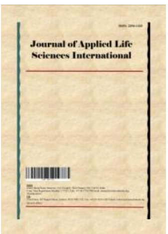

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Preliminary Study of Insect Diversity and Its Economic Importance in Agulu-Nanka Gully Sites

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Authors' contributions

This work was carried out in collaboration among all authors. Author OCS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors OJJ and IEC managed the analyses of the study. Author IEC managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The study was designed to investigate the insect diversity and its economic importance in Agulu and Nanka gully sites using standard procedures. A total of 1,609 insects belonging to 15 species were identified from the study sites, which comprised of 1026 individuals belonging to 15 species from Agulu and 583 specimens belonging to 8 species from Nanka. The diversity of the insect species highlighted the dominance, diversity index, species richness and species evenness. Blattodea were the most dominant order in both Agulu site (43.27%), and Nanka site (56.60%). The order Blattodea was the most diverse (0.725) in Nanka site, whereas the order Coleoptera was the most diverse (0.740) in Agulu site. Results from the economic importance revealed 8 insect species as harmful, 3 species as beneficial, while 4 insect species were considered as both beneficial and harmful. Beneficial insects are edible and good agents of pollination while the harmful insects devour agricultural produce and stored food. The result of this study shows that gully erosion site is dominated by insect diversity, probably due to the flora regeneration.

Keywords: Economic insect; insect diversity; insect abundance; gully erosion; Agulu; Nanka.

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1. INTRODUCTION

Insects are the most diverse organisms, accounting for about half of the described species of living things and about three quarter of all known animals [1]. Insects are hexapod (six-legged) invertebrates and the largest group within the arthropod phylum. The word "insect" comes from the Latin word *insectum*, meaning "with a notched or divided body", or literally "cut into", because insects appear "cut into" three sections. Insects have a chitinous exoskeleton, a three-part body (head, thorax and abdomen), three pairs of jointed legs, compound eyes and a pair of antennae [2]. Insects may be found in nearly all environments, although only a small number of species reside in the oceans, which are dominated by another arthropod groups, such as crustaceans [3,4]. Traditionally, insects are divided into "Apterygota" the wingless insects—and Pterygota—the winged insects [5].

Man has been interested mainly in two categories of insects: harmful and beneficial species. The beneficial species are seen as friends by humans while the harmful species are seen as enemies [6]. Some insects are beneficial and harmful as well such as grasshopper, termite, honeybees and many others. The majority of insects may be both directly important to humans and the environment [7]. For example, several insect species are predators or parasitoids on other harmful pests; others are pollinators, decomposers of organic matter or producers of valuable products such as honey or silk. Some insect species can be a serious menace to people; inflicting damage to humans, farm animals and crops [6,8].

Agulu and Nanka are richly agrarian community in the South eastern part of Nigeria. The diversity and abundance of economic insects in Agulu and Nanka has hardly been studied. Economic insects' biodiversity studies conducted in Nigeria have largely been on the insects' diversity of specific orders [e.g. Coleoptera and Lepidoptera (and/or species of insects. Few have considered the insect community altogether [9]. Both taxonomic and ecological knowledge of economic insects were poorly investigated in Nigeria. Therefore, regarding many insect species their territorial distribution and abundance are poorly known and their associated ecosystem services are mostly assumed. The current study was design to investigate the economic insect diversity in Agulu-Nanka gully sites.

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out at Agulu-Nanka. The study area is located in the south eastern part of Anambra state, Nigeria. The study area has a humid climate with average temperature of 30ºC to 37°C. Vegetation is predominantly grassland with scattered forest and wood land areas. The study area falls within the rainforest belt and is characterized by growth of tall trees amidst thick undergrowth [10].

