6	*E. alacris alacris*	30	0	25	20
7	*L. indica*	49	55	135	109
8	*A. luteipes*	13	12	55	30
9	*A. patruelis*	48	51	76	130
10	*A. humbertianus*	9	2	27	23
11	*A. insubricus*	8	0	21	0
12	*G. africanus*	0	0	23	10
13	*G. marmoratus*	13	5	13	9
14	*O. abruptus*	30	24	53	62
15	*O. infernalis*	33	6	74	20
16	*S. longipennis*	17	0	42	18
17	*T. annulata*	60	52	159	80
18	*M. fasciata*	2	0	12	15
19	*O. velox*	3	0	9	0
20	*O. japonica japonica*	50	23	49	54
21	*S. prasiniferum*	158	76	206	191
	Total	625	322	1171	848
	Dominane (D)	21.07	10.86	39.48	28.59

abundant species in zone II were *S. prasiniferum* (D = 16.2) and *T. annulata* (D = 15.1). In zone III, *S. prasiniferum* (D = 21.23) and *A. patruelis* (D = 11.96) were the most dominant species (Table 1).

Overall, the maximum number of grasshopper abundances were observed in zone I (D = 42.14) followed by zone III (D = 30.18) and zone II (D= 27.68) (Table 1). PCA analysis also shows that most of the species studied were closer to zone I followed by zone III and zone II. *Oxya velox*, *Morphacris fasciata*, and *Acrotylus insubricus* were specific to zone I and *Eyprepocnemis alacrisalacirs* and *Oedaleus infernalis* were specific to zone II. *Acrida* gigantea and *P. infumata* were specific to zone III. Principal component 1 (variance explained = 56.87%; eigen value = 11.94) represents the higher abundances of species. Principal component 2 (variance explained = 43.13%; eigen value = 9.05) represents the lower abundance of species (Figure 2).

The comparison of the abundances in the different seasons revealed that the higher number of species were recorded in pre-monsoon (D = 39.48) followed by monsoon (D= 28.59), post monsoon (D = 21.07) and summer (D = 10.86) (Table 2). PCA score showed seven dominants, six sub dominant and eight rare species were recorded during the study period. *S. prasiniferum*, *T. annulata*, *L. indica*, and *P. infumata* were most dominant in pre-monsoon whereas, *A. patruelis*, *O. japonica japonica*, *O. abruptus* were most dominant in monsoon. Principal component 1 analysis showed highest variance and eigen value (total variance of 92.25 %; eigen value of 6413.65) represents the higher species composition while principal component 2 showed lowest variance and eigen value (total variance of 4.98 %; eigen value of 346.46) represents the lower species composition of acridids (Figure 3).

Shannon diversity index, Margalef richness, and evenness for three environmental zones and four different seasons were calculated. In the present study, Shannon diversity index varied from 1.87 to 2.67. The minimum species diversity was recorded in zone II during summer and the maximum level was observed in zone I during pre-monsoon (Fig. 4). Margalef richness fluctuated between 1.54 to 3.07. The minimum species richness was observed in zone II during summer, and the maximum was noted in zone I during pre-monsoon (Fig. 5). Shannon and Margalef index showed similar results. Whereas, values on evenness index showed little contrast; it was highest during summer in zone III and lowest during monsoon season in zone I. The species evenness index varied from 0.57 to 0.86 (Fig. 6).

Renyi indices (α-diversity) plot clearly demonstrates the diversity pattern in three zones. The number of species and individuals were higher in zone I followed by zone III and zone II but individuals were distributed more equitably in zone II (8.59) followed by zone III (7.39) and least in the zone I

