

Original Research Article

Diversity and abundance of edible Orthopteran insects consumed by tribal people in Baksa district, Assam, India

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 are 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 has incredible prospects in food security. According to recommendation of WHO, the edible Orthopteran species can be an alternative source of nutritious food to combat malnutrition for human consumption. The diversity and abundance of edible Orthopteran insects were first time studied and analysed in three different habitats in Baksa district Assam. Insects were caught by hands, forceps, and by the ordinary aerial insect nets etc. 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). 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: abundance, alternative, diversity, malnutrition, ethnic, orthopteran

Comment [AC1]: Include the type of sampling and the experimental design used. Describe more the methodology and the variables evaluated.

Comment [AC2]: This is methodology, it is necessary to present in a general way the impact at the biological, agronomic level and for the communities of the results found.

Comment [AC3]: It is recommended to include words other than those in the title.

I. INTRODUCTION

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 (Cigliano et al. 2018). Orthoptera are essential elements in trophic food webs as they represent first order consumers in grassland ecosystems (Jamison et al. 2002). 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 (Badenhausser et al. 2009). 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 (Thakkar et al. 2015). Orthoptera fauna are one of the most important invertebrate groups for environmental monitoring and assessment (Jamison et al. 2002). These insects' needs 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 (Ghosh et al., 2016). Tribal people in Assam including a few non-tribal people accept insects as food for their high nutritional value. Out of all modes of consumption, frying is the most popular mode of consumption of orthopteran insects. Grasshoppers and locusts in the order Orthoptera are one of the most diverse and ecologically important insects found in the grassland habitat (Latchininsky et al., 2011). Grasshoppers cause significant damage to tree seedlings and agricultural crops. Grasshoppers are considered agricultural pests because they feed on crops and their continual chewing on plant parts ruins harvests. Mole crickets and crickets are major pests of vegetables in lawns. Orthoptera are mostly associated with open-area vegetation such as agricultural fields and savannas (Capinera et al. 2004). Because of its importance, the present study has been designed to investigate the abundance and diversity of edible Orthopteran species in Baksa district, Assam.

II. MATERIALS AND METHODS:

A. 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 °C and summer

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Comment [AC4]: In the introduction it is suggested that the problem definition and justification present recent quantitative data. General Orthopteran information may be more up-to-date. Background studies on the research topic in the international, national and regional context should be included. The last lines of the introduction should present the impact of the research.

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temperature goes up to 35⁰ 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.

Comment [AC5]: Figures must be related in the text.



Figure.-1: Location Map of study area. Assam, India.

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B.Sampling method for field Survey:Extensive field survey on edible orthopteran insects was conducted from October 2011 to February 2014 and after five years gap only Orthopteran insects in the studyb ~~area~~ ~~are~~ ~~area~~ ~~are~~ conducted from October, 2020 to March 2022 by performing interviews using questionnaire format. A questionnaire was developed with questions like what type of edible Orthopterans people consumed their local names, seasons of their availability, mode of consumptions etc.
The specimens were directly collected by hand pickingor 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. 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.

Comment [AC6]: Include the type of sampling used and the experimental design.

C. **Identification:** Collected edible insects were identified on spot with the help of available literatures and books providing standard taxonomic keys, illustration, picture guide, and internet. A few specimens were identified by entomologist, Department of Zoology, Gauhati University, Guwahati, Assam. Some insects were identified in the ZSI, Shillong, N.E, India.

Comment [AC7]: Include the bibliographical references of the texts used to obtain the taxonomic keys.

D. **Population Survey:** To get the population diversity, 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. CITES.

E. **Statistical analysis methods for insect diversity:** Species diversity was determined following Shannon Wiener's Index (Shannon and Weaver, 1963, Ludwig and Reynolds, 1988). 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).

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

$$D = \sum \left(\frac{n_i}{N} \right)^2$$

Where n_i = 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:

$$H = - \sum \frac{n_i}{N} \log \frac{n_i}{N}$$

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

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

$$J = H / \ln S$$

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

III. RESULT AND DISCUSSION:

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. A total of 36 species of orthoptera belonging to 30 genera, and four families was recorded from Kaziranga National Park during the survey period (Senthilkumar, N. 2010).

