ORTHOPTERAN DIVERSITY IN TROPICAL ECOSYSTEMS OF CENTRAL KERALA, INDIA

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ORTHOPTERAN DIVERSITY IN TROPICAL ECOSYSTEMS OF CENTRAL KERALA, INDIA. Orthoptera is a diverse arthropod taxon that includes locusts, grouse locusts, short-horned grasshoppers, long-horned grasshoppers, katydids, crickets and mole crickets. They play crucial roles in food chains, nutrient cycling and pollination. The diversity of orthopterans in agroecosystems and grasslands located in the highlands and lowlands of Central Kerala were studied from December 2019 to March 2020. The study was conducted in Avoly of Ernakulam District and Venmony of Idukki District in Kerala by employing random sampling in 10 x10 m quadrats. A total of 35 species of orthopterans, belonging to two suborders, 10 families, 20 subfamilies, and 33 genera were recorded. Family Acrididae with fourteen species was the most dominant family followed by Tettigoniidae. Two species namely, *Chitaura indica* and *Burrinia burri* are endemic to the state of Kerala. It was found that the ranges of most of the orthopteran genera reported in our study extend all over the South East Asian countries. The highest number of Orthoptera was reported in December in both locations and it decreased towards March. Simpson's diversity index value shows that both regions harbour a highly diverse orthopteran community. The diversity index value of Venmony is comparatively higher which might be due to the proximity of the study site to the natural forest ecosystem and fewer disturbances. More studies on the orthopteran fauna of Kerala are recommended which would help control their pest status and exploit their economic potential as food in animal husbandry.

Keywords: Grasshoppers, locusts, highlands, Western Ghats, ecotone, diversity, Kerala

KEANEKARAGAMAN ORTHOPTERAN PADA EKOSISTEM TROPIS DI CENTRAL KERALA, INDIA. Orthoptera adalah takson arthropoda yang mencakup belalang, belalang belibis, belalang bertanduk pendek, belalang bertanduk panjang, jangkrik semak, jangkrik dan jangkrik mol. Mereka memainkan peran penting dalam rantai makanan, siklus nutrisi dan penyerbukan. Keanekaragaman orthoptera di ekosistem pertanian dan padang rumput yang terletak di dataran tinggi dan rendah Central Kerala dipelajari dari Desember 2019 hingga Maret 2020. Penelitian dilakukan di Avoly, Distrik Ernakulam dan Venmony, Distrik Idukki di Kerala dengan menggunakan random sampling pada kuadrat 10 x10 m. Tercatat sebanyak 35 spesies orthoptera, yang termasuk dalam dua subordo, 10 famili, 20 subfamili, dan 33 genera. Famili Acrididae dengan empat belas spesies merupakan famili yang paling dominan diikuti oleh Tettigoniidae Dua spesies yaitu, Chitaura indica *dan* Burrinia burri *adalah endemik negara bagian Kerala. Ditemukan bahwa kisaran sebagian besar genera orthopteran yang dilaporkan dalam penelitian ini meluas ke seluruh negara-negara Asia Tenggara. Jumlah Orthoptera tertinggi dilaporkan pada bulan Desember di kedua lokasi dan menurun pada bulan Maret. Nilai indeks keanekaragaman Simpson menunjukkan bahwa kedua wilayah memiliki komunitas orthopteran yang sangat beragam. Nilai indeks keanekaragaman Venmony relatif lebih tinggi yang mungkin disebabkan oleh kedekatan lokasi penelitian dengan ekosistem hutan alam dan gangguan yang lebih sedikit. Studi lebih lanjut tentang fauna orthopteran Kerala direkomendasikan yang akan membantu mengendalikan status hama mereka dan memanfaatkan potensi ekonomi mereka sebagai makanan di peternakan.*

Kata kunci: Belalang, belalang, dataran tinggi, West Ghats, ekoton, keanekaragaman, Kerala

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I. INTRODUCTION

Orthopterans are found to be one of the oldest lineages of insects with primitive unspecialized wings. Order Orthoptera belongs to class Insecta and is divided into two suborders namely Ensifera and Caelifera. The word Orthoptera is derived from Greek words 'Ortho' means straight and 'Pteros' means wing (Tandon & Hazra, 1998). They are also known as 'saltatoria' for their saltatorial hind legs which aids in leaping. Caelifera consists of short-horned grasshoppers, grouse locusts and locusts whereas Ensifera includes long-horned grasshoppers, mole crickets, crickets and katydids.

