International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 22-05-2025, Accepted: 21-06-2025, Published: 07-07-2025
Volume 10, Issue 7, 2025, Page No. 12-18

Seasonal diversity of grasshopper fauna in different tropical dry deciduous forest habitat of Sambalpur district, Odisha, India

Basudev Bacha
Department of Sciences, Soil Ecology Branch, Sambalpur University, Odisha, India

Abstract
This study examines seasonal assemblage of grasshopper fauna across three tropical dry deciduous forests in Sambalpur district, Odisha. Grasshoppers were sampling was conducted from November 2022 to October 2023 using sweep nets, visual transect surveys, and pitfall traps in three different tropical dry deciduous forest habitat. During this study a total of 35 grasshopper species were recorded that belongs to 26 genera and four families i.e. Gryllidae, Acrididae, Pyrgomorphidae, and Tettigoniidae were recorded. Acrididae were recorded as the most dominant family then others. Higher species richness and individual was recorded in undisturbed reserved forests, followed by reserve-planted and disturbed forests. The most abundant species included *Acridaexaltata, Acridagigantea, Attactomorpha crenulata, Diabolocatantopsaxillaris, Diabolocatantopspinguis, Oxyafusco vittata, Oxya hyla, Spathosternum prasiniferum,* and *Teleogryllustestaceus.* Diversity indices, such as species richness and abundance varied significantly across three forest habitats, reflecting the influence of environmental conditions and vegetation structure on Grasshopper assemblages. Seasonal variations significantly influenced diversity pertain across the tropical dry deciduous forest habitat of the study areas in which highest species richness observed during the rainy season in reserve-planted forests and the lowest during summer in disturbed forests. Grasshopper abundance in reserve-planted forests during the rainy season underscores their adaptability to tropical dry forest habitats, which is largely influenced by vegetation cover. This study highlights the ecological significance of tropical dry deciduous forests as critical habitats for Grasshoppers. Continuous, large-scale research is essential to understand their ecological roles, distribution, and microhabitat preferences, contributing to biodiversity in these tropical dry deciduous forests ecosystem.

Keywords: Orthoptera, pest, disturbed forest, reserved forest and species richness

Introduction

Grasshoppers are an omnivorous group that inhabit diverse habitat of the terrestrial ecosystems [1]. They are considered as valuable bio indicators, reflecting environmental conditions and landscape changes play a pivotal role in ecosystem function such as regulating plant populations [2] [3], insect predation [4], seed dispersal [5], and pollination [6]. The population dynamics significantly impact environmental stability and biodiversity structure [7]. [8] Emphasized that environmental changes significantly influence grasshopper species richness, with small-scale disturbances having particularly adverse effects on their populations.

Forests habitat are critical for regulating biodiversity and ecosystem services, supports larger pollinator and seed dispersal organism [7]. Due to the loss of other terrestrial habitats, the majority of terrestrial biodiversity currently exists in forests [9]. In contrast to this, the relatively high population densities that have resulted in agricultural development and increased human dependence for fuelwood, non-timber forest products, and livestock grazing have made tropical dry forests one of the most vulnerable tropical forest ecosystems [10]. Indian tropical dry deciduous and tropical moist deciduous forests dominating, covering 34.80% of the country's area [11] and exhibit significant floristic diversity, especially in protected areas like reserve forests and demarcated protected forests [12]. [13] Highlighted the need for targeted faunal surveys in different forest ecosystems to identify potential indicator species. The Deccan Plateau region of India, shaped by geographical variation, due to a wide range of agricultural practice and also supports wild plant and animal species. Consequently, assessing species diversity is vital to highlight the significance of local and regional landscapes for grasshopper populations.

The study of grasshopper diversity in tropical deciduous forest habitats is crucial for understanding ecosystem dynamics and ecological adaptations. Globally, over 29,530 grasshopper species have been documented [14], with India still accounted 12, 74 species [15]. Previous research on grasshopper diversity across various Indian forest ecosystems has provided valuable insights into different geographical distribution. For example, [16] recorded 14 species in the Western Himalayas, while 21 grasshopper's species were recorded in the forests of North Gujarat [17]. Similarly, Deva and Senthilkumar (2017) [18] documented 28 species in Coimbatore, Tamil Nadu, and Raghavender and Vastrad (2017) [19] reported 42 short-horned grasshopper species in the Dharwad forests of Karnataka. Govindaraj *et al.* (2021) [20] identified 15 species in the Shola forests and grasslands of the Nilgiris, Tamil Nadu. Additionally, Koli *et al.* (2009) [21] reported 17 species near Chandoli National Park, Maharashtra, and Gupta and Chandra (2017) [22] compiled a checklist of 19 species from different ecosystem of Chhattisgarh districts. Likewise, Saha and Haldar (2013) [23] documented 39 species in disturbed habitats in the same region. These studies highlight the ecological importance of grasshoppers, not only as vital functional components of ecosystems but also as sensitive indicators of ecological balance and habitat integrity. In Odisha, however, studies on grasshopper diversity remain limited. Shishodia *et al.* (2010) [24] provided an annotated checklist of 129 grasshopper species in Odisha, spanning 97 genera and 11 families. More recently, Pradhan *et al.* (2023) [25] reported the presence of the hooded grasshopper (*Teratodes monticollis*) in the Bonai Forest Division Sundargarh districts of Western