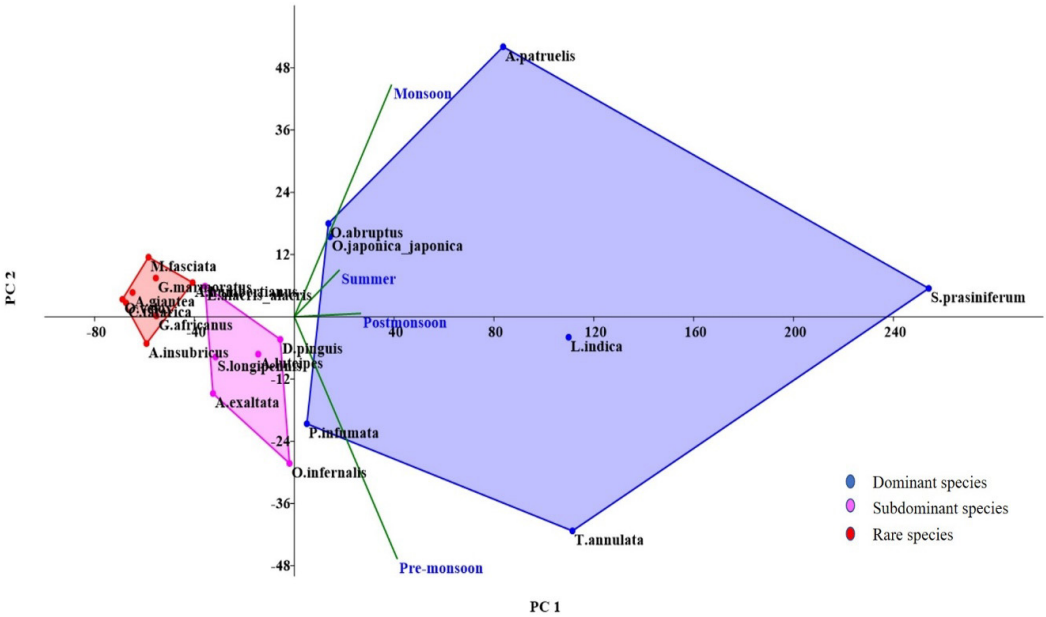

Fig. 2. Correlation of acridids between the different zones using principal component analysis.

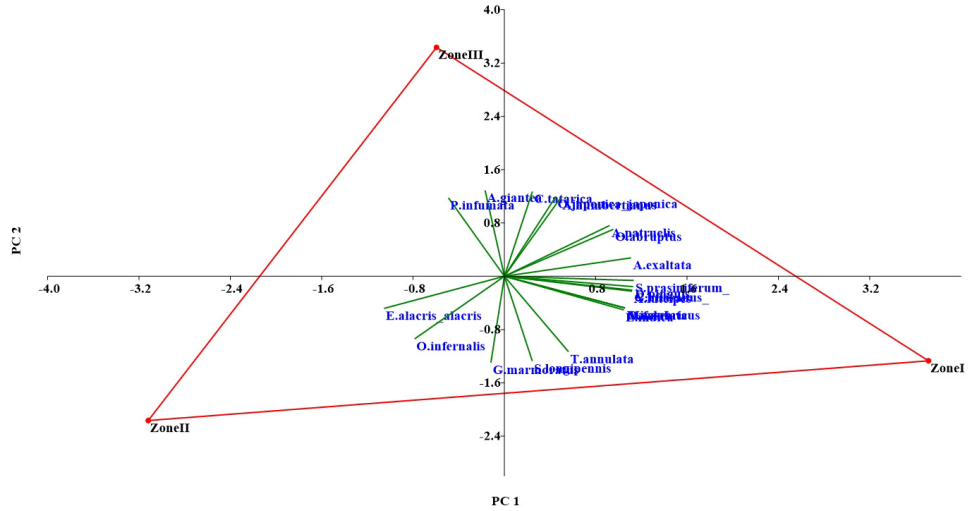

Fig. 3. Disposition of acridids between the different seasons using principal component analysis.

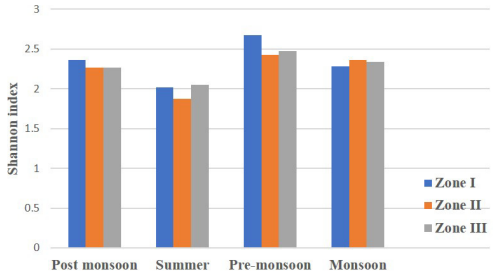

Fig. 4. Shannon-Weiner diversity indices of acridids in different zones and seasons.

