Diversity of edible insects consumed by ethnic tribes in Baksa District of Assam, India

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***Abstract*: Biodiversity refers to the variety of life and its processes, including the variety of living organisms. Species diversity is the number of different species in a particular ecosystem or on Earth. The number of species that live in a certain location is called species richness. Study reveals that 30 no of species of edible insects are consumed by ethnic tribes in the study area. Out of 30 edible insects consumed, Orthopterans order shared with maximum number of 10 species followed by Hymenoptera of 6 species, Coleopteran of 5 species then Hemipterans by 3 species and Lepidoptera by 2 species and then Odonota, Mantodea, Blattollidea and Isopteran by 1 species respectively. The various tribes choose the edible insects on the basis of their traditional belief, taste and regional and seasonal availability. Calculating Shannon's index of diversity in four different sampling habitats, shows that, the highest diversity of edible insects found in Open field ((H'=2.563) followed by Agricultural Field (H'= 2.442) then Forest/Backyard habitat (H'=2.45) and the least diversity found in Swampy Area (H'=1.329). Diversity of edible insects plays an important role in the creation of a sustainable global food economy as well as food security. The present study investigates to assess diversity of the edible insect consumed by ethnic people of Baksa, Assam.**

***Keywords*: Diversity, Ethnic, Livelihood, Nutritional, Sustainable**

Introduction: Insects are the most diverse and abundant form of life and organize a main component of the total faunal biodiversity on earth. Species diversity is the number of different species that are represented in a given community. Species diversity of insects is a good criterion for judging the health of an ecosystem. Many insects have traditionally been used as food of tribal people in and around India since ancient time. Diversity and abundance of edible insect species are significantly different in different locations Most of the insects found in the Study area are edible that provide food and livelihood to the ethnic people in the study area. As per scientific literature, there are 1.4 million species of insects that are an intrinsic part of the Earth's ecosystem (Kulshrestha and Jain, 2016). A recent data reveals that 2141 different species are consumed by the people of all over the world (Mitsuhashi, 2016). Insects influence not only by their immense species richness but also by their variety of life forms and their role in energy flow (Tiple and Khurad, 2009).

It has been recorded that over 2 billion people eat insects on a regular basis (Van Huis *et al.*, 2013). In recent years edible insects have been projected as a potential 'new' protein source in order to combat nutritious food crisis in the world. Currently, 324 species of edible insects from 11 orders were documented in China, which include the common edible species. Out of these, the nutritional values of 174 species including edible, feed and medicinal species are reported in China (Feng *et al.*, 2017). In the book of Li Shizhen's Compendium of Materia Medica, which is one of the largest on Chinese medicine (1368-1644) listed approximately 300 medicinal insect species (distributed in 70 genera, 63 families and 14 orders) that have been used as entomotherapy (Jung, 2016). The study of diversity of insects consumed by the people in Dhemaji District, Assam revealed that a total of 14 species of insects were used as food (Doley and Kalita, 2011). Information on diversity of edible insects is very important in order to understand whether the edible insects are available and sustainable in the study area. Therefore, there lies the significance of diversity study of edible insects. The present investigation is undertaken with the following objectives.

- To explore and document the insects consumed by different ethnic people in the study area.
- To find out the diversity and abundance of edible insects in the study area.

2. MATERIALS AND METHODS (Research Elaborations):

2.1 Study area:

The study area of the present study is 'Baksa Distrct', Assam, India. The latitude and longitude of the study area is 26.6935° N, 91.5984° E. Baksa District is located in the foothills of Bhutan and northern part of Brahmaputra flood plain (26º 32' -26º 40' N, 90º 56'- 91º 43'E). The total geographical area of the study area is 2400 square Kms.

Fig-1: The study area Baksa District in the map of Assam.