Odisha. Despite these efforts, there is no systematic study on grasshopper diversity in the tropical dry deciduous forests of Sambalpur District of Western Odisha. Therefore, the present study aims to assess the grasshopper assemblage and seasonal diversity patterns in different tropical deciduous forest areas of Sambalpur. This investigation seeks to fill a critical research gap by enhancing our understanding of grasshopper diversity and the potential ecological disturbances in this region will be an essential step toward biodiversity conservation.

Material and methods

Study sites

The study area consists of tropical dry deciduous forests, characterized by harsh and dry conditions in summer, humid conditions during the monsoon, and cold temperatures in winter, primarily influenced by the southwest monsoon. The region has an average elevation of 150.75 meters above sea level [26]. To understand the Grasshopper assemblage and seasonal diversity pattern, three distinct tropical dry forest habitats were selected i.e. RDF (reserve disturbed forest), UDF (undisturbed reserve forest), and RPF (Reserve plantation forest), which lies in 21°44'53"N, 84°26'56"E with elevation 292m; 21°23'39"N, 84°04'52"E with elevation 228m and 21°04'53"N,84°18'12"E with elevation 238m, respectively. The different location of study area was given in (Fig.1).

Data collection

The present study was conducted from November 2022 to October 2023 in monthly interval. Grasshopper survey was performed in the early morning hours between 08.00-10.00 A.M. and the evening time from 03.00-05.00 PM. Grasshoppers were collection, at each sampling sites in three of 10×10m quadrate transects using three sampling techniques, i.e., sweep nets, visual transect surveys, and pitfall traps [27] [28]. As mentioned a nylon wire-made sweep net of about 60 cm in diameter was continuously performed for one hour on both the lower and above vegetation surfaces of the transect line in single run. The collected specimens were transformed into a formalin-sprinted plastic bottle and then preserved in a clean bottle with phenolphthalein balls. Some damaged specimens were preserved in glass bottles filled with 70% ethanol and then levelled with proven markers. On field active grasshoppers were photographed using Nikon 5300D DSLR cameras. The specimens were identified up to the lowest taxonomic level by using the identification key and published literature of [29] [30] [31] and web sites (https://indiabiodiversity.org) [32] and (http://orthoptera.speciesfile.org) [33] used for taxonomic nomenclature. All examined specimens were preserved in the School of Life Sciences at Sambalpur University for future reference.

