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Practices and Scopes of Anthropo-entomophagy

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Abstract
Edible insects are found in different habitats such as forests, agricultural fields and aquatic ecosystems. The practice of eating edible insects and insect based food is called entomophagy and when it is related to humans, it is called anthropo-entomophagy or human entomophagy. About one million insect species are reported and even more are yet to be documented. Insect origin is very old and evolution produces their great biodiversity. Out of million insect species, only about 5000 species are considered to be harmful. Anthropo-entomophagy is considered very primitive and taboo in many regions of the world especially in western countries, while in some regions it is widely accepted and important part of regular diets. It is estimated that anthropo-entomophagy is practiced by at least 2 billion people of the world. More than 2000 edible insects are reported in literatures. Edible insects are eaten in their all stages of life cycles *viz*. eggs, larvae, pupae and adults. Edible insects can provide good alternative and sustainable source of protein other than livestock protein.

Keywords: anthropo-entomophagy, edible insects, FAO, neophobia, semi-cultivation

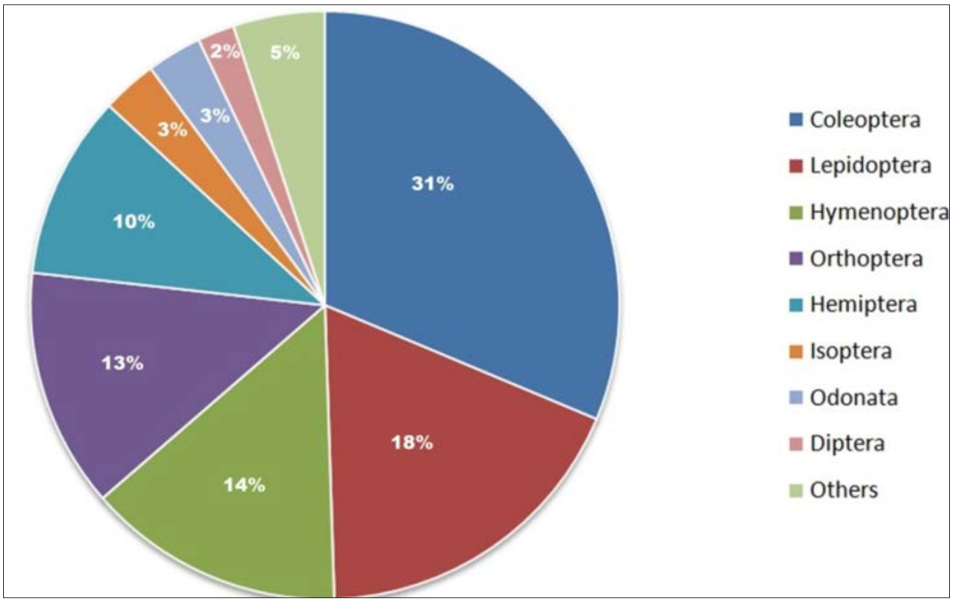
Introduction

We quote that "insects are glorified invertebrates". The practice of eating edible insects and insect based food is called entomophagy and when it is related to humans, it is called anthropo-entomophagy or human entomophagy. About one million insect species are reported and even more are yet to be documented. Insect origin is very old and evolution produces their great biodiversity. Out of million insect species, only about 5000 species are considered to be harmful [1]. Insects are very important for ecosystem as they do various roles such as pollination, pest control, composting *etc*. Various animals are entomophagus *viz*. spiders, lizards, birds, mammals and even some insects. Anthropo-entomophagy is considered very primitive and taboo in some regions of the world especially in western countries, while in many regions it is widely accepted and important part of regular diets. Most edible insects are not reared or cultured, they are harvested in the wild but only few insect groups (honeybees, silk moths, cochineal insects *etc*.) have been domesticated because of their economical values [2]. It is estimated that anthropo-entomophagy is practiced by at least 2 billion people of the world. More than 2000 edible insects are reported in literatures. Edible insects are eaten in their all stages of life cycles *viz*. eggs, larvae, pupae and adults. Temperature is controlling factor in insect population and diversity so anthropo-entomophagy is more common in tropical countries in comparison to temperate countries. Even insect size is bigger in tropics, which facilitate their harvesting. Most popular edible insect groups are caterpillars, bees, ants, beetles, wasps, locusts, grasshoppers, cicadas, crickets, termites, dragonflies, true bugs, plant-hoppers, scale insects *etc*. Edible insects are rich in proteins, fibers, amino acids (essential and non-essential), vitamins, saturated fatty acids (palmitic acid and stearic acid), MUFA (oleic acid, palmitoleic acid), PUFA (linoleic acid, α-linoleic acid, γ-linoleic acid, omega-3, omega-6, omega-7 and omega-9) and micronutrients (iron, sodium, copper, phosphorus, zinc, selenium, manganese, magnesium, calcium *etc* [3, 6]. A data shows that insect have more caloric value than soybean, corn, fish, lentils, beans, wheat and rye. Chitin (N-acetyl glucosamine) is a polysaccharide and main component of insect exoskeleton. Chitin is believed to be indigestible but most human have chitinase in their digestive tract. Edible insects are found in different habitats such as forests, agricultural fields and aquatic ecosystems. Mode of consumption of insects include roasting, boiling, frying *etc*. and sometimes spices are also added to increase to taste.

