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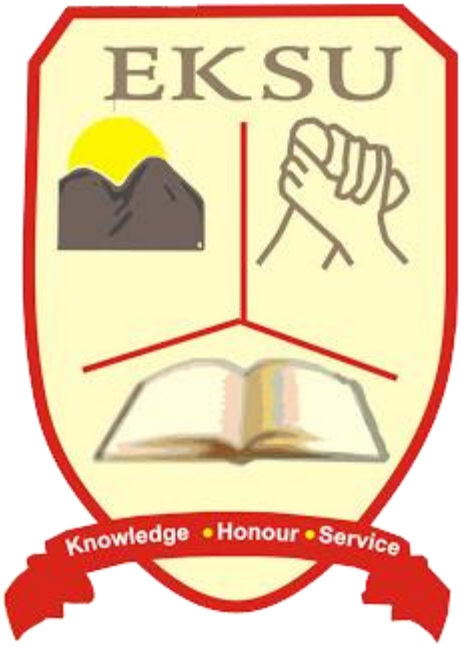

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EDITORIAL

This is Volume 7 of the Journal of Researches in Agricultural Sciences published by the faculty of Agricultural Sciences, University of Ado-Ekiti, Nigeria. It is the fifth out of the seven editions published by the current Editorial Board in fulfillment of the mandate given to her to revive and ensure the regular publication of the Faculty Journal. The articles are the results of research carried out in different areas of agriculture by scientists who have dared to tread the path of providing solutions to the myriad of challenges that make the desire for food and nutrition security a moving target. The edition consists of articles on two issues: No 1 and 2.

We are grateful to all contributors who submitted articles online and promptly responded to the aspects that required attention as pointed out by the reviewers. Also, the review process has allowed the authors/contributors to improve the quality of the articles. The efforts of our various reviewers in this regard are greatly appreciated.

The pursuit to widen the spread of authors' institutions and the areas of specialization and the desire for online publication of the journal in response to the expanding readership/referencing, subscription and submission of articles are receiving attention. Efforts are on to create a new and running website for the journal which can be visited to obtain relevant information since its initial link to the Faculty of Agricultural Sciences website had been compromised.

The Editorial Board is grateful for the support given by the Dean and Board of the faculty of Agricultural Sciences for the regular and timely publication of the Journal. We desire to get better with each edition.

Professor O.J. Ayodele
Editor-in-Chief

AIMS AND SCOPE

The *Journal of Researches in Agricultural* Sciences publishes original articles and reviews in agriculture and related interdisciplinary studies that explore and exploit the production of food for mankind. It also publishes scientific works related to strategic and applied studies in all aspects of agricultural science. The Journal publishes regular issues as well as special issues including symposia, conferences etc.

Instructions for authors.

Please note that the Instructions include guidelines that are specific to the *Journal of Researches in Agricultural* Sciences.

Author representations

Submission of a manuscript implies: that the work described has not been published before; that it is not under consideration for publication anywhere else; that its publication has been approved by all co-authors, if any, as well as by the responsible authorities at the institution where the work has been carried out.

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Authors must submit their manuscripts online via the *Journal of Researches in Agricultural Sciences* Editorial Manager at jras.foas@gmail.com or foas.jras@eksu.edu.ng

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Regular articles report original research on, or techniques for studying, the fundamental relationships between natural resources utilization and agricultural productivity.

Articles in special issues

Special issues are collections of themed articles, sometimes arising from conferences, symposia or other notable events. Only full papers of the same standard as regular articles will be considered for publication in special issues.
Articles submitted to the Journal for inclusion special issues are subjected to the same editorial processes as regular articles.

Reviews

Review articles are intended to be comprehensive summaries of topical issues in particular aspects of agricultural science. Prospective authors of reviews should contact the Editor-in-Chgief before preparing such articles.

Manuscript format

Cover letter

All submissions must include a cover letter that includes:
A confirmation of author representations that the work described has not been published before; it is not under consideration for publication anywhere else, and publication has been approved by all co-authors.

A statement of the novelty and significance of the work and the relevance to the mission of the *Journal of Researches in Agricultural* Sciences.

Names, affiliations and E-mail addresses of at least three suitable referees, together with a brief statement of why they are qualified to evaluate the manuscript.

Referees should be selected from institutions other than those of the author(s).

Approval from the ethics communities of the author(s) institution for the techniques / methodology and materials used.

Title page

The title page should include:
The name(s) of the author(s), with symbols to link each name with the author's institutional affiliation and an asterisk to denote the corresponding author.

A concise and informative title

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Abstract

The abstract should be 150 to 250 words. The content should state the main purposes and research questions of the study, the methods used, the main results, and the key conclusions.

Keywords

Authors should provide 4 to 6 keywords, which can be used for indexing purposes.

Main body

Manuscripts describing original research will typically include the following sections:

Introduction: a concise, up-to-date description of the background to provide a general reader of the Journal with enough context to understand the research being presented and its significance, as well as providing a clear statement of the research question and any hypotheses being explored.

Materials and Methods: techniques, materials, and equipment described in sufficient detail for another trained researcher to be able to reproduce the experimental work reported. Methods that are identical to published procedures should be summarized and include a citation to the original work.

Data Analysis: in submissions that have a significant theoretical or mathematical component, a description of the analytical procedures may be required.

Results: a description of the analyses and measurements related to answering the central research questions.

Discussion: the interpretation of the results, considering their significance, and putting them into a wider context through comparison with previously published research.
The use of a combined "Results and Discussion" section is also allowed as the format for the journal.

Conclusions: a concise statement of the main conclusions drawn from the research reported in the manuscript.

Acknowledgments: a list of people who contributed to the work in the manuscript but who are not named in the author list, and a list of funding sources that supported the research presented.

Text

Text formatting

- Manuscript should be submitted in Microsoft Word.
- Use a normal, plain font (e.g., 12-point Times New Roman) for text.
- Use italics for scientific names.
- Use the automatic page numbering function number the pages.
- *Do not use field functions*
- Use tab stops or other commands for indents, not the space bar.
- Use the table function, not spreadsheets, to make tables.
- Use the equation editor or Math-Type for equations.
- Save your file in .docx format (Word 2007 or higher) or .doc format (older Word versions).

Headings

No more than three levels of displayed headings should be used.

Abbreviations

Abbreviations should be defined at the point of first use and be used consistently thereafter.
Abbreviations defined in the abstract should be redefined in the main body of the submission.

Scientific style

Internationally-accepted signs and symbols for units (SI units) should be used throughout.
Negative exponents should be used instead of slash, e.g., ms^{-2} rather than m/s2

Nomenclature

In so far as possible, authors should use systematic names similar to those used by Chemical Abstracts Service or IUPAC.

References

The list of references should only include works that are cited in the text and that have been published or accepted for publication. Personal communications and unpublished works should only be mentioned in the text.
Reference should be arranged in alphabetical order (APA format) of authors' names at the end of the paper.
Each should be given in the following form:

- Authors' names,
- Year of publication,
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- The title of the Journal in full and italicized,
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Braimah, A.K. (2000). Land evaluation for sorghum. *Nigerian Journal of Soil Science* 12:4-11

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In the text, reference should be given by the name of the author, followed by the year of publication in brackets; the letters, a b, etc. should be used to distinguish between papers published by the same author in a single year.

Volume 7, No 1 (March, 2019)

Journal of Researches in Agricultural Sciences Vol. 7

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Bitumen Seepage: Impact and Interaction on Heavy Metal Concentrations in Surface Water

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Abstract

The association and interaction among metals in bitumen-polluted water may affect the availability of the metals even at toxic levels to the surrounding environment and biota that are dependent on such water. This study was carried out at Ode-Irele in Ondo State bitumen belt, Southwest of Nigeria, where there are bitumen seepages and at Ebute-Irele where there are no records of seepages to serve as a control. Composite samples of surface water were collected to a depth of 30 cm midstream in the sites and heavy metals- manganese, iron, copper, zinc, lead, chromium, cadmium, nickel, vanadium and arsenic, and alkali metals- calcium, magnesium, potassium, and sodium were determined using standard methods. The data of metal concentrations were analyzed using descriptive statistics and t-test at $p < 0.05$. The associations that exist among metals of surface water were determined using regressive correlation. The concentrations of the metals were compared with standards in the Federal Environmental Protection Agency and World Health Organisation Guidelines. The results show that nickel, calcium, magnesium, and sodium were higher in the seepage site than in the control, with only nickel in the seepage sites (0.40 ± 0.00 mg L^{-1}) significantly different from the control (0.30 ± 0.00 mg L^{-1}). Manganese, iron, copper, zinc, chromium, cadmium, nickel, vanadium, arsenic, and calcium concentrations were higher than the guideline levels. The correlation coefficients were positive and significant between iron and copper, manganese and vanadium, iron and sodium, calcium and magnesium, and between magnesium and sodium while the negative correlation between lead and zinc was significant. The metals whose concentrations were higher in the surface water of the seepage site and exceeded the guideline values, especially the component elements of bitumen (nickel, iron, manganese, vanadium, calcium, and sodium), would have toxic effects on the environment if not closely monitored during the bitumen development phase.

Keywords: Bitumen, heavy metals, concentration, toxicity, surface water

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Introduction

Bitumen, also known as asphalt, is a highly viscous liquid or semisolid material mainly produced from crude oil refinery process, and also present in some natural deposits (Rasoulzadeh *et al.*, 2011). Asphalt composition can be divided into four generic groups: saturates, aromatics, resins, and asphaltenes (Rasoulzadeh *et al.*, 2011). Also present in bitumen are the heteromolecules of sulphur, oxygen, nitrogen, and metals as well as combinations of alkanes, cycloalkanes, and aromatics (Read and

Whiteoak, 2003). Asphalt Institute and Eurobitume (2015) gave the elemental analysis of bitumen from various sources as, % by weight, carbon (80.2-84.3), hydrogen (9.8-10.8), nitrogen (0.2-1.2), sulphur (0.9-6.6) and oxygen (0.4-1.0); and in mg kg^{-1}, nickel (10-139), vanadium (7-1590), iron (5-147), manganese (0.1-3.7), calcium (1-335), magnesium (1-134) and sodium (6-159).

How bitumen functions have to do with how the molecules interact with each other as well as with other materials such as aggregate surfaces and water. The amount of hetero-molecules of sulphur, nitrogen, oxygen, and metals in some bitumen molecules makes them slightly polar. In bitumen chemistry, if the molecules contain hetero-atoms, they are better able to form molecular associations, and this has a great influence on the physical properties as well as the performance of bitumen (Goodrich *et al.*, 1986). However, bitumen is very much insoluble in water because of its inert property (Kriech, 1990; Brandt and de Groot, 2001).

Bituminous products are often used in lining drinking water reservoirs and pipelines for the supply of drinking water; retention ponds are often coated with asphalt to prevent liquid industrial waste products from leaching into the soil; while bitumen is also used to line hazardous waste sites to prevent rainwater from leaching the wastes into groundwater (APA, 2011). The paving and roofing materials made from bitumen materials are subject to water runoff from rainfall. The heavy metal contamination of highway runoff water and roadside soils has been reported (Warren and Birch, 1987; Strecker *et al.*, 1990; Pagotto *et al.*, 2000; Lau *et al.*, 2009) but Cooper *et al.* (1996) noted the source as the vehicles that plied the roads rather than from bitumen pavements.

Heavy metals including both essential and non-essential elements have eco-toxicological effects on living organisms (Storelli *et al.*, 2015). The pollution of water by heavy metals is a serious global problem due to the toxicity and the ability to accumulate in the water and the subsequent consumers (Fabio *et al.*, 2016). Heavy metal toxicity is one of the major current environmental health problems and is potentially dangerous because of bio-accumulation through the food chain (Aycicek *et al.*, 2008) and this can cause hazardous effects on animal and human health (Aschner, 2002). The concentrations of heavy metals in the aquatic ecosystems are generally monitored by analyzing water, sediments and associated biota samples to assess the levels of accumulation (Camusso *et al.*, 1995).

Several studies on the bituminous deposits in Ondo State, Nigeria have been carried out (Lameed and Ogunsusi, 2002a, b; Adebiyi and Asubiojo, 2008; Olajire *et al.*, 2007, 2008; Olabemiwo *et al.*, 2011; Fagbote and Olanipekun, 2013; Victor-Oji *et al.*, 2017; Ogunsusi and Adeleke, 2019) with emphasis on the characteristic constituents, hydrocarbon content and metal toxicity of the mineral. There is the paucity of information on the quality of surface water bodies in the bitumen belt of Ondo State, Nigeria, particularly with regards to the inter-relationships of the heavy metals with one another. This study is aimed at evaluating the impact of bitumen seepage on the heavy metal concentration of the surface water in the bitumen belt of Ode-Irele, Ondo State, Nigeria, and how the metals associate with one another to influence their availability. The hypothesis is that the metal concentrations of surface waters in the seepage and control sites are not significantly different and that there are no associations between the levels of the metals.

Materials and Methods

Study site

The study was carried out at Ode-Irele in Ondo State, Southwest of Nigeria (Fig 1). Ode-Irele is located in the southern fringe of the state between latitudes 06º 16′ to 06º 40′N and longitudes 04º 47′ to 05º 10′E.

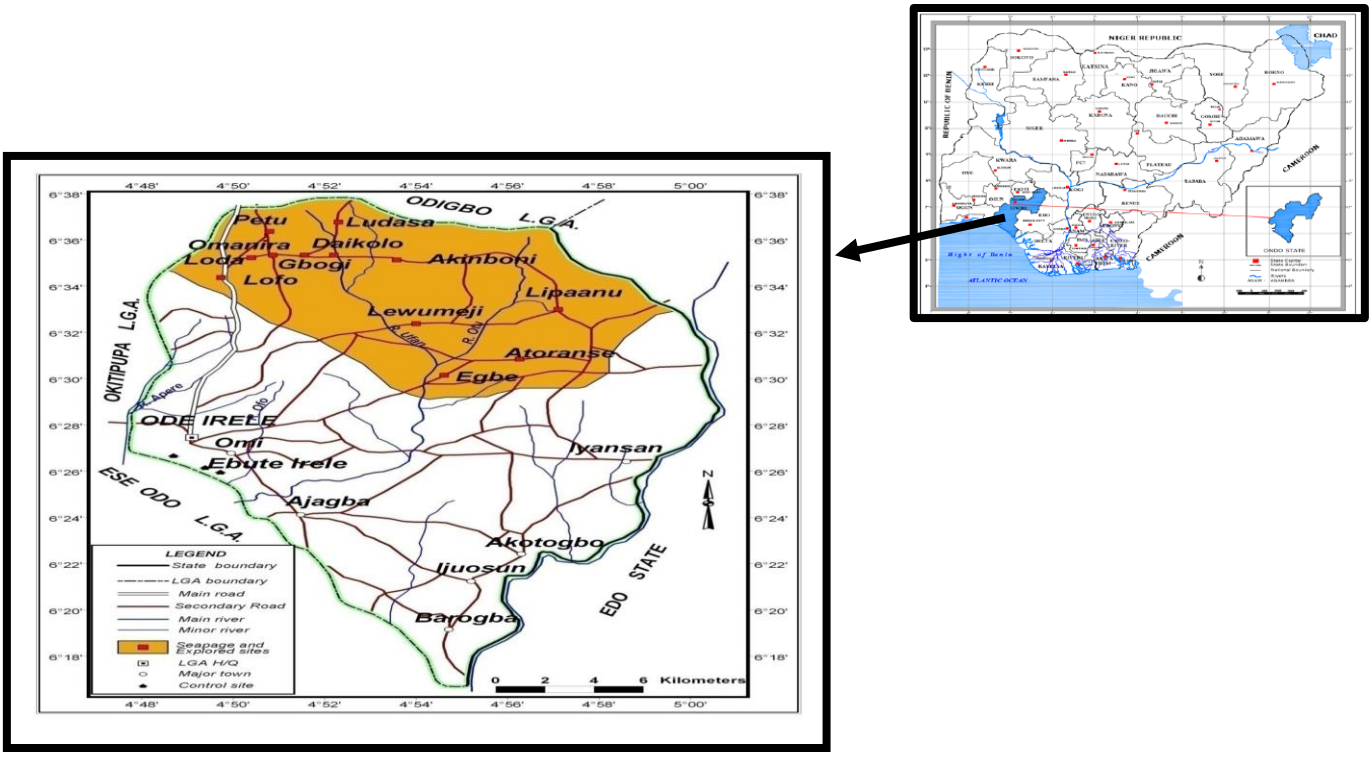

Fig. 1: The bitumen exploration belt of Irele Local Government Area, Ondo State, Nigeria
Source: Ogunsusi and Adeleke (2017)

Sampling Techniques

Composite water samples were collected to a depth of 30 cm midstream at seepage sites in Loda (S1), Ludasa (S2), Petu (S3) and Omanira (S4); and at four locations (C1, C2, C3, and C4) in Ebute-Irele, about 12 km away from the seepage sites, which served as the control. The water samples were collected in plastic bottles, pre-rinsed at least three times with the sample water, and taken to the Department of Agronomy, University of Ibadan, Nigeria within 12 hours for analysis to determine the metal concentrations. The heavy metals - Fe, Mn, Cu, Pb, Cd, Cr, Ni, V, Zn, and As; and alkali metals- Ca, Mg, K, and Na were determined on an atomic absorption spectrometer (Perkin-Elmer, 1968).

Data analysis

The data of metals' concentrations from the seepage and control sites were analyzed using descriptive statistics and t-test at $p<0.05$. The associations that exist among metals of surface water were analysed using regressive correlation. The values of the metals were compared between seepage and control sites, and with recommended Federal Environmental Protection Agency (FEPA, 1991; 2003), World Health Organization (WHO, 2004; 2010), and FEQGs (2016) guidelines. The standard guidelines are useful in assessing the risk of surface water pollution (Song *et al.*, 2013) and for the proper management of water (Adhikary *et al.*, 2010).

Results

Heavy metal concentrations in surface water

The mean concentrations of the metals in the surface water of bitumen seepage site and the control are shown in Table 1. The concentrations of Ni, Ca, Mg, and Na were higher in the seepage site but only Ni showed a significant difference between the surface water of the seepage site (0.40 ± 0.00 mg L^{-1}) and the control (0.30 ± 0.00 mg L^{-1}). The contents of Mn, Fe, Cd, V, and As were the same while the control contained higher Zn, Pb, Cr, and K which were not significantly different.

Table 1: Heavy metals and alkali metals in surface water of the bitumen belt in Ondo State

Metal	Mean mg L^{-1}		t-value	Df	P	SD		FEPA (1991)	FEPA (2003)	WHO (2004)	WHO (2010)	FEQGs (2016)
	Seepage Site	Control Site				Seepage	Control	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}
Mn	12.00	12.00	0.26	6	0.81	0.0030	0.0010		0.03		0.40	
Fe	2.10	2.10	0.38	6	0.71	0.0000	0.0000		0.03		0.30	
Cu	0.65	0.60	1.00	6	0.36	0.0006	0.0008		0.03		2.00	
Zn	1.50	1.70	0.83	6	0.44	0.0001	0.0004		0.012		3.00	
Pb	0.05	0.07	0.30	6	0.77	0.0000	0.0000		0.06		0.01	
Cr	0.05	0.07	2.18	6	0.10	0.0000	0.0000	0.05			0.05	
Cd	0.03	0.03	0.66	6	0.54	0.0000	0.0000		0.04		0.003	
Ni	0.40*	0.30*	2.45*	6	0.05*	0.0000*	0.0000*	0.1-0.2			0.07	
V	0.30	0.30	0.47	6	0.66	0.0002	0.0001					0.12
As	0.01	0.01	0.00	6	1.00	0.0000	0.0000	0.01			0.01	
Ca	141.30	137.50	0.75	6	0.48	0.0090	0.0141			150		
Mg	57.80	53.00	1.96	6	0.10	0.0039	0.0029			150		
K	3.00	4.00	1.73	6	0.13	0.0008	0.0008			200		
Na	13.30	4.00	1.00	6	0.36	0.0185	0.0008			200		

NB: marked t-value is significant at $P < 0.05000$

Heavy metal concentrations and the permissible limits

The Mn level across all locations sampled ranged from 9.80 to 16.20 mg L^{-1} (Table 2). The range of Mn values exceeds the WHO (2010) guideline of 0.40 mg L^{-1} and FEPA (2003) guideline of 0.03 mg L^{-1}. The Fe level ranged between 1.80 and 2.20 mg L^{-1} and was higher than the WHO (2010) guideline of 0.3 mg L^{-1} and FEPA (2003) guideline of 0.03 mg L^{-1}. The Cu level ranged between 0.60 and 0.70 mg L^{-1} and was lower than the WHO (2010) limitation guideline of 2.0 mg L^{-1} but higher than FEPA (2003) limitation guideline of 0.3 mg L^{-1}. The Zn level varied between 1.50 and 1.70 mg L^{-1} being below the WHO (2010) guideline of 3.0 mg L^{-1} but less than the FEPA (2003) guideline of 0.012 mg L^{-1}. The Pb content was between 0.005 and 0.05 mg L^{-1} and far below the WHO (2010) guideline at 0.01 mg L^{-1} and FEPA (2003) guideline of 0.06 mg L^{-1}. The range of values for Cr was between 0.02 and 0.07 mg L^{-1} with the lower limit below the WHO (2010) and FEPA (1991) guideline of 0.05 mg L^{-1} while the upper range was higher. The Cd varied between 0.02 and 0.03 mg L^{-1} and was higher than the WHO (2010) guideline of 0.003 mg L^{-1} but lower than FEPA (2003) guideline of 0.4 mg L^{-1}. The range of nickel was 0.004 to 0.40 mg L^{-1} with the lower limit below the WHO (2010) guideline of 0.1mgL-1 and FEPA (1991) 0.1-0.2 mg L^{-1} but the upper value was higher. The range of V was 0.03 to 0.4 mg L^{-1} with the lower value less than FEQGs guideline of 0.12 mg L^{-1} while the upper value was higher. The level of As ranged between 0.01 and 0.02 mg L^{-1} which is within the WHO (2010) and FEPA (1991) guideline of 0.01 mg L^{-1}.

Table 2: Heavy metals in the surface water at various locations in the bitumen belt of Ondo State

Location	Elements (mg L^{-1})									
	Mn	Fe	Cu	Zn	Pb	Cr	Cd	Ni	V	As
S1	12.20	2.20	0.60	1.50	0.06	0.06	0.03	0.4	0.30	0.01
S2	9.90	1.80	0.70	1.50	0.04	0.05	0.02	0.4	0.40	0.01
S3	16.20	2.20	0.60	1.60	0.005	0.02	0.02	0.4	0.03	0.02
S4	9.80	2.00	0.70	1.50	0.04	0.06	0.03	0.4	0.40	0.01
Mean	12.00	2.10	0.65	1.50	0.04	0.05	0.03	0.3	0.3	0.01
C1	11.20	2.00	0.60	2.20	0.04	0.06	0.03	0.3	0.3	0.02
C2	12.00	1.90	0.50	1.60	0.03	0.07	0.3	0.2	0.4	0.01
C3	13.30	2.20	0.70	1.80	0.05	0.08	0.02	0.4	0.3	0.01
C4	9.90	2.30	0.60	1.20	0.04	0.07	0.03	0.3	0.3	0.01
Mean	12.00	2.10	0.60	1.50	0.04	0.05	0.03	0.3	0.3	0.01
FEPA(1991)						0.05		0.1 - 0.2	-	0.01
FEPA(2003)	0.03	0.03	0.30	0.0123	0.06		0.04		-	
WHO(2010)	0.40	0.3	2.00	3.00	0.01	0.05	0.003	0.01	-	0.01

Alkali metal concentrations and the permissible limits

The concentrations of alkali metals and their permissible limits are as presented in Table 3. The Ca level ranged between 132 and 152 mg L^{-1} in seepage site with the lower limit less than the WHO (2004) guideline at 150 mg L^{-1} but the upper limit higher than the guideline. Mg ranged between 55 and 62 mg L^{-1} and the values were lower than the WHO (2004) guideline of 150 mg L^{-1}. The range of K was between 2 and 4 mg L^{-1} which was lower than the WHO (2004) guideline of 200 mg L^{-1}. The Na ranged between 4 and 41 mg L^{-1} and lower than WHO (2004) guideline at 200 mg L^{-1}.

Table 3: Available alkali metals in surface water of the bitumen belt in Ondo State

Location	Elements (mg L^{-1})			
	Ca	Mg	K	Na
S1	132.00	54.00	2.00	4.00
S2	145.00	60.00	3.00	4.00
S3	136.00	55.00	3.00	4.00
S4	152.00	62.00	4.00	41.00
Mean	141.00	58.00	3.00	13.00
C 1	125.00	55.00	3.00	4.00
C 2	145.00	51.00	5.00	5.00
C3	121.00	50.00	4.00	3.00
C 4	149.00	56.00	4.00	4.00
Mean	135.00	53.00	4.00	4.00
WHO (2004)	150 mg L^{-1}	150 mg L^{-1}	200 mg L^{-1}	200 mg L^{-1}

Associations between the metals

The correlation coefficients of the associations between the metals in surface water of the bitumen belt are presented in Table 4. The positive correlations are: Fe with Cu, Mn, Pb, Cr, Ni, V, and Zn, and Ca, Mg, K and Na but only Cu and Na were significant ($P<0.05$); and Mn with Cu, Pb, Cr, Ni, V, and Zn; Ca, Mg, K, and Na but only V was significant ($P<0.05$). The other metals had positive correlations: V with Cu, Pb, Cr, Ni, As, Zn, Ca, Mg, K and Na but only Mn was significant. Cu with Pb, Cr, Ni, Zn, and Na; Ni with Pb, Cr, As, Zn and Na; Pb with Ca, and Na; Cr with Cd, As and Zn; Cd with As, Zn, Ca, Mg and K; As with Zn, Mg, and K; Zn with Ca, Mg and K; Ca with Mg and K; Mg with Ca, K and Na; and K with Na. The negative correlations are Cd with Fe, Cu, Mn, Pb, Ni, V, and Na but the association between Pb significant ($p<0.05$); As with Fe, Cu, Mn, Pb, Ca and Na; Cu with Cd, As, Ca, Mg, and K; Pb with Cr, Zn, Mg and K; Cr with Ca, Mg and K; and Ca with Na.

Table 4: Correlation matrix of the relationships between the metals in the surface water of the bitumen belt in Ondo State

	Fe	Cu	Mn	Pb	Cr	Cd	Ni	V	As	Zn	Ca	Mg	K	Na
Fe	1.0	0.8*	0.8*	0.6	0.0	-0.7	0.2	0.4	-0.4	0.3	0.2	0.1	0.1	0.8*
Cu	0.8*	1.0	0.6	0.5	0.2	-0.6	0.4	0.2	-0.2	0.3	-0.3	-0.4	-0.4	0.7
Mn	0.8*	0.6	1.0	0.6	0.4	-0.7	0.6	0.9*	-0.1	0.3	0.2	0.1	0.0	0.8
Pb	0.6	0.5	0.6	1.0	-0.3	-1.0*	0.3	0.4	-0.8*	-0.5	0.1	-0.3	-0.2	0.5
Cr	0.0	0.2	0.4	-0.3	1.0	0.1	0.8*	0.6	0.8*	0.6	-0.6	-0.2	-0.3	0.3
Cd	-0.7	-0.6	-0.7	-1.0*	0.1	1.0	-0.4	-0.4	0.7	0.4	0.1	0.4	0.3	-0.6
Ni	0.2	0.4	0.6	0.3	0.8*	-0.4	1.0	0.8*	0.3	0.2	-0.6	-0.4	-0.4	0.5
V	0.4	0.2	0.9*	0.4	0.6	-0.4	0.8*	1.0	0.2	0.2	0.1	0.3	0.2	0.6
As	-0.4	-0.2	-0.1	-0.8	0.8*	0.7	0.3	0.2	1.0	0.7	-0.3	0.2	0.0	-0.1
Zn	0.3	0.3	0.2	-0.5	0.6	0.4	0.2	0.2	0.7	1.0	0.0	0.3	0.1	0.3
Ca	0.2	-0.3	0.2	0.1	-0.6	0.1	-0.6	0.1	-0.3	0.0	1.0	0.9*	0.7	-0.0
Mg	0.1	-0.4	0.1	-0.3	-0.2	0.4	-0.4	0.3	0.2	0.3	0.9*	1.0	0.9*	0.1
K	0.1	-0.4	0.0	-0.2	-0.3	0.3	-0.4	0.2	0.0	0.1	0.7	0.9*	1.0	0.3
Na	.8*	0.7	.8*	0.5	0.3	-0.6	0.5	0.6	-0.1	0.3	-0.0	0.1	0.3	1.0

* Correlations are significant at $P < 0.05000$

Discussion

The mean concentrations of the metals in the surface water were not significantly different between the bitumen seepage and the control sites. This suggests that the levels of these metals in bitumen are probably not enough to bring about their release to cause accumulation in the water sources. However, the concentrations of Ni, Ca, Mg, and Na was higher in the seepage site probably in relation to the elemental analysis of bitumen samples which has shown the preponderance of Ni, V, Fe, Mn, Ca, and Na (Asphalt Institute and Eurobitume, 2015). These metals might have leached from the bitumen and may be potential environmental threats if allowed to accumulate in surface water. This is, however, not in agreement with Elinge *et al.* (2011) who reported

higher levels of some metals (Ca, Mg, Na, and K) in the control site than this seepage site.

The higher levels of some metals than the WHO (2010) and FEPA (2003) guidelines point to the possible levels of toxicity in the surface water impacted by bitumen seepage. The higher level of Mn may not be unconnected with its wide distribution as one of the most abundant elements in the earth's crust. It is an essential trace element with many biological functions but toxic at higher doses (Erikson *et al.*, 2005). Zhang *et* al. (2014) noted that very high mean concentrations of Mn in drinking water are correlated with cancer incidences and mortality. Since Mn is a component of bitumen (Asphalt Institute and Eurobitume, 2015), the potential toxicity in the study area would be from bitumen seepage. Fe as one of the elemental components of bitumen was higher than the WHO (2010) and FEPA (2003) guidelines and this may pose a potential environmental threat. This toxicity might have resulted from the transportation of the metal from bitumen seepage to the nearby surface water.

The Cu level was lower than WHO (2010) guideline but higher than FEPA (2003) standard such that the upper limit may pose a potential environmental threat. Although man can adapt to excessive exposure to Cu from water by decreasing the absorbed fraction (Turnlund *et al.*, 1989; Uauy *et al.*, 1998), its consumption above 5-6 mg L^{-1} results in nausea, vomiting, and diarrhoea (WHO, 2003). The Zn level was higher than FEPA (2003) guideline and can be a potential environmental threat. It has poor mobility in anaerobic environments such that severe contamination can occur in surface water primarily near a point source of its release (Barceloux and Barceloux, 1999). The exposure to excess Zn compounds has been implicated in cases of irritation and corrosion of the gastrointestinal tract, acute renal tubular necrosis, and interstitial nephritis.

The Pb level was lower than WHO (2010) and FEPA (2003) guidelines and may not pose a serious threat to the environment. However, Pb accumulation in surface water should be avoided because chronic exposure can result in mental retardation, brain damage, and kidney damage in man (Martin and Griswold, 2009).

The upper limit of Cr was higher than WHO (2010) and FEPA (1991) guidelines. The potential environmental threat relates to its high solubility in water, high mobility, and ease of reduction. Excessive exposure to Cr can affect the respiratory tract, liver, kidney, gastrointestinal and immune systems, and the blood, and also cause dermatitis and ulceration of the skin (Saha *et al.*, 2011). The higher Cd level than WHO (2010) guideline has the potential to pose environmental threats. Jaishankar *et al.* (2014) observed that Cd is highly soluble in water which would enhance its bioaccumulation and bioavailability. The long-term exposure causes morpho-pathological changes in the kidneys. Although Ni is naturally-occurring in surface water, the upper limit higher than the WHO (2010) and FEPA (1991) guidelines might have come from bitumen (Asphalt Institute and Eurobitume, 2015) and this accumulation can pose a potential threat to the environment. The upper limit of V was higher than FEQGs (2016) guideline which can pose threats to livestock and human health. A variety of health problems have been reported in humans exposed to high doses of V, even as food supplements (EFSA, 2004). The As upper value was higher than the WHO (2010) and FEPA (1991) guidelines and may pose potential environmental problems to livestock and man. Smith *et al.* (2000) and IARC (2004) have provided pieces of evidence linking long-term As exposure and intake from drinking water with nausea and vomiting, reduced production of erythrocytes and leukocytes, etc.

The total cationic content of natural water comes from Ca^{2+}, Mg^{2+}, $K^{+,}$ and Na^{+}. The levels of these alkali metals below WHO (2004) and FEPA (1991) guidelines in this study show their low environmental pollution potentials. The Ca level would be beneficial to human and animal consumption through its contribution to the hardness of water which is one of the natural characteristics that enhances its palatability and consumer acceptability. Mortality rates and heart diseases are lower in areas with hard water (Tiwari *et al.*, 2015). The upper limit which was higher than the WHO (2004) guideline could have been due to leaching from the bitumen (Asphalt Institute and Eurobitume, 2015). Mg also contributes to total hardness in water but it is not a potential environmental threat despite being one of the elemental components of bitumen (Asphalt Institute and Eurobitume, 2015). K is the least abundant of the four cations in natural water (Tallin, 2010) and the potential threat of its low concentration is to limit the distribution of aquatic organisms. The low Na level in the study area may not pose a potential environmental threat even as van Dam *et al.* (2014)

noted that replacement of Ca and Mg with Na ion did not cause toxicity but increased the reproduction in an aquatic organism.

