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A review on edible insects and their utilization in Northeastern Himalaya

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Abstract

North East India is known for its hot spot for biodiversity and has different food habit from the rest of mainland India. Many communities in this region accept insects as the part of their diets and considered as delicacy. Entomophagy is practiced and also a part of their culture in this region since early days but, due to the influence of western culture in new generations; eating insects are regarded as disgust and primitive nature. Therefore, the practice of entomophagy is fading day by day in this region. However, edible insects are good source of proteins and also contain many minerals and vitamins and can contribute in food security for growing population. More than 200 species of edible insects are documented so far and out of which 92 different species are consumed in Nagaland, 69 species in Manipur, 67 species in Assam, 65 species in Arunachal Pradesh and few insect species in Meghalaya, Mizoram and Tripura. This review mainly describes about the species of edible insects consumed by different community of North East India and their future prospect.

Keywords: Edible insects, entomophagy, farming, nutrition, North East India

1. Introduction

Food demand is increasing with fast and rapid growing population. FAO estimates that the world needs to increase its food production by 2050 in order to serve a global population of 9 billion. According to Jansson and Berggren ^[1], about 70% of all agricultural land used accounts for livestock production and the demand for livestock products is expected to increase by double in 2050 due to urbanization. Therefore, we need to find the alternative source of protein. In many regions of the world, insects are being used as food and regarded as delicacy. Moreover, these insects are also rich in proteins and other important minerals and therefore they have a great potential in contributing to global food security. In North East India, entomophagy is generally practised by many communities and also a part of their culture. In Assam, a red tree ant (*Oecophylla smaragdina*) is one of the important food items during the festival "Bohag Bihu" which is celebrated in the month of April. The formic acid of these insects keep the health free from infection of diseases like scabies, malaria, tooth aches, stomach disorders and blood pressure anomalies ^[2]. In India, a total of 255 species of edible insects are recorded so far and it is mostly practiced in North Eastern State of India however few tribes from Tamil Nadu, Karnataka, Kerala, Odisha, Madhya Pradesh and Indian Andaman Islands use termites, locusts, ants and bees as food ^[3-10]. In many countries, except in European and North America, insects are included in their diet and also considered a delicacy ^[11] and it is practiced since time immemorial. The practice of eating insects by human as food is term as entomophagy and is derived from two Greek words "entomon" means "insect" and "phagein" means "to eat". According to FAO, 2013, more than 1900 insect species are currently used as a part of the diets for at least 2 billion people around the globe. The most commonly consumed insects worldwide belongs to order Coleoptera (31%), Lepidoptera (18%), Hymenoptera (14%), Orthoptera (13%), Hemiptera (10%) and 3% each of Isoptera, Odonata and Diptera. Entomophagy is predominantly practiced in Asia, Africa, Australia and Latin America.

2. Why insects are eaten?

- Edible insects are delicious
- They are very nutritious (rich in protein, fat, vitamins and minerals)
- They are used in therapeutic purposes

- Insects are easily available in the wild and easy to harvest
- Some edible insects can be easily domesticated (silkworms and honeybees)
- They require small area of land for rearing and not necessarily a land-based activity
- They can be fed on locally available plants
- They require less water for survival
- They have high feed conversion efficiency and
- They emit less greenhouse gases (GHGs) than the most livestock

3. Nutritional Value of edible insects

Proteins are very important essential nutrients for human growth and development and serve as a fuel source [12]. There is a serious worldwide nutritional problem due to good quality protein deficiency affecting low income people [13]. Protein and energy malnutrition has continued to plague the developing world despite the benefits reaped from Green Revolution [14]. Protein energy malnutrition contributes to more than 50% of the deaths of children under 5 years all over the developing countries [15]. Insects are generally high in crude protein and fats however; their nutrient content varies between species to species and also between their different developmental phases [16-19]. Many edible insects are also rich in amino acid and micro-minerals such as copper, iron, magnesium, manganese, selenium, calcium, sodium, potassium, phosphorus and zinc, as well as vitamins such as riboflavin, pantothenic acid and biotin and, in some cases folic acid, all of which are valuable in terms of human nutrition [8, 20, 21]. Nutritional values of different insects are shown in Table 1.

4. Preparation of insects in North East India

Edible insects are prepared mostly in the traditional way and consumed in the forms of curry, roasted, fried, raw or chutney. Depending upon the type of insects and form of the consumption, these are prepared with or without other ingredients like spices and oil. For example, winged termite and weaver ants are eaten in raw form by some people and hard bodied insects like grasshoppers, crickets, cicada, beetles, dragonflies, bugs etc. are eaten in roasted or fried whereas soft bodied insects like silkworms etc. are eaten as curry. The giant water bug is one of the favourite edible insect among the Meitei community as it is used in preparation of chutney with dry fermented fish or in eromba. Generally, nymphs/grubs and adults stages are mainly eaten in Dictyoptera, Orthoptera, Hemiptera, Isoptera and Coleoptera groups. Odonates are eaten in nymph stage only but Lepidoptera are eaten in both larval and pupal stages. In Hymenoptera insects, eggs are also eaten along with other stages [22]. Preparations of different edible insects in North East India are shown in figure 1.

