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Acceptability and Economic Viability of Edible Insects in South Western, Nigeria

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ABSTRACT

Edible insects are a good source of protein, minerals and vitamins. This study investigated the acceptability and economic viability of edible insects within the three ecological zones, in south-western, Nigeria. Six hundred (600) structured questionnaires were administered among the habitants of the selected ecological zones on the acceptability, economic benefits and types of edible insects. The data collected were statistically analysed. The insects identified were: *Macrotermes bellicosus*, *Brachytrypes* spp, *Oryctes boas* (larvae), *Zonoceros variegatus*, *Apis mellifera*, *Anaphe reticulata*, *Rhynchophorus phoenicis* (Larvae and Adult), *Oryctes boas* (Adult). Ondo in Derived Savannah has the highest diversity of 0.99 while *M. bellicosus* recorded the highest dominance per species. The insects were mostly fried (38.5%) before consumption. In terms of distribution, there is an abundance of *Oryctes boas* (37.6%) in Ogun (lowland rainforest) while there was a higher occurrence of *O. boas* larvae (17.6%) in Oyo State (Derived Savannah). The most acceptable edible insect within the ecological zones studied was *M. bellicosus* (51.9%). On the economic viability of insects, 22.3% of the respondents strongly agreed that the insects are in very high demand, 40.5% believed that the cost required to produce them is not much in regards to the benefits derived from them. Some of the respondents (38.9%) strongly agreed that insects act as an excellent source of proteins. This research has shown that people are practicing Entomophagy which should be further encouraged by the government to serve as an alternative source of protein and for income generation since they can be afforded by the masses.

INTRODUCTION

Every culture has significant traits used to describe its way of life in terms of economy. In West Africa, Nigeria, the Yoruba race constitutes the Southwestern part of the country along the coast (Forde, 2017). They are one of Africa's most important cultural groups, with a thriving economy based on agriculture, trade, and art. Woodcarving, sculpting, metalwork, textiles, and bead making are among their distinguishing and unique artistic traditions (Kashim *et al.*, 2011).

The Yorubas are known for eating insects as food for humans and livestock. Some insects are prized mainly for their nutritional and therapeutic properties (Adeoye *et al.*, 2014). However, the practice is rapidly evolving due to changes in eating habits and tastes. Locusts, termites, crickets, bees, grasshoppers, and various caterpillars and worms have all been found to be consumed in different parts of the world according to several researchers (Banjo *et al.*, 2006; Oibiokpa *et al.*, 2018).

The term used to qualify insects, as food by a human, is known as Entomophagy (FAO, 2013). Many people eat insects without knowing, such as the eggs, nymphs, larvae, or the adults, which are fried, grilled, or pickled and eaten along with some other food substances (Johnson, 2010). Consumption of insects is at both larvae stages, such as grubs, caterpillars and silkworms, and adult stages such as grasshoppers, termites, crickets, and some beetles. As result, in non-industrialized regions of the world, Entomophagy is an old and well-established custom (Adeboye *et al.*, 2016). They have been reported to provide a significant nutritional contribution and wading off malnutrition during times of drought and famine relief as well as more varied, pleasant, and balanced diets (Glover and Sexton, 2015; Alamu *et al.*, 2013). (Alamu 13;Glover,15)

The edible insects are food resources that help to provide protein and other food classes, particularly minerals and vitamins to huge village populations in some Third World nations (Agbidye *et al.*, 2009a; Ekop *et al.*, 2010; Oibiokpa *et al.*, 2018). Many African households consider the pallid emperor moth, *Cirina forda*, a defoliator of the shea butter tree, *Vitellaria paradoxa*, a delicacy (Agbidye *et al.*, 2009b; Amadi and Kiin-Kabari, 2016).

Because insects' populations plummet without trees and foliage to munch on, the distribution and availability of high-quality edible insects are closely linked to healthy, intact forests. As a result, in many areas where forest degradation is severe, residents are too preoccupied with day-to-day survival to consider the luxury of protecting the environment, which could induce insect (edible) population growth (Yen, 2009a; Vantomme, 2015).

Eating insects provides low-income families with more food and revenue, reducing the need for land clearing and permitting intense monoculture agriculture and pesticide use (Yen, 2009b; Melo *et al.* 2011; Hartmann *et al.*, 2015). Recently, there has been a strong desire to use insects as an alternative source of protein for food and feed for humans and animals worldwide (Van Huis *et al.*, 2013; Hartmann and Siegrist, 2017). Protein-energy malnutrition is thought to be responsible for more than half of all fatalities of children under the age of five in underdeveloped nations (Brundtland, 2000; Ahmed *et al.*, 2012; Ubesie *et al.*, 2012).

Given these, it is essential to carry out the study on the geographical distribution, abundance, and Economic benefits of some edible insects in Southwestern, Nigeria to re-awake an awareness of the economic advantages of Entomophagy in West Africa and the world in general.

MATERIALS AND METHODS

Study Area:

The study took place in Nigeria's southwestern states (Fig. 1), within latitude 6°34'N - 8° 44'N, longitude 3 ° 18'E - 4 ° 50'E and elevation 39.4-330.0m which comprises of six states viz: Lagos, Ogun, Ondo, Ekiti, Oyo, and Osun.

Sample Size and Selection:

The selection of sample size was on the instance of states, and the ecological zones, identified as lowland rainforest, savannah (derived and guinea), and the mangrove forest

zone noted with indigenous habits of insect-eating. The administration of questionnaires was among the residents, traders, and indigenes of each state within the southwestern zones.