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

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Scientific name	Order	Family	English name	Seasonal availability	Edible part
<i>Gryllotalpa africana</i>	Orthoptera	Gryllotalpidae	Mole cricket	Whole Year	Adult
<i>Eupreponotus inflatus</i>	Orthoptera	Acrididae	Short-Horned Grasshopper	May-Sep	Adult
<i>Choroedocus robustus</i>	Orthoptera	Acrididae	Short-Horned Grasshopper	June-Oct	Adult
<i>Chondracris rosea</i>	Orthoptera	Acrididae	Short horned Grasshopper	June-August	Adult
<i>Heiroglyphus</i>	Orthoptera	Acrididae	Grasshopper	June-Oct	Adult

<i>banian</i>					
<i>Gryllus bimaculatus</i>	Orthoptera	Gryllidae	Field Cricket	May-Sept.	Adult
<i>Oxya hyla hyla</i>	Orthoptera	Acrididae	Short horned Grasshopper	April-September	Adult
<i>Acheta domestica</i>	Orthoptera	Gryllidae	House Cricket	May-Sept	Adult
<i>Mecopoda elongate</i>	Orthoptera	Tettigoniidae	Long horned grasshopper	May-Sept	Adult
<i>Ruspoliabaileyi</i>	Orthoptera	Tettigoniidae	Bush cricket	June-Oct	Adult

3.2-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 No-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 ~~Aerididae~~ 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~~ 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: Abundance of Orthopteran edible insect in different terrestrial habitats.

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Species	AFH	Quadrat Occurance	Abundance	FBH	Quadrat Occurance	Abundance	OFH	Quadrat Occurance	Abundance
<i>Achetadomestica</i>	251	71	3.54	155	59	2.63	445	148	3.01
<i>Chondracrisrosea</i>	988	56	17.64	24	11	2.18	76	44	1.73
<i>Choroedocusrobustus</i>	1256	206	6.10	8	7	1.14	40	27	1.48
<i>Eupreponotusinflatus</i>	1205	212	5.68	0	0	0.00	73	32	2.28
<i>Gryllotalpaaficana</i>	56	48	1.17	29	16	1.81	532	153	3.48
<i>Gryllusbimaculatus</i>	41	8	5.13	79	45	1.76	1043	208	5.01
<i>Heiroglyphusbanian</i>	1224	212	5.77	0	0	0.00	66	21	3.14
<i>Mecopoda elongate</i>	602	111	5.42	4	3	1.33	29	13	2.23
<i>Oxyahyla</i>	678	169	4.01	76	34	2.24	77	29	2.66
<i>Ruspolibaileyi</i>	567	138	4.11	87	42	2.07	157	56	2.80

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AFH:Agricultural Field Habitat