5. Insect farming in North East India

In North East India, most of the edible insects are generally harvested from the wild based on their seasonal appearance. For example grasshoppers are collected from the rice or grassland field by using nylon net or cloths, field cricket and mole cricket by hand-picking at night. The wild hornet, honeybees and wasps are harvested after smoking the hive during the night. Some of the terrestrial hemipteran bugs and red ants are collected by jerking the branches of the plant or looking their hideout below the big stones of seasonal river. The aquatic edible insects are generally collected through

fishing from ponds, lakes and rivers. Those harvested insects are either use for home consumption or sold in the markets. However, some of the edible insects are rear for their commercially valuable products like silkworm (Mulberry, Muga, Tasar and Eri) and honey bee (*Apis cerana* and *Apis mellifera*) and sometimes some people used to eat them for delicacy since long back. Therefore, insect farming is not a new word in these regions. The Mulberry and Eri silkworms are rear indoor in a plastic or bamboo tray feeding on mulberry and castor leaves respectively and Muga and Tasar silkworms are rear outdoor. Som (*Machilus bombycina*) and Soalu (*Litsaea polyantha*) are use as a host for Muga silkworm and Oak tree (*Quercus* sp.) is use for rearing Tasar in the region. The last larval stage and pupa of silkworms is generally used for food and sometime sell in the market in different places. The domesticated honeybees are rear in the wooden box, logs or in mud wall and the developing broods are sometimes consumed for delicacy. Edible insects sole in different markets of North East India are shown in figure 2. In countries like Thailand, Laos and Vietnam, insects like *Gryllus bimaculatus* and *Acheta domesticus* are rear for human consumption [23, 24] however in Europe and North American countries, crickets, mealworms, grasshopper, wax moths, cockroaches and maggots of the housefly are rear mainly for pet food and fish bait not for human consumption.

6. Edible insects in North East Region of India

The North East India is known for its hot spot for bio-diversity and comprises 8 states: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim. The region is surrounded by foreign territories like Nepal, Tibet-China and Bhutan in the North, Myanmar in the East and Bangladesh on the South-West. The regions occupy an area of 262,179 sq km and are mostly hilly terrain comprises about 7% of the India's landmass. The region is having more than 220 ethnic tribal communities of which 78 are large each with a population of more than 5000. They constitute around 12 per cent of the total tribal population of India and 25.81 per cent of the total population of North East India [25]. The North East region has different food habit from the rest of India due to its distinct socio- cultural environment. Entomophagy is generally practiced and also a part of their culture since time immemorial however, due to the influence of western culture in new generations; eating insects are regarded as disgust and primitive nature. Therefore, the practice of entomophagy is fading day by day in this region. However, many scientist and researchers have collected and documented more than 200 edible insects from North East region. A total of 92 different species belongs to 9 orders and 29 families are consumed by Angami, Ao, Chakhesang, Khamnuingang, Konyak, Lotha and Sumi tribes of Nagaland [26, 27, 28] (Table 2.). In Manipur, Meitei, Tarao, Tangkhul, Chothe and Thadou tribes consume higher number of species compare to other ethnic groups. About 69 species belonging to 29 families and 9 orders are found to consume in the state [22, 29, 30] (Table 3.). Entomophagy is also a common practice among the ethnic peoples of Assam especially among the tribes of Dhemaji, Morigaon, Udalguri, Baksa and Karbi Anglong districts and are closely associated with their culture. In Assam, around 67 species of edible insects under 8 orders and 27 families are consumed [2, 16, 31-34] (Table 4.). In Arunachal Pradesh, 65 species of edible insects belonging to 9 orders and 24 families were reported. The ethnic tribes of Nyishi of East Kameng, the Galo of West Siang, Adi tribe of

East Siang, Wangcho (Wancho) and Nocte tribes of the Tirap District and the Shingpo, Tangsa, Deori and Chakma of the Changlang District are generally practiced entomophagy^[29, 35, 36] (Table 5.). Thakur and Firake^[37] reported that the cinnamon bug *Ochrophora montana* is fried in oil and

consumed in Assam, Mizoram, Manipur and Tripura. Paul and Dey^[38] also mentioned termites from Meghalaya and *Ochrophora montana*, a pentatomid bug as a delicacy for inhabitants of Mizo hills^[39].

Table 1: Nutritive value of different insects

Insects	Protein (gm)	Fat (gm)	Carbohydrate (gm)	Calcium (gm)	Iron (gm)
Giant water beetle	19.8	8.3	2.1	43.5	13.6
Red ants	13.9	3.5	2.9	47.8	5.7
Silk worm pupa	9.6	5.6	2.3	41.7	1.8
Mealworms	20.27	12.72	N/A	13.3	N/A
Wax moths	15.50	22.19	N/A	28.3	N/A
Super worms	17.41	17.89	N/A	12.4	N/A
Fly larvae	15.58	7.81	N/A	87.4	N/A
Dung beetle	17.2	4.3	2.0	30.9	7.7
Cricket	21.32	6.01	5.1	75.8	9.5
Small grasshopper	20.6	6.1	3.9	35.2	5.0
Large grasshopper	14.3	3.3	2.2	27.5	3.0
June beetle	13.4	1.4	2.9	22.6	6.0
Caterpillars	6.7	N/A	N/A	N/A	13.1
Termites	14.2	N/A	N/A	N/A	35.5
Weevils	6.7	N/A	N/A	N/A	13.1