Orthoptera is a diverse arthropod taxon with 28,702 species globally (Cigliano, Braun, Eades, & Otte, 2021). Around 2,000 species are known from South East Asia (Dawwrueng, Tan, Artchawakom, & Waengsothorn, 2017). In India, around 1,093 species belonging to 404 genera and 21 families of Orthoptera were identified (Chandra, Raghunathan, & Rizvi, 2021; Chandra et al., 2020; Chandra & Sheela, 2019; Chandra & Sheela, 2018; Chandra et al., 2017; Chandra et al., 2016; Venkataraman et al., 2015; Venkataraman et al., 2014; Venkataraman, 2013; Shishodia et al., 2010). In Kerala, 13 families, 99 genera and 130 species of Orthoptera from two suborders were reported (Bhaskar, Easa, & Hochkirch, 2018).

Orthoptera is popularly known for their pest status in Kerala but they also perform ecological roles as in nutrient cycling, trophic food chain, pollination and plant growth. They are excellent ecological indicators of the health of the grassland ecosystem (Tan, Choi, & Shankar, 2017). Grasshoppers play a significant role in the food chain as they convert plant tissue into large units of animal material and serve as food for vertebrate animals. Orthopterans are also economically important as pests and food sources (Priya, 2005).

The study of Orthoptera in the Indian sub-continent was initiated in the nineteenth century by Agustin Stahl. Boliviar (1900, 1902, 1917) made major contributions to the orthopteran fauna of India. Monographs by Chopard (1928, 1969) also remain as a major guide to the studies of Indian Orthoptera. Another important contribution to Indian Orthoptera (Caelifera) was the 'Fauna of British India - Orthoptera' (Kirby, 2015). Bhowmik (1985) provided a technical monograph about orthopteran subfamilies especially on Acrididae. Tandon and Hazra (1998) studied the orthopterans distributed throughout the physiographic zones of the Indian subcontinent. Shishodia, Chandra, and Gupta (2010) prepared a preliminary checklist of Orthoptera of India.

Orthopteran diversity in Kerala has been documented by various isolated studies like Shishodia and Hazra (1986), Vasanth (1991), Mathew (2004), Prabakar and Radhakrishnan (2005), Koya et al., (2017), Eldhose et al. (2019) and Kuruvila et al. (2019). A compiled checklist of the Orthoptera of Kerala was prepared by Bhaskar et al. (2018). Nevertheless, orthopteran diversity in Central Kerala has not been well explored. Central Kerala is the broadest part of the state with myriads of ecosystems stretching along an altitudinal gradient from the mangroves along the coast to the sholas in the hills. These ecosystems host a diverse orthopteran fauna which are underexplored till date. The present study attempts a comparison of the orthopteran diversity along the altitudinal gradient in grasslands and the agroecosystems of Central Kerala along with its diversity statistics.

II. MATERIAL AND METHOD

A. Study Site

The selected study sites were Avoly (9°58'14.9"N, 76°36'54.5"E) and Venmony (9°57'35.4"N, 76°52'03.6"E) in Central Kerala, India (Figure 1). Avoly is situated at an altitude of 45 m asl. The average temperature here ranges from 24–36°C and receives monsoon rain. In both areas, the study was conducted in agroecosystems and open grasslands. The agroecosystem selected for the study included monoculture plots of rubber and mixed plots with crops namely, plantain, turmeric, tapioca

