International Journal of Biodiversity and Conservation Vol. 5(4), pp. 215-222, April 2013
Available online http://www.academicjournals.org/IJBC
DOI: 10.5897/IJBC12.121
ISSN 2141-243X ©2013 Academic Journals

Full Length Research Paper

Diversity and nutritional status of edible insects in Nigeria: A review

Alamu, O. T.[1]*, Amao, A. O.[1], Nwokedi, C. I.[1], Oke, O. A.[2] and Lawa, I. O.[3]

[1]Savanna Forestry Research Station, P. M. B. 1039, Samaru, Zaria, Nigeria.
[2]National Horticultural Research Institute (NIHORT), Ibadan, Nigeria.
[3]Forestry Research Institute of Nigeria, Jericho, Ibadan, Nigeria.

Accepted 14 December, 2012

Information on insects as food in Nigeria was collected by reviewing the literature of what scientists have done locally in the country. A list of 22 edible insect species from six orders were compiled. Of these, 77.3% were Lepidoptera (27.3%), Coleoptera (27.3%), Orthoptera (22.7%) and 22.7% Isoptera, Hemiptera and Hymenoptera. These insects are rich in protein, vitamins and minerals. Some anti-nutritional factors are detected from some insects but the contents are below toxic level to man. Edible insects have a wide range of host plants from forest trees to agricultural crops and their consumption stages are available at different periods of the year. They are collected by hand picking, digging of soil and luring into water traps at night. Processing of collected insects could be carried out by boiling, sun drying, frying and roasting methods. To manage insects in the interest of food security, more attention should be given to environmentally sustainable collecting methods. These insects could be made better available throughout the year by developing improved conservation methods or by raising them as a minilivestock. Considering the economic, nutritional and ecological advantages of this traditional food source, its promotion deserves more attention both from national governments and assistance programmes.

Key words: Diversity**,** Nigeria, edible insects, collection, insects as food, conservation.

INTRODUCTION

Insects are the biggest animal group on earth; the immense biodiversity harboured by the class insect is reflected in the well-known fact that this single class has more species than all the species of all other classes of animals combined. Indeed insects constitute as much as 80% of the animal kingdom (Premalatha, 2011). Today, over 1,600 species of insects are eaten deliberately by humans, but cultures are highly variable, spanning the spectrum from active avoidance to occasional and substantial consumption (Raubenheimer and Rothman, 2012). Most humans in developed countries regard the consumption of insects with some revulsion, and where exceptions occur, insects are generally considered as food more for their novelty than their nutrients, for example, embedded in chocolates or ice cream (Johnson, 2010), or as a means of survival when wilderness adventures go wrong (Yoshimoto, 1999). However, this may not apply in all cases; for example, in Japan, insects are eaten as part of the traditional diet (Nonaka, 2010), and in some parts of Italy (Overstreet, 2003) and Croatia (Miokovic et al., 1997) the cheese maggot (*Piophila casei* L.) is regarded as a delicacy.

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). Some edible insects have nutritional value that can be compared with that of meat and fish, while others have higher proportion of proteins, fat and energy value (De Foliart, 1992). In West and Central Africa, insects are not used as emergency food to strive against starvation, but are included as a normal part of the diet throughout the year or in seasons of occurrence (Banjo et al., 2006).

Considering the popularity of the edible insects, it is not

*Corresponding author. E-mail: olaniyialamu@yahoo.com.

surprising that scores of species have been and are prominent items of commerce in the town and village markets of Africa, tropical and semi-tropical regions of the world (De Foliart, 2002). In several areas of Zimbabwe, South Africa, Zambia and Nigeria, many families make fairly good living from selling insects (Chavunduka, 1975; Fasoranti and Ajiboye, 1993; Mbata and Chidumayo, 2003; Adeduntan and Bada, 2004). Nigeria also has its own share of edible insects and caterpillars, most of which are gathered from bushes and farmlands by women and children, processed and eaten or sold in school premises and open markets.

This article argues that the eating of insects is a common practice in Nigeria. It deals with the diversity of edible insects in Nigeria, their nutritional value, host plants, collecting techniques and the processing methods. It is also argued that edible insects should receive more attention, in particular on how to manage this sustainable food source in the interest of food security and wealth creation.

MATERIALS AND METHODS

The information presented here was collected by reviewing the literature of the works scientists have done on edible insects in Nigeria and the proofs of their nutrient status that guarantee their inclusion as food components. Local libraries and the internet were used as sources of information. Literature information from the internet was obtained using the key words such as edible insects, diversity of edible insects, nutrient status of edible insects, anti-nutrients in edible insects and methods of processing edible insects. From the resulting articles, a selection was made of those focusing on edible insects most especially as it relates to Nigeria and their nutrient composition. Some of the numerical data collected especially on crude protein, crude fibre, vitamins A, B and C were compiled in a Microsoft Excel spreadsheet and for each nutrient; the mean and the range were calculated.