2.2: Collection method of insects:

The edible insect diversity of Baksa district, Assam is done mainly based on the personal interview of the inhabitants in the study area. The questionnaire survey was conducted from February, 2013 to January, 2014 mainly during the early morning between 6.00 am to 08.00 am. Terrestrial edible insects were collected using entomological nets, beating tray, water traps, digging and handpicked. Most of the aquatic insects were trapped through local traditional equipment like Jakoi, Saloni etc. and also hand-picked from the different aquatic habitats.

2.3 Identification of edible insects:

The edible insect specimen were identified and classified with valid taxonomic key. Collected edible insects were identified on spot with the help of available literatures and books providing standard taxonomic keys, illustration, picture guide, and internet. Some insects were identified in the ZSI, Shillong, N.E, India. Insects were preserved with standard methods (Ghosh and Sengupta, 1982).

2.4: Statistical methods used in Population Survey:

To get the population diversity, the whole study area was divided in to four different habitats such as Agricultural Field Habitat (AFH), Forest/Backyard forest Habitat (FBH);Swampy and Aquatic Habitat (SAH) and Grazing land habitat or Open Field 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 four different habitats such as Agricultural field, Forest/backyard forest, Swampy areas and in Open field habitat in each season. In each sample plot, different collection techniques viz. Hand picking, light trap and sweep net capture were employed to collect edible insects.

2.5: Data Analysis of Insect Diversity

Diversity indices were computed using Past 3 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). Species diversity was determined following Shannon Wiener's Index (Shannon and Weaver, 1963). 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.

3. Results or Findings:

During survey, a total of 30 species of edible insect belonging to 18 families and 9 orders were recorded from local inhabitants. Out of these 30 species, Orthopterans order shared with maximum number of 10 species followed by Hymenoptera of 6 species and Coleoptera of 5, Hemiptera of 3, Lepidoptera by 2 species and then 1 species each from Odonota, Mantodea, Blattodea and Isopteran respectively. Table -1 shows the diversity of edible insects consumed by the ethnic people in Baksa.

Table-1: Taxonomy of edible insects in Baksa District

Sl. No.	Scientific name	Order	Family	English name	Edible part	Mode of eating
1	*Vespa affinis*	Hymenoptera	Vespidae	Potter wasp	Eggs &Larvae	Raw, Roasted, fried,
2	*Polistis olivaceus*	Hymenoptera	Vespidae	Paper wasp	Eggs &Larvae	Raw, Fried, smoked
3	*Parapolybia varia*	Hymenoptera	Vespidae	Lesser paper wasp	Larvae	Fried, raw
4	*Oecophylla smaragdina*	Hymenoptera	Formicidae	Weaver ant	Eggs	Raw,Fried,
5	*Lethocerus indicus*	Hemiptera	Belostomatidae	Giant Water bug	Adult	Fried or Smoked
6	*Laccotrephes ruber*	Hemiptera	Nepidae	Water scorpion	Adult	Fried or Smoked
7	*Hydrophilus olivaceus*	Coleoptera	Hydrophilidae	Water Scavenger	Larvae and Adult	Fried or Curry
8	*Gryllotalpa africana*	Orthoptera	Gryllotalpidae	Mole cricket	Adult	Fried or smoked
9	*Eupreponotus inflatus*	Orthoptera	Acrididae	Short-Horned Grasshopper	Adult	Fried or smoke
10	*Choroedocusrobustus*	Orthoptera	Acrididae	Short-Horned Grasshopper	Adult	Fried
11	*Chondracrisrosea*	Orthoptera	Acrididae	Short horned Grasshopper	Adult	Fried
12	*Heiroglyphusbanian*	Orthoptera	Acrididae	Grasshopper	Adult	Fried, smoked
13	*Gryllusbimculatus*	Orthoptera	Gryllidae	Field Cricket	Adult	Fried, smoked
14	*Oxya hyla hyla*	Orthoptera	Acrididae	Short horned Grasshopper	Adult	Fried, smoked
15	*Mantis religiosa*	Mantodea	Mantidae	Praying mantis	Adult	Fried, smoked
16	*Periplaneta americana*	Blattodea	Blattellidae	Cockroach	Adult	Fried
17	*Acheta domestica*	Orthoptera	Gryllidae	House Cricket	Adult	Fried, smoked
18	*Eretes stictus*	Coleoptera	Dytiscidae	Larva of diving bettle	larvae	fried
19	*Phyllophaga spp.*	Coleoptera	Scarabaeidae	June beetle	Adult	fried
20	*Ictinogomphus rapax*	Odonota	Gomphidae	Dragon fly	Nymph	Fried
21	*Mecopoda elongate*	Orthoptera	Tettigoniidae	Long horned grasshopper	Adult	Roasted orfried
22	*Ruspolia baileyi*	Orthoptera	Tettigoniidae	Nsenene	Adult	Fried, smoked
23	*Orycetes rhinoceros*	Coleoptera	Scarabaeidae	Rhinoceros beetle	Larvae(Grubs)	fried
24	*Philosamia ricini*	Lepidoptera	Saturnidae	Erisilkworm	Larvae, pupae	fried
25	*Anthera assama*	Lepidoptera	Saturnidae	Muga silkworm	Larvae, pupae	Fried
26	*Apisindica*	Hymenoptera	Apidae	Indian honey bee	Egg& larvae	Raw
27	*Apis dorsata*	Hymenoptera	Apidae	Rock bee	Egg& larvae	Raw
28	*Plectroderma scalator*	Coleoptera	Cerambycidae	Wood borer	Larvae	Fried
29	*Diplonychu srusticus*	Hemiptera	Belostomatidae	Water beetle	Adult	Fried or curry
30	*Microtermes obesi*	Isoptera	Termitidae	Termite	Larvae, Adult	Fried