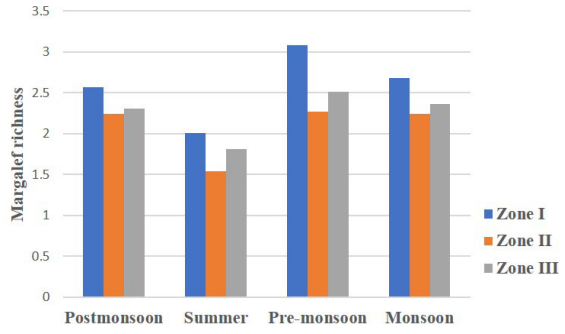

Fig. 5. Margalef richness indices of acridids in different zones and seasons.

(6.18)(Figure 7). Species richness was highest in pre-monsoon followed by post monsoon, monsoon and summer but α-diversity index (number of individuals) was highest in pre-monsoon (8.82) followed by monsoon (6.59), post-monsoon (6.16) whereas, least index was noted during summer

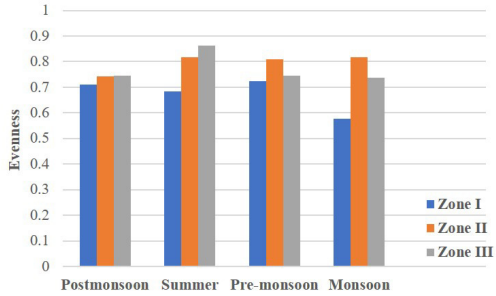

Fig. 6. Evenness of acridids in different zones and seasons.

season (5.73) (Figure 8).

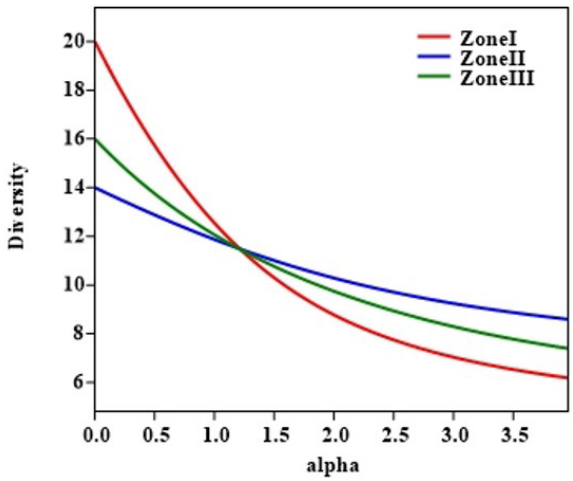

Fig. 7. Species accumulation curves in different zones of Coimbatore.

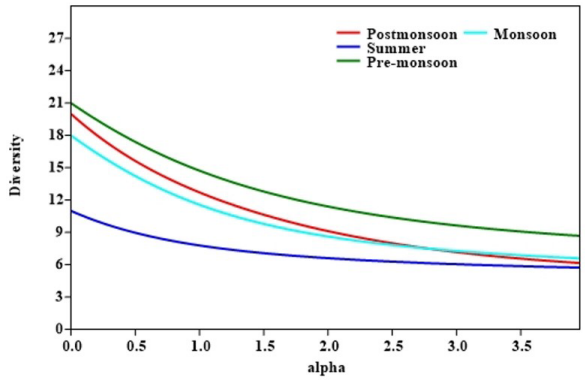

Fig. 8. Comparison of species accumulation in different seasons of Coimbatore.

Discussion

Studies on the diversity and abundances of acridids from Coimbatore, Tamil Nadu India were carried out from January to December, 2019. A total of 2966 acridids belonging to 21 species and eight subfamilies were collected from all three zones. The trend of numerical distribution of different grasshopper in Acrididae family were recorded in the present study is similar to the observations of Paulraj *et al.,* (2009) who also reported that the family Acrididae was the most dominant with 21 species under 15 genera of seven subfamilies from Tamil Nadu**.** Other studies Thakkar *et al*., (2015) and Arya *et al*., (2015) also found Acrididae family as the most dominant as well as most distributed. In addition, Chandra and Gupta, (2013) reported that the 29 species of acridids presented in Tamil Nadu. Acridids are graminivorous in nature and the grasslands found in the ecosystem provides wide variety of food as well as breeding site for acridids.

