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Diversity and Abundance of Edible Orthopterans Insects and their Future Prospects for Food Security of the People in Baksa District, Assam, India

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Assam in North East India is very rich in diversity of edible insects. Most of the insects are eaten by tribal people as nutritious and tasty food. Orthopteran species such as grasshoppers (Acrididae and Tettigoniidae) and crickets (Mole cricket and House cricket) are major insects eaten by tribal people such as Bodo, Rabha, Sarania, Tea Tribes etc. in study area. Most of these species are pests of crops and vegetables which damage the crops and reduce their yield. These species are eaten as food by ethnic people of the study area and they have incredible prospects in food security. The diversity of orthopterans was calculated by using "Shannon Wiener Index. Species diversity was determined following Shannon Wiener's Index (Shannon and Weaver, 1963, Ludwig and Reynolds, 1988). During this study period, a total of 10 species of Orthoptera belonging to 4 families of 10 genera were recorded. Family Acrididae was dominant with (5 species), followed by Tettigoniidae (2 species), Gryllidae (2 species) and then followed by Gryllotalpidae (1 species). Agricultural Field habitat such as Paddy fields and Open field habitat such as grassland areas

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contribute to richness in diversity of Orthopteran species. Shannon-Weiner diversity index (H') was applied to find out whether any significant difference existed in the insect diversity between different habitats. Simpson's diversity index was used to measure the diversity which allows the number of species present as well as the relative abundance of each species. The largest number of edible Orthopteran is available during June to September (pre monsoon and monsoon) and then gets gradually reduced from retreating monsoon to winter season.

Keywords: Acrididae; diversity; grassland; nutritious malnutrition; significant; tettigoniidae.

1. INTRODUCTION

"Edible insects pose an important part of the diet in almost all developing nations. Order Orthoptera includes short and long-horned grasshoppers, pygmy grasshoppers, grouse locusts, crickets, mole crickets, katydids, raspy cricket, and cave crickets. The Orthopteran insects represent a major number of total insect biodiversity. The order Orthoptera is one of the largest orders under the phylum Arthropoda with more than 28134 species worldwide" [1]. "Orthoptera are essential elements in trophic food webs as they represent first order consumers in grassland ecosystems" [2]. Most granivorous birds depend on Orthopteran insects for part of their diet. They also play a significant trophic role, being prey for other invertebrates and many vertebrates [3]. "The order Orthoptera includes grasshoppers, locust, katydids, crickets, etc., with elongated hind legs and musculature adapted for jumping. Over 17,250 Orthopteran species are identified throughout the world [4]. Orthoptera fauna are one of the most important invertebrate groups for environmental monitoring and assessment [2]. "These insects need to focus on their ecological services. Many species of Orthoptera can be highly destructive to crops. Most of the Orthopteran species found in the study area are pest insects that damage on crops over wide land areas. The Orthopteran insects show high population densities under certain environmental conditions. From literature, it is found that they are good sources of amino acids, fatty acids, crude carbohydrates, fibre and ash" [5]. "Orthopterans are important components of grassland invertebrate assemblages in European agricultural ecosystems particularly due to their significant role in food chain"(Baldi & Kisbenedek, 1997). Tribal people in Assam as well as a few non-tribal people accept insects as food for their high nutritional value [6-9]. The eating habit of these people help to fight malnutrition and food insecurity. Out of all modes of consumption, frying is the most popular mode of consumption of Orthopteran insects. This study also revealed that orthopteran insects which were considered as pests of crop and vegetables also have high contents of protein [10-14]. As for example Mole crickets, Cricket and all the species of Grasshoppers have high protein and lipid and considerable amount of carbohydrate [15]. Because of its importance, the present study has been designed to investigate the abundance and diversity of edible Orthopteran insect species in Baksa district, Assam [16-19]. Eades et al (2016) provided data on 27,260 species of Orthoptera fauna in the world, of which 1033 species were reported in India by Shishodia et al [20]. There is little scientific information about the presence of edible Orthoptera in the Baksa, Assam, India. The aims of future studies on this geographically important Orthoptera fauna basically need to focus on its ecological importance and, to gather the knowledge of orthopteran diversity in this region.

2. MATERIALS AND METHODS

Study area and location: The study area of the present study is Baksa district in Assam, India. The latitude and longitude of the study area is 26.6935° N, 91.5984°E. The Baksa district, Assam is one of the 27 districts in Assam of the north- eastern India. The total geographical area of the study area is 2400 square kms. The climate of the district is sub-tropical in nature with warm and humid summer. The winter temperature drops to 10^0C and summer temperature goes up to 35°C. This area is characterized by remarkable for the wealth and diversity of vegetation and flora. The diverse vegetation patterns and climatic condition might affect the diversity of edible insects in Assam.