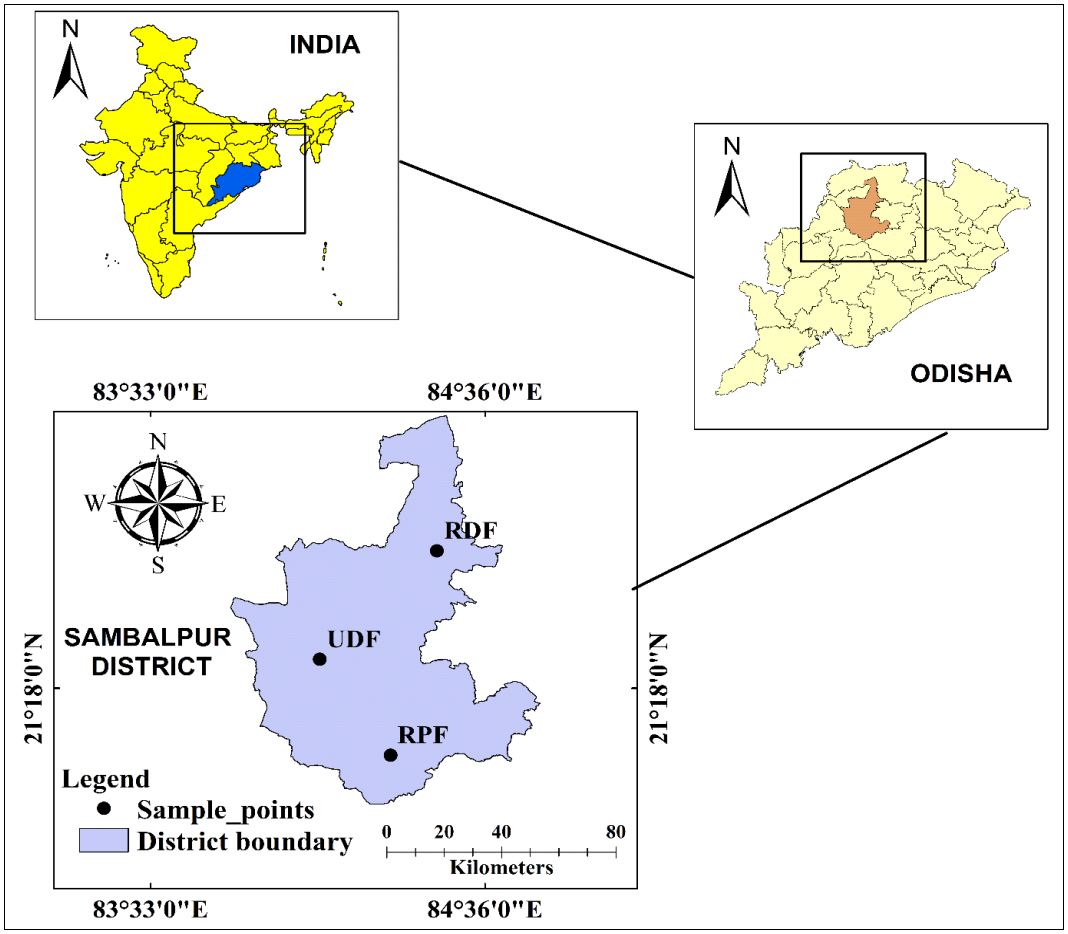

Fig 1: Study area map

Data analysis

PAST software used to calculate ecological indices such as the Species richness, and abundance. The data were log transferred to calculate all statistical analysis. The Bray-Curtis similarity index performed to evaluate similarity among the sites. Two-way ANOVA were used to estimate the seasonal significance of grasshopper diversity indices. A Venn diagrammatic illustration was used to explain

percentage of species distribution between the three tropical forest sites (https://bioinfogp.cnb.csic.es/tools/venny).

Result

During this study, a total of 35 grasshopper species were recorded that belong to 28 genera, 19 subfamilies, and four families, i.e., Gryllidae, Acrididae, Pyrgomorphidae, and Tettigoniidea. Family Acrididae were the most dominant family consist of (71%, 19 species), followed by Tettigoniidea (consist of 18%, 9 species), Gryllidae (consist of 10%, 4 species), and Pyrgomorphidae were the least dominated family (consist of 2%, 3 species). The most abundant grasshopper species were including *Acrida exaltata*, *Attactomorpha crenulata*, *Diabolocat antopsaxillaris*, and *Diabolocat antopspinguis*, *Oxya fuscovittata*, *Oxya hyla*, *Spathosternum prasiniferum*. The assemblage of species in three sites i.e. RDF, UDF, and RPF depicted in the Venn diagram(Fig. 2) which illustrating that 30's species (85.7% species of total) sharing all three forest habitat,however a district site specificity observed in reserve plantation and disturbed forest sites for example, species *sphingonotus longipennis* was only recorded in the disturbed reserved forest, whereas species *Cyrtacanthacris tatarica*, *Gymnobothrus sp.*, and *Modicogryllus confirmatus* were recorded in the plantation reserved forest, this results which demonstrating that the species distribution vary in responses to anthropogenic activity as well as vegetation coverage, as result revels that the reserve plantation forest has maximum species richness(33 no's), followed by undisturbed reserve forest (32 no's), and reserved disturbed forest (30 no's).This result also supported in the Bray-Curtis similarity index which shows the abundance of grasshopper species forms two clusters in which the RDF site forms dissimilar cluster, while UDF and RFF share common features, suggesting a unique assemblage of grasshopper species abundance across the three forest habitats (Fig.3). Checklist few images of grasshopper species abundance across the three tropical habitats of Sambalpur district Odisha was given in (Table 1,Fig.5 However, the result of seasonal analysis found that the species richness ($F(2,27) = 24.46$, $p = 0.001$) and abundance ($F(2,102) = 31.58$, $p = 0.001$) in three different forest habitat were significant which demonstrated that the highest species (Taxa-s) recorded during the rainy season in the reserved plantation forest (25.3±3.10) and lowest (13.25±2.06) was recorded in the reserved disturbed forest in the summer season (Table 1). Similarly, maximum grasshopper individuals (Ind m-2) were recorded in the rainy season in the reserved plantation forest (262.5±25.9 Ind m-2), while the lowest were in the summer (66.75±8.50 ind m-2) in disturbed forest sites. Importantly, the rainy season found more favourable climatic condition for species like *Acrida gigantea*, *Acrida crenulata*, *Duroniella axillaris*, *Grylllodes sibilates*, *Oxya hyla*, and *Spathosternum prasiniferum.* However, species richness almost remained similar in summer season. The multiple linear regressions analysis between grasshopper abundance with precipitation and temperature clearly explains 38.16% of the variability at ($p=0.00036$), in which the precipitation increases the abundance by 8.77 individuals per unit increase, and reduces abundance 4.39 individuals per unit increase temperature, suggesting a positive significance for precipitation of 8.77 ($p< 0.001$) and negatively significant for temperature -4.39 ($p< 0.001$) respectively (Fig 4).