Kumar and Usmani *et al.,* (2015) observed that the members of subfamily Oedipodinae was more diverse and abundant species. Shishodia *et al.,* (2010) found seven subfamilies with maximum number of species in subfamily Oedipodinae (31%). The present study also revealed subfamily Oedipodinae has the highest diversity and more population structure in all the zones and seasons compared to other seven subfamilies of acridids.

On the basis of the total number of individuals collected, S. *prasiniferum* was found to be most dominant in all the zones and seasons. These species have greater ecological plasticity as it is able to reproduce and increase in its population in different ecological zone and different seasons. Kumar and Usmani *et al.,* (2015); Raghavender and Vastrad, (2017) also reported that *S. prasiniferum* was found to be most abundant.

The maximum number of species and populations were recorded in zone I. The second largest number of acridids were noted in zone III. Zone I was found to have some region of higher vegetation structure and less human disturbance while in zone II had few regions of vegetation and high human disturbance which showed the least diversity and abundances of acridids. The higher number of vegetation provides hideouts from predators and harsh climatic conditions like high temperature and heavy rainfall. It also provides a variety of food for acridids which translates to an increase in population and distribution. According to Miller and Onsager, (1991) the dynamic in population structure is closely related to changes in the spatial pattern and the structure of vegetation. Kemp *et al.,* (1990 a, b) observed that the composition of acridid species depends on the availability of host plant species. In addition, Evans, (1988) reported a positive correlation between vegetation structure and grasshopper species richness. According to Morin, (1999) habitats with fewer plant species have a relatively lower diversity of insects and other consumers. Parmenter *et al.,* (1991); Joshi *et al.,* (1999); Saha and Haldar, (2009 and 2013) reported that species richness and diversity were higher in undisturbed sites compared to disturbed sites. Present study also showed that similar patterns for acridids diversity and greatest species abundance were associated with the undisturbed zone.

Higher species diversity and higher abundances of acridids were noted during pre-monsoon and monsoon season whereas, lower species and composition were recorded during summer. Higher acridids population structure in this specific season is probably due to higher amount of vegetation. During pre-monsoon and monsoon season rainfall and humidity was high in study area. Rainfall enhances the growth rate of vegetation which ultimately influences acridid population. In general, the summer season prevalence the higher temperature and lower vegetation structure adversely affected the biological activity of acridid leading to their little population and low acridid species. Joern, (2004) reported that the rainfall may also be an important factor playing positive role in diversity of grasshoppers. According to Arya *et al*., (2015) the maximum

grasshopper activities were observed during the rainy season. In addition, Hussain *et al.*, (2017) also recorded the greater population abundance during rainy seasons. Thakkar *et al*., (2015) reported that their presence was more prevalent during monsoon seasons, which concedes with the optimum growth of all type of vegetation. Seasonal fluctuation could change the number of species in each zone which in turn affect the species diversity and abundances. In the present study, the ecological indices used to assess acridid community structure which revealed variances among different zones as well as in different seasons.

Conclusion

The present study is work of one year which deals with the diversity and abundance of acridids in different zones as well as seasons. This is the first report from Coimbatore as no notable work has been done on this aspect. Statistical analysis infers that the quantitative concentration of acridid species varies from location to location as well as season to season. Biodiversity is one of the important cornerstones for maintaining overall environmental health and stability of various kinds of ecosystems. Geographical and evolutionary factors play a strong role in determining a diversity and composition of species. The world is currently facing greatest biodiversity crisis. Species are becoming extinct because of habitat loss, overpopulation, pollution and threat of global climatic changes. A long-term study is required to observe the species distribution and their interaction with the environmental changes, in order to get better and comprehensive information and also helpful to identify new species of acridids. However,this study will provide information on the present status of species richness, abundance, rarity and commonness of acridids species from different ecological zones and seasons. Promotion of biodiversity conservation as well as management of ecosystem is an important step for sustainable environment. Higher amount of vegetation structure might have alternate impact of species composition through protecting them against predators, adverse environmental factors and human interference. Recording the list of acridids species richness, abundance and rarity of species diversity from different environmental zones and seasons could be the valuable indices to the ecosystem management.

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