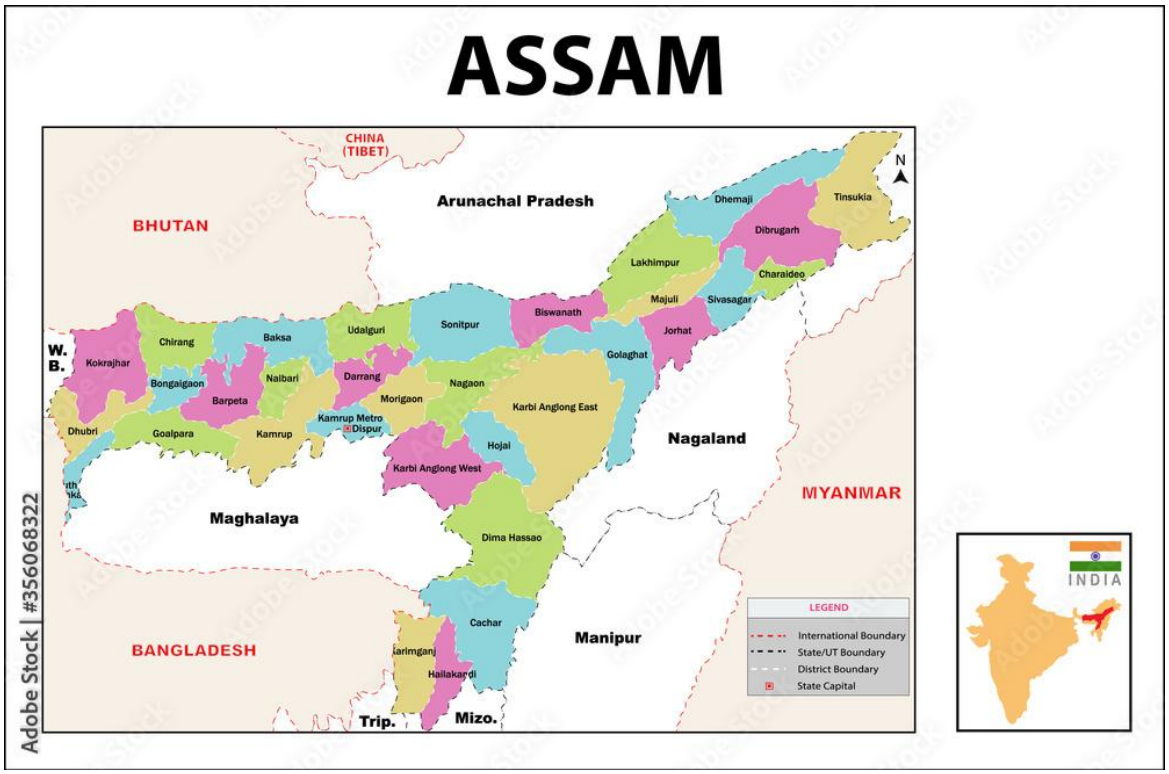

Fig. 1. Location map of study area, Assam, India

Sampling method for field survey: Extensive field survey on edible orthopteran insects was conducted during October 2011 to February 2014 and reassessed from March, 2021 to February, 2022 by performing interviews using questionnaire format. The most of the Orthopteran fauna were collected from the paddy field of study area. The specimens were directly collected by hand picking or sweeping insect net or by forceps over vegetation. The grasshopper and the house cricket can also be caught in early in the morning when they are less mobile due to their low body temperature. Moreover, the mole cricket and field crickets were dug out of holes by digging soil with the help of spade. The Sweep net was used for collecting grasshoppers and other insects which are insects hiding in low grass- or herb-dominated vegetation and in small shrubs. Sampling collection was executed from 6.00 a.m. to 9.00 a.m. After collection, insects were kept into a plastic jar that contained cotton soaked in ethyl acetate.

Identification: Collected edible insects were identified with the help of available literatures and books providing standard taxonomic keys, illustration, picture guide, and some species are identified following the works of Kirby, [21], Farooqi & Usmani,. [22]. Specimens were identified with data from Dirsh and Descamps [23].

Population survey: To get the population diversity of Orthoptera , the whole study area was divided in to three different habitats such as Agricultural Field Habitat (AFH), Forest/Backyard forest Habitat (FBH), Open Field/ Grazing Habitat (OFH). Four quadrates (sample plots) of 2 m X 2 m in size were applied to find out the diversity of edible insects in three different habitats.

Statistical analysis methods for insect diversity: Species diversity was determined following Shannon Wiener's Index [24,25]. Shannon-Weiner diversity index (H') was applied to find out whether any significant difference existed in the insect diversity between different habitats. Diversity indices were computed using Past3 software for data analysis of insect diversity. SHE analysis was used to test whether the data conform mostly to MacArthur's broken stick model using Estimates' (MacArthur and MacArthur 1961). The relative abundance data were used to calculate the equitability component of the species diversity.

Dominance: The Dominance value was calculated using Simpson's index:

$$D = \sum (\frac{ni}{N})$$

Where ni= important value for each component, and N= total of importance value.

Abundance: Total no. of individuals of the species in all sampling units/ Total no. of sampling units in which species occurred.

Diversity index: The diversity index was calculated using Shannon and Weaver index:

$$H = -\sum \frac{ni}{Nlog\ ni/N}$$

Where *ni*= important value for each component, and N= total of importance value.