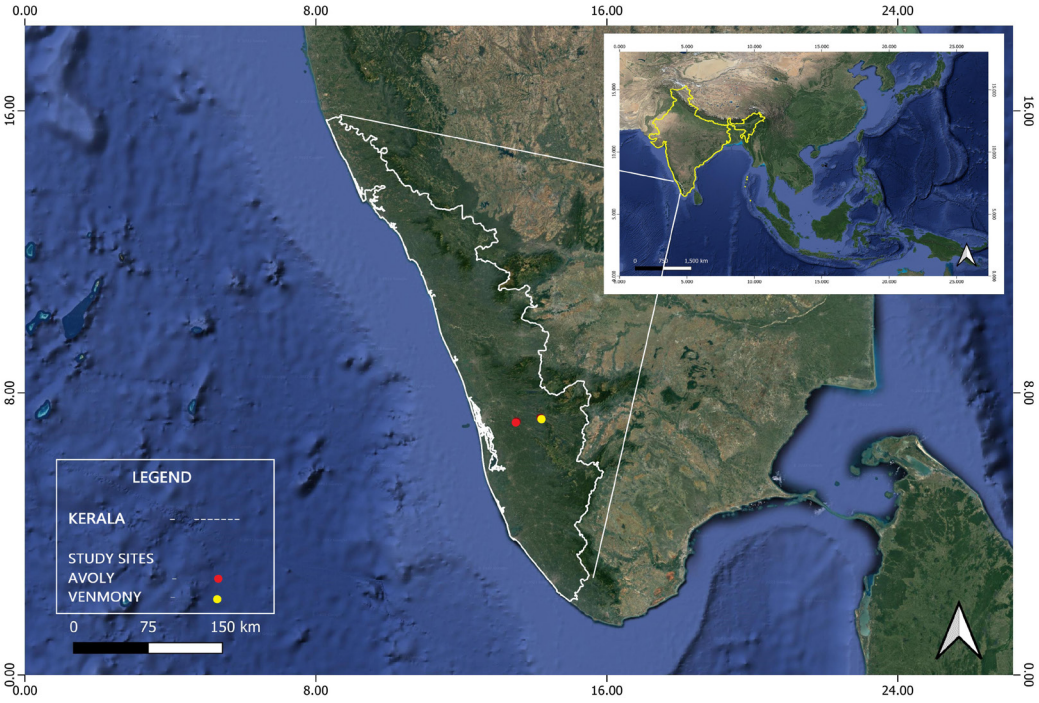

Figure 1. Map showing study site

and vanilla. The study site in Venmony is an ecotone, an immediate periphery of the natural forest area under Mullaringad forest range of the Western Ghats which is situated at an elevation of 540 m asl. Temperature ranges from 20–32°C. The study site was separated from the natural forest by a perennial stream flowing between them. The agroecosystem in Avoly was near human interferences like roads and playgrounds.

B. Methods

The study was carried out from December 2019 to March 2020. Field visits were conducted during the morning [7:00 to 11:30 a.m. IST] and evening [3:30 to 6:00 p.m. IST] hours. Sampling was conducted once every month in both sites. Random sampling was done using the quadrat method. Five quadrats of size 10 x10 m were laid randomly in both locations. Pitfall trap was used to sample the litter dwelling orthopterans. Pitfall trap was made using a cylindrical plastic cup of 10 cm depth and 8 cm diameter. Soap solution was filled upto a height of 3 cm to prevent the trapped insects from escaping. They were employed one per quadrat in monoculture plantations of rubber and grasslands. Insects were collected from quadrats by visual search for 20 min followed by handpicking. Sweep net sampling was used to collect orthopterans from plants inside the quadrat. The sweep net has a 90 cm long handle and a 30 cm ring onto which a white coloured muslin cloth of 60 cm was attached. To ensure that the whole area of the quadrat was swept at least once, five sweeps per quadrat was done. Shaking or beating was also performed five times per quadrat to collect orthopterans from plants. Abrupt shaking of bushes inside the quadrat made the insects fall onto a white cloth spread beneath the plant. Only adult specimens were collected. The collected specimens were photographed using a Samsung A10S mobile with 13 MP rear camera.

After the collection, insects were transferred into specimen bottles containing cotton soaked in ether. The dead insects are preserved in 70% alcohol. Some of the sacrificed insects were pinned by insect pins and dried. Identification has been done mainly by comparing the morphological characters of

specimens with descriptions in taxonomic keys, standard textbooks (Mathew, 2004; Prabakar & Radhakrishnan, 2005; Shishodia et al., 2010; Tandon & Hazra, 1998) and the aid of Orthoptera Species File (Cigliano et al., 2021). Existing literatures were referred to confirm the geographical distribution of the identified species also.

C. Analysis

Diversity of both sites were calculated using Shannon diversity index and Simpson's diversity index. Shannon diversity index takes into account species richness and evenness whereas Simpson's diversity index is a dominance index (Magurran, 2004). The significance of the values obtained were analysed using a simple t-test and ANOVA. Monthly variation of Orthoptera in both sites were analysed by comparing the number of individuals recorded in different months. PAST 4.06b and MS Excel softwares were used for the statistical analysis.

III. RESULT AND DISCUSSION

A. Orthopteran Species Diversity

The study reports 35 different species of orthopterans belonging to two suborders, 10 families, 20 subfamilies and 33 genera (Table 1). A total of 27 species were recorded from Avoly and 25 species from Venmony. This study reveals 27% of the orthopteran fauna was reported from Kerala state (Bhaskar et al., 2018). *Chitaura indica* and *Burrinia burri* was reported in the study to be endemic to Kerala (Chandra & Gupta, 2013).