** N/A= Not Analyzed (Source: Florence, 1996)

Table 2: List of edible insects by different ethnics of Nagaland

Sl. No.	Order	Family	Scientific name	Common name
1	Coleoptera	Dytiscidae	<i>Hydrophilus caschmirensis</i>	Water scavenger
2	Coleoptera	Dytiscidae	<i>Hydrophilus indicus</i>	Water scavenger
3	Coleoptera	Dytiscidae	<i>Cybister limbatus</i>	Water beetle
4	Coleoptera	Scarabaeidae	<i>Xylotrupes gideon</i>	Scarab beetle
5	Coleoptera	Scarabaeidae	<i>Lepidiota stigma</i>	Scarab beetle
6	Coleoptera	Scarabaeidae	<i>Phyllophaga portoricensis</i>	Scarab beetle
7	Coleoptera	Cerambycidae	<i>Aeolesthes holosericea</i>	Long horn beetle
8	Coleoptera	Cerambycidae	<i>Batocera rubus</i>	Long horn beetle
9	Coleoptera	Cerambycidae	<i>Batocera parryi</i>	Long horn beetle
10	Coleoptera	Cerambycidae	<i>Anoplophora sp.</i>	Long horn beetle
11	Coleoptera	Cerambycidae	<i>Datecera albefaciata</i>	Long horn beetle
12	Coleoptera	Cerambycidae	<i>Orthosoma sp.</i>	Long horn beetle
13	Coleoptera	Curculionidae	<i>Rhynchophorus sp.</i>	Palm weevil
14	Coleoptera	Chrysomelidae	<i>Aplosomyx chalybaeus</i>	Taro leaf beetle
15	Hemiptera	Belostomatidae	<i>Lethocerus indicus</i>	Giant water bug
16	Hemiptera	Pentatomidae	<i>Tessaratomya javanica</i>	Litchi stink bug
17	Hemiptera	Pentatomidae	<i>Chinavia hilaris</i>	Green stink bug
18	Hemiptera	Pentatomidae	<i>Ochrophora montana</i>	Pentatomid bug
19	Hemiptera	Pentatomidae	<i>Dolycoris sp.</i>	Pentatomid bug
20	Hemiptera	Pentatomidae	<i>Erthesina fullo</i>	Pentatomid bug
21	Hemiptera	Pentatomidae	<i>Eurostus grossipes</i>	Pentatomid bug
22	Hemiptera	Nepidae	<i>Laccotrephes ruber</i>	Water scorpion
23	Hemiptera	Cicadidae	<i>Pomponia sp.</i>	Cicada
24	Hemiptera	Cicadidae	<i>Dundubia intemerata</i>	Cicada
25	Hemiptera	Cicadidae	<i>Dundubia oopaga</i>	Cicada
26	Hemiptera	Cicadidae	<i>Pycna sp.</i>	Cicada
27	Hemiptera	Coreidae	<i>Dalader planiventris</i>	Coreid bug
28	Hemiptera	Coreidae	<i>Anoplocnemis phasiana</i>	Coreid bug
29	Hemiptera	Coreidae	<i>Notobitus meleagris</i>	Coreid bug
30	Hemiptera	Aetalionidae	<i>Darthula hardwickii</i>	Tree hopper
31	Hemiptera	Dinidoridae	<i>Coridius singhalanus</i>	Stink bug
32	Hemiptera	Dinidoridae	<i>Coridius chinensis</i>	Stink bug
33	Hemiptera	Dinidoridae	<i>Coridius ianus</i>	Stink bug
34	Hemiptera	Dinidoridae	<i>Aspongopus nepalensis</i>	Bug
35	Hemiptera	Dinidoridae	<i>Cyclopelta siccifolia</i>	Bug
36	Hymenoptera	Apidae	<i>Apis cerana</i>	Honey bee
37	Hymenoptera	Apidae	<i>Apis florea</i>	Little bee
38	Hymenoptera	Apidae	<i>Apis dorsata</i>	Giant Honey bee
39	Hymenoptera	Apidae	<i>Lepidotrigona arcifera</i>	Stingless bee