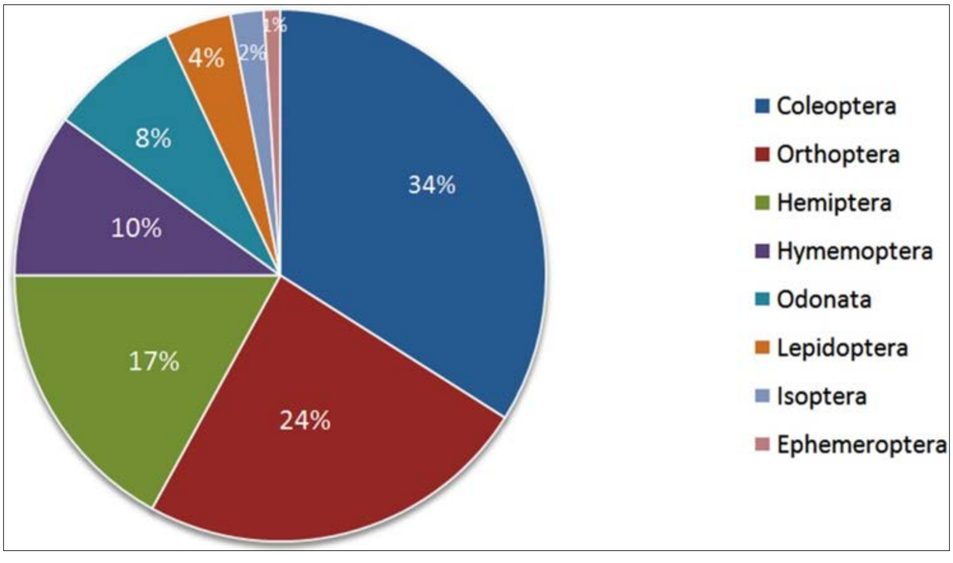
Results and Discussion

The practice of anthropo-entomophagy is very primitive. Bible mentioned desert locust (*Schistocerca gregaria*) as food in book of Levictus. Anthropo-entomophagy is also mentioned in Islamic literatures, Chinese [4] and Jewish literatures [5]. Aristotle in his book "Historia animalium" mentioned that larva of cicada tastes best before the last moult and adult females taste better before copulation due to presence of eggs. Ancient Rome literature also mentioned *Cerambyx cerdo* (cossus larvae of longhorn beetles) as renowned food dish. German soldiers also ate fried silkworm in Italy during 1602 treaties. Anthropo-entomophagy might be adopted for many reasons. The most important reason is food security and health. Second reason is environmental as insects emit lesser ammonia (NH_3) and greenhouse gases (GHGs) such as methane (CH_4), than other conventional livestock. Third reason is that insect farming does not require much land, water and feed as other livestock do. Another reason is higher efficiency of converting feed into protein than livestock because they are cold blooded (poikilothermic) and they also reproduce at faster rate and reproduce even through parthenogenesis. Another reason is that insects can also be fed on organic and inorganic waste as plants do. One more reason is that insect farming and harvesting does not require high capital investment, skill and technology. Ethical issue is also minimal in anthropo-entomophagy. Although genes for nociception are same for mammals and insects but most studies suggests that, insect lack nociception and cognitive ability to experience pain. Even risk of zoonotic infection is very low in case of anthropo-entomophagy than other meat consumption because insect are far more evolutionary distinct than other livestock.