RESULTS AND DISCUSSION

Diversity of edible insect species in Nigeria

Table 1 shows a list of some edible insects in Nigeria, plant hosts, period of occurrence during the year and the stages at which they are consumed in their developmental cycle. Twenty two (22) insect species from six different orders have been recorded with potential for consumption among the three major ethnic groups (Yoruba, Hausa and Ibo) in Nigeria. These insect orders are Isoptera, Orthoptera, Coleoptera, Hymenoptera, Hemiptera and Lepidoptera. Of these, the majorities are Lepidoptera (27.3%), Coleoptera (27.3%) and Orthoptera (22.7%); below 20% are the Isoptera (13.6%), Hemiptera (4.5%) and Hymenoptera (4.5%) (Figure 1). Winged reproductive and queen castes are consumed in the order Isoptera, adults in the orders Orthoptera and Hemiptera, larvae in the orders Coleoptera and Lepidoptera, while in the order Hymenoptera, eggs, larva and pupa stages are consumed.

Yam beetle (*Heteroligus meles*) and grass - hopper (*Zonocerus variegatus*) are commonly eaten by some people in South Eastern Nigeria and some parts of Benue State while Grubs of the palm weevil, *Rhynchophorous phoenicis* Fabr. (Coleoptera: Curculionidae), are eaten in several parts of Oyo, Ondo, Osun, Ekiti, Ogun, Lagos (western Nigeria), Delta and Edo States (Ekop et al., 2010; Elemo et al., 2011). The larva of *Oryctes monoceros* is consu-med in the Niger Delta regions (Ifie and Emeruwa, 2010). The population of variegated grasshopper, *Z. variegatus* (Linn.) (Orthoptera: Pyrgomorphidae) is high during the dry season in southwestern Nigeria; and has been repor-ted eaten in the Akoko area of Ondo State (Fasoranti and Ajiboye, 1993). The winged termites are known locally in various parts of Nigeria by different names such as ‘aku’ in Ibo, ‘chinge’ in Hausa and ‘Esusu’ in Yoruba and are regarded as traditional delicacies (Fasoranti and Ajiboye, 1993). *Macrotermes nigeriensis* and *Macrotermes bellicosus* are enjoyed in all parts of Nigeria, especially because it is present at the onset of the rainy season when livestock is lean, new crops have not yet produced food, and store produced from previous growing season is running low (Banjo et al., 2006; Igwe et al., 2011). *Anaphe venata* larvae (African Silkworm) are commonly found and consumed in Western part of Nigeria (Iwalewa et al., 2005). *Cirina forda, Bunaea alcinoe, Macrotermes natalensis and Brachytrupes membranaceus* are all marketed and consumed in different parts of Benue State (Agbidye et al., 2009). The larvae of *C. forda* are consumed among the Yoruba and Nupe tribes of Kwara and Niger States respectively (Fasoranti and Ajiboye, 1993). The dung beetle, *Aphodius rufipes* has been reported as a traditional delicacy of the Gbagyi people in Niger State (Paiko et al., 2012). The caterpillar of *B. alcinoe* is popularly called *Egu and consumed* by the Igbo speaking tribe of eastern and southern part of Nigeria (Amadi et al., 2005; Braide et al., 2010b). The larva of *Lepidoptara litoralia* is common and consumed in the North Central region of Nigeria especially in Plateau State (Solomon and Prisca, 2012).

Observation on the distribution and consumption of edible insects in Nigeria revealed that the practice of entomophagy is common in the humid forest, derived savanna and some parts of Southern Guinea Savanna agro-ecological zones of the country (Figure 2). The occurrence of the plant hosts of most of these insects is common in these three agro-ecological zones than in the far northern parts of the country. This is because the climate of the Southern and middle belt of Nigeria supports the growth of trees than savanna regions where the vegetation is mainly grasses with scattered trees. However, that does not suggest that edible insects are not available in the northern parts of the country. The practice of entomophagy is not well pronounced in the northern Nigeria which is predominantly of Hausas probably due to cultural reasons. Another reason may be the possibility of insufficient work on the subject of entomophagy and its documentation in literatures in this part of the country.

Table 1. Some edible insects in Nigeria.

Scientific name	Common name	Order	Family	Plant/food host	Seasonal occurrence	Consumption stage
Macrotermes nigeriensis	Termite	Isoptera	Termitidae	Timber woods	May - June	Winged adult, queen
Macrotermes bellicosus	Termite	Isoptera	Termitidae	Timber woods	May - June	Winged adult, queen
Macrotermes natalensis	Termite	Isoptera	Termitidae	Timber woods	May - June	Winged adult, queen
Brachytrupes membranaceus	Giant African cricket	Orthoptera	Gryllidae	Yam	July – September	Adult
Gymnogryllus lucens	Cricket	*Orthoptera*	Gryllidae	Yam	July - September	Adult
Cytacanthacris naeruginosus	Short horned grasshopper	Orthoptera	Acrididae	Grasses	May-October	Adult
Zonocerus variegatus	Grasshopper	Orthoptera	Pygomorphidae	Cassava	November – April	Adult
Gryllotalpa africana	Mole cricket	Orthoptera	Gryllotalpidae	Rice	Year round	Adult
Analeptes trifasciata	Stem girdler	Coleoptera	Cerambycidae	Cashew	October - February	Larva
Oryctes boas	Rhinoceros beetle	Coleoptera	Scarabaeidae	Coconut tree	June – July	Larva
Oryctes monoceros	Rhinoceros beetle	Coleoptera	Scarabaeidae	Coconut tree	June – July	Larva
Aphodius rufipes	Dung beetle	Coleoptera	Scarabaeidae	Cow dung	June-July	Larva
Rhynchophorus phoenicis	Palm weevil	Coleoptera	Curculionidae	Oil palm	December - May	Larva
Heteroligus meles	Yam beetle	Coleoptera	Dynastidae	Yam	November - March	Larva
Nezara viridula	Stink bug	Hemiptera	Soya bean		May - October	Adult
Apis mellifera	Honey bee	Hymenoptera	Apidae	Flowering plants	Year round	Egg, larva, pupa
Anaphe venata	African silkworm	Lepidoptera	Notodontidae	Obeche tree	July – September	Larva
Anaphe infracta	African silkworm	Lepidoptera	Notodontidae	Obeche tree	July – September	Larva
Anaphe recticulata	African silkworm	Lepidoptera	Notodontidae	Obeche tree	July – September	Larva
Bunaea alcinoe	Emperor moth	Lepidoptera	Saturnidae	African Mahogany	June – July	Larva
Lepidoptara litoralia	-	Lepidoptera	-	Isoberlina	August – September	Larva
Cirina forda	Pallid emperor	Lepidoptera	Saturnidae	Shea butter tree	June - August	Larva