40	Hymenoptera	Apidae	<i>Lophotrigona canifrons</i>	Stingless bee
41	Hymenoptera	Apidae	<i>Xylocopa violacea</i>	Carpenter bee
42	Hymenoptera	Vespidae	<i>Vespa affinis</i>	Wasp
43	Hymenoptera	Vespidae	<i>Vespa mandarinia</i>	Japanese giant hornet
44	Hymenoptera	Vespidae	<i>Vespa auraria</i>	Asian hornet
45	Hymenoptera	Vespidae	<i>Vespa basalis</i>	Black bellied hornet
46	Hymenoptera	Vespidae	<i>Vespa ducalis</i>	Black tailed hornet
47	Hymenoptera	Vespidae	<i>Vespa tropica</i>	Greater banded hornet
48	Hymenoptera	Vespidae	<i>Vespa soror</i>	Hornet
49	Hymenoptera	Vespidae	<i>Vespula sp.</i>	Yellow jackets
50	Hymenoptera	Vespidae	<i>Polistes stigmata</i>	Paper wasp
51	Hymenoptera	Vespidae	<i>Polistes olivaceus</i>	Paper wasp
52	Hymenoptera	Vespidae	<i>Provespa barthelemy</i>	Night hornets
53	Hymenoptera	Vespidae	<i>Parapolybia varia</i>	Lesser Paper wasp
54	Hymenoptera	Formicidae	<i>Oecophylla smaragdina</i>	Red Ant
55	Hymenoptera	Formicidae	<i>Formica indica</i>	Wood ants
56	Orthoptera	Acrididae	<i>Chondacris rosea</i>	Short horn Grasshopper
57	Orthoptera	Acrididae	<i>Acrida exaltata</i>	Short horn Grasshopper
58	Orthoptera	Acrididae	<i>Melanoplus bivittatus</i>	Two striped grasshopper
59	Orthoptera	Acrididae	<i>Melanopus sp.</i>	Two striped grasshopper
60	Orthoptera	Acrididae	<i>Oxya hyla</i>	Short horn Grasshopper
61	Orthoptera	Acrididae	<i>Atractomorpha sp.</i>	Tobacco grasshopper
62	Orthoptera	Acrididae	<i>Hieroglyphus banian</i>	Short horn Grasshopper
63	Orthoptera	Gryllidae	<i>Meloimorpha cincticornis</i>	Cricket
64	Orthoptera	Gryllidae	<i>Gryllus sp.</i>	Cricket
65	Orthoptera	Gryllidae	<i>Teleogryllus sp.</i>	Cricket
66	Orthoptera	Gryllidae	<i>Tarbinskiellus portentosus</i>	Cricket
67	Orthoptera	Gryllidae	<i>Acheta sp.</i>	House cricket
68	Orthoptera	Gryllotalpidae	<i>Gryllotalpa orientalis</i>	Mole cricket
69	Orthoptera	Tettigoniidae	<i>Mecopoda elongata</i>	Bush cricket
70	Orthoptera	Tettigoniidae	<i>Mecopoda nipponensis</i>	Bush cricket
71	Orthoptera	Tettigoniidae	<i>Mecopoda elongata</i>	Bush cricket
72	Orthoptera	Tettigoniidae	<i>Pseudophyllus titan</i>	Bush cricket
73	Orthoptera	Tettigoniidae	<i>Tettigonia sp.</i>	Shield backed katydid
74	Odonata	Libellulidae	<i>Crocothemis servilia</i>	Dragonfly
75	Odonata	Libellulidae	<i>Neurothemis fulvia</i>	Dragonfly
76	Odonata	Libellulidae	<i>Diplacodes trivialis</i>	Dragonfly
77	Odonata	Libellulidae	<i>Orthetrum pruinosum</i>	Dragonfly
78	Odonata	Libellulidae	<i>Orthetrum sabina</i>	Dragonfly
79	Odonata	Libellulidae	<i>Orthetrum triangulare</i>	Dragonfly
80	Odonata	Libellulidae	<i>Potamarcha congener</i>	Dragonfly
81	Odonata	Libellulidae	<i>Pantala flavescens</i>	Dragonfly
82	Lepidoptera	Saturniidae	<i>Philosamia ricini</i>	Eri silkworm
83	Lepidoptera	Crambidae	<i>Omphisa sp.</i>	Bamboo worm
84	Lepidoptera	Crambidae	<i>Omphisa fuscidentalis</i>	Bamboo worm
85	Lepidoptera	Herperiidae	<i>Erionota torus</i>	Banana skipper
86	Lepidoptera	Lasiocampidae	<i>Malacosoma sp.</i>	Moth
87	Lepidoptera	Cossidae	<i>Cossus sp.</i>	Moth
88	Lepidoptera	Cossidae	<i>Prionoxystus robiniae</i>	Carpenterworm moth
89	Dictyoptera	Mantidae	<i>Tenodera sinensis</i>	Preying mantid
90	Dictyoptera	Mantidae	<i>Heirodula coarctata</i>	Preying mantid
91	Isoptera	Termitidae	<i>Macrotermes sp.</i>	Termite
92	Diptera	Tipulidae	<i>Tipula sp.</i>	Crane fly

Table 3: List of edible insects by different ethnics of Manipur

Sl. No.	Order	Family	Scientific name	Common name
1	Coleoptera	Hydrophilidae	<i>Hydrous olivaceous</i>	True water beetle
2	Coleoptera	Hydrophilidae	<i>Hydrous indicus</i>	Water scavenger beetle
3	Coleoptera	Hydrophilidae	<i>Tropistemus sp.</i>	Water beetle
4	Coleoptera	Dytiscidae	<i>Cybister sugillatus</i>	Water beetle
5	Coleoptera	Dytiscidae	<i>Cybister tripunctatus</i>	Water beetle
6	Coleoptera	Dytiscidae	<i>Cybister ventralis</i>	Water beetle
7	Coleoptera	Dytiscidae	<i>Rhantus sp.</i>	Water beetle
8	Coleoptera	Dytiscidae	<i>Hydrophilus triangularis</i>	Giant water scavenger
9	Coleoptera	Dytiscidae	<i>Cybister fimbriatus</i>	Cybister beetle
10	Coleoptera	Curculionidae	<i>Cyrtotrachelus dux</i>	Bamboo beetle
11	Coleoptera	Dynastidae	<i>Oryctes rhinoceros</i>	Rhino beetle
12	Coleoptera	Cerambycidae	<i>Anoplophora glabripennis</i>	Long horn beetle

