Chapter 2

Review of literature

Chapter 2

2.1. History of Entomophagy

History of entomophagy dates back to millennia. According to the Bible John the Baptist at the commencement of the first millennium survived on locusts. Silk worm (*Bombyx mori*) larvae consumed by the Chinese are some of the historic evidences of entomophagy. But edible insects scientifically gained attention only until Holt (1885) attempted to contradict the western chauvinism against consuming insects. Bequaert (1921) augmented the contribution of edible insect as food for humans in the past and recent times. With much positivity the palatability and good taste of edible insects were described by Bristowe (1932). In 1951, Bodenheimer reported that the benefits of consuming insects for the environment as well as for humans. G.R. Defoliart with his series of publications between 1975 to 1999 popularized the concept of edible insects creating much impetus for carrying out further research on their nutritional status, their economic use and farming practices. Meyer-Rochow (1973) scrutinized insects used in Papua New Guinea and recommended the utilization of pest species as food. By 1975 through isolated researches around the world edible insects as a rich source of protein was established. Later on; publications emphasized mostly towards exploring the nutritional benefits as well as food safety in this protein rich food. To date largest body of work on edible insects have been produced from Africa followed by South America. From the year 1984, Ramos Elorduy started the work to identify and prepare a record of the edible insects consumed in Mexico (Ramos Elorduy 1984). This beginning quickly extended to include nutritional analysis as well for edible insects. Present fields on edible insects research has began to shift the focus to research that includes analysis into the ecological aspects of insect consumption as well as ways and means of domesticating and semi-domesticating edible insects as agricultural products.

2.2 A brief history of the Bodos

The Bodos, are a very imperative piece of the cultural mosaic of Assam, one of India's most ethnically diverse states (Boro 2015). On nutritional habits, the delicacies enjoyed by the Bodos include dried fish, insects, wild meat and small

freshwater fishes. Rice is the staple food along which the delicacies are served. A plate of rice, a bowl of roasted herbs, and a bowl of meat, fish or insect are regarded as a healthy, nutritious and a perfect diet by the Bodos since ancient times. As during ancient times fish were abundant and could be collected in large quantities, the small fishes were sun dried and was exchanged for rice and silk (*eri*) via barter system. The tools used for collecting fish, insects and mollusks were mainly two, *i.e.*, (1) the *zakai* and (2) the *palha*, the former being employed chiefly by women and the later by men (Endle 1911). Both the trapping equipments are made from split bamboo works fastened by a cane together to stitch the split bamboo together. A number of wild aquatic insects are harvested with these equipments by Bodo women without causing harm or overexploiting the ecosystem. The Bodos collect a number of wild products and edible insects comprise a major part of this wild products. Many edible insect species of these localities are still unknown and hence it is right time to document as much of the indigenous knowledge for future security.

The Bodos traditionally harvest edible insects from natural forest, so, traditional forest dwellers among the Bodos possess remarkable knowledge of insects and their management. Insects are food obtained at low environmental cost, which contributes positively to livelihoods. Sketchy reports by Bodo historians working on rural Bodo communities, suggest that insects still form an important element of the Bodos diet, tradition and culture which expands to some measure into urban communities.

2.3 Entomophagy around the world

In nearly all countries wherever edible insects are consumed traditionally, research is focused on documenting the indigenous knowledge around the insects, identifying the species used and developing databases to accumulate information (FAO 2012). Excluding Antarctica, literature on traditional entomophagy at one time or the other has been reported almost in every continent of the world. Least documented cases of entomophagy have been observed in Europe. Lengthy dormant seasons and relatively low temperatures depress the developmental rates and activities of insects therefore towards the equator as biodiversity, and activity tends to increase so do the opportunities of entomophagy (Schabel 2010). An

epigrammatic review of tradition and scientific literature associated with entomophagy in different locations will highlight its positive and negative aspects.

2.3.1 The Asia context

Excessive consumption of edible insects is generally assumed to be exclusive in tropical countries. The prevalence of insect consumption is also observed in temperate Asian countries like China and Japan. In Asia; earliest records of entomophagy were documented from China as far back as the first millennia. A number of trends in favour of entomophagy persist in Asia and some of them are well supported with literature. The historical context of entomophagy in Asia through literature can be discussed as:

2.3.1.1 Status of Entomophagy in India

The mulberry silkworm (*Bombyx mori*) is symbolized as the most ancient domesticated insect in the world. Large cultivated farms for rearing different varieties of silkworms are seen in different parts of India. The domestication of a variety of non mulberry silkworm for silk as well as food is a common scenario in Northeastern part of India. Domesticating silkworm for food is rare in other parts of India but the use of the edible pupae as poultry feed has been reported (Krishnan *et al* 2011). Feeding poultry with sericulture waste showed superior and healthier conversion rates than those achieved by feeding conventional feed stock.