Sources: Banjo et al., 2006; Agbidye et al., 2009; Ekop et al., 2010; Ifie and Emeruwa, 2011; Igwe et al, 2011; Opara et al., 2012; Solomon and Prisca, 2012.

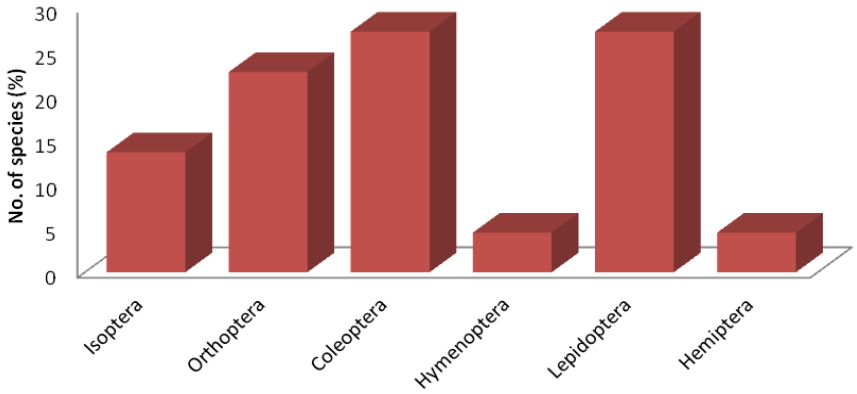

Figure 1. The percentage of insect species per order eaten in Nigeria.

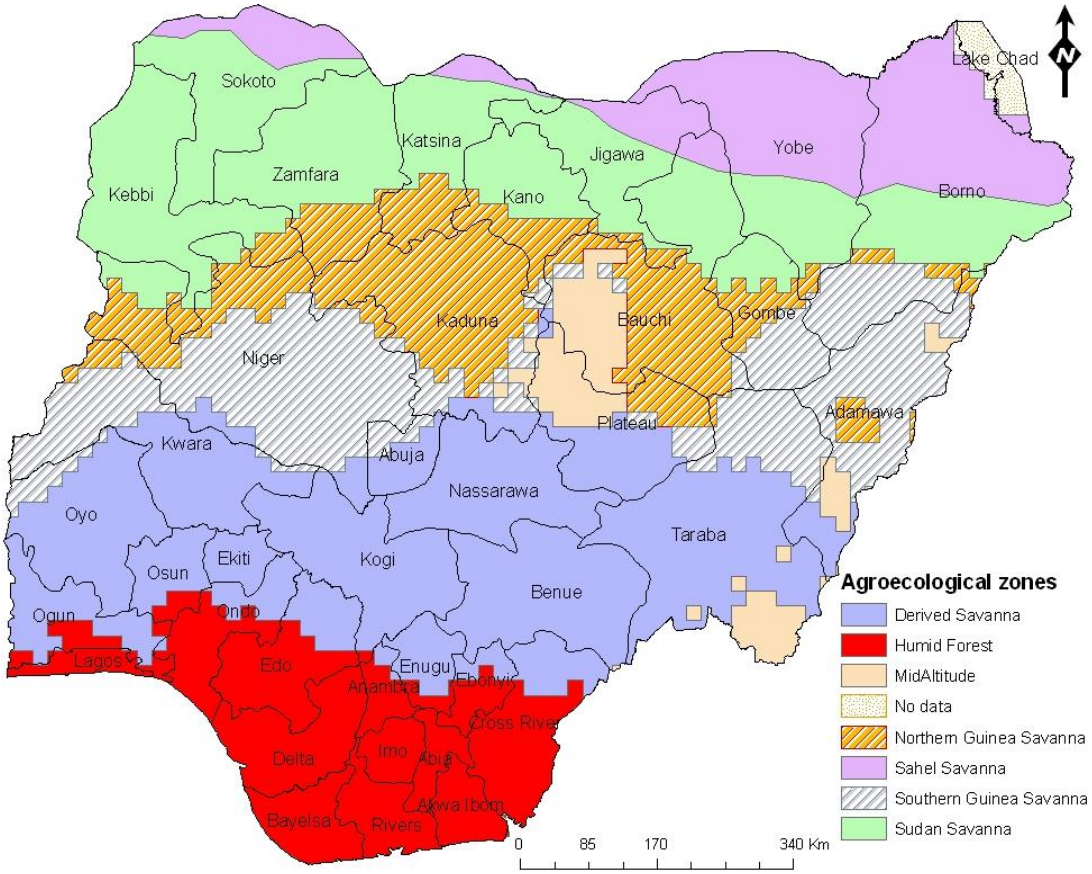

Figure 2. Map of Nigeria showing different States and agroecological zones.