Most of the orthopteran species reported are native to the tropical belt. *Atractomorpha crenulata*, *Phlaeoba antennata*, *Ducetia* sp. and *Mecopoda* sp. found in the two locations are also reported throughout Southeast Asia (Buzzetti & Devriese, 2008). The following genus reported in our study namely Acrida, Chitaura, Oxya, Atractomorpha also has been reported from Sulawesi, Indonesia (Walton et

Table 1: Orthopteran diversity in Avoly and Venmony of Central Kerala

Sl. No	Family	Subfamily	Genus	Species
SUBORDER -CAELIFERA				
1.	Acrididae	Acridinae	*Phlaeoba*	*antennata* Brunner Von Wattenwyl, 1893
2.				*infumat*a Brunner Von Wattenwyl, 1893
3.				*panteli* Bolivar,1902
4.			*Carliola*	*carinata* Uvarov,1929
5.			*Acrida*	sp.
6.		Catantopinae	*Xenocatantops*	*humilis* Serville,1838
7.			*Diabolocatantops*	*innotabilis* Walker,1870
8.		Eyprepocnemidinae	*Eyprepocnemis*	*alacris* Serville,1838
9.		Oedipodinae	*Ceracris*	*striata Uvarov,1925*
10.			*Dittopternis*	*venusta Walker,1870*
11.			*Trilophidia*	*annulata Thurnberg,1815*
12.		Oxyinae	*Chitaura*	*indica Uvarov,1929*
13.			*Caryanda*	*cachara* Kirby,1914
14.			*Oxya*	*hyla* Serville,1831
15.		Spathosterninae	*Spathosternum*	*prasiniferum* Walker,1871
16.	Chorotypidae	Chorotypinae	*Burrinia*	*burri* Bolivar,1914
17.	Pyrgomorphidae	Orthacridinae	*Neorthacris*	*acuticeps* Bolivar,1902
18.		Pyrgomorphinae	*Atractomorpha*	*crenulata* Fabricius,1793
19.			*Chrotogonus*	sp.

Table 1. Continued

Sl. No	Family	Subfamily	Genus	Species
20.	Tetrigidae	Scelimeninae	*Eucriotettix*	sp.
21.			*Criotettix*	sp.
	SUBORDER – ENSIFERA			
22.	Gryllidae	Gryllinae	*Acheta*	*domesticus* Linnaeus,1758
23.			*Gryllodes*	*sigillatus* Walker,1869
24.			*Cophogryllus*	sp.
25.	Gryllacrididae	Gryllacridinae	*Brachyntheisogryllacris*	*maindroni*, Griffini,1913
26.	Gryllotalpidae	Gryllotalpinae	*Gryllotalpa*	*africana* Beauvois,1805
27.	Myrmecophilidae	Myemecophilinae	*Myrmecophilus*	*albicinctus* Chopard,1924
28.	Tettigoniidae	Conocephalinae	*Conocephalus*	*maculatu*s Le Guillou,1841
29.		Mecopodinae	*Mecopoda*	sp.
30.		Hexacentrinae	*Hexacentrus*	sp.
31.		Phaneropterinae	*Ducetia*	sp.
32.		Pseudopyllinae	*Acanthoprion*	*suspectum* Brunner von Wattenwyl,1895
33.			*Phyllozelus*	sp.
34.			*Tegra*	*viridivitta* Walker,1870
35.	Trigonidiidae	Trigonidiinae	*Trigonidium (Trigonidium)*	*cicindeloides* Rambur,1838

al., 1997). The genera *Phlaeoba*, *Xenocatantops*, Diabolocatantops, *Caryanda*, *Oxya*, *Conocephalus*, *Gryllus* and *Spathosternum* are also distributed in the South East Asian countries of Vietnam and Thailand (Dawwrueng et al., 2017; Kim & Pham, 2014).