The three ecological zones studied were the mangrove forest which includes: Badagry, Itokin, Epe and Lekki axis (Lagos State), the derived savanna (Iseyin and Ogbomosho both in Oyo State), Aiyedun, Omuo, Ikere (Ekiti State) and Akungba (Ondo State). The lowland rainforest, are Abeokuta, Sagamu, Ijebu Igbo (Ogun State), Ikire, Ife and Ilesa (Osun State), Okitipupa and Ondo (Ondo State) (Fig 1).

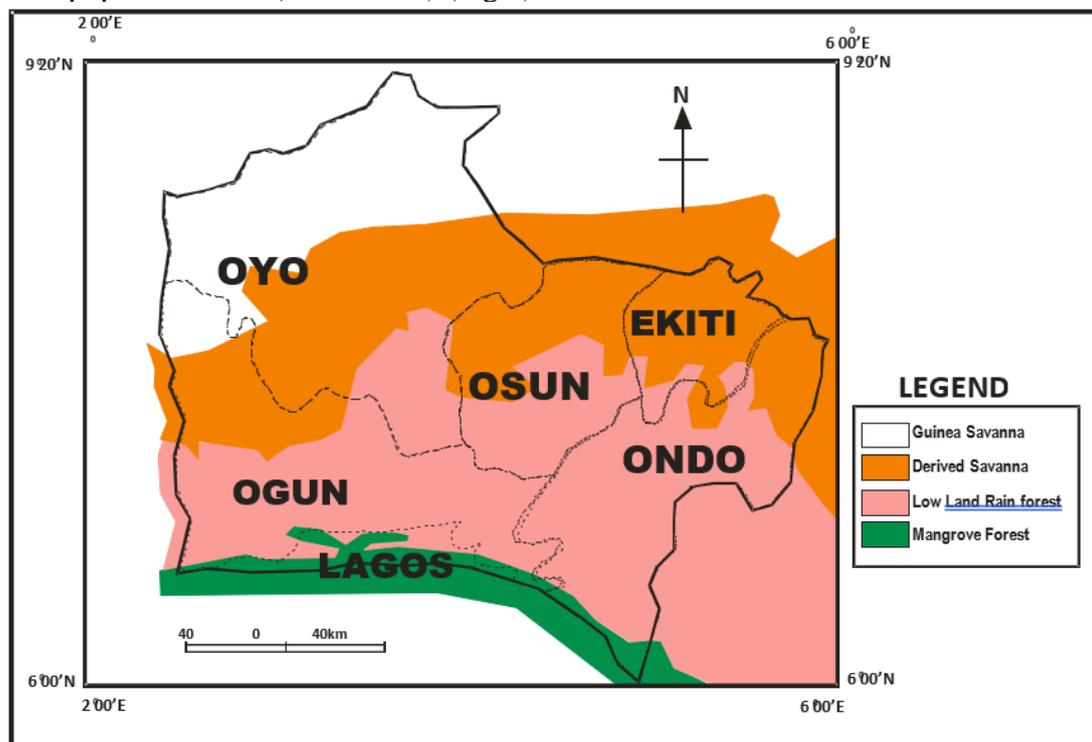


Fig. 1: Ecological zones within Southwestern Nigeria

This work was done in two stages; firstly, the identification and collection of commonly eaten insects through a preliminary survey in areas where the culture of insect-eating is still being practiced within the south-western states. Secondly, a study on the acceptability, economic benefits, and types of edible insects within ecological zones of the study area was also conducted.

Insect Collection:

The collection was based on their time of occurrence, conditions, and consumption stages. The larvae of *Oryctes boas* (Ipe) and *Rhyncophorus* larvae (Itun) were handpicked and kept in well-ventilated containers from Igbokoda (Ondo State), Epe and Itokin in Lagos State while adult grasshoppers *Zonoceros variegatus* (Tata) were collected by handpicking from Ijebu Igbo (Ogun State), Omuo Ekiti (Ekiti State), and Ikare - Akoko (Ondo State). They were processed within 12 hours of collection.

Winged termites were collected with water traps (bowl with water under a bulb) at night during the raining season between the hours of 8 pm – 10 pm at Ijebu Ode and Abeokuta (Ogun State), Okitipupa (Ondo State), Oyo (Oyo State) and Epe (Lagos State).

Preservation of Insects:

Adult stages collected were preserved dried. They were dried by frying and sun drying for 2 - 6 days after subjecting them to boiled water for about 10 – 15 minutes and stored in airtight containers to prevent microbial contamination. For identification, the larval stages of insects were preserved in a 70% alcohol bottle.

Identification of Insects:

The insects were identified at the University of Ibadan's Entomological Laboratory of Crop Protection and Environmental Biology and Olabisi Onabanjo University's Department of Zoology and Environmental Biology in Ago - Iwoye.

Density, Diversity and Abundance of Edible Insect:

In the three biological zones, the Shannon-Wiener index (H') for diversity, the Simpson index (D) for dominance, and the Margalef index for species richness were calculated.

In addition, order-wise relative abundance and species-wise abundance in various ecosystems were calculated. PAST (v.3.26) (Hammer *et al.*, 2019) and SPSS were used to calculate the descriptions indices (v.23). The Shannon-Weiner index (H') measures the diversity of insect species in a given habitat. The more the diversity, the higher the H' value. The formula is given by expression (1).

$$H = -\sum P_i(\ln P_i) \quad \text{-----} \quad 1$$

where pi is the proportion of individuals present in the species in question.