Conclusion

The concentrations of some metals determined in surface water samples collected from the bitumen belt of Ondo State, Nigeria showed that Ni, Ca, Mg, and Na were higher in seepage sites than in the control site with only the Ni significantly different. The ranges of values of the metals- Mn, Fe, Cu, Zn, Cr, Cd, Ni, V, As, and Ca were higher than WHO (2004; 2010) and FEPA (1991; 2003) guidelines. The levels of these metals, especially Ni, should be monitored to avoid hyperaccumulation in surface water during the actual development of bitumen.

The metals with which Fe, Mn, Ni, V, and Ca had positive correlations and especially where significant should be closely monitored during the bitumen development phase. This is because the metals, apart from being at higher concentrations than the guidelines, are elemental components of bitumen whose exploitation can speed up the seepage and accumulation of the metals in surface water and raise their toxicity levels

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Performance Evaluation of African Catfish (*Clarias gariepinus*) Fingerlings Fed African Locust Bean (*Parkia biglobosa*) Meal Diets

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Abstract

The high cost of conventional feedstuffs, especially the protein sources, due to competitive use in livestock feed and as industrial raw materials has necessitated the search for cheaper, locally available alternative feedstuffs as replacement in order to reduce the cost of production in aquaculture. A feeding trial was conducted to evaluate the growth and nutrient utilization of African catfish (*Clarias gariepinus*) fingerlings (average weight of 3.00 g) using African locust bean (*Parkia biglobosa*) meal (ALBM) to replace soybean meal as plant protein source. The fish fingerlings were stocked in fifteen glass tanks at the rate of ten fish tank^{-1} and fed five diet treatments in three replicates. The ALBM was used to replace soybean meal at 0, 25, 50, 75 and 100% substitution levels (denoted as D1, D2, D3, D4 and D5 respectively with D1 as the control) in the diets formulated at the 40% crude protein level required for *Clarias gariepinus*. The fish were fed daily to satiation and the experiment lasted for 70 days. The results show that fish fed diet D5 gave the best growth parameters which did not differ from D1 but both were significantly different ($P<0.05$) from the other diets. The cost of producing 1 kg of feed reduced as the level of inclusion of the ALBM increased in the diets. Therefore, African locust bean meal can replace soybean meal as plant protein source up to 100% in the diet of *Clarias gariepinus* fingerlings without any negative effect on the growth and nutrient utilization while the lower cost of feed production has the potential to increase the profit.

Keywords: Soybean meal, African locust bean meal, *Clarias gariepinus*

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Introduction

Fish is one of the most important sources of protein available in the tropics; fish protein improves nutrition because it has a high biological value in terms of high protein retention in the human body (Ogunlade, 2007). The African catfish, *Clarias gariepinus* (Burchell 1822), family Clariidae, is a fresh water fish generally considered to be one of the most important tropical catfish species for aquaculture in West Africa (Clay, 2009).

Aquaculture, as a food production enterprise, has become established in many African countries. A major prerequisite for successful fish farming is the availability of suitable artificial feeds that will supply adequate nutritional requirements for the cultured fishes (Craig and Helfrich, 2017). Fish nutrition is a major aspect of research in aqua-feed operations and for fish culture, the optimum dietary requirement at a reduced production cost is essential in order to maximize profit. One of the major ingredients for preparing such suitable feeds is soybean. In the developing countries, soybean meal is the most widely-used plant protein source in aqua- and other livestock feeds which account for the high cost (Obasa *et. al.*, 2009). Since feeding

cost represents the greatest single high cost item in fish farm operations (Jamiu and Ayinla, 2003; Fagbenro *et. al.,* 2005), the use of costly ingredients will further increase the cost of production, reduce the profit margin and bring about high price tag of fish for consumers. Therefore, the reduction of feed cost is a major challenge in aquaculture nutrition.

The high cost of conventional feedstuffs has brought about the need to have alternative feedstuffs that can replace the very expensive ones in order to reduce the cost of livestock and fish production (Longe, 2006). In the search for plant protein substitutes, the African locust bean (*Parkia biglobosa* (Jacq.) G.Don) is being considered for study. African locust bean (locust bean) is a perennial deciduous leguminous tree (family Fabaceae) which grows in the savannah region of Nigeria, to the southern edge zone (Campbell-Platt, 1980). The tree is particularly valued for its fermentable seeds that are relatively cheaper, more widely available and less competitive in use for both human and livestock consumption than soybean. Due to the savoury taste and high protein and fat values of the seed, it is sometimes described as a meat or cheese substitute (PFAF, 2012). It is rich in protein, lipids and vitamin B_2 but deficient in the amino acids such as methionine, lysine and tryptophan. However, the fermented locust bean is rich in lysine (Campbell-Platt, 1980) such that the use as an alternative plant protein source will reduce the challenges faced in fish feed formulation and save fish farmers the high cost of production. This, in turn, will improve fish production and bring about improved profit margin to the fish farmers. Therefore, this study was carried out to evaluate the effect of boiled African locust bean meal as an alternative plant protein source to soybean meal in the diet of African catfish *Clarias gariepinus* (Burchell 1822) fingerlings.

Materials and Methods

The study was carried out at the Department of Fisheries and Aquaculture Management, Ekiti State University, Ado Ekiti. The experiment involved fifteen 30-litre plastic tanks, each of 70 45 40 cm dimension with the water level maintained at $^2/_{3^{rd}}$ capacity of the tank throughout the period of the experiment. The dietary ingredients: fish meal, soybean meal, groundnut cake, maize meal and vitamin/mineral premix were purchased from a reputable livestock feed mill; vegetable oil and starch were bought from the city market while African locust bean seeds were sourced from Oko-Egan at Awo-Ekiti.

The African locust bean seeds were washed and cooked in water at a temperature of 100^{o}C for 6 h and the water was topped up occasionally to compensate for the loss due to evaporation. After cooking, the water was strained away with the aid of a basket lined with mesh. The seeds were de-hulled by pounding in a mortar, washed thoroughly and sieved to remove the hulls. The de-hulled seeds were sun-dried for three days, milled with a locally-fabricated grinding machine and the African locust bean meal (ALBM) packed in air-tight containers until needed for use.

The dietary ingredients were measured according to the gross composition in Table 1. Diet D1 to diet D5 were formulated to replace soybean meal with ALBM at inclusion levels of 0, 25, 50, 75 and 100% respectively. The diets were formulated at 40% crude protein level as required for *Clarias gariepinus* (Wilson and Moreau, 1996, FAO, 2019). Starch was added to act as binder and the feeds were pelletized with a locally-fabricated pelleting machine to 2 mm diameter size. The pellets were sun-dried and packed in labelled air-tight containers and stored in a cool and dry place.

One hundred and fifty (150) fingerlings of African catfish (*Clarias gariepinus*; mean initial weight = 3.00 g) were sourced from the farm of the Directorate of Fisheries, Ministry of Agriculture and Rural Development, Ado-Ekiti. The fish were acclimatized for seven days in the glass tanks and fed with Coppens®. The fish were weighed and randomly stocked at the rate of ten tank^{-1} and each treatment was replicated thrice. The experiment lasted for 70 days during which the fish were fed to satiation twice daily between the hours of 8-9 a.m. and 5-6 p.m. The left-over feeds and faeces were siphoned out of the tanks on daily basis to reduce water pollution. The water was changed twice a week. The fish were weighed fortnightly and at the end of the experiment, the final weight of each batch of fish was taken. The water quality parameters were monitored weekly: temperature using an ordinary mercury-in-glass thermometer, pH by a pH meter and Dissolved Oxygen (DO) analysis using Winklers' titration method.

. Table 1: Gross Composition of Experimental Diets (g/100g)

	D1 (0%)	D2 (25%)	D3 (50%)	D4 (75%)	D5 (100%)
Fishmeal (72%)	25.00	25.00	25.00	25.00	25.00
ALBM (41.14%)	-	4.90	9.80	14.70	19.60
SBM (45%)	24.50	19.60	14.70	9.80	4.90
GNC (38%)	23.00	23.00	23.00	23.00	23.00
Yellow Maize (10%)	23.50	23.50	23.50	23.50	23.50
Vegetable Oil	1.00	1.00	1.00	1.00	1.00
Starch	1.00	1.00	1.00	1.00	1.00
*Vit/Min. Premix	2.00	2.00	2.00	2.00	2.00

*Each kg contains: Vit A: 4,000,000 IU; Vit B 800,000 IU Vit E: 16,000 mg; Vit K_3: 800 mg; Vit B_1: 600 mg; Vit B_2 :2,000 mg; Vit B_6 :1,600 mg; Vit B_{12}: 8 mg; Niacin: 16,000 mg; Caplan: 4,000 mg; Folic Acid: 400 mg; Biotin: 40 mg; Antioxidant: 40,000 mg; Chlorine: 120,000 mg; Manganese: 32,000 mg; Iron: 16,000 mg; Zinc: 24,000 mg; Copper: 32,000 mg; Cobalt: 120 mg; Selenium: 800 mg (manufactured by DSM Nutritional Products Europe Limited, Basle, Switzerland)

The growth and nutrient utilization parameters in the fish were assessed as follows:

i. Weight gain = final weight of fish (W_2)-Initial weight (W_1)

ii. Specific growth rate (SGR)

$$= \frac{\text{Log}_e W_2 - \text{Log}_e W_1 \times 100}{T_2 - T_1}$$

where W_2 = Final Weight

W_1 = Initial Weight

T_2-T_1= Number of Days.

Log_e = Natural Logarithm to Base e

iii. Protein efficiency ratio (PER) = $\frac{\text{fish weight gain (g)}}{\text{Protein consumed (g)}}$

iv. Feed conversion ratio (FCR) = $\frac{\text{weight of feed (g)}}{\text{Fish weight gain (g)}}$

The proximate analysis of the test ingredient and the fish after the experiment was carried out to determine the moisture content, crude protein, crude fibre, ash content, lipid and carbohydrate using the methods described in AOAC (2000).

The costs of producing 1 kg of the different feeds with ALBM at different inclusion levels were calculated and compared with the production cost of 1 kg of the control diet which has no ALBM. The costing was done based on the prevailing market prices of the ingredients used in the diets at the time of the experiment.

Data (mean weight gain, specific growth rate, protein efficiency ratio, feed conversion ratio) obtained were subjected to One-Way Analysis of Variance (ANOVA) using the SAS package and differences between treatments separated using the Duncan Multiple Range Test at P=0.05 level.

Results

Table 2 shows the proximate composition of the test ingredient (boiled African locust bean meal, ALBM). The ALBM contained 41.14±0.00% crude protein, 1.20±0.01% total ash and 6.25±0.01 fat.

Table 2: Proximate analysis of the test ingredient.

Composition%	Average ±SD
Protein	41.14±0.00
Ash Content	1.20±0.01
Moisture Content	8.60±0.01
Crude Fibre	10.90±0.00
Fat	6.25±0.01
Carbohydrate	31.91±0.06

Laboratory analysis, 2018

Table 3 shows the growth performance and nutrient utilization of the experimental fish. The highest final mean weight of 6.10 g was obtained in fish fed diet D5, followed by diet D1 (5.69 g) while the least was in the fish fed diet D2 (4.64 g). The final mean weights in fish fed diet D5 and diet D1

were not significantly different (p>0.05) but differed significantly from other diets. The final weights were also not different among diet D1, diet D3 and diet D4. The highest weight gain (3.10 g) was in the fish fed diet D5 followed by diet D1 (2.69 g) which did not differ significantly while the least weight gain (1.64 g) was in the fish fed diet D2. The daily weight gain and specific growth rate followed the same trend with the fish fed diet D5 recording the highest values and fish fed diet D2 recording the lowest values. The best food conversion ratio (FCR) was obtained in the fish fed diet D5 (2.16) while fish fed diet D2 had the poorest (2.51).

Table 3: Growth parameters and nutrient utilization of the fish fed African locust bean meal

Parameters	D1	D2	D3	D4	D5
Initial weight (g)	3.01±0.006^{a}	3.00±0.006^{a}	3.00±0.000^{a}	3.01±0.006^{a}	3.01±0.006^{a}
Final weight (g)	5.69±0.189^{ab}	4.64±0.275^{c}	5.36±0.331^{b}	5.37±0.482^{b}	6.10±0.195^{a}
Weight gain (g)	2.69±0.189^{ab}	1.64±0.276^{c}	2.36±0.331^{b}	2.37±0.478^{b}	3.10±0.190^{a}
Daily weight gain (g)	0.04±0.000^{a}	0.02±0.006^{b}	0.03±0.006^{a}	0.03±0.006^{a}	0.004±0.006^{a}
Specific growth rate (%/day)	0.91±0.045^{ab}	0.62±0.078^{c}	0.83±0.085^{b}	0.82±0.129^{b}	1.01±0.045^{a}
Protein efficiency ratio	0.51±0.031^{ab}	0.31±0.053^{c}	0.44±0.064^{b}	0.45±0.091^{b}	0.58±0.035^{a}
Feed conversion ratio	2.51±0.031^{ab}	3.15±0.053^{a}	2.94±0.403^{a}	2.90±0.539^{a}	2.16±0.130^{b}

Means with different superscripts along the same row are significantly different (P<0.05)

Fig. 1 shows the graph of the growth curve of the fish fed with the experimental diets. Fish fed diet D5 (100% ALBM) peaked faster than all other diets while fish fed diet D2 (25% ALBM) was the lowest in growth. The growth curve from 0 to 2 weeks represented the slow growth phase while from 8 to10 weeks represented the marginal growth phase .

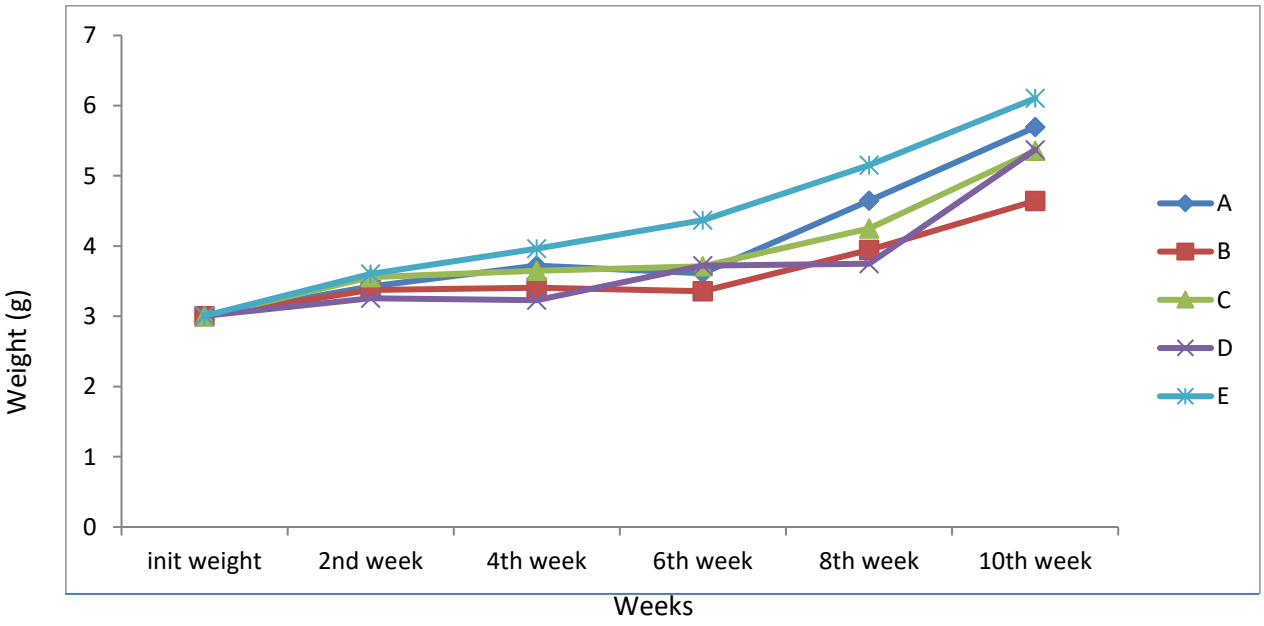

Fig. 1: Growth of fish fed ALBM diets

A = D1 (control diet), B = D2, C = D3, D = D4, E = D5, init weight = initial weight

Table 4 shows the carcass composition of the fish after 70 days of feeding with the experimental diets. The moisture content differed significantly (p<0.05) among the fish fed the various diets, being least in the fish fed diet D1 (17.48±0.001%) and increased to the highest in fish fed diet D4

(22.76±0.001) and followed by decrease to 20.22±0.02% in diet D5. The protein content differed significantly ($p<0.05$) among the fish fed the diet treatments. The fish fed diet D1 contained the highest protein (42.07±0.001%) while the least value was in the fish fed diet D5 (26.25±0.002%). The protein content increased with the level of ALBM inclusion to diet D4 and followed by decrease in fish fed diet D5. The lipid contents differed significantly ($p<0.05$) among the fish fed the diets with the highest value obtained with diet D5 (2.51±0.001%) while the fish fed diet D2 contained the least (0.41±0.002%). The lipid content increased with the level of ALBM inclusion rising from 0.41±0.002% in fish fed diet D2 to the highest value at D5 (2.51±0.001%). The lipid content was the same in the fish fed diets D1 and D3 (1.91±0.001%). The fish fed diet D4 contained the highest total ash and diet D3 contained the least. All the values differed significantly among the diets and had no particular trend in relation to the level of ALBM inclusion.

Table 4: Carcass composition of the experimental fish

Composition	D1(Control)	D2	D3	D4	D5
Moisture	17.48±0.001^{d}	19.76±0.001^{c}	22.23±0.002^{a}	22.76±0.001^{a}	20.22±0.00^{b}
Crude protein	42.07±0.001^{a}	28.20±0.002^{d}	29.24±0.002^{c}	30.38±0.002^{b}	26.25±0.002^{e}
Crude fat	1.91±0.001^{c}	0.41±0.002^{d}	1.91±0.001^{c}	2.10±0.001^{b}	2.51±0.001^{a}
Carbohydrate	37.23±0.003^{e}	49.82±0.004^{b}	45.92±0.006^{c}	42.46±0.009^{d}	49.93±0.003^{a}
Total ash	1.31±0.002^{c}	1.82±0.002^{b}	0.70±0.002^{e}	2.29±0.003^{a}	1.10±0.001^{d}

Means with different superscripts along the same row are significantly different ($P<0.05$)

Table 5 shows the water quality parameters during the period of the experiment. The temperature and the dissolved oxygen in the water were 25.52-25.68^{o}C and 5.26-5.30 mg l^{-1} respectively throughout the period of the experiment, while the pH values ranged between 6.81 and 6.89. However, there were no significant differences ($p>0.05$) between all the treatments for all the parameters. The cost of replacing soyabean meal with ALBM in the diets is shown in Table 6. The costs of the diets decreased with increasing levels of ALBM.

Table 5: Water quality parameters during the experiment

Tanks	Temperature ^{o}C	pH	DO (mg/l)
D1	25.53±0.142^{a}	6.81±0.133^{a}	5.30±0.049^{a}
D2	25.52±0.214^{a}	6.89±0.039^{a}	5.29±0.010^{a}
D3	25.62±0.128^{a}	6.88±0.040^{a}	5.27±0.035^{a}
D4	25.68±0.172^{a}	6.86±0.050^{a}	5.26±0.025^{a}
D5	25.62±0.202^{a}	6.89±0.036^{a}	5.29±0.040^{a}

Means with same superscripts along same column are not significantly different ($P<0.05$)

Table 6: Costs of the experimental diets fed to African catfish (₦ kg^{-1})

Ingredients	D1 (Control)	D2	D3	D4	D5
Fish Meal (72%)	843.75	843.75	843.75	843.75	843.75
Groundnut cake (38%)	73.60	73.60	73.60	73.60	73.60
Soybean meal (45%)	111.48	89.18	66.89	44.59	22.30
ALBM (41.14%)	-	18.38	36.75	55.13	73.50
Yellow Maize (10%)	65.80	65.80	65.80	65.80	65.80
Vegetable oil	13.75	13.75	13.75	13.75	13.75
Starch	2.50	2.50	2.50	2.50	2.50
Fish Premix	82.50	82.50	82.50	82.50	82.50
Total	1193.39	1189.46	1185.54	1181.62	1177.70

Discussion

This study has revealed the possibility of utilizing cooked African locust bean meal (ALBM) in the diet of African catfish and as a potential substitute for soybean meal in enhancing its productivity. The proximate analysis of ALBM used in this study shows higher crude protein (CP) level than 25.57-30.12%, 31.00-40.00% and 30.04-31.07% reported by Femi-Ola *et al*. (2008), Anyanwu *et al*. (2012) and Olujobi (2012) respectively. The cooking, sun-drying and milling of the African locust bean to prepare the ALBM could have been responsible for the higher CP recorded and this is in agreement with Femi-Ola *et al*. (2008) that the CP in boiled *P. biglobosa* seeds was higher than in the raw seeds. The variation in the values of CP could be attributed to environmental factors as indicated by Olujobi (2012) that location significantly affected the nutritional composition of African locust bean fruits.

The CP of ALBM recorded in this study is slightly higher than the CP at 40% and 37.69% reported for soybean meal by NSRL (2013) and Ogbemudia *et a*l. (2017) respectively and slightly lower than 43-44% reported for "conventional" soybean meal (Heuze *et al*., 2019). Thus, the CP in ALBM compares favourably with soybean which is responsible for its ability to replace soybean in this study without any adverse growth effects or defects.

Cooking was employed as a processing method for ALBM in this study in order to deactivate anti-nutritional factors present in the ingredient and make the nutrients readily available for fish (Aletor, 1993, Ajaiyeoba, 2002). This agrees with Nwanna *et al*. (2005) who found cooking as the best processing method that produced the highest numerical total phosphorus, mean weight gain, specific growth rate, mineral liberation and best feed conversion ratio from the study on the effects of different treatments of dietary soybean meal and phytase on the growth and mineral deposition in *Clarias gariepinus*.

The diet D5 (100% inclusion of ALBM) performed better than all other diets including the control diet. This implies that ALBM can totally replace soybean meal in the diet of *Clarias gariepinus* without any adverse effect. The result obtained in this study is similar to that reported by Obasa *et al*. (2003) that pressure-cooked pigeon pea seeds would replace 60% of soybean meal in the diet of *Oreochromis niloticus* with improved growth performance in the fish over that fed the control diet. Robinson and Li (1994) and Olude *et al*. (2008) reported better growth performance over the control diet when soybean was replaced at 30% with cottonseed meal and soaked copra meal in catfish and *Oreochromis niloticus* diets respectively.

The growth curve represented by a slow growth phase from 0 to 2 weeks and the marginal growth phase from 8 to 10 weeks is in line with natural exponential growth situation in fish. The growth curve indicated a general increase in weight gain from the first week to the last week of the experiment with the highest weight observed in the fish fed diet D5 which shows that the fish was able to utilize the nutrients in the diet efficiently and that the nutrients were sufficient to bring about an increase in weight gain. The feed conversion ratio of 2.1 obtained in fish fed diet D5 is lower than in other diets which indicates that the fish is of better quality. The result agrees with Olele *et al*. (2003) that low food conversion ratio indicates higher protein efficiency ratio thereby resulting in better growth. Adikwu (2003) also noted that the lower the FCR, the better the feed utilization by the fish. The lowest FCR of fish fed diet D5 indicates better feed utilization which obviously accounted for the better growth performance of *Clarias gariepinus*.

High priority is given to protein requirement in any nutritional study because it is the single nutrient that is required in the largest quantity for growth, development and the most expensive ingredients in formulation of diet (Craig and Helfrich, 2017), such that studies aimed at replacing the conventional and expensive protein source with a less expensive and less competitive protein source are worthwhile. The cost of producing 1 kg of the experimental diets decreased as the inclusion levels increased such that the control diet without ALBM had the highest production cost. The reduction was progressive being ₦4.93, 3.91, 3.92 and 3.92 between D1 and D2, D2 and D3, D3 and D4 and D4 and D5 respectively such that the cost of production in D5 was lower by ₦16.68 representing 1.40% of the production cost kg^{-1} of diet D1.

Conclusion

This study found that 100% replacement level of soybean with boiled African locust bean seeds as an alternative plant protein source in the diet of fish increased growth rate of *Clarias gariepinus* than the control diet. The study also found out that feeds

from 25-100% inclusion levels of ALBM were less costly compared to the soybean-based diet. The diet containing 100% replacement level of ALBM was the cheapest, the most economical and can effectively replace soybean meal-based diets in fish feed composition to bring about enhanced growth to fish and reduce the cost of feeding which would guarantee higher profit.

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Supplemental values of Poultry litter, *Leucaena leucocephala* and Groundnut haulms on growth, nutrient digestibility, and economy of Yankasa rams' fattening.

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Abstract

Fattening of sheep by small farm holders in Nigeria entails mainly feeding with crop byproducts. There is a need to evaluate other strategies such as incorporating leguminous crops and poultry wastes. Therefore, experiment to determine the growth performance, nutrient digestibility, and economic analysis of Yankasa rams fed a basal diet of *Panicum maximum* and groundnut haulms hay, with supplemental diets of dried poultry litter and *Leucaena leucocephala* leaf meal-based concentrates designated as T1, T2 and T3 was conducted. The 12 weeks study involved fifteen (15) yearling yankasa rams with initial weights of 16-18.2 kg, randomly assigned in a completely randomized design of three treatments and five replicates. The result showed significant differences ($p<0.05$) among the means of total weight gain, average daily metabolic weight gain, and feed conversion ratio in T1 when compared to the other two treatments. Animals on T2 and T3 had statistically similar ($p>0.05$) values in total weight gain (5.33±0.2kg and 5.17±0.2kg), average metabolic weight gain (23.12 ±0.2gd^{-1} and 21.17±0.2gd^{-1}) and feed conversion ratio (15.2±0.8 and 15.9±0.1). These values were significantly higher ($p<0.05$) than the values obtained for animals on T1($P<0.05$). However, total feed intake in all the 3 treatments did not show any significant differences ($p>0.05$).

Animals on the groundnut haulms diet (T1) recorded significantly higher ($p<0.05$) cost of feed per kilogram weight gain than animals on T2 and T3 diets. Crude protein digestibility and CF in T2 and T3 were similar but significantly higher than the CP digestibility of T1($p<0.05$). Supplementation of sheep diets with groundnut haulms hay or with dried poultry litter and *Leucaena leucocephala* leaf meal-based concentrate enhanced utilization and reduction in the cost of feed by sheep.

Keywords- Growth, Groundnut haulms, Poultry litter, Leucaena, Digestibility, Economic analysis.

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Introduction

Sheep production in southwestern Nigeria is centered on the West African Dwarf (WAD) breed. Even though Yankasa as a northern breed is not traditionally managed in this area, its seeming adaptability to the area and its bigger size compared with the traditional WAD, merits its fattening by smallholder farmers in southwestern Nigeria (Fasae *et al* .,2014)

Apart from supplying meat, sheep are important to the smallholders' livelihood because it forms an integral part of the family unit as an asset and an emergency source of fund to meet financial needs. Sheep are also featured predominantly in the socio-cultural functions like ceremonies and religious feasts. Sheep and especially rams are favorite animals, during Muslim festivals of Id el-Kabir,

because fattened rams command extremely high market prices during the festival. (Alfa *et al.*, 2016)

Fattening has been defined as an intensive feeding of highly nutritious feed to promote fast growth and fat deposition to achieve desired carcass growth and quality (Alemu, 2007). The main aim of fattening is to achieve maximum growth and higher carcass in a short period with the intent to increase production per unit of land and the addition of value to the animal. Fattening can be applied to sheep because they can easily adapt to an intensive system of production under feedlots (Pasha, 2006).

Smallholder livestock fatteners/farmers especially in north and central states of Nigeria in an attempt to increase the live weight and quantity of meat in a relatively short time usually feed sheep with crop by-products and household wastes such as millet straw, cowpea hay and groundnut haulms (Ayantunde *et al.*, 2008). Groundnut haulms are one of the cherished crop residues, tradable, and highly-priced in the fodder market because of its superior nutritional benefits than other by-products (Samireddypalle *et al.*, 2017). But the sheep traders and butchers seem to be the only category of people who have better value addition from fattening because they have the resources to buy both sheep and feeds (Babale *et al.*, 2018). This category of people fatten ram for the same reason that other men operate factories, mainly to make a profit by converting raw materials which are of low value in their natural form into a product for which there is a good demand and sell for better prices (Mbanasor, 2000)

Though sheep have a way of converting poor food into desirable products, the current traditional fattening practice by smallholder farmers make sheep offered for sale to have variable size, age, and body condition (Ayantunde *et al.*, 2008). Besides, most of the crops by-products mentioned above are either in short supply or expensive in the southwest because of the cost of transportation (Adegun 2014). Because groundnut is not traditionally cultivated in southwestern Nigeria, so the haulms come at an increased cost in this area due to prohibitive transportation costs from north to southern Nigeria. Different strategies are being designed for smallholder farmers in tropics to overcome feed problems. These include further processing of the highly lignified matured pasture and crop residue, supplementing the basal diet with leguminous plants and agro-industrial by-products, and /or production of multi-nutrient blocks (Bensalem and Smith, 2008; Adegun 2014; Adegun and Adelabu, 2016). Any strategy that must be adopted by the smallholder farmer needs to consider the cost. The high cost associated with the limited and seasonal supply of concentrates hampers their wide-scale use, especially by smallholder farmers, and as such, any strategy being considered for adoption by the livestock farmers must be relatively cheap while not compromising quality (Bello and Tsado, 2013).

Leguminous (herbaceous or tree) such as Leucaena leucocephala are widespread in the humid tropics and are cheap, readily available less competitive protein source for ruminants (Aye and Adegun 2013). By-product feeds such as poultry litter are other options in ruminant feeds. The high content of protein, energy, and minerals in poultry waste indicates its importance as a partial substitute for concentrates (Onimisi and Omage, 2006)).

Poultry litter is an agricultural waste from poultry farms. It is a non-conventional feed resource that can be incorporated into livestock feeds as a means of effective waste management and a low-cost protein source for animals. Studies show that it can be used as a protein supplement for ruminants. Sheep, being the most suitable ruminants for in vivo experiments, have been used in most studies involving the feeding of poultry waste (Onimisi and Omage, 2006; Agbor *et al.*, 2013; Jokthan *et al.*, 2013; Bello and Tsado, 2014). Sheep is an excellent converter not only of roughages but also of NPN sources. Poultry waste is utilized by sheep in the same manner as cattle, and because of their lower plane of nutrition, sheep can also utilize poultry manure of low quality with a higher portion of bedding, normally unsuitable for cattle under intensive feeding management (Tadele, 2015).

Trials on the response of ruminants to browse plants such as *Leucaena leucocephala* as good sources of quality food were conducted in the humid zone of West Africa. Animals' responses to levels, times, and forms of browse plants compared with their utilization as mulch for crop production have been documented (Jabbar *et al.,* 1997). Results also indicate that at any level of supplement, sheep grew twice as fast as goats. The benefits of supplementation came through increased growth, survival, and economic considerations (Longo *et al.*, 2008; Agbor *et al.*, 2013).

Fattening must provide sheep with the ingredients it needs to live and function while meeting up with the

required body weight with minimal cost and maximum profit. This study is undertaken to evaluate the growth, nutrient digestibility, and economic viability of feeding Yankasa rams with supplements containing *Leucaena leucocephala* and dried poultry manure as compared with groundnut haulms in southwestern Nigeria.

Materials and Method

Experimental Site

This study was carried out at the small ruminants' section of the Teaching and Research Farm, Ekiti State University, Ado-Ekiti southwestern Nigeria. Ado-Ekiti lies between latitude 07º37'15'' N and longitude 05º13'17'' E, average humidity of 72%. It experiences a tropical with temperature ranges of 20ºC-28ºC and a bimodal rainfall distribution between April and October with peaks in June and September and a break in August. The dry season is between November and March. The average precipitation in this area is 1367mm. The experimental period was between April and July 2018.

Experimental diet

Panicum maximum was harvested in the university premises, wilted overnight, and fed as basal diet. Groundnut haulms were sourced from the ruminant market in Lokoja and fed to the animals on the basal diet. Two concentrate diets were formulated for this experiment. Concentrate 1 and Concentrate 2 varied with the inclusion of *Leucaena leucocephala* and dried poultry manure respectively as shown in Table 1. Poultry manure was collected at the teaching and research farm of Ekiti State University by spreading nylon under the layer's battery cage overnight, sundried for 7 days, and stored in bags. *Leucaena leucocephala* leaves were harvested in the university premises sundried and milled into leaf meal. Other ingredients in the concentrate diets sourced from the local agro-allied shop in Ado Ekiti include maize, rice husk, groundnut cake, brewers' dry grain, growers' premix, and salt.

Experimental animals and design

Twelve (15) healthy yearling yankasa rams weighing 16 to 18.2kg were purchased from the ruminant market in Lokoja, Kogi State, a melting pot state between northern and southern Nigeria. The animals were tagged for easy identification purposes. The pen and equipment used for this experiment were thoroughly washed and disinfected to prevent any form of infection before the arrival of the animals. The animals were held in the quarantine unit for 30 days for acclimatization. Mandatory and prophylactic medications were given to animals during this period.

The preliminary feeding period lasted for 7 days during which the animals could adjust to the experimental diets before randomly assigning them to their various treatments. The animals were allotted to three (3) treatments with five (5) replicates in a completely randomized design which lasted for 84 days. A basal diet of 3% *Panicum maximum* was fed to the animals. Rams on treatment 1 were given 400g of groundnut haulms (GHH), treatment 2 were rams fed dried poultry manure-based supplements (DPL) while treatment 3 had rams fed *Leucaena leucocephala* based supplement (LLM). The concentrates were also fed at 400g per replicate. Clean and freshwater was given *adlibitum* throughout the experiment.