13	Hemiptera	Belostomatidae	<i>Lethocerus indicus</i>	Giant water bug
14	Hemiptera	Belostomatidae	<i>Diplonychus rusticus</i>	Water bug
15	Hemiptera	Nepidae	<i>Ranatra sp.</i>	Water scorpion
16	Hemiptera	Nepidae	<i>Laccotrephes maculatus</i>	Water scorpion
17	Hemiptera	Nepidae	<i>Laccotrephes ruber</i>	Water scorpion
18	Hemiptera	Nepidae	<i>Laccotrephes variepes</i>	Water scorpion
19	Hemiptera	Nepidae	<i>Cercometus sp.</i>	Water bug
20	Hemiptera	Dinidoridae	<i>Coridius sp.</i>	Bug
21	Hemiptera	Pentatomidae	<i>Udonga montana</i>	Stink bug
22	Hemiptera	Cicadidae	<i>Pomponia sp.</i>	Cicada
23	Hemiptera	Corixidae	<i>Micronecta sp.</i>	Lesser water boatmen
24	Hemiptera	Notonectidae	<i>Notonecta sp.</i>	Backswimmer
25	Hemiptera	Notonectidae	<i>Paranisops sp.</i>	Backswimmer
26	Hemiptera	Notonectidae	<i>Enithares ciliata</i>	Backswimmer
27	Hemiptera	Notonectidae	<i>Enithares mandalayensis</i>	Backswimmer
28	Hemiptera	Hydrometridae	<i>Hydrometridae greeni</i>	Marsh treaders
29	Hemiptera	Hydrometridae	<i>Hydrometra sp.</i>	Water measurer
30	Hemiptera	Garridae	<i>Geris sp.</i>	Water strider
31	Hemiptera	Garridae	<i>Aquarius sp.</i>	Water strider
32	Hemiptera	Garridae	<i>Limnogonus sp.</i>	Water strider
33	Hymenoptera	Apidae	<i>Apis cerana</i>	Honey bee
34	Hymenoptera	Apidae	<i>Apis mellifera</i>	Honey bee
35	Hymenoptera	Apidae	<i>Apis dorsata</i>	Giant Honey bee
36	Hymenoptera	Vespidae	<i>Vespa affinis</i>	Lesser banded hornet
37	Hymenoptera	Vespidae	<i>Vespa mandarinia</i>	Japanese giant hornet
38	Hymenoptera	Vespidae	<i>Vespa cincta</i>	Common oriental hornets
39	Hymenoptera	Vespidae	<i>Vespa vulgaris</i>	Common yellow jacket
40	Hymenoptera	Vespidae	<i>Polistes sp.</i>	Paper wasp
41	Hymenoptera	Vespidae	<i>Polistes sp.</i>	Paper wasp
42	Hymenoptera	Formicidae	<i>Solenopsis geminata</i>	Ant
43	Orthoptera	Acrididae	<i>Oxy hyla</i>	Rice Grasshopper
44	Orthoptera	Acrididae	<i>Acridium melanocorne</i>	Short horn Grasshopper
45	Orthoptera	Acrididae	<i>Gryllus sp.</i>	Field cricket
46	Orthoptera	Gryllotalpidae	<i>Gryllotalpa orientalis</i>	Mole cricket
47	Odonata	Libellulidae	<i>Pantala flavescens</i>	Dragonfly
48	Odonata	Libellulidae	<i>Acisoma panorpoides</i>	Dragonfly
49	Odonata	Libellulidae	<i>Crocothemis servilia</i>	Dragonfly
50	Odonata	Libellulidae	<i>Orthetrum triangulare</i>	Dragonfly
51	Odonata	Libellulidae	<i>Orthetrum sabina</i>	Dragonfly
52	Odonata	Libellulidae	<i>Sympatrum sp.</i>	Dragonfly
53	Odonata	Libellulidae	<i>Rhyothemis variegata</i>	Dragonfly
54	Odonata	Libellulidae	<i>Diplacodes trivialis</i>	Dragonfly
55	Odonata	Libellulidae	<i>Libulla sp.</i>	Dragonfly
56	Odonata	Libellulidae	<i>Leucorrhina sp.</i>	Dragonfly
57	Odonata	Libellulidae	<i>Palpopleura sexmaculata</i>	Dragonfly
58	Odonata	Libellulidae	<i>Tramea basilaris</i>	Dragonfly
59	Odonata	Libellulidae	<i>Urothemis signata</i>	Dragonfly
60	Odonata	Corduliidae	<i>Corduliidae sp.</i>	Dragonfly
61	Odonata	Coenagrionidae	<i>Pseudagrion microcephalum</i>	Damselfly
62	Odonata	Coenagrionidae	<i>Ischnura sp.</i>	Damselfly
63	Ephemeroptera	Baetidae	<i>Baetid sp.</i>	Mayfly
64	Dictyoptera	Mantidae	<i>Heirodula sp.</i>	Preying mantid
65	Isoptera	Termitidae	<i>Odontotermes sp.</i>	Termite
66	Lepidoptera	Bombycidae	<i>Bombyx mori</i>	Mulberry silkworm
67	Lepidoptera	Saturniidae	<i>Samia Cynthia ricini</i>	Eri silkworm
68	Lepidoptera	Saturniidae	<i>Antheraea proylei</i>	Tasar silkworm
69	Lepidoptera	Crambidae	<i>Omphisa fuscidentalis</i>	Bamboo worm