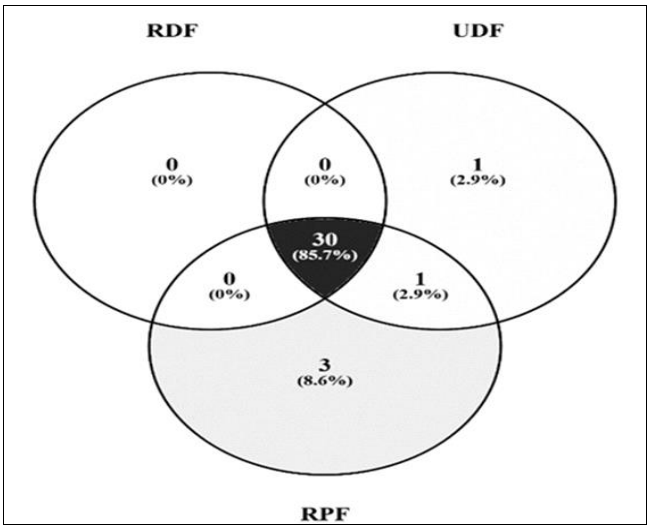

Fig 2: The overlap distinctive circle of the three sites i.e. RDF, UDF, and RPF depicted in the Venn diagram which illustrating that maximum species sharing all habitat and can see a district variance of species assemblage belong to reserve plantation forest sites.

Table 1: Checklist of grasshopper species abundance across the three tropical forest habitats of Sambalpur district Odisha (W=winter, S=summer=Rainy).

SL no	Family	Species Name	RDF			UDF			RPF		
			W	S	R	W	S	R	W	S	R
1	Acrididae	*A.exaltata*(Walker,1859)	+	+	+	+	+	+	+	+	+
2	Acrididae	*A.gigantea* (Herbst, 1794)	+	+	+	+	+	+	+	+	+
3	Acrididae	*Catantopinae sp* (Brunner 1893)	+	-	-	-	-	+	+	-	+
4	Acrididae	*C.apterus*(Redtenbacher, 1892)	-	-	-	-	-	-	-	-	+
5	Acrididae	*C.tatarica* (Linnaeus, 1758)	+	+	+	-	-	+	-	-	+
6	Acrididae	*D.axillaris*(Jago,1984)	+	+	+	+	+	+	+	+	+
7	Acrididae	*D.pinguis* (Stål, 1861)	+	+	+	+	+	+	+	+	+
8	Acrididae	*E.alacris*(Serville, 1838)	-	-	+	+	+	+	-	+	+
9	Acrididae	*E.praemorsa* (Walker,1870)	+	+	+	+	-	+	+	-	+
10	Acrididae	*Gymnobothrus sp* (Bolívar, 1889)	-	-	-	-	-	-	-	-	+
11	Acrididae	*Hieroglyphus sp*(Krauss, 1877)	-	+	-	+	-	+	-	-	-
12	Acrididae	*O. abruptus* (Thunberg, 1815)	+	-	+	+	-	+	+	+	+
13	Acrididae	*O. fuscovittata*(Herbst,1786)	+	+	+	+	+	+	+	+	+
14	Acrididae	*O. hyla*(Serville,1831)	+	+	+	+	+	+	+	+	+
15	Acrididae	*P.antennata* (Brunner,1893)	-	+	-	+	-	-	-	-	+
16	Acrididae	*P.vinosa*(Walker, 1870)	+	+	+	+	+	+	-	-	+