Acrididae was found to be the largest family with 15 species followed by Tettigoniidae with seven species. Families namely Trigonidiidae, Gryllacrididae, Gryllotalpidae, Myrmecophilidae and Chorotypidae constituted only 3% of the total species composition (Figure 2). Acrididae is a dominant family of grasshoppers widely distributed. Many studies have reported similar results where Acrididae dominated. Our results are in accordance with the study conducted in Nanda Devi Biosphere Reserve and Achanakmar Wildlife Sanctuary which reports Acrididae as the dominant family with six species and 15 spp. respectively followed by Tettigoniidae as the second most abundant family with four species in the former study area (Arya et al., 2015; Gupta & Chandra, 2017). Orthopteran diversity in Anamudi Shola National Park is also dominated by the family Acrididae with six species (Eldhose et al., 2019). A similar study which compares orthopteran fauna of highlands and lowlands of Kerala conducted in Kattapana and Kottayam presents similar results with Acrididae as the dominant family with 10 spp. and Tettigoniidae the second dominant family with three species (Kuruvila et al., 2019). Acrididae was the largest family with 26 spp. in a study conducted at Vaniyamkulam village of Palakkad (Koya et al., 2017). Studies of paddy fields in Uttar Pradesh also have Acrididae as the largest family with 21 spp. (Akhtar & Usmani, 2014).

Families namely Acrididae, Tetrigidae, Gryllidae, Gryllacrididae, Gryllotalpidae and Tettigoniidae are also reported in studies conducted in Borneo islands (Tan & Wahab, 2018). Tetrigidae is widely distributed and occurs in Cambodia, Myanmar, Sumatera in

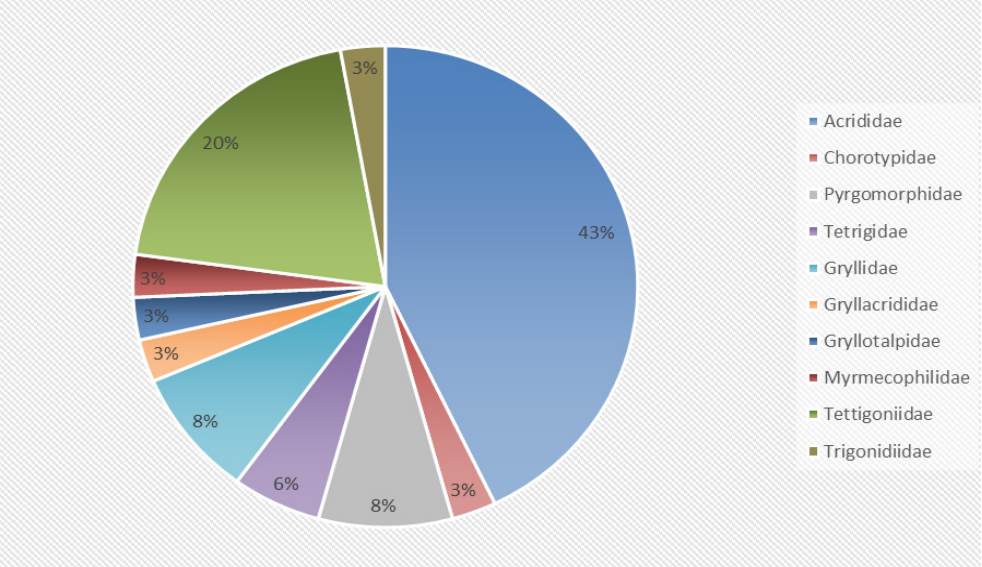

Figure 2. Distribution of orthopteran families in Central Kerala

Indonesia, Vietnam, Thailand, Singapore and Borneo (Dawwrueng et al., 2017; Kim & Pham, 2014; Storozhenko, 2019; Tan et al., 2013; Tan & Wahab, 2018).

Though orthopterans observed in the study area are not considered as serious pests of regional crops, most of these species have been reported as pests of various cereals and vegetables across India. *P. antennata*, *Phlaeoba infum*ata, *Xenocatantops humili*s, *Eyprepocnemis alacri*s, *Dittopternis venusta*, *Trilophidia annulat*a, *Oxya hyl*a, *Spasthosternum prasiniferum*, *Neorthacris acuticep*s, *Atractomorpha crenulata* and *Trigonidium cicindeloide*s have been reported as pests (Garg & Tandon, 1982; Mandal et al., 2007).

Some of the orthopterans reported in the study area have been suggested as future alternative food source and their nutritional potential have been studied. *O. hyla*, *Ducet*ia sp., *Phyllozellu*s sp. and *Gryllus africana* observed in our study were identified as potential nutritional supplement for livestock and humans (Chakravorty et al., 2018; Gahukar, 2018; Magara et al., 2021; Mandal et al., 2007).