Best example of insect farming is cricket farming in Thailand, where two species *viz.* house cricket (*Acheta domesticus*) and native cricket (*Gryllus bimaculatus*) are farmed. Food and Agriculture Organization United States (FAO) is working in promotion of anthropo-entomophagy and also provides basic information, technical information and videos about edible insects on their webportal (www.fao.org/forestry/edibleinsects). The most common edible insect group (31%) are beetle (Coleoptera). Second most edible insect group (18%) is of butterflies and moths (Lepidoptera). Third most edible insect group (14%) is of bees, wasps and ants (Hymenoptera). Fourth most edible insect group (13%) is of locusts, grasshoppers and crickets (Orthoptera). Next most edible insect group (10%) is of cicadas, plant-hoppers, leaf-hoppers, true bugs and scale insects (Hemiptera). Another edible insect group (3%) is of termites (Isoptera). Remaining edible insect groups are Odonata (3%) and Diptera (2%) and other groups (5%) [3] (Graph 1). If we talk about India, highest consumed insect orders are Coleoptera (34%), Orthoptera (24%), Hemiptera (17%), Hymenoptera (10%), Odonata (8%), Lepidoptera (4%), Isoptera (2%) and Ephemeroptera (1%) respectively in descending order [29] (Graph 2). Orthoptera, Hemiptera and Isoptera are mostly eaten as adults. Other orders are eaten in their larvae as well as imago forms.



Graph 1: Pie chart showing edible insect orders consumed worldwide according to their proportion.



Graph 2: Pie chart showing edible insect orders consumed in India according to their proportion.

Most edible coleopterans are aquatic beetle, wood-boring larvae and dung beetles. Ramos *et al*, (2009) documented 78 edible aquatic beetle species, mainly included in Dytiscidae, Gyrinidae and Hydrophilidae families [7]. Most famous edible beetle is the palm weevil (*Rynchophorus*). *Rynchophorus phoenicis* is consumed in Africa while *Rynchophorus palmarum* is consumed in West Indies, Mexico and some parts of South America. *Rynchophorus ferrugineus* is eaten in Indonesia, Malaysia, Japan, Thailand, Phillipines and Papua New Guinea. Palm weevil larvae are harvested, washed and fried for eating. Indigenous Australians eat moths of cutworms (*Agrotis infusa*). Hawkmoths (*Theretra* spp.) are consumed after removing their legs and wings in Lao People's Democratic Republic. Among Lepidoptera, the mopane caterpillar (*Imbrasia belina*) is the most popular edible insect that is consumed. Mopane caterpillars are found on its host, the mopane tree (*Colophospermum mopane*). About 10 billion mopane caterpillars are annually harvested in Africa. They are harvested by hand then degutted and boiled in salt water and sun dried. Dried mopane caterpillars preserved for several months. Protein content of mopane caterpillar is 50-60% and fat content is 15-20%. Bamboo caterpillar (*Omphisa fuscidentalis*) are harvested and eaten in Asia. Witchetty grubs (*Xyleutes leucomochla*) are consumed in Australia [8]. Ants are eaten for their delicacies in many regions of the world [9, 10]. Black weaver ants (*Polymachis dives*) are used in many tonics and health food in Chinese market. Health Ministry of China has approved more than 30 health products which contain ants [11]. Larvae of yellow jacket wasp (*Dolichovespula* spp. and *Vespula* spp.) are consumed in Japan. In Mexico, two leaf cutter ants (*Atta cephalotus* and *Atta mexicana*) are very popular for feeding. A leafcutter colony is considered similar to the cow. In Thailand along with wasps, honeybees (*Apis mellifera*) are most important and expensive edible insects [12]. In Australia, the hives of stingless bee (*Trigona* spp.) are famous source of sugar [13, 14].