Evenness: Evenness or equitability of species was calculated using Margalef's equation:

J= H / LnS

Where H= Shannon and Weaver diversity index, S= number of species.

3. RESULTS

Diversity of species: A total of 10 species of Orthoptera belonging to 4 families were identified from the study sites during the study period (Table 1). The edible Orthopteran found in the study area belongs to the families of Acrididae (short-horned grasshoppers), Tettigoniidae (long-horned grasshoppers and katydids), Gryllidae (true crickets), Out of these 10 species, five species belong to family Acrididae, two belong to family Tettigoniidae, two species belong to family Gryllidae and only 01 species belongs to family Gryllotalpidae. They are easily recognisable by their hind legs, which are usually enlarged for jumping. Species diversity is used to explain the variety of edible orthoptera insects in the study area.

Diversity analysis of edible Orthopteran insects: A total of 9868 numbers of individuals of Orthopteran edible insect were counted among the three different habitats (Table 2). The edible insect species with a total of 6868 number of individuals was recorded from agricultural field habitat, 462 number of edible insect was in forest and backyard forest habitat, 2538 number of insect was in open field habitat during the time of field observation. No common abundant species was found in a single habitat. Many species are common to two or three habitats during the study period. The Orthopteran species are widely distributed in different habitats such as Agricultural Field Habitat (AFH), Forest/Backyard forest Habitat (FBH), and Open Field Habitat (OFH). Orthopteran species found in the study area belong to the families of Acrididae (short-horned grasshoppers), Tettigoniidae (long-horned grasshoppers and katydids), Gryllidae (true crickets), Gryllotalpidae crickets). They are easily recognisable by their hind legs, which are usually enlarged for jumping. Most species of Acrididae (short-horned grasshoppers) family are predominant in paddy field and crop field and grasslands and they feed on grasses. Two species belonging to family Tettigoniidae (long horned grasshoppers) are found in the study area. The diet of long horned grasshoppers includes leaves, bark, and seeds, but many species are predatory, feeding on other insects, snails etc. There are two species belonging to Grillidae family which eat dried organic materials, fresh plant matter, small fruits, seeds, and dead insects. The only species in Gryllotalpidae family eaten in the study area is *Gryllotalpa africana* commonly called mole cricket. As a pest, it disturbs germinating seeds and damages the delicate young roots of seedlings.

Table 2 shows that out of the edible orthopteran insect species in selected habitats *Choroedocus robustus* has the highest relative abundance is (8.92%) followed by *Eupreponotus inflatus* (8.75%). The least relative abundant insect species amongst the edible orthopteran found in the study area is *Gryllotalpa africana*(4.22%).

The present study shows that species abundance was found to be the highest in *Chondracris rosea* with 17.64 and lowest in *Gryllotalpa africana* with 1.17 that in Agricultural Field Habitat. In Forest and Backyard habitat, the highest species abundance was found in *Acheta domestica* with 2.63 and lowest in *Choroedocus robustus* with 1.14. The highest species abundance in open forest habitat *was Gryllus bimaculatus* with 5.01and lowest was *Choroedocus robustus with* 1.48 (Table 3).

Table 1. List of Orthopteran edible insects with their seasonal availability in Assam

Scientific name	Order	Family	English name	Seasonal availability	Edible part
Gryllotalpa africana	Orthoptera	Gryllotalpidae	Mole cricket	Whole Year	Adult
Eupreponotus inflatus	Orthoptera	Acrididae	Short-Horned Grasshopper	May-Sep	Adult
Choroedocus robustus	Orthoptera	Acrididae	Short-Horned Grasshopper	June-Oct	Adult
Chondracris rosea	Orthoptera	Acrididae	Short horned Grasshopper	June-August	Adult
Heiroglyphus banian	Orthoptera	Acrididae	Grasshopper	June-Oct	Adult
Gryllus bimculatus	Orthoptera	Gryllidae	Field Cricket	May-Sept.	Adult
Oxya hyla hyla	Orthoptera	Acrididae	Short horned Grasshopper	April-September	Adult
Acheta domestica	Orthoptera	Gryllidae	House Cricket	May-Sept	Adult
Mecopoda elongate	Orthoptera	Tettigoniidae	Long horned grasshopper	May-Sept	Adult
Ruspolia baileyi	Orthoptera	Tettigoniidae	Bush cricket	June-Oct	Adult

Table 2. Relative abundance of edible orthopteran insect species from selected habitats

	Order	Family	Species	Relative abundance
1	Orthoptera	Gryllidae	*Acheta domestica*	5.82
		Acrididae	*Chondracris rosea*	7.45
		Acrididae	*Choroedocus robustus*	8.92
		Acrididae	*Eupreponotus inflatus*	8.75
		Gryllotalpidae	*Gryllotalpa africana*	4.22
		Gryllidae	*Gryllus bimaculatus*	7.96
		Acrididae	*Heiroglyphus banian*	8.83
		Tettigoniidae	*Mecopoda elongate*	4.35
		Acrididae	*Oxya hyla*	5.69
		Tettigoniidae	*Ruspolia baileyi*	5.55