B. Species Composition of Orthoptera in the Study Sites

The study revealed that Venmony had a greater number of orthopterans – 578 individuals than the lowland region Avoly with 493 individuals (Table 4). This is in accordance with the findings of (Kuruvila et al., 2019) which recorded a greater number of orthopterans in high-range areas in summer and monsoon seasons when compared to the low-range areas. The study site at Avoly is a lowland region with an altitude of 45 m asl while Venmony is located at 540 m asl which falls in a mid-altitude region with respect to the altitudinal gradient of Kerala. Several studies have shown a similar trend of higher orthopteran diversity in the medium altitudes than in lower and higher altitudes (Azil & Benzehra, 2020; Sirin et al., 2010). Besides, the proximity to natural forest area and less human interferences might be a favourable factor for high orthopteran diversity in Venmony. Avoly is located amidst a semi-urban habitat which is subjected to anthropogenic disturbances. Many studies have reported a lower diversity of orthopterans when ecosystems where disturbed (Baldi & Kisbenedek, 1997; Senthilkumar & Barthakur, 2013).

The species composition of orthopteran diversity in Avoly Panchayat and Venmony shows that 17 out of the 35 species were common to both study sites. The rest were found in any one of the two sites. Ten species were found only in

Avoly Panchayat and eight species were found only in Venmony (Table 2). *E. alacris*, *D. venusta*, *T. annulat*a, *B. burri*, *N. acuticeps*, *Chrotogonus* sp., *Gryllus domesticus*, *Brachyntheisogryllacris maindroni*, *Myrmecophilus albicinctus* and *Tegra viridivitta* were observed only in Avoly in the study. These species are commonly seen in agroecosystems and some are even pestiferous (Mayya et al., 2005; Soundararajan, 2000; Srinivasan & Prabakar, 2013). *E. alacris*, *D. venust*a, *T. annulata*, *N. acuticeps*, *Chrotogonus* sp., *G. domesticus* and *T. viridivitta* were observed in grasslands in the present study as well as (Srinivasan & Prabakar, 2013) *B. burri* and *B. maindroni* were found near vegetable crops. *M. albicinctus* was observed among leaf litter in rubber plantations.

Table 2: Variation in Species Composition of Avoly and Venmony

Sl. No	Species	Avoly	Venmony
1.	*Phlaeoba antennata*	✓	✓
2.	*Phlaeoba panteli*	✓	✓
3.	*Phlaeoba infumata*		✓
4.	*Carliola carinata*		✓
5.	*Ac*rida sp.	✓	✓
6.	*Xenocatantops humilis*	✓	✓
7.	*Diabolocantantops innotabilis*	✓	✓
8.	*Eyprepocnemis alacris*	✓	
9.	*Ceracris striata*		✓
10.	*Dittopternis venusta*	✓	
11.	*Trilophidia annulata*	✓	
12.	*Chitaura indica*	✓	✓
13.	*Caryanda cachara*		✓
14.	*Oxya hyla*	✓	✓
15.	*Spasthosternum prasiniferum*	✓	✓
16.	*Burrinia burri*	✓	
17.	*Neorthacris acuticeps*	✓	
18.	*Atractomorpha crenulata*	✓	✓
19.	*Chrotogonu*s sp.	✓	
20.	*Eucriotettix* sp.	✓	✓
21.	*Criotetti*x sp.	✓	✓
22.	*Gryllus domesticus*	✓	
23.	*Gryllodes sigillatus*	✓	✓
24.	*Cophogrylu*s sp.	✓	✓
25.	*Brachyntheisogryllacris maindroni*	✓	
26.	*Gryllotalpa Africana*	✓	✓
27.	*Myrmecophilus albicinctus*	✓	
28.	*Conocephalus maculatus*	✓	✓
29.	*Mecopoda* sp.	✓	✓
30.	*Hexacentrus* sp.		✓
31.	*Ducetia* sp.		✓
32.	*Acanthoprion suspectu*m		✓
33.	*Phyllozellu*s sp.		✓
34.	*Tegra viridivitta*	✓	
35.	*Trigonidium cicindeloides*	✓	✓

P. infumata, *Carliola carinata*, *Ceracris striata*, *Caryanda cachara*, *Hexacentrus* sp., *Ducetia* sp., *Acanthoprion suspectum* and *Phyllozellus* sp. were reported only in Venmony in the study. *Hexacentrus* sp., *Ducetia* sp., *A. suspectum* and *Phyllozellus* sp. were found around shrubs and crops like Cocoa. A. suspectum prefer shrubs (Yadav & Kumar, 2020). *P. infumata*, *C. carinata* and *C. striata* were observed in monoculture plantations of rubber as well as in open grasslands. The presence of bamboo thickets at the forest edges near the agroecosystem in Venmony and that of *C. striata* are in accordance with the foodplant preference of the species (Srinivasan & Prabakar, 2013). *C. cachara* was observed from grassland in Venmony.