2.2 Experimental Design

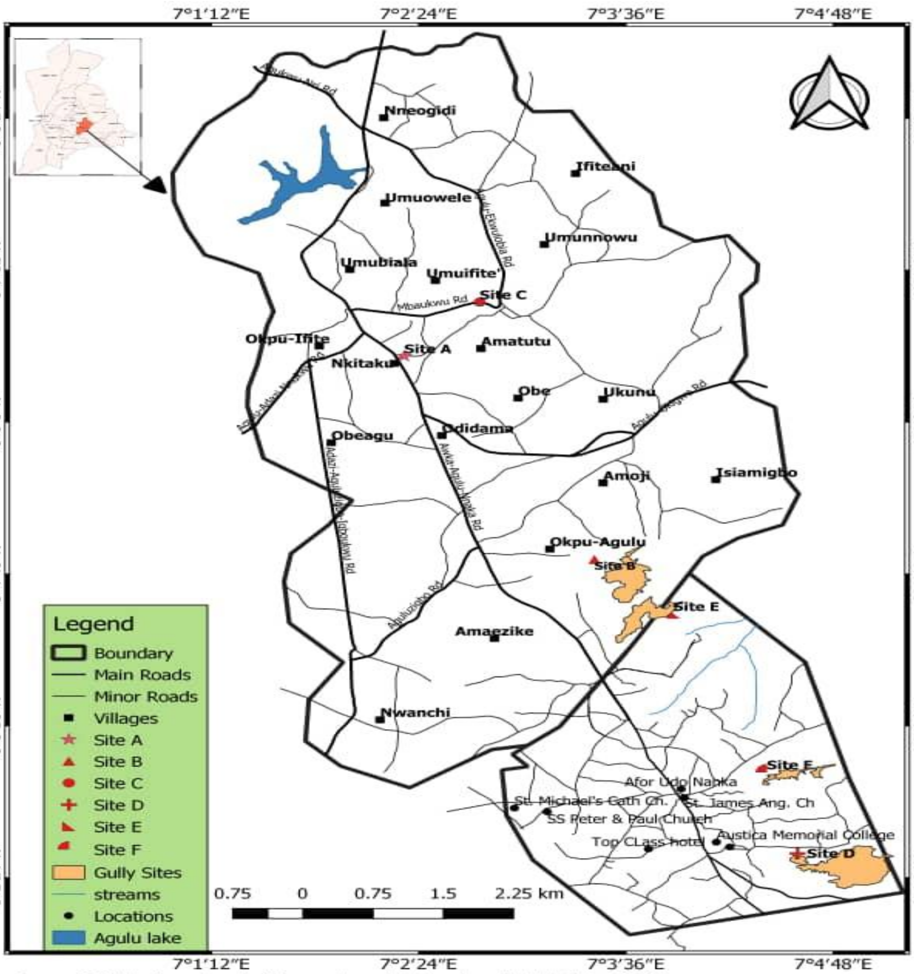
The research was carried within the months of June and July. Six (6) different sites were used for the study; three sites located on each community (Agulu and Nanka). Sites A, B, and C were located in Agulu and sites D, E, and G were located in Nanka.

Site A: Located beside Madonna Assumpta Catholic church, Agulu-Amatutu, Agulu.
Site B: located behind Obeleagu Community Secondary school, Nkitaku village, Agulu.
Site C: Located at Eke-ntai market, Ududoka village, Agulu.
Site D: Located behind Austica memorial College, Amako, Nanka
Site E: located at Haba shrine, Ududoka-Nanka, Nanka.
Site G: Located behind Rock tama pure water industry, Enugwu-Nanka, Nanka.

2.3 Sampling Techniques

Insects are diversified in nature and as a result demands diversified techniques for their capture. Sampling of the insects for the study was done twice in a week in the early hours of the morning (6-9 am) and late in the evening (4-6 pm). This was done for a period of eight weeks. The sampling method employed include; sweep net method, pitfall trap, sticky trap, and light trap. Two of each type of traps were used in a study site.

Preservation: the insects collected were temporary preserved in 70% ethanol in specimen bottles labelled to show sample station description and collection date. The insects were then emptied into labelled polythene bag and taken to the laboratory for washing. Organism were then preserved 10% formation solution.



Source: GIS Lab, Department of Geography and Meteorology, N.A.U., Awka (2019)

Fig. 1. Topography of the study area

Identification**:** **i**dentification of all insects was carried out in the Department of crop protection and agricultural research, Ahmadu Bello University, Zaria by a taxonomist.

Analysis: for calculating the evenness of species, the Pielou's Evenness Index (e) was used.

Species Evenness =

$$\frac{Species\ diversity}{Natural\ logarithm\ (\ln)\ of\ species\ richnes}$$

Shannon Diversity index $D = \exp(-\sum_{i=1}^{s} P_i \ln P_i)$ [10]

Where Pi = $\frac{S}{N}$

S = number of species, N = total number of individuals, In = natural logarithm

Species richness:

$\sum_{i=1}^{s} Pi^0$ [11]

Dominance = $\frac{N}{n} \times 100$

2.4 Questionnaire Study

a questionnaire was designed and administered to respondents from each area in order to access the edible, non-edible and harmful insect and how these insects have affected humans (farmers, market men and women and people residing at and around the monitoring sites).

3. RESULTS

3.1 Species Recovered from the two Study Sites

The total number of insect specimen collected from the two study locations were represented in the Table 1 below. The number was categorized based on the period of collection.

Table 1. Total number of insect specimens collected within three weeks

Location	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8		Total
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	
Agulu	13	50	16	59	17	69	19	90	40	93	42	96	48	160	52	162	1026
Nanka	25	30	26	33	28	36	28	36	30	38	32	39	46	50	52	54	583
Total	38	80	42	92	45	105	47	126	70	131	54	135	94	210	104	216	1609

AM – Morning. PM – Evening

The table revealed the number of insects collected from each site in the morning and evening of every week. Higher numbers of insects were collected in the evening compared to morning in all the sites (a total of 38 insects were collected from both sites in the morning of week 1, and 80 insect specimens in the evening of the same week; 42 insects were collect in the morning of week 2 and 92 insects in the evening of the same week; 45 insects were collected in the morning of week 3 and 105 in the evening of the same week). Week 8 showed the highest number of insect fauna (214 Agulu site, 106 Nanka site) while week 1 showed the lowest number of insect fauna (63 Agulu site, 55 Nanka) (Table 1).