Nutritional values of edible insects in Nigeria

Crude protein and fibre

The crude protein and crude fibre of some edible insect orders in Nigeria are reported in Table 2. The highest amount of crude protein is found in insects in the order Lepidoptera followed by the order Coleoptera, while the order Hymenoptera has the least. Insects in the orders Coleoptera and Isoptera have high crude fibre content than the Orthoptera, Lepidoptera and Hymenoptera.

Edible insects have been shown to have higher protein content, on a mass basis, than other animal and plant foods such as beef, chicken, fish, soybeans, and maize (Teffo et al., 2007). Protein is the basis of all organism activity and constitutes many important materials such as enzymes, hormones and haemoglobin. Protein is an important component of antibodies as it bolsters the immunity function of the body. It is the only material to produce nitrogen for maintaining acid and alkali balance, transforming genetic information and transporting important materials in the human body. As a nutritive element that produces heat, it can supply energy. The nutritional value of food largely depends on the quality of the protein that it contains. This in turn, is determined to a great extent, by the amino acid composition. In the majority of edible insects, either tryptophan or lysine is the first limiting amino acid (Bukkens, 1997). However, the presence of lysine has been reported in *Rhychophorus phoenicis* (Elemo et al., 2011) and tryptophan in *Oryctes monoceros* (Ifie and Emeruwa, 2011). The inclusion of these insect species in diet could be of immense benefit in complementing lysine-poor staple cereals.

Vitamins

Vitamins are one group of organic compounds that are necessary for metabolism in human bodies. As vitamins cannot be synthesized in the human body, they must be supplied constantly by food. The vitamin contents of some insect orders are shown in Table 3. Each of the orders contains appreciably high amounts of vitamins A, B2 (riboflavin) and C. *The termite, M. nigeriensis has also* been reported with appreciable amounts of vitamins B3 (niacin) and B1 (thiamine) in addition to vitamins A and C (Igwe et al., 2011). Vitamin C maintains blood vessels flexibility and improves circulation in the arteries of people including smokers. One of the most important benefits derivable from vitamins A and C is their role as antioxidants, oxygen free radical scavengers, while that of the

Table 2. Protein and fibre contents in some edible insect orders in Nigeria.

Insect order	N	Crude Protein		Crude fibre	
		Range	Mean	Range	Mean
Isoptera	3	20.4 – 22.1	21.15	2.2 – 5.7	3.53
Coleoptera	6	26.0 – 37.63	30.07	1.96 – 28.12	8.30
Orthoptera	4	6.25 – 50.75	23.98	1.01 – 2.40	2.05
Lepidoptera	6	18.9 – 74.34	30.37	1.68 – 5.55	2.81
Hymenoptera	1		21.00		2.00

N, Number of insect species in each order. Sources: Banjo et al., 2006; Ekop et al., 2010; Ifie and Emeruwa, 2011; Igwe et al., 2011; Solomon and Prisca, 2012.

Table 3. Vitamin (mg/100 g) contents in some edible insect orders in Nigeria.

Order	N	Vitamin A		Vitamin B2		Vitamin C	
		Range	Mean	Range	Mean	Range	Mean
Isoptera	3	0.026 – 0.05	0.14	1.54 – 1.98	1.69	3.01 – 17.76	8.06
Coleoptera	3	0.086 – 0.125	0.11	0.08 – 2.62	1.64	4.25 – 7.59	5.75
Orthoptera	3	0.0 – 0.068	0.03	0.03 – 0.08	0.06	0.0 – 8.64	3.21
Lepidoptera	5	0.028 – 0.034	0.03	0.09 – 2.21	1.50	1.95 – 4.52	2.83
Hymenoptera	1		0.12		3.24		10.25

N, Number of insect species in each order. Sources: Banjo et al., 2006; Ekop et al., 2010; Ifie and Emeruwa, 2011; Igwe et al., 2011.

B-vitamins is their role as co-enzymes in several enzyme systems of the body. The high vitamins content of edible insects presents them as a highly potential, good source of food supplement for malnourished people and animals.