The likelihood of choosing any two individuals at random from a vast group of the same species is defined by Simpson's index (D). This index, defined by expression (2), considers both the richness and evenness of diversity.

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)} \right) \quad \text{-----} \quad 2$$

where, n = individuals in ith species, N = total number of individuals.

Margalef's index (R) provides a precise estimate of species diversity. It aims to adjust for sampling effects by dividing the total number of individuals in a sample by the species richness ratio, which is expressed as:

$$R = (S - 1) = \ln N \quad \text{-----} \quad 3$$

Where S denotes the total number of species in a community and N denotes the number of individuals.

Entomophagy Study:

Understanding the attitudes and distribution of entomophagy among the six southwestern states of Nigeria required conducting a survey. Six hundred (600) structured questionnaires were randomly administered among the six southwestern states of Nigeria, with an average of a hundred within each state through the various markets and local governments in each state. Where necessary, the services of interpreters for an explanation were employed. The questionnaire was to evaluate the (A) socio-economic characteristics of respondents (B) perception of respondents on the edibility of insects (in terms of types eaten, where found, seasonal occurrences and their general acceptability) and (C) economic benefits derived from insects' edibility in terms of nutritional value and financial gains accrued from their sales.

RESULTS**Density, Diversity and Abundance of Edible Insect:**

The variety, dominance and species richness of the collected insects during this study were represented in Table 1 while diversity per location was represented in Table 2. It was observed that per species, *M. bellicocus* had the highest Shannon Winer's diversity and Simpson indices of 0.86 and 0.824 respectively, *A. mellifera* was the richest by speciation with a Margalef index of 0.92 while *O. boas* (adult) had the lowest, although the most abundant was *Brachytrypes* spp (14.20%). This showed that although the Isopterans are more diverse, the hymenopterans are richer in species than every other insect.

Furthermore, observation by location revealed that Ogun state had the highest number of insects population (28.78%) but Ondo state had the highest number of diverse species (0.99) and dominant by speciation (0.8866) than Ogun State.

Table 1: Diversity, Dominance and Species richness Indices per species

	<i>M. bellicosus</i>	<i>Brachytrypes spp</i>	<i>O. boas</i> (larvae)	<i>Z. variegatus</i>	<i>R. phoenicis</i> (larvae)	<i>A. mellifera</i>	<i>A. recticulata</i>	<i>R. phoenicis</i> (Adult)	<i>O. boas</i> (Adult)
States	7	7	7	7	7	7	7	7	7
Individuals	740	1107	1004	748	844	678	807	905	919
Simpson	0.8238	0.8219	0.8201	0.7909	0.7777	0.8103	0.8006	0.7746	0.7678
Shannon	0.8591	0.8547	0.8409	0.7974	0.747	0.8302	0.8043	0.7523	0.7433
Margalef	0.9082	0.856	0.8681	0.9067	0.8905	0.9204	0.8964	0.8813	0.8793

Table 2: Diversity, Dominance and Species richness Indices per location

	Lagos	Ogun	Oyo	Osun	Ondo	Ekiti	Others
Species	9	9	9	9	9	9	9
Individuals	494	2231	1142	778	1470	1460	177
Simpson 1-D	0.8856	0.8825	0.8837	0.8132	0.8866	0.886	0.8857
Shannon H	0.9848	0.9715	0.9779	0.7349	0.99	0.9866	0.9859
Margalef	1.29	1.038	1.136	1.202	1.097	1.098	1.546

Socio-economic Characteristics:

Out of the 600 questionnaires administered in the six states of the Southwestern geopolitical zone of Nigeria, 566 were eventually retrieved for the purpose of this study. On the sex distribution of respondents, 58.83% of them were females, and 41.17% were males. For marital status, a cumulative of 38.52% were married, 57.07% were singles. In terms of age groupings of respondents, 36.75% and 36.57% were within the age brackets of 21-30years and 31-49 years, respectively, as shown in figure 2.

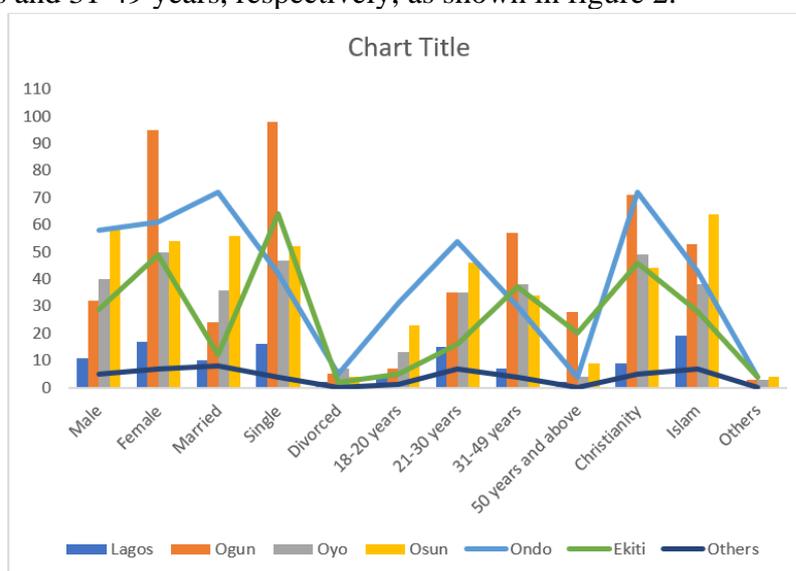


Fig. 2: Chart showing demographic distribution of respondents.

