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Survey of edible insects in relation to their habitat and abundance in awka and environ

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Abstract
Malnutrition is one of the problems facing developing countries including Nigeria due to deficiency of protein supply. It becomes imperative therefore to carry out a survey to identify the edible insects, their habitats relation to their time of availability in Awka and environ. This study was carried out in Awka, Agulu, Nibo, Amawbia, and Okpuno between May, 2016 and March, 2017. Collection of the insects was carried out using different collection methods. The collected insects were identified and their habitat as well as time of availability duly recorded. Data generated from the abundance of the edible insects was subjected to Analysis of Variance (ANOVA) at 5% significant level. The results revealed that two species of Coleoptera (*Oryctes monoceros* and *Rhynchophorus phoenicis*), two species of Orthoptera (*Brachytrupes membranaceous, Zonocerus variegatus)* and one species of Isoptera (*Macrotermes bellicosus*) were collected in the study area. It was observed that the larval stages of *O. monoceros* and *R. phoenicis* and the adult stage of *B. membranaceus, Z. variegatus* and *M. bellicosus* were consumed. *O. monoceros* was collected between the month of June and July, while *R. phoenicis* was between December and May, *B. membranaceus* was collected between July and September, *Z. variegatus* was collected between November and April while *M. bellicosus* was collected between May and June. The result revealed that the habitat for *O. monoceros* in the study area was coconut tree and goat dung between the months of June and July. *R. phoenicis* habitat raffia palm tree between December and May. *B. membranaceus* standard farming soil between July and September. *Z. variegatus* green, leafy crops and grasses between November and April. *M. bellicosus* Timber woods and termitarium between May and June. Conclusively, acceptance of edible species in Awka and environ is a proof that the inhabitants practice entomophagy. Further research for documentation of more edible species in Anambra State and mass rearing techniques development for commercial scale of several edible insect species was recommended.

Keywords: survey, edible insects, habitat, awka and environ

1. Introduction
The word insect derives from the Latin word "Insectum'', meaning "with a notched or divided body", literally "cut into sections", from the fact that insects' bodies have three parts. Pliny the Elder created the word, translating the Greek word (entomos) or insect (as in entomology, which was Aristotle's term for this class of life), also in reference to their "notched" bodies. The term was first documented in English in 1601 in Holland's translation of Pliny (Harpe and McCormack, 2001) [22]. Insects are a class of animals within the arthropod group that have a chitinous exoskeleton, a three-part body (head, thorax and abdomen), three pairs of jointed legs, compound eyes and two antennae. Insects are among the most diverse groups of animals on earth. There are more than one million described species, which is more than half of all known living organisms. The total number of species is estimated at 6–10 million, and the class potentially represents over 90 percent of the differing animal life forms on Earth (Food and Agricultural Organization, 2006) [20]. Insects may be found in nearly all environments, although only a small number of species occur in the oceans, a habitat dominated by another arthropod group, the crustacean (FAO, 2006).
Entomophagy is the term used to describe the process of eating insects as a food source. It can be divided into two categories: insects used as nutrients source and others as condiments. Historically, insects have played an important part as regards human nutrition in Africa, Australia, Asia and the Americas (Temitope *et al*., 2014). Hundreds of species have been used as human food but the more important groups include grasshoppers, caterpillars, beetle grubs and (sometimes) adults, and winged termites (Temitope *et al*., 2014). Others include bees, wasp, and ants and their brood (larvae and pupae), ants, cicadas, and a variety of aquatic insects. Therefore, insects are not used as emergency food to ward off starvation, but are included as a normal part of the diet throughout the year or when seasonally available (Banjo *et al*., 2005) [8].
There is considerable variation in the most consumed insect order by continent, country and community. For example, an estimated 96 insect species are eaten in the Central African Republic (Amadi, and Kiin-Kabari, 2016) [5] Orthoptera (locusts and grasshoppers) is the most consumed class (40 percent), followed by Lepidoptera (caterpillars) (36 percent), Isoptera (termites) (10 percent), Coleoptera (beetles) (6 percent) and others such as cicadas and crickets (8 percent) (Roulon-Doko, 1998) [29]. They can be reared for their high nutritional qualities and sold to the populace that regards them as delicacies. The potentials of insects needs to be more seriously considered in food security and poverty alleviation strategies in Sub-Saharan Africa (Pal and Roy, 2014). Yen (2015) [33] compiled an exhaustive edible insects list of 2,040 species from across the world. The largest group of insects eaten worldwide is the Order Coleoptera, or the beetles and weevils, at around 31% of the total number of recorded edible species (FAO, 2006). Caterpillars are of the Order Lepidoptera (moths and butterflies), and true bugs here, refers to the Order Hemiptera, including things like cicadas, stink bugs and giant water bug (FAO, 2006).