Mineral elements in edible insects

The mineral profile of some edible insects in Nigeria is presented in Table 4. These insect species contain appreciable amounts of calcium (Ca), iron (Fe), phosphorus (P) and magnesium (Mg). Other mineral elements like potassium (K), sodium (Na), zinc (Zn), manganese (Mn) and copper (Cu) have been reported in *O. monoceros*, *M. nigeriensis* and *R. phoenicis* (Elemo et al., 2011; Ifie and Emeruwa; 2011; Igwe et al., 2011). Minerals are known to play important metabolic and physiologic roles in the living system. Iron, zinc, copper and manganese strengthen the immune system as antioxidant enzyme cofactors (Talwar et al., 1989). Similarly, magnesium, zinc and selenium prevent cardiomyopathy, muscle degeneration, growth retardation, impaired spermatogenesis, immunelogic dysfunction and bleeding disorder (Chaturvedi et al., 2004). Iron deficiency is a major problem in women's diets in the developing world, particularly among pregnant women, and especially in Africa (Orr, 1986). Vegetarians everywhere are at risk of zinc deficiency. Magnesium is needed for more than 300 biochemical reactions in the body. It helps to maintain normal muscle and nerve function, keeps heart rhythm steady, supports a healthy immune blood and regulates blood sugar levels (Saris et al., 2000). Therefore, edible insects can supply necessary nutritive elements for human body functions and could be consumed along with other food and animals rich in other essential minerals to further complement the diet of these insects.

Carbohydrates and fats

Carbohydrates and fats are important nutritive elements in the human body. They are the main energy source, can reduce consumption of protein and help detoxification. Ekop et al. (2010) reported 13.08, 21.71, 22.70 and 24.90% dry weight for *G. lucens* (cricket), *H. meles* (yam beetle), *R. phoenicis* (palm weevil) and *Z. variegatus* (grasshopper), respectively. *M. nigeriensis* was also reported to contain 20.70% by composition of carbohydrate (Igwe et al., 2011) while *C. forda* contains 54.30% by composition (Osasona and Olaofe, 2010). These insect species may not be desirable as a good source of carbohydrate as human adult need about 400 to 500 g carbohydrate intake as starch.

The termi*te, M. nigeriensis* has also been reported to be rich in oleic acid, palmitic acid and linoleic acid, an essential fatty acid, but poor in myristic acid, lauric acid and palmitoleic acid (Igwe et al., 2011). It was further reported (Igwe et al., 2011) that the total saturated fatty acid content of the termite is 39.35%, while that of the unsaturated fatty acids is 60.64%, with monosaturated fatty acids (MUFA) comprising 53.07% and polyunsaturated fatty acids (PUFA) making up 7.57% only. It is noteworthy that saturated fatty acids are not good for human consumption because they have been implicated in

Table 4. Mineral and ash (mg/100g) contents in some edible insects of Nigeria.

Insect specie	Ca	P	Fe	Mg	Ash
M. nigeriensis	1.00*	14.90*	9.56*	60.96*	7.60*
M. bellicosus	21	136	27	0.15	2.90
M. natalensis	18	114	29	0.26	1.90
Brachytrypes spp.	9.21	126.9	0.68	0.13	1.82
C. aeruginosus	4.40	100.2	0.35	0.09	2.10
Z.variegatus	42.16	131.2	1.96	8.21	1.20
A. trifasciata	61.28	136.4	18.2	6.14	4.21
A. infracta	8.56	111.3	1.78	1.01	1.60
A. recticulata	10.52	102.4	2.24	2.56	2.50
L. litoralia	12.0	9.00	19.50	0.50	4.30
A. venata	8.57	100.5	2.01	1.56	3.20
C. forda	8.24	111.0	1.79	1.87	1.50
A. mellifera	15.4	125.5	25.2	5.23	2.20
O. boas	45.68	130.2	2.31	6.62	1.50
O. monoceros	NA	NA	85.00	175.00	10.50
G.lucens	NA	NA	NA	NA	6.40
R.phoenicis	54.1	685.0	30.8	131.8	2.70
A. rufipes	42.16	131.2	30.82	11.72	2.74

*mg/kg body weight ; NA, not available. Sources: Banjo et al., 2006; Ifie and Emeruwa, 2011; Igwe et al, 2011; Paiko et al., 2012; Solomon and Pisca, 2012.

certain cardiovascular disorders such as atherosclerosis, cancer and aging (Anita et al., 2006). However, the low saturated fatty acid and high desirable unsaturated fatty acid contents of *M. nigeriensis* may consider it an important food component for those who have high blood cholesterol content and probably at a risk of cardiovascular disease.

Anti-nutrient components of edible insects

Anti-nutrients such as hydro-cyanide, oxalates, phytates and tannins have been reported in edible insects in Nigeria (Ekop et al., 2010; Ifie and Emeruwa, 2011). The presence of hydro-cyanide (HCN) (2.187 to 3.203 mg/kg), oxalate (13.20 to 28.40 mg/kg), phytate (0.28 to 0.289 mg/kg) and tannin (0.329 to 0.430 mg/kg) are found in four edible insects: *G. lucens* (cricket), *H. meles* (yam beetle), *R. phoenicis* (palm weevil) and *Z. variegatus* (grasshopper), respectively (Ekop et al., 2010).

Tannin (14.3 mg/100 g), phytic acid (178 mg/100 g) and oxalate (2.1 mg/100 g) have also been reported in *O. monoceros* (Ifie and Emeruwa, 2011). High level of HCN has been implicated for cerebral damage and lethargy in man and animals (Akyildiz et al., 2010). The lethal dose of HCN to human is considered to be 35mg (Oke, 1969) while NRC (1974) gave the toxic level to be between the range 50 to 200 mg/100 g.