Data collection

During the twelve weeks of the feeding trial, weights of sheep were taken weekly with a weighing scale. The sheep were fed weighed amount of feed and leftovers were collected and weighed to determine the amount of feed consumed by the sheep. Growth performance indices were taken by calculating the feed intake, weight gain, and feed conversion ratio. At the end of the feeding trial, three rams were selected from each treatment based on the group average weight and weighed into the metabolic units. Each animal was individually confined in a wooden metabolic cage where the animal had free access to feed, freshwater.

The first two weeks (14 days) were used as the adjustment period designed to allow the sheep to adjust to the environment. Thereafter daily feed intake was measured by offering the experimental diets to each animal and the leftover was weighed. Each animal was weighed before the commencement and the end of the digestibility trial. During the last seven days, the total feed refused, faeces and urine were collected and measured.

The total faeces voided were collected and weighed and 10% aliquot samples were taken and oven-dried for 48 hours. Urine samples were frozen while the faecal samples were dried at 65ºc to a constant weight, milled using the laboratory hammer mill, to pass through 2mm sieve and stored in airtight polythene bag till required for laboratory analysis.

The milled samples were subjected to proximate analysis for dry matter (DM) crude protein (CP), ether extract (EE), crude fibre (CF), ash, nitrogen-free extract (NFE) as described by AOAC (2005). The milled faeces and aliquots of urine samples were then analyzed for nitrogen. The results obtained were used to determine the apparent digestibility of the diets. The economics of the feeds were calculated by summing up the cost of feeds per weight gain in all the treatments.

Statistical analysis

The data obtained were analyzed using analysis of variance (ANOVA), followed by Duncan's multiple range comparison at a 5% level of significance ($P < 0.05$). The computer software used to analyze is SAS.

Results

The composition of groundnut haulms hay (GHH), dried poultry litter (DPL), and *Leucaena leucocephala* leaf meal (LLM) based supplementary diets are presented in Table 1. The results showed that GHH (treatment 1) used in the study had 12.68% of CP, 1940 Kcal kg^{-1} metabolizable energy and crude fibre of 22. 62%. Treatment 2 (DPL) and treatment 3 (LLM) based concentrate diets had crude protein contents of 13.46 and 13.72%, metabolizable energy values of 2,359, and 2,249 Kcal kg^{-1} while the CF was 20.10 and 15.46% respectively.

Table 1: Ingredients (%) And Calculated Composition of Diets Formulated

Ingredients	Treatment		
	1	2	3
	Groundnut haulms	Poultry manure	Leucaena leucocephala
Maize	--	30	30
Rice Husk	--	10	10
Groundnut cake	--	2	2
BDG	--	20	20
Ground Nut Haulms	100	--	--
Leucaena leucocephala	--	--	36
Dried poultry manure	--	36	--
Growers Premix	--	1.5	1.5
Salt	--	0.5	0.5
Total	100	100	100
Calculated analysis			
Crude protein	12.68	13.46	13.72
Energy ($kcalkg^{-1}$)	1940	2359	2249
Crude fiber (%)	22.62	20.10	15.46

Table 2 shows the proximate composition of the test ingredients used in this study. The dry matter ranged from 95.30±2.4% in Pm to 97.20±1.2% in GHH. *Leucaena leucocephala* leaf meal (LLM) recorded the highest CP (21.62 ±2.0%) and EE (7.80±0.6%) while GHH had the lowest value of 12.76±0.8 and 2.62±0.1% respectively. Crude fibre ranged from 12.50±1.4% in LLM to 23.75±1.0% in GHH. Ash Table 3 shows the growth performance of yankasa rams fed groundnut haulms, poultry manure, and *Leucaena leucocephala* based supplements. There were no significant differences ($p>0.05$) in total feed intake (TFI) and average daily feed intakes (ADFI) in all the treatments. These values were 80.35±2.12kg, 83.93±1.12kg, and 78.51±1.02kg for T1, T2, and content was increased in DPL (19.20±2.0%) while LLM recorded the lowest value of 10.20±0.4%. Nitrogen free extract were 48.05±2.0, 41.75±3.0 and 47.88±1.6% in GHH, DPL, and LLM, respectively. The metabolizable energy of the test ingredients ranged from 1960. 0±2.0$kcalkg^{-1}$ in GHH to 2537.6±3.0 kcal kg^{-1} in LLM.

T3 respectively for TFI. The average daily intake ranged from 934.60±24.0gd^{-1} to 999.20±32.0gd^{-1} in T1 and T3. Significant differences ($p<0.05$) exist among the means of total weight gain (TWG), average daily weight gain (ADWG), average daily metabolic weight gain (ADMWG), and feed conversion ratio (FCR) in all the treatments. Animals

on T2 and T3 had statistically similar ($p>0.05$) values in TWG (5.33±0.2kg and 5.17±0.2kg), ADMWG (23.12 ±0.2gd^{-1} and 21.17±0.2gd^{-1}) and FCR (15.2±0.8 and 15.9±0.1). These values were significantly higher ($p<0.05$) than the values obtained for animals on T1 which were 3.96±0.2kg, 18.09±0.3$gd^{-1,}$ and 20.15±2.0 for TWG, ADMWG, and FCR, respectively. The result of ADWG showed significant differences ($p<0.05$) in all the treatments with animals on T2 (Pm) having the highest value of 65.87±3.0gd^{-1}, followed by T3 (61.53±2.0gd^{-1}) while T1 had the lowest ADWG of 47.45±4.0gd^{-1}.

Table 2: Proximate Composition of Test Ingredients

	Ingredients		
Parameters (%)	Groundnut haulms	Poultry manure	*Leucaena leucocephala*
Dry matter	97.20±1.2	95.30±2.4	95.50±2.4
Crude protein	12.76±0.8	15.72±2.0	21.62±2.0
Crude fibre	23.75±1.0	20.52±2.2	12.50±1.4
Ether extract	2.62±0.1	2.80±0.2	7.80±0.6
Ash	12.82±0.6	19.20±2.0	10.20±0.4
Nitrogen free extract	48.05±2.0	41.75±3.0	47.88±1.6
Energy $kcalkg^{-1}$	1960. 0±2.0	1863.8±4.0	2537.6±3.0

Table 3. Growth Performance Of Yankasa And Balami Rams Fed Poultry Manure And Leucaena Leucocephala Based Supplements

	Treatment		
Ingredients	**1**	**2**	**3**
Total feed intake (g)	80345±0.0	83933±112.0	78507±102.0
Daily feed intake (g)	956±0.0	999.20±32.0	934.60±24.0
Total weight gain (g)	$3956±0.0^{b}$	$5533±21.0^{a}$	$5167±24.0^{a}$
ADWG (g)	$47.45±0.0^{b}$	$65.87±3.0^{a}$	$61.53±2.0^{a}$
ADMWG (g)	$18.09±0.0^{c}$	$23.12±2.0^{a}$	$21.97±2.0^{b}$
Feed conversion ratio	$20.15±0.0^{a}$	$15.2±0.8^{b}$	$15.9±1.0^{b}$

Means with different superscripts a,b,c along the same row are significantly different.
ADWG – Average daily weight gain; ADMWG – Average daily metabolic weight gain

Table 4 depicts the economic analysis of yankasa rams fed groundnut haulms, poultry manure, and *Leucaena leucocephala* based supplements. There were significant differences ($p<0.05$) in the cost of feeds per kilogram, live weight gain, and cost of feed per live weight gain in all the treatments. The cost of feeds per kilogram was statistically similar in T2 (₦48.60kg^{-1}) and T3 (₦50.80kg^{-1}) but higher than that of T1 (₦43.80kg^{-1}). Animals on the groundnut haulms diet (T1) recorded significantly lower ($p<0.05$) live weight gain of 3.96kg and significantly higher ($p<0.05$) cost of feed per kilogram weight gain of ₦393.76±15.0 kg^{-} than animals on T2 and T3 diets). There were no significant differences ($p>0.05$) in the mean values of live weight gains (5.53kg and 5.16kg) and cost of feed per kilogram live weight gain (₦295±3.0 kg^{-} and ₦309 ±3.0 kg-) in animals fed T2 and T3 respectively. The total feed consumed (35.60±2.8kg, 33.57±5.13kg, and 31.40±3.65 kg) and the cost of feeding per ram (₦1,559±28.0, ₦1,631±12.0, and ₦1,595±12.0) in T1, T2, and T3 respectively did not show any significant differences ($p>0.05$).

Table 5 shows the nutrient digestibility of yankasa rams fed groundnut haulms or dried poultry manure and *Leucaena leucocephala* based supplemental diets. There were no significant differences ($p>0.05$) among the DM digestibility in all the treatments. The values were 82.08±3.0, 76.02±2.0, and 77.50±2.2% in T1, T2, and T3, respectively. Crude protein digestibility in T2 and T3 were similar (62.20±1.6% and 64.80±2.0%) but increased significantly ($p<0.05$) than the CP digestibility of T1 (58.68±2.0). The digestibility of CF also followed the same order with animals on T1 having a significantly lower ($p<0.05$) value of 60.62±1.6% than animals on T2 (72.06±2.5%) and T3 (70.88±2.7%). Significant

differences ($p<0.05$) exist in EE digestibility across the treatments. Leucaena based supplement (T3) recorded the highest EE digestibility (75.77±2.8%), followed by T1 (69.82±3.2) with animals on T2 recording the lowest EE digestibility of 65.53±3.0%. The utilization of ash and NFE was comparable among the dietary treatments. Digestibility of ash were 70.02±2.0, 74.026±2.7 and 72.20±2.1% in T1, T2 and T3 respectively while for NFE 60.20 ±0.8, 58.9 and±0.7, 59.6% ±1.3 % were recorded for T1, T2 and T3 respectively

Table 4. Economic Analysis Of Yankasa And Balami Rams Fed Poultry Manure And Leucaena Leucocephala Based Supplement

	Treatment		
Ingredients	**1**	**2**	**3**
Cost/kg feed (₦)	43.80±0.0	48.60 ±0.0	50.80 ±0.0
Total feed consumed (kg)	35.60±2.8	33.57 ±5.1	31.40 ±365.4
Cost of feeding (₦ /ram)	10599±28	1,631 ± 12.0	1,595 ±12.0
Live weight gain (kg)	3.96±0.02^{b}	5.53±2.1 ^{a}	5.16±2.4 ^{a}
Cost of feed/weight gain (₦kg^{-1})	393.76±0.0^{a}	295±3.00^{b}	309 ±3.0^{b}

Means with different superscripts a,b, along the same row are significantly different.

Table 5. Apparent Digestibility (%) of Yankasa Rams fed Groundnut Haulms or Poultry Manure and Leucaena-based Supplemental Diets.

	Treatment		
Ingredients	**1**	**2**	**3**
Dry Matter	82.02±3.0	76.02c±2.0	77.50c±2.2
Crude Protein	58.68±2.0^{b}	62.20±1.6^{a}	64.80±2.0^{a}
Ash	70.02±2.0	74.02±2.7	72.20±2.1
Ether Extract	69.82±3.2^{b}	65.53±3.0^{b}	75.77±2.8^{a}
CF	60.62±1.6^{b}	72.06±2.5^{a}	70.88±2.7^{a}
NFE	60.20±0.8	58.90±0.7	59.60±1.2

Means with different superscripts a,b, along the same row are significantly different.

Discussion

The result of the CP of DPL used in this study was like the CP of 15.4% reported by Lanyasunya *et al.* (2006) but lower than 21.88% by Bello and Tsado (2013). This could be due to the nature of bedding, age of bedding, processing, type of bird, level of feeding, presence of feather in the droppings used (Ogunsipe, 2014). The CP of GHH used in this study is lower than for 14.4% and 14.12% reported by Tekle and Gebre (2018) and Nuwan (2015). The CP of LLM used in this study is like 21.88% reported by Adedeji *et al.* (2013) but lower than 33% for LLM dried for 72 hours by Agbo *et al.* (2012). Lower NFE of 33.67% was observed for LLM (Agbo et al., 2012). The differences in the proximate analysis could be due to the age of plant and processing methods.

The result of the chemical composition of the basal and supplemental diets used in this study revealed that groundnut haulms, dried poultry manure, and *Leucaena leucocephala* based concentrate have crude protein values above 7% which is the optimum value for microbial growth in the rumen. These values were also adequate for the 10 to 12% CP recommended for growing sheep and goats (Gatemby, 2002). The CP of GHH is like the CP of the 2 concentrate diets but the energy is probably reduced in GHH due to other ingredients included in the concentrate diets. The intake of poultry manure-based diet obtained in this result was slightly higher to the value reported by Hadjipanayiotou *et al.,* (1993) who also compared Poultry manure to other diets. The slightly lower but insignificant response of yankasa rams to Leucaena based supplements compared to DPL in terms of intake may be due to palatability problems, presence of the toxic amino acid mimosine and its breakdown products and lignification which may affect both intake, digestibility, and growth (Kayouli *et al* 1993; Agbor

et al., 2013). The significant increase in weight in T3 over T1 could be due to the condensed tannin in LLM, which may have promoted higher protein escape due to tannin binding at the rumen that protects the protein from excessive microbial degradation and make them more available posterior to the site of absorption (Longo *et al.,* 2008). The significant weight gain T2 compared with T1 could also be because of urea present in DPM. It is high in urea, a source of nitrogen, which improves the rumen environment making the feed more efficiently utilized and the animal better nourished with whatever feed that is made available. Uric acid present in DPL is also a major component of poultry excretions that can be efficiently utilized by rumen microbes for protein production. It is not easily dissolved in the rumen fluid and so the ammonia that is gradually and slowly released is efficiently utilized even more than other non-protein nitrogenous feed sources (Adegbola *et al*., 2010). Agbor *et al*. (2013) also recorded the highest intake of DPM compared with LLM when WAD goats were fed with these feed ingredients, but higher weight gain was obtained with LLM based diet compared with DPM in their trial. The work of Jokthan *et al*. (2013) revealed that 30% of broiler litter improved weight gain and feed cost in yankasa rams with CP and EE digestibility of 62.09 and 69.44%. However, the positive growth rate in all the treatment groups is in line with the need for supplementation of ruminants' diet with fodder crops and agro-industrial waste as a panacea for improved productivity of ruminants especially during the dry season (Lamidi and Ologbose 2014; Adegun, 2014). This result implies that the protein and energy levels of the feeds in all the treatment groups were above the maintenance level. The result obtained in this study from T1 confirms that GHH supplementation support moderate live weight and has a positive linear effect on DM, fibre digestibility, live weight gain, and feed conversion efficiency (Abdou *et al*., 2014; Addah *et al.,* 2019). The similar feed intake in the basal diet and the concentrate diets of T2 and T3 despite the lower weight gain in T1 could be because energy concentration is being compensated for in T1 (Bello and Tsado 2013). Higher CP digestibility in DPL and LLM based treatments could be due to the presence of NPN present in DPM and bypass protein present in LL. Reduced CP digestibility in groundnut haulms could be due to a decrease in caloric density of the diet coupled with increased dietary fibre in the diet (Bawa *et al* ., 2008). The result obtained in this study aligns with the one obtained by Agbor *et al*. (2013) that dry matter digestibility of CP and CF of the concentrate group was significantly higher than that of the control.

The reduction in the cost of feed per weight gain in rams fed DPM (T2) is in line with the result obtained by Mahmoud (2004) who reported reduced feeding costs when DPM was used as supplements in all trials involving Sudanese desert sheep. The reduced cost of feeding at positive weight gain supports the findings of other authors that the use of non-conventional feed sources such as DPM and LLM minimize feed costs and maximize productivity (Amata, 2014; Beigh *et al*., 2017). The increased cost of feed per weight gain in animals on T1 diet is as a result of the lower growth rate of the animals compared with those on concentrate diets and the high cost incurred in the purchase of groundnut haulms coupled with a transportation cost of the byproduct from the market to the farm.

Conclusion

This study shows that groundnut haulms hay and *Leucaena leucocephala* meal or dry poultry litter (DPL) based concentrates have similar nutritive values. These nonconventional feeds improved sheep performance and are potential sources of readily available energy and protein which would fill the gap in feed available to ruminant during the dry season. However, rams DPL and LLM based supplements had better weight gain, feed conversion, and feed cost per weight gain than those fed GHH. Supplementation with DPL or LLM enhanced utilization and reduced feed cost and can be used at 36% in concentrate diets for sheep fattening.

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Comparative Evaluation of Bird Species Diversity in Different Ecosystems of Akure Forest Reserve, Ondo State

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Abstract

Birds are crucial to maintenance of the balance in many ecosystems by providing various ecological services. The comparative evaluation of different ecosystems to bird species diversity and structure were investigated in different ecosystems in Akure Forest Reserve, Ondo State, Nigeria, to elucidate the effect of habitat modification on bird communities. Point count method was employed to identify bird species in three plantations between June and July, 2017 for comparative evaluation of avifauna abundance and diversity. A total of 55 bird species belonging to 11 Orders and 23 families were recorded in the plots. The highest number of birds was recorded in the Queen's plot (34) followed by the Enrichment plots (33) and the Cocoa plantation (29). On the whole, 281 individual bird species were counted and the abundance of birds varied between the three ecosystems. The Enrichment plots recorded the highest number of individual birds (114) while Cocoa plantation and Queen's plot recorded 97 and 70 respectively. Among the three ecosystems, the highest species diversity was found in Queen's forest (3.37) while the least was recorded in cocoa plantation (3.13). The species composition of Queen's and Enrichment plots were more similar than the cocoa plantation. The community structure of birds was dominated by insectivores with 41.2% in the Queen's plot, 33.3% in Enrichment plot and 24.1% in the Cocoa plantation plot. The study has shown that different types of ecosystems would alter birds' community structure and that maintenance of vegetation of the ecosystems is paramount to conservation of the native and ecologically-important bird species.

Keywords: Bird species, diversity, ecosystem, community structure, abundance

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Introduction

Habitat loss and numerous undesirable environmental disturbances associated with agricultural practices have spurred conservation scientists to conclude that agriculture is one of the major contributors towards biodiversity loss (Sala et al., 2001). Musters et al., (2001) asserted that roughly one-third of the world land area has been taken over by agricultural systems while Tilman et al., (2002) reported that the world's demand for food is expected to be twice the present trend in demand and more land area is expected to be cleared for agricultural practices. Conservation in the tropics has it focus and attention on natural, undisturbed habitats like the rainforests (Raman, 2003) while lesser attention is given to the agricultural landscape in ecological and conservation research (Naidoo, 2004). With the advancement of civilization and development of socio-economic infrastructure demanded by rapid urbanization and population growth, the natural habitats have been encroached upon causing decrease in area and large numbers of species of wild creatures have no alternative than to depend on the same land heavily used by man.

The types and scale of agriculture systems being practiced are reported to have significant roles to

play on the populations of wild creatures whose ecosystems fall within the agricultural areas (Chamberlin et al., 2000; Benton et al., 2000).

As the rate of clearing of pristine habitats for agricultural practices increases, the survival of diversity of species that depend on them either decreases or increases. Thus, the patterns of land use and the types of crops planted in agricultural landscapes determine the extent of species diversity. This implies that the effects of various patterns of agricultural land use on wildlife species and populations must be adequately studied in order to incorporate them into conservation management plans. The future increase in agricultural areas has been predicted to be mostly concentrated in the lowland rainforest where majority of the planet's most important conservation areas are located (Myers, 1998, Myers et al. 2000).

One can, therefore, infer that the pertinent challenges that will confront nature conservationists in the nearest future will be the correlation existing between the changing environments and how agriculture as a major driving force in the alteration of pristine ecosystems can be managed effectively to accommodate both human needs and biodiversity conservation. Hence, there is the need to establish the contribution of the various forms of agricultural system on the sustainability of bird species diversity in different ecosystem.

Materials and Methods

Study area

This study was carried out in Akure Forest Reserve and its surroundings in Ondo East Local Government Area of Ondo State, Southwest Nigeria (Fig. 1). It lies between latitudes 7 16′ and 7 18′ N of the Equator and longitudes 5 9′ and 5 11 ′E of the Greenwich Meridian. The forest reserve covers an area of about 600 hectares (Adeduntan, 2007). The area experiences humid tropical climate characterized by rainy season between March and November and dry season from December and February; the mean annual temperature is about 26ºC (minimum 19ºC and maximum 34ºC) and annual rainfall of up to 2500 mm. It is located within the rainforest ecological zone with vegetation dominated by broad-leaved hardwood trees that form dense, layered stands. This portion of Akure Forest Reserve was carved out and designated as a Strict Nature Reserve (SNR) in 1954 by the Forestry Research Institute of Nigeria (FRIN).

Plantations of indigenous and exotic tree species were established at the boundaries and buffer zone of the reserve. The Strict Nature Reserve is bounded on one side by a river which has reduced accessibility to the forest. There are several rural communities around the reserve which are involved in its management and protection. All the anthropogenic activities, namely, organized taungya farming, collection of falling twigs and branches as firewood and gathering of other non-timber forest products (NTFPs) were restricted to the buffer zone of the reserve with adequate monitoring and effective patrol by forest guards.

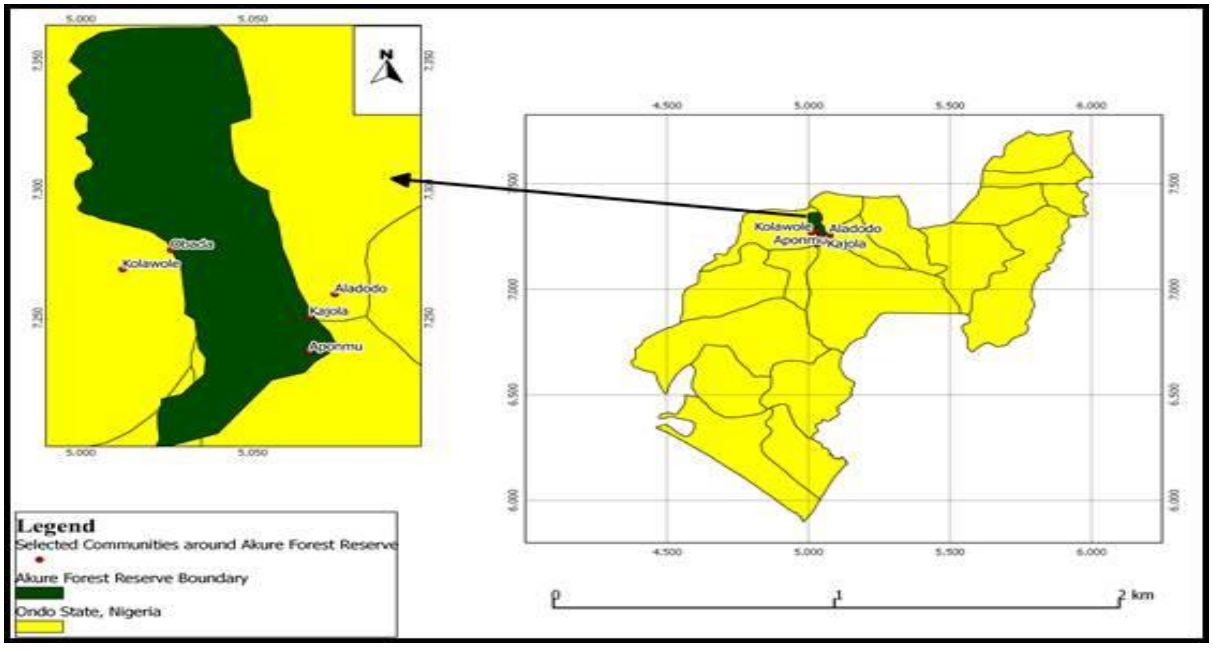

Fig. 1: The Akure Forest Reserve

Bird Assessment

The survey assessment of abundance and diversity of bird species of agro-ecosystems: cocoa plantation and natural forest habitat in Akure Forest Reserve and its surroundings was carried out between June and July, 2017. Point counts method as described by Bibby *et al*; (2000) was used for the collection of data on bird species diversity and abundance in the sample sites. This method involves the location of seven sampling points in each of the three habitats. Birds was observed within 50 m radius at each sampling point for 30 min on clear mornings between sunrise and 09 30 hours (Ogunyemi, 2012). During each survey, all birds were counted and The abundance scores employed were ≤1.0 (rare), 1.1 – 2.0 (uncommon), 2.1 - 10 (frequent), 10.1 – 40.0 (common) and 40 (abundant). Two-way analysis of variance (ANOVA) was used to analyse the data based on the general linear model (GLM) procedure of SAS (2002). The means of variables whose F-value showed significant differences were compared using Duncan's multiple range tests. Diversity and evenness were calculated on the identified bird and plant species to describe the abundance of species and individuals within the study habitat. Birds' diversity was calculated using Shannon-Weiner diversity index (H') which was calculated using formula:

Shannon-Wiener index of diversity (H') = $-\sum p_i \log p_i$

where pi is the proportion of ith species to total abundance value

Species Richness index (D) was calculated by with the following equation:

$$D = \frac{S-1}{\ln N}$$

where D= Species Richness Index,
S=Total number of species
N=Total number of individuals

recorded as they were seen from the centre of the 50 m used as a cut off for bird observations. The sampling points were spaced about 500 m apart (Oksanen, 2001).

Data analysis

The cumulative list of birds' species recorded in the varying ecosystems was used as basic measures of avian richness. All bird species were grouped according to their main habitat. The relative abundance of avian species was determined using encounter rates that gives crude ordinate scales of abundance (Bibby *et al,* 2000). The encounter rate incorporates the field period of observation and number of individuals of each species observed.

The bird community similarity among habitats was determined by calculating the Sorensen's coefficient represented as:

$$C = \frac{2W}{A+B+C} \times 100$$

where C= index of similarity

W= No of species common to both sample

A = No of species in sample A

B = No of species in sample B

C= No of species in sample C

The graphs and maps are presented as figures while result of analysis of variance and mean separation are presented in tables.

Results

Table 1 shows that a total of 55 bird species was recorded in the three habitats of the study area. The birds belong to 11 Orders and 25 families. Not all the bird species were recorded at every location and the highest number of birds was recorded in the Queen's plot (34) compared to 33 in Enrichment plot and 29 in Cocoa plantation (Table 2).

Table 1: Avian distribution based on family, order and species composition in the study area

S/N	Species	Scientific Name	Family	Order
1	Yellow-fronted tinkerbird	*Pogoniulus chrysoconus*	Lybiidae	Piciformes
2	Little greenbul	*Eurillas virens*	Pycnonotidae	Passeriformes
3	African grey parrot	*Psittacus erithacus*	Psittacidae	Psittaciformes
4	Blue-spotted wood dove	*Turtur afer*	Columbidae	Columbiformes
5	Puff-throated sunbird	*Anthreptes griseigularis*	Nectariniidae	Passeriformes
6	Black bee-eater	*Merops gularis*	Meropidae	Coraciiformes
7	Piping hornbill	*Ceratogymna fistulator*	Bucerotidae	Bucerotiformes
8	Red-bellied paradise flycatcher	*Terpsiphone rufiventer*	Monarchidae	Passeriformes
9	African emerald cuckoo	*Chrysococcyx cupreus*	Cuculidae	Cuculiformes
11	Black and White casqued Hornbill	*Ceratogymna subcylindricus*	Bucerotidae	Bucerotiformes
12	Collared sunbird	*Hedydipna colyaris*	Nectariniidae	Passeriformes
13	Splendid sunbird	*Cinnyris coccinigastrus*	Nectariniidae	Passeriformes
14	Olive-green camaroptera	*Camaroptera chloronota*	Cisticolidae	Passeriformes
15	Blue-headed wood dove	*Turtur brelimeri*	Columbidae	Columbiformes
16	Yellow-throated tinkerbird	*Pogoniulus subsulphureus*	Lybiidae	Piciformes
17	Black spotted barbet	*Capito niger*	Pycronotidae	Passeriformes
18	Narina trogon	*Apaloderma vittatum*	Trogonidae	Trogoniformes
19	White-tailed flycatcher	*Cyornis concretus*	Muscicapidae	Passeriformes
20	African pied Hornbill	*Tockus fasciatus*	Bucerotidae	Bucerotiformes
21	African green pigeon	*Treton calvus*	Columbidae	Columbiformes
22	Black-winged oriole	*Oriolus nigripennis*	Oriolidae	Passeriformes
23	Bronze manikin	*Lonchura cucullata*	Estrildidae	Passeriformes
24	Cassin's flycatcher	*Muscicapa cassini*	Muscicapide	Passeriformes
25	Common bulbul	*Pcynonotus barbatus*	Lybiidae	Passeriformes
26	Forked-tailed drongo	*Dicrurus adsimilis*	Dicrulidae	Passeriformes
27	Green hylia	*Hylia prasina*	Sylviodae	Passeriformes
28	Green turaco	*Tuaraco persa*	Musophagidae	Musophagiformes
29	Grey-backed camaroptera	*Camaroptera brachyyura*	Cisticolidae	Passeriformes
30	Lizard buzzard	*Kaupifalco monogrammicus*	Accipitridae	Accipitriformes
31	Yellow casqued Hornbill	*Ceratogymna elata*	Bucerotidae	Bucerotiformes
32	Olive sunbird	*Cyanomita olivacea*	Nectariniidae	Passeriformes
33	Red-checked wattle-eye	*Dyaphorophyia blissetti*	Monachidae	Passeriformes
34	Red-rumped tinker bird	*Pogoniulus atroflavus*	Lybiidae	Piciformes
35	Tambourine dove	*Turtur tympanistria*	Columbidae	Columbiformes
36	White-crested Hornbill	*Tockus albocristatus*	Bucerotidae	Bucerotiformes
37	White-tailed ant thrush	*Neocossyphus poensis*	Turdidae	Passeriformes
38	Yellow-rumped tinker bird	*Pogoniolus bilineatus*	Lybiidae	Piciformes
39	Yellow-whiskered greenbul	*Andropadus latirostis*	Pycnonotidae	Passeriformes
40	Splendid sunbird	*Cinnyris coccinigastus*	Nectariniidae	Passeriformes
41	Black dwarf Hornbill	*Tockus hartlaubi*	Bucerotidae	Bucerotiformes
42	Little bee-eater	*Meropus pusillus*	Meropidae	Coraciiformes
43	Swamp boubou	*Laniarius bicolor*	Malaconotidae	Passeriformes
44	Red-headed malimbe	*Malimbus rubricollis*	Ploceidae	Passeriformes
45	Tawny- flanked prinia	*Prinia subflava*	Cisticolidea	Passeriformes
46	Malachite king fisher	*Corythonis cristatus*	Alcedinidae	Coraciiformes
47	Black casqued Hornbill	*Ceratogymna atrata*	Bucerotidae	Bucerotiformes
48	Swamp palm bulbul	*Thescelocichla leucopleura*	Pycnonotidae	Passeriformes
49	Moustached-tinkerbird	*Pogoniulus leucomystax*	Lybiidae	Piciformes
50	African finfoot	*Podica senegalensis*	Heliornithidae	Gruiformes
51	Blue-shouldered robin chat	*Cossyphya cyanocampter*	Muscicapidae	Passseriformes
52	Forest robin	*Stiphrornis erythrothorax*	Muscicapidae	Passseriformes
53	Green crombec	*Sylvietta virens*	Macrophendae	Passseriformes
54	Grey-headed negrofinch	*Nigrita canicapillus*	Estrildidae	Passseriformes
55	Western bluebill	*Sailia Mexicana*	Estrildidae	Passseriformes

Table 2. Avian distribution and relative abundance of bird species in the three study habitats

S/N	Common names	Q.P	E.P	C.P	Ordinal Scale
1	African emerald cuckoo	+	+	-	Uncommon
2	African finfoot	+	-	-	Rare
3	African green pigeon	+	+	+	Frequent
4	African pied hornbill	+	+	+	Frequent
5	Black-winged oriole	+	+	-	Uncommon
6	Blue-headed wood dove	+	+	-	Uncommon
7	Blue-shouldered robin chat	+	-	-	Rare
8	Blue-spotted wood dove	+	+	+	Frequent
9	Blue-throated brown sunbird	+	+	-	Rare
10	Bronze manikin	-	+	-	Rare
11	Cassin's flycatcher	+	+	-	Frequent
12	Collared sunbird	+	+	+	Frequent
13	Common bulbul	+	+	+	Frequent
14	Forest robin	+	-	-	Rare
15	Forked-tailed drongo	+	+	-	Rare
16	Green crombec	+	-	-	Rare
17	Green hylia	+	+	+	Uncommon
18	Green turaco	+	+	-	Rare
19	Grey-backed camaroptera	-	+	-	Uncommon
20	Grey-headed negrofinch	+	-	-	Rare
21	African grey-parrot	+	+	-	Rare
22	Lizard buzzard	+	+	+	Uncommon
23	Yellow casqued Hornbill	+	+	-	Rare
24	Olive sunbird	-	+	-	Rare
25	Olive-green camaroptera	+	-	-	Rare
26	Pipping hornbill	+	+	+	Frequent
27	Red-bellied paradise fly catcher	+	+	+	Frequent
28	Red-checked wattle-eye	+	+	-	Uncommon
29	Red-rumped tinker bird	+	+	-	Frequent
30	Tambourine dove	-	+	-	Frequent
31	White-crested hornbill	+	+	-	Frequent
32	White-tailed ant thrush	+	+	-	Uncommon
33	Yellow-rumped tinker bird	-	+	+	Frequent
34	Yellow-throated tinkerbird	+	+	-	Uncommon
35	Yellow-whiskered greenbul	+	+	-	Rare
36	Splendid sunbird	-	+	+	Frequent
37	Yellow-fronted tinker bird	+	+	-	Frequent
38	Little greenbul	+	+	+	Frequent
39	Black dwarf Hornbill	+	+	-	Uncommon
40	Little bee-eater	+	+	-	Uncommon
41	Narina trogon	-	-	+	Rare
42	Puff throated sunbird	-	-	+	Uncommon
43	Swamp boubou	-	-	+	Rare
44	Black spotted barbets	-	-	+	Frequent
45	Black-bee eater	-	-	+	Uncommon
46	Red-headed malimbe	-	-	+	Rare
47	Tawny-flanked prinia	-	-	+	Rare
48	Malachite kingfisher	-	-	+	Rare
49	Western bluebill	-	-	+	Rare
50	Little greenbull	-	-	+	Rare
51	Blackk casqued Hornbill	-	-	+	Rare
52	Swamp palm bulbul	-	-	+	Frequent
53	Bruce's green pigeon	-	-	+	Rare
54	White-tailed flycatcher	-	-	+	Rare

55	Moustached-tinkerbird	-	-	+	Rare

Q.P = Queen's plot; E.P = Enrichment plot; C.P = Cocoa plantation

The Orders, Families and species composition of bird species in the study plots were not homogenous (Table 3). The Enrichment plot had the same number of Order as the Queen's plot (9) but a higher number of families (16) while Queen's plot and Cocoa plantation plot had the same number of families. The Enrichment plot and Queen's plot had the same number of species (34) while the Cocoa plantation plot had the least (28). The exclusive bird species were more prevalent in the Cocoa plantation followed by the Queen's plot while the Enrichment plot had the least number at 15, 6 and 3 representing 62.5, 25.0 and 12.5 % of the bird species respectively.