For the population survey, only wild species belonging to 7 orders were considered for statistical analysis.

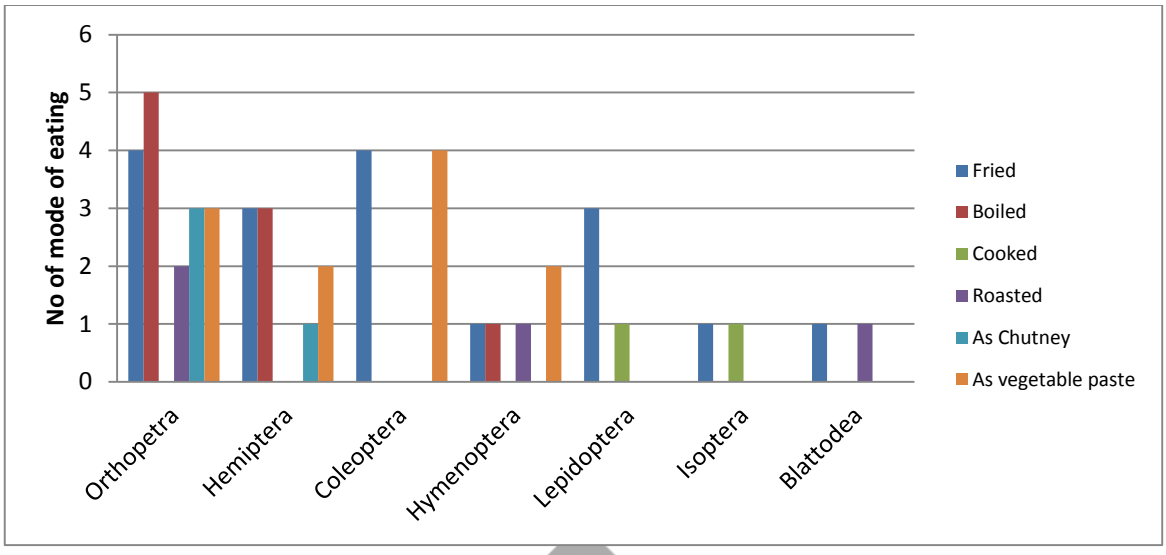


Fig-2 Mode of Insect consumption (Order-wise) in the Study Area

Table -2 shows the density of edible insects in four different habitats during the field study.