Oxalates are known to sequester and precipitate some useful metallic elements, thus making them unavailable for adsorption in human system (Groff et al., 1995). The lethal dose of oxalate is between 200 and 500 mg/100 g (Pearson, 1973). Phytate, like oxalates, limit the availability of some notable minerals like magnesium, iron, and even calcium (Groff et al., 1995). Phytic acid has also been implicated in the removal of phosphorus and causing indigestion and flatulence in human system (Ndubuakaku et al., 1989). Tannins possess both toxic and therapeutic functions. They are toxic in that they coagulate protein (Groff et al., 1995). Tannins are capable of lowering available protein by antagonistic competetion and can therefore elicit protein deficiency syndrome (Ekop, 2004). However, anti-nutrients analyses of *G. lucens, H. meles*, *R. phoenicis* and *Z. variegatus* showed that the values of HCN, oxalate, phytates and tannins in them are negligible and are considered to be below toxic level in humans when consumed. In addition, with detoxification through processing, edible insects are safe for consumption.

Host plants, seasonal occurrence, collection and processing of edible insects in Nigeria

Edible insects are associated with one or more host plants and their collection depends on the season in which the consumption stage is available. The seasonal occurrence of the Grubs of the palm weevil, *R. phoenicis* Fabr. (Coleoptera: Curculionidae) on the field is from December to May (Opara, 2012). They are collected from the trunks of palm trees and are eaten fried (Banjo et al., 2006). The larva of *O. monoceros* is collected between June and July

during the year and commonly consumed raw, boiled, smoked or fried (Ifie and Emeruwa, 2011). The consumption stage of *L. litoralia* is present on its host tree, *Isobelina doka* between August and September. The caterpillars of *L. litoralia* are processed by boiling and sun drying (Solomon and Pisca, 2012). Termites feed on different tree species in Nigeria (Malaka, 1973; Agwu, 1981; Ashiru, 1988; Appiah and Aisagbonhi, 2000; Akanbi and Ashiru, 2002). They are usually attracted to sources of illumination during nuptial flight at the onset of rainy season. They are collected by women and children by placing a bowl of water under a light source. In most parts of Nigeria, *M. nigeriensis* is processed by washing, salting to taste and mild frying or roasting. Oil is not usually needed during frying, since their bodies are naturally rich in oil (Igwe et al., 2011). It can also be consumed as raw food. The pallid emperor moth, *C. forda*, is a defoliator of Shea butter tree, *Vitellaria paradoxa* and is collected during the rainy season between June and August (Odeyemi and Fasoranti, 2000; Agbidye and Nongo, 2009). The larvae are usually boiled and dried in the sun before they are sold (Fasoranti and Ajiboye, 1993; Agbidye et al., 2009). The larva of the moth, *Bunaea alcinoe,* is a defoliator of many forest trees including *Parkia biglobosa*, *Prosopis africana*, *Khaya senegalensis* and are present on the field between June and July (Akanbi and Ashiru, 2002). They also feed on the leaves of some economic and ornamental plants such as *Gmelina arborea, Spondias mombim, Pentaclethra macrophylla, Terminlia cattapa, Cananga odorata, Harungana madagascariensis, Anthocleista* species, and cause enormous defoliation of the trees. The leaves are rich in nutrients (Braide et al., 2010b) and provide food for the highly voracious larvae. The matured larvae are usually collected directly from the leaves or handpicked when they fall on the ground. It is also a common practice by some collectors to dig out larvae that burrow into the ground to pupate. The large African cricket, *Brachytrupes membranaceus*, is a pest of forest nurseries where severe defoliation may result (Akanbi and Ashiru, 2002; Hill, 1983). They are collected by digging them out of their holes in the ground. Adult crickets are eaten as fried or roasted.

Most of the insects consumed in Nigeria are available for collection during the rainy season due to availability of their host plants. The edible larvae at this time feed voraciously and grow robust with food store up in their fat bodies. The sluggishness of the insect at their larva stage make their collection becomes easy. Excess of large collections of insects made during the season of occurrence are processed and kept to be sold at high prices during the off seasons.

Conclusion

Edible insects are rich in protein and amino acid, especially essential amino acids for the human body. They are one source of good protein. They can supply rich fat, fatty acid, mineral elements, vitamins and carbohydrates, especially high unsaturated fatty acid, which has an excellent nutritive value. Most of the edible insects reported in Nigeria largely depend on forest for their survival. Foresters worldwide have traditionally looked at insects as either a nuisance or as tree and wood pests, something to be avoided, suppressed or controlled. Several efforts have been made in different parts of the world to wage war against forest insects. However, we currently seem to have more forest pest problems than ever, and with the current invasion of exotics and anticipated effects of global warming, the trend appears upward. Schabel (2008) in his opinion advocated for a rethink from forest entomology, the management of pest insects for the sake of trees, to *entomoforestry*, which concerns itself with managing trees and forests for the sake of edible and other useful insects. This may in turn open up at least supplementary perspectives for forest management and potentially fostering the development of forest-based insect industries (Schabel, 2006). Especially where food security is at stake, traditional entomophagy must become a priority and be taken from opportunistic extraction to the next level, that is, regulatory mechanisms and the deliberate, science-based manipulation of forest edible insects, in or out of their natural habitat.