In future decades, humans will be confronted by a lack of nutritive resources (FAO, 2012). By 2050, the global population is estimated to be 9 billion people leading to a global food demand increase of up to 70% compared with our current food requirements (FAO, 2012). Conventional sources of protein will not be sufficient for the global human population, alternative sources such as insects may be required. The main advantage of insect production is the high environmental safety when compared to conventional livestock and food with potential of contributing to attainment of household food security (Defoliart, 1999; Huis, 2013) [12, 22]. Currently, there are approximately 870 million of undernourished people in the world (FAO, 2012b).

Edible insects as a human food source could help developing countries to support their needs for proteins, fats, vitamins and minerals (De Foliart, 2002), thus provide complementary food for developed countries. Feeding on insects is an age long practice in some countries of the world. Thus Insect-based food was estimated to include 2000 species of edible insects consumed by 3071 ethnic groups (Ramos-Elorduy *et al*., 2011). Insect farming could overcome the lack of insect availability in the nature, which are dependent of seasons or biomass availability (Yen, 2015) [33]. Environmental impact of entomophagy development should also be integrated when compared to traditional livestock breeding and use. Indeed, insect mass-rearing produces fewer pollutants and residues than other animals (FAO, 2006). Insects are a popular food in many cultures all over the world, be it as an occasional delicacy or as a replacement food in times of shortages, droughts, floods or war. Insects and meat play the similar in the human body hence, insects provide man not only with protein, but vitamins, minerals and fats. Many edible insects have been found to contain abundant stores of lysine, an amino acid deficient in the diets of many people who depend heavily on grain. Insects generally have higher food conversion efficiency than most traditional meats and reproduce at a faster rate than livestock production. Thus, not with standing many academic institutions lack research focus on edible insects which is a barrier to conducting research on the subject (FAO, 2010b).

Ramos-Elorduy *et al*. (1997) analysed 78 insect species from Oaxaca State, Mexico, and determined that caloric content was 293–762 kilocalories per 100 g of dry matter. The present energy values expressed in kilocalories per 100 g fresh weight of selected wild and farmed insects worldwide. Xiaoming *et al*. (2010) [32] evaluated the protein content of 100 species from a number of insect orders. The protein content was in the range 13–77 percent of dry matter and that there was large variation between and within insect orders. Bukkens (1997) [10] showed that the mopane caterpillar had lower protein content when dry-roasted than when dried (48 and 57 percent, respectively). The same was true for termites: protein content was 20 percent in raw termites and 32 percent and 37 percent of fresh weight when fried and smoked, respectively (the difference due to varying water content). The protein content of insects also depends on the metamorphosis stage (Ademolu *et al*., 2010) [2] adults usually have higher protein content than instars source proteins. Edible insects can be produced with less environmental impact than livestock. Insect meal can replace scarce fishmeal as feed ingredient, in particular in the fast growing aquaculture industry. Edible insects can alleviate waste disposal problems by growing them on organic by-products (Huis, 2015) [14, 22].

In Nigeria, insect farming is not given much attention and the ever growing population rely on the limited livestock for sources of meat and other nutreints required by man (Okore *et al*., 2014) [26]. Therefore, there is an urgent need to assess insect biodiversity as a whole with special emphasis on conserving this valuable natural resource and survey the local traditional knowledge of entomology for posterity. This will therefore, provide, insights on commonly eaten insects of eastern Nigeria (Awka and environ), their time of availability, habitat and abudnace. Together with other evidences from the literature, research on entomophagy has been carried out in Nigeria with the aim of promoting the contribution of edible insects to food security and adequate nutrition (Okore *et al*., 2014) [26].