Dating back to 1945, the locust *Schistocerca gregaria* was analyzed for utilizing it as human food and manure in India (Das 1945). Preliminary nutritional analysis of eight species of insects commonly consumed by tribes in Manipur area of India was determined in 1983 (Gope *et al* 1983). Vernacular names were assigned for around 42 species of insects used as food by Ao-Nagas in Nagaland (Meyer-Rochow and Changkija 1997). Scientific records on wild edible insects and their nutritional status were very scarce until 2006 except a few publications on nutrient values of domesticated silkworms were obtainable (Rao 1994; Mishra 2003). Wilsanand (2007) gave a detailed description of six insect species used in traditional therapeutics and their products for treating over 15 kinds of ailments in Kerala. Following this; four species of acridids were studied for their nutritional content which showed that acridids have a higher protein content compared with the

local conventional foods as soybean and fishmeal (Anand *et al* 2008). A brief overview of insect bioprospecting in India was presented by (Srivastava *et al* 2009). In the next year Das *et al* (2010) laid the idea of establishment of acridid farm for the production of poultry feed that could continuously produce low cost but highly nutritive feed. Edible insect became a relevant issue in Northeast India when Kato in the year 2009 for the first time observed and documented ethnozoology among Galo tribe in West Siang district of Arunachal Pradesh, Northeast India. Through Kato's data twelve species belonging to eight families and ten genera were identified as edible. The documentation on the fascinating world of insects showcased the varieties of aspects by which insects can be exploited and utilized sustainably (Lokeshwari *et al* 2010). This document attracted many to the field of insect research. Longvah *et al* (2011 and 2012) through nutritional studies testified insect as a rich source of nutrients and edible oils with high α-linolenic acid significant to nutrition.

Correspondingly in Northeast India a study on entomophagy by indigenous tribe of Dhemaji district in Assam revealed fourteen species of edible insects that are consumed as food, among them four species were also used as medicine (Doley *et al* 2011). 81 species of edible insects belonging to twenty six families and five orders found use as food among the Nyishi and Galo tribes of Arunachal Pradesh Northeast India (Chakraborty *et al* 2011). Shantibala *et al* (2012) pointed out forty one species of edible insects consumed by the ethnic communities in Manipur in Northeast India. Chakraborty *et al* (2013) prepared a consolidated list of edible insects consumed by Wancho and Nocte tribes of Tirap district and the Shingpo, Tangsa, Deori and Chakma tribes of the Changlang districts in the eastern part of Arunachal Pradesh of North East India. They recorded a total of fifty one species belonging to nine orders as edible. Again Singh (2014) reported 11 species of insects used as medicine. Shantibala *et al* (2014) analyzed the nutritional value of five aquatic insects. Again nutrients of two insects consumed in Arunachal Pradesh were analyzed by Chakraborty *et al* (2014). Twenty five species of edible insects consumed by the Bodo tribe of Assam were documented by Narzari and Sarmah (2015a). Narzari and Sarmah (2015b) analyzed the proximate composition of twenty

species of edible insects. Ghosh *et al* (2016) recommended for consideration of *O. hyla hyla* biomass as an alternative protein rich feed component in the feed of fish and livestock. Recent report of 2016 is that the nutritional and anti nutritional compositions of two species of insects *Oecophylla smaragdina* and *Odontotermes* sp. consumed in Arunachal Pradesh were analyzed by Chakraborty *et al*. (2016).

Evaluations of data on entomophagy in India specify that the full potential of insects as food and medicines still need to be apprehended in a proper manner. Literature on edible insects in India is scarce so it becomes difficult to compare results or arrive to conclusion on this topic. So the time is apt to consider the situation and document as many of the traditional knowledge among the indigenous tribes of India by redeeming everything before the knowledge erodes.