Moreover, in terms of the occupational disposition of respondents, most of them were students (31.6%), followed by professionals who were mostly skilled workers with 28.8%, while farmers and craftsmen took the least percentage of 5.8% and 3.7% respectively as seen in Figure 3.

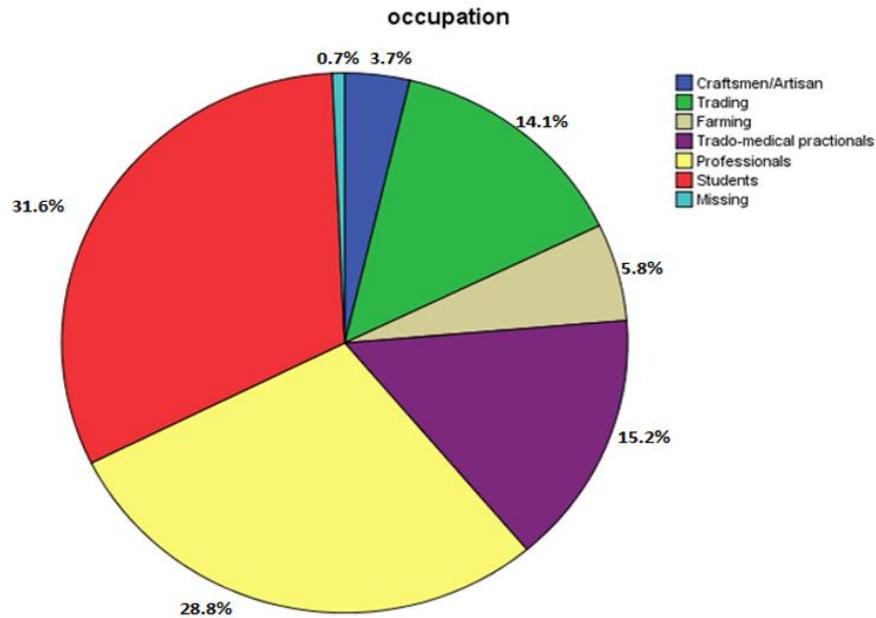


Fig. 3: Pie Chart of the occupational distribution of respondents.

Perception of Respondents on Insects Eating:

On responses based on the frequency of eating the edible insects they are interested in, over half of them chose seasonally as regards when the insects are really in abundance with (53.31%) and 13.95% on weekly basis. In response to ‘where they harvest them from, 47.68% indicated from farmlands and 23.75% from the forest; their method of preparation was mostly by frying (38.46%), roasting (34.62%) and smoking (26.92%) depending on the type of insects being consumed. It is of note that methods of preparation vary from one state to another within the Southwestern regions of Nigeria, with options like roasting and frying for consumption purposes (Plates 1 to 4), smoking and sun drying for preservation purposes especially *Z.variegatus*, in Omuo-Ekiti and Akoko areas of Ekiti and Ondo states. Moreover, there was a high percentage of acceptances that these edible insects do not destroy their farm crops as shown in figure 4.

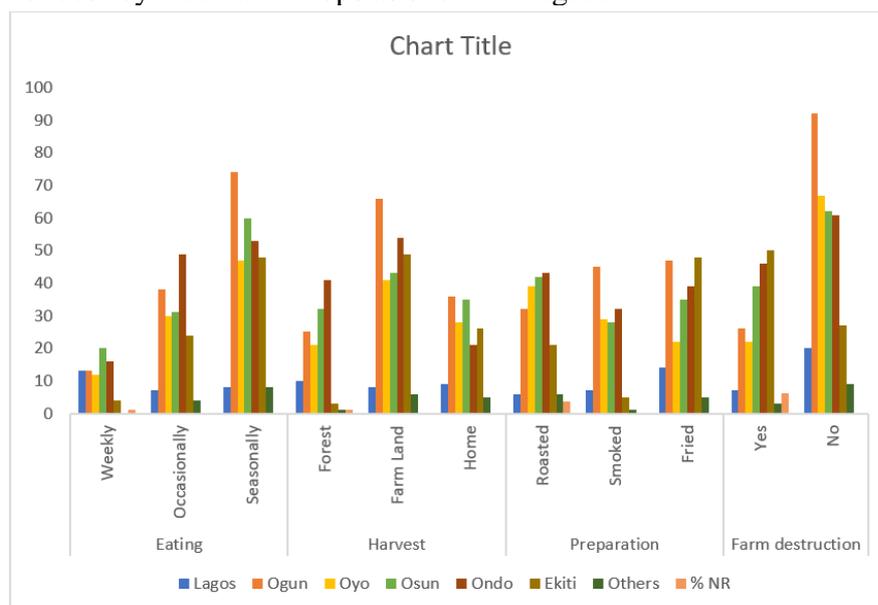


Fig. 4: Perception of respondents on insects eating, method of harvest and preparation

Perception of Religious Belief to Insects' Edibility:

Results obtained showed that Christians are tuned to eating more of *Zonoceros variegatus* (55.4%) and *Brachytrypes* spp (54.7%), the Islam religion practitioners tend to prefer edible insect species like *A. reticulata* (46.1%) and *M. bellicosus* (45.6%). In contrast, another form of religion showed a preference for *Z. variegatus* (3.2%) as shown in Table 5.