The agroecosystem in Venmony has a perennial stream flowing around its boundaries separating it from the natural forest area, whereas Avoly was comparatively dry. *P. infumata* found only in Venmony prefers moist areas (Srinivasan & Prabakar, 2013) and *Chrotogonus* sp. which prefer places where the amount of water is less in the soil (Mandal et al., 2007) was seen only in Avoly. Thus, the presence and absence of orthopterans in each area is dependent upon various biotic and abiotic environmental factors characteristic to each area.

C. Relative Abundance

O. hyla was found to be the most abundant species in both Avoly and Venmony with abundance values of 21.3 and 17.6 respectively. *O. hyla* has been reported as an abundant species occurring in various parts around the world (Akhtar & Usmani, 2014; Gupta & Chandra, 2017; Itterbeeck et al., 2019). This might be due to its multivoltine and polyphagous nature (Ghosh et al., 2015). *O. hyla* is infamous as a pest of rice in the Indian subcontinent (Das et al., 2012). *A. crenulata* was the second most abundant species in Avoly with an abundance value of 19.9 whereas, *P. antennata* was the second most abundant species in Venmony with abundance value of 16.3 (Table 3). *A. crenulata* is a well-known pest of crops like tobacco and its abundance might be attributed to its nature to breed freely throughout the year (Srivastava, 1957).

Table 3: Relative abundance of species observed in Avoly and Venmony

Avoly		Venmony	
Species	Abundance	Species	Abundance
1. *Phlaeoba antennata*	4.06	1. *Phlaeoba antennata*	16.27
2. *Phlaeoba panteli*	1.62	2. *Phlaeoba panteli*	6.10
3. *Acrida* sp.	2.84	3. *Phlaeoba infumata*	10.00
4. *Xenocatantops humilis*	2.03	4. *Carliola carinata*	6.10
5. *Diabolocantantops innotabilis*	13.39	5. *Acrida* sp.	1.86
6. *Eyprepocnemis alacris*	0.61	6. *Xenocatantops humilis*	1.86
7. *Trilophidia annulata*	2.43	7. *Diabolocantantops innotabilis*	6.95
8. *Dittopternis venusta*	0.61		
9. *Chitaura indica*	4.06	8. *Ceracris striata*	1.53
10. *Oxya hyla*	21.30	9. *Chitaura indica*	2.03
11. *Spasthosternum prasiniferum*	3.04	10. *Caryanda cachara*	2.20
12. *Burrinia burri*	0.41	11. *Oxya hyla*	17.63
13. *Neorthacris acuticeps*	0.61	12. *Spasthosternum prasiniferum*	1.86
14. *Atractomorpha crenulata*	19.88	13. *Atractomorpha crenulata*	4.41
15. *Chrotogonus* sp.	0.61	14. *Eucriotettix* sp.	2.37
16. *Eucriotettix* sp.	1.62	15. *Criotettix* sp.	6.95
17. *Criotettix* sp.	4.26	16. *Gryllodes sigillatus*	4.75

Table 3. Continued

Avoly		Venmony	
Species	Abundance	Species	Abundance
18. *Gryllus domesticus*	1.42	17. *Cophogryllus* sp.	1.69
19. *Gryllodes sigillatus*	3.45	18. *Gryllotalpa africana*	0.85
20. *Cophogryllus* sp.	2.64	19. *Conocephalus maculatus*	0.17
21. *Brachyntheisogryllacris maindroni*	0.41	20. *Mecopoda* sp.	1.86
22. *Gryllotalpa africana*	1.83	21. *Hexacentrus unicolor*	0.17
23. *Myrmecophilus albicinctus*	2.03	22. *Ducetia* sp.	0.34
24. *Conocephalus maculatus*	2.64	23. *Acanthoprion suspectum*	0.17
25. *Mecopoda* sp.	1.22	24. *Phyllozellus* sp.	0.34
26. *Tegra viridivitta*	0.41	25. *Trigonidium cicindeloides*	1.53
27. *Trigonidium cicindeloides*	0.61		