2.3.1.2 Status of Entomophagy in Thailand

Insect consumption is a very integral part of the long history of Thailand's traditions. Through research findings, above 150 insect species in eight orders are consumed in Thailand (Hanboonsong 2010). Literature on edible insects in Thailand can be traced as behind to 1932. Bristowe (1932) in his report identified a number of insects and invertebrates consumed in Siam. A report on edible insects used in various local recipes in Northeast Thailand was published by Wara-asawapiti *et al* (1975) wherein edible insects as stink bugs, water-scorpions, and mantids were listed as edible in Northeast Thailand. A study was conducted on wild forest products as edible insects encompassing the whole of Thailand (Mungkorndin 1981). Sangpradub (1982) conducted studies on edible invertebrates in northeast Thailand. The investigation revealed that insects form 44 percent of the total edible invertebrates. Sungpuag *et al* (1983) analysed nutritional value of insects and emphasized them as an unconventional source of protein for human consumption. Watanabe (1984) described 15 species, their prices, seasons and other details of edible insects sold as food at the public market in Khan Kaen, a major city of northeastern Thailand. Yhoung-Aree *et al* (1995) reported that over 50 species of insects including silk worm pupae, bamboo worms, locusts, beetles, crickets, red ants, and other insects were edible and could be consumed throughout the year thereby filling the gap in protein deficient diets.

Chen *et al* (1998) through their investigation listed nearly 48 species as edible in Thailand. Yang *et al* (2006) investigated lipid profile of six species of terricolous and aquicolous insects and found that aquicolous insects may be an alternative dietary source of C20 long-chain Polyunsaturated Fatty Acid (PUFA). Eating insects in Thailand has been popularized currently, even expensive restaurants in US, Thailand and Japan has included insects in menu (Fernquest 2013). Barennes *et al* (2015) assess the prevalence and characteristics of insect consumption among adult people and insect vendors of Laos and concluded that entomophagy is common in Laos, however a decreasing trend in consumption was seen over the last decade. As far as entomophagy is concerned, in Thailand reports on edible insects are very rare. Thailand encompasses very wealthy and varied insect fauna, but insects of Thailand have been poorly studied which is evident from the fragmentary and scanty literature on edible insects of Thailand.

2.3.1.3 Status of Entomophagy in China

A majority of the population in China consume insect. Even though the history of insect consumption in China dates back to millennia; scientific data on edible insects are not available. Early works on edible insects in China include the findings of (Shu-wen 1982; Xing 1991; Sun *et al* 1996). The book of Shu-wen beautifully portrays the eating customs and nutritive value of edible insects in ancient China. Towards 1996 a small scatter in insect research from edible to different uses was observed. (Cui 1996; Guanhuan 1998; Zimian *et al* 1997). Chen and Feng (1999) recorded overall 177 species of edible insects in China out of which around 50 of them had been nutritionally analyzed. Jach in 2003 laid an expedition in the Guangdong province of China in search of water beetles namely *Hydrophilus* and *Cybister*, farmed and sold at high price for human consumption (Jach 2003). Chen *et al* (2009) reviewed and estimated a total of one-hundred and seventy-eight insect species from 96 genera, 53 families and 11 orders as commonly eaten in China. Chinese edible black ant was investigated for its nutritional components by Shen *et al* (2006). The results indicated the insects are rich in nutrients and is a potential ingredient for health food. The fatty acid profiles of sun dried edible black ant in China were analyzed by Bhulaidok *et al* (2010). Rural utilization of insect

resources in China was finely described by Yi *et al* (2010). It is noteworthy that some ethnic groups of China are still keeping the tradition of insect consumption intact (Peng *et al* 2003). Insect rearing practices has been reported among rural communities in China. Mass rearing of insects for food would pose bigger challenge in making this protein source available on a large scale to exhume protein deficiency.

2.3.1.4 Status of Entomophagy in Japan

Early surveys conducted by Miyake in 1919 recognized 55 insects as food and 123 species as medicine in Japan (Miyake *et al* 1919). From 1934 to 1937 a series of investigation was carried out on a grasshopper species Inago that was commonly consumed in Japan. Korikawa (1934) biochemically evaluated the protein quality of Inago by feeding to experimental mice and found that it contained good quality proteins. Ichikawa (1936) commented on the chemical differences throughout seasons of the year and also between two sexes of Inago and found that compositions were high at the end and females contained protein twice to males. Ishimori (1944) through his nutritional quest on dried pupae revealed that insect contain high protein even when dried. Hocking *et al* 1960) investigated the nutrient content of bee broods and found that they were rich in protein and vitamins. Mitsuhashi (1992) a famous Japanese entomologist published *Edible insects of the world.* The more recent works of Mitsuhashi (2005) explores edible insects in Japan. Nonaka (2010) illustrated the use of edible wasps in culture and commerce of Japan. The consumption of grasshoppers and bee brood was found to be common in Japan through literature. Moreover; most of the authors have also mentioned that edible insects in Japan are rich in protein and their protein content is static even after being dried.