Table 5: Frequency and percentage of respondent religious belief to insects' edibility in southwestern Nigeria

Religion		<i>M. bellicosus</i>	<i>Brachytrypes</i> spp	<i>O. boas</i> larvae	<i>Z. variegatus</i>	<i>R. phoenicis</i> larvae	<i>A. mellifera</i>	<i>A. reticulata</i>	<i>R. phoenicis</i> Adult	<i>O. boas</i> Adult
Christianity	Sum	278.00	392.00	362.00	486.00	415.00	394.00	396.00	453.00	475.00
	% of Total	51.6%	54.7%	52.5%	55.4%	54.3%	52.6%	50.9%	54.4%	55.0%
Islam	Sum	246.00	307.00	308.00	364.00	332.00	334.00	359.00	357.00	364.00
	% of Total	45.6%	42.8%	44.6%	41.5%	43.5%	44.6%	46.1%	42.9%	42.2%
Others	Sum	15.00	18.00	20.00	28.00	17.00	21.00	23.00	23.00	24.00
	% of Total	2.8%	2.5%	2.9%	3.2%	2.2%	2.8%	3.0%	2.8%	2.8%
Total	Sum	539.00	717.00	690.00	878.00	764.00	749.00	778.00	833.00	863.00
	% Of Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Seasonal Occurrence of Edible Insects:

The seasonal occurrence of these edible insects as shown in Table 6 indicated that there was a difference in the time of relative abundance and availability within a year, the ecological zones revealed that termites are most abundant during the wet season (84.5%) followed by the caterpillar (30.95%) and Rhinoceros beetle 32.1%. In the dry season, crickets (55.3%), Grasshopper (38.0%), and Snout beetle 34.9% had the highest level of occurrence.

Table 6: Seasonal occurrences of Edible Insects within the ecological zones of South Western, Nigeria.

Edible Insects	ECOLOGICAL ZONES														
	Guinea Savannah			Derived Savannah			Lowland Rain forest			Mangrove Swamp			%	%	%
	Wet	Dry	Non-Seasonal	Wet	Dry	Non-Seasonal	Wet	Dry	Non-Seasonal	Wet	Dry	Non-Seasonal	Wet	Dry	Non-Seasonal
<i>M. bellicosus</i>	40	3	2	74	20	5	195	22	4	23	2	1	84.5	12.0	3.1
<i>Brachytrypes</i> spp	18	24	2	22	59	8	66	113	40	4	14	8	28.9	55.3	15.3
<i>O. boas</i> (larvae)	11	14	18	19	28	35	49	57	104	1	10	15	22.1	30.1	47.5
<i>Z. variegatus</i>	19	9	15	30	44	18	52	74	91	6	17	3	28.2	38.0	33.5
<i>R. phoenicis</i> (larvae)	2	12	26	15	22	40	21	72	98	3	11	12	12.2	34.9	52.5
<i>A. mellifera</i>	5	5	33	6	23	59	34	58	116	2	6	16	12.9	25.3	61.5
<i>A. reticulata</i>	13	16	13	29	20	36	62	70	62	3	6	15	30.9	32.4	36.4
<i>R. phoenicis</i> (Adult)	11	10	15	20	21	40	40	52	111	6	9	11	22.1	26.4	50.9
<i>O. boas</i> (Adult)	20	6	11	25	22	38	62	48	100	8	8	9	32.1	23.5	44.1

Acceptability of Insects' Edibility in Southwestern Nigeria:

The most acceptable edible insects for human consumption among the six states was *M. bellicosus* (51.9%), followed by *Brachytrypes* spp (23.3%) while the least accepted is *O. boas* (adult) (8.5%). One hundred and fifty-one (26.7%) of the respondents do not eat *Z. variegatus* while only 4.8% have never tasted *M. belliosus* (Fig. 4).

Marketability of Edible Insects in Southwestern Nigeria:

The marketability of edible insects within this geographical area was based on four main questions as regards the economic gains derived from them. The numbers of respondents vary on marketability, out of the 410 that responded, 52.44% do not sell it, while 47.56% do. On how long can the preservation of these edible insects last 343 responded; out of which 34.69% responded for a week, while the least response was for more than a month (12.83%). Two hundred and forty-seven (247) responded to the question on the number of days or hours it takes to sell; 36.44% responded for more than a day, while 30.77% responded for a day. The question of, if they enjoy a good percentage of sales was answered by 270 respondents, out of which 78.89% said yes, as shown in Table 8. It was observed that some of these insects had been offered for sales as a means of income generation for the populace, as shown in Plates 1-4.

Table 8: Respondents' perception of the marketability of edible insects in Southwestern, Nigeria

Questions	Number of Respondents per State									% NR
	Lagos	Ogun	Oyo	Osun	Ondo	Ekiti	Others	Total	%	
Do you collect these insects to sell as food?										
Yes	11	75	18	4	61	21	5	195	47.56	27.56
No	12	36	39	13	53	56	6	215	52.44	
How long can the preservation last?										
Below a week	5	21	20	6	20	20	4	96	27.99	39.40
A week	10	21	13	3	43	24	5	119	34.69	
More than a week	1	55	2	0	17	3	0	84	24.49	
More than a month	4	7	8	1	12	18	0	44	12.83	
How many days/hours does it take you to sell your goods										
2-3 hours	3	10	3	0	16	5	4	41	16.60	56.36
4-6 hours	0	7	7	2	18	5	1	40	16.19	
1 day	12	15	8	2	22	16	1	76	30.77	
More than a day	1	58	3	0	22	5	1	90	36.44	
Do you enjoy a good percentage of sales										
Yes	12	87	18	5	69	18	4	213	78.89	52.30
No	3	10	12	1	11	17	3	57	21.11	