Table 3. Orders, families, species and number of exclusive species in three ecosystem types of Akure Forest Reserve

Ecosystem Type	Order	Family	Species	Individuals	Exclusive species	
					Numbers	%
Cocoa Plantation	8	15	28	97	15	62.5
Queen's Plot	9	15	34	70	6	25.0
Enrichment Plot	9	16	34	114	3	12.5

All the birds utilize the three habitat types but the abundance of birds varied from one habitat to another (Table 4). The highest percentage of individual sightings was recorded in the Enrichment plot and comprised 40.57% (n=114) of the total number of individuals, followed by Cocoa plantation plot at 34.52% (n=97) while the Queen's plot recorded the least (34.91%) (n=70). In the Enrichment plot, 114 individuals belonging to 33 species were recorded and African green pigeon (*Tretron calvus)* was the most frequently recorded species representing 9.65% of the total sightings, followed by African pied hornbill (*Tockus fasciatsus)* (7.02%) and Tambourine dove (*Turtur tympanistria)* (6.14%). There were three (3) bird species exclusive to the Enrichment plot (Table 3). In the Cocoa plantation plot, 97 individuals, representing 28 bird species, were recorded. The Nectarinidae and Columbidae were the most represented families with 4 species each (4.1%) followed by families Mycrononidae, Lybiidae and Cisticollidae with 2 species each (2.1%) while the rest of the families were represented by 1 bird species each. The order Passeriformes constituted the predominant group representing (38.40%) of families (n=29) and 52.7% of species, whereas remaining orders exhibited lower percentages (Table 1). The family with the highest number of species is Bucerotidae n=7 and Nectarinidae n=5 . At species level, African green pigeon (*Treton calvus) ,* African pied hornbill *(Tockkus faciatus),* Blue-spotted wood dove (*Turtur afer*), Common bulbul (*Pcynonotus barbatus)*, Pipping hornbill (*Ceratogymna fistulator)* and Yellow-rumped tinkerbird (*Pogoniulus bilineatus)* were the dominant species with 15,19,12,12,9, and 10 number of individuals respectively, contributing 27.40% of the total bird abundance of the study area. (Table 7). Bucerotidae was the most species-rich family with 7 bird species, namely Black and White casqued hornbill (*Ceratogymna subcylindricus*), White-crested hornbill (*Tockus albocristatus*), Piping hornbill (*Ceratogymna fistulator*) Black casqued hornbill (*Ceratogymna atrata)*, Yellow-casqued hornbill (*Ceratogymna elata*), Black dwarf hornbill (*Tockus hartlaubi)* and African pied hornbill (*Tockus faciatus)*. Three species: Yellow-throated tinkerbird (*Pogoniulus subsulphureus)* Red-bellied paradise flycatcher (*Terpsiphone rufliventer)* and Blue spotted wood dove (*Turtur afer*) were the most often-sighted species and represented 11.39% of the total number of individuals (Table 7).

Species diversity and community similarity

The Queen's plot had the highest values of species diversity (H'=3.37) and species richness (D'=7.77) compared to the Enrichment plot and Cocoa plantation plots with H'=3.30 and 3.13, and D'=6.97 and 5.9 respectively. The index of species evenness (E) for the three habitat types slightly varied between the Queen's plot and Cocoa plantation plots but the difference in distribution was higher while comparing Queen's and Enrichment plots and Cocoa plantation and Enrichment plots (Table 4). Comparison of bird species between study sites were made by using Sorenson's quotient of similarity, Queen's and Enrichment plots were found to be more similar with the highest value of 0.82 whereas lowest similarity was calculated between Queen's and

Cocoa plots (Table 8). Queen's and Enrichment plots shared 82% of their bird species composition, whereas Cocoa and Enrichment plots shared 39% and Queen's and Cocoa plots shared 32%.

Table 4: Diversity indices of bird species observed in the three study plots

Diversity Indices	Queens' Plot	Enrichment Plot	Cocoa Plantation Plot
No of species (S)	34	34	29
Total no of individuals (N)	70	114	97
Shannon-Wiener index (H')	3.37	3.30	3.13
Evenness (E)	0.85	0.79	0.82
Margalef Species richness (D')	7.77	6.97	5.90

Relative abundance of birds

Based on the relative abundance scores, 25 birds (47.3%) were rare species, 14 birds (23.6%) as uncommon species while 16 (29.1%) were frequent species (Table 5). Majority of the bird species had low population sizes and was grouped under rare species.

Table 5: The relative abundant categories of bird species in the three land use types

Ecosystem Type	Rare	Uncommon	Frequent
Queen's Plot	18	4	12
Cocoa Plantation	17	3	8
Enrichment Plot	23	3	8

Avifauna foraging structure

A feeding guild is a group of species that exploits similar food resources in a habitat, and its characterization is based on the types of food being consumed, which would determine the feeding behaviour of the different birds' species and the availability of food resources. Foraging guild is highly useful in making comparison between changes in species rich communities because their functional organization can be investigated even if no species are shared. In the present study, 9 types of feeding guilds were identified: insectivore-frugivore (IF), carnivore (C), frugivore (F), nectarivore (N), frugivore-granivore (FG), omnivore (O), granivore-insectivore (GI), nectarivore-insectivore, (NI) and insectivore (I). The entire ecosystem types were dominated by insectivores at 41.2, 33.3 and 24.1% in the Queen's plot, Enrichment plot and Cocoa plantation plot respectively (Table 6). African green pigeon *(Treton calvus)*, pipping hornbill (*Bycansistes fistulator)*, red-rumped tinkerbird (*Pogoniulus atroflavus)* and yellow-throated tinkerbird (*Pogoniulus subsulphureus)* were the most common insectivore species occurring in the study habitat types.

The similarity in feeding guild structure was greater between Enrichment Plot and Cocoa Plantation at 65.27% similarity compared to Queen's Plot (42.73%). The frugivore bird species were the next most abundant bird species in the three habitat types with 6, 7 and 6 species in the Queen's, Enrichment and Cocoa plantation plots respectively. The most abundant frugivore in the Enrichment plot was African Green Pigeon (*Tockus fascitus*) which was frequently observed foraging on fruiting trees with small and ripe fruits in the Cocoa plantation plot. The yellow-throated tinkerbird (*Pogoniulus subsulphureus)* was the most abundant insectivore species followed by red-bellied paradise fly catcher (*Terpsiphine rufiventer*) and green hylia (*Hylia prasina)*. Only one species of carnivores: lizard buzzard (*Kaupifalco monogrammjicus*) was recorded in the three habitat types.

Table 6: Feeding guilds distribution in the three ecosystem types

Trophic Guilds	Number of Individual Birds			
	Queen's Plot	Enrichment Plot	Cocoa Plantation	Total
Insectivore-frugivore (I.F)	4	3	3	10
Carnivore (C)	1	1	1	3
Frugivore (F)	6	7	6	19
Nectarivore (N)	1	0	0	1
Frugivore-granivore (F.G)	4	4	3	11
Omnivore (O)	2	2	4	8
Granivore-insectivore (G.I)	0	2	2	4
Nectarivore-insectivore (N.I)	2	3	3	8
Insectivore (I)	14	11	7	32

TABLE 7. Avian Species observed in the three Ecosystem types

SN	Common names	Scientific names	Queen's plot	Percent %	Enrichment plot	Percent %	Cocoa plantation	Percent %
1	African Emerald cuckoo	*Chrysococcyx cupreus*	4	5.71	1	0.88	0	0
2	African finfoot	*Podica senegalensis*	2	2.86	0	0	0	0
3	African green pigeon	*Tretron calvus*	3	4.29	8	7.02	8	8.25
4	African pied hornbill	*Tockus fasciatsus*	1	1.43	11	9.65	3	3.09
5	Black-winged Oriole	*Oriolus nigripennis*	3	4.29	1	0.88	0	0
6	Blue-headed wood dove	*Turtur brehmeri*	2	2.86	4	3.51	0	0
7	Blue-shouldered Robin chat	*Cossyphya cyanocampter*	1	1.43	0	0	0	0
8	Blue-spotted wood Dove	*Turtur afer*	4	5.71	6	5.26	2	2.06
9	Blue-throated Brown sunbird	*Cyanomitra cyanolaema*	1	1.43	1	0.88	0	0
10	Bronze manikin	*Lonchura cucullata*	0	0	2	1.75	0	0
11	Cassin's flycatcher	*Muscicapa cassini*	2	2.86	6	5.26	0	0
12	Collared Sunbird	*Hedydipna collaris*	3	4.29	3	2.63	3	3.09
13	Common Bulbul	*Pcynonotus barbatus*	2	2.86	6	5.26	4	4.12
14	Forest Robin	*Stiphrornis erythrothorax*	2	2.86	0	0	0	0
15	Forked-tailed Drongo	*Dicrurus adsimilis*	1	1.43	2	1.75	0	0
16	Green Crombec	*Sylvietta virens*	3	4.29	0	0		
17	Green Hylia	*Hylia prasina*	1	1.43	3	2.63	2	2.06
18	Green Turaco	*Tuaraco persa*	1	1.43	1	0.88	0	0
19	Grey-backed camaroptera	*Camaroptera brachyyura*	0	0	4	3.51	0	0
20	Grey-headed Negrofinch	*Nigrita canicapillus*	1	1.43	0	0	0	0
21	African grey-parrot	*Psittacus robustus*	1	1.43	2	1.75	0	0
22	Lizard buzzard	*Kaupifalco monogrammicus*	0	0	1	0.88	5	5.15
23	Yellow casqued Hornbill	*Ceratogymna elata*	1	1.43	2	1.75	0	0
24	Olive sunbird	*Cyanomita olivacea*	0	0	3	2.63	0	0
25	Olive-green Camaroptera	*Cametoptera chloronota*	2	2.86	0	0	0	0
26	Pipping hornbill	*Ceratogymna fistulator*	1	1.43	4	3.51	4	4.12
27	Red-bellied paradise fly catcher	*Terpsiphone rufiventer*	2	2.86	2	1.75	6	6.19
28	Red-checked wattle-eye	*Dyaphorophyia blissetti*	4	5.71	1	0.88	0	0
29	Red-rumped tinker bird	*Pogoniulus atroflavus*	3	4.29	5	4.39	0	0
30	Tambourine Dove	*Turtur tympanistria*	0	0	7	6.14	0	0
31	White-crested Hornbill	*Tropicanus albocristatus*	1	1.43	5	4.39	0	0

32	White-tailed Ant Thrush	*Neocossyphus poensis*	1	1.43	4	3.51	0	0
33	Yellow-rumped tinker bird	*Pogoniolus bilineatus*	3	4.29	3	2.63	4	4.12
34	Yellow-throated tinkerbird	*Pogoniulus subsulphureus*	3	4.29	2	1.75	5	5.15
35	Yellow-whiskered greenbul	*Andropadus latirostis*	1	1.43	1	0.88	0	0
36	Splendid sunbird	*Cinnyris coccinigastus*	0	0	1	0.88	7	7.22
37	Yellow-fronted tinker bird	*Pogoniulus chrsoconus*	6	8.57	1	0.88	0	0
38	Little greenbul	*Eurillas virens*	1	1.43	6	5.26	1	1.03
39	Black dwarf Hornbill	*Tockus hartlaubi*	1	1.43	3	2.63	0	0
40	Little bee-eater	*Meropus pusillus*	2	2.86	2	1.75	0	0
41	Narina trogon	*Apaloderma vittatum*	0	0	0	0	2	2.06
42	Puff throated sunbird	*Anthreptes griseigularis*	0	0	0	0	6	6.19
43	Swamp boubou	*Laniarius bicolor*	0	0	0	0	1	1.03
44	Black spotted barbet	*Capito niger*	0	0	0	0	8	8.25
45	Black-bee eater	*Merops gularis*	0	0	0	0	4	4.12
45	Red headed malimbe	*Malimbus rubricollis*	0	0	0	0	2	2.06
46	Tawny-flanked prinia	*Prinia subflava*	0	0	0	0	3	3.09
47	Malachite kingfisher	*Corythonis cristatus*	0	0	0	0	3	3.09
48	Western bluebill	*Sailia Mexicana*	0	0	0	0	1	1.03
49	Little greenbull	*Eurillas virens*	0	0	0	0	2	2.06
50	Black casqued Hornbill	*Ceratogymna atrata*	0	0	0	0	2	2.06
51	Red-billed Dwarf hornbill	*Tockus camurus*	0	0	0	0	1	1.03
52	Swamp palm bulbul	*Thescelocichla leucopleura*	0	0	0	0	8	8.25
53	Black and White casqued Hornbill	*Ceratogymna subcylindricus*	0	0	0	0	1	1.03
54	White-tailed flycatcher	*Eminia albicauda*	0	0	0	0	3	3.09
55	Moustached tinkerbird	*Pogoniulus leucomystax*	0	0	0	0	1	1.03

Table 8: Sorenson's coefficient of similarities among the birds' community structure of the three study plots

Compared Plots	Sorenson's quotient
Queen's & Enrichment	0.82
Enrichment & Cocoa	0.39
Queen's & Cocoa	0.32

Discussion

The results of this study show the higher bird diversity in the Queen's plot than in Cocoa plantation and Enrichment plot which agrees with Azman *et al*; (2011) that the mixture of tall trees, fruit bearing trees with wide canopy cover favours higher diversity with regard to structure of bird communities in different land-use types. The high abundance of individual bird species in the Enrichment plot might have been influenced by the presence of important resources like food, nesting materials, nesting sites that allow birds to tolerate disturbance due to land use change. Most species of bird sighted in this land use types were residents and forest dependent. The Shannon- Weiner diversity index was higher in Queen's plot than the Enrichment plot and Cocoa plantation plot .This might indicate that bird species inhabiting the vegetation of Queen's plot might be associated with the floristic composition that could create variations in food sources, nesting and protection cover. Mengesha and Bekele (2008) were of opinion that highest avian species diversity might be linked with the type of plant species and feeding habits of birds. The African green pigeon (*Treron calvus)* was the most abundant and this species belongs to the Columbidae family, a group important and noted for the role play in forest restoration due to their efficient seed dispersal activity. The result of this study agrees with Harvey and Villalobos (2007) that mixed proportion of agricultural trees with forest plants contain bird assemblages that are as abundant, species-rich and diverse like the natural forests as found in the Enrichment plot of the study.

However, the structure of the bird community was altered with fewer forest-dependent species and different dominant generalist species, in a view of which bird diversity was more closely related to structural and floristic characteristics of the different land use types. Waltert *et al*; (2005) found that young secondary forests and agro forests sustain high numbers of bird species that are similar to the adjacent, near primary forests. The lowest species diversity was recorded in the monoculture Cocoa plantation. Greater conservation value found in agro forest system is due to the often complex nature and the ability to support diversity than monocultures. However, the high level of wild biodiversity may often depend on the proximity to the natural habitat which is still most favourable to many wildlife species, especially birds (Mcneely and Schroth 2006; Harvey and Villalobos 2007).

The foraging habits of the birds were used to explore the variation in avifauna composition among the habitat types. According to Pearman (2002), the variation in structure affects the distribution of bird foraging guilds. Out of the nine feeding guilds identified in the study, the insectivore bird species were the most dominant group. The insectivorous feeding guild composed of species from families Monarchidae, Meropidae and Muscicapidae. In Queen's plot, the insectivore and frugivore birds were the most abundant species while in the Cocoa plantation plot, insectivore birds were the most abundant species. The insectivore birds were relatively more in Enrichment and Queen's plots compared than cocoa plantation plot. The low population of insectivorous bird species in Cocoa plot might be ascribed to the frequent usage of agrochemicals in the management of cocoa farms which has resulted in drastic reduction in the insect population. Devine and Furlong (2007) reported significant population decline on birds as a result of indirect imparts of insecticides which have exhibited population declines changes in birds' abundance and distribution. According to Blake and Loiselle (2001), insectivore bird species are most abundant in tropical forests which provide ready availability of a variety of food sources for both adult and young. Besides, safe habitats for nesting are important for the occurrence and abundance of insectivorous species (Krizler, 2015). The frugivores which ranked next in abundance were found more in the Enrichment plot compared to the Queen's and Cocoa plantation plots because of the readily available food resources. The abundance and richness of fruiting plants is important and associated with the diversity of frugivorous bird species and foraging behaviours in certain habitat types (Moegenburg and Levey, 2003). The nectarivores were the least abundant

in the three habitat types with only one (1) species present which may be due to the non-availability of flowering resources and the seasons of flowering.

Conclusion

Birds are essential to the sustainability of ecosystems where they function as bio-monitors, alerting people about what is going wrong in an ecosystem. Therefore, it is necessary to elucidate the effects of habitat modification on bird communities especially the ability to perform ecosystem functions. The result of this study shows species composition and abundance varied among the ecosystems. Bird species diversity and abundance was highest in Queen's and Enrichment plots respectively while the diversity and abundance of bird species was relatively low in the Cocoa plantation. This suggests more ecological stability in the Queen's and Enrichment plots which have higher similarity in species composition. The differences that exist in resources availability between the ecosystems may be responsible for restriction of some species to certain ecosystem type while allowing others to be ubiquitous. The study further provides evidence that though ecosystem modification may lead to low diversity, yet the Enrichment plot and Cocoa plantation are important part of the ecosystem that support bird community structure dominated by insectivorous species. If a substantial part of bird community of Akure Forest Reserve surroundings is to be maintained, efforts must be geared towards conservation of in the natural ecosystem and adjoining modified agro-ecosystems.

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Boldness-aggression Syndromes in the zebrafish and the guppies

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Abstract

Correlations between unrelated personality traits in different contexts often referred to as behavioural syndromes, have been found to exist among individuals. Behavioural syndromes have been documented in a wide variety of taxa and may arise due to correlated behaviours having a similar underlying genetic basis, so that they have become coupled (genetic constraint), or when one hormone acts on several traits (hormonal constraints) or if adaptations to existing selection pressure act simultaneously on multiple traits (adaptive constraints). We examined if there were correlations between boldness and aggression, which would be an indication of a behavioural syndrome in three strains of zebrafish and the guppy. There was some evidence of a boldness and aggression syndrome in only females of two of the zebrafish strains and in the male guppies. Given the limited correlation of these traits within the populations studied, this syndrome was probably due to adaptations to prevailing selection pressures rather than due to genetic constraints.

Keywords: behavioural syndromes, zebrafish, guppies, boldness, aggression.

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Introduction

Behavioural syndromes occur when consistent but unrelated personality traits, such as boldness and aggression, become correlated across contexts (Bell & Stamps, 2004; Bell, 2005). This means that organisms do not express the traits independently of each other but together, such that, in a bold-aggression syndrome, a bold individual would also be aggressive too, and so it may be impossible for behavioural traits to develop separately (Bell, 2005; Brydges *et al.*, 2008). In the rodent *Dipodomys merriami*, Dochtermann & Jenkins (2007) found that boldness and aggression were significantly correlated and bold and aggressive individuals were A number of possible mechanisms have been suggested, which include genetic constraints, where a single gene controls the unrelated traits (Deng *et al.*, 1994; Dingemanse *et al.*, 2007), hormonal often less flexible in their responses to changing environmental situations. This inflexibility is consistent with other studies (Koolhaas *et al.*, 1997, 1999). The activity–boldness behavioural syndrome in the damselfly, *Lestes congener*, is carried over from the larval stage into the adult, such that, an active larva may survive but an active adult may fall prey to a predator (Brodin, 2009). However, despite being a taxonomically widespread phenomenon (reviewed in Sih *et al.*, 2004a, b; Bell, 2007), the mechanisms sustaining the occurrence of these syndromes are unclear.

constraints, when the same hormones act on several traits (Koolhaas *et al.*, 1999; Veenema *et al.*, 2003) and adaptive constraints, or if adaptations to existing selection pressure act simultaneously on multiple traits (Bell, 2005; Bell & Sih, 2007). The consequence of behavioural syndromes in a population, apart from being maladaptive in specific context, is that it may constrain the ability of such a population to respond to selection. In this study, we explored the possibility of a boldness-aggression syndrome in three strains of zebrafish and the guppies which are species that are widely used in behavioural and experimental studies.

Materials and methods

All the zebrafish strains (London Wild Type (LWT), Tupfel Long fin (TL) and Nacre)) and the guppies used in this study came from laboratory-maintained stock at the University of Sheffield. Prior to behavioural testing which was similar to that described in Ariyomo and Watt (2012, 2013a, b, 2015) and Ariyomo *et al.*, (2013), zebrafish were housed in 10 litre tanks (30 cm x 15 cm x 24 cm) in a recirculatory system kept at 26 ± 1 C, whereas the guppies were placed in aerated tanks (18 cm x 11.5 cm x 11.8 cm) and the water changed daily, under a 12:12 h light/dark photoperiod with a 40 min dusk and dawn period. The fish were fed twice daily with dry fish food and brine shrimp.

Behavioural testing

Twenty-five males and 25 females of each of the zebrafish strains (LWT, TL and Nacre) and 25 male and 25 female guppies were tested for boldness and aggression. Behavioural testing was similar to that described in Ariyomo and Watt (2012, 2013a, b, 2015) and Ariyomo *et al.*, (2013). The open field test which has been previously shown to be the most valid measure of boldness (Burns 2008; Ariyomo & Watt, 2012, 2013a &b, 2015; Ariyomo et al., 2013) was used to test for boldness in this study. The number of lines crossed and the degree to which a fish utilized the open field was used as a measure of boldness (Burns 2008; Ariyomo & Watt 2012, 2015; Ariyomo et al., 2013). Fish were placed in a novel tank (48 cm X 26 cm X 22 cm), with the base marked into 24 rectangles (each 8 cm 9 5.5 cm) and filled with 3 L of dechlorinated water heated to 26 C (Ariyomo *et al.*, 2013). Fish that effectively utilized the inner and outer rectangles on the base of the tank and crossed more lines were deemed bold, while the shy ones were those that crossed the fewest lines and did not utilize the inner and outer rectangles on the base of the tank; (Ariyomo *et al.*, 2013). Two 18 W daylight fluorescent tubes were placed about 34 cm above the tank to provide light during the experiments. Fish tested for boldness in the open field assays were then tested for aggressiveness using the mirror test (Gerlai *et al.* 2000; Moretz *et al.* 2007a, b; Ariyomo and Watt 2012; Ariyomo *et al.*, 2013). The number of aggressive interactions made by an individual towards its mirror image was recorded. Fish with the greatest number of aggressive interactions were considered aggressive while those with few aggressive interactions were considered non aggressive.

Statistical analysis

The relationship between boldness and aggression in the males and females of the three strains of zebrafish and the guppies was analysed using the non-parametric Spearman's rank correlation (rho). Statistical analyses were conducted using R statistical software, version 2.12.2 (R Development Core Team 2011).

Results

Behavioural syndromes in strains of the zebrafish

There was a positive correlation between boldness and aggression in LWT females (Spearman correlation: rho = 0.52, $p = 0.008$; Fig. 1a) and in TL females (Spearman correlation: rho = 0.50, $p = 0.017$; Fig. 1b), but not for any males or females of the other strains (Table 1).

Behavioural syndromes in the guppy

There was a positive correlation between boldness and aggression in the male guppies (Spearman correlation: rho = 0.50, $p = 0.012$; Fig. 2a) but not for the females (Spearman correlation: rho = 0.14, $p = 0.504$; Fig. 2b

Table 1: Correlation between boldness and aggression in strains of zebrafish

Strain/sex	rho value	*p* value
Nacre female	0.13	0.525
Nacre male	0.13	0.329
LWT male	0.03	0.877
TL male	0.19	0.372

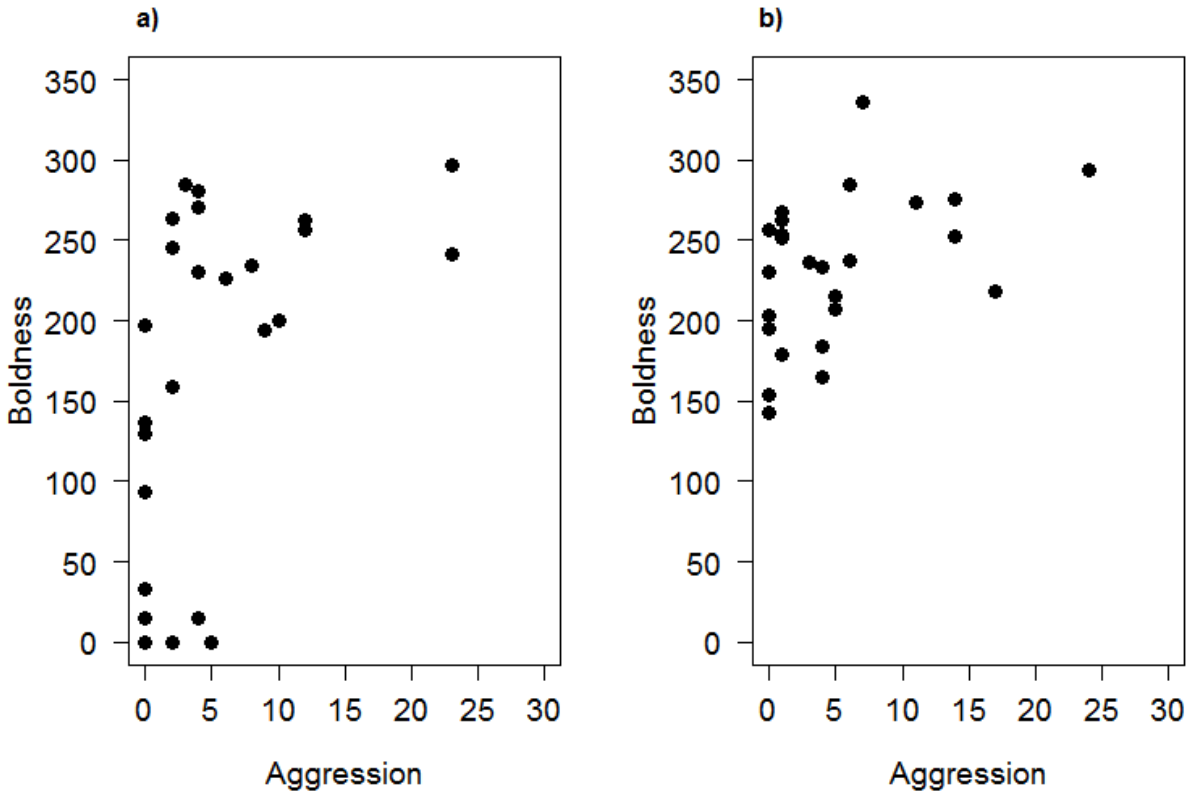

Fig. 1: Correlation between boldness and aggression in females of (a) LWT and (b) TL strains of zebrafish.

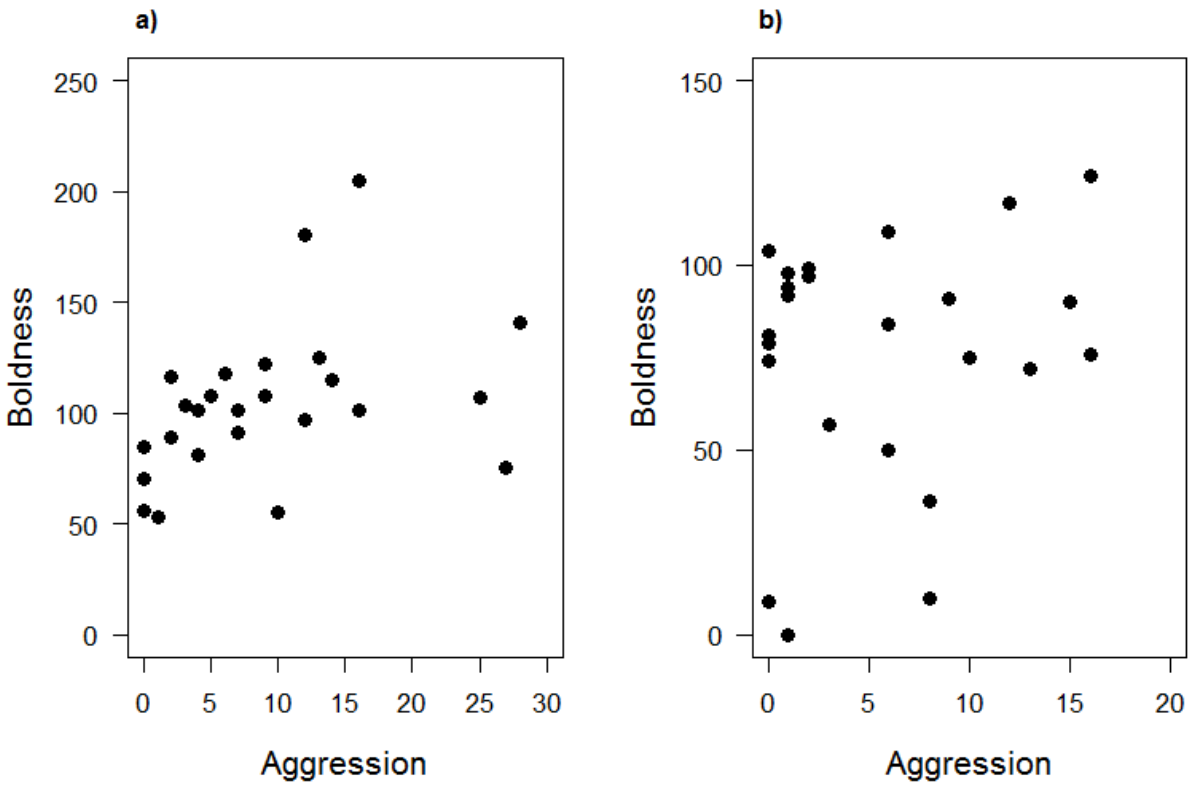

Fig. 2: Correlation between boldness and aggression in (a) the male and (b) the female guppies

Discussion

Evidence of a behavioural syndrome in females of two strains was noticed. It has been suggested that behavioural syndromes are more likely to be present in populations with high predation levels rather than in populations with little or no predation, such as in the populations tested in this study (Bell & Stamps, 2004; Bell, 2005; Dingemanse *et al.*, 2007, 2010). This is because directional selection by predators might act on multiple traits of a phenotype simultaneously, resulting in a strong correlation between such traits and hence the behavioural syndrome. It may be more advantageous for individuals to show behavioural plasticity across multiple contexts (Sih *et al.*, 2004a) because there are costs associated with rigidity, for example, an overly aggressive individual might be aggressive in situations where care is needed, such as towards offspring (Johnson & Sih, 2005) or mates (Wingfield *et al.*, 1990).

There was no evidence of a boldness-aggression behavioural syndrome in the female guppies but there was in the males. It is not clear why there were differences between the sexes. The males were more risk prone and curious than the females and so it could be that the behaviours expressed by the males reflected their adaptive responses to what was optimal in the two contexts (Dingemanse *et al.*, 2007) hence the strong positive correlation found between both traits. The notion of behavioural syndromes opposes the adaptive hypothesis (Wilson, 1998), which suggests that personality traits are context specific and involve organisms adjusting to the prevailing conditions in their environment (Wilson, 1998). For example, pumpkinseed sunfish, *Lepomis gibbosus,* were consistent with respect to individual variation when exposed to a non-threatening stimulus and also to a predator. However, there was no correlation between these variations across both situations (Coleman & Wilson 1998). Similarly, male Iberian rock lizards, *Lacerta monticola,* that were bold when exposed to high risk predatory attacks, were not particularly bold when faced with low risk predatory attacks (Lopez *et al.*, 2005). These studies indicate that organisms show adaptive

individual differences to the prevailing selection pressures in their environment in order to maximise fitness (Wilson, 1998; Dingemanse *et al*., 2007). An important ecological implication of behavioural syndromes is that they involve tradeoffs that may reduce behavioural plasticity and they may be maladaptive in specific contexts (Sih *et al*., 2004a, b). Furthermore, correlated traits are forced to evolve together and this may constrain the ability of populations, where behavioural syndromes persist, to respond to selection (Dochtermann & Jenkins, 2007).

Overall, there was some evidence of a boldness and aggression syndrome in females of two of the zebrafish strains and in the male guppies, but, given the limited correlation of these traits within the populations studied, this syndrome was probably due to adaptations to prevailing selection pressures rather than due to genetic constraints (Dingemanse *et al*., 2007).