2.3.1.5 Status of Entomophagy in Korea

Korea has very less number of reports of insect consumption. Among the few assessable a majority of the reports available are from South Korea. Grasshoppers are preferred insect food in South Korea. Silkworm pupae are sold in local markets (Pimberton 1994). Literature on insects used in traditional Korean medicine has also been documented by Pemberton (1999). Meyer Rochow (2013)

prepared a list of insects used for therapeutics in Korea. Entomophagy is not elaborated in Korea. Series of reports are available in Korean language but the data is not assessable. More elaborate research activities can give a transparent view on entomophagy in Korea as from previous studies we can draw crystal clear conclusion that insect resources are available in Korea but they need to be exploited scientifically.

2.3.1.6 Status of Entomophagy in Malaysia

In a study conducted by Chung *et al* (2002) in Sabah Malaysia 50 species of insects were observed as edible. Entomophagy was not a common or traditional practice in Malaysia. Insects were consumed among the rural population as an alternative food. Chung (2010) traced entomophagy in Sarawak through insufficient literatures as of Bragg (1990) mentioning the consumption of the stick insect *Haaniella grayi grayi* (Westwood) eggs as a delicacy by the local people. Besides the records of Chung, no other records on entomophagy in Malaysia is available. Through the available records the potential of widening and popularizing insect food as a rich source of protein in Malaysia is desirable in near future.

2.3.2 The African context

2.3.2.1 Status of Entomophagy in South Africa

Many insect species are important items of commerce in the town and village markets of Africa (De Foliart 2002). Many Lepidopterans are popularly enjoyed as a delicacy in South Africa (Cunningham 1996). Mopane worm, *Gonimbrasia belina* is a delicacy among some local Zambians (Silow 1976; Mbata 1995; Mbata 2002). *Macrotermes subhyalinus, Usta terpsichore, Imbrasia ertli, Rhynchophorus phoenicis* are common insect foods consumed in Angola and are found to be nutritionally rich. The authors suggested the possibility of their use in exotic and acceptable food preferences (Santos Oliveira 1976). When animal proteins become unaffordable for underprivileged people, insects act as valuable sources of proteins for certain regions in Zambia (Mwizenge 1993). Teffo *et al* (2007) advocated sustainable harvesting to ensure the availability of stink-bugs of Limpopo province, South Africa due to its high demand that often exceeds the local supply. For producing insects on a commercial scale the life cycle and culture structure of two

commonly eaten worms in Zambia *Isoberlinia paniculata* and *Miombol Mopani* were evaluated by growing them on an artificial medium (Ghaly 2009). Five major types of insects eaten in most parts of Zambia included *Inswa* (flying ants), *mafulufute*, *shongonono* (green grasshoppers), *nyenje* or *chenje* (cicadas), and *finkubaba* or *motonda* (caterpillars) (Tembo 2013). Through a study conducted by Randrianandrasana and Berenbaum (2015) approximatly 65 species from seven orders of insects, including Lepidoptera, Hemiptera, Coleoptera, Odonata, Hymenoptera, Orthoptera and Mantodea, and two orders of arachnids, including Ixodida and Araneae, were recorded as the most frequently consumed arthropods in Madagascar. Entomophagy in Zimbabwe is a long-standing practice whose continuity has not been affected by revolutionized lifestyles and passage of time (Ashipala *et al* 1996; Dube *et al* 2013). Mopane worm, *Imbrasia belina* remains the most consumed and commercialized species in Zimbabwe (Dube and Dube 2010). Stinkbugs are known for their noxious defence chemicals but it is surprising that some ethnic groups Vhavenda, Mapulana, and Bolobedu of Africa has recipes that can elucidate the taste of stinkbugs luscious and attractive for commercialization (Dzerefos *et al* 2013). Egan *et al* (2014) reported the consumption of *Hemijana variegata* (Lepidoptera) a protein, fat and carbohydrate rich insect food in Blouberg Region, Limpopo, South Africa. However; around 30 insect species have been considered edible in Blouberg region (Egan *et al* 2009). Amino acid and mineral composition of African metallic wood boring beetle, *Sternocera orissa Buquet* (Coleoptera: Buprestidae), frequently consumed by certain rural communities of Limpopo Province, South Africa was investigated for its nutritional status (Shadung *et al* 2012). Nutritional analysis data of the larvae of *G. belina* consumed in semiarid subcontinent of southern Africa confirmed that it is an excellent source of many nutrients essential for growth and development of children (Clew *et al* 1999). Illgner and Nel (2000) explored the magnitude of entomophagy in Africa within the perspective of food security and indigenous knowledge. The findings visibly specified the contribution of insects to the diet of rural Africans. Womeni *et al* (2009) investigated the oils of insects consumed in sub-Saharan Africa and found that they were potential sources of polyunsaturated fatty acids that could