- NR – No Response



Plate 1: *Z. variegatus* on sale at Ocele market, Ikare, Ondo



Plate 2: *O. boas* (larvae) garnished with pepper at Igbokoda, Ondo

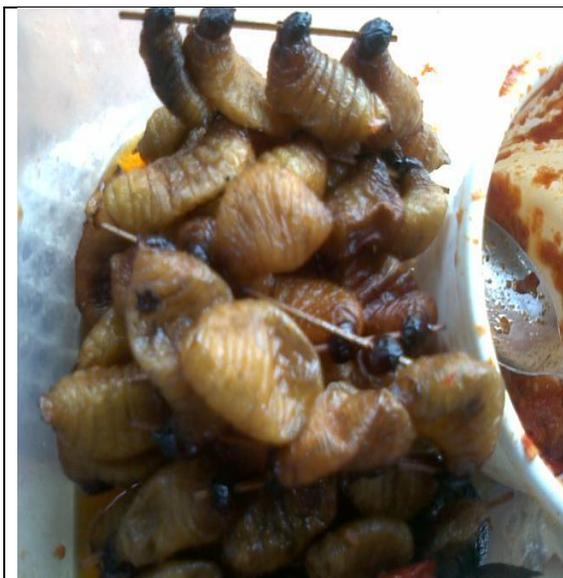


Plate 3: *R. phoenicis* (larvae) displayed for sale at Epe market, Lagos.

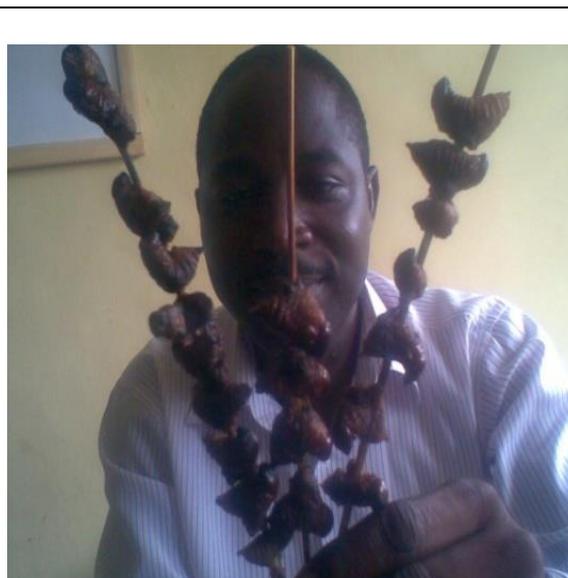


Plate 4: Stick rows of edible insects

The Economic Viability of Edible Insects:

Table 9 displays the level of respondent agreement to the economic viability of edible insects. The results indicated that 22.3 % and 28.4 % of the respondent did strongly agree (SA) and agree (A), respectively on the fact that economically, these insects are in very high demand. This suggests that approximately half of the population accepts that these insects are of economic value. One hundred and forty-three (25.3 %) disagreed that the cost required is higher or much more compared to the benefit derived while only 11.1 % strongly agreed with the statements. However, it indicated that 40.5 % of the respondent believed that the cost required is not much as regards the benefit derived from insect edibility.

Many accepted that these insects act as an excellent source of protein SA = 38.9 %, A = 22.8 %, while only 9.0 % disagree, and 3.0 % strongly disagree. Moreover, 28.4 % strongly agree, and 24.7 % agreed that they could be used as a substitute for meat, and a total of 56.3% of respondents have a general acceptance that they supplied the body with vitamins. The percentage of respondents that strongly agreed that edible insects were economically important because of the income obtained from it was 21.2%, and while 22.8% disagree, and 8.8 % strongly disagree.

There was a significant response (4.9 % Strongly Agreed and 25.4% Agreed) that if edible insects were available on the menu of restaurants, they would order it. However, many disagree with the concept of eating the insect raw with 30.2% strongly disagreeing and 23.1 % disagreeing.

Table 9: Perception on the Economic Viability of Edible insects

Questions	Statement agreement level of respondents per view				
	SA	A	D	SD	NR
Economically, these insects are in very high demand	126 22.3%	161 28.4%	95 16.8%	39 6.9%	145 25.6%
The cost required when embarked on is high or much more compared to the benefit derived	63 11.1%	124 21.9%	143 25.3%	86 15.2%	150 26.5%
Benefit derived from these insects' sales is higher compared to the cost	91 16.1%	146 25.8%	124 21.9%	44 7.8%	161 28.4%
The cost and benefit involved in these insects is the same percentage	38 6.7%	91 16.1%	218 38.5%	63 11.1%	156 27.6%
These insects serve as an excellent source of protein	219 38.9%	129 22.8%	51 9.0%	17 3.0%	150 26.5%
It can be used as an inexpensive substitute for meat or fish	161 28.4%	140 24.7%	64 11.3%	50 8.8%	151 26.7%
These insects supply the body with vitamin	127 22.4%	192 33.9%	69 12.2%	27 4.8%	151 26.7%
These insects are low in cholesterol and fat	83 14.7%	156 27.6%	140 24.7%	38 6.7%	149 26.3%
It is economically important because of the income obtained from it	120 21.2%	112 19.8%	129 22.8%	50 8.8%	155 27.4%
It has an effect on the individual feeding on it	44 7.8%	95 16.8%	176 31.1%	100 17.7%	151 26.7%
If edible insects were available on the menu at a restaurant, would you order for them?	141 24.9%	144 25.4%	76 13.4%	60 10.6%	145 25.6%
It is better to eat the insects raw	34 6.0%	75 13.3%	171 30.2%	131 23.1%	155 27.4%
While travelling, do you normally buy these insects as refreshment delicacies?	125 22.1%	132 23.3%	94 16.6%	60 10.6%	155 27.4%
Entertaining our visitors with some of these insects would be good	99 17.5%	191 33.7%	84 14.8%	47 8.3%	145 25.6%
Edible insects are widely accepted as a food delicacy in Nigeria	96 17.0%	190 33.6%	65 11.5%	70 12.4%	145 25.6%