Van Huis (2003) reported that the use of traditional food is sustainable and has economic, nutritional and ecological benefits for rural communities in sub-Saharan Africa. Therefore to manage insects in the interest of food security, more attention should be given to environmentally sustainable collecting methods, the use of improved conservation practices, the enhancement of cottage industries for farming insects and the development of economically feasible ways of mass-rearing edible species. This can be achieved with the cooperation of all stakeholders in food security.

REFERENCES

Adeduntan SA, Bada FA (2004). Socio-Economic Importance of Local Silkworm (*Anaphe venata*) to the Rural Dwellers in Ondo State, Nigeria. Book of Abstracts, 35th Ann. Conf. Entomol. Soc. Nigeria. Pp: 7.

Agbidye FS, Ofuya TI, Akindele SO (2009). Marketability and nutritional qualities of some edible forest insects in Benue State, Nigeria. Pakistan J. Nutri. 8 (7):917-922.

Agbidye FS, Nongo NN (2009). Harvesting and processing techniques for the larvae of the Pallid Emperor moth, *Cirina forda* Westwood (Lepidoptera: Saturniidae), among the Tiv people of Benue State, Nigeria J. Res. forestry, wildlife Enviro. 1 (1):123-132

Agwu SI (1981). A checklist of insects injurious to oil palm in Nigeria. J. Nig. Institute for Oil Palm Res. Pp. 59-64.

Akanbi MO, Ashiru MO (2002). A Handbook of Forest and Wood Insects of Nigeria. Agbo Areo Publishers, Ibadan, Pp 66.

Akyildiz BN, Kurtoglu S, Kondolot M, Tunc A (2010). Cyanide Poisoning caused by Ingestion of Apricot seeds. Ann. Trop. Paediatr. 30(1):39-43.

Amadi EN, Ogbalu OK, Barimalaa IS, Pius M (2005). Microbiology and nutritional composition of an edible larva (*Bunaea alcinoe* .Stoll) of the Niger Delta. J. Food Safety, 25:193-197.

Anita BS, Akpan EJ, Okon PA, Umoren IU (2006). Nutritive and Antinutritive Evaluation of Sweet Potatoes Leaf. Pak. J. Nutri 5:166-168.