About 80 grasshopper species are consumed worldwide. *Ruspolia differns* is consumed in many parts of Africa. In Japan, Thailand and Korea, *Oxya* spp. is harvested with rice crops and consumed as side dish and snacks. Locusts reproduce by parthenogenesis and make swarms, which makes them easy to harvest. In Africa, the migratory locust, the desert locust, the red locust and brown locust are eaten [15]. In Niger, grasshoppers are harvested in millet fields and sold at higher price than millet itself. They are sold as snacks in local market. In Mexico, chaupulines (*Sphenarium purpurascens*) has been part of local diets for centuries and still consumed [16]. In some parts of Asia, crickets (*Acheta domesticus*, *Teleogryllus occipitalis*, *T. mitratus* and *Gryllus bimaculatus*) are harvested and consumed as food. Thailand has about 20,000 cricket farmers. In Malawi, cicadas (*Ioba* spp., *Platypleura* spp. and *Pycna* spp.) are consumed as food. They are harvested from trunks of trees using long reeds of *Phragmites mauritianus* or grasses of *Pennisetum purpureum* with attaching latex obtained from *Ficus natalensis* tree. Carmine dye (E120) derived from cactus cochineal bug (*Dactylopius coccus*) used in food products. In Republic of Sudan, a pentatomid bug (*Agonoscelis versicolor*) and melon bug (*Coridius vidutus*) is a pest of sorghum and eaten by locals after roasting. Oil derived from these bugs is also used for cooking food. This oil is also used as preservative for meat and meat products to control gram positive bacteria [17]. The popular Mexican caviar, "ahuahutle" is made up of the eggs of seven aquatic hemipteran species of Corixidae and Notonectidae families. The most common edible termite genus is *Macrotermes*. In Amazon, *Syntermes aculeosus* are eaten [18]. Queen termites are reserved for special occasions and they are fed to undernourished children in Uganda and Zambia. Termite oil is extracted by crushing dried termites in a tube. Sun dried termites are crushed to powder and then used in crackers, muffins, sausage *etc*. In Botswana, winged termites (*Hodotermes mossambicus*) are roasted on hot sand and consumed [19]. Stink bugs (*Encosternum* and *Tessaratoma*) are very common food item throughout Mexico and Southeast Asia. They provide livelihood for Norumedzo community of Zimbabwe. List of most popular edible insects are given in Table 1.

Table 1: List of major edible insect species with their common name and location where they consumed.

Common name	Scientific name	Location of consumption
Migratory locust	*Locusta migratoria*	International
Desert locust	*Schistocerca gregaria*	International
Coconut rhinoceros beetle	*Oryctes rhinoceros*	International
Mulberrry longhorn stem beetle	*Apriona germari*	Asia
Indian red date palm weevil	*Rhynchophorus ferrugineus*	Asia
Chapulines	*Sphenarium purpurascens*	Mexico
South African migratory locust	*Locustan pardalina*	Africa
Variegated grasshopper	*Zonocercus variegates*	Africa
African palm weevil	*Rhynchophorus phoenicis*	Africa
Scarab beetle	*Augosoma centaurus*	Africa
Wild silkmoth	*Anaphe panda*	Africa
Emperor silkmoth	*Gynanisa maja*	Africa
Sweet potato hawkmoth	*Afrius convolvuli*	Zimbabwe
Australian plague locust	*Chortoicetes terminifera*	Australia
Green ant	*Oecophylla smaragdina*	Australia
Red legged grasshopper	*Melanoplus femurrubrum*	Canada
Yellow mealworm	*Tenebrio molitor*	USA

Leaf cutter ant	*Atta Mexicana*	Mexico
Honey ant	*Myrmecocystus melliger*	Mexico
Domesticated silkworm	*Bombyx mori*	Thailand
Rice grasshopper	*Osya japonica*	Thailand
Field cricket	*Gryllus bimaculatus*	Thailand
Giant water bug	*Lehocerus indicus*	Thailand
Stink bug	*Tessratoma quadrata*	Lao People's Democratic Republic
Bamboo caterpillar	*Omphisa fusidentalis*	Lao People's Democratic Republic