Table 4: List of edible insects by different ethnics of Assam

Sl. No.	Order	Family	Scientific name	Common name
1	Coleoptera	Dytiscidae	<i>Dytiscus marginalis</i>	Great diving beetle
2	Coleoptera	Dytiscidae	<i>Hydrochera rickseckeri</i>	Water beetle
3	Coleoptera	Dytiscidae	<i>Cybis sp.</i>	Water beetle
4	Coleoptera	Dynastidae	<i>Eurytrachelus titan</i>	Beetle
5	Coleoptera	Dynastidae	<i>Eurytrachelus sp.</i>	Beetle
6	Coleoptera	Lucanidae	<i>Odontolabis cuvera</i>	Stag beetle
7	Coleoptera	Scarabaeidae	<i>Analeptes trifasciata</i>	Flat-faced longhorn beetle
8	Coleoptera	Scarabaeidae	<i>Lepidiota mansueta</i>	Scarab beetle
9	Coleoptera	Cerambycidae	<i>Batocera horsefieldi</i>	Long horn beetle
10	Coleoptera	Cerambycidae	<i>Batocera rufomaculata</i>	Long horn beetle
11	Coleoptera	Cerambycidae	<i>Dihammus cervinus</i>	Long horn beetle
12	Coleoptera	Curculionidae	<i>Rhynchophorus ferrugineus</i>	Palm weevil
13	Coleoptera	Curculionidae	<i>Rhynchophorus phoenicis</i>	Palm weevil
14	Hemiptera	Belostomatidae	<i>Lethocerus indicus</i>	Giant water bug
15	Hemiptera	Pentatomidae	<i>Ochrophora montana</i>	Pentatomid bug
16	Hemiptera	Nepidae	<i>Laccotrephes ruber</i>	Water scorpion
17	Hemiptera	Cicadidae	<i>Pomponia imperatoria</i>	Cicada
18	Hemiptera	Cicadidae	<i>Okanagana sp.</i>	Cicada
19	Hemiptera	Naucoridae	<i>Pelocoris femoratus</i>	Creeping water bug
20	Hymenoptera	Apidae	<i>Apis cerana</i>	Honey bee
21	Hymenoptera	Apidae	<i>Apis mellifera</i>	Honey bee
22	Hymenoptera	Apidae	<i>Apis florea</i>	Little bee
	Hymenoptera	Apidae	<i>Apis dorsata</i>	Giant Honey bee
23	Hymenoptera	Vespidae	<i>Vespa affinis</i>	Wasp
24	Hymenoptera	Vespidae	<i>Polistes stigmata</i>	Paper wasp
25	Hymenoptera	Vespidae	<i>Polistes olivaceus</i>	Paper wasp
26	Hymenoptera	Vespidae	<i>Parapolybia varia</i>	Lesser Paper wasp
27	Hymenoptera	Formicidae	<i>Oecophylla smaragdina</i>	Red Ant
28	Hymenoptera	Formicidae	<i>Dorylus orientalis</i>	Army ants
29	Hymenoptera	Formicidae	<i>Atta sp.</i>	Leaf cutter ants
30	Hymenoptera	Formicidae	<i>Myrmica rubra</i>	Common red ant
31	Hymenoptera	Formicidae	<i>Formica indica</i>	Wood ants
32	Orthoptera	Acrididae	<i>Chondacris rosea</i>	Short horn Grasshopper
33	Orthoptera	Acrididae	<i>Phlaeoba infumata</i>	Short horn Grasshopper
34	Orthoptera	Acrididae	<i>Melanoplus sp.</i>	Short horn Grasshopper
35	Orthoptera	Acrididae	<i>Oxya fuscovittata</i>	Short horn Grasshopper
36	Orthoptera	Acrididae	<i>Cyrtacanthacris aeruginosus</i>	Short horn Grasshopper
37	Orthoptera	Acrididae	<i>Hieroglyphus banian</i>	Short horn Grasshopper
38	Orthoptera	Acrididae	<i>Schistocerca gregaria</i>	Desert locust
39	Orthoptera	Acrididae	<i>Eupreponotus inflatus</i>	Short horn Grasshopper
40	Orthoptera	Acrididae	<i>Choroedocus robustus</i>	Short horn Grasshopper
41	Orthoptera	Pyrgomorphidae	<i>Zonocerus variegatus</i>	Grasshopper
42	Orthoptera	Gryllidae	<i>Schizodactylus monstrosa</i>	Cricket
43	Orthoptera	Gryllidae	<i>Gryllus campestris</i>	Field cricket
44	Orthoptera	Gryllidae	<i>Brachytrupes sp.</i>	Cricket
45	Orthoptera	Gryllidae	<i>Tarbinskiellus portentosus</i>	Cricket
46	Orthoptera	Gryllidae	<i>Acheta domestica</i>	House cricket
47	Orthoptera	Gryllidae	<i>Acheta sp.</i>	House cricket
48	Orthoptera	Gryllotalpidae	<i>Gryllotalpa africana</i>	Mole cricket
49	Orthoptera	Tettigoniidae	<i>Mecopoda elongata</i>	Bush cricket
50	Orthoptera	Tettigoniidae	<i>Ruspolia baileyi</i>	Bush cricket
51	Odonata	Libellulidae	<i>Crocothemis servilia</i>	Dragonfly
52	Odonata	Libellulidae	<i>Neurothemis fluctuans</i>	Dragonfly
53	Odonata	Aeshnidae	<i>Aeshna mixta</i>	Dragonfly
54	Lepidoptera	Bombycidae	<i>Bombyx mori</i>	Mulberry silkworm
55	Lepidoptera	Saturniidae	<i>Philosamia ricini</i>	Eri silkworm
56	Lepidoptera	Saturniidae	<i>Antheraea assamensis</i>	Muga silkworm
57	Lepidoptera	Saturniidae	<i>Cirinaforde sp.</i>	Wild silkworm
58	Lepidoptera	Notodontidae	<i>Anaphe infracta</i>	Moth
59	Lepidoptera	Notodontidae	<i>Anaphe reticulata</i>	Moth
60	Lepidoptera	Notodontidae	<i>Anaphe venata</i>	Moth
61	Dictyoptera	Mantidae	<i>Mantis religiosa</i>	Preying mantid
62	Dictyoptera	Mantidae	<i>Mantis inornate</i>	Preying mantid
63	Isoptera	Termitidae	<i>Odontotermes obesus</i>	Termite
64	Isoptera	Termitidae	<i>Macrotermes natalensis</i>	Termite
65	Isoptera	Termitidae	<i>Macrotermes bellicosus</i>	Termite
66	Isoptera	Termitidae	<i>Macrotermes sp.</i>	Termite
67	Isoptera	Rhinotermitidae	<i>Reticulitermes flavipes</i>	Termite