So far, some research works have been reported with regards to edible insects in southern region of Nigeria (Okore *et al*., 2014) [26] without documentation of those of Awka and Environ. However, the documentation the edible insects in relation to their p habitat in Awka and environ will provide better insights into edible insect species, knowledge of its nutritional composition, will encourage individual to embrace edible insects as a source of food for nutritional benefits and source of income to farmers.

2. Materials and Methods

Study Area

The study was carried out in Awka (6˚ 25'N, 7˚- 8˚ E), Agulu, (6˚ 23' N, 6˚ -7˚ E), Amawbia (6°12′0.9612″N) (7°02′51.0534E'), Nibo (6° 10' 0" N, 7° 4' 0') and Okpuno. Awka is the capital of Anambra State which is the eight most populous State in the Federal republic of Nigeria and the second most densely populated State in Nigeria after Lagos State with an estimated density of 1,500 – 2000 persons per square kilometer, covering an area of 4,419sqm with an average of 4,055,048 people in accordance with 2006 census (Ebenebe and Okpoko, 2015) [13]. Thus, the State is one of those grossly affected by food shortage problems in Nigeria (Ebenebe and Okpoko, 2015) [13]. The study lasted between May, 2016 and March, 2017. Awka, Agulu, Nibo, Amawbia, and Okpuno lie in the tropical rain forest zone of Nigeria and experience two distinct seasons - rainy and dry.

Methods of Collection and Identification of Edible Insects

Collection of the insects was carried out by using different collection methods. Collection was done at the study sites twice a week and two times daily between 8am and 10 am and 4pm-6pm, during the study periods. Before collection, the habitats which the insects were found were photographed with digital camera (Panasonic DMC-LZ7 model, Japan). Termites were collected by the means of light trap (Brown *et al.*, 1969) [9], while grasshoppers were sampled and collected by using quadrat net (Cherrill and Brown, 1990) [10].

Larvae were handpicked. Crickets were collected by digging them out from their burrows (Nordstorm and Rundgren, 1972) [25]. Soldier termites were collected by pulling down their termite mound and digging into the brood chamber to bring out the queen. The location, local name, host plant, habitat and temporal distribution of each species were noted. Edible insects were identified by indigenes of the localities who are employed as research assistants. Only edible insects unidentified in the different habitats were put in a glass jam-jars containing small amount of damp soil and vegetation, thus transported to the laboratory for proper identification (Ausden, 1993) [6]. Specimens were subsequently identified

by an entomologist. Laboratory analysis involved examination of the insects by means of compound microscope for identification and classification. Samples of adult insects were pinned using entomological pins to prevent damage to the scales on their wings (Sutherland, 1996) [30], and kept in insect boxes with naphthalene as preservatives. Larval forms were preserved in 70% ethanol glycerin medium and were transported to the laboratory.

Determination of the Habitats for the Edible Insects Species

The habitat of the edible insects, were determined by observations made at the study area for a period of 10 minutes between 10.00 and 11.00am during their seasons of occurrence (Abdullahi *et al*., 2011; Akunne *et al.,* 2016) [1, 4]. A habitat is said to be if it is highly visited by the edible insect species.

Determination of Abundance and Distribution of Edible Insect in the Study Area

The quadrats and transect method as explained by Teklay (2011) [31] was used to determine the abundance of field crickets and African locust in the surveyed area. The quadrats ($25m^2$) were laid at random after the study site was stratified. The distance between transects was three (3) meters. The remaining quadrats were laid at equal intervals along transects. However, direct count method was used to determine the abundance of winged termites, Rhinocerus beetle larva and palm weevil.

Statistical Analysis

Data generated from the of the edible insects was subjected to Analysis of Variance (ANOVA) at 5% significant level while the questionnaires were analysed with weighted mean descriptive statistics using SPSS computer package (version 20). The sample means were separated using Duncan's Multiple Range Test (DMRT).