Table 2: Density of edible insects in different habitats in the study area.

Species	Density in AFH	Density in FBH	Density in SAH	Density in OFH
Eretes stictus	0.20	0	0.56	0
Hydrophilus olivaceus	0.98	0.02	4.32	1.78
Orycetes rhinoceros	0.31	0.09	0	0.19
Phyllophaga spp.	0.14	0.36	0	0.33
Plectroderma scalator	0.06	0.20	0	0.02
Diplonychus rusticus	0.05	0.02	0.41	0
Laccotrephes ruber	0.11	0.01	1.18	0.02
Lethocerus indicus	0.27	0.03	3.13	0.12
Apis dorsata	0	0.51	0	0.13
Parapolybia varia	0.06	0.40	0	0.16
Polistis olivaceus	0.20	0.88	0	0.20
Vespa affinis	0.02	0.82	0	0.01
Antheraassama	0.01	0.03	0	0.41
Mantis religiosa	0.52	0.13	0	0.34
Ictinogomphus rapax	0.98	0.26	0.11	0.85
Acheta domestica	1.16	0.72	0	2.06
Chondracris rosea	4.57	0.11	0	0.35
Choroedocus robustus	5.81	0.04	0	0.19
Eupreponotus inflatus	5.58	0	0	0.34
Gryllotalpa africana	0.26	0.13	0	2.46
Gryllusbimaculatus	0.19	0.37	0	4.83
Heiroglyphusbanian	5.67	0	0	0.31
Mecopoda elongate	2.79	0.02	0	0.13
Oxyahyla	3.14	0.35	0	0.36
Ruspoliabaileyi	2.63	0.40	0	0.73

Fig. - 3 shows the SHE analysis plot that predicts average species abundance and distribution indicates that the species richness and diversity will tend to increase but the evenness will remain constant.

Relative Abundance:

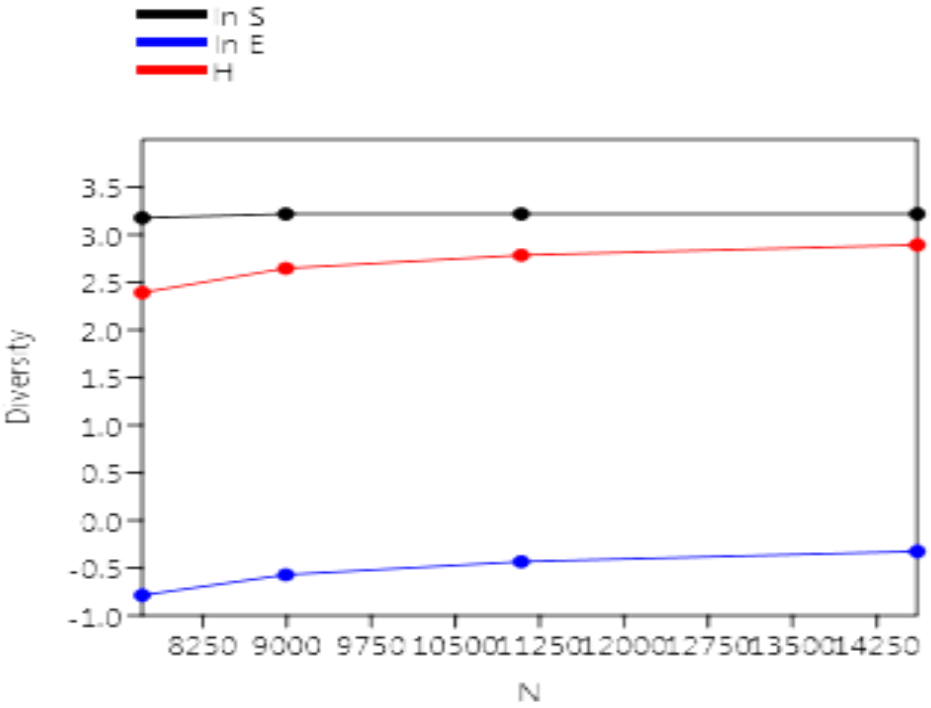


Fig-3: SHE analysis showing the average speccies abundant distribution of edible insects.