Table 5: List of edible insects by different ethnics of Arunachal Pradesh

Sl. No.	Order	Family	Scientific name	Common name
1	Coleoptera	Dytiscidae	<i>Hydrophilus triangularis</i>	Giant water scavenger
2	Coleoptera	Dytiscidae	<i>Cybister fembriolatus</i>	Water beetle
3	Coleoptera	Lucanidae	<i>Dorcus sp.</i>	Stag beetle
4	Coleoptera	Lucanidae	<i>Lucanus laminifer</i>	Stag beetle
5	Coleoptera	Scarabaeidae	<i>Xylotrupes gideon</i>	Brown rhinoceros beetle
6	Coleoptera	Scarabaeidae	<i>Heliocopris sp.</i>	Large dung beetles
7	Coleoptera	Scarabaeidae	<i>Anomala sp.</i>	Leaf chafers
8	Coleoptera	Scarabaeidae	<i>Propomacrus sp.</i>	Scarab beetles
9	Coleoptera	Scarabaeidae	<i>Lepidiota sp.</i>	Scarab beetles
10	Coleoptera	Cerambycidae	<i>Anoplophora versteegi</i>	Long horn beetle
11	Coleoptera	Cerambycidae	<i>Batocera roylei</i>	Long horn beetle
12	Coleoptera	Cerambycidae	<i>Aristobia sp.</i>	Long horn beetle
13	Coleoptera	Cerambycidae	<i>Haplocerambyx sp.</i>	Long horn beetle
14	Coleoptera	Buprestidae	<i>Sternocera sp.</i>	Jewel beetle
15	Hemiptera	Pentatomidae	<i>Coridius chinensis</i>	Stink bug
16	Hemiptera	Pentatomidae	<i>Coridius viduatus</i>	Stink bug
17	Hemiptera	Pentatomidae	<i>Aspongopus nepalensis</i>	Stink bug
18	Hemiptera	Pentatomidae	<i>Halyomorpha picus</i>	Stink bug
19	Hemiptera	Pentatomidae	<i>Nezara viridula</i>	Green stink bug
20	Hemiptera	Pentatomidae	<i>Rhynchoris humeralis</i>	Pentatomid bug
21	Hemiptera	Pentatomidae	<i>Tessaratomya quadrata</i>	Lychee giant stink bug
22	Hemiptera	Pyrrhocoridae	<i>Dalader acuticosta</i>	Coreid Bug
23	Hemiptera	Pyrrhocoridae	<i>Mictis tenebrosa</i>	Coreid Bug
24	Hemiptera	Pyrrhocoridae	<i>Antilochus coquebertii</i>	Bug
25	Hemiptera	Cicadidae	<i>Unknown sp.</i>	Cicada
26	Hymenoptera	Apidae	<i>Apis cerana</i>	Honey bee
27	Hymenoptera	Apidae	<i>Apis mellifera</i>	Honey bee
28	Hymenoptera	Apidae	<i>Apis florea</i>	Little bee
29	Hymenoptera	Apidae	<i>Apis dorsata</i>	Giant Honey bee
30	Hymenoptera	Apidae	<i>Xylocopa sp.</i>	Carpenter bee
31	Hymenoptera	Vespidae	<i>Vespa affinis</i>	Lesser banded hornet
32	Hymenoptera	Vespidae	<i>Vespa mandarinia</i>	Japanese giant hornet
33	Hymenoptera	Vespidae	<i>Vespa cincta</i>	Common oriental hornets
34	Hymenoptera	Vespidae	<i>Vespa tropicana</i>	Common oriental hornets
35	Hymenoptera	Vespidae	<i>Vespa orientalis</i>	Oriental hornet
36	Hymenoptera	Vespidae	<i>Polistes stigmata</i>	Paper wasp
37	Hymenoptera	Vespidae	<i>Polistes olivaceus</i>	Paper wasp
38	Hymenoptera	Vespidae	<i>Polistes sp.</i>	Paper wasp
39	Hymenoptera	Vespidae	<i>Vespula sp.</i>	Yellow jacket wasp
40	Hymenoptera	Vespidae	<i>Eumenes sp.</i>	Potter wasps
41	Hymenoptera	Formicidae	<i>Oecophylla smaragdina</i>	Red Ant
42	Orthoptera	Acrididae	<i>Oxy hyla</i>	Rice Grasshopper
43	Orthoptera	Acrididae	<i>Acridium sp.</i>	Short horn Grasshopper