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Genetic Variability of some Tilapia Species from three different Reservoirs in Southwestern Nigeria

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Abstract

The technique of random amplified polymorphic DNA (RAPD) marker has been used for stock identification and discreteness and population analysis in fish but the potential for species and stock characterization has not yet been fully established for tilapias in Nigeria. A study on the genetic similarity within and between three species of tilapia (*Sarotherodon galilieaus, Tilapia guineensis,* and *Oreochromis niloticus*) was carried out to identify novel traits for the improvement of breeding techniques and production in aquaculture. One hundred and eighty-five tilapias were collected from three reservoirs: Owena, Asejire, and Aiba in Southwestern Nigeria. RAPD primers were used to estimate the genetic variation and their phylogenetic relationships. A total of thirty-five RAPD primers were screened for this study out of which, twelve RAPD markers gave reproducible bands and four primers yielded a clear and consistent DNA banding pattern. Seventy-seven detected alleles were generated by the twelve RAPD primers consisting of thirty-two alleles as monomorphic and forty-five as polymorphic. UPGMA cluster analysis of genetic data showed a high level of genetic similarity and produced two main clusters: CI and CII at 59.8% similarity level. Cluster I had twenty-four samples and Cluster II had eleven samples. The result of this study on the genetic similarity of fish and its genome is vital for improved fish breeding techniques.

Keywords: Random amplified polymorphic

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Introduction

Tilapia fish species represent the most important group of the family Cichlidae and common fishes' native to the fresh waters of Africa and found in the mouthbrooding genera *Oreochromis* and *Sarotherodon* and substrate spawning genus *Tilapia* (Trewavas, 1983). The species are characterized by delicious taste and cheap price which make them a valuable part of national income. Furthermore, many researchers use it as a fish model to investigate different items (El-Serafy *et al,* 2003). The world aquaculture production of tilapia is second only to carp and exceeds 1.5 million tons per year (FAO, 2004) being increasingly important in tropical and subtropical countries: the Philippines, Taiwan, Israel, and several Sub-Saharan African countries- Cote d'Ivoire, Malawi, Benin Republic, etc (Liu and Cordes, 2004). Tilapia has been cultured intensively for more than four decades but its genetic resources have been poorly managed. Perdices *et al.* (2005) considered that the application of molecular

techniques would permit enhanced detection of evolutionary structure and taxonomy across the widespread species. Some of the modern approaches in genetic characterization of aquatic species to study the genetic variation include Restriction fragment length polymorphism (RFLP) of mitochondrial DNA (mtDNA) (Supungul *et al.*, 2000), Microsatellite DNA analysis (Sekino *et al.* 2002,), Allozyme analysis (Klinbunga *et al.* 2000) and Random amplification of polymorphic DNA (RAPD) (Degani *et al.* 2000). Despite some progress made (Rutten *et al.* 2004; Shirak *et al.* 2009), the potential of using DNA markers for species and stock characterization has not yet been fully established for tilapias. The technique of the RAPD marker (Welsh and McCelland, 1990; Williams *et al.*, 1990) has been successfully exploited for stock identification and population analysis in fish. Also, many RAPD fingerprinting studies on fish provide evidence of stock discreteness (Bartfai *et al.,* 2003; El-Zaeem *et al.*, 2001). The objective of this study is to determine the genetic variation within and between the tilapia populations in the three reservoirs at different locations in Southwestern Nigeria.

Materials and Methods

Study areas

Owena, Asejire, and Aiba reservoirs in Southwestern Nigeria were selected for the study. Owena reservoir is situated across River Owena in Ondo State (latitude 7.19ºN and longitude 5.01ºE). It is about 300 m long and 9 m in its deepest part with the capacity of approximately 600,000 m^3 of water and with a catchment area of 790 km^2 (FAO, 2004). Aiba reservoir is located in Iwo, Osun State on latitude 7.63ºN and longitude 4.19ºE. It has an average altitude of 245 m above the sea level and a surface area of 28.75 km^2. It was built in the early 1950s primarily for the provision of potable water. The reservoir drains into River Osun via River Oba and attains its flood level peak between June and July yearly. Asejire reservoir is a man-made lake situated along with River Osun about 30 km east of Ibadan, Oyo State, and located on latitude 7.35ºN and longitude 4.13ºE. It has an impounded area of 2342 hectares.

Collection of blood samples and storage

Blood sample (1 ml) was collected aseptically from each fish sample into EDTA bottles using 2 ml disposable syringe by gill vein puncture. The blood samples were stored on ice blocks and transported in a 10 L closed lid Plastic cooler to the Molecular Biology Laboratory, Biotechnology Centre, Federal University of Agriculture, Abeokuta for molecular analysis.

Extraction of genomic DNA

Total DNA was extracted from the whole blood samples using CTAB (hexadecyl trimethyl ammonium bromide) DNA extraction modified protocol of Doyle and Doyle (1987). 200 µl of the blood sample was transferred into an Eppendorf tube containing 600 µl of 2X CTAB extraction buffer (100 mM Tris-HCl, 1.4M NaCl, 20 mM EDTA, 2% CTAB and 0.1 mg mL^{-1} proteinase K, pH 8.0) for nuclear-lysis. The sample was incubated at 65ºC for 1 h and allowed to cool to room temperature. Proteins and polysaccharides were removed by adding 500 µl of chloroform/isoamyl alcohol (24:1) solution, mixed for 5 min, and spun for 10 min at 14,000 rpm. 1 µL RNase was added into the tube to remove RNA, thereafter incubated at 37ºC for 30 min. The sample was vortexed for 5 min and spun at 14,000 rpm for 15min. The supernatant was transferred into a new Eppendorf tube leaving the white interphase. DNA was then precipitated from the aqueous layer by adding 500 µl of cold isopropanol, kept in the freezer for 2 h. at -20ºC and later spun at 14,000 rpm for 10 min. The DNA pellets were then washed with 500 µl 70% ethanol, air-dried for 30 min on the bench, and re-suspended in 100 µl of sterile water. The extracted DNA was kept at -20^{0}C for further analysis. DNA quantification was performed and a dilution of 20-50 ng μl^{-1} was used in the downstream application. The DNA concentration (µg μl^{-1}) was determined by absorbance at 260 nm and 280 nm in each sample

using Nanodrop®ND-1000 spectrophotometer. The ratio A_{260}/A_{280} in each sample was used as an indicator of the genomic purity. The DNA integrity was checked by size fractionation on 1% agarose gel stained with ethidium bromide, visualized, and photographed on a gel documentation system (Gel DocTM, *BIO-RAD*). The quantified DNA was subjected to PCR amplification.

RAPD-PCR analysis

A total of thirty-five Operon random primers was tested for RAPD-PCR analysis. The reaction mix was carried out in 20 ul final volume containing 60 ng genomic DNA, 2 mM $MgCl_2$, 125 uM of dATP, dCTP dGTP and dTTP each, 0.1 uM of the primers and 1 unit of Taq DNA polymerase. Amplification was performed in a PCR thermocycler. (Biotop AGCT Thermal Cycler) The thermocycler profiles were an initial denaturation step for 3 min at 94ºC followed by 45 cycles of denaturation step at 94ºC for 20 seconds, annealing at 37ºC for 40 seconds, and primer extension at 72ºC for 40 seconds, and final extension temperature at 72ºC for 5 min. The total volume of the PCR products was evaluated in 2% agarose gels and visualized by ethidium bromide staining. Bands obtained on the gel were measured by comparing the PCR product with the DNA ladder mix.

Molecular data analysis

The banding pattern was transformed into numerical values, where the presence of a band was scored 1 and the absence scored as 0. The binary value was transferred into NTSYS (Numerical Taxonomic Systems) software. A dendrogram was constructed from the matrix of similarity coefficients, using the unweighted pair group method of the arithmetic average (UPGMA) (Rolf, 2000). Genetic distances (GD %) were obtained by subtracting the similarity indices from 1 and multiplying the outcome by 100 [(1-Sij) x 100] (Kim *et al.*, 1992).

Results

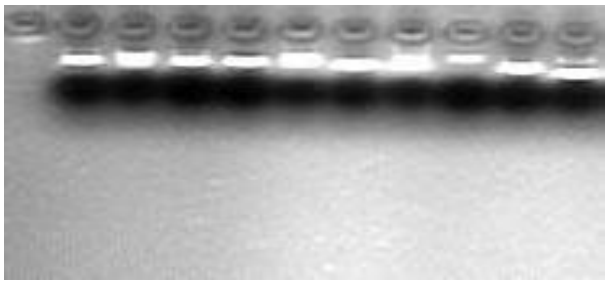
DNA extraction and primer screening

The concentrations of the DNA ranged between 150 to 300 $\mu g\ \mu l^{-1}$ and the percentage genome purity of the extracted DNA was within the purity level of 1.8-2.0 for all the DNA samples and the fragment obtained was over 35 kb for all the samples (Fig. 1). Twelve decamer primers were used for this study (Table 1). The extracted genomic DNA from the different samples was screened using random primers (Operon Technologies, Almeda, 6 kits: OPAE, OPAD, OPI, OPC, OPB, and OPAF). A total of thirty-five RAPD primers were screened to test their ability to provide scorable DNA banding patterns. Among the primers screened, twelve RAPD markers gave informative bands and out of which five primers (OPAD-09, OPAF-09 OPB-15, OPC-09, and OPI-03) showed clear and distinct DNA banding patterns.

RAPD-PCR profiles

All the primers showed a different percentage of polymorphism. The number of bands and banding pattern were variable depending upon the primers and type of species tested and ranged from 3 to 15. The maximum polymorphism was produced by the primers OPC-09, OPAD-09, OPAF-09, OPB-15, and OPI-03 having 80, 92, 67, 75, and 75% respectively. The highest percentage of polymorphism loci was obtained for OPAD-09 (92%) while OPAE-04 showed the least polymorphism (20%). A total of 77 bands were amplified. The size of RAPD fragments ranged from 150 to 5000 bp (Table 1). Out of the total bands, 45 (58.4%) were polymorphic while 32 (41.6%) were monomorphic (Table 2).

M 1 2 3 4 5 6 7 8 9 10



M 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35

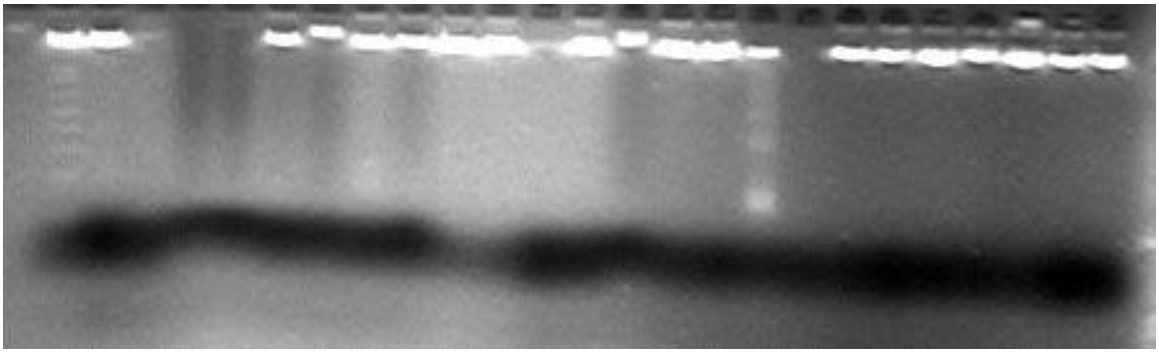


Fig.1: Electrophoresis gel for DNA extraction

Table: 1 Sequence and Operon codes of the random primers used to study variation in Tilapia species

S/N	Primer Name	Nucleotide sequence (5' to 3')	Fragment size (bp)
1	OPAD 09	TCGCTTCTCC	200-2500
2	OPAE 04	CCAGCACTTC	200-2500
3	OPAE 05	CCTGTCAGTG	250-2500
4	OPAE 09	TGCCACGAGG	250-3000
5	OPAF 07	GGAAAGCGTC	250-3500
6	OPAF 08	CTCTGCCTGA	250-3500
7	OPAF 09	CCCCTCAGAA	200-4500
8	OPAF 11	ACTGGGCCTC	200-3500
9	OPAF 12	GACGCAGCTT	200-3000
10	OPB 15	GGAGGGTGTT	250-5000
11	OPC 09	CTCACCGTCC	200-3500
12	OPI 03	CAGAAGCCCA	150-4000

Table 2: The percentage polymorphism of the RAPD markers used

S/N	Primer name	No of polymorphic markers	No of monomorphic markers	Total no of markers	% polymorphism
1	OPAD 09	11	1	12	92
2	OPAE 04	1	4	5	20
3	OPAE 05	1	3	4	25
4	OPAE 09	1	3	4	25
5	OPAF 07	2	3	5	40
6	OPAF 08	1	3	4	25
7	OPAF 09	10	5	15	67
8	OPAF 11	1	3	4	25
9	OPAF 12	1	2	3	33
10	OPB 15	6	2	8	75
11	OPC 09	4	1	5	80
12	OPI 03	6	2	8	75
Total no of markers		45	32	77	

UPGMA cluster analysis of all primers

The dendrogram based on the similarity matrix differentiated the species into two distinct clusters: Cluster I (CI) and Cluster II (CII) at 59.8% similarity level. Cluster I had 24 samples of different species out of which seven (7) were *Oreochromis niloticus*, eleven (11) were *Sarotherodon galilieaus* and six (6) belonged to *Tilapia guineensis* from all the three reservoirs showing different levels of genetic relationships. Cluster II had eleven (11) samples out of which six (6) belonged to *Tilapia guineensis,* four (4) were *Sarotherodon galileaus* and one (1) sample was *Oreochromis niloticus*. Cluster II consisted of samples from Aiba and Asejire reservoirs at different similarity coefficients.

Cluster I was further divided into two sub-clusters and had shown a high level of genetic variation at 69.4%. Sub-cluster I had eighteen (18) samples and consisted of samples from Asejire and Aiba reservoirs collectively showing a 74.4% similarity level. Sub-cluster II had six (6) samples which comprised samples from Owena reservoir only at 96.7% similarity level. Cluster II was also observed to consist of two sub- clusters: Sub-cluster I had three (3) samples from Asejire reservoir only showing 76.7% similarity level while Sub-cluster II had eight (8) samples which consisted of samples from Asejire and Aiba reservoirs together at 71.4% similarity level.

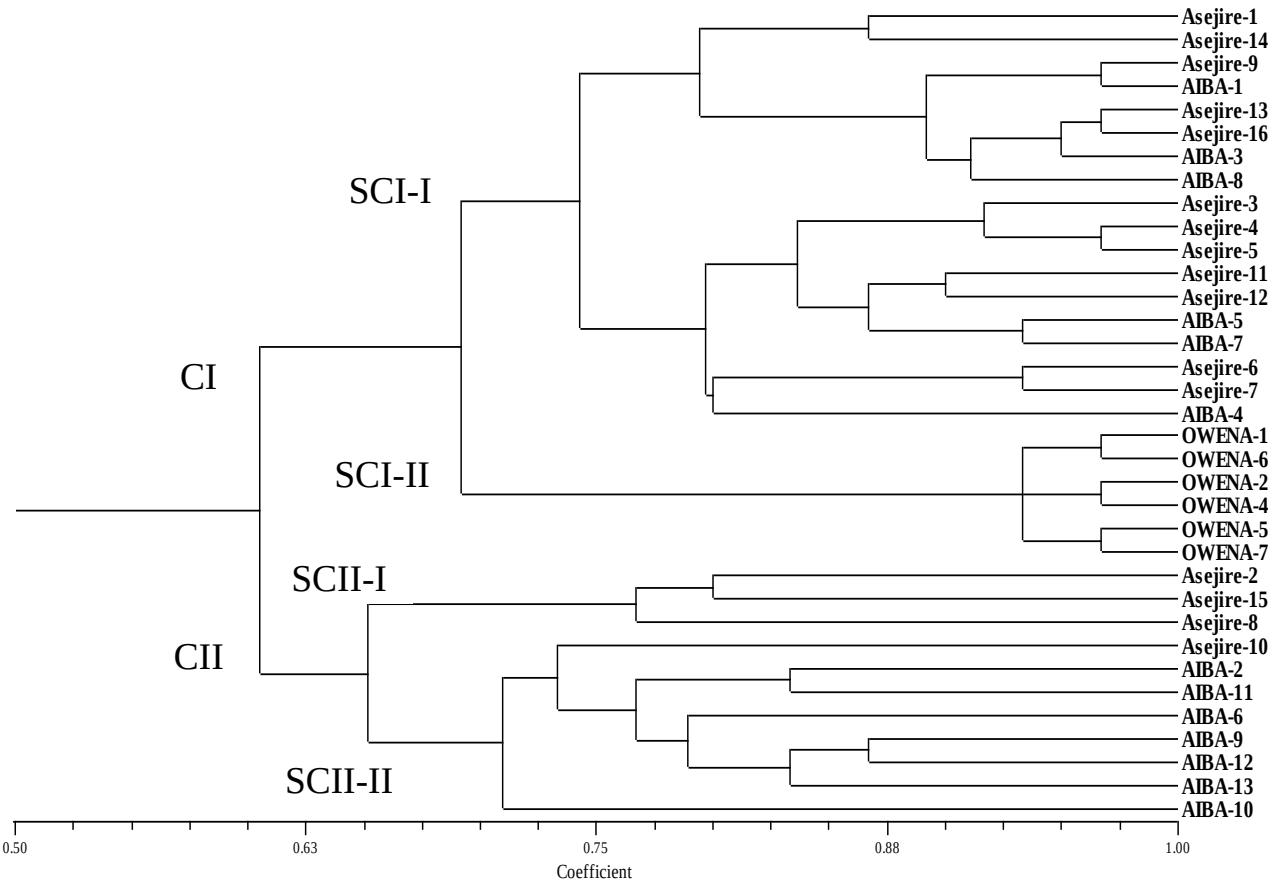


Fig. 2: Cluster analysis-based dendrogram depicting the genetic relationships among different Cichlid species (based on Nei's and Li's (1972) coefficients of similarity). CI = Cluster I; CII= Cluster II; SC = Sub clusters I and II:

Discussion

The presence of variability within species (among populations and also between individuals within a population) is essential to their ability to survive and successfully respond to environmental changes (Rehbein *et al.*, 1995). Out of the thirty-five primers screened, twelve primers (OPAD-09, OPAE-04, OPAE-05, OPAE-09, OPAF-07, OPAF-08, OPAF-09, OPAF-11, OPAF-12, OPB-15, OPC-09, and OPI-03) generated reproducible bands and gave satisfactory results whereas twenty-three primers produced highly inconsistent amplification products. The RAPD-PCR results of all genomic DNA isolated from the different samples were compared with each other. The primer OPAD-09 had the greatest degree of DNA polymorphism over the other four primers. Primer OPC-09 showed a greater percentage over primers OPI-03 and OPB-15 while primers OPI-03 and OPB-15 are of the same percentages (75%).

The twelve random decamer primers generated a total of 77 unambiguous, readable, and reproducible amplified products. The number of amplified bands varied from three to fifteen and the size of the amplified products varied from 150 to 5000 bp. This agrees with Welsh *et al.* (1991) that the number and size of the bands generated strictly depend upon the nucleotide sequence of the primer used and the source of the template DNA, resulting in the genome-specific fingerprints of random DNA bands. The results showed that all the samples had different banding composition. OPI-03 generated a total of 8 bands, OPC-09 had 5 bands, OPB-15 generated 8 bands, OPAF-09 generated a total of 15 bands, and OPAD-09 had a total of 12 bands. The highest

number of bands was generated by OPAF-09 and revealed 67% polymorphism, while OPAD-09 showed the highest polymorphism (92%) across the samples. The variations in the number of bands amplified by different primers were influenced by variable factors such as primer structure, template quantity and less number of annealing sites in the genome (Davis and Hetzel, 2000). Of the 77 bands, 45 (58.44%) were polymorphic while 32 (41.56%) were monomorphic in all the samples. The percentages of polymorphism RAPD bands ranged from 20 to 92% in all studied Tilapia species.

This study has demonstrated that RAPD markers can differentiate between and determine genetic relatedness within some populations of cichlids species. The RAPD fragments observed in the populations showed a high degree of polymorphism within and between the populations. Unweighted pair-group method using arithmetic average (UPGMA) analysis of the RAPD markers and pair-wise genetic similarities among the populations from the three studied reservoirs was estimated to range from 0.292 to 0.967 indicating a high genetic distance among the sampled populations. The result of the cluster analysis among the cichlids showed that the species from Asejire and Aiba reservoirs interbreed thereby producing mixed breeds. This might be as a result of natural selection based on breeding partners and as a result of seasonal migration. The similarity coefficients recorded in the populations among the sampling reservoirs varied greatly being 0.900-0.967, 0.333-0.958, and 0.292-0.875 for the samples from Owena, Asejire, and Aiba reservoirs respectively.

The phylogenetic tree indicated that all the populations are polyphylogenetic. The results of the similarity coefficient also indicated the polyphylogenetic relationships of the different species. The populations from Asejire and Aiba reservoirs were closely related even though they are different species of cichlids as seen from the dendrogram. The populations from Owena reservoir were genetically related sharing some characteristics but not purely of the same strain. In contrast, those with similar strain are paired together showing a high similarity coefficient of 0.967. This might be a result of the short period of reproduction (Barman *et al.,* 2003) and that the samples originated from a common ancestor, hence the results give solutions to cichlids diversities in their natural environments. It also means that the species *O. niloticus* collected from Owena reservoir are mono-phylogenetic (common ancestor) while the other populations display another origin. This supports Farias *et al.* (1999) and El-Serafy *et al.* (2003) who used restriction fragment length polymorphisms of nuclear and mitochondrial DNA-PCR products (RELPs/PCR) as a basis for examining the relationships among Tilapia species and found out that Tilapia species are poly-phylogenetic species and some are mono-phylogenetic. Similar results were obtained for Tilapia by Yapi-Gnaore (2001) who found that the molecular techniques provide good markers and significant genetic characterization for the studied species. The monophyletic relationship of Tilapia fish has been confirmed by Oberst *et al.* (1996), Zowail and Baker (1998), Yapi-Gnaore (2001) and Rognon and Guyomard (2003) by using several electrophoretic techniques including polyacrylamide gel electrophoresis, isoelectric focusing, immune electrophoresis, and allozyme electrophoresis. The present study also showed a significant correlation between genetic identity and geographical distance. Fernandez, (2001) reported that the population structure of freshwater organisms is dependent on the distributions of river systems. Among the three reservoirs studied, Asejire and Aiba are closer than the Owena reservoir.

The genetic similarity values obtained in the sampled populations from the three reservoirs were in line with the expected values for individuals of the same population. This is supported by the findings of Haroun, (1999) that 98% of populations of the same species have a genetic similarity of over 0.85. This could have enhanced interbreeding between the populations from Asejire and Aiba reservoirs, which resulted in the improvement of genetic variation

within the populations. The genetic distance values for the populations from the three reservoirs were 11.10-59.30 (Asejire), 3.30-10.00 (Owena), and 8.30-66.70 (Aiba) which might be due to isolation by distance. The similarity coefficient between *Sarotherodon galileaus* in Asejire and Aiba reservoirs was 0.533-0.933; *O. niloticus* in Asejire and Owena was 0.600-0.800 and *T. guineensis* was 0.400-0.767 in Asejire and Aiba reservoirs. The result showed that the populations from Owena reservoir were genetically related to the highest value of the coefficient of similarity such that the probability of having a pure breed is higher in the Owena reservoir.

Conclusion

The knowledge of the genetic structure and variability of stocks should be a prerequisite for any fish breeding program as this would provide a greater understanding of the genetic resources and for proper management of genetic data using genetic tools to avoid inbreeding and to improve the quality of fish produced. The results of this study indicate that RAPDs markers are appropriate for the characterization of germplasm and estimation of genetic diversity in fish populations.

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Germination and Seedling Growth of African Star Apple (*Chrysophyllum albidum* G. Don Syn. *Gambeya albida*) in Soils of Ekiti State

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Abstract

Most indigenous forest tree species are of utmost importance yet they are not largely domesticated for many ecological reasons. Therefore, this study examined the germination and early seedling growth of African star apple (*Chrysophyllum albidum)* in the soils collected from Ikere and Ado-Ekiti (rain forest), Ayede-Isan and Igede (Savanna) in Ekiti State. *C. albidum* seeds were extracted from matured fruits, subjected to four treatments control (untreated seeds), hot water scarification and cold water before sowing. Laboratory analysis of some soil properties was done to determine differences among the locations. Seedling growth variables were monitored every fortnight for twelve weeks. Coldwater produced germination that ranged between 11.1-100% followed by scarification with the germination of 33.3-88.9% among the locations. Likewise, the control produced germination of between 11.1-55.6% whereas seeds pretreated with hot water did not germinate. Analysis of variance did not reveal any significant difference for seedling height but the highest mean height value of 8.95cm, followed by 8.77cm and the least of 5.25cm were obtained in Igede-Isan, Ikere and Ado respectively in the locations throughout the assessment period. Also, the highest mean collar diameter value (0.35cm) was obtained in Igede-Isan and the least (0.30cm) in Ado Ekiti. Therefore, scarification and cold water can be used to overcome dormancy in *C. albidum* seeds. Also, *C. albidum* can be successfully raised in the two ecological zones of Ekiti State since there were no marked differences among the locations studied.

Keywords: Indigenous fruit tree, soil effects, pretreatments, seedling emergence

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Introduction

Many indigenous tropical fruit tree species are of great economic potentials. Sales of some of these edible fruits serve as a means of livelihood for many rural people in Nigeria. Some of these fruit tree species include African pear *Dacryodes edulis*; Bush mango *Irvingia gabonensis*; Velvet tamarind *Dialium guineense*; Yellow mombin *Spondias mombin*,; Soursop *Annona muricate;* Breadfruit *Artocarpus altilis;* African breadfruit *Treculia africana* and *Chrysophyllum albidum* (syn. *Gambeya albida*). *C. albidum* commonly called African star apple or White star apple is from the family Sapotaceae. It is called different names by the diverse tribes in Nigeria. It is known as "agbalumo" in Yoruba, "udara" in Ibo, Efik, and Ibibio; "ehya" in Igala and "agwaluma" in Hausa (Olayode and Otufale, 2018). It is primarily a forest tree species and its natural occurrence has been reported in diverse ecozones in Nigeria, Uganda, Niger Republic, Cameroon, and Cote d'Ivoire (Bada, 1997). The tree often grows to a height of 36.5m. The African star apple fruit is a

large berry containing 4 to 5 flattened seeds or sometimes fewer due to seed abortion (Gbile, 1997). Many people both old and young relish the fruit of *C. albidum*, therefore they are considered to be of great commercial interest wherever they exist. Likewise, research has buttressed the fact that the economic potentials of *C. albidum* have improved significantly in recent times (Kazeem-Ibrahim *et al.*, 2013).

Perhaps the popularity of *C. albidum* is as a result of the many uses derivable from it. Its fruit is said to be very rich in ascorbic acid (1000 to 3,300mg per 100g of edible fruit) up to about 100 times that of orange and 10 times that of guava or cashew. Likewise, its fruit has been explored for the preparation of wine, spirits, soft drinks, jams, and jellies (Umelo, 1997). Its wood is said to be valued because it is easy to saw and suitable for construction purposes. Also, its seeds are a source of oil that is used for many purposes (Orwa, *et al.*, 2009). Furthermore, the various plant parts of *C. albidum* such as its leaves, cotyledon in the seed, and roots have been used for diverse purposes many of which are medicinal (Olapade, 1997; Amusa *et al.*, 2003; Okunomo and Egho, 2010).

C. albidum has been reported to be found in the semi-deciduous lowland rainforests underlain by ferruginous tropical soils of basement complex and also ferrallitic tropical soils of coastal plains sands (Bada, 1997). The medium in which any tree species is growing is very crucial to its survival and ability to attain its maximum potential in terms of development. The roles of soil in the growth and development of plants are diverse; they range from the provision of mechanical support, nutrients, air, water to harbouring many microorganisms some of which are very beneficial to plant growth (Boyle, 2005). An ideal soil is that which has about half of its content being solid while the remaining half is occupied by water and air in equal proportions (Crouse, 2018). However, it is known that this hardly occurs in reality due to the various modifications that might have taken place on such soil consequent upon anthropogenic activities with some aiding plant growth while others are detrimental to it. All seeds require adequate moisture and air in the soil to commence internal processes as well as permit gaseous exchange respectively as conditions necessary for germination to occur. Air, water, and nutrients present in any soil vary from location to location, and even in a particular site, there can be variations based on the slope as well as the physical properties of the soil. Furthermore, soil varies both laterally and vertically. Soil variability can be a result of the interaction among the soil-forming factors which are topography, parent materials, climate, soil physical and chemical processes, biological activities, cropping system and tillage practice. There seems to be limited information on site preferences for *C. albidum* although Bada (1997) reported that the species grows well in undulations with deep soils and good drainage based on existing stands. This study, investigates seed germination and early growth of *C. albidum* on soils from selected locations in Ekiti State to prescribe the location that would best support its growth.

Materials and Methods

The experiment was carried out at the nursery site of the Faculty of Agricultural Sciences, Ekiti State University, Ado-Ekiti, Nigeria (EKSU). Ekiti State enjoys a tropical climate with two distinct seasons. These are the rainy season (April–October) and the dry season (November–March). Temperature ranges between 21 C and 28 C with high humidity. The south-westerly wind and the northeast trade wind blow in the rainy and dry (Harmattan) seasons respectively. The tropical forest exists in the south, while savanna occupies the northern peripheries. The soils derived from the basement complex rocks are mostly well-drained, having a medium to a fine texture.

The topsoil used for this study was collected from four locations in Ekiti State with two locations from the rainforest and two from the derived savanna. The two rainforest locations are Ado-Ekiti and Ikere-Ekiti while the derived savanna locations are Ayede-Ekiti and Igede-Isan Ekiti. This topsoil was collected from the teak plantation in each of these locations to eliminate bias from the depth of 0 – 7cm.

Matured fruits of *C. albidum* were collected from its area of natural range in Ekiti State. Seeds were extracted from the fruits, de-pulped, washed in water, and air-dried before sowing. Samples of the topsoil collected from the four locations were analyzed in the laboratory for their physical and some chemical properties (Nitrogen, Phosphorus, Potassium, and pH) to determine differences. Samples were analyzed according to the official methods of analysis described by the Association of Official Analytical Chemists (A.O.A.C., 2005).

The pretreatments used for breaking seed dormancy were scarification, hot water, cold water, and control. Scarification was achieved by scratching the seed hilum on sandpaper while hot water pretreatment was achieved by soaking the seeds in water brought to boil and allow the water to cool with the seeds overnight. Coldwater pretreatment was done by soaking seeds in water at room temperature for 12 hours while the seeds under control did not receive any form of pretreatment. One hundred and forty-four seeds were used with thirty-six seeds subjected to each treatment and sown in the polythene pots previously filled with topsoil collected from the various locations thereby making the topsoil from each location the replicate for each pretreatment. Polythene pots were watered daily in the morning and germination count was done daily till no further germination occurred for about 7 days. Uniformly growing seedlings were then later separated to continue into the phase of seedling growth assessment. Data collected were subjected to 2-way analysis of variance (ANOVA) while Duncan's Multiple Range Test (DMRT) was used to separate the means that were significantly different at the 5% probability level.

Results

Germination of *Chrysophyllum albidum* in Soils from Four Locations in Ekiti State under Different Pretreatments

The germination data of *C. albidum* seeds in the soils of the different locations subjected to different pretreatments are shown in Table 1. Germination began in Ikere under control at 33 Days After Sowing (DAS) and was completed at 40 DAS with germination of 55.6%. No germination was observed under hot water treatmentuntil the experiment was terminated. Germination began under scarification at 29 DAS and was completed at 39 DAS giving germination of 55.6%. In cold water treatment, germination began at 26 DAS and ended at 38 DAS with 100% germination obtained. Figure 1 shows the germination percentage at different assessment periods in Ikere.

Furthermore, in Ayede, germination began in control at 32 DAS and was completed at 37 DAS with germination of 55.6%. However, hot water gave germination of 0% whereas, under scarification, germination began at 28 DAS and ended at 39 DAS with germination of 77.8%. Under cold water, germination began at 26 DAS and was completed at 32 DAS with germination of 66.7%. Figure 2 reveals germination in Ayede during the assessment period.

In Igede-Isan, germination began in control at 33 DAS and ended on 39 DAS with germination of 33.3%. A similar result to what was got in the other locations aforementioned was observed under hot water treatment with no germination till the experiment was concluded. On the other hand, scarification began at 31 DAS and was completed at 40 DAS with germination of 88.9% whereas, in cold water, germination was first observed at 32 DAS and ended on 39 DAS with germination of 33.3%. Germination in Igede-Isan under the various pretreatments are shown in Figure 3.

Lastly in Ado, germination was first observed under control at 43 DAS and none was observed after that day. Meanwhile, as it was observed in other locations, hot water did not germinate throughout the duration of the experiment. Nevertheless, scarification produced germination of 33.3% with germination first observed at 26 DAS while it was completed at 37 DAS. Germination started in cold water at 35 DAS and ended the same day producing germination of 11.1%. Figure 4 shows germination under the different pretreatments in Ado.