Table-3: Relative abundance of edible insect species (species-wise).

Order	Family	Species	Relative abundance
Coleoptera	Dytiscidae	*Eretesstictus*	1.13
	Hydrophilidae	*Hydrophilusolivaceus*	10.50
	Scarabaeidae	*Orycetes rhinoceros*	0.88
	Scarabaeidae	*Phyllophaga spp.*	1.24
	Cerambycidae	*Plectrodermascalator*	0.42
Hemiptera	Belostomatidae	*Diplonychusrusticus*	0.71
	Nepidae	*Laccotrephesruber*	1.96
	Belostomatidae	*Lethocerusindicus*	5.23
Hymenoptera	Apidae	*Apisdorsata*	0.94
	Vespidae	*Parapolybiavaria*	0.92
	Vespidae	*Polistisolivaceus*	1.89
	Vespidae	*Vespa affinis*	1.27
Lepidoptera	Saturnidae	*Antheraassama*	0.66
Mantodea	Mantidae	*Mantis religiosa*	1.46
Odonota	Gomphidae	*Ictinogomphusrapax*	3.25
Orthoptera	Gryllidae	*Achetadomestica*	5.82
	Acrididae	*Chondracrisrosea*	7.45
	Acrididae	*Choroedocusrobustus*	8.92
	Acrididae	*Eupreponotusinflatus*	8.75
	Gryllotalpidae	*Gryllotalpaafricana*	4.22
	Gryllidae	*Gryllusbimaculatus*	7.96

	Acrididae	*Heiroglyphusbanian*	8.83
	Tettigoniidae	*Mecopoda elongate*	4.35
	Acrididae	*Oxyahyla*	5.69
	Tettigoniidae	*Ruspoliabaileyi*	5.55

Eight diversity indices were used in four selected habitats to find out the interrelationship between them (Table-4).

Table-4: Diversity indices (Habitat wise) of Edible insects in four selected habitats

Diversity indices	AFH	FBH	SAH	OFH
Species Richness	24	22	6	23
Total individual encountered	7713	1277	2096	3525
Dominance_D	0.1148	0.08871	0.3223	0.1467
Simpson_1-D	0.8852	0.9113	0.6777	0.8533
Shannon_H	2.392	2.622	1.329	2.354
Evenness_e^H/S	0.4559	0.6254	0.6293	0.4578
Menhinick	0.2733	0.6156	0.1311	0.3874
Margalef	2.57	2.936	0.6538	2.694
Equitability_J	0.7528	0.8482	0.7415	0.7508
Fisher_alpha	3.065	3.776	0.7569	3.297

AFH: Agricultural Field Habitat, **FBH:** Forest/Backyard Forest Habitat**, SAH:** Swampy area, **OFH:** Open Field Habitat