FBH:Forest and Backyard habitat

OFH: Open Field Habitat

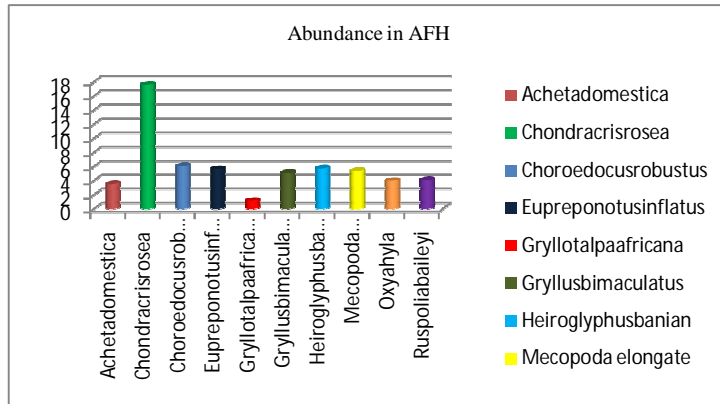


Fig.2: Graphical representation of Orthopteran abundance in AFH

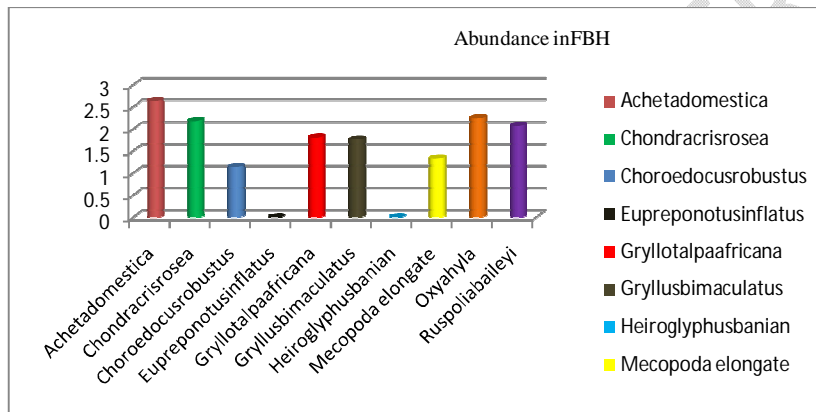


Fig.3: Graphical representation of Orthopteran abundance in FBH

Comment [AC9]: Do not present single figures, they must be preceded by the text that explains their content. All figures must be explained.

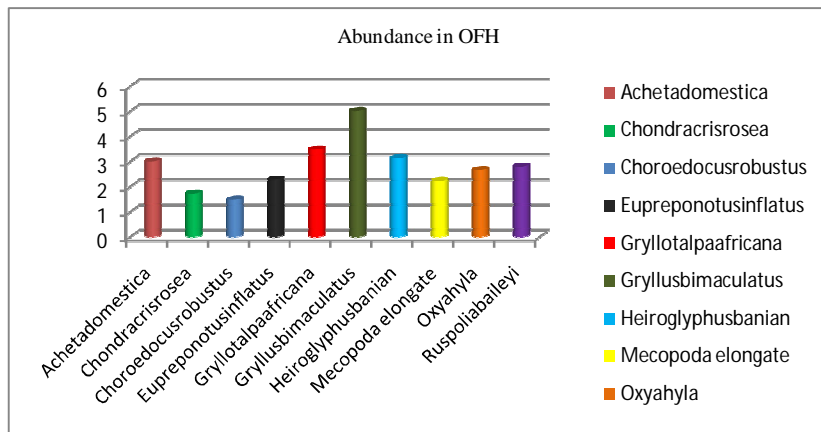


Fig. 4: Graphical representation of Orthopteran abundance in OFH.

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.

Table-3: 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

The most commonly used diversity indices used in ecology are the Shannon (1948) 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 (Melo, 2008), but does not provide any information on the rare species which, however, are very important in studies of biodiversity.

Comment [AC10]: Here a concept is presented but the results are not shown or discussed.

Comment [AC11]: The tables must be related in the text.