Table 1: Germination of *C. albidum* Seeds Subjected to Different Pretreatments across the Locations

Loc.	Control			Hot Water			Scarification			Cold Water		
	GP (%)	Onset of Germ. (DAS)	End of Germ. (DAS)	GP (%)	Onset of Germ. (DAS)	End of Germ. (DAS)	GP (%)	Onset of Germ. (DAS)	End of Germ. (DAS)	GP (%)	Onset of Germ. (DAS)	End of Germ. (DAS)
Ikere	55.6	33	40	0	-	-	55.6	29	39	100	26	38
Ayede	55.6	32	37	0	-	-	77.8	28	39	66.7	26	32
Igede-Isan	33.3	33	39	0	-	-	88.9	31	40	33.3	32	39
Ado	11.1	43	43	0	-	-	33.3	26	37	11.1	35	35

Loc. = Locations, GP = Germination percentage, DAS = Days After Sowing

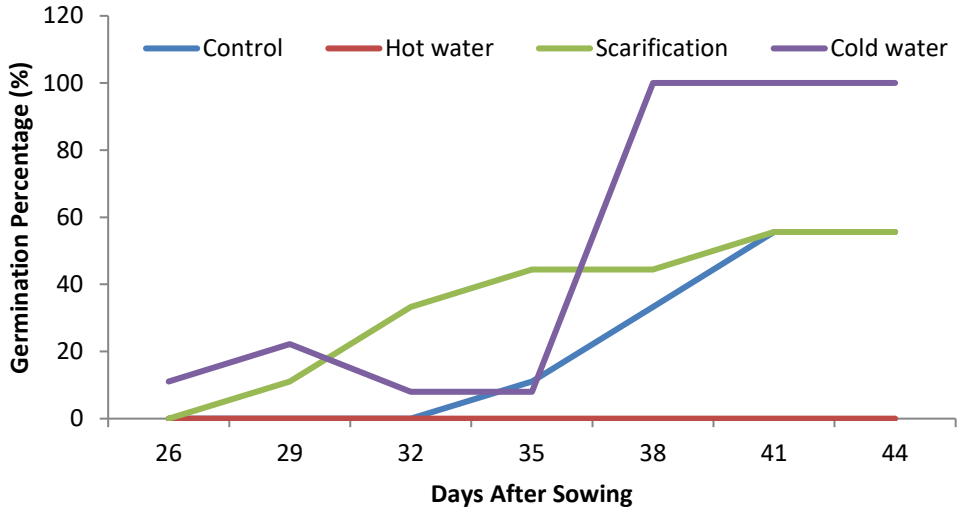

Figure 1: Germination of *C. albidum* seeds under the various pretreatments sown in Ikere soil

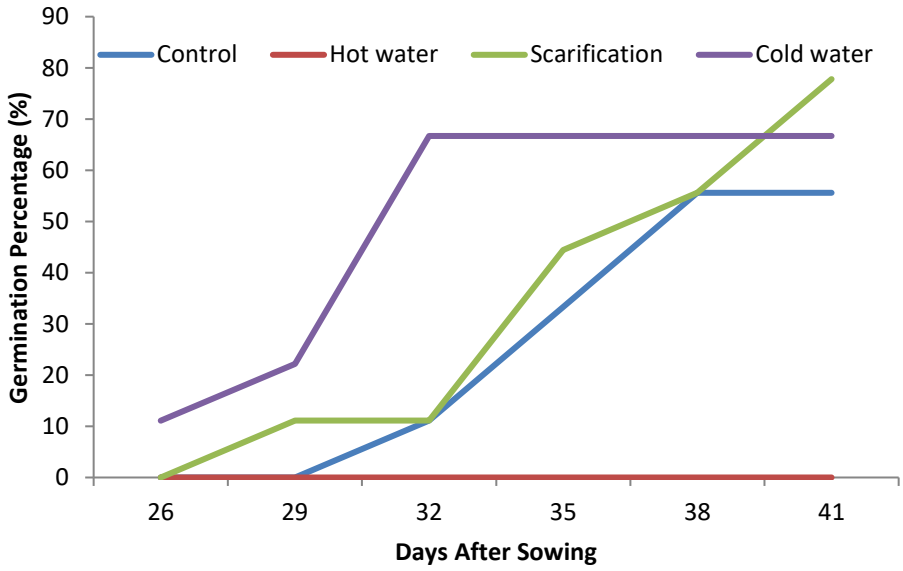

Figure 2: Germination rate of *C. albidum* seeds subjected to various pretreatments raised in Ayede soil

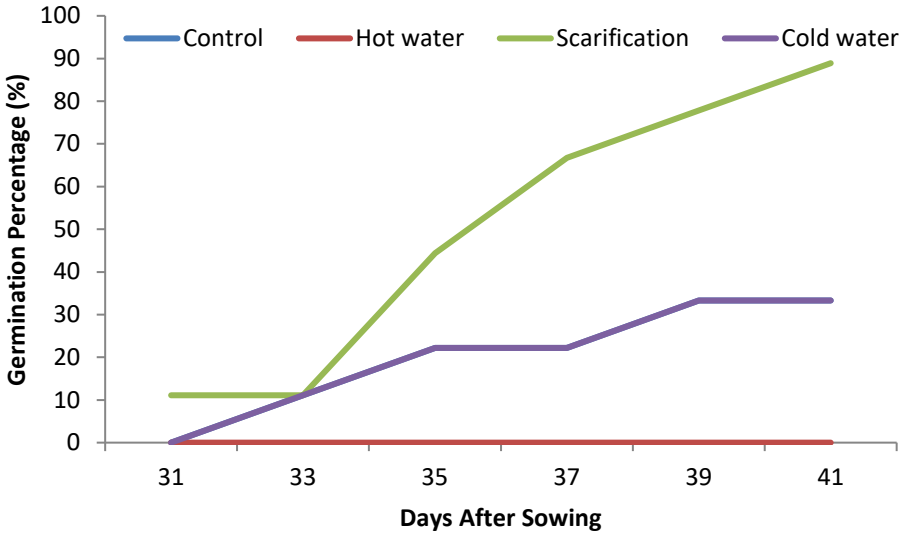

Figure 3: Germination of *C. albidum* seeds under different pretreatments sown in Igede-Isan soil

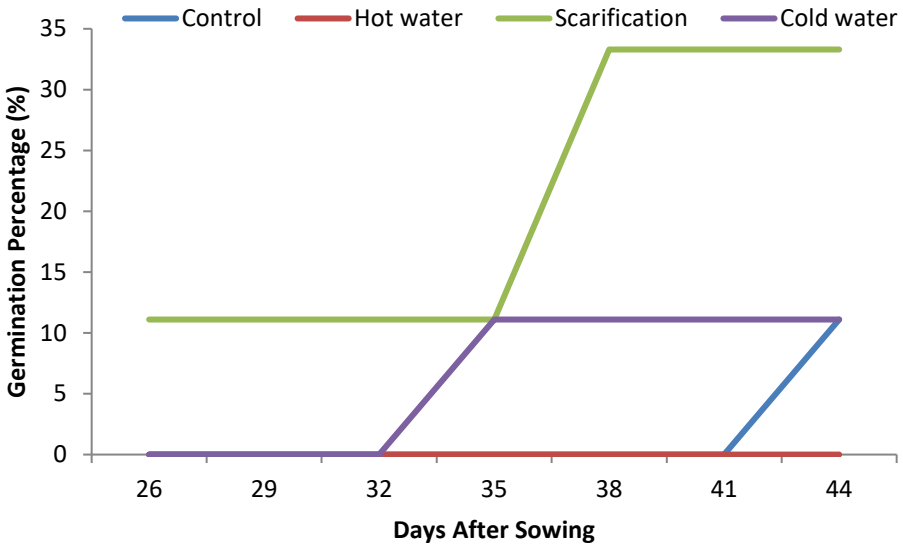

Figure 4: Germination rate of *C. albidum* seeds subjected to various pretreatments raised in Ado soil

Seedling Growth Variables

Results of the seedling growth variables of *C. albidum* are presented in Table 2. ANOVA result for the mean number of leaves revealed significance at 6 and 8 weeks, however, when DMRT was used to separate the means, it showed that at 6 weeks, the mean number of leaves for Ado was different from both Ikere and Ayede but not different from that of Igede-Isan. However, the means across the locations were not significantly different from one another at 8 weeks. Moreover, Ikere had the highest mean value of 3.17 while the least mean value was 2.00 and this was obtained across all the locations at different times during the assessment period.

ANOVA result did not indicate a significant difference in mean seedling height values of *C. albidum* in all the different locations throughout the assessment period. However, when the mean values were considered, Igede-Isan had the highest value of 8.95 cm at 12 weeks, followed by 8.77 cm in Ikere while the least value of 5.25 cm was recorded in Ado at 2 weeks.

The result of ANOVA for mean collar diameter values of *C. albidum* revealed significant differences at 4, 6, and 8 weeks. When DMRT was used to separate the means, it showed that at 4 weeks, mean collar diameter values were not different from one another. Nevertheless, at 6 weeks, Igede-Isan differed from the other locations. Likewise, Igede-Isan differed from both Ikere and Ayede at 8 weeks but was not different from Ado. The highest mean collar diameter value of 0.35 cm was recorded in Igede-Isan at both 10 and 12 weeks closely followed by 0.34 cm under the same location while the least value of 0.30 cm was obtained in Ado at 4 weeks.

Table 2: Mean Values for Seedling Growth Variables in the Study Locations across the Assessment Period

Weeks	Mean Number of Leaves				Mean Seedling Height (cm)				Mean Collar Diameter (cm)			
	Ikere	Ayede	Igede-Isan	Ado	Ikere	Ayede	Igede-Isan	Ado	Ikere	Ayede	Igede-Isan	Ado
2	3.00	2.00	2.00	2.00	6.88	5.50	6.95	5.25	0.32	0.31	0.31	0.30
4	2.00	2.00	2.00	2.00	7.02	5.67	7.23	6.20	0.31	0.31	0.33	0.30
6	2.80^{a}	2.70^{a}	2.50^{ab}	2.00^{b}	7.68	6.35	8.10	6.30	0.31^{b}	0.31^{b}	0.34^{a}	0.31^{b}
8	3.00	3.00	3.00	3.00	8.03	6.73	8.23	6.40	0.31^{b}	0.31^{b}	0.34^{a}	0.33^{ab}
10	3.17	3.00	3.00	3.00	8.38	7.23	8.53	6.50	0.32	0.32	0.35	0.32
12	3.17	3.00	3.00	3.00	8.77	8.00	8.95	7.50	0.32	0.32	0.35	0.31

Rows without superscript did not indicate significance at that assessment period
Means with the same letter in each row are not significantly different at p 0.05

Some Soil Properties from the Study Locations

The results of the laboratory analysis of some soil properties of the study locations are shown in Table 3. When the soil textural diagram was used for sand, silt, and clay values of each location, it revealed that Ikere and Igede-Isan are loamy sand while Ayede and Ado have sandy soil. Also, the highest value for Nitrogen was obtained in Ado while the least was obtained in Igede-Isan soil. The result of pH in water revealed all the values across the locations being close to neutral although that of Ikere appeared slightly acidic with the others slightly alkaline.

Table 3: Results of Laboratory Analysis of some Soil Properties from the Study Locations

Locations	pH (H_2O)	Sand	Silt	Clay)	N	P	K	Org matter
	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}	g kg^{-1}
Ikere	6.80	89.4	4.4	6.2	0.81	12.07	0.12	15.34
Ayede	7.30	90.4	4.4	5.2	1.74	17.06	0.43	36.03
Igede-Isan	7.35	88.4	4.4	7.2	1.64	26.62	0.35	28.27
Ado	7.25	91.4	4.4	4.2	1.69	6.15	0.34	30.34

Discussion

Germination of *Chrysophyllum albidum* in the Soils of the Different Locations subjected to Different Pretreatments. The various pretreatments impacted the germination of *C. albidum* seeds differently. Scarification and cold water favoured the germination of *C. albidum* best whereas the result from the former appeared more consistent across

the locations. The untreated seeds (control) also germinated well giving above 50% germination in both Ikere and Ayede whereas hot water did not favour germination in all the locations. Aduradola *et al*. (2005) earlier reported that mechanical scarification enhanced germination in *C. albidum* seeds although their scarification method differed from the one adopted in this study. Similarly, Oyebade *et al.* (2012) used the mechanical method to overcome dormancy in *C. albidum* seeds and achieved between 21-53% germination although the description of the method used was not given. Hartmann *et al*. (1997) already defined scarification as any process of breaking, scratching, mechanically altering or softening the seed covering to improve the permeability of water and gases, and includes mechanical, chemical and hot water treatments. Therefore, irrespective of the way it is applied, the most important thing is for such a method to allow the imbibition of water and gases. Also, the fact that untreated seeds gave appreciable germination percentage in some locations in this study is similar to the result obtained by Olayode and Otufale (2018) who reported that freshly extracted seeds of *C. albidum* gave close to 100% germination and in a short time although watering frequency was controlled. However, Aduradola *et al*. (2005) reported that hot water treatment favoured the germination of *C. albidum* seeds. The fact that this result is different from of those obtained in this study could be a result of the exposure time which in this study is much longer than what they adopted. It has been opined that sudden dip of seeds in boiling water leads to changes and subsequent germination of the embryo however, it may be detrimental when in excess leading to the death of the embryo.

Seedling Growth Assessment of *C. albidum* in the Soil obtained from the Different Locations

The result of the statistical analysis for all the growth variables had shown that there was no significant difference in most of the weeks across all the locations. This might have been because the soil used from each location was collected at a similar depth from forest reserve that harbours plantation. The soils from the various locations must have had similar characteristics as revealed in their properties many of which were very similar. Forest soil usually gets impacted by the recycling of organic matter and nutrients, including wood, litter, debris, and wide varieties of soil-dwelling organisms even where such forests were not naturally forested (Boyle, 2005). Likewise, the observed minor differences in the seedling growth variables might have resulted from the fact that all the locations were subjected to similar anthropogenic activities such as annual burning, cropping, and grazing. Furthermore, the values obtained for the growth variables appeared small. This is similar to the result of Olayode and Otufale (2018) on *C. albidum* seedlings despite the variations in watering frequencies. Also, Oyebade *et al.* (2012) reported data transformation of seedling growth variables in *C. albidum* before analysis; this must have enhanced the figures documented for the seedling growth variables which seemed bigger than what was observed in this study.

Conclusion

This study had indicated that *C. albidum* can be raised in the two ecological zones of Ekiti State. Furthermore, seeds pretreated with scarification and cold water during the experiment gave the highest germination percentage and rate which makes them the best methods of breaking seed dormancy in *C. albidum*. Untreated seeds of *C. albidum* will also yield good germination if they are sown soon after extraction

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Comparative Assessment of the Avifauna Species Composition of the Beach Environment in Badagry-West Local Government, Lagos State.

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Abstract

Anthropogenic pressures and threats to coastal ecosystems are on the increase in this 21 century and can only be halted through strategic conservation planning. This study examined the comparative assessment of the avifauna species composition of the beach environment in Badagry west local government using standard methods. Avian species diversities were calculated using the Shannon diversity index. The result indicates that the highest bird species in the study area is found in Suntan beach (51), among the 24 families recorded, the Family Ardeidae has the highest number of bird species (17) enumerated while, the following families Acrocephalidae, Alaudidae, Bucerotidae, Coliidae, Corvidae, Falconidae, Hirundinidae, Jacanidae, Muscicapidae, Nectariniidae, Phalaciocoras africanus, Ziconotide, Sternidae, and Sturnidae each has one bird species as the lowest families recorded in the study area. The status of the bird species in the study sites, resident bird species (R) are the highest (71%), followed by the Palearctic (P) (24%) and the lowest is the Intra African Migrants (M) (5%). Habitat specialization indicates that the wetland area has the highest (Forty) bird species, followed by the Understory strata layer with (Nine) while the Tall Emergent layer has the lowest (Seven) bird species. Shannon -H Diversity indices of Bird Species in both Dry and Wet seasons individual bird species were higher (281) in the Dry season than the wet season (13) and Shannon-H diversity indicates that dry season was higher (3.575) than a wet season (3.238). This is also higher in with another parameter. In conclusion bird species were higher in the dry season (56) than the wet season (39). The study provided a quantitative description of beach ecosystems in the study areas from which future ecological changes may be assessed, and it documented differences that exist between beaches in Badagry west local government, Lagos State

Keywords: Assessment, avifauna, Shannon diversity index, counting station, habitat, ecosystem,

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Introduction

Coastal zone wetland areas are among the most threatened landscape features in the arid Middle Eastern countries. Wildlife-rich habitats such as intertidal lagoons and mangroves are spatially scarce and poorly studied. Stamatis Z. and Athanasios K. (2016). In several rapidly developing areas in this region, human-induced pressures seem to especially stress coastal zone habitats (Richer, 2009). Qatar is a good example of a country where industrial and housing development is occurring at an unprecedented rate along the coast, and biodiversity surveys are scarce and seldom systematically

updated (Richer,2009, GSDP, 2009). The human population has boomed after industrial oil production, and landscape conservation awareness has only recently begun to influence protected-area policies (Richer, 2009, Sillitoe *et al.*, 2010). Anthropogenic pressures and threats to coastal ecosystems can only be rationally managed through strategic conservation planning, immediate site protection, and conservation measures. Biodiversity should be given utmost consideration, and certain indicator species groups, such as birds, may provide useful, practical guidelines for conservation planning (Bibby *et al.* 1998).

In areas lacking organized biodiversity inventories, rapid assessment procedures using birds can build biodiversity knowledge baselines (Bibby *et al.* 1998). In our case study, we conducted a rapid assessment of bird numbers and their habitat use in different habitat types during spring migration at Fuwairit, a small intertidal inlet system in Northern Qatar. To best depict bird habitat, use and preliminarily assess relevant biodiversity patterns, analyses were made at three levels of organization: habitat-based bird assemblage, food-centered ecological guild, and species residence status. It could be very essential to recognize the variety and structure of bird groups to explain the significance of local or neighborhood landscapes for avian conservation. Also, assessment of bird community has come to be an important device in biodiversity conservation for figuring out conservation actions in regions of excessive human pressure (Kremen, 1992; Safiq et al., 1997).

Most of the birds are aesthetically substantial to mankind and Bird-watching has become one of the most famous recreational sports across the world(Kronenberg, 2014; and has direct and indirect economic advantages through numerous resident programs regarding bird-watchers(Greenwood, 2007). Sekercioglu, C. (2002).

Birds recording performs massive roles in offering the baseline facts regarding the distribution of a selected species in a specific region and also provide useful information for identifying priority regions for conservation (Triviño et al. 2018). The diversity of birds is one of the most important ecological indicators to assess changes in the habitat, (Manjunath and Joshi, 2012). Birds are also the critical animal institutions of an atmosphere and numerous bird species maintain a nutrient level through their foraging ecology. Due to each herbal and anthropogenic disturbance inclusive of floods, drought, deforestation, change in land use, herbal resources, and seasonal climatic changes, the global diversity of birds is reducing continually (Chen et al., 2011). Although, habitat destruction is considered one of the main purposes of decreasing in chicken population. Most of the birds require specific habitats from season to season for nesting, foraging, roosting, and loss of such habitats may cause their extinction (Chaudharfi-Pachpande and Pejaver, 2016). Habitat alteration and indiscriminate destruction of herbal habitats by cutting off nesting trees and foraging plants are the foremost factors accountable for restriction in avian habitats. Sewell, S. R., and Catterall, C. P. (1998).

Numerous ornithological studies on diversity, and its status, have been carried out in different areas in Nigeria. .Taiwo, et al, (2011) recorded 10,180 individual birds that belong to 123 species and 51 families in Yankari Game Reserve wetlands. Out of the total number of species, 32 bird species belong to waterbirds and 91 bird species belong to terrestrial birds. Okosodo, et al, (2018) reported a total of sixteen (16) Ciconiiformes species belonging to three (4) families recorded in the Badagary creek of Lagos state. They recorded the following families *Ardeidae, Ciconiidae, Thresthiornithidae,* and *Scopidae*. Odewumi, (2017) recorded a total of 35 bird species belonging to 20 families and 10 orders were identified and recorded in Owena Multipurpose Dam, Ondo State, Southwest, Nigeria. Chapman, (2011) recorded 47 bird species belonging to 21 families and 10 orders in the fragmented deltaic formation located in the River Niger Delta and 80% of the bird species enumerated were of mangrove forest of the coastal environment

Badagry falls into the ecological zone of wetland soils and lies on the coast where inland water empties into the Atlantic Ocean. It has a geologic origin of deltaic basis and tidal flats (FADAMA, 2011). It is blessed with many Tourists attractions such as the slave trade zone, the first school in Nigeria, the first storey building and so on, The aim of this study, therefore, is to evaluate the species composition, relative abundance, and distribution of avifauna of the beach environment in Badagry west local government.

Materials and Method

Study area

Badagry is a coastal town and Local Government Area (LGA) in Lagos State, Nigeria. It is situated between the city of Lagos and the border with Benin

at Seme. As of the preliminary 2006 census results, the municipality had a population of 241,093 (Federal Republic of Nigeria Official Gazette, 2007). The study areas selected in Lagos lie between 6 °46" N and 2 °23" E with an elevation of about 19ft at Badagry.

Badagry falls into the ecological zone of wetland soils and lies on the coast where inland water empties into the Atlantic Ocean. It has a geologic origin of deltaic basis and tidal flats (FADAMA, 2011). The natural vegetation is mangrove. The floras of the area consist of Rhizophora mangle and *Rhizophora racemosa* (otherwise referred to as red mangrove and black mangrove respectively). These two species are strongly zoned, with the former occupying areas closer to the water while the latter are in the upper reaches. Other species occurring to a lesser extent *include Avicennia Africana, Laguncularia racemosa*; plus, the palms Prodococcu water and *Ancistrophylum opacum.*

Fig. 1 Map of Badagry Greek area

Source: Lawson, *et al.,* (2010).

Method

The point count method as used by Okosodo *et al.,* (2016) was used. In this method counting stations or predefined spots were established in roosting sites, wetland and feeding sites as well as forest edges. Counting bands of 50 m radius were used for all the stations. The minimum distance between the two counting stations was 200 m. The number of counting stations was determined by the site size. On arrival at the sites, birds were allowed time to settle before recording all the birds seen or heard for a predetermined time (20 minutes). Bird calls were also recorded with a voice recorder and played back later for confirmation. Physical features of birds sighted but could not be identified immediately were taken and field guidebook of West African birds (Burrow and Demey, 2013) was used to identify the bird species within the study sites. Data on each site were collected for six months (3 months in the wet seasons and 3 months in the dry season from June 2016 to December 2017) on 8 days per month and twice a day from 07.00 – 10.00 hours and 16.00 – 18.00 hours. Bird species identified were categorized according to Burrow and Demey (2013) as follows:

R= resident;

M= intra-African migrant;

P= Palearctic migrant and

V= vagrant

These were derived from the seasonal occurrence of these birds in the study areas. Birds sighted in the wet season and not seen in the dry season as compared with a range map of West Africa birds guide as documented by (Burrow and Demey 2013).

Data analysis

From the data collected, avian species diversity was calculated using the Shannon diversity index, (Usher, 1991) which is given as:

$$Hi = Pi\ ln\ Pi$$

Where: Hi = diversity index

Pi = is the proportion of the ith species in the sample

InPi = is the natural logarithm of the species proportion.

Result

Birds Species composition of the Study Area

A total of fifty-six bird species belonging to 24 families and 10 orders were enumerated in the study areas with order Pelicaniformes having the highest order in the study areas. Fig. 2 below indicates the number of bird species that occurred in each study site. The highest bird species occurred in Suntan beach (51) while Asakpo beach has the lowest bird species recorded (44).

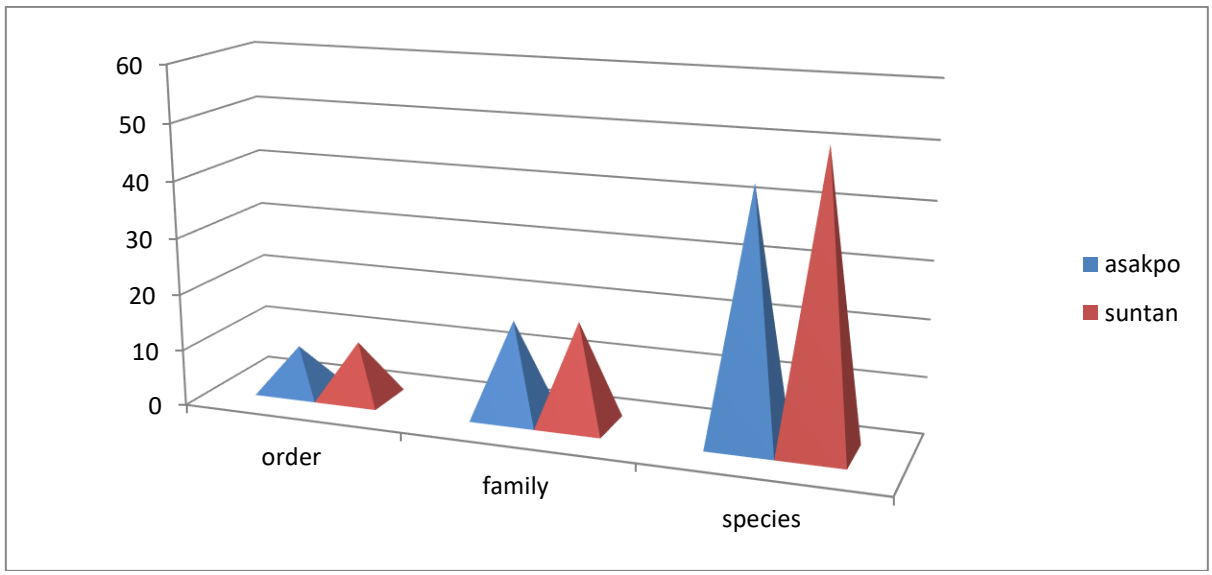

Fig 2: Number of bird species that occurred in each study site.

Source: Field Survey 2018

Family composition of Bird Species in the Study Areas

A total of 24 families were recorded in the two selected sites (Fig. 3). The Family Ardeidae has the highest number of bird species (17) enumerated while the following families Acrocephalidae, Alaudidae, Bucerotidae, Coliidae, Corvidae, Falconidae, Hirundinidae, Jacanidae, Muscicapidae, Nectariniidae, *Phalaciocoras africanus*, Ziconotide, Sternidae, and Sturnidae each has one bird species as the lowest families recorded in the study area.

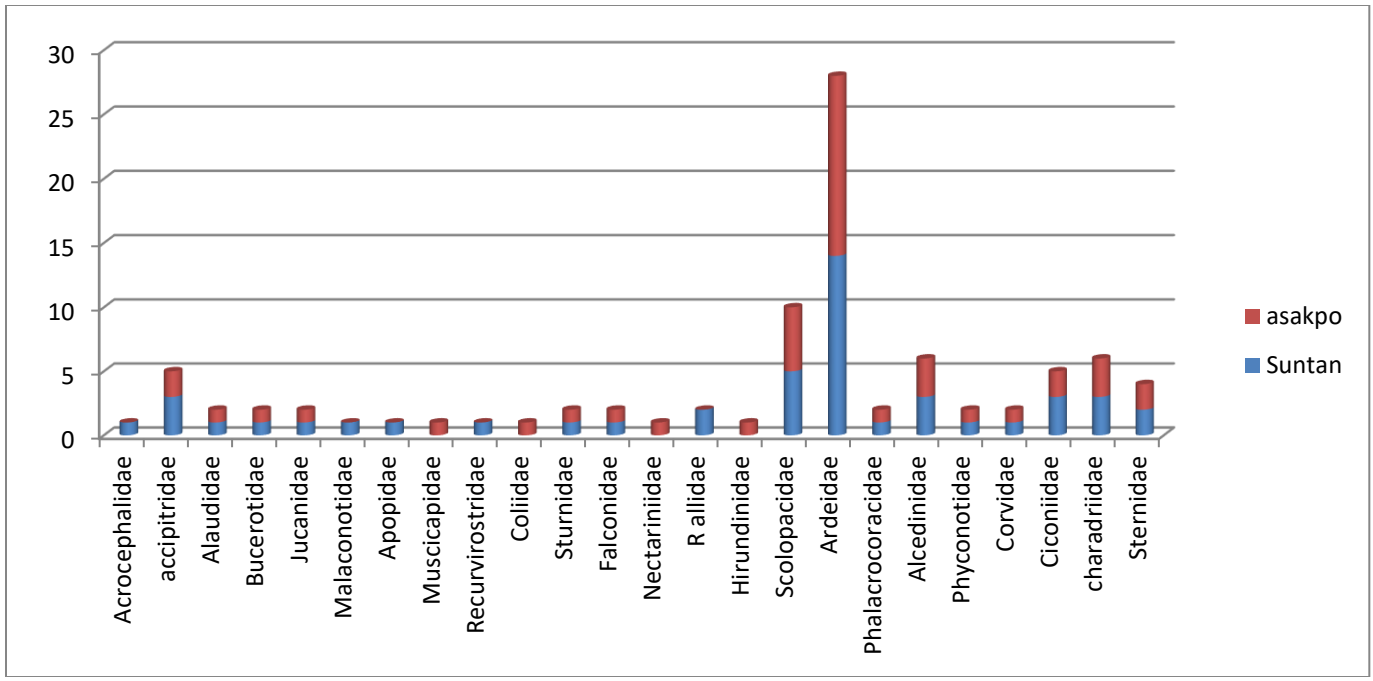

Fig 3 Bird Species Family composition in the Study Areas
Source: Field Survey 2018

The status of the bird species in the study sites

The status of the bird species in the study sites indicates that they are in different categories as Shown in Figure 4 Resident bird species are the highest (71%), followed by the Palearctic (24%) and the lowest in the Intra African Migrants (5%).

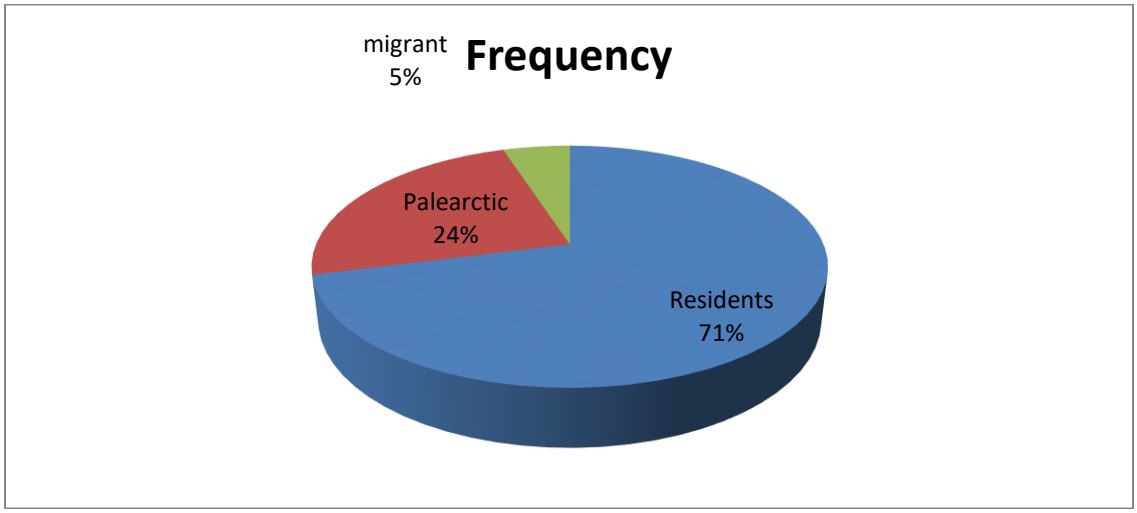

Fig. 4: **Status of the Bird species in the study sites**

Habitat specialization of Bird species in the Study Areas

Habitat specialization in the study Areas indicates that the wetland area has the highest bird species of (40), this is followed by Understory strata layer with (9) bird species while the Tall Emergent layer has the lowest bird species of (7).

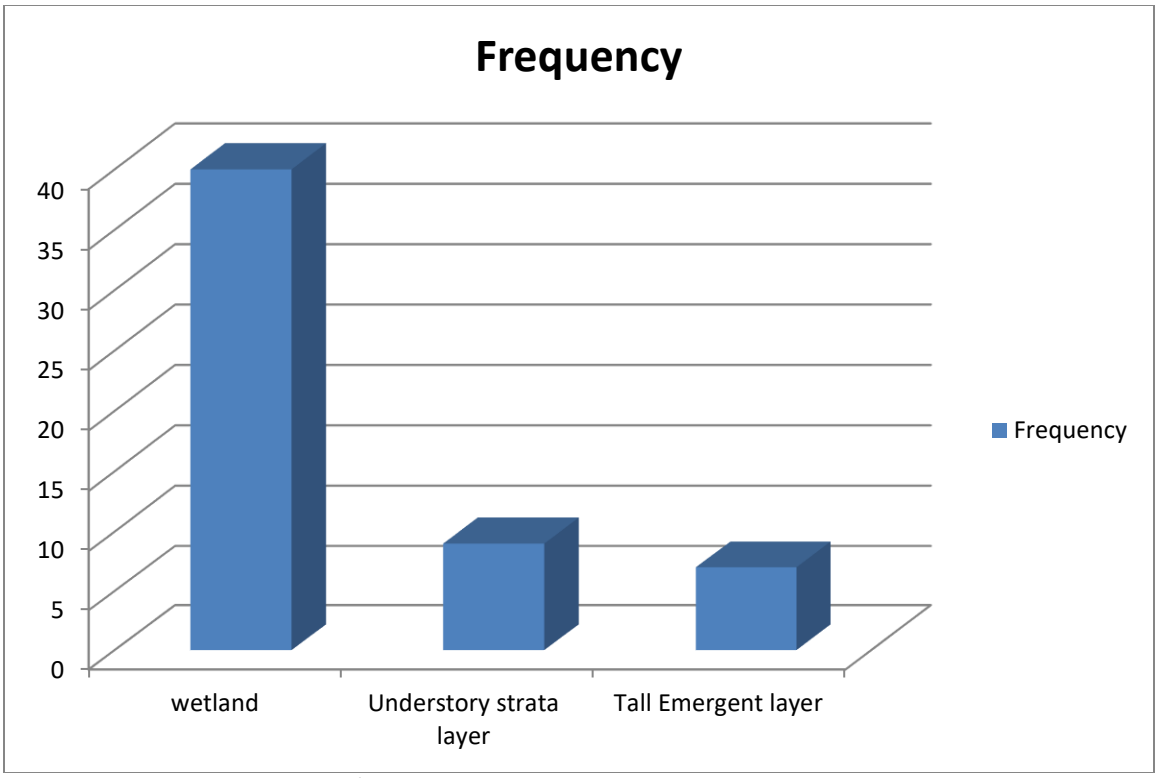

Fig. 5: Habitat Specialization of Bird Species in the Study area

Source: Field survey 2018

Shannon –H Diversity indices of Bird Species in both Dry and Wet seasons.