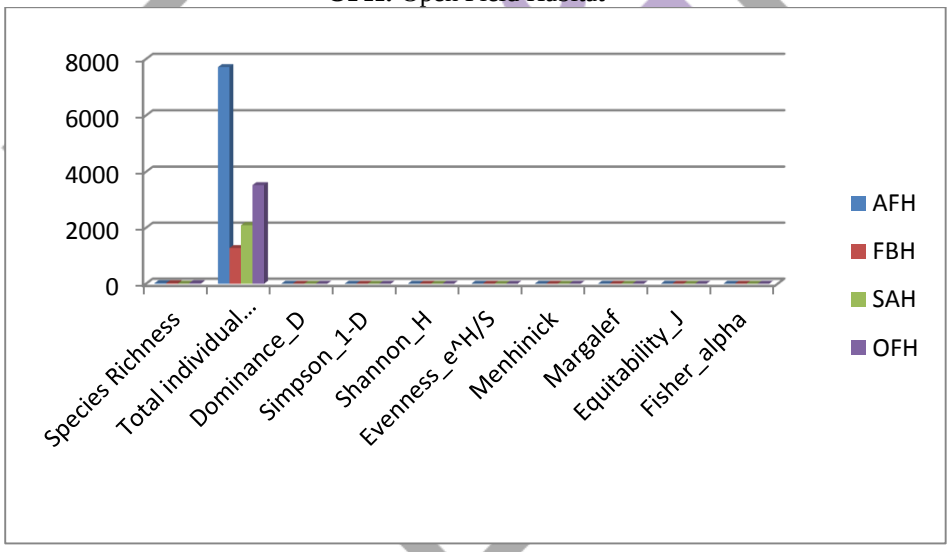


Fig-4: Graphical representation of diversity indices in four habitats

Table-5 shows Order wise relative abundance of edible insect species.

Table-5: Relative abundance and Diversity indices of edible insects' orders

Order	Relative Abundance	Dominance	Shannon_H	Evenness_e^H/S	Menhinick	Margalef	Equitability_J
Coleoptera	14.16	0.36	1.18	0.81	0.09	0.39	0.85
Hemiptera	7.90	0.79	0.46	0.40	0.12	0.43	0.33
Hymenoptera	5.02	0.62	0.69	0.67	0.11	0.30	0.63
Lepidoptera	0.66	0.83	0.36	0.48	0.30	0.44	0.33
Mentodea	1.46	0.41	0.97	0.88	0.21	0.37	0.88
Odonota	3.25	0.37	1.13	0.77	0.18	**0.49**	0.81
Orthoptera	**67.54**	0.56	0.74	0.70	**0.03**	**0.22**	0.67

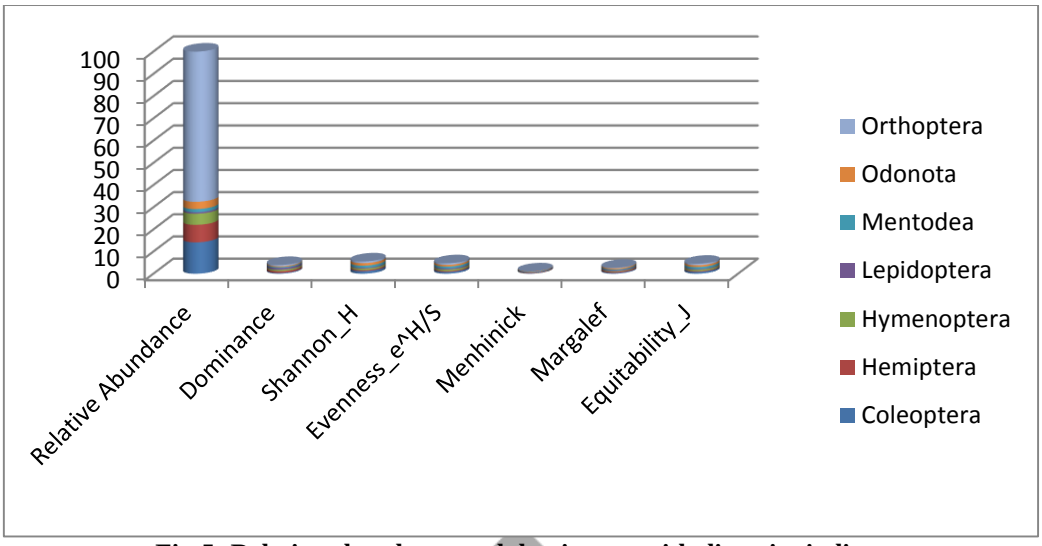
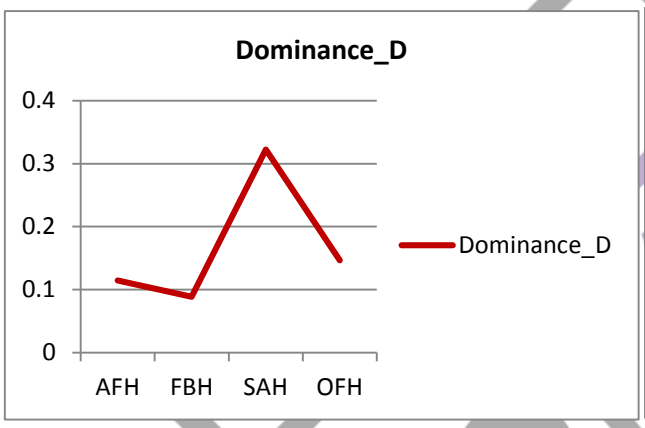