recompense the insufficiency of essential fatty acids in tropical vegetable oils. Insects are still commonly consumed in most African countries. The constant positive attitude of Africans towards entomophagy is appreciable.

2.3.2.2 Status of Entomophagy in Eastern Africa

Ruspolia nitidula locally known as *Nsenene* is a delicacy and has been a valuable source of income for many poor people in central Uganda (Agea *et al* 2008). The proximate amino acid composition, minerals and fatty acids of two pentatomid species consumed in Sudan were investigated. The study showed that this two pests species *Aspongupus viduatus* (melon bug) and the *Agonoscelis pubescens* (sorghum bug) have high nutritional qualities that are often in short supply in parts of Sudan (Mariod 2011). *Epiphora Bauhiniae*, a Lepidoptera: Saturniidae has enough nutrients to be candidate source of human diet or as security food item in Sudan. It is widely distributed and found especially in Gedarif, Sinnar, Blue Nile, White Nile, South Kassala, South Gazira, Kordofan and Darfur (Etalyb *et al* 2013). A study by Kelemu *et al* (2005) presented 470 species of edible insects in Africa and they mentioned Central African region as the most important hotspot of culture of entomophagy. The nutritional values of four winged termite species consumed in western Kenya were investigated (Kinyuru *et al* 2013). Literature on entomophagy is very less compared to that of South Africa but still edible insects remains the favourite of many Africans.

2.3.2.3 Status of Entomophagy in Western Africa

Insect as a source of protein in Africa was documented by (Chavunduka 1975). Four popular species consumed in South Benin reported by Tchibozo *et al* (2004) were the larvae of *Oryctes* sp., *Rynchophorus phoenicis*, *Grig brachytrupes*, membranaceus winged termites and the queen of *Macrotermes falciger* (Gerstacker). A case study conducted by Riggi *et al* (2016) among the Wamas in Benin portrayed the importance of edible insects in traditional lifestyles in a food insecure region like Benin in South Africa. Data on insect consumption of four ethnic groups of Benin in West Africa including the Anii, Fon, Nagot and Waama were also collected from 2005 to 2012 by Riggi *et al* (2016) and the study revealed twenty-nine arthropods species, a majority of them from orders Orthoptera and Coleoptera. Reports on

entomophagy from Benin in West Africa are rare but literatures described above convey that insect consumption is traditional and rich among varied tribes of Benin.

The use of the larvae of *Anaphe venata* used as food by peasant farmers in the rural areas of Nigeria was proposed to be supplement meals deficient in protein and mineral elements (Ashiru 1988). Utilitarian perspectives of seven species of edible insects that are generally acceptable within the four dominant tribes in Kwara State in Nigeria were described (Fasoranti and Ajiboye 1993). *Cirina forda, Macrotennes natalensis* and *Rhynchophorus phoenicis* were the most popular and widely marketed edible insect in Kwara State. Akanbi and Ashiru (2002) prepared a handbook of forest and wood insects of Nigeria.