The Taxa of bird species in the Study Areas indicates that bird species were higher in the dry season (56) than the wet season (39). The result indicates that individual bird species were higher (281) in the Dry season than the wet season (13). Shannon-H diversity indicates that dry season was higher (3.575) than a wet season (3.238). This is also higher in with other parameters

Table 1:**Shannon –H Diversity indices of Bird Species in both Dry and Wet seasons.**

Diversity Index	Dry Season	Wet season
Taxa_S	56	39
Individuals	231	131
Dominance_D	0.04661	0.06148
Shannon_H	3.575	3.238
Evenness_e^H/S	0.6376	0.6537
Menhinick	3.685	3.407

Discussion

A total of fifty-six bird species belonging to 24 families and 10 Orders were enumerated in the study areas and most bird species enumerated are species that utilized mangrove and freshwater swamps in the coastal areas. Examples of such species are Common Tern (*Sterna hirundo),* Common Snipe (*Gallinago gallinago*), Common Sandpiper (*Actitis hypoleucos*), Black Headed Heron (*Ardea melanocephala*) and Black Heron (*Egretta ardesiaca*) and others. This finding is consistent with Zakaria et al, (2009) reported that wetland bird species are adapted to a semi-aquatic life, being important components of aquatic ecosystems. He further stated that they spend their lives around water that provides food which consists of insects, worms, snails, amphibians, toads, lizards, snakes, mice, and

fish (Okosodo and Kolawole, (2018) reported that wetlands are known for their abundance of birds. He further stated that the use of wetlands and their resources is widespread among many diverse bird taxa of the world, avian adaptation to utilize wetlands, and other aquatic systems are diverse and include anatomical, morphological, and behavioral changes. This finding is consistent with Taiwo, et al, (2011) who recorded 10,180 individual birds that belong to 123 species and 51 families in Yankari Game Reserve wetlands. Out of the total number of species, 32 bird species belong to waterbirds (4673 detections; 26.83%) and 91 bird species belong to terrestrial birds (5507 detections; 73.12%). Okosodo, et al, (2018) who reported a total of sixteen (16) Ciconiiformes species belonging to three (4) families recorded in the Badagary creek of Lagos state. They recorded the following families *Ardeidae, Ciconiidae, Thresthiornithidae,* and *Scopidae* which are similar to those recorded in this research study. Odewumi, (2017) recorded a total of 35 bird species belonging to 20 families and 10 orders were identified and recorded in Owena Multipurpose Dam, Ondo State, Southwest, Nigeria. The common species they encountered includes Great egret (*Ardea alba*), Spur-winged lapwing (*Vanellus spinosus*), Grey heron (*Ardea cinerea),* Great cormorant (*Phalacrocorax carbo*), Black Kite (*Milvus migrans*), Squacco heron (*Ardeola ralloides*), African jacana (*Actophilornis africanus),* Long-Tailed Cormorant *(Microcarbo africanus)* and Cattle egret *(Bubulcus ibis)* which are similarly recorded in the coastal area of Lagos state. Chapman, (2011) recorded 47 bird species belonging to 21 families and 10 orders in the fragmented deltaic formation located in the River Niger Delta and 80% of the bird species enumerated were of mangrove forest of coastal environment The result of Shannon-H diversity indicates that dry season was higher (3.575) than a wet season (3.238) these findings are supported by Okosodo, et al, (2018) who reported that the Shannon-H diversity for *Ciconiiformes* species was higher in the wet season (2.257) was higher than the dry season (2.153). The finding in this research study is also supported by these authors. MacArthur (2001) reported that diversity increases with the number of layers in the vegetation. Pearson (2001) reported that tropical wet evergreen forests support more rare bird species than other habitats. Manu (2000) reported that birds select vegetation variables according to how an individual habitat affects access to food, mates, or vulnerability to predators. The result of the habitat specialization indicates that most of the bird species were hydrophanous species. This finding is consistent with Zakaria et al. (2010) who reported that wetland bird species are adapted to a semi-aquatic life, being important components of aquatic ecosystems. He further stated that they spend their lives around water that provides food which consists of insects, worms, snails, amphibians, toads, lizards, snakes, mice, and fish. Ezealor, (2002) reported that wetlands are known for their abundance of birds. He stated further that the use of wetlands and their resources is widespread among many diverse bird taxa of the world, avian adaptation to utilize wetlands, and other aquatic systems are diverse and include anatomical, morphological, and behavioral changes. Anatomically, they include designs for diving and swimming, such as body compression to increase gravity, or adaptation for plunge-diving from great heights.

Most bird species were encountered in areas with a higher percentage of tree density increase than the ground cover. This observation indicated that some wetland birds used the trees as a roosting site. This was observed with some species such as the Egrets, Ibises, Herons, and Storks. These species were found during the survey on the bare ground feeding on the mudflats fish and another vertebrate. These findings are supported by (Huston 2011) who reported that habitat has long been used as a predictor of bird species abundance, and each variety of birds has developed different preferences for habitat. Also agrees with (Cody, 1999) who reported that birds select vegetation variables according to how an individual habitat affects access to food, mates, or its vulnerability to predators This observation also suggests that the wetland bird species may be affected by quality and quantity of food. Vegetarian birds (folivores) like white-faced whistling duck will be affected by the quality of the vegetation as it was observed during this study. Birds were found on the vegetation on the water, observed during the study, also the spur-winged lapwing found on the lakeshore scattered. The jacanas were observed in the vegetated part of the lake in the three sites and the same for the lily trotters. The bird species found in wetlands need specific areas to carry out reproductive activities especially nesting sites (Hansen et al., 2008). This also supported (Moorcroft, et al, 2006) in his research that the

species composition of a specific area is inter-linked to the available resources in the area which includes physical structures of the habitat, food availability, and biotic factors.

Conclusion

The study provided a quantitative description of beach ecosystems in the study areas from which future ecological changes may be assessed, and it documented differences that exist between beaches in Badagry west local government, Lagos State

Recommendation

Human activities such as deforestation, soil excavation, industrialization, and human settlement should be logically planned so as not to affect the flora and fauna in the coastal areas where the beaches are located. These resources must be managed sustainably by always protecting ecological integrity. Coastal development and management plans should be adopted to ensure the protection of the ecosystem. There are needs for initiation of education and awareness programme targeted at children and the youth, stressing the direct and indirect values of beach tourism and the scientific basis of traditional conservation method at protecting the beaches ecosystem

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Heavy Metals Concentration in African Mud Catfish (*Clarias gariepinus*) and Obscure Snakehead (*Parachanna obscura*) from River Ogbese, Ondo State, Nigeria

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Abstract

Wastes from domestic, industrial, and other anthropogenic activities are sources of heavy metal pollution in aquatic environments. Heavy metals contamination has been a source of concern because of the devastating effects on the ecological balance of the aquatic environment and the diversity of organisms, especially fish which bioaccumulate them in their muscles causing pituitary damage, testicular degeneration and decrease in offsprings and extinction of fish stocks. This study assessed the concentrations of heavy metals in the head, trunk, and tail regions of African mud catfish (*Clarias gariepinus*) and obscure snakehead (*Parachanna obscura*) collected from River Ogbese, Ondo State using standard methods. The results show that the head portions of the two fish species contained the highest concentrations of the heavy metals which differed significantly from the fish trunks while the tails contained the least amounts. The heavy metal concentrations in the head portions were 8.02 ± 1.32, 30.19 ± 2.63, 7.39 ± 1.02 and 68.45 ± 3.24 mg g^{-1} in *C. gariepinus* and 2.02 ± 0.12, 11.85 ± 1.55, 9.09 ± 1.99 and 108.45 ± 5.85 mg g^{-1} in *P. obscura* for Cu, Zn, Pb, and Fe respectively. In the head and trunk regions, *P. obscura* (carnivore) bioaccumulated heavy metal than *C. gariepinus* (omnivore) fish. The variations were significant ($P<0.05$) among the fish samples except in the tail parts of *P. obscura* with the variation not significant ($P>0.05$) due to low concentrations of the heavy metals in the region. *C. gariepinus* tail revealed low concentration as well. The heavy metals levels were in the order head > trunk > tail in the fish samples. The range of values was slightly above permissible / recommended limit in *C. gariepinus* except for Cu and Zn which had non-significant values for head and tail regions. Cu was higher in *C. gariepinus* than in *P. obscura,* sediment, and water. Hence, the result obtained indicated bioaccumulation of heavy metals can be aided by feeding habits and environmental conditions. The *P. obscura* and *C. gariepinus* are likely to be exposed to pollutants from anthropogenic substances as indicated by the bioaccumulation level of heavy metals on the fish samples from the environment, therefore, there is need for surveillance to safe guide fish and environment for healthy fish food for consumers.

Keywords: Heavy metals, River Ogbese, *Clarias gariepinus, Parachanna obscura*

Cite as: Abidemi-Iromini A.O (2019). Heavy Metals Concentration in Tissues of Adult African Mud Catfish (*Clarias gariepinus*) and Obscure Snakehead (*Parachanna obscura)* from River Ogbese, Ondo State, Nigeria. *Journal of Researches in Agricultural Sciences.* Vol. 7(1): 76-83

Introduction

The contamination of aquatic environments with pollutants from domestic, industrial, and other man-caused activities has become a matter of concern (Adamu *et al.,* 2015). Heavy metal contamination may have devastating effects on the ecological balance of the recipient environment and a diversity

of aquatic organisms, especially fish which are notorious for the ability to bioaccumulate heavy metals in their muscles and tissues (Ahmed *et al.*, 2015a). The heavy metal bioaccumulation is largely attributed to differences in uptake and depuration period for various metals in different fish species (Erhunmwunse *et al.*, 2013). The heavy metals cause pituitary damage, testicular degeneration, and decrease in fry numbers (Zaki *et al.,* 2015). Also, the exposure of fish to heavy metals could exert deleterious effects on the reproductive organs leading to a decline in the number of offspring and hence to the eventual extinction of fish stocks.

Fish species play important roles in human nutrition and are widely used to evaluate the health of the aquatic ecosystem because pollutants build up in the food chain being responsible for adverse effects and death in the aquatic ecosystem (Bai *et al.,* 2011). The aquatic environments are exposed to varying levels of pollutants and accumulation of heavy metals in aquatic organisms can pose a long-lasting effect on biogeochemical cycling in the ecosphere (Hayat *et al.,* 2007). Therefore, it is imperative to investigate the fish of economic importance to know the status of the environment. African mudfish (*Clarias gariepinus*) and Obscure snakehead (*Parachanna obscura*) are fish species of economic importance in the freshwater environment in Nigeria. The objective of this study is to determine the concentrations of heavy metals: iron (Fe), lead (Pb), copper (Cu) and zinc (Zn) in the tissue of *Parachanna obscura* and *Clarias gariepinus* in River Ogbese, Ondo State, Nigeria.

Materials and Methods

Study area

The study was carried out in River Ogbese, Ondo State, Nigeria. River Ogbese is one of the major perennial rivers in south Western Nigeria, runs through Ogbese town, and lies between longitude 5°26′E and latitude 6°43′N (Olawusi-Peters *et al.*, 2014).

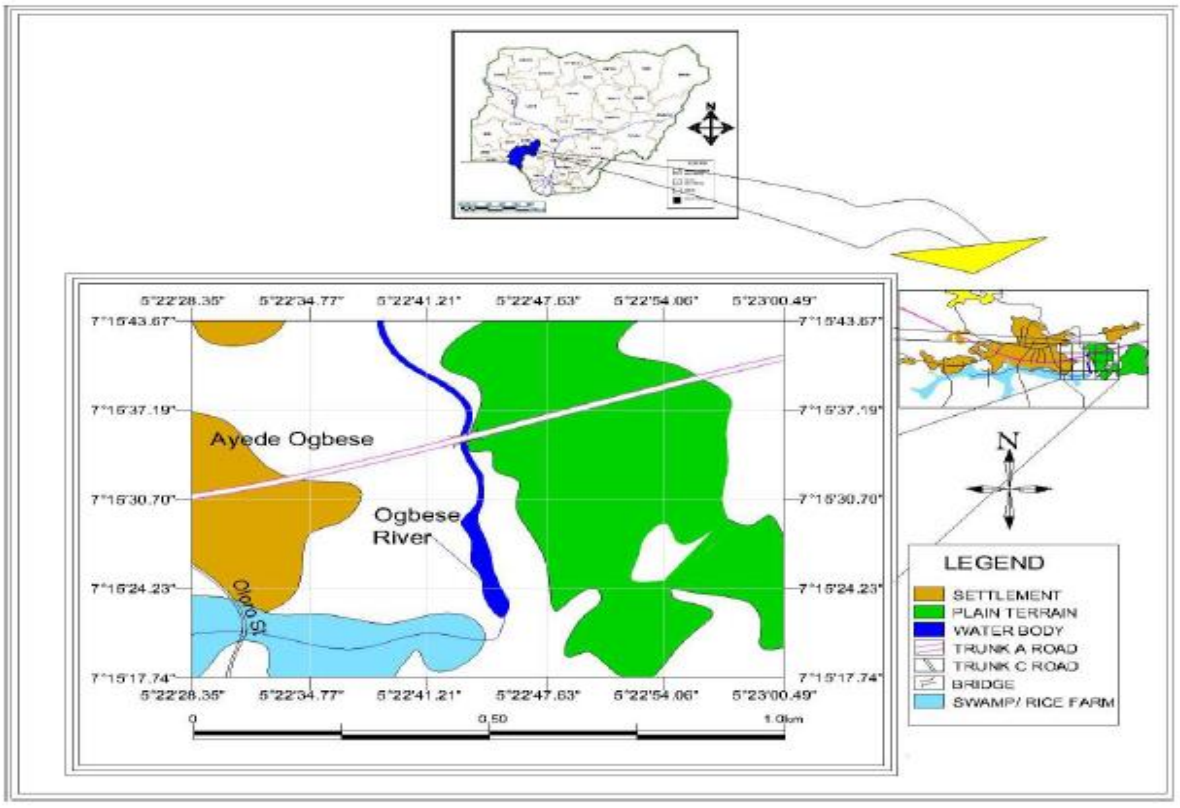

Fig. 1: Map of River Ogbese

Collection of samples

Thirty (30) *Clarias gariepinus* and 30 *Parachanna obscura* fish species were randomly collected by the

assistance of fishermen from River Ogbese and transported to the laboratory for heavy metal determination. Water samples were collected at 10 cm depth within River Ogbese while sediments of the river were collected using a grab.

Measurements of fish: The lengths (cm) of the fish species were measured using graduated ruler and weights (g) of the fish species measured using Mettler Toledo sensitive electronic weighing balance (Model: PBS001).

Determination of heavy metals in *Clarias gariepinus* and *Parachanna obscura*

The fish samples (divided into head, trunk and tail) and soil samples were oven-dried, weighed into crucible and heated in muffle furnace for two hours at 750 C and milled. 5 g of the milled samples were weighed into 100 ml beaker, 15 m1 freshly prepared mixture of nitric acid/hydrogen peroxide at 1:1 ratio added to each sample, covered with wash glass and allowed to stand for 30 minutes during which initial reaction subsided. The fish, soil and water samples were digested on hot plate with gradual increase in temperature to a maximum of 160 C in a fume cupboard for 2 hours to evaporate and reduce in volume. The beakers and contents were air cooled and the content filtered into 50 m1 volumetric flask and made up to mark with distilled water (AOAC, 2005). The samples were analyzed for Pb, Zn, Cu and Fe using Buck 211 Model atomic absorption spectrophotometer with aqueous calibration standard prepared from the stock standard solutions of the respective elements.

Percentage metal Concentration of Fe, Pb, Cu and Zn heavy metals determined respectively in sediment, water and fish species (*P. obscura* and *C. gariepinus*) were carried out using the formula:

$$\% \text{ Metal Concentration Index (MCI)} = \frac{\text{Metal concentration value (mg/g)}}{\text{Total Metals concentration Values ((mg/g)}} \times 100$$

Statistical analysis

The data were analyzed with descriptive statistics of means and standard error at $P < 0.05$; and significance among samples was determined using Duncan's Multiple Range Test in to SPSS Statistics package 18th edition.

Results

The mean lengths and weights of the two fish species collected from River Ogbese are shown in Table 1. The lengths of *C. gariepinus* ranged from 12.26 to 18.41 cm while *P. obscura* was 14.47-21.22 cm long with the means at 14.7±2.55 and 17.05±3.04 cm respectively. The weight of *C. gariepinus* was 234.14-382.85 g and *P. obscura* ranged from 313.46 to 456.38 g with mean values of 260±73.54 and 348±93.34 g respectively.

Table 1: Means and standard deviations of length (cm) and weight (g) of *C. gariepinus* and *P. obscura*

Fish Species	No of samples	Mean ± SD Length (cm)	Mean ± SD Weight (g)
Clarias gariepinus	30	14.7 ± 2. 55	260 ± 73.54
Parachanna obscura	30	17.05 ± 3.04	348 ± 93.34

The heavy metals contained in the head, trunk and tail portions of *Clarias gariepinus* and *Parachanna obscura* are shown in Table 2. The head portions of the two fish species contained the highest concentrations of the heavy metals which differed significantly from the fish trunks while the tails contained the least amounts. In *C. gariepinus*, the highest concentrations of the head portion were 8.02 1.32, 30.19 0.63, 7.39 1.02 and 68.45 0.24 mg g^{-1} of Cu, Zn, Pb and Fe respectively. The trunk followed the head for every heavy metal and differed significantly with the tail portion except the Cu content. The heavy metal content followed the same trend in *P. obscura* with the highest values of Cu, Zn, Pb and Fe at 2.02 0.12, 11.85 1.55, 9.09 1.99 and 108.45 1.85 mg g^{-1} respectively in the head portion. The slight variations in the trend of

concentrations are: similar values of Zn in the head and trunk; Pb in the trunk and tail did not differ while Cu content was not different in the fish parts.

Table 2: Mean Concentrations of Heavy Metals in *C. gariepinus* and *P. obscura*

	Heavy Metals (mg g^{-1})			
Fish Parts	Fe	Pb	Cu	Zn
Clarias gariepinus				
Head	68.45 ± 0.24a	7.39 ± 1.02a	8.02 ± 1.32a	30.19 ± 0.63a
Trunk	26.05 ± 1.04b	3.32 ± 0.32b	4.22 ± 2.82b	11.99 ± 1.05b
Tail	3.01 ± 0.98c	2.82 ± 1.62b	0.85 ± 0.15c	3.64 ± 0.52c
Parachanna obscura				
Head	108.45 ± 1.85a	9.09 ± 1.99a	2.02 ± 0.12a	10.69 ± 1.49a
Trunk	86.05 ± 3.96b	4.86 ± 3.79b	0.92 ± 0.48a	11.85 ± 1.55a
Tail	3.01 ± 0.98c	2.82 ± 1.62b	1.25 ± 0.45a	3.64 ± 0.52b
Permissible limits	146.00 mg g^{-1} (IAEA-407 (Wyse *et al.,* 2003))	0.12 mg g^{-1} (IAEA-407 (Wyse *et al.,* 2003))	3.28 mg g^{-1} (IAEA-407 (Wyse *et al.,* 2003) 0.03 mg g^{-1} (Khayazadeh and Abbasi, 2010)	3.00 mg g^{-1} (WHO, 2003)

The heavy metals concentrations in whole fish species samples, sediments and water are shown Table 3. The highest heavy metal in *P. obscura* was Fe (65.84±3.59 mg g^{-1}) and followed by Zn (26.18±3.56 mg g^{-1}). The concentrations of Fe, Zn and Pb (5.59±2.47 mg g^{-1}) were higher in *P. obscura* than in *C. gariepinus* samples which contained more Cu (4.36±1.43 mg g^{-1}). The heavy metal concentrations were higher in the sediments than in the water samples. The highest heavy metal in the sediments and water samples was Fe (152.57±6.34; 5.65±1.28 mg g^{-1} respectively) followed by Zn (1.47±0.08 and 0.14±0.04 mg g^{-1} in the sediments and surface water samples respectively) while Cu was least.

Relationship and contributions of the environment to heavy metals accumulation in fish from River Ogbese was determined and results were indicated in Figure 2. Which shows the comparative levels of heavy metals in the fish, sediment and water samples collected.

Table 3: Mean Heavy Metals Concentrations in Whole Fish, Sediments and Water samples from River Ogbese Compared to Recommended Limits

Heavy metals (mg g^{-1})	*Clarias gariepinus*	*Parachanna obscura*	Ogbese Water	Ogbese Sediments	Recommended limits*
Fe	32.5±0.28c	65.84±3.59b	5.65±1.28d	152.57±6.34a	146.00 mg g^{-1} (IAEA-407 (Wyse *et al.,* 2003))
Pb	4.51±1.24b	5.59±2.47a	0.12±0.02c	0.15±0.04c	0.12 mg g^{-1} (IAEA-407 (Wyse *et al.,* 2003))
Cu	4.36±1.43a	3.00±0.21b	0.04±0.00d	0.11±0.01c	3.28 mg g^{-1} (IAEA-407 (Wyse *et al.,* 2003)) 0.03 mg g^{-1} (Khayazadeh and Abbasi, 2010)
Zn	15.57±2.26	26.18±3.56	0.15±0.04	1.47±0.08	3.00 mg g^{-1} (WHO, 2003)

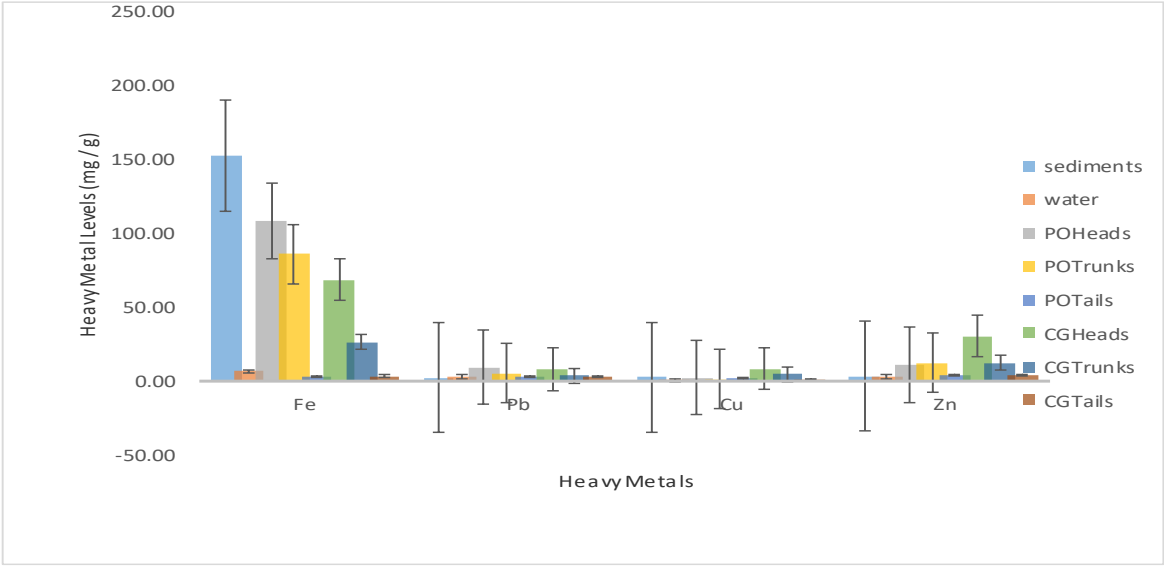

Figure 2: Mean heavy metal levels in fish parts, water and sediments samples collected from River Ogbese
PO: *Parachanna obscura*, CG: *Clarias gariepinus*

The percentage concentration of Zn, Cu, Pb, and Fe heavy metals determined respectively in sediment, water and fish parts (Head, Trunks and Tail) of *P. Obscura* and *C. gariepinus* samples is shown in Figure 3. The highest-ranking heavy metal was Fe>Zn>Pb>Cu.

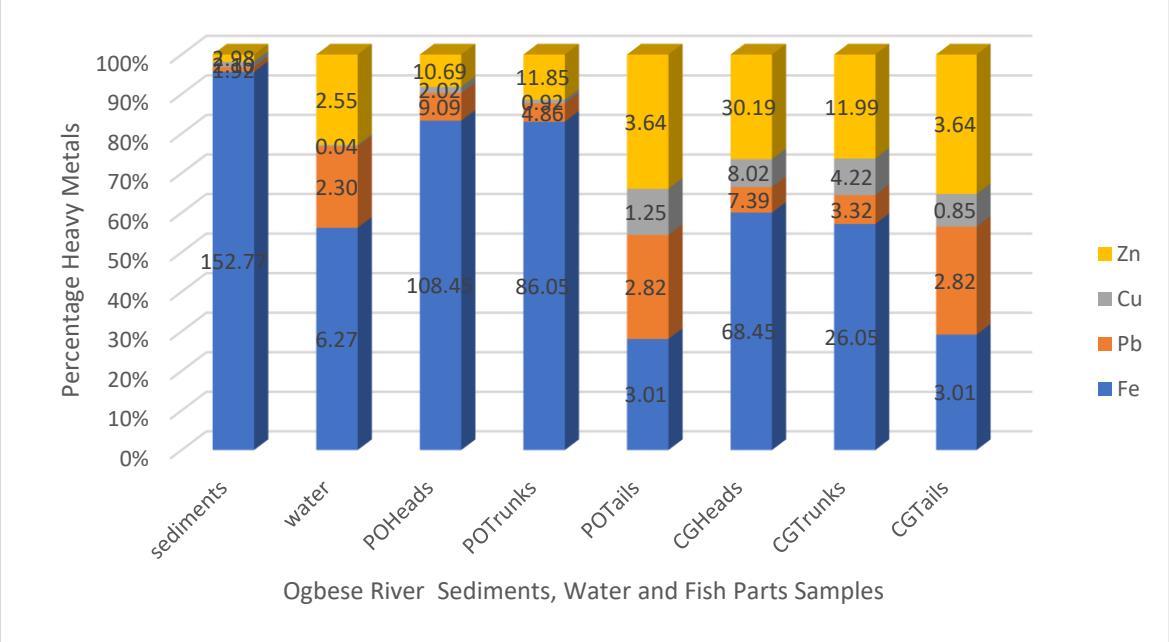

Figure. 3: Percentage heavy metal in fish, water and sediments samples from River Ogbese

Comparative description of heavy metals determination in *C. gariepinus and P. obscura* is revealed by the mean concentrations of the heavy metals (Figure 4). The heavy metals determined in *P. obscura* are higher than in *C. gariepinus* samples except Cu which had a slightly lower concentration.

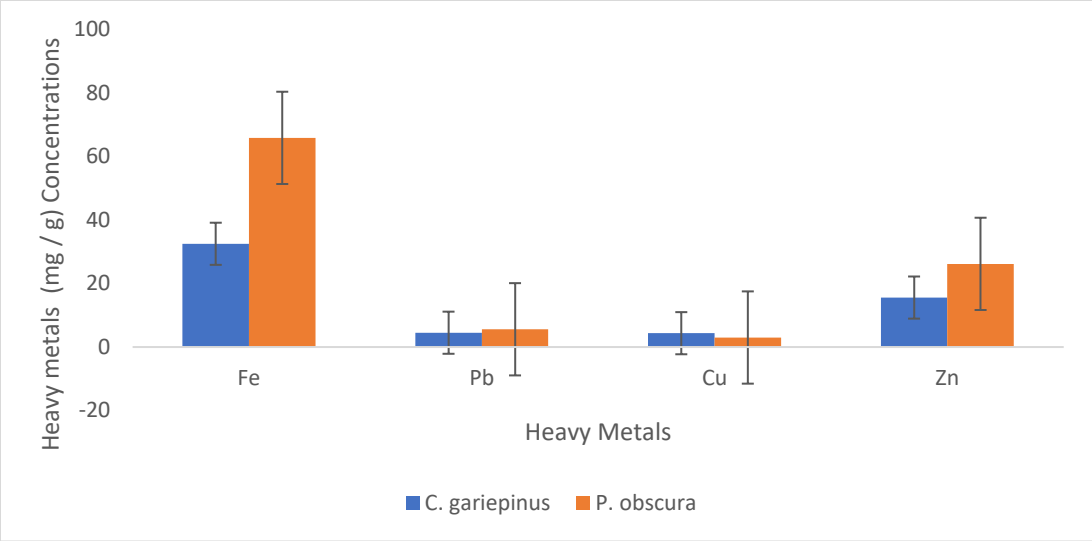

Fig. 4: Comparative description of heavy metals determination in *C. gariepinus and P. obscura*

Discussion

The heavy metals varied among the fish parts and between fish species from River Ogbese. The variations were significant (P<0.05) among the fish samples except in the tail parts of *P. obscura* with variation not significant (P>0.05) due to low concentrations of the heavy metals at the region. *C. gariepinus* tail has low heavy metal concentration as well. The heavy metals levels were in the order head > trunk > tail in the fish samples. The range of values were slightly above permissible / recommended limit (WHO, 2003, Wyse *et al.,* 2003) in *C. gariepinus* except for Cu and Zn which had non-significant values for head and tail regions.

Cu was higher in *C. gariepinus* than in *P. obscura,* sediment and water; and this corroborated with the work of Babatunde *et. al.,* (2012) who reported *C. gariepinus,*an omnivorous fish had higher Cu than *P. obscura* which is carnivorous. High concentration of copper can alter haematology (James *et al.,* 2008); respiratory and cardiac physiology (Sorensen, 1991). Iron (Fe) ranked highest in the sediment, followed by the head and trunk of *P. obscura*, water; *C. gariepinus* head and truck. It is low with no significant difference (P <0.05) in tails of *P. obscura* and *C. gariepinus*; and it ranked lower than permissible limit in head, trunk and tail of the fish species. Fe is essential for production of hemoglobin, myoglobin and its deficiency can cause anemia (Anderson and Fitzgerald, 2010) while excess Fe in biological tissues causes rapid increase in pulse rate and coagulation of blood in blood vessels, hypertension and drowsiness; this is implicative on state of well-being and haematology of fish to stress conditions (Davies *et al.,* 2006).

Zinc (Zn) accumulations in samples were higher than the permissible limit. Highest concentration recorded in *C. gariepinus* head is indicative of the benthic nature of the fish and is supported by the feeding habit of the fish as stated by Arvind *et. al.,* (2002) and Amiard *et. al.,* (2006); indicated pollution from the environment. Limit toxicity may be characterized by symptoms of irritability, muscular stiffness and pain, loss of appetite, and nausea (Jeyaraj *et al.*, 2016); and bioaccumulation of zinc result in decreased plasma protein, it affects tissue respiration leading to death by hypoxia, (Kori- Siakpere *et. al.,* 2005).

Lead (Pb) was lowest in sediment and higher in water than sediment. Pb was highest in P. obscura head than *C.gariepinus*; and the result is in line with the work of Hashim *et. al.*, 2014 and Babatunde *et. al.,* (2012), who reported feeding habit influence Pb accumulation in fish, and that carnivore's bio accumulated Pb than omnivore and herbivore fishes. The value determined in samples were slightly higher (P>0.05), having no significant different among the head, truck and tail samples. Pb causes lamella shrinkage degeneracy of epithelium; branchial arterial rupture and ischemia; reduction in growth rate and loss in body weight; neurological defect, renal tubular dysfunction, anemia which result in stress condition (Olojo *et. al.,* 2005).

The result revealed evidence of pollution, hence, need for public health and environmental guidance

toward pollution mitigation to ensure the fish species of the Ogbese River are fit for consumption without health hazard.

Conclusion

Heavy metals accumulation in the *C. gariepinus* and *P. obscura* heads, trunks and tails indicated level of pollution within the environment. Absorption of heavy metal from the environment through fish gills suggest the cause of increased heavy metal in fish head. The result on Ogbese River therefore, suggested evident of fish been prone to toxicity. This calls for public health concern if consumed over a long period of time. Therefore, a long-term monitoring program of heavy metals bioaccumulation in fish from River Ogbese and nearby waste sites would be necessary to assess and mitigate potential biological risks to human health and the environment.

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Water Physico-Chemical Parameters Inter-Relationship and Heterotrophic Fungal Count of Ureje Dam in Ekiti State, Nigeria.

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Abstract

The study of water quality and heterotrophic fungi count have great impact on the quality of aq`uaculture production. The interaction among water physico-chemical parameters of Ureje dam in Ekiti State and heterotrophic fungal count was studied from January to May, 2017 and five water samples were collected once every month at different depths using water sampling bottles. The dissolved oxygen, temperature, pH and water transparency were measured while the malt extract method was used for fungal count. The results show a mean of 22.68^{0}C for temperature, 7.41 for pH, 4.1mg/l for dissolved oxygen, 162.97µ for conductivity and 1.35 m for transparency at different depths and seasons. The highest temperature (25.2^0 c) was obtained in February, dissolved oxygen (6.28-6.50mg/l) was highest in January compared to other months while pH at 7.80-7.02 indicates that this water is very good for fish production. The mean pH for the wet season was 7.30 and 7.80 for the dry season. The conductivity was significantly different in all the depths and water samples collected at different days. Thus, the physico-chemical parameters observed at Ureje Dam were within the range that can support aquatic life and that the dam will be able to support diverse number of organisms from planktons, benthos to fishes and macrophytes. The fungal count was 4.2 x 10^2 (cfu/ml) and the major species were *Aspergillus fumigatus* (strain B), As*pergillus flavus* and *Penicillium sp.* The fungi count indicates that the water is contaminated with effluents from run-off, domestic and agricultural waste emptied into the dam via erosion. The data obtained should be used as baseline for decision making when Ureje dam is considered for human and animal use.