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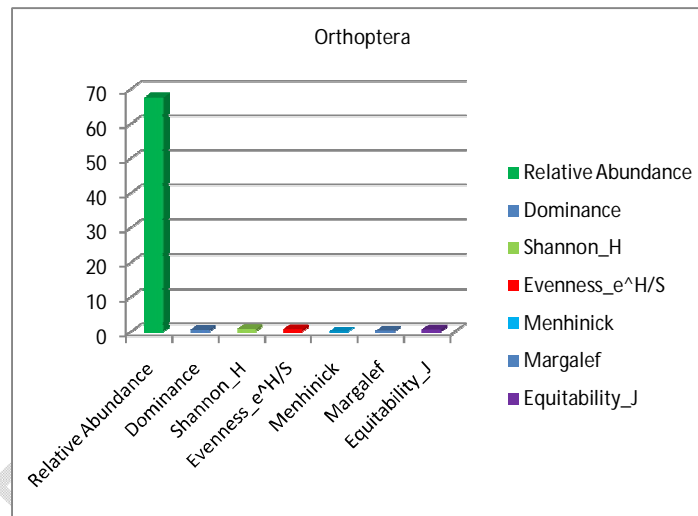
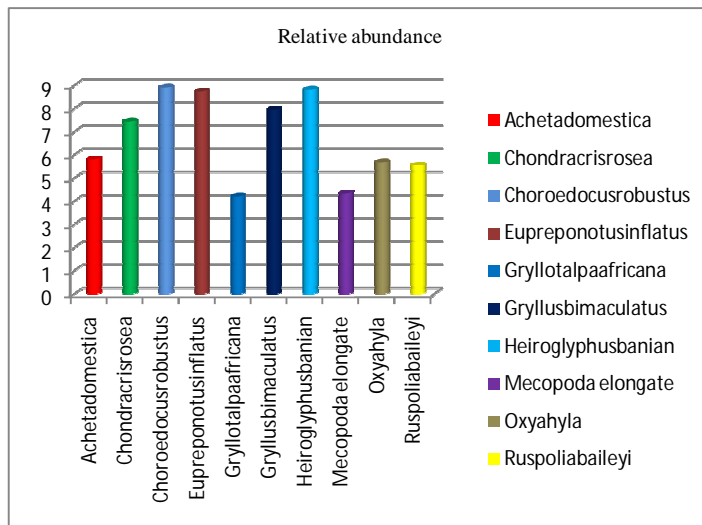


Figure-5: Relative abundance of edible Orthopteran species

Figure-6: Diversity Indices of edible Orthopteran insects

Comment [AC12]: The figures should be related in the text and discussed and analyzed.

The species-wise relative abundance of Orthopteran species are graphically represented in the figure-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 figure- 6. The table-3 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. The recorded data revealed that, a total of 10 species of edible Orthopteran insects was found in Baksa, Assam. Shishodia and Gupta (2009) recorded 165 species of grasshoppers under 16 families in Himachal Pradesh. Koli et al (2010) studied reported 62 species belonging to 8 families of Orthoptera fauna in Chandoli National park. Whereas Akhtar et. al (2012) had recorded 26 species of grasshoppers belonging to 2 families in Uttar Pradesh. Chara (2017) 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 species abundance of Orthoptera was highest in *Chondracris rosea* with 17.64 in Agricultural Field Habitat. 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 robustus* 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 (Gupta, 2016). 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 Shishshodia 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 (Joern, 2004). The Baksa district is inhabited by many ethnic tribes including Bodo, Rabha, Sarania, Madahi and Adivasi with other non-tribal people. These tribes are often dependent on the nature and its resources for their livelihood.

In the light of the above discussed facts, it can be inferred that Shannon-Weiner and Simpson diversities increase as richness increases for a given pattern of evenness, and increase as evenness increases for a given richness, but they do not always follow the same trend. Simpson diversity is less susceptible to richness and more sensitive to evenness than Shannon index which in turn, is more receptive to evenness. According to Akhtar (2012) grasshopper species presented variations in seasonal abundance.

IV. 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. The Orthopteran species are widely distributed in different habitats with significant economic importance. The edible insect species with a total of 6868 number of individuals of Orthoptera insects were recorded from agricultural field habitat, 462 number of edible insect was in forest and backyard forest habitat, 2538

Comment [AC13]: The decimal pattern is not homogeneous throughout the document.

Comment [AC14]: The results and the discussion are very descriptive, it is suggested to make a deeper analysis including other aspects such as biological, agronomic and/or cultural.

Comment [AC15]: It is suggested to complement the results and the discussion with photos of the insects identified in the study area.

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number of insect was in open field habitat during the time of field observation. Species diversity index, richness and its dominance and abundance give us an idea about the variety and diversity of Orthopteranspecies in the study sites.

Comment [AC16]: The conclusions should show more the impact of the research than be a abstract of the main results.

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Comment [AC17]: Revise the citation pattern so that it is homogeneous and in some topics you can have more current references.

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