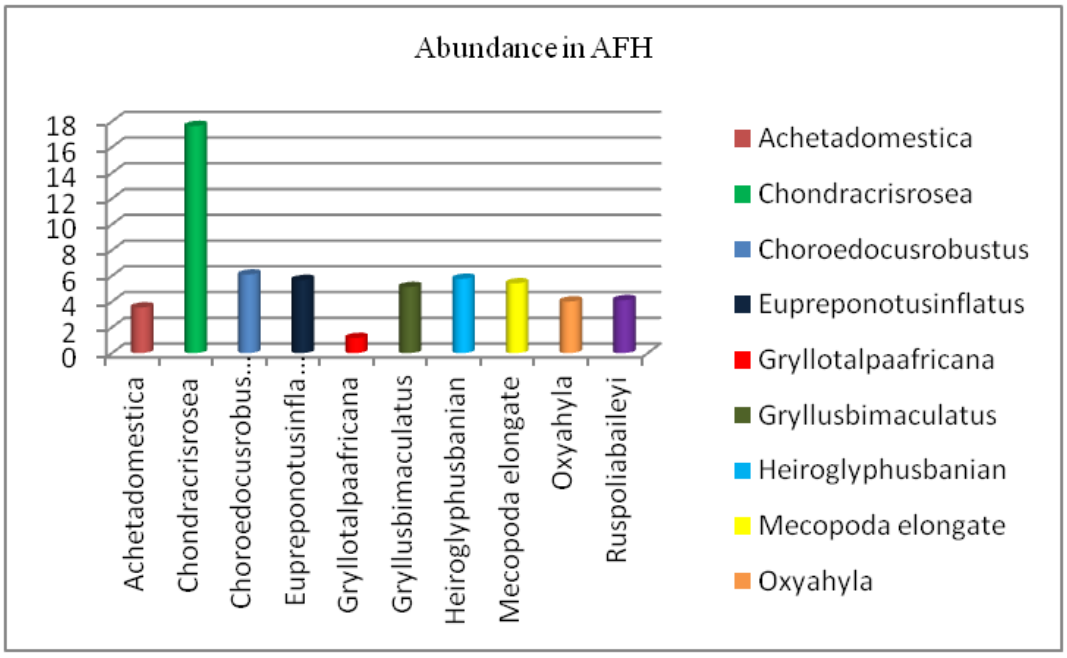

Fig. 2. Graphical representation of Orthopteran abundance in AFH

Table 3. Abundance of Orthopteran edible insect in different terrestrial habitats

Species	AFH	Quadrate Occurrence	Abundance	FBH	Quadrate Occurrence	Abundance	OFH	Quadrate Occurrence	Abundance
Acheta domestica	251	71	3.54	155	59	2.63	445	148	3.01
Chondracris rosea	988	56	17.64	24	11	2.18	76	44	1.73
Choroedocus robustus	1256	206	6.10	8	7	1.14	40	27	1.48
Eupreponotus inflatus	1205	212	5.68	0	0	0.00	73	32	2.28
Gryllotalpa africana	56	48	1.17	29	16	1.81	532	153	3.48
Gryllus bimaculatus	41	8	5.13	79	45	1.76	1043	208	5.01
Heiroglyphus banian	1224	212	5.77	0	0	0.00	66	21	3.14
Mecopoda elongate	602	111	5.42	4	3	1.33	29	13	2.23
Oxya hyla	678	169	4.01	76	34	2.24	77	29	2.66
Ruspolia baileyi	567	138	4.11	87	42	2.07	157	56	2.80

AFH: Agricultural Field Habitat FBH: Forest and Backyard habitat OFH: Open Field Habitat