Appiah FO, Aisagbonhi CI (2000). Termite Damage Assessment in a Five-Year Old date Palm Plantation in Dutse, Jigawa State. Nig. J. Ent., 17:31-38.
Ashiru MO (1988). The food value of the larvae of *Anaphe venata* Butler (Lepidoptera: Notodontidae). Ecol. Food, Nutr. 23:313 - 320
Banjo AD, Lawal OA, Songonuga EA (2006). The nutritional value of fourteen species of edible insects in Southwestern Nigeria. Afr. J. Biotechnol. 5(3): 298- 301.
Braide W, Sokari TG, Hart AD, Nwaoguikpe RN (2010b). The nutritional status of seven species of plant leaves as food for an edible larva of a lepidopteran, Bunaea alcinoe. Int. J. Biol. Sci. 2(3): 96-102.
Bukkens SGF (1997). The nutritional value of edible insects. Ecol. Food Nutr. 36:287-319
Chaturvedi VC, Shrivastava R, Upreti RK (2004). Viral Infections and Trace Elements: A complex Interaction. Current Sci. 87:1536-1554.
Chavunduka DM (1975). Insects as a Source of Protein to the Africa. Rhodesia Sci. News 9:217-220.
De Foliart GR (1992). Insects as human food. Crop Protection, 11(5): 395-399.
De Foliart GR (2002). Oceania: Australia. In The human use of insects as a food resource: a bibliographic account in progress, pp. 1-51.
Durst PB, Shono K (2010). Edible forest insects: exploring new horizons and traditional practices. Proceedings of a Workshop on Asia-Pacific Resources and Their Potential for Development, 19–21 February 2008, Chiang Mai, Thailand. Bangkok: Food Agric. Organ. United Nations, Pp. 1-4.
Ekop AS (2004). Effects of Processing on the Chemical Composition of Maize. 24th Annual Conference of Nigerian Society of Biochemistry and Molecular Biology. University of Calabar. Nov 24th -27th.
Ekop EA, Udoh AI, Akpan PE (2010). Proximate and anti-nutrient composition of four edible insects in Akwa Ibom State, Nigeria. World J. Appl. Sci. Technol. 2 (2): 224 – 231
Elemo BO, Elemo GN, Makinde MA, Erukainure OL (2011). Chemical evaluation of African palm weevil, *Rhychophorus phoenicis,* larvae as a food source. J. Insect Sci. 11:146 available online: insectscience.org/11.146.
Fasoranti JO, Ajiboye DO (1993). Some edible insects of Kwara State, Nigeria. Am. Entomol. 39:113–116.
Groff J, Gropper S, Hunt S (1995). Advanced Nutritional and Human Metabolism. 2nd ed., New York. Pp. 221- 362
Hill DS (1983). Agricultural Insect Pests of the Tropics and their Control. Cambridge University Press, Cambridge, Pp. 746.
Ifie I, Emeruwa CH (2011). Nutritional and anti-nutritional characteristics of the larva of *Oryctes monoceros*. Agric. Biol. J. N. Am., 2(1):42-46
Igwe CU, Ujowundu CO, Nwaogu LA, Okwu GN (2011). Chemical Analysis of an Edible African Termite, *Macrotermes nigeriensis*; a Potential Antidote to Food Security Problem. Biochem & Anal Biochem 1:105. doi:10.4172/2161-1009.1000105
Iwalewa EO, Onayade OA., Oyedapo OO, Daniyan OM (2005). Sub-Acute toxicity and biochemical effects of extracts of *Anaphe venata* larvae in mice. Afr. J. Biomed. Res. 8: 89–93.
Johnson DV (2010). The contribution of edible forest insects to human nutrition and to forest management. Proceedings of a Workshop on Asia-Pacific Resources and Their Potential for Development, 19–21 February 2008, Chiang Mai, Thailand. Bangkok: Food Agric. Organ. United Nations, pp. 5–22.
Malaka OSL (1973). Some measures applied in the control of Termites in parts of Nigeria. Nigeria Entomologists' Magazine, Pp: 137-141.
Mbata KJ, Chidumayo EN (2003). Traditional Value of Caterpillars (Insecta: Lepidoptera) among the Bisa people of Zambia. Insect Sci. Appl. 23: 341- 354.
Miokovic B, Zivkovic J and Kozacinski L (1997). Autochthonous Croatian "rotten" cheese. Vet. Arch. 67:25 – 32.
Ndubuakaku VO, Uwangbute AC, Nnanyelugo DO (1989). Flatulence and other abdominal discomforts associated with cowpea. Appitite. 13:171- 181.
Nonaka K (2010). Cultural and commercial roles of edible wasps in Japan. Proceedings of a Workshop on Asia-Pacific Resources and Their Potential for Development, 19–21 February 2008, Chiang Mai, Thailand. Bangkok: Food Agric. Organ. United Nations, pp. 123–30
Odeyemi MO, Fasoranti JO (2000). Distribution of the Emperor moth Caterpillar, *Cirina forda* (Lepidoptera: Saturniidae) on sheanut tree Canopy at Ilorin, Nigeria. Nig. J. Entomol., 17: 59-67.
Opara MN, Sanyigha FT, Ogbuewu IP, Okoli IC (2012). Studies on the production trend and quality characteristics of palm grubs in the tropical rainforest zone of Nigeria. J. Agric. Technol. 8(3): 851-860
Orr B (1986). Improvement of women's health linked to reducing widespread anemia. Int. Health News 7:3.
Osasona AI, Olaofe O (2010). Nutritional and functional properties of *Cirina forda* larva from Ado-Ekiti, Nigeria. Afr. J. Food Sci. 4(12): 775–777.
Overstreet RM (2003). Flavor buds and other delights. J. Parasitol. 89(6):1093–107.
Paiko YB, Dauda BEN, Salau RB, Jacob JO (2012). Preliminary data on the nutritional potentials of the larvae of edible dung beetle consumed in Paikoro Local Government Area of Niger State, Nigeria. Continental J. Food Sci. Technol. 6 (2): 38 – 42.
Pearson D (1973). Laboratory Techniques in Food Analysis. Butter-worths, London. pp. 33- 52.
Premalatha M, Abbasi T, Abbasi T, Abbasi SA (2011). Energy-efficient food production to reduce global warming and ecodegradation: The use of edible insects. Renewable and Sustainable Energy Rev. 15: 4357–4360.
Raubenheimer D, Rothman JM (2012). Nutritional Ecology of Entomophagy in Humans and Other Primates. Annu. Rev. Entomol. 58:141–60.
Saris NE, Mervaala E, Karppanen H, Khawaja JA, Lewenstam A (2000). Magnesium: an update on physiological, clinical, and analytical aspects. Clinica Chimica Acta ; 294:1-26.
Schabel HG **(**2006). Forest entomology in East Africa: forest insects of Tanzania. Dordrecht, The Netherlands, Springer.
Schabel HG (2008). Forest insects as food: a global review. In Proceedings of a workshop on Asia-Pacific resources and their potential for development, Chiang Mai, Thailand. Pp. 37 – 64
Solomon M, Prisca N (2012). Nutritive value of L*epidoptara litoralia* (edible caterpillar) found in Jos Nigeria: Implication for food security and poverty alleviation. Afr. J. Food, Agric. Nutri. Develop. 12(6): 6737-6747.
Talwar GP, Srivastava LM, Mudgil KD (1989). Textbook of Biochemistry and Human Biology. Prentice Hall of India Private Limited, India.
Teffo LS, Toms RB, Eloff JN (2007). Preliminary data on the nutritional composition of the edible stink-bug, *Encosternum delegorguei* Spinola, consumed in Limpopo province, South Africa. South Afr. J. Sci. 103: 434 - 436.
Van HA (2003). Insects as food in Sub-Saharan Africa. Insect Sci. Appl. 23 (3), 163 – 185.
Yoshimoto CM (1999). Entomophagy and survival. Wilderness Environ. Med. 10:208.