3. Results

The scientific, English and local names of the edible insects were ascertained and the stage of consumption of the five edible insect species collected in Awka and environ, Southeastern Nigeria were presented in Table 1. From the result, it was observed that two species of Coleoptera (*Oryctes monoceros* and *Rhynchophorus phoenicis*), two species of Orthoptera (*Brachytrupes membranaceus*, *Zonocerus variegatus)* and one species of Isoptera (*Macrotermes bellicosus*) were collected in the study areas. It was the larval stages of *Oryctes monoceros* and *Rhynchophorus phoenicis* were consumed while the adult stage of *Brachytrupes membranaceus*, *Zonocerus variegatus* and *Macrotermes bellicosus* were consumed (Table 1).

Table 1: Common edible insects in Awka and environ

Order	Family	Species	English names	Local names	Consumption stage
Coleoptera	Scarabacoidae	*Oryctes monoceros*	Rhinocerus beetle larva	Akpa Agbugbo	Larva
	Curculionidae	*Rhynchophorus phoenicis*	Palm weevil	Elulu Ngwo	Larva
Orthoptera	Glyllidae	*Brachytrupes membranaceus*	Field crickets	Abuzu	Adult
	Acrididae	*Zonocerus variegatus*	African locust	Ukpana	Adult
Isoptera	Termitidae	*Macrotermes bellicosus*	Winged termite	Aku, Mbe	Adult

The result on the habitat for the edible insects in Awka and environ is presented in Table 2. The result revealed that the habitat for *O. monoceros* in the study area is coconut tree and goat brothel between the months of June and July. *Rhynchophorus phoenicis* raffia palm tree between December and May. *Brachytrupes membranaceus* standard farming soil between July and September. *Zonocerus variegatus* Green, leafy crops and grasses between November and April. *Macrotermes bellicosus* timber woods and termitarium between May and June.

Table 2: The habitats for the edible insect species in Awka and environ

Species	Habitats	Seasonal occurrence
Oryctes monoceros	Coconut tree/ goat brothel	June- July
Rhynchophorus phoenicis	Raffia palm tree	December- May
Brachytrupes membranaceus	Standard Farming soil	July- September
Zonocerus variegatus	Green, leafy crops and grasses	November- April
Macrotermes bellicosus	Timber woods and termitarium	May- June

The result of the species-related abundance of the edible insect species in Awka and environ is presented in table 4. The table showed that *M. bellicosus* had the highest mean abundance 351.60(59.09%) followed by *Z. variegatus* 83.60(14.05%) while *B. membranaceus* had the least in 38.20(6.42%). However, there was no significant difference between the mean abundance of the edible insect species in relation to location (P>0.05).

Table 4: Species-related abundance of the edible insect species in Awka and environ

Location	Abundance of edible insects' species				
	O. monoceros	***R. phoenicis***	***B. membranaceus***	***Z. variegatus***	***M. bellicosus***
Awka	0	0	21	88	306
Agulu	129	187	68	107	437
Amawbia	0	0	17	57	243
Nibo	89	110	49	92	410
Okpuno	66	27	36	74	362
Total	284	324	191	418	1758
Mean abundance ±SE*	56.80 ± 25.29^{b}	64.80 ± 36.61^{b}	38.20 ± 9.37^{b}	83.60 ± 8.48^{b}	351.60 ± 35.13^{a}
Relative abundance (%)	9.55	10.89	6.42	14.05	59.09

Rows sharing similar superscripts (a, b) are not significantly different (P>0.05)

Super scripts are letters used to separate sample means using Duncan Multiple range tes

4. Discussion

The edible insects collected during this study belong to the order Coleoptera; (*Oryctes monoceros, Rhynchophorus phoenicis*), Orthoptera (*Brachytrupes membranaceus, Zonocerus variegatus)* and Isoptera (*Macrotermes bellicosus*). This finding is in line with the report of Adeoye (2014) who stated that edible insects belong to the order Orthoptera, Lepidoptera, Coleoptera, Hymenoptera and Isoptera. Alamu *et al*. (2013) also stated that the majorities of edible insects in Nigeria are Lepidoptera (27.3%), Coleoptera (27.3%), Orthoptera (22.7%) and Isoptera (22.7%). Banjo *et al*. (2006) [8] reported that fourteen insect species were consumed as food in South-western Nigeria which include *Macrotermes bellicosus*, (termites: Isoptera); *Brachytrypes* spp., *Zonocerus variegatus*, *Cytacanthacris naeruginosus unicolor* (Uvarow), (Orthoptera); *Analeptes triafasciata*, *Oryctes boas* (Fabr.), *Rhynchophorus phoenicis* (Fabr.) (Coleoptera), *Anaphes infracta* (Walsinghan), *A. recticulata* (Walker), *A. venata* (Butler) and *Cirina forda* (Westwood) (Lepidoptera).