3.2 Identification of Insect Fauna Collected

The names, orders, and families of the various insect species collected from Agulu and Nanka are summarized in the table below.

The table above showed the different species of insects collected from the two sites (Agulu and Nanka). The insect species were from the order Coleoptera, Hymenoptera, Blattodea, Orthoptera, and Mantodea. It can be observed that more species of insects were found the order Coleoptera while just one species were found under the order Hymenoptera and Isoptera (Table 2). The diversity of insect species collected from Agulu was higher than diversity of insect species collected from Nanka; five orders of insects were identified in Agulu insect collection while four orders were identified in Nanka insect collection. Higher variety of insect families was also identified in Agulu insect collection compare to Nanka (Table 2).

3.3 Abundance of Insects Species

The abundance of the insects collected from the two study sites are summarized in the tables (Table 3 and 4) below.

Table 2. List of species recovered from the two study sites (Agulu and Nanka)

Location	Order	Family	Scientific name	No. of individual	Collection Method
Agulu	Coleoptera	Cerambycidae	*Oxyprosopus superbus*	2	Pitfall/Sweep net
	Coleoptera	Carabidae	*Stereostoma sp*	2	Sticky trap
	Coleoptera	Scarabaeidae	*Heteronychus arator*	61	Pitfall/Sweep net
	Coleoptera	Scarabaeidae	*Oryctes Monoceros*	23	Sticky trap
	Coleoptera	Curculionidae	*Rhynchophorus phoenicis*	206	Sticky trap
	Hymenoptera	Formicidae	*Dorylus sp*	86	Pitfall
	Blattodea	Blattoidea	*Deropeltis sp*	8	Light trap
	Mantodea	Mantidae	*Sphodromantis lineola*	131	Pitfall/Sweep net
	Blattodea	Blattidae	*Periplaneta Americana*	104	Light trap
	Blattodea	Blaberidae	*Gyna costalis*	13	Light trap
	Orthoptera	Acrididae	*Acrida bicolor*	52	Sweep net
	Orthoptera	Acrididae	*Humbe tenuicornis*	10	Sticky trap
	Orthoptera	Gryllidae	*Bruchytrupes membranaceus*	82	Light trap/sweep net
	Orthoptera	Acrididae	*Zonocerus variegatus*	58	Sweep net/pitfall
	Blattodea	Termitidae	*Macrotermes bellicosus*	188	Light trap
Nanka	Coleoptera	Scarabaeidae	*Heteronychus arator*	58	Pitfall/Sweep net
	Coleoptera	Scarabaeidae	*Oryctes Monoceros*	37	Sticky trap
	Coleoptera	Curculionidae	*Rhynchophorus phoenicis*	108	Sticky trap
	Mantodea	Mantidae	*Sphodromantis lineola*	89	Pitfall/Sweep net
	Blattodea	Blattidae	*Periplaneta Americana*	64	Light trap
	Orthoptera	Acrididae	*Humbe tenuicornis*	8	Sticky trap
	Orthoptera	Gryllidae	*Bruchytrupes membraniaceus*	42	Light trap/sweep
	Blattodea	Termitidae	*Macrotermes bellicosus*	177	Light trap

Table 3. Species abundance of insects collected from Agulu

Order	Family	Scientific name	No. of individuals	% Abundance
Coleoptera	Cerambycidae	*Oxyprosopus superbus*	2	0.20
Coleoptera	Scarabaeidae	*Stereostoma sp*	2	0.20
Coleoptera	Scarabaeidae	*Heteronychus arator*	61	5.90
Coleoptera	Scarabaeidae	*Oryctes monoceros*	23	2.20
Coleoptera	Curculionidae	*Rhynchophorus phoenicis*	206	8.40
Hymenoptera	Formicidae	*Dorylus sp*	86	20.10
Blattodea	Blattoidea	*Deropeltis sp*	8	0.80
Blattodea	Mantidae	*Sphodromantis lineola*	131	12.80
Blattodea	Blattidae	*Periplaneta Americana*	104	10.10
Blattodea	Blaberidae	*Gyna costalis*	13	1.30
Orthoptera	Acrididae	*Acrida bicolor*	52	5.10
Orthoptera	Acrididae	*Humbe tenuicornis*	10	1.00
Orthoptera	Gryllidae	*Bruchytrupes membraniaceus*	82	8.00
Orthoptera	Acrididae	*Zonocerus variegatus*	58	5.60
Blattodea	Termitidae	*Macrotermes bellicosus*	188	18.30
Total			1026	100