Fig-5: Relative abundance and dominance with diversity indices



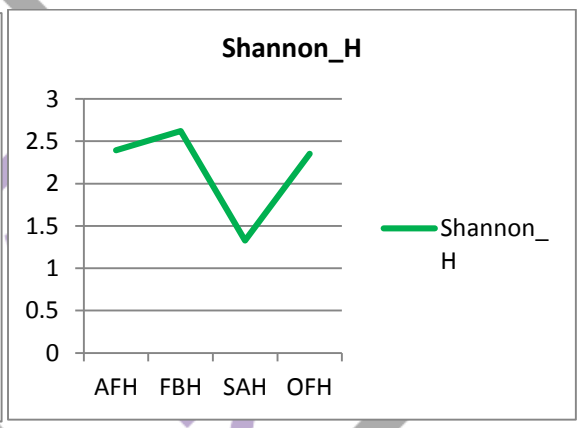


Fig-6: A: Dominance index of insects **Fig-6:B: Simson diversity Index of edible insects**

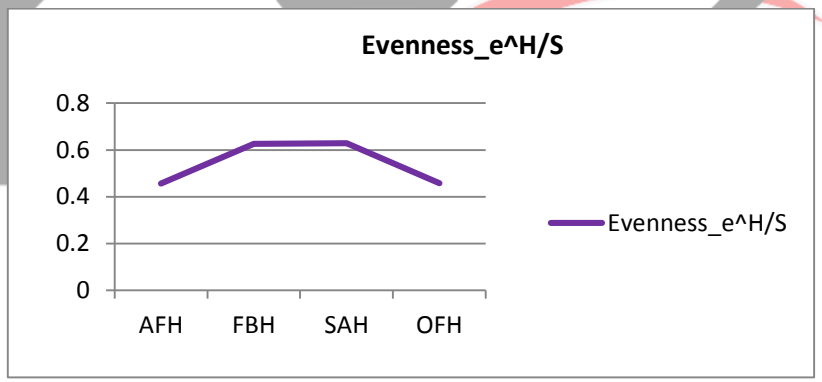


Fig-6: Diversity indices of Evenness of edible insects in different habitats

The result of the calculation of Shannon's index of diversity in four different sampling habitat, shows that, the highest diversity of edible insects found in Forest/Backyard habitat (H'=2.622)followed by agricultural field (H'= 2.392) then open field habitat (H'=2.354) and the least diversity found swampy area (H'=1.329). T-test between open and backyard habitat and agricultural field habitat has shown significant difference between two habitats (test value =0.64071). Again the t-test value of Forest and Backyard forest also showed no significant difference (0.0473).

Fig-6 shows the seasonal variation in abundance of edible insects. Some edible insects are abundant in a particular season whose number may decline in another season. *Heiroglyphus banian* is the most abundant species (489) found in Pre-Monsoon season followed by *Acheta domestica* (452) and least abundant species in pre-monsoon season is *Mantis religiosa*