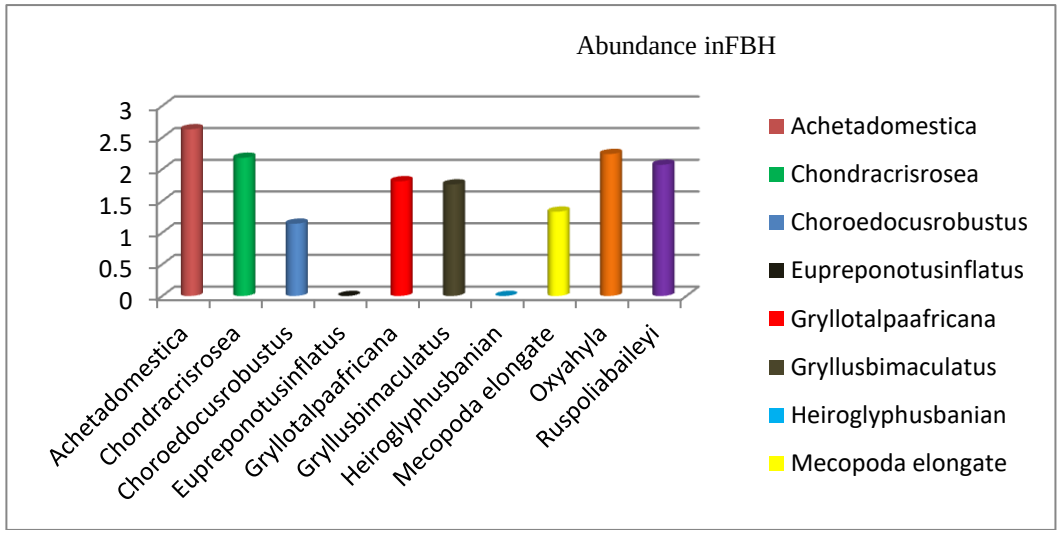

Fig. 3. Graphical representation of Orthopteran abundance in FBH

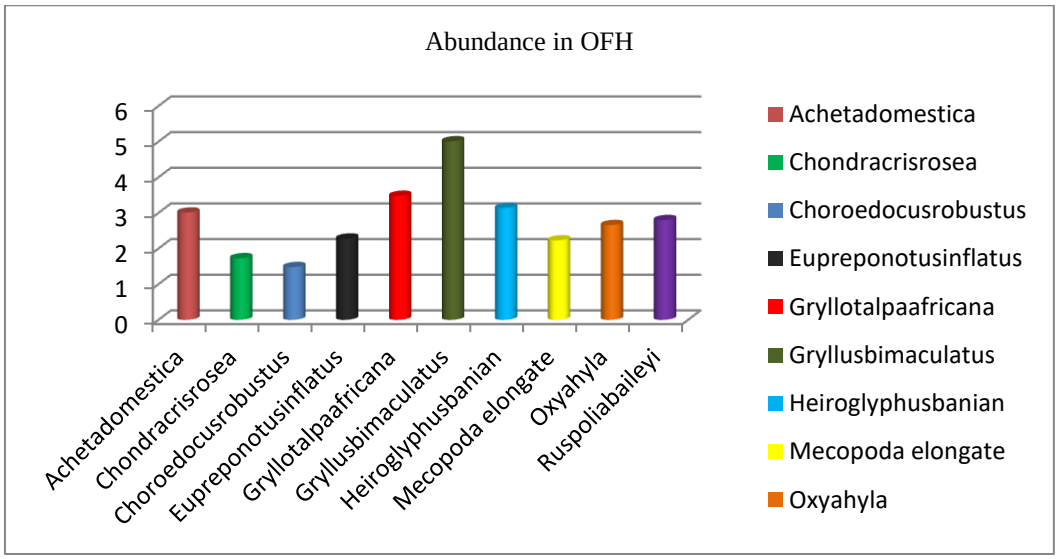

Fig. 4. Graphical representation of Orthopteran abundance in OFH

Relative abundance is the percentage composition of an organism of a particular kind relative to the total number of organisms in the area. Relative species abundance refers to how common or rare a species is relative to other species in a given location or community. Species diversity is a measurement of different number of species in an area and its abundance and the distribution of these species in that ecosystem.

"The most commonly used diversity indices used in ecology" are the Shannon [24] and Simpson (1949). "Simpson index is used to assess the dominance, but fails to provide an idea about species richness. Shannon-Wiener index is expected to determine both diversity characteristics, that is evenness and richness [26], but does not provide any information on the rare species which, however, are very important in studies of biodiversity".

The species-wise relative abundance of Orthopteran species are graphically represented in the Fig. 5. The species diversity generally consists of two components, namely species richness and species evenness. Species richness is computed by using Shannon's diversity index (H) and Simpsons's diversity index (λ) and it is represented in the Fig. 6. The Table 4 shows the relative abundance and diversity of edible orthopteran insect species. The Orthoptera insects have the highest relative abundance (67.54%) and a good diversity of Orthopteran species at Baksa, Assam. Shannon's diversity index was calculated as a measure of diversity within the habitat. The edible insects are predominantly available and most dominant in pre-monsoon and monsoon season.

4. DISCUSSION

The results presented in this study were based on a thorough survey of edible Orthoptera species in Baksa district, Assam. The Family Acrididae (5 species) was most dominant, followed by Tettigoniidae as well as Gryllidae (2 species each), and Gryllotalpidae belonging to 1 species collected from three different habitats.

The present study revealed that there were 10 Orthopteran species found in the study area out of which the species of the families of Acrididae (short-horned grasshoppers) are the highest in number in the study area. Similar study on diversity of Orthoptera was carried out by Senthilkumar, N. 2010 in which a total of 36 species of Orthoptera belonging to 30 genera, and four families was recorded from Kaziranga National Park. Koli et al (2010) studied reported 62 species belonging to 8 families of Orthoptera fauna in Chandoli National park. Whereas Akhtar et al. [27] had recorded 26 species of grasshoppers belonging to 2 families in Uttar Pradesh. Chara [28] reported 16 species belonging to 3 families of suborder Caelifera from three date palm groves in Ouargla (South Algeriz). The diversity and abundance of Orthopteran fauna of Gibbon wildlife sanctuary in Assam was recorded 25 species (Senthikumar et. al, 2006). The present study shows that

Table 4. Relative abundance and Diversity indices of edible insects of Orthoptera