The table above showed the abundance of the various insect species collected from the study site in Agulu. A total of one thousand and twenty-six (1026) insects were collected from the study site at Agulu. *Rhynchophorus phoenicis* had the highest abundance of 20.10% (206 individuals) while *Oxyprosopus superbus* and *Stereostoma sp* had the least abundance of 0.20% (2 individuals respectively). Other insect species such as *Macrotermes bellicosus*, *Sphodromantis lineola*, *Periplaneta americana, Rhynchophorus phoenicis,* and *Bruchytrupes membraniaceus* had abundances of 18.3% (188 individuals), 12.8% (131 individuals), 10.1% (104 individuals), 8.4% (86 individuals) and 8% (84 individuals) respectively. This is illustrated in the chart below.

The abundance of insect species collected from Nanka site is summarized in the table below;

From the table above, five hundred and eighty-three (583) insects were caught in the study site in Nanka. The table revealed *Macrotermes bellicosus* as the most abundant species with percentage abundance of 30.36% (177 individuals) while *Humbe tenuicornis* had the least abundance of 1.37% (8 individuals). *Rhynchophorus phoenicis* and *Sphodromantis lineola* also showed high abundance (18.52% and 15.27% respectively) but were not above the abundance percentage observed for *Macrotermes bellicosus*. This is illustrated in the chart below.

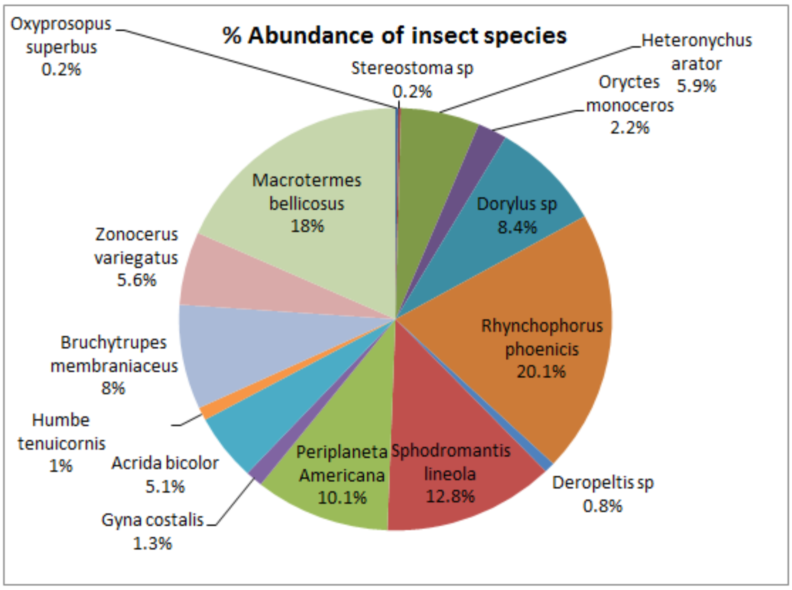


Fig. 2. Abundance (%) of insects species collected in Agulu

Table 4. Species abundance collected in Nanka

Order	Family	Scientific name	No. of individuals	% Abundance
Coleoptera	Scarabaeidae	*Heteronychus arator*	58	9.95
Coleoptera	Scarabaeidae	*Oryctes monoceros*	37	6.35
Coleoptera	Curculionidae	*Rhynchophorus phoenicis*	108	18.52
Blattodea	Mantidae	*Sphodromantis lineola*	89	15.27
Blattodea	Blattidae	*Periplaneta americana*	64	10.98
Orthoptera	Acrididae	*Humbe tenuicornis*	8	1.37
Orthoptera	Gryllidae	*Bruchytrupes membraniaceus*	42	7.20
Blattodea	Termitidae	*Macrotermes bellicosus*	177	30.36
Total			583	100

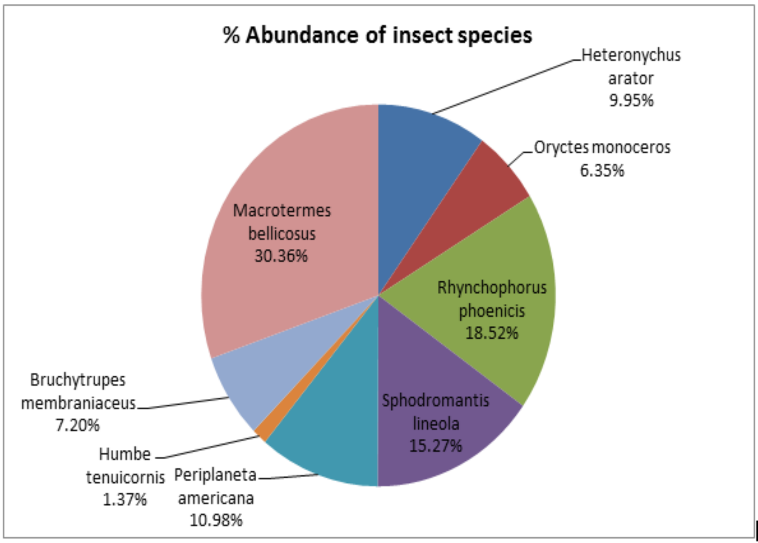


Fig. 3. Abundance (%) of insects species collected in Agulu

3.4 Diversity of the Insect Species

The diversity of the insect species, evenness, and richness are summarized in the Table 4 below.