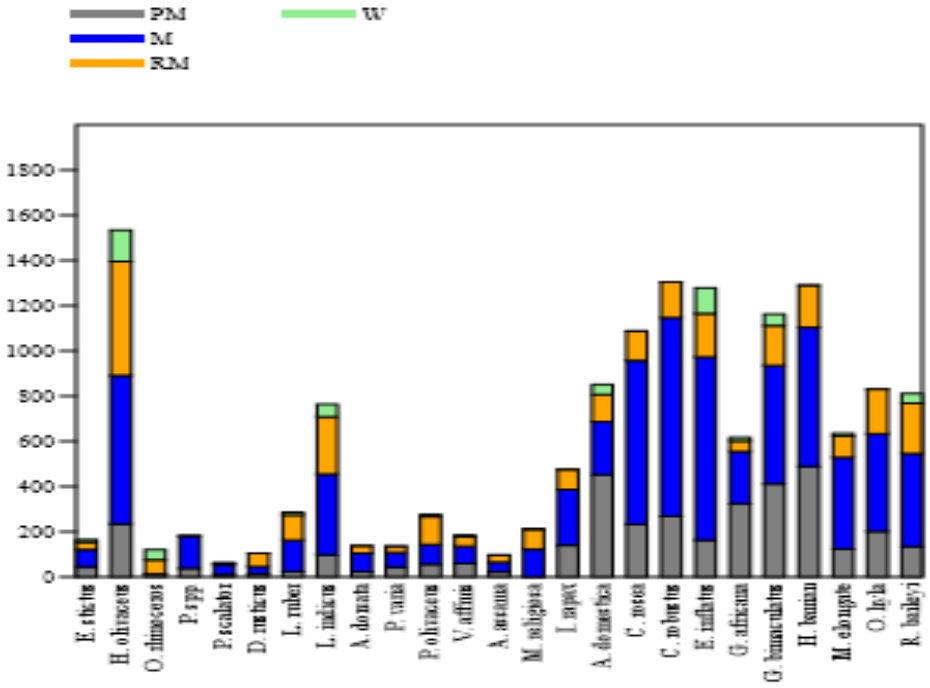


Fig-7: **Diagram showing seasonal abundance of different edible insect (Season PM: Pre-monsoon, M: Monsoon, RM: Retreating Monsoon and W: Winter)**

4. Discussion: A total of 14611 numbers of individuals of edible insect were recorded from the four different habitats. No common abundant species was found in a single habitat. Most of insects were found in two or three habitats during the study period. Maximum number of 16 species is found common in agricultural field habitat, forest and backyard forest habitat and open field habitat.A variety of insects are currently farmed in China for food, feed and other purposes (Zhang *et al.*, 2008). Rural communities of the North- Eastern India have a long cultured history of eating insects (Borgohain. *et al.*, 2014). From the report of Chakravorty *et al.*,(2011) it was found that a total of 81 species were eaten in Arunachal Pradesh by two ethnic tribes namely Galo and Nyishi. Out of the 81 species, 9 are representatives of the Odonata, 17 of the Orthoptera, 16 of the Hemiptera, 15 of the Hymenoptera and 24 of the Coleoptera (Chakravorty *et al.*, 2011). The present study on edible insects in Baksa district also indicates high diversity of edible insects consumed by ethnic tribal people in the study area.

In many developing countries and among various cultures scattered throughout the world, insects remain a vital and preferred food and an essential source of protein, fat, minerals and vitamins (Durst and Shono, 2010). Tchibozo *et al.*(2009) observed that edible insects contribute to the prevention and alleviation of malnutrition due their rich protein content.A recent study reveals that a total of 25 species of local insects, belonging to eight orders and fourteen families, are consumed as food by the Bodos in Assam (Narzary and Sarmah, 2015). The Bodo people have traditionally been interested for eating insects and this habit of insect eating is well rooted in their culture and ethnicity. The people of the study area have been using many insects as food and feed. No negative impacts are found among the insect consumers in the study area, rather they are seen to be well-fed. Further, it is very much important to study the nutritional status of edible insects consumed by the people in this particular area.

5. Conclusion-Insects are important group of organisms both in terms of numbers and types of species and vital role in ecosystem services. The consumption of diverse species of edible insects reflects the diversity in wild edible insect species of Baksa district, Assam. The high diversity of insects provides great potential for understanding ecosystems and also measures of ecosystem health. Nature is the home of insects and it is our duty to provide a healthy home to all insects for our food security.

5. Acknowledgements:

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