Order	Relative Abundance	Dominance	Shannon_H	Evenness_e^H/S	Menhinick	Margalef	Equitability_J
Orthoptera	67.54	0.56	0.74	0.70	0.03	0.22	0.67

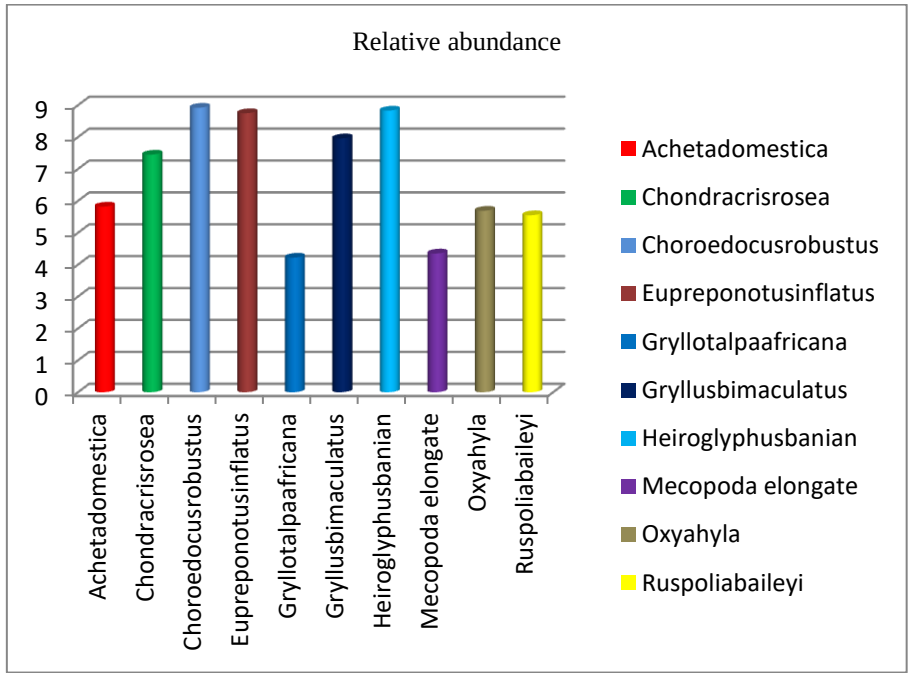

Fig. 5. Relative abundance of edible Orthopteran species

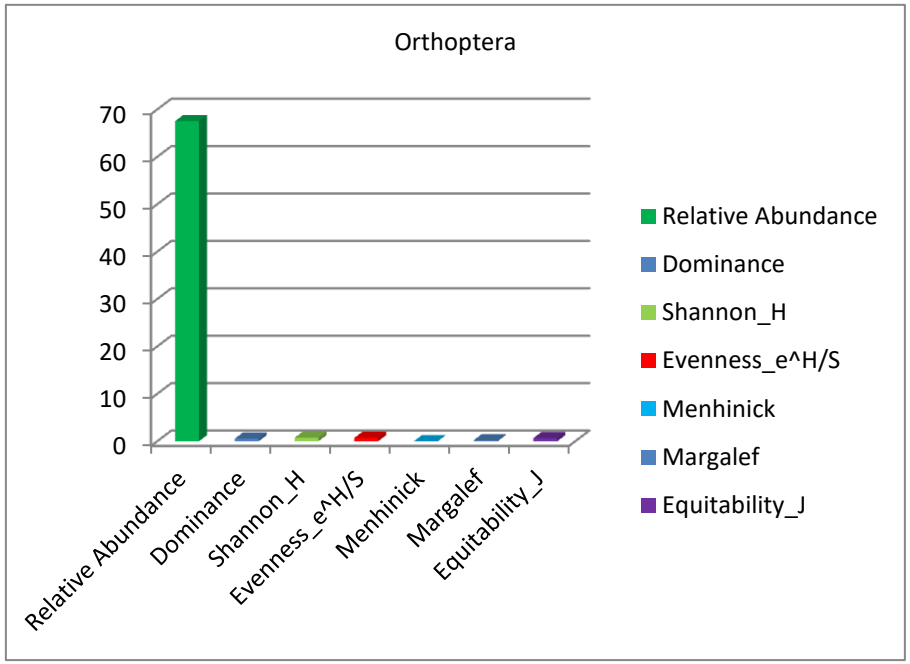

Fig. 6.Diversity Indices of edible Orthopteran insects

species abundance of Orthoptera was highest in *Chondracris rosea* with 17.64 in Agricultural Field Habitat. Agricultural field habitats are habitats that globally support high diversities of edible Orthoptera and other edible insects [29]. In Forest and Backyard habitat, the highest species abundance was in *Acheta domestica* with 2.63 and in Open forest habitat *Gryllus bimaculatus* was the highest abundant species with 5.1. The highest relative abundance is Choroedocus *robostus* belonging to order Orthoptera(8.92%). Similarly, a total no of 41 species of Orthopterans under five families was reported from Surguja district of Chhattisgarh [30]. A report on Orthoptera given by Eades et. al (2016) stated that 27,260 species of Orthoptera fauna were in the world, of which 1033 species were reported in India by Shisshodia et. al. (2010). Most of the grasshopper species attack at the juicy stage of our paddy and crops and destroy in the milky stage of our rice. Crickets attack Rabi and summer vegetables and damage vegetables. Mole cricket also attacks crops and winter vegetables in seedling stage. The present results also confirm this observation that edible orthopteran species are available during June to November and a few species are available in whole year. The rainfall may be an important factor increasing the diversity of grasshoppers during the rainy season [31]. The Baksa district is inhabited by many ethnic tribes including Bodo, Rabha , Sarania, Madahi and Adibasi with other non- tribal people. These tribes are often dependent on the nature and its resources for their livelihood. The agricultural fields are the easiest sites for collecting edible insects. The tribal communities collect insects along with their other agricultural activities. It is obvious that the forest habitat also holds most of the insects but they have very difficult to collect due to its dense vegetation. Orthopteran insects are cold-blooded organisms that require high ambient temperatures for most favourable growth and reproduction that is often interrelated with vegetation structure [32].