A total of 1026 insect species were collected from gully erosion site in Agulu. Among these insect collection, the numbers of family observed were in the following decreasing order; Coleoptera 4, Dictyoptera 2, Orthoptera 2, Hymenoptera 1, and Isoptera 1. Dictyoptera had the highest dominance of 24.95% while Isoptera had the least dominance of 18.32%. Coleoptera and Orthoptera showed high diversity with Shannon diversity indices of 1.086 and 1.309 respectively (Table 4). Also these two orders (Coleoptera and Orthoptera) showed high species richness of 0.775 and 0.665 respectively compared to the other orders identified.

A total of 583 insect species were collected from gully erosion site in Nanka. All the orders identified had two families except for the order Isoptera. The dominance was observed in the following descending order; Coleoptera 34.82%, Isoptera 30.36%, Dictyoptera 26.24%, and Orthoptera 8.58%. Coleoptera was observed to show highest species diversity (1.004), species richness (0.376), and species evenness (0.335) compared to the other species identified.

3.5 The Extent of Significance of the Economic Insects Identified in the two Study Sites (Agulu and Nanka)

3.5.1 Demography of the respondents

The study of the demography of the respondents revealed higher percentage of the respondents to be within the age range of 26 to 49 years (35.56%), followed by the age range within 15 to 25 (28.89%), respondents in the age range of above 60 had the least percentage participation (2.77%0. The percentage participation of respondents within the age range less than 15 years and 41 to 60 years are 13.89% and 18.89% respectively.

Table 5. Species diversity, dominance, evenness and richness

Order	No. of Family	Total No. of species	Total No. of individuals	Dominance %	Species Diversity	Species richness	Species evenness
Agulu Site							
Coleoptera	4	5	174	16.96	0.740	0.170	0.418
Hymenoptera	1	1	206	20.08	0.724	0.201	0.451
Blattodea	3	5	444	43.27	0.696	0.433	0.832
Orthoptera	2	4	202	19.69	0.726	0.197	0.447
Total			1026	100			
Nanka Site							
Coleoptera	2	3	203	34.82	0.693	0.348	0.657
Blattodea	3	3	330	56.60	0.725	0.566	1.274
Orthoptera	2	2	50	8.58	0.810	0.086	0.330
Total			583	100			

Majority of the respondents are male (53.33%), while the females are 46.67%. 51.67% of these respondents are married, 36.11% are single, 2.22% are divorced, and 10.00% are widows or widowers. The household size of the respondents ranges from 1-2, 3-4, 5-6, and above 6. The highest percentage of respondents came from a household size of above 6 (40.00%), while the least percentage of respondents came from the household size of 1-2 (6.67%).

Table 6. Demographic information of the respondents

Parameters	Age	Participants	Percentage (%)
Age	Less than 15	25	13.89
	15-25	52	28.89
	26-40	64	35.56
	41-60	34	18.89
	Above 60	5	2.77
	Total	180	100
Sex	Male	96	53.33
	Female	84	46.67
	Total	180	100
Marital Status	Married	93	51.67
	Single	65	36.11
	Divorced	4	2.22
	Widow	18	10.00
	Total	180	100
Household Size	1-2	12	6.67
	3-4	42	23.33
	5-6	54	30.00
	Above 6	72	40.00
	Total	180	100
Educational attainment	No formal education	20	11.11
	Primary education	60	33.33
	Secondary education	52	28.89
	NCE/B.Sc.	47	26.11
	M.Sc. and Above	1	0.56
	Total	180	100
Member of Social group	1-2	115	63.89
	3-4	45	25.00
	5-6	18	10.00
	Above 6	2	1.11
	Total	180	100
Occupation	Full time farmer	58	32.22
	Part time farmer	12	6.67
	Civil/public servant	42	23.33
	Business man/woman	68	37.78
	Total	180	100