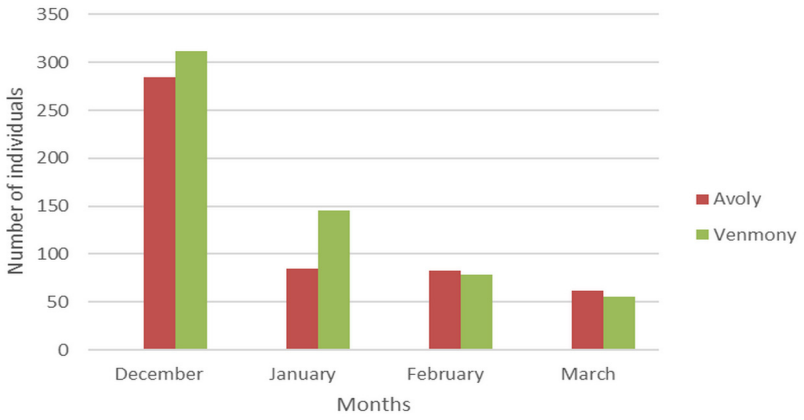

Figure 3. Monthly variation in number of orthopterans between two selected sites

B. burri, *B. maindroni* and *T. viridivitta* were the least abundant species in Avoly with an abundance value of 0.41. In Venmony, *Conocephalus maculatus*, *Hexacentrus* sp. and *A. suspectum* were the least abundant species with an abundance value of 0.17 (Table 3). The vegetation structure and other environmental variables like temperature might be a factor that caused the variations in abundance of orthopterans(Geppert et al., 2021).

D. Monthly Variation in the Occurrence of Orthopterans

In both the study sites, the largest number of orthopterans was observed during the month of December and declined gradually in the following months (Figure 3). The significance of the monthly variation of orthopterans were tested using ANOVA and the P value was found to be less than 0.05 which means the variation is significant. This might be due to the optimum vegetation cover during the post-monsoon months of December (Thakkar et al., 2015; Mayya et al., 2005). Venmony had a slightly greater number of orthopterans than Avoly in the months of December and January. During the dry months of February and March, Avoly had a slightly greater number of species than Venmony. The comparison of monthly data of the two sites using a t-test shows that the variation in numbers of orthopterans between sites is not statistically significant.

Table 4. Diversity statistics of Avoly and Venmony

Sl.No	Diversity indices	Avoly	Venmony
1.	Richness (Taxa)	27	25
2.	Evenness	0.52	0.60
3.	Shannon Index(H)	2.65	2.70
4.	Simpson's Diversity Index (1-D)	0.89	0.91

The slight variations might be attributed to the variations in various environmental factors like temperature, humidity, floral composition and cover that is characteristic of each area (Mayya et al., 2005).

E. Diversity Statistics of Orthoptera in Central Kerala

The number of species in Avoly was 27 and that of Venmony was 25. The evenness value is 0.60 in Venmony, higher than that of Avoly which is 0.52 (Table 4). So Venmony has a more stable community than Avoly. Venmony has a slightly higher biodiversity index value than Avoly. The value of Shannon index of Venmony and Avoly are 2.70 and 2.65 respectively (Table 4). The difference in value of Shannon diversity index between the two sites is not statistically significant since the p value is 0.32. Venmony has a Simpson's diversity index value of 0.91 and Avoly has a value of 0.89; hence the former location is slightly more diverse than the latter (Table 4). The P value for the simple t-test on Simpson's diversity index is 0.01 which means the difference between the two sites is significant. Both sites have high Simpson's diversity index value and hence harbour high orthopteran diversity. Venmony is located near to the natural forest ecosystem which might be a reason for the comparatively high evenness and diversity. Proximity of cultivable lands to forest landscapes increase insect interchanges between ecosystems and hence a higher diversity and stable community of insects are seen in the forest-edge agroecosystems (González et al., 2016).

IV. CONCLUSION

The present study reveals an account of the diverse orthopteran fauna in the central part of Kerala state in South India across the altitudinal gradient. The highlands in Central Kerala are comparatively less disturbed from anthropological interferences and hence harbour more biodiversity than the lowland regions. There is significant seasonal variation in orthopteran fauna and hence they can be adversely affected by the global climate change. Identification of orthopterans of a particular area can also help in monitoring and keeping potential pest species under check and thus protecting crops of the region. A long-term study covering more ecosystems is recommended in the future which would reveal the population dynamics of orthopterans of this region.

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