Ande (2003) revealed that emperor moth *Cirina forda* consumed in Nigeria is a good source of unsaturated fatty acids, principally Linolenic acid which is renowned for its many health benefits in human. Insects are economic resource and livelihoods for many. Seventeen edible insect species from south western Nigeria were analyzed for nutrient composition and were declared as a significant part of diet among the people of south western Nigeria (Banjo *et al* 2006). Ten species of edible insects found acceptance as food in Benue state of Nigeria was shown through the study of Agbidye *et al* (2009a). Emphasizing the Tiv people in Benue state of Nigeria the techniques for harvesting and processing larvae of Emperor moth was described by Agbidye and Nongo (2009). Jonathan (2012) determined the proximate and anti-nutritional composition of two common edible insects: yam beetle (*Heteroligus meles*) and palm weevil (*Rhynchophorus phoenicis*) and found that they could serve as supplementary sources of protein and fat. Alamu *et al* (2013) compiled a list of 22 edible insects belonging to Lepidoptera, Coleoptera, Orthoptera, Isoptera, Hemiptera and Hymenoptera. Ekpo (2010) showed that the larva of *Rhynchophorus phoenicis* consumed in Nigeria if defatted upto a level could form a base for new food or feed products of considerable nutritive value. Nutrients discovered from *Epiphora bauhiniae* pupal stage of Sudan in northeast Africa are important agents for human health. This species, can contribute two revenues from the same source (nutrients and silk) creating new income for the farmers in the rural areas thereby contributing to national income of Sudan (Eltayb *et al* 2013). Through

literature it is confirmed that Nigeria has its own allocate of edible insects and caterpillars, mostly gathered from bushes and farmlands and eaten or sold in school premises and open markets. The culture of eating insects in Nigeria is rich and is well supported by literature dealing with their nutritional value, host plants, collecting techniques, processing methods and their sustainable use. Literature on entomophagy in North African countries has scanty documentation except Sudan.

Insect foods or entomophagy is common in southern, western and eastern parts of Africa. In most of the countries of Africa species from order Lepidoptera are mostly consumed and commercialized.

2.3.3 The American context

2.3.3.1 Status of Entomophagy in Mexico

The earliest literature describing the different benefit of insects to man from North America was "Man in a world of insects" by Delong (1960). The pioneering work on edible insects in North America comes mainly from Mexico. Highest literatures on edible insects have been contributed by Ramous Elorduy of Mexico (1997). De Conconi *et al* (1984) initially analyzed the protein content of 101 insect species and concluded that they are rich in protein and their amino acid profiles were favourably comparable with those recommended by the Food and Agriculture Organisation (FAO 1981). Works on edible insects initially began as a record of edible insects of an area but it rapidly broadened to wider areas of research as nutritional analysis. In the year 1987 the attitude of western people towards edible insects was discussed by Ramos-Elorduy (1987). Pemberton (1988) described the use of the Thai giant waterbug, *Lethocerus indicus,* as human food in California. Ladron de Guevara *et al* (1995) analysed the amino acids content of edible insects from various province and found that the amino acid content in insects were higher than adult requirements as indicated in (FAO/WHO/UNU 1985) values. Efforts for farming and sustainable developments of edible insects to provide a reliable and sustainable source of high-quality animal protein were emphasized through many publications (Ramos-Elorduy 1997; Ramos-Elorduy 2008; Ramos-Elorduy 2009). 178 species of edible insects included in 8 orders were recorded in Chiapas, Mexico of which 99.5% of the species recorded were terrestrial (Ramos-Elorduy 2002).

Through a review study in Hidalgo, Mexico 14 species were found to be in threatened category which was alarming for Mexico (Ramos-Elorduy 2006). Cerritos and Cano-Santana (2008) proposed that the manual harvest of edible insects is a practical method of pest control and can be extensively applied in other crop systems in Mexico or in any part of the world in lieu of pesticides. Acuna *et al* (2011) investigated 17 species of insects and a new record (Mormidea (Mormidea) notulata, Hemiptera: Pentatomidae) for the state of Puebla in Mexico which added a new record for the Edible insect database in Mexico. The nutritive value of 25 edible Orthoptera in Mexico was publicized and the quantity and quality of nutrients of these edible orthopterans could provide a significant nutrient to the peasants who consumed them (Ramos-Elorduy 2012). A total of eight stingless bees species in municipality of Nocupetaro, Michoacan, Mexico as well as three additional unidentified taxa recognized by people through the local names were obtained through a study by Reyes-Gonzalez (2014).

Ecological studies are particularly important especially when investigating the impact of harvesting on insect communities. As Ramos-Elorduy in the year 2006 in a study on threatened edible insect species of Hidalgo, Mexico, pointed out that overharvesting of 14 edible insects has led to the degradation of their ecosystem. Since then various research has listed a number of contingency measures to prevent this degradation. The long history of research on edible insects in Mexico has enabled to generate a useful and emergent database of edible insect species in Mexico (Acuna *et al*. 2011).