Table 7. Categories of insects identified based on their economic importance

S/N	Insects	Beneficial		Harmful		Both	
		No.	(%)	No.	(%)	No.	(%)
1	*Oxyprosopus superbus*	32	17.78%	110	61.11%	48	26.67%
2	*Stereostoma sp*	28	15.56%	128	71.11%	24	13.33
3	*Heteronychus arator*	10	5.56%	117	65.00%	53	29.44%
4	*Oryctes monoceros*	60	33.33%	98	54.44%	32	17.78%
5	*Rhynchophorus phoenicis*	49	27.22%	103	57.22%	28	15.56%
6	*Dorylus sp*	63	35.00%	29	16.11%	88	48.89%
7	*Deropeltis sp*	20	11.11%	88	48.89%	72	40.00%
8	*Sphodromantis lineola*	107	59.44%	25	28.89%	48	26.67%
9	*Periplaneta Americana*	27	15.00%	61	33.89%	92	51.11%
10	*Gyna costalis*	16	8.89%	50	27.79%	114	63.33%
11	*Acrida bicolor*	32	17.78%	55	30.56%	93	51.67%
12	*Humbe tenuicornis*	110	61.11%	20	11.11%	50	27.78%
13	*Bruchytrupes membraniaceus*	12	6.67%	131	72.78%	37	20.56%
14	*Zonocerus variegatus*	22	12.22%	120	66.67%	38	21.11%
15	*Macrotermes bellicosus*	140	77.78%	5	2.78%	35	19.44%

A larger percentage of the respondents have received some form of formal education. Only 11.11% of the respondents have no formal education while 33.3% have received primary education. 28.89% are secondary school graduate, 26.11% have NCE or B.Sc. certificate, and 0.56% have M.Sc. and above (Table 5).

The table above revealed the respondent categorization of the insects collected into beneficial, harmful or both. Out of the fifteen (15) species of insects collected, eight (8) insect species were considered to be harmful such insects include; *Oxyprosopus superbus* (61.11%), *Stereostoma sp* (71.11%), *Heteronychus arator* (65.00%), *Oryctes monoceros* (54.44%), *Rhynchophorus phoenicis* (57.22%), *Deropeltis sp* (48.89%), *Bruchytrupes membraniaceus* (72.78%), and *Zonocerus variegatus* (66.67%). Three (3) insect species were considered to be beneficial [*Sphodromantis lineola* (59.44%), *Humbe tenuicornis* (61.11%), and *Macrotermes bellicosus* (77.78%)]. Four insect species were considered to be both beneficial and harmful [*Dorylus sp* (48.89%), *Periplaneta Americana* (51.11%), *Gyna costalis* (63.33%), and *Acrida bicolor* (51.67%)] (Table 6).

3.5.2 Consumption of insect analysis

A larger percentage of the respondents concerted to the idea that they consume insects. 54% of the respondents eat some kind of insects while 28% eats all kind of insects. 18% of the respondents do not eat insects at all (Fig. 4). Out of the 180 respondents, 143 agreed they consume insects. 32% of the respondents eat insects once a month, 29% eats insects once a year, 27% eats insects once a week, while 12% eats insects daily (Fig. 5).