A study estimated that 10 hectares of land is required to produce a quantity of beef protein. 2-4 hectares of land is required to produce similar amount of chicken or pork protein. 2-5 hectares of land is required to produce same amount of milk protein while only 1 hectare of land is required to produce similar amount of mealworm protein [20]. Semi-cultivation may be best strategy for edible insects. Semi-cultivation is mixture of harvesting and cultivation with manipulation of habitat and use of efficient tools and skills. Best example of semi-cultivation can be seen in case of grub (*Rhynchophorus*) which inhabit palm trees. Palm trees are cut deliberately at particular time and after one to three months grubs are harvested [21]. Major disadvantages of anthropo-entomophagy include organic and inorganic contamination, toxicity, unpalatability, bioaccumulation and allergies. Insects are usually consumed quickly after collection. Insect may be infected with pathogens and some may be toxic. There are few cases of side effects of insect too. Tremors, impaired consciousness and ataxia are reported after eating silkworm (*Anaphe venata*) in Nigeria [22]. Grasshopper and locusts consumption without removing their legs caused constipation. A study shows that, yellow mealworm larvae (*Tenebrio molitor*) bioaccumulates Cadmium and Lead in their bodies [23]. Edible insects can stimulate allergic reactions (IgE mediated) in sensitive humans. These allergies may cause eczema, dermatitis, conjunctivitis, rhinitis, congestion, angioedema and asthma [24, 25]. Sometimes chitin may also act as allergen [26]. Overexploitation is a threat for anthropo-entomophagy. Reduction in particular edible insect species may cause adverse affects on population of other insect species and ambient ecosystem. Their unsustainable harvesting may affect distribution of other species [27, 28]. A survey reveals that about 250 species of edible insects are consumed in India by many indigenous tribes. Edible insects are chosen according to their taste, tradition, season and availability. Anthropo-entomophagy is most common in North-East India. However it is also found among ethnic people of Kerala, Madhya-Pradesh, Odisha, Jharkhand and Tamil-Nadu. Negrito tribes of Andaman Islands use insects as food. Irulars tribe of Tamin-Nadu consumed winged termite as food commonly called "Easal". Cinnamon bug (*Corizus hyoscyami*) is fried and consumed in Mizoram, Assam, Manipur and Tripura [29]. Nyishi tribe and Galo tribe of Arunachal Pradesh consume short-horned grasshopper (*Chondacris rosen*) and ground cricket (*Brachytrupes orientalis*) [30]. Mishings and Ahome tribes of Assam eat red ants (*Oecophylla smargdina)* during Assames festival called "Bohag Bihu" [31]. If properly preserved and treated, edible insects and insect based food may be efficient, sustainable and safe source of nutrion [32]. According to a survey anthropo-entomophagy could be a effective mitigation tool in control of desert locust (*Schistocerca gregaria*) [33]. Another survey show that anthropo-entomophagy has many merits and potential in the post COVID time and may play a key role in global food security [34]. Some researcher emphasis that research gap must be filled before adoption of anthropo-entomophagy. Anthropo-entomophagy may raises issues regarding consumer information, animal protection and food safety [35]. An another survey says that anthropo-entomophagy is related to adventurous, daring and wild emotions, while its refusal as food is related to disgust and food nemophobia. Further age, sex, personality, emotions and motivations play key roles in developing attitudes towards anthropo-entomophagy [36]. A study also suggested that to introduce anthropo-entomophagy as regular practice, psychological motivation must be encouraged [37].

Conclusion

Feeding ever growing world population in future will be a major challenge. When we talk about food security, many alternatives are suggested such as algae, fungi, *in-vitro* meat and edible insects. Edible insects can provide good alternative and sustainable source of protein. Various edible insects are pests to agricultural crops. Eating these pests can protect the crop without chemical control. It can also provide livelihood in rural areas, particularly for women, who can harvest them with minimal expenditure and skill. Rural communities and indigenous peoples can use insect cultivation and harvesting for additional revenue generation which might be helpful in alleviating poverty. In areas where food security is minimal, edible insects might play a key role as food for coping under nutrition. Negative perception about anthropo-entomophagy is major barrier in adoption of it. In India farmers got depressed whey they face swarms of locusts and grasshoppers but they must see it as an opportunity and harvest them as additional food source. Government must popularize the slogan "eat it before it eats your crops". Government must educate and aware people about their potential as food and feed. Common misconception that insects are inferior to other protein source such as beef, eggs, chicken and fish must be removed from society. Government must evaluate, document and promote sustainable traditional practices of ethno-entomophagy.

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