17	Acrididae	*S.Longipennis* (Saussure,1884)	-	-	-	-	-	+	-	-	-
18	Acrididae	*S.prasiniferum*(walker,1871)	+	+	+	+	+	+	+	+	+
19	Acrididae	*T.annulata*(Thunbrg,1815)	+	+	+	+	+	+	+	+	+
20	Gryllidae	*G.furcata(*Saussurre,1877)	+	+	+	-	-	+	-	-	+
21	Gryllidae	*G.sigillatus*(Walker,1869)	+	+	+	+	+	+	+	+	+
22	Gryllidae	*M.confirmatus*(Walker,1869)	-	-	-	-	-	-	+	-	+
23	Gryllidae	*T.testaceus*(Walker.1869)	+	+	+	+	+	+	+	+	+
24	Pyrgomorphidae	*A.miliaris*(Linnaeus,1758)	-	-	+	-	-	+	+	-	+
25	Pyrgomorphidae	*C.turanicus* (Kuthy, 1905)	+	+	+	+	+	+	+	+	+
26	Pyrgomorphidae	*letana sp*(Walker, 1869)	+	-	+	+	+	+	+	+	+
27	Tettigoniidae	*A.crenulata*(Fabricius,1793)	+	+	+	+	+	+	+	+	+
28	Tettigoniidae	*C.maculatus*(Le Guillou, 1841)	-	-	-	+	+	+	+	+	+
29	Tettigoniidae	*H.unicolor* (Serville, 1831)	+	+	+	-	+	+	+	-	+
30	Tettigoniidae	*H.vidhyavadhiae*(Ingrisch & Muralirangan, 2004)	+	-	+	+	-	+	-	-	+
31	Tettigoniidae	*M.elongata* (Linnaeus, 1758)	+	+	+	+	+	+	+	+	+
32	Tettigoniidae	*P. pictus*(Fabricius,1775)	-	-	+	-	-	+	+	-	+
33	Tettigoniidae	*S.bicolor*(Saussure,1877)	+	-	+	+	+	+	+	+	+
34	Tettigoniidae	*S.rugosa*(Linnaeus 1758)	-	-	+	+	-	+	+	-	+
35	Tettigoniidae	T.unicolor(Stoll,1789)	-	-	+	+	+	+	+	+	+

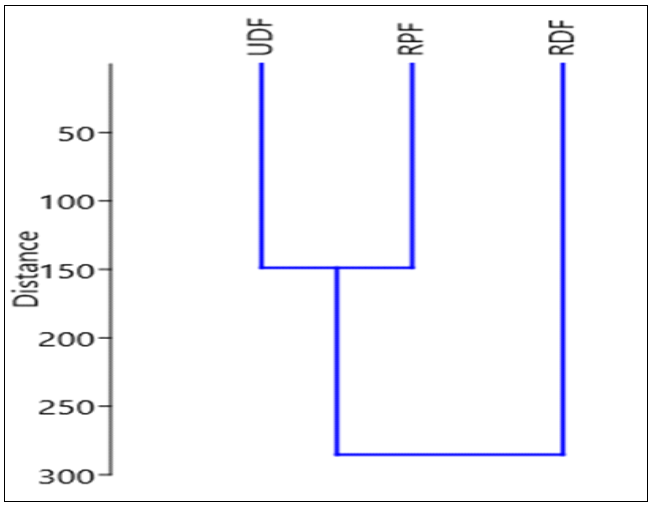

Fig 3: Based on species abundance, the Bray-Curtis similarity index shows RDF is the most dissimilar cluster, while UDF and RFF share common features, suggesting a unique assemblage
Of grasshopper species across the three forest habitats.