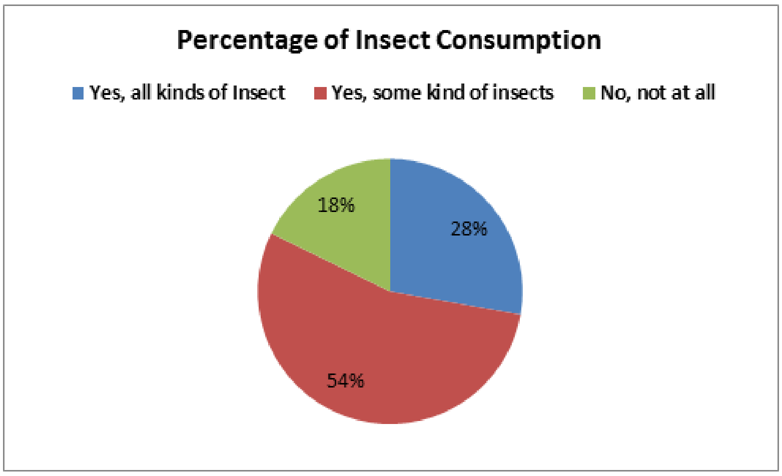


Fig. 4. Pie Chart showing the percentage of insect consumption

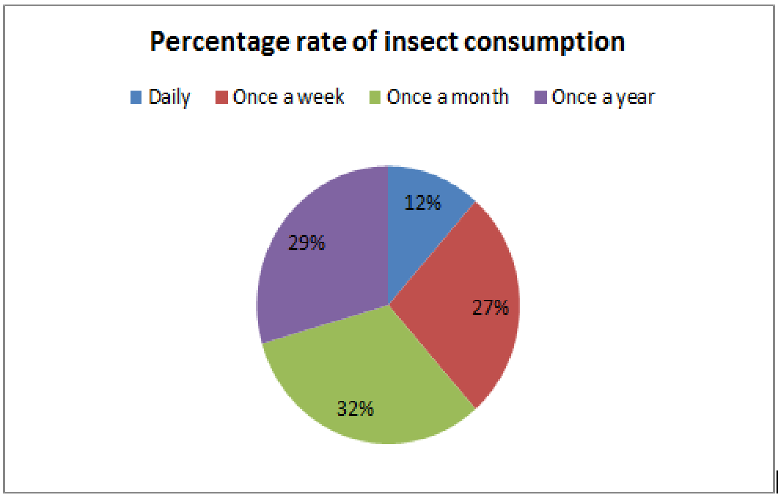


Fig. 5. Pie Chart showing the percentage level of insect consumption

Table 8. Economic importance of edible insects

S/N	Items	Mean	SD	Decision
1	Insects consumption is highly nutritious	3.75	0.40	Accepted
2	Insects consumption helps maintain the body health	3.01	0.68.	Accepted
3	Insects are rich source of protein	4.00	0.50	Accepted
4	Insects are majorly consume in rural areas	3.25	0.58	Accepted
5	Less satisfaction is derived from the consumption of insects	2.82	0.68	Rejected
6	Harmful insects are not advisable to consume	3.65	0.32	Accepted
7	Insects consumption is reduced due to fear of its structure, prestige and cultural taboo	3.36	0.49	Accepted
8	Some edible insects are consume more during certain seasons (such as rainy or dry season)	3.78	0.82	Accepted
9	Access to edible insects are limited to market areas and farms	3.21	0.62	Accepted
10	Edible insects can be prepared with other food	3.41	0.30	Accepted

The table above revealed the edibility status of insects in Agulu and Nanka communities. It can be observed that the inhabitants of these communities perceived insect consumption to be highly nutritious (3.75±0.40), maintains the body health (3.01±0.68), rich source of protein (4.00±0.50), majorly consumed in rural areas (3.25±0.58), insects are consumed more during certain seasons (3.78±0.82). Insect consumption is reduced due to fear of its structure; prestige and cultural taboo (3.36±0.49), as access to edible insects are limited to market areas and farms (3.21±0.62). The respondents were in agreement that Harmful insects are not advisable to consume (3.65±0.32) and that edible insects can be prepared with other food (3.41±0.30). The idea that less satisfaction was derived from the consumption of insect was rejected based on the response of the respondents (2.82±0.68) (Table 8)

Table 9. Beneficial aspect of economic important insect species

S/N	Items	Mean	SD	Decision
1	Insect farming is a lucrative business	3.30	0.35	Accepted
2	Some insects are medicinal and are used in treatment of diseases	3.21	0.84	Accepted
3	Insects play an important role in decomposition	3.44	0.61	Accepted
4	Some insects produce other materials (such as honey and silk) that are useful	3.87	0.38	Accepted
5	Insects play a vital role in crop pollination	3.80	0.48	Accepted
6	Insects can be used as bait in fishing	3.12	0.66	Accepted
7	Some insects are used to control the population of other insects as predators	2.81	0.51	Rejected
8	Insects can also be used as poultry and livestock feed	4.01	0.67	Accepted

Table 10. Harmful aspects of economic important insect species

S/N	Items	Mean	SD	Decision
1	Harmful insects can feed on plants thus reducing crop yield	4.10	0.50	Accepted
2	Some insects can vector diseases of plant, animal, and even human	3.80	0.68	Accepted
3	Insects can damage both household and stored food	3.30	0.34	Accepted
4	Harmful insects destroys home furniture and equipment	3.01	0.60	Accepted
5	Some harmful insects are poisonous (possess venoms)	3.28	0.42	Accepted

The beneficial roles of insects in these communities include Insect farming as a lucrative business (3.30±0.35), some insects are medicinal and are used in treatment of diseases (3.21±0.84), insects play an important role in decomposition (3.44±0.61), some insects produce other materials (such as honey and silk) that are useful (3.87±0.38), insects play a vital role in crop pollination (3.38±0.48), insects can be used as bait in fishing (3.12±0.66), and insects can also be used as poultry and livestock feed (4.01±0.67). The idea that some insects are used to control the population of other insects as predators was rejected in the study (2.81±0.51) (Table 9).

The harmful effects of these insects in the study communities were observed as follows; they can feed on plants thus reducing crop yield (4.10±0.50), some insects can vector diseases of plant, animal, and even human (3.80±0.68), insects can damage both household and stored food (3.30±0.34), harmful insects destroy home furniture and equipment (3.01±0.60), Some harmful insects are poisonous (possess venoms) (3.28±0.42).

4. DISCUSSION

The present study focused on the diversity and economic importance of insects collected from gully erosion sites in Agulu and Nanka in Anambra state. The study of the diversity of insect species highlighted the dominance, diversity index, species richness and species evenness. A total of 1,609 insect fauna belonging to 15 species were identified from the study sites. 1026 insect specimens belonging to 15 species were identified in Agulu while 583 insect fauna belonging to 8 species were identified in Nanka. The result of this study shows that gully erosion site is dominated by diverse insects, probably due to the flora regeneration. This is in line with Nandini et al. [12] that agroecosystem, have a rich variety of entomofauna, which is was mainly because of the availability of varieties of crop plants and microhabitats. Nandini et al. [12] also attributed diversity of plants to insect diversity.