44	Orthoptera	Acrididae	<i>Chondacris rosea</i>	Short horn Grasshopper
45	Orthoptera	Acrididae	<i>Laptysma sp.</i>	Short horn Grasshopper
46	Orthoptera	Gryllidae	<i>Schizodactylus monstrosa</i>	Cricket
47	Orthoptera	Gryllidae	<i>Gryllus campestris</i>	Field cricket
48	Orthoptera	Gryllidae	<i>Brachytrupes portentosus</i>	Field cricket
49	Orthoptera	Gryllidae	<i>Brachytrupes orientalis</i>	Field cricket
50	Orthoptera	Gryllotalpidae	<i>Gryllotalpa africana</i>	Mole cricket
51	Orthoptera	Tettigoniidae	<i>Macrolyristes sp.</i>	Giant katydid
52	Orthoptera	Tettigoniidae	<i>Microcentrum sp.</i>	Katydid
53	Orthoptera	Tettigoniidae	<i>Unknown sp.</i>	Katydid
54	Odonata	Libellulidae	<i>Crocothemis servilia</i>	Dragonfly
55	Odonata	Gomphidae	<i>Unknown sp.</i>	Dragonfly
56	Odonata	Coenagrionidae	<i>Unknown sp.</i>	Damselfly
57	Lepidoptera	Bombycidae	<i>Bombyx mori</i>	Mulberry silkworm
58	Lepidoptera	Saturniidae	<i>Philosamia ricini</i>	Eri silkworm
59	Lepidoptera	Saturniidae	<i>Antheraea assamensis</i>	Muga silkworm
60	Lepidoptera	Crambidae	<i>Omphisa fuscidentalis</i>	Bamboo worm
61	Lepidoptera	Noctuidae	<i>Pericyma cruegeri</i>	Poinciana looper
62	Dictyoptera	Mantidae	<i>Mantis religiosa</i>	Preying mantid
63	Isoptera	Termitidae	<i>Odontotermes sp.</i>	Termite
64	Isoptera	Termitidae	<i>Termes sp.</i>	Termite
65	Ephemeroptera		<i>Unknown sp.</i>	Mayfly



Fig 1: Preparation of different edible insects in North East India: (A) Fried silkworm larva serving in Boro Restaurant in Guwahati (B) Deep fired hornet grubs (C) Fried naiads of Odonata (D) Fried Diving beetle (E) Roasted crickets (F) Roasting cicada.



Fig 2: Edible insects sole in different markets of North East India: (A) Red ants selling in Dimapur Market, Nagaland (B) Red ants selling in Lamlong Bazar Market, Manipur (C) Silkworm pupa selling in Noghphoh Market, Meghalaya (D) Silkworm larva selling in Dimapur Market, Nagaland (E) Hornet larva selling in Dimapur Market, Nagaland (F) Giant water bug selling in the market of Manipur.

7. Conclusion

Insects are a good source of proteins and fats and entomophagy is widely practiced not only for food but also as medicinal and a part of the culture in different ethnic tribes in North East India. More than 200 species of insects have been identified by many scientist and researchers from the region. However, the practices of eating insects are fading due to urbanization and adoption of western culture. Therefore, popularization of entomophagy is very much needed through awareness programme in different places. Moreover, insects farming other than silkworm and honey bees, their conservation and marketing facilities can also be promoted in this region to improve the income of landless farmers.

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