In the light of the above discussed facts, it can be inferred that Shannon-Weiner and Simpson diversities increases as richness increase for a given pattern of evenness, and increase as evenness increases for a given richness, but they do not always follow the same trend [33,34]. Simpson diversity is less susceptible to richness and more sensitive to evenness than Shannon index which in turn, is more receptive to evenness. It is evident from the study of Govindaraj et al., [35] that the upland forests provide refuges to highly mobile insects like grasshoppers when lowland sites have an impact on climatic fluctuations. They observed clear upward shifts in the elevational ranges of species, with the influence of global warming [35]. Grasshopper diversity was predicted to decrease significantly in higher altitude however; species richness is predicted to more towards higher altitudes [36]. It is evident from the study of Chen et al., [37] that tropical insect species have undertaken a shift towards higher altitudes, confirming the global reach of climate change impacts on biodiversity.

5. CONCLUSION

From the results of the present study, it can be concluded that Baksa, Assam is a rich place of the diversity of edible Orthopteran insects. Species diversity index, richness and evenness give us an idea about the variety and diversity of Orthopteran species in the study sites. The diets of grasshoppers and crickets in Orthoptera are still very common for tribal people in Assam Though insect eating is not much popularised in the world as a whole , but remains a significant source of food for tribal people in and around Assam, India. The most of the grasshoppers and crickets in Orthoptera are used as a popular food for ethnic tribal people in the study area. Natural habitat of Orthopteran species particularly grass biomass conservation is very important for the existence of Orthopteran insect species diversity. Moreover, the habit of eating such insects reduces pesticide problem in agricultural or crop field.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Cigliano MM, Braun H, Eades DC, Otte D. Orthoptera species File. Version 5.0/5.0; 2018.