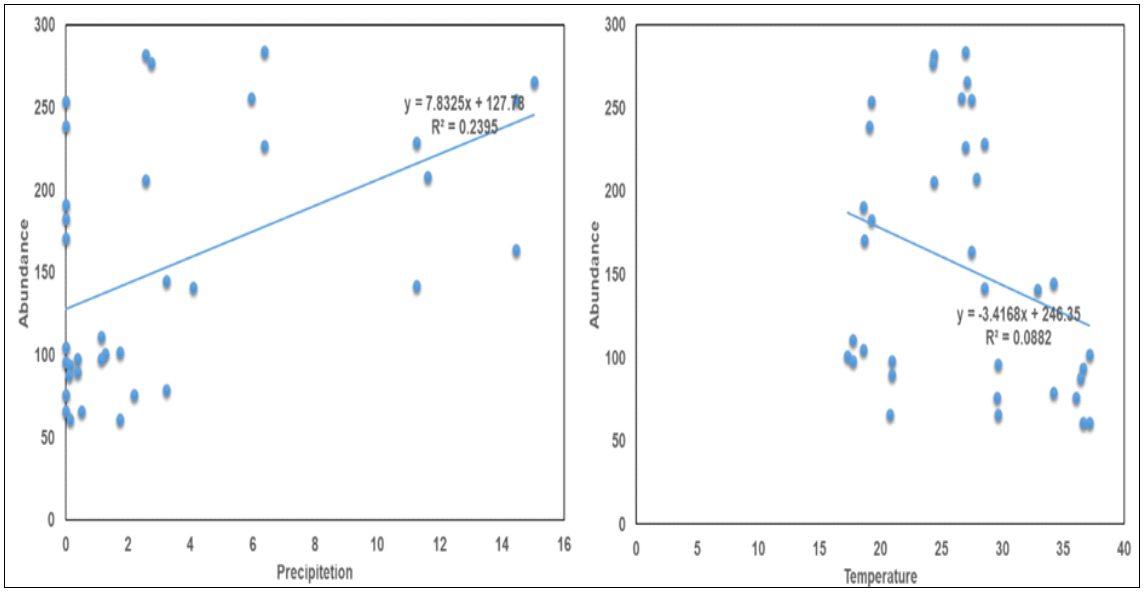

Fig 4: The multiple linear regressions between monthly grasshopper abundance with precipitation and temperature found grasshopper is more sensitive to changes in precipitation than temperature. The multiple linear regression analysis shows a moderate relationship between precipitations, temperature with the abundance variable, explaining 38.2% of the variance, suggesting a reasonable fit.

Fig 5: Images of grasshopper from the Sambalpur District, Odisha, India: a) *Poekilocerus pictus* (Fabrics, 1775), b) *Himertula kinneari* (Uvarov 1923), c) *Oxya hyla (Serville, 1831)*, d) Eucoptacra praemorsa (Walker, 1870), e) *Aularches miliaris* (Linnaeus, 1758), and f) *Stenocatantops splendens* (Thunberg, 1815).

Table 1. Seasonal Diversity indices (Mean ± SD) in three tropical forest habitats of Sambalpur district, Odisha.

Diversity indices		Winter	Summer	Rainy
Sp. Richness	RDF	14.25±6.02	13.25±2.06	21±1.83
	UDF	15.75±6.55	13.75±0.96	24±1.41
	RPF	15.25±4.79	13±2.16	25.3±3.10
Individuals	RDF	119±43.10	66.75±8.50	184.8±38.7
	UDF	163.5±73.01	109.3±24.07	262.5±25.9
	RPF	144.3±76	95.25±32.02	251.8±30.7

Discussion

During this study, a total of 35 grasshopper species were recorded that belong to 28 genera, 19 subfamilies, and four families from three different tropical dry deciduous forest habitat of Sambalpur district Odisha. Previously Shishodia *et al*. (2010) [24] reported an annotated checklist that listed 129 Grasshopper species from Odisha. In contrast, this current study recorded 35 species, which is 27.13% of the total from that annotated checklist of Odisha. Paulraj *et al*. (2009) and Arya *et al*. (2015) reported previously 33 grasshopper species in Tamil Nadu and 14 species in the Western Himalayas forest habitat respectively, with acrididae being the dominant group then others family [32] [16]. These findings indicate acrididae is a dominance family across all vegetation gradients. *Acrida exaltata, Attactomorpha crenulata, Acrida gigantean, Diabolocatantops axillaris, Diabolocatantops pinguis, Oxya fuscovittata, Oxya hyla, Spathosternum prasiniferum* and *Teleogryllu testaceus* are the most dominant species in this studied habitat. *Attactomorpha crenulata* species reported as

most abundant species in tropical deciduous forest ecosystems [13] as well as *Acrida exaltata, Oxya fuscovittata, Oxya Hyla*, and *Spathosternum prasiniferum* are widely distributed in the Indian forest and grassland habitat [35] [36] .Species *P. antennata, Eyprepocnemis alacris, Trilophidia annulata, Oxya hyla, Spasthosternum prasiniferum, Atractomorpha crenulata*are knows as pest species in Indian agroecosystem [36], these finding support the dominance of these species in this ecosystem. During this study grasshopper species abundance varied in three forest sites, mostly human disturbed sites found less abundances in compared to preserved sites. This has been found that the composition of grasshopper species richness was strongly correlated with the degree of habitat disturbance. Disturbed habitat with fewer plant species supports lower insect diversity [37]. It suggests that grasshopper species were relatively adaptable in this dry tropical forest habitat where their abundance was determined by the vegetation coverage. It has been observed that changing seasonality, temperature, and precipitation play crucial roles in grasshopper abundance across the study habitat. Recent study has also reported that the grasshopper population structure is largely influenced by climatic factors, particularly rainfall and temperature, which influence the diversity and distribution of the grasshopper population [38] [12] [39]. During this study maximum species richness and abundance was found in the monsoon season, followed by the post-monsoon and pre-monsoon seasons respectively. This result corresponds to other findings of across the Indian continent for example Muralidharan and Potel (2007) [17], who examined the diversity of grasshoppers in a forest ecosystem in north Gujarat and reported that the grasshopper species richness varied from 2 to 21 throughout the season where maximum specimen observed in monsoon season. Similarly, it has been observed that grasshopper species in the Western Himalayas protected forest area and reported the highest population density in the rainy season, followed by summer and winter [16].