The result of this study revealed that people in Awka and environconsume larval stages of rhinocerus beetle, palm weevil and adult stages of field crickets, African locust and Winged termite. Ekpo *et al*. (2010) [14] reported that the stages of winged reproductive and queen castes of termites are consumed, adults in the order Orthoptera, larvae in the order Coleoptera and Lepidoptera, 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 (Ekpo *et al*., 2010) [14]. In addition, the larva of *Oryctes monoceros* is consumed in the Niger Delta regions (Ifie and Emeruwa, 2010) [24].

Habitat is a function of special behavior types which illustrates the active habitat choice for special purposes of the life cycle (Groning *et al*., 2007) [21] such as courtship sites and an oviposition substrate (Fabrig, 2003) [15]. This study revealed that the habitat for *O. monoceros* is coconut tree, and heaps of goat dung between the months of June and July. The larva of *O. monoceros* has previously been collected between June and July by Ifie and Emeruwa (2011) [24]. The palm weevil raffia palm tree between December and May. This observation supports the findings of Opara (2012) [27] who reported that the seasonal occurrence of the grubs of palm weevil on the field is from December to May. Banjo *et al*. (2006) [8] also collected *R. phoenicis* from the trunks of palm trees. The large African cricket, *B. membranaceus* standard farming soil. This could be attributed to the availability of it feeds since *B. membranaceus*, is a pest of forest nurseries which may cause severe defoliation (Akanbi and Ashiru, 2002) [3]. *B. membranaceus* was collected between July and September which marks the rainy season. Most of the insects consumed in Nigeria are available for collection during the rainy season due to availability of their host plants (Alamu *et al*., 2013).

The African locust, *Z. variegatus* green, leafy crops and grasses between November and April which marks the dry season of the study area. Similar observation has been made by Fasoranti and Ajiboye (1993) [19] who stated that the population of *Z. variegatus* was high during the dry season in Southwestern Nigeria; and has been reported to be eaten in the Akoko area of Ondo State (Fasoranti and Ajiboye, 1993) [19]. *Macrotermes bellicosus* timber woods and termitarium between May and June which marks the beginning of rainy season in the study area. Similar observation was made by Alamu *et al*. (2013). Previous researches revealed that the reason why *M. bellicosus* are enjoyed in all parts of Nigeria, is due to its availability 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 and Igwe *et al*., 2011) [8].

Furthermore, there was no statistical difference ($P>0.05$) between the mean abundance of the edible insect species collected in Awka and environ although *M. bellicosus* had the highest mean abundance (351.60) followed by *Z. variegatus* (83.60) while *B. membranaceus* had the least in (38.20). This implies that the edible insect species could be collected at any of the locations sampled in Awka and environ. It was also observed that the highest mean abundance of edible insects was recorded in Agulu (185.60) followed by Nibo (150.0) while least in Amawbia (63.40) but there was no significant difference between the mean abundance of the edible insects in relation to location ($P>0.05$). This could indicate that the edible insects could be collected at any of the locations sampled in Awka and environ. Based on this observation, the mass rearing of these insects in any of the areas could be possible.

5. Conclusion

This study revealed that the edible insect species collected from Awka and environ include O. *monoceros* and *R. phoenicis*, *B. membranaceus*, *Z. variegatus* and *M. bellicosus*. It was observed that *O. monocero*s habitat coconut tree and goat brothel between the months of June and July, *R. phoenicis* raffia palm tree between December and May, *B. membranaceus* standard farming soil between July and September. *Z. variegatus* green, leafy crops and grasses between November and April while *M. bellicosus* timber woods and termitarium between May and June. It was recommended that mass rearing of edible insects would be the most appropriate solution for its availability all year round hence more studies should be conducted on the development of techniques for mass rearing of edible insect species. There is need for insect eaters and entomologist to educate the public about the value of edible insects.

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