2.3.3.2 Status of Entomophagy in South America

Fewer literature on entomophagy from South America is available. As reported by Kenneth (1973) many Yukpa subgroups at present face shortages of animal protein due to the macrofauna depletion. Insects belonging to 22 genera and 7 orders were deemed edible and was worth in supplying proteins in protein deficient diets to the subgroups. Ancestral tradition of entomophagy was observed among the native isolated population in Ecuador. 83 edible insects included in order Coleoptera and Orthoptera were listed to be consumed by the natives (Onore 1997). The use of insects as medicines was observed among Brazilians. Around 42 species belonging

to nine orders with a majority of Hymenopteras found use in folk medicine in the state of Bahia, northeastern Brazil (Costa-Neto 2002). Entomophagy in South America has less supportive literature hence entomophagy is not well studied until recent times.

History of entomophagy over the last two decades, have been characterized by several conferences and many publications (Yen 2009). Most publications on edible insects deal with the descriptive overviews in different countries and annotations on the indigenous knowledge such as the ways diverse ethnic communities identify, collect and consume insects. The major portion of this literature is related to a variety of ethnic communities with unique traditions in Asia, Africa, America and to some extend Australia. Research focused on traditionally insect consuming countries include activities as the documentation of indigenous knowledge around the insects, species identification and storing information as databases (FAO 2012). Industrialised, and Western countries focuses mainly on developing insect products, and increased palatability of insect protein to promote consumption (Van Huis 2010). Literature of entomophagy in Europe and Australia is very scanty and is inaccessible still some fragmentary literatures on entomophagy have been observed in this two continents (Harris 1987; Siemianowska *et al* 2013). Overall it is repeatedly referenced that premeditated entomophagy is very infrequent in westernized civilizations.

2.4 Review on the Nutritional Value of edible insects

Insects as biological resources have not been utilized all around the globe. Insects as a suitable source of nutrition for humans have already been proven through various studies in most of the continents. Insects are delicious food in many cultures of the world. The nutritive value offered by insects is an attraction for many nutritionists health workers and physicians (Xiaoming *et al* 2010). Banjo *et al* (2006) documented the nutritional value of edible insects in South western Nigeria (Banjo *et al* 2006). Fatty acid composition of some edible dung beetles in Thailand were interpreted by Bophimai *et al* (2010). Study on nutritional and fatty acid profiles of sun dried edible insects was performed by Bhulaidok *et al* (2010). Complete nutrient content of four species of feeder insects was described by Finke

et al (2012). Tom *et al* (2013) elaborately described the nutritional constituents of wild silk moth in Sudan. Crude protein analysis contents of numerous edible insects from Mexico and Central Africa, on a dry weight basis exceeded 80 percent and ranged as high as 82 percent, with digestible protein as high as 64 percent (Ramos Elorduy 2005; De Foliart 1989). Emperor moth caterpillar (*Cirina forda*) was nutritionally investigated for proximate, amino acid, fatty acid and mineral compositions, the findings were high protein and lipid contents of 31.40 ± 0.3 and 16.12 ± 1.1 (% dry weight). Nutritional value of *Rhynchophorus palmarum L*. Larva was analyzed by Gbogouri *et al* (2013). Proteins in this species were found to be rich in essential amino acids with a high protein score ranging between (90% to 172%) and (52.4%) of unsaturated fatty acids with linoleic and linolenic acids. The nutritional value of edible insects in Northeast India was documented. The documentation showed that their protein content is of significance (Narzari and Sarmah 2015b; Chakraborty *et a*l 2016; Shantibala *et al* 2014).

Insects are also rich in minerals a majority of edible insects have a very high proportion of K, Ca, Fe and Mg (Ramos- Elorduy 2005). Owing to their status as a delicacy and palatability edible insects are marketed profitably in public places as open markets in insect consuming regions of India. Indian tribals know their way around to the sustainable use of insects in multiplicity of conducts. Edible insects consumed contain valuable protein, good quality digestible fatty acids and considerable amounts of vitamins and minerals have been proved by many researchers throughout literature. Ethnoentomology should be a field of research with inputs from multidisciplinary disciplines encompassing the subjects of life sciences. The goal to utilize and promote insects as food and feed involve long process as recognition, identification, nutrient test, storage and marketing, this can create more opportunities to improve rural livelihoods and regional and national economies.