Conclusion

This study is the first to evaluate grasshopper diversity in the tropical dry deciduous forests of Sambalpur district, Odisha. The results highlight that the region is rich in grasshopper diversity. Many environmental factor such as temperature and precipitation, along as well as land-use practices significantly influencing their assemblage and distribution of grasshopper species. Grasshopper pest species, including *Acrida exaltata, Acrida gigantea, Attactomorpha crenulata, Diabolocat antopsaxillaris, Diabolocat antopspinguis, Oxyafuscovittata, Oxya hyla, Spathosternum prasiniferum,* and *Teleogryllus testaceus* were recorded in these forest habitat areas which are reported as pest species and threat to crop productivity, therefore underscoring the need for effective pest management strategies to maintain sustain ecosystems and conserve the biodiversity. The findings suggest that these ecosystems hold potential for discovering additional grasshopper species, offering valuable opportunities to large-scale and long-term research to understand grasshopper population dynamics and their ecological roles in diverse tropical dry deciduous forest ecosystems.

Acknowledgement

I am thankful to Sambalpur Forest Division, Sambalpur for necessary facility during the field work and also thanks to the Head of School Life Sciences, Sambalpur University for providing all laboratory facility. I would give thanks to Manash Kumar Jena research scholar, Sambalpur University for making this study area map.

Conflict of interest

The author doesn't have confliction of interest

References

1. Schmitz OJ, Suttle KB. Effects of top predator species on direct and indirect interactions in a food web. Ecology,2001:82(7):2072–81.
2. Rodell CF. A grasshopper model for a grassland ecosystem. Ecology,1977:58(2):227–45.
3. Lockwood JA. Environmental issues involved in biological control of rangeland grasshoppers (Orthoptera: Acrididae) with exotic agents. Environmental Entomology,1993:22(3):503–18.
4. Laws AN. Climate change effects on predator–prey interactions. Current Opinion in Insect Science,2017:23:28–34.
5. Fischer SF, Poschlod P, Beinlich B. Experimental studies on the dispersal of plants and animals on sheep in calcareous grasslands. Journal of Applied Ecology,1996:33(6):1206–22.
6. Hudewenz A, Klein AM, Scherber C, Stanke L, Tscharntke T, Vogel A. Herbivore and pollinator responses to grassland management intensity along experimental changes in plant species richness. Biological Conservation,2012:150(1):42–52.
7. Brockerhoff EG, Barbaro L, Castagneyrol B, Forrester DI, Gardiner B, González-Olabarria JR, *et al*. Forest biodiversity, ecosystem functioning and the provision of ecosystem services. Biodiversity and Conservation,2017:26(11):3005–35.
8. Steck CE, Bürgi M, Bolliger J, Kienast F, Lehmann A, Gonseth Y. Conservation of grasshopper diversity in a changing environment. Biological Conservation,2007:138(3–4):360–70.
9. Singh JS, Kushwaha SP. Forest biodiversity and its conservation in India. International Forestry Review,2008:10(2):292–304.
10. Anitha K, Joseph S, Chandran RJ, Ramasamy EV, Prasad SN. Tree species diversity and community composition in a human-dominated tropical forest of Western Ghats biodiversity hotspot, India. Ecological Complexity,2010:7(2):217–24.
11. Reddy CS, Jha CS, Diwakar PG, Dadhwal VK. Nationwide classification of forest types of India using remote sensing and GIS. Environmental Monitoring and Assessment,2015:187(1):1–30.
12. Meena P, Prajapat R, Kumawat N, Meena S. Grasshopper species composition and severe attack in the semi-arid region of Rajasthan, India. Environment and Ecology,2023:41(4):3111–19.
13. Joshi PC, Lockwood JA, Vashishth N, Singh A. Grasshopper (Orthoptera: Acridoidea) community dynamics in a moist deciduous forest in India. Journal of Orthoptera Research,1999:8(1):17–23.
14. Cigliano MM, Braun H, Eades DC, Otte D. Orthoptera species file, 2024.
15. Chand DS, Das SK, Chakraborty R, Kumar H. Checklist of fauna of India: Arthropoda: Insecta: Orthoptera. Version 1.0. Zoological Survey of India, 2024, 2.