The results from Agulu site, shows that Blattodea were most dominant order (43.27%) representing 444 insect samples of which all the species observed belongs to the following families; Blattoidea, Blaberidae, Blattidae, and Termitidae (Table 2 and 4). This is in contrast to Nandini et al. [12] that reported Hymenoptera as the most dominant order (78.86%) representing 8,925 insect samples of which 8,813 belongs to family Formicidae with 2 species i.e. *Camponotus compressus* and *Monomorium scabriceps*, family Crabonidae is represented by 2 species i.e. *Cerceris sp* and *Liris sp* and family Halictidae is represented by *Halictus sp* and *Nomia sp*. The order Blattodea was also the most dominant order (56.60%) identified in Nanka site, representing 330 insect specimens of which 89 belongs to the family Mantidae, 64 belongs to the family Blattidae, and 177 belongs to the family Termitidae (Table 2 and 4).

In Agulu site, species diversity index showed the order Coleoptera to be the most diverse (0.740) in the study, followed by Orthoptera (0.726). Biswas (2015) stated that Coleopterans commonly known as beetles constitutes the largest order of all animals. In Nanka, the order Orthoptera was the most diverse (0.810) followed by the order Blattodea (0.725) (Table 4).

The following insect species *Oxyprosopus superbus* (61.11%), *Stereostoma sp* (71.11%), *Heteronychus arator* (65.00%), *Oryctes monoceros* (54.44%), *Rhynchophorus phoenicis* (57.22%), *Deropeltis sp* (48.89%), *Bruchytrupes membraniaceus* (72.78%), and *Zonocerus variegatus* (66.67%) were categorized as harmful. These insects are the order Coleoptera and Orthoptera. This lends support to Biswas [13] that Coleopterans commonly known as beetles' major ecological impact results from their effects on green plants, their contribution to breakdown of plant and animal debris and their predatory activities. Kirby [14] reported that the species under the order orthoptera feed on plant foliage, with a particular fondness for grasses and spurges. FAO [15] reported that insects from the family Coleoptera were major crop and stored grain pest. Three (3) insect species were considered to be beneficial [*Sphodromantis lineola* (59.44%), *Humbe tenuicornis* (61.11%), and *Macrotermes bellicosus* (77.78%)] from the family Dictyoptera, Orthoptera, and Isoptera respectively. this in line with Akunne et al. [6] that insects also have beneficial properties which include; insect products (such as honey, silk, dye etc.), role in pollination, as source of food (for man and livestock), as scavenger, and as experimental animal.

Four insect species were considered to be both beneficial and harmful [*Dorylus sp* (48.89%), *Periplaneta Americana* (51.11%), *Gyna costalis* (63.33%), and *Acrida bicolor* (51.67%)]. This lend support to Van Lenteren and Overholt [16] that a vast group of insects are classified as neutral, that is they are both harmful and beneficial to man. The study showed higher category of harmful insects compared to beneficial or both (Table 6). This is in line with Jordan and Verma, [17] that "compared with beneficial insects, injurious insects are very numerous".

The respondents were in support to the following statements: insects consumption helps maintain the body health; insects are rich source of protein, insects are majorly consume in rural areas; harmful insects are not advisable for consumption, insects consumption is reduced due to fear of its structure, prestige and cultural taboo; some edible insects are consume more during certain seasons (such as rainy or dry season); access to edible insects are limited to market areas and farms; and that edible insects can be prepared with other food. The respondents disagreed with the statement that less satisfaction is derived from the consumption of insects. Also the following statement was accepted on the benefits of insects: some insects are medicinal and are used in treatment of diseases; insects play an important role in decomposition; some insects produce other materials [such as honey and silk (Gullan and Cranston, [18]) that are useful; insects can be used as bait in fishing; and that insects can also be used as poultry and livestock feed. The statement that some insects are used to control the population of other insects as predator was rejected.

The harmful effects of insects highlighted in this study include; some insects can vector diseases of plant, animal, and even human, insects can damage both household and stored food, harmful insects destroy home furniture and equipment, and that Some harmful insects are poisonous (possess venoms).

5. CONCLUSION

Insects can be beneficial or harmful to man. The order of arthropods observed in the study were Coleoptera, Blattodea, Hymenoptera, and Orthoptera; their species diversity, richness, and dominance were of different proportions in the study sites. The order Blattodea was the most dominant arthropod observed in both study sites. Coleoptera had the most species diversity in Agulu, while Blattodea had the most species diversity in Nanka. The study highlighted the beneficial use of these insects as food, fishing baits, poultry feed, and as medicine; and also the harmful effect of these insects were observed as disease vector to man and animals, and their role in the destruction of stored food, farm equipment and home furniture were also noted.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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