2. Jamison BE, Robel RJ, Pontius JS, Applegate RD. Invertebrate biomass: associations with lesser prairie-chicken habitat use and sand sagebrush density in southwestern Kansas. Wildl Soc Bull. 2002:517-26.
3. Badenhausser I, Amouroux P, Lerin J, Bretagnolle V. Acridid (Orthoptera: Acrididae) abundance in Western European Grasslands: sampling methodology and temporal fluctuations. J Appl Entomol. 2009;133(9-10):720-32.
4. Thakkar B, Parmar S, Parikh P. Study on diversity of Orthoptera fauna in South Gujarat, India. Int J Pure Appl Zool. 2015; 2(4):368-74.
5. Ghosh S, Haldar P, Mandal DK. Evaluation of nutrient quality of a short horned grasshopper, Oxya hyla hyla Serville (Orthoptera: Acrididae) in search of new protein source. J Entomol Zool Stud. 2016;4(1):193-7.
6. Abusarhan M, Amr ZS, Ghattas M, Handal EN, Qumsiyeh MB. Grasshoppers and locusts (Orthoptera: Caelifera) from the Palestinian territories at the Palestine Museum of Natural History. Zool Ecol. 2017;27(2):143-55.
7. Arya MK, Joshi PC, Badoni VP. Studies on taxonomy, distribution, ecology and behaviour of grasshoppers (Insecta: Orthoptera) in Nanda Devi Biosphere Reserve, Western Himalayas, India. InBiological Forum. 2015;7(2):591-598. Research Trend.
8. Chandra K, Gupta SK. A checklist of Orthoptera from Madhya Pradesh and Chatttisgarh; 2007.
9. Chandra K, Gupta SK, Shoshodia MS. A checklist of Orthoptera (Insecta) of India. Zoological survey of India (M.P). India. 2010;1-57.
10. Gupta SK, Chandra K. Diversity of Orthoptera (Insecta) fauna of Achanakmar Wildlife Sanctuary, Bilaspur, Chhattisgarh, India. J Asia Pac Biodivers. 2017;10(1):91-103.
11. Hochkirch A, Nieto A, Criado MG, Cálix M, Braud Y, Buzzetti FM et al. European red list of grasshoppers, crickets and bush-crickets; 2016.
12. Hussain M, Akbar R, Malik MF, Kazam SN, Zainab T. Diversity, distribution and seasonal variations of grasshopper populations in Sialkot, Punjab, Pakistan. Pure Appl Biol. 2017;6(4):1372-81.
13. Kumar, Hirdes H, Usmani MK. Adv Life Sci. A Checklist of Acrididae (Orthoptera: Acridoidea) of Himachal Pradesh. 2012;1(2):162-3.
14. Kumar H, Usmani MK. Taxonomic studies on Acrididae (Orthoptera: Acridoidea) from Rajasthan (India). J Entomol Zool Stud. 2014;2(3):131-46.
15. Das JK. Variations of protein content of orthopteran edible insects consumed by tribal people in baksa of Assam, India. Journal of Emerging Technologies and Innovative Research. 2018;5(12).
16. Latchininsky A, Sword G, Sergeev M, Cigliano MM, Lecoq M. Locusts and grasshoppers: behavior, ecology, and biogeography. Psyche J Entomol. 2011; 2011:1-4.
17. McEwen LC. Function of insectivorous birds in a shortgrass. IPM Syst. 1987:324-33.
18. Samejo AA, Sultana R, Khatri I. Incidence of the desert locust Schistocerca gregaria (Forskål, 1775) (Cyrtacanthacridinae: Acrididae: Orthoptera) in the Thar Desert, Sindh (Pakistan). Arq Entomoloxicos. 2016;15:85-9.
19. Senthilkumar N, Barthakur D. Nizara and Borab, N.J.. Orthopteran fauna of the Gibbon wildlife sanctuary Assam. Zoos Print J. 2006;21(8):2347-9.
20. Shishodia MS, Chandra K, Gupta SK. An annotated checklist of Orthoptera (Insecta) from India. Zoological Survey of India; 2010.
21. Kirby WF. The Fauna of British India, including Ceylon and Burma. Orthoptera (Acrididae). The fauna of British India, including Ceylon and Burma. Orthoptera (Acrididae); 1914.
22. Farooqi MK, Usmani MK. Review of genus Conocephalus Thunberg, 1815 (Orthoptera: Tettigoniidae: Conocephalinae) with one new species from India. Zootaxa. 2018;4461(3):381-398.
23. Dirsh VM, Descamps M. Insectes Orthopteres Acridoidea Pyrgomorphidae et Acrididae. Institut de recherche scientifique; 1968.
24. Shannon CE, Weaver W. The mathematical theory of communication. Urbana: University of Illinois Press; 1963.
25. Ludwig JA, QUARTET L, Reynolds JF, Reynolds JF. Statistical ecology: a primer in methods and computing (Vol. 1). John Wiley & Sons; 1988.

26. Melo AS. What do we win'confounding'species richness and evenness in a diversity index?. Biota Neotropica. 2008;8(3).
27. Akhtar H, Usmani K, Nayeem R, Kumar H. Species Diversity and abundance of Grasshopper fauna (Orthoptera) in rice ecosystem. Annals of Biological Research. 2012;3(5):2190-2193.
28. Chara M. Contribution à l'étude des Orthoptères dans une région saharienne (Cas de la région d'Ouargla). Mém. Más. acad. Ouargla: Universidad KasdiMerbah, Algérie. 2017;104 p.
29. Van Huis A, Van Itterbeeck J, Klunder H, Mertens E, Halloran A, Muir G et al. Edible insects: future prospects for food and feed security. Food and agriculture organization of the United Nations. 2013; 171.
30. Gupta SK. Records of Orthoptera (Insecta) fauna from Surguja District, Chhattisgarh, India. J Entomol Zool Stud. 2016;4(2):258-63.
31. Joern A. Variation in grasshopper (Acrididae) densities in response to fire frequency and bison grazing in tallgrass prairie. Environ Entomol. 2004;33(6): 1617-25.
32. Poniatowski D, Fartmann T. The classification of insect communities: lessons from orthopteran assemblages of semi-dry calcareous grasslands in central Germany. Eur J Entomol. 2008;105(4): 659-71.
33. Senthilkumar N. Orthopteroids in Kaziranga national park, Assam, India. J Threat Taxa. 2010;2(10): 1227-31.
34. Ullah M. Investigations on rangeland grasshoppers: Ecoregion level distribution, identification, feeding performance, and vegetation clipping; 2012.
35. Govindaraj D, Senthikumar N, Periyasamy SS. Altitudinal gradients and species richness: A study on diversity of Orthoptera in Nilgiris Shola Forests and Grasslands. Rec Zool Surv India. 2022;121(4):465-72.
36. Maes D, Titeux N, Hortal J, Anselin A, Decleer K, De Knijf G et al. Predicted insect diversity declines under climate change in an already impoverished region. J Insect Conserv. 2010;14(5):485-98.
37. Chen IC, Shiu HJ, Benedick S, Holloway JD, Chey VK, Barlow HS et al. Elevation increases in moth assemblages over 42 years on a tropical mountain. Proc Natl Acad Sci U S A. 2009;106(5): 1479-83.

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