16. Arya MK, Joshi PC, Vinod PB. Species composition, abundance, density and diversity of grasshoppers (Insecta: Orthoptera) in a protected forest ecosystem in the western Himalaya. International Journal of Fauna and Biological Studies,2015:2(5):42–6.
17. Muralidharan CM, Patel GM. Species richness, evenness and diversity status of grasshopper community in a forest ecosystem of north Gujarat. 2007:103–9.
18. Senthilkumar N. Orthopteroids in Kaziranga National Park, Assam, India. Journal of Threatened Taxa,2010:2(8):1227–31.
19. Raghavender B, Vastrad AS. Changing scenario of short horned grasshopper diversity in agriculture and forest ecosystems in Dharwad. Journal of Entomology and Zoology Studies,2017:5(2):268–72.
20. Govindaraj D, Senthikumar N, Periyasamy SS. Altitudinal gradients and species richness: a study on diversity of Orthoptera in Nilgiris shola forests and grasslands. Records of the Zoological Survey of India,2021:121(1):465–72.
21. Koli YJ, Aland SR, Bhawane GP. A report on the occurrence of short horned grasshopper (Insecta: Orthoptera: Acrididae) from adjoining areas of Chandoli National Park, Maharashtra, India. The Ecoscan,2009:3(3):331–4.
22. Gupta SK, Chandra K. New record of seven species of short-horned grasshoppers and ground hoppers (Orthoptera: Insecta) from Chhattisgarh, India. Records of the Zoological Survey of India,2016:116:337–45.
23. Saha HK, Haldar P. Response of acridids diversity (Orthoptera: Acrididae) in different disturbed habitats across seasons on dry deciduous forest. Caspian Journal of Applied Sciences Research,2013:2(7):1–7.
24. Shishodia MS, Chandra K, Gupta SK. An annotated checklist of Orthoptera (Insecta) from India. Zoological Survey of India, 2010.
25. Pradhan I, Rout S, Kumar S. Hooded grasshopper *Teratodes monticollis* (Gray, 1832) morphometric and intraspecific colour variation from Bonai Forest Division, Odisha, India. Asian Journal of Biology,2023:18(4):1–5.
26. Bacha B, Sahoo S. Effect of different land use practices on earthworm abundance and soil properties. International Journal of Scientific Research,2018:9(4):1290–4.
27. Rácz IA, Déri E, Kisfali M, Batiz Z, Varga K, Szabó G, *et al*. Early changes of orthopteran assemblages after grassland restoration: a comparison of space-for-time substitution versus repeated measures monitoring. Biodiversity and Conservation,2013:22(10):2321–35.
28. Rudd WG, Jensen RL. Sweep net and ground cloth sampling for insects in soybeans. Journal of Economic Entomology,1977:70(3):301–4.
29. Kirby WF. The fauna of British India, including Ceylon and Burma. Orthoptera (Acrididae). London, 1914.
30. Gupta SK, Chandra K. A taxonomic study of the pygmy grasshopper (Orthoptera: Tetrigidae) from India with description of a new species. Biodiversity Journal,2017:8(2):739–48.
31. Rajapandian R, Natchiappan S. Diversity and distribution records of Orthoptera (Insecta) in Nagarhole Tiger Reserve, Karnataka, India. Proceedings of the Zoological Society,2020:73(4):362–79.
32. India Biodiversity Portal. https://indiabiodiversity.org
33. Orthoptera Species File. http://orthoptera.speciesfile.org
34. Paulraj MG, Anbalagan V, Ignacimuthu S. Distribution of grasshoppers (Insecta: Orthoptera) among different host plants and habitats in two districts of Tamil Nadu, India. Journal of Threatened Taxa,2009:1(8):230–3.
35. Tandon SK, Hazra AK, Mandal SK. Observations on the field biology and ecology of some grasshoppers (Orthoptera: Acridoidea) near Calcutta. Records of the Zoological Survey of India,1988:84:301–18.
36. Mathew LR, Joseph GK, Cyril AE. Orthopteran diversity in tropical ecosystems of Central Kerala, India. Indonesian Journal of Forestry Research,2022:9(1):121–33.
37. Schowalter TD. Insect responses to major landscape-level disturbance. Annual Review of Entomology,2012:57(1):1–20.
38. Hussain M, Akbar R, Malik MF, Kazam SN, Zainab T. Diversity, distribution and seasonal variations of grasshopper populations in Sialkot, Punjab, Pakistan. Pure and Applied Biology,2017:6(4):1372–81.
39. Youngblood JP, Cease AJ, Talal S, Copa F, Medina HE, Rojas JE, *et al*. Climate change expected to improve digestive rate and trigger range expansion in outbreaking locusts. Ecological Monographs,2023:93(1):1550.