*SA - Strongly agreed, A- Agree, D- Disagree, SD - Strongly disagree, NR - No response

DISCUSSION

Insects have, along the years, been regarded as an animal with great diversity and interests due to their numerous advantages over mammals and other vertebrates or invertebrates. This does not exclude the fact that insects have also been a contributory factor to food security in different parts of the world.

It was observed during the course of this study that people actually enjoy eating edible insects depending on their geographical location. This is in agreement with Banjo *et al.* (2006), who reported the existence of fourteen insects' that are eatable species in the Southwestern part of Nigeria. Reports of Solomon *et al.* (2008), Fazoranti and Ajiboye (1993), as well as Okaraonye and Ikewuchi (2009), indicated that the edibility of insects occurs in different parts of the country. Therefore, the possibility of enhancing this study cannot be overemphasized since the world population keeps increasing with an increasing need to find an alternative means of providing for human nutritional demands as stated by Ashiru (1988). Entomophagy can significantly contribute to the reduction of protein deficiency in the growing population of a country.

The three Ecological indices used in this study revealed that there is variation in population, dominance and distribution of insects. *M. bellicosus* was most dominant and diverse while *A. mellifera* is the richest of all species these are in conformities with the findings of Okia *et al.* (2017).

In this study, the variability in the distribution of insects' edibility in the Southwestern States of Nigeria belongs to Coleoptera (4), Hymenoptera (1), Isoptera (1), Lepidoptera (1) and Orthoptera (2). This is supported by the findings of was Fazoranti and Ajiboye (1993) who reported these orders of insects among the most consumed insects in

western Nigeria. According to Meyer-Rochow *et al.* (2021), eatable insects belong to eight orders and are cockroaches, termites (Blattodea), beetles (Coleoptera), flies (Diptera), true bugs (Hemiptera), ants, bees and wasps (Hymenoptera), butterflies and moths (Lepidoptera), dragonflies, damselflies (Odonata), grasshoppers, crickets and locusts (Orthoptera).

R. phoenicis and *O. boas* showed a larger frequency of distribution in Ogun, Ondo, Ekiti, and Lagos based on the fact that these areas fall within the Lowland Forest, Derived savannah and Mangrove zones respectively, which are noted for plants like date palms, oil palms, coconut palms and sugarcane which had been noted to be plants infested and destroyed by these insects as reported by Aldryhim and Al-Bukiri (2003).

The distribution of these insects' edibility was largely dependent on the type of vegetation present in the six States of Southwestern, Nigeria, as reflected through the ecological zones each state belongs to. All states and ecological zones showed a significant distribution of *Macrotermes* spp and *A. mellifera* since these areas are characterized by a considerable level of rainfall and humidity, which promotes their nuptial period and honey production, respectively.

The season played a very important role in the existence and availability of living organisms in any given environment, especially insects. The influence of climate on seasonal changes cannot be overemphasized; hence, in Nigeria, there are two main seasons; wet and dry. Each of the states studied falls within definite ecological zones and shows variability in the occurrence level of these edible insects. The larvae of *R. phoenicis*, *O. boas*, and *M. bellicosus* were mostly present during the wet season while *Z. variegatus*, *Brachypterus* spp, *A. reticulata* and adults of *O. boas* and *R. phoenicis* were agreed to be more observed during the dry season. Others like *A. mellifera* were regarded to be non-seasonal, although respondents do ascertain that some of these edible insects could be available during the wet and dry season. According to Adeoye *et al.* (2014), the major seasonal changes make these insects be abundant in Forest and luxuriant green vegetation especially in Southwest and Southeast Nigeria.

The presence of edible insects in different geographical zones of Nigeria has necessarily initiated the need to determine their acceptability as eatable products and delicacies in our feeding diets. Ajayi and Adedire (2007) reported that it is notable that they are rich in protein-energy. All the states surveyed showed that these edible insects were all acceptable for eating with *Macrotermes* spp, *Brachypterus* spp and *O. boas* (larvae) showing a relative over 50% level of acceptability out of the 566 responses received while others were within the range of 42 – 48% level of acceptability.

In terms of religion and edibility acceptability, results indicated that Christians showed a higher percentage of acceptability than Muslims and another form of religion although it must be realized that most of these respondents if not all are generational descendants of trado-religion, hence, it cannot be totally divorced from the fact that eating of insects had been a generational habit even though religious book like the Holy Bible had stated that 'eating of insects like locusts after its kind and the bald locusts after its kind and the beetle after its kind and the grasshopper after its kind' (NIV version).

In respect to occupation, the skilled profession consisting of businessmen, teachers, bankers, and civil servants, as well as students occupied the highest percentages of the occupational cadre that patronized the eating of different species of edible insects within the Southwestern zones of Nigeria. The professionals (29.2%), showed a higher level of patronage for *O. boas* (larvae), *A. reticulata* (29.6%), *M. bellicosus* (28.7%) and *A. mellifera* (28.3%) in comparison to other assessed occupations which recorded percentage patronage of less than 20% in all the insects surveyed. Students also showed a considerable level of patronage for all the edible insects with an average of more than 25% which is in

agreement with the report that the most commonly eaten insects among tertiary institution students are: *Macrotermes* spp, *Anapleptes trifaciata* and *R. phoenicis* (Lawal *et al.*, 2010).

Roasting and frying methods were more preferable to smoking, which is in line with the work of Lawal *et al.* (2010) that many students prefer the frying and roasting methods than others. Akinnawo *et al.* (2002) reported that boiling and sun drying treatment of the larvae might have helped in eliminating the possible neurotoxin in the larvae of *Cirina forda* and could also have accounted for the possible increase in the serum total protein and globulin as well as improving the nutritional quality of proteins and cause partial inactivation of protease inhibitors. Oyegoke *et al.* (2006) reported that the old method of smoking and drying insects results in high content of riboflavin and niacin.

In terms of edibility level, it was observed that there was a higher percentage of consumption during the seasonal periods compared to the occasional level and weekly consumption level. These could be supported based on the fact that the availability and abundance of these insects' species have been observed to be dependable on their seasonal occurrence (dry and wet season).

Edible insect sources have been linked more to farmlands than from the forest and around the home. These are due to the fact that there has been a continuous increase in the human population, thereby encouraging deforestation and the destruction of the natural habitat of these insects. Edible insects from the forest are regarded as an important source of protein, unlike those from agricultural land, for the fact that they are free from pesticides (Vantomme, 2004).

It was shown from the study that out of all the edible insects' species surveyed, four of them were commonly sold or showed possible economic gains to the populace in Southwestern, Nigeria. Consequently, their marketability was largely dependable on their level of availability, seasonal occurrence, and acceptability in each state within the ecological and geographical zones.

Economically, it was observed that edible insects could also serve as a means of income for the wellbeing of the people both in the rural and urban areas of these regions and could well help in poverty and unemployment alleviation in a developing country like Nigeria as attested to by Fasonranti and Ajiboye (1993), Defoliart (1992) and Agbidye *et al.* (2009). Many of the respondents also stated that these insects are of economic importance both financially and nutritionally in terms of protein sources.

Conclusion

Results obtained have shown that the availability and consumption of these insects are dependable on their sources (forest, farmland, or around our homes) and seasonal variations; which had been a pointer to the fact that the indiscriminate attitude of deforestation should be stopped or minimized in order to prevent these insects from going into extinction. Likewise, their harvesting should be limited to their season of abundance depending on insects' species, or probably there should be an alternative method of rearing them for the purpose of consumption when out of season. However, it should be noted that the reproductive cycle of some of these insects depends largely on seasonal variation. Therefore, studies must be carried out to know the best suitable conditions necessary for the growth and rearing of these insects in terms of environmental conditions.

It has become highly imperative to encourage the practice of insects eating and making them as delicacies in our food menu as well as using them as feed supplements for our farm animals so that indirectly we (humans) can benefit from the nutritional contents of these edible insects. Moreover, it is of note that whatever a man eats has a great indication of his health. Therefore, it is required that further studies on the toxicological effects of these edible insects on human consumption, albeit as on other vertebrate animals should.

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ARABIC SUMMARY

القابلية والجدوى الاقتصادية للحشرات الصالحة للأكل في جنوب غرب نيجيريا

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الحشرات الصالحة للأكل مصدر جيد للبروتينات والمعادن والفيتامينات. بحثت هذه الدراسة في مقبولية الحشرات الصالحة للأكل والجدوى الاقتصادية لها في المناطق البيئية الثلاث، في جنوب غرب نيجيريا. قد تم عمل ستمائة (600) استبيان منظم تم إجراؤه بين سكان المناطق البيئية المختارة حول المقبولية والفوائد الاقتصادية وأنواع الحشرات الصالحة للأكل. تم تحليل البيانات التي تم جمعها إحصائياً. الحشرات التي تم تحديدها هي: *Macrotermes*، *Oryctes boas*، *Brachytrypes spp*، *bellicosus*، *Adult* & *Rhynchophorus phoenicis* (Lavae، *Anaphe reticulata*، *Apis mellifera*) *M. Oryctes boas* (للبالغين). يحتوي *Ondo* في السافانا المشتقة على أعلى تنوع قدره 0.99 بينما سجل *bellicosus* أعلى هيمنة لكل نوع. تم قلي معظم الحشرات (38.5%) قبل الاستهلاك. من حيث التوزيع، توجد وفرة من *Oryctes boas* (37.6%) في *Ogun* (غابات الأراضي المنخفضة المطيرة) بينما كان هناك ارتفاع ليرقات *O. boas* (17.6%) في ولاية أويو (السافانا المشتقة). أكثر الحشرات قبولاً للأكل ضمن المناطق البيئية المدروسة هي *bellicosus* (51.9%). وفيما يتعلق بالجدوى الاقتصادية للحشرات، وافق 22.3% من المبحوثين بشدة على أن الحشرات مطلوبة بشدة، بينما اعتقد 40.5% أن التكلفة المطلوبة لإنتاجها ليست كبيرة فيما يتعلق بالفوائد المستمدة منها. وافق بعض المستجيبين (38.9%) بشدة على أن الحشرات تعمل كمصدر ممتاز للبروتينات. أظهر هذا البحث أن الناس يمارسون أكل الحشرات والتي يجب أن تشجعها الحكومة بشكل أكبر لتكون بمثابة مصدر بديل للبروتين ولزيادة الدخل للجماهير.