Keywords: Heterotrophic fungi, Physico-chemical, Ureje, transparency, conductivity, *Aspergillus fumigatus*

Introduction

It is generally accepted that good water quality is needed to maintain viable aquaculture production (King, 1998). This is because poor water quality results in low profit, low product quality and potential human health risks. The reduction in production occurs when the water contain contaminants that can impair development, growth, reproduction, or even cause mortality to the cultured species (Stone and Thormforde, 2003). Some contaminants may cause no obvious adverse effects but accumulate to the point where they threaten human health even at low concentrations (King, 1998). Efficient feed conversion, growth and marketability of the final product cannot occur unless the pond system is balanced or in harmony with nature. Therefore, the overriding concern of

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chemistry (Wurts, 2000). The required water quality is determined by the specific organisms to be cultured and has many components that are interwoven. Sometimes a component can be dealt with separately, but because of the complex interaction between the components, the composition of the total array must be addressed (Wurts, 2000).

Water quality for aquaculturist refers to the quality of water that enables successful cultivation of the desired fish species. Water is known to contain large quantities of chemical elements and physical parameters. The inter – relationship of both the physical and chemical parameters plays a great and important role in distribution and abundance of aquatic organisms (Summerfelt, 2008). Thus testing the quality of water is an important part of environmental monitoring because when water quality is poor it affects not only aquatic life but the surrounding ecosystem as well. Ground water is considered much more desirable for aquaculture because it has much more consistent water quality than surface water, and it is less likely to be contaminated by pathogens. As it may be impractical to regulate the volume of water in open ponds, species selection is largely dependent on the kind of water available (Huet, 2008).

There is a strong relationship between the quality of the water in the pond and that in the water-surrounding environment (Boyd, 1995). The fish perform all its physiological activities in the water – breathing, excretion of waste, feeding, maintaining salt balance and reproduction. Thus, water quality is the determining factor on the success or failure of an aquaculture operation. Optimal water quality varies by species and must be monitored to ensure growth and survival. The quality of the water in the production systems can significantly affect the organism's health and the costs associated with getting a product to the market. Water quality parameters that are commonly monitored in the aquaculture industry include temperature, dissolved oxygen, pH, alkalinity, hardness, ammonia, and nitrites. Depending on the culture system, carbon dioxide, chlorides, and salinity may also be monitored. Some parameters such as alkalinity and hardness are fairly stable but dissolved oxygen and pH fluctuates daily. It is important to establish a standardized water quality testing protocol for particular situations, know the tolerance range for the culture species, establish critical levels, and be prepared to act if a problem occurs (Boyd, 1998). Research and development in water quality have been going on for decades (Dunning et al, 1998). The balance of physical, chemical and biological properties of any given water body is thus an essential ingredient for successful production of fish and other aquatic resources. The presence or absence of certain chemical elements in a water body might be a limiting factor in the productivity of such water body (Adeosun *et.al*, 2014). Water quality should be maintained at levels sufficient for supporting healthy and fast growing fish. Operating a fish farm under limited water quality conditions can reduce the profitability of fish farming because the water quality problems can later lead to stress and reduce growth. These also increase the risk of infectious disease outbreaks and catastrophic loss of fish (Apeloko, 2013).

The objective of this study are to; analyze the temperature, pH, dissolved oxygen, conductivity and transparency of Ureje dam at different depths during the dry and wet seasons, determine the inter – relationship between the physico – chemical parameters of Ureje dam at different depths and compare the values of physio–chemical parameters of Ureje dam at different depths and seasons.

Materials and methods

Study site

The study was carried out at Ureje Dam (7º37'N, 5º13'E) in Ado local Government Area, Ekiti State.

Fig 1: Google map of Ureje Dam

Water sample collection

Water samples were collected once every month at different depths between January and May, 2017 and a total of five samples were taken using water sampling bottles. The sampling bottles were rinsed thoroughly with the dam water. Water samples were taken on board from canoe, the samples were taken very early in the morning at depth 30cm, 60cm and 90cm by avoiding trapping of atmospheric oxygen and holding the bottles upward. The samples were taken to the Department of Fisheries and Aquaculture Management, Ekiti State University for analysis using APHA, (1985) methods.

Dissolved oxygen analysis

The concentration of dissolved oxygen in the sample collected was measured using Winkler's titration method.

Temperature

Readings was taken in the laboratory using mercury – in – glass thermometer graduated in degree Celsius (^{0}C). The thermometer was placed in water sample for about 5 minutes for it to stabilize after which the reading was taken and recorded and this was done thrice and the mean was determined.

pH

The pH meter electrode was dipped in the water sample; the readings were taken and recorded.

Conductivity

Conductivity meter was dipped in the water sample and reading was taken and recorded.

Transparency

Water transparency was measured with a Secchi disk. A Secchi disk is a metal disk, 8 inches in diameter that is lowered into the water on a cord. The depth that the Secchi disk can no longer be seen through the water is the Secchi depth. When the water transparency is high, the Secchi depth is high. When the water transparency is low and cloudy, the Secchi depth is low.

Total heterotrophic fungal count

The fungal count of the dam was done using malt extract. The medium was prepared according to Premalatha (2001) procedure and was sterilized at 121^{0}C in the autoclave for 15 minutes. One mililitre of each dilution of the water samples from Ero dam and Ureje dam was plated out in duplicates into sterile petri dishes. The prepared malt extract agar of 10 mls in molten form was poured into the petri dishes holding 1 mililitre of water sample using pour plate method. For the agar to solidify, the petri dishes were allowed to stand. The plates were labeled accordingly and incubated at 30^{0}C for 5 days. The developed colonies were observed and counted while the isolates were identified using methylene blue stain.

Results and Discussion

Results

Table 1 shows the physic-chemical parameters determined in water samples collected from Ureje Dam.

Temperature

Temperature at date 1, 3, 4 and 5 did not differ with depth but decreased with depth at date 2. The highest temperature was recorded throughout the period water was sampled at date 2; depth 30 and 60.

pH

The pH values were not significantly different with depth at date 1, 2, 3, 4 and 5.

Dissolved oxygen

Dissolved oxygen though reduced with depth at dates 1 and 3 but the values were not significantly different at date 1 and date 3 at depth 30. Dissolved oxygen reduced at date 4 in depth 60 and 90 and also at date 5 in all the depth.

Conductivity

Conductivity decreased at date 1 and 2 and increased at date 3, 4 and 5.

Table 1: The physico-chemical parameters of water samples in Ureje dam.

Period	Depth [cm]	Temperature [^{0}C]	pH	DO_2 [mg/l]	Conductivity [µ]
Day 1	30	22.40±0.06^a	7.80±0.00^a	6.50 ± 0.05^a	256.67 ± 0.03^a
(24/1/17)	60	21.68±0.03^a	7.51±0.00^a	6.43 ± 0.21^a	270.33 ± 0.33^a
	90	22.07±0.03^a	7.40±0.00^a	6.28 ± 0.02^a	269.33 ± 0.33^a
Day 2	30	25.23±0.09^b	7.25±0.02^a	5.50 ± 0.20^a	285.67 ± 0.03^a
(20/02/17)	60	25.13±0.12^b	7.04±0.06^a	5.58 ± 0.08^a	272.67 ± 0.88^a
	90	22.53±0.03^a	7.02±0.02^a	3.75 ± 0.03^b	272.33 ± 1.33^a
Day 3	30	21.30±0.06^a	7.40±0.00^a	4.06 ± 0.02^a	310.33 ± 0.33^a
(3/03/17)	60	20.13± 0.03^a	7.40 ± 0.00^a	3.34 ± 0.04^b	308.67 ± 0.33^a
	90	20.30±0.06^a	7.43 ± 0.03^a	3.20 ± 0.02^b	304.00 ± 2.08^a
Day 4	30	22.47±0.03^a	7.30 ± 0.00^a	4.05 ± 0.05^a	318.67 ± 0.33^a
(11/04/17)	60	21.40±0.06^a	7.30 ± 0.00^a	3.10 ± 0.20^b	310.33 ± 0.33^a
	90	22.03±0.03^a	7.33 ± 0.03^a	3.10 ± 0.30^b	310.33 ± 0.58^a
Day 5	30	21.63±0.07^a	7.27 ± 0.01^a	1.70 ± 0.20^b	317.27 ± 0.01^a
(11/05/17)	60	21.97±0.03^a	7.33 ± 0.01^a	2.30 ± 0.03^b	317.33 ± 0.01^a
	90	22.03±0.03^a	7.40 ± 0.02^a	2.00 ± 0.03^b	317.39 ± 0.02^a

Means with the same superscript are not significant (P<0.05) using SPSS

Comparison of temperature at different, depths and dates

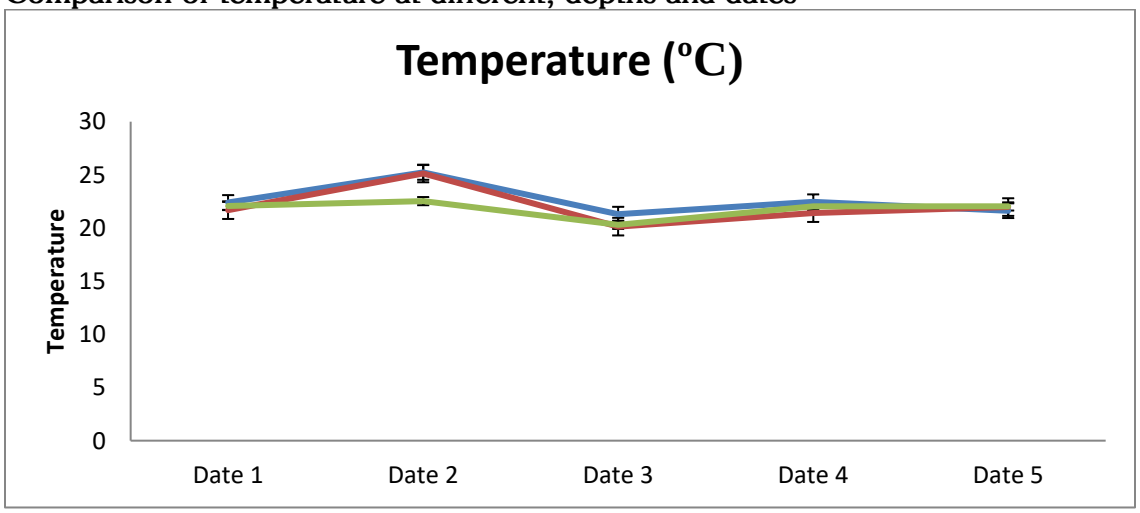

Fig. 2: Temperature of water collected at different depths and dates

As shown in fig 2, highest temperature was recorded on date 1, 2, 3 and 4 at depth 30 while on date 5, it was recorded at depth 90. The highest overall temperature recorded was on date 2 and at depth 30 while the lowest was on date 3 at depth 90.

Comparison of pH at different dates, depth and season

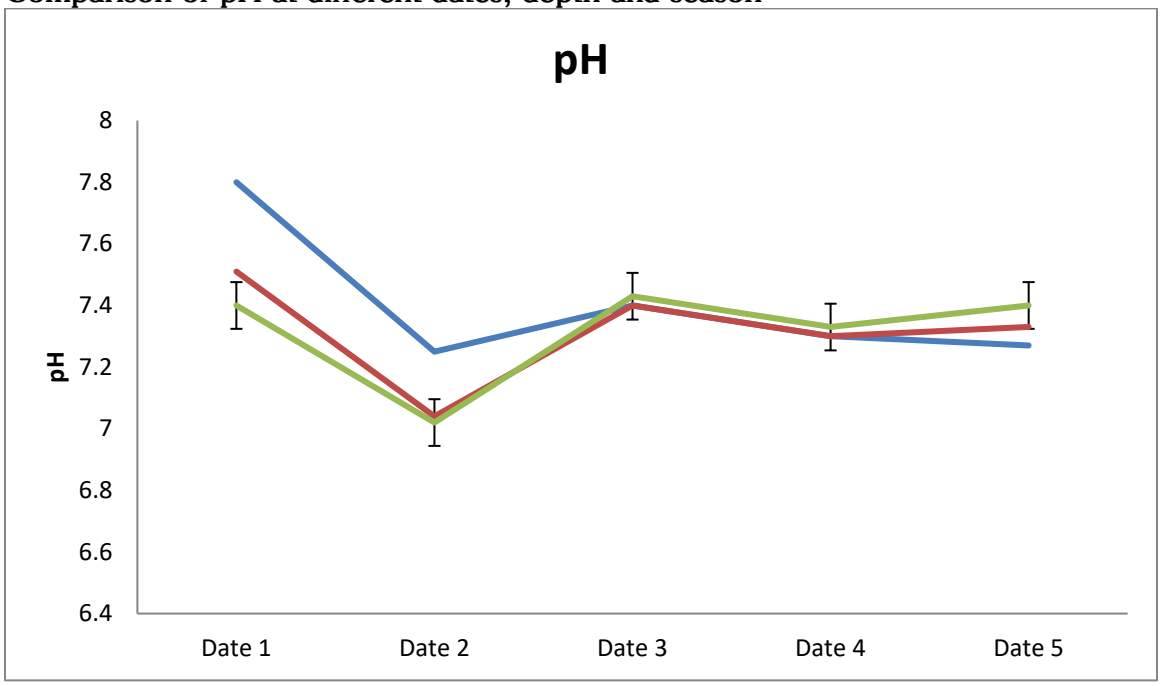

Fig. 3: Effect of sampling dates and depth on pH of water samples

Fig 3 shows the pH values as affected by sampling depth and date. The overall highest pH recorded was on Date 1 and at depth 30 and lowest on Date 2 and at depth 90. Date 1, 2, 3, 4 and 5 had the highest temperature at depths 30, 30, 90, 90 and 90 respectively while the lowest was at depths 90, 90, 30/60, 30/60 and 30 respectively

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Comparison of DO_2 at different dates and depth

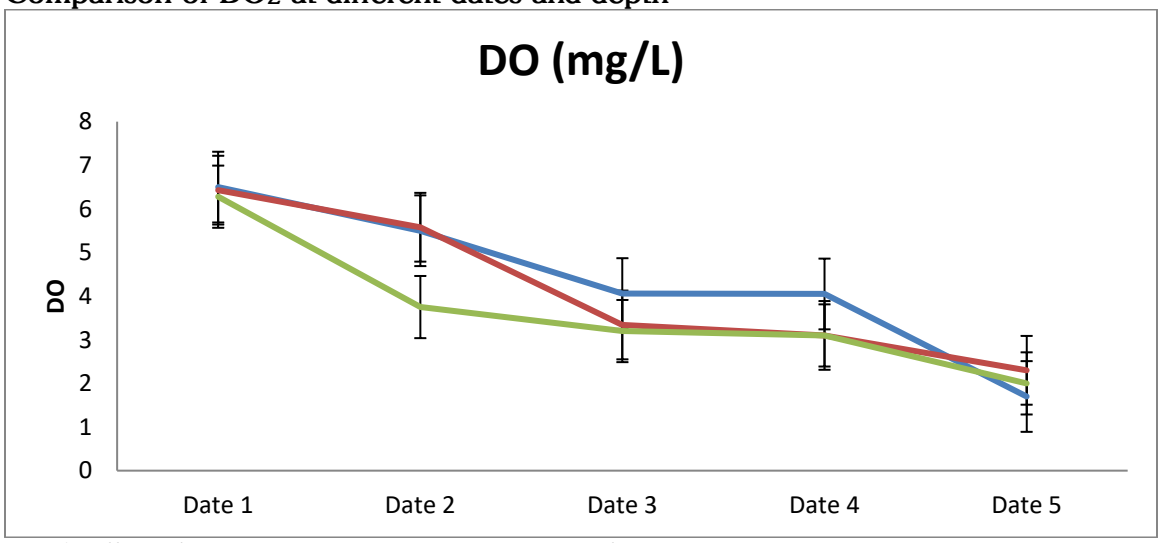


Fig. 4: Effect of sampling dates and depth on DO_2 of water samples

Fig. 4 shows that the overall highest DO_2 recorded was on Date 1 at depth 30 and the lowest on Date 5 at depth 90. Dates 1, 2, 3, 4 and 5 had the highest DO_2 at depths 30, 60, 30, 30 and 60 respectively while the lowest DO_2 was at depths 90, 90, 90, 60/90 and 30.

Comparison of conductivity at different dates an depths of sampling

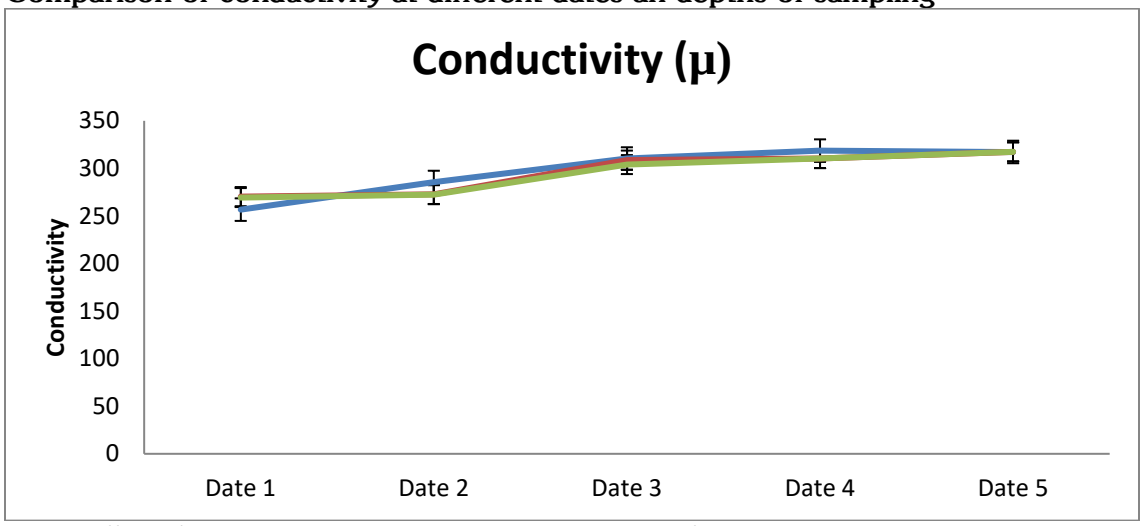


Fig. 5: Effect of sampling dates and depth on conductivity of water samples

As shown in Fig 5, conductivity decreased with time at dates 2 and 3. The highest conductivity was recorded on date 4 and the lowest was on date 1. It was also revealed that as dates increases, conductivity increased.

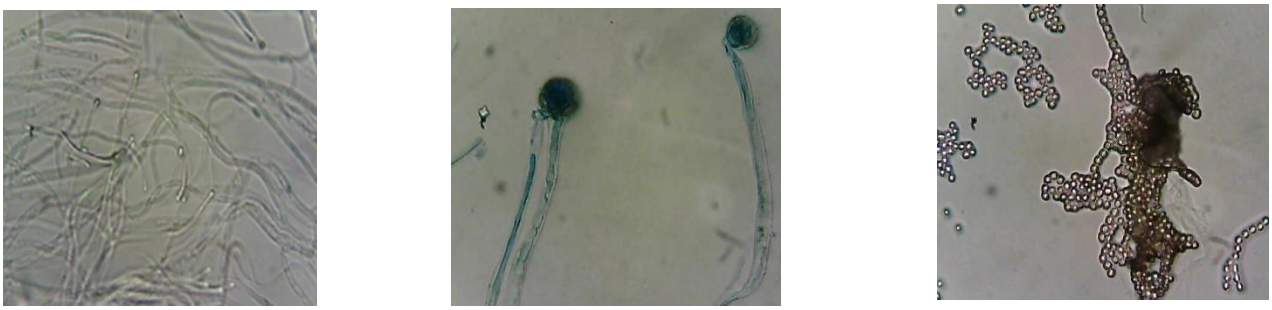
Table 2 shows the heterotrophic fungal count (HFC) of Ureje dam. *Aspergillus fumigatus* (strain B) had the mean count of 1.2x 10^2 (cfu/ ml) while *Penicillium sp* had the highest count of 2.0 x 10^2 (cfu/ml) and As*pergillus flavus* the lowest (1.0 x 10^2 cfu/ml).

Total heterotrophic fungal count (HFC).

Table 2: Heterotrophic fungal count (HFC)

Fungal species	Heterotrophic fungal count (cfu/ml)		
	Minimum	Maximum	Mean
Aspergillus fumigatus (strain B)	1.4 x 10^2	1.0 x 10^2	1.2 x 10^2
As*pergillus flavus*	1.0 x 10^2	1.0 x 10^2	1.0 x 10^2
Penicillium sp.	1.5 x 10^2	2.5 x 10^2	2.0 x 10^2
Total heterotrophic count	-	-	4.2 x 10^2

The microscopic view of fungi isolates from Ureje dam are as shown in Plate 1.



a: *Aspergillus fumigatus* (strain B) b: As*pergillus flavus* *c: Penicillium sp*

Plate 1: Microscopic view of identified fungi in water samples collected from Ureje Dam.

Discussion

The collection of water samples was done in the dry (January - February) and early wet (March - May) seasons, in which the amount and type of rainfall may play a significant part in regulating the various seasonal biological rhythms (Ayoade *et al.*, 2006). The variations in physical and chemical conditions of fresh water ponds have generally been attributed to the effects of rainfall (Bello Olusoji *et al.,* 2006).

In the month of February, pH decreased with a rise in temperature, Kanu and Achi, (2011) reported that temperature determines fish culture conditions and any compound in pond water could bring about changes in water quality which may impair the development and survival of fish.

The fluctuation pattern showed a steady fall in the dissolved oxygen throughout the period of the experiment except for the month of April where the dissolved oxygen remained the same as in the month of march despite the rise and fall in the temperature and pH, which is in contrast with the relationship standard for water quality parameters, this could be due to a few reasons paramount amongst which is the dumping of refuse along the banks of the dam, effluents run-off been emptied into the Dam (Schwartz, 1994) and also the local people's habit of defecating in the water. This corroborates Kanu and Achi, (2011) report that effluents are characterized by their abnormal chemical oxygen demand (COD), turbidity and conductivity. The maximum value of temperature was obtained in the month of February, this disagree with Adeosun *et al.,* (2014) whose maximum temperature was obtained in the month of March. This variance may be due to differences in the onset of wet season.

The temperature variation recorded during the study was optimum for normal growth and survival of aquatic organisms (Ugwumba *et al.,* 1993), Adebisi, (1981). Dissolved oxygen ranged between 6.28 to 6.50mg/l. These corroborate Oyekanmi *et al.,* (2017) where the average dissolved oxygen value was 6.21mg/l. Results obtained shows that the dissolved oxygen in Ureje dam is good for fish culture because throughout the five months of water collection the dissolved oxygen was not below 1.5mg/l (Adebola *et al.*, 2016).

The pH of Ureje dam (7.80-7.02) is very good for fish production. Boyd and Claude, (1979) reported that water with pH range of 5.5 to 9.0 are most suitable for fish production while Murdoch *et al.,* (2001) also stated that the optimal pH range for sustainable aquatic life is 6.5 – 8.2.

The average mean value of pH for wet season was 7.30 and dry season 7.80 (which was the peak of dry season). This might be due to the deposition of some organic matters into the Dam from run-off during wet seasons (Adefemi *et.al* 2007).

Conductivity also increased with increase in pH because increase in alkalinity hikes conductivity value. This corroborates the work of Oyekanmi *et al.*, (2017) who reported an increase in conductivity as pH increased. Dissolved oxygen reduced with increase in temperature.

It was also revealed from the analysis of February that as temperature increases, conductivity also increased, this was explained by Perlman (2014) where the interaction of electrical conductivity and temperature was studied.

The fungi Aspergillus flavus strain grew well at high temperature and it is an opportunistic human pathogen capable of causing diseases producing toxin called Aflatoxin B-type which can also cause liver cancer in humans (Bryden, 2012). The occurrence and presence of *Aspergillus fumigatus* and *Penicillium sp*s in the water of the dam revealed microbiological contamination and the water therefore needs to be treated by chlorination if it should be taken for drinking by man to avoid water borne diseases such as typhoid, diarrhea and cholera (Obasi *et. al* 2012).

Conclusion and Recommendation

The physico-chemical parameters observed at Ureje Dam were within the range that can support aquatic life. The dam has been quite productive and will support diverse number of organisms from planktons, benthos to fishes and macrophytes going by the abundance of chemical ions needed for inter-conversion of energy and production of organic materials present in the dam. The physico-chemical data obtained in this river could be used as a baseline and reference point when assessing the changes caused by nature and man within the dam. Ureje dam should be protected from destruction as a result of human activities so as to prevent the fishes from mortality.

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Nutritional and Anti-nutritional Composition of *Parkia biglobosa and Adansonia digitata* in Guinea Savanna region, Taraba state, Nigeria

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Abstract

Savanna biome is endowed with many tree species bearing edible fruits, seeds and nuts for human consumption. These fruits play an important role in human nutrition owing to their nutritional values, vitamins, minerals, anti-oxidants and low anti-nutritional factors. This study examined the nutritional and anti-nutritional composition of *Adansonia digitata* and *Parkia biglobosa* pulp and seeds from guinea savanna eco-system in Taraba state, Nigeria. The nutritional Analysis of the seeds was carried out using the standard methods.The results show that moisture content was higher (11-18%) in the fruit pulp than in the seeds while the seeds of the two species are rich in protein (16-20%). *Parkia biglobosa* seeds proved a better source of crude fat (13%), crude fiber (10%), the ash content was slightly higher (4-5%) in the seeds than the fruit pulp. Crude fat (7.91%), crude fibre (7.52%) was higher in *Adansonia digitata* seed than the fruit pulp. Anti-nutritional content of *Adansonia digitata* and *Parkia biglobosa* was generally low, indicating that their consumption would not pose nutritional or health challenges. Therefore, the higher anti-nutritional factor in the seeds could be reduced through appropriate processing techniques.

Keywords: Savanna biome, Anti – nutritional, Techniques, Consumption

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Introduction

Tropical forests are endowed with diversity of important indigenous tree species that are edible and of socioeconomical importance. These fruits have contributed to human diets due to their richness in nutrients, vitamins, minerals, antioxidants and their low anti-nutrients content (Onyekwelu *et al.*, 2015). They have enormous potentials in alleviating poverty and amelioration of food problems especially to rural dwellers. The constituents obtained in fruits include water, carbohydrates, fats, proteins, fiber, minerals, organic acids, pigments, vitamins and antioxidants among others. They are good sources of fiber, selected minerals, vitamins and antioxidants (Vincente *et al.*, 2009).

Rural dwellers in developing countries cannot afford animal products which are rich sources of protein because they are either too costly and often times out of reach (Gernah *et al.*, 2007). However, this is a blessing in disguise as plant pose a better source of protein with less saturated fat and no cholesterol (Chodosh, 2018). In addition, studies (Richter, 2015; Chodosh, 2018) have shown that plant protein is much better than animal protein. Meta- analysis that compared people who eat animal versus plant proteins found out that plant consumer tends to have less cardiovascular disease and fewer cancer cases (Campbell, 2017). Among the plant species, grain legumes are considered as the major source of dietary proteins (Olujobi, 2012). They are consumed

widely, especially in developing and under developed countries where consumption of animal protein maybe limited as a result of economic, social cultural or religious factors. An important protein substitute is the African locust bean (*Parkia biglobosa* Jacq.) and Baobab (*Adansonia digitata* L.). *Parkia biglobosa* has found very popular use especially in the fermented 'dawadawa' form, which is a product of the seeds (Hassan and Umar, 2005). The fruit pulp is generally eaten raw and used in rural communities in Africa during emergencies, when the grain stores are empty (Edem and Miranda, 2011). The pulp is also used as an ingredient in the preparation of various stews, and soups (Odebunmi *et al.*, 2010). The pulp which is used to prepare numerous foods and drinks has both sweet and underline sour taste which indicate the presence of natural sugar and ascorbic acid (vitamin c) while the attractive yellow colour indicates the presence of phyto-nutrients, possibly carotenoids, which are important precursors of retinol (Vitamin A) (Gemah *et al.*, 2001; Orwa *et al.*, 2009; Sina *et al.*, 2002). Hassan and Umar (2005) stated that the seeds and pulp are good source of protein and most essential amino acids. He reported protein content of seeds with and without hull to be 28.20% and 32.40% respectively while that of pulp is 1.84%.

Adansonia digitata L. (Malvaceae) commonly known as baobab tree native to Africa, is a multi-purpose tree which offers protection and provides food, clothing and medicine as well as raw material for many useful items. The fruit pulp, seeds, leaves, flowers, roots, and bark of baobab are edible (Rahul *et al.*, 2015). *Adansonia digitata* seeds has been proven to be a good source of energy, protein and fat, and are used as thickening agent in soups, they can also be fermented and used as a flavoring agent or roasted and eaten as snacks (Kabore *et al.*, 2011). Rural dwellers considered the fruits as an important foodstuff as the dried fruit pulp is commonly used in cold and hot drinks. The fruit pulp is said to be very rich in vitamin C, calcium, phosphorus, carbohydrates and soluble and insoluble fibers (Gruenwald, 2009). Its ability to dissolve in water and milk, makes it suitable for production of a drink and as fermentation agent in local brewing (Rahul *et al.*, 2015). The contribution of these wild edible fruits to the dietary need and nutritional requirement of people in the rural area cannot be overemphasized. However, since environmental factors under which food legumes are grown could influence their nutritional composition (Bhatty *et al.,* 2000). This study aim to evaluate the nutritional and the anti-nutritional composition of *Adansonia digitata* and *Parkia biglobosa* in Guinea savanna region, Taraba state, Nigeria.

Materials and Methods

The experiment was carried out in Guinea savanna region of Taraba state. Taraba state is located at the North Eastern part of Nigeria. It lies between latitude 6^0 30′and 9^0 36′N and longitude 9^0 10′and 11^0 50′ E (Adebayo and Oruonye, 2012). The State lies largely within the tropical zone and has a vegetation of forest in the southern part and grassland in the Northern part. Like most parts of northern Nigeria, Taraba State has a wet and dry climate. The wet season lasts, from April to October while the dry season lasts from November to March. Mean annual rainfall varies between 1058mm in the north around Jalingo and Zing, to over 1300mm in the South around Serti and Takum (Reuben and Mshelia, 2011).

Matured and dried fruits of *Parkia biglobosa and Adansonia digitata* were randomly collected from five (5) trees from an agroforestry farmland in Tor-musa village in Wukari Local government in Taraba state, Nigeria. The seeds were depulped and dehulled manually, followed by washing off of the pulp with distilled water. Both pulp and seeds were air dried separately at room temperature.

Nutritional Analysis was carried out using the standard methods of the Association of Official Analytical Chemists (AOAC, 2000) for determination of moisture, crude protein, crude fat, total ash and crude fibre contents of each sample. Moisture content was determined by heating 2.0 g of each fresh sample to a constant weight in a crucible placed in an oven maintained at 105 0C. The dry matter was used in the determination of the other parameters. Crude protein (% total nitrogen x 6.25) was determined by digesting 2.0 g of the sample using Kjeldhal method. Crude fat was determined by exhaustively extracting 5.0 g of each sample in a Soxhlet apparatus using petroleum ether (boiling point range 40 – 60 0C) as the extractant. Ash was determined by the incineration of 10.0 g samples placed in a muffle furnace maintained at 550 0C for 5 hours. Crude fibre was obtained by digesting 2.0 g of sample with 4.0 ml of 8% conc. H2SO4 and 40% NaOH and incinerating the residue in a muffle furnace maintained at 550 0C until

constant weight was obtained. The anti-nutritional compositions examined were phytate, oxalate, phenol, tannin, saponin and cyanogenic glycosides (HCN).

Tannins determination

Spectrophotometric method of Trease and Evans (1989) was used in the determination of tannin in the samples. One gram of the ground sample was dissolved in 10 ml distilled water and agitated, left to stand for 30 minutes at room temperature. Sample was centrifuged and the extract recovered 2.5 ml of the supernatant was dispersed into 50 ml volumetric flask. Similarly, 2.5 ml of standard tannic acid solution was dispersed into a separate 50 ml flask. A 1.0 ml folin-dennis reagent was measured in each flask followed by 2.5 ml of saturated Na_2CO_3 solution. The mixture was diluted to 50 ml in the flask and incubated for 50 minutes at room temperature. The absorbance of each sample was measured at 250 nm with the reagent blank at zero.

Phytate determination

The phytate of each of the samples were determined through phytic acid determination using the procedure described by (Lucas and Markaka, 1975). This entails the weighing of 2 g of each sample into 250 ml conical flask. 100 ml of 2% conc. HCl was used to soak the samples in the conical flask for 3 h and then filtered through a double layer filter paper, 50ml of each of the sample filtrate was placed in a 250 ml beaker and 107 ml of distilled water added to give or improve proper acidity. 10 ml of 0.3% ammonium thiocyanate solution was then added to each sample solution as indicator and titrated with standard iron chloride solution which contained 0.00195 g iron/ml to give the end point which signified by brownish-yellow colouration that persisted for 5 min.

Determination of Oxalate

The determination was calculated according to Day and Underwood (1986). One gram (1g) of the samples were put into a separate plastic bottles followed by the addition of 75 ml of 1.5N H_2SO_4. The content was mixed properly and allowed to extract for 1 hour with constant agitation using a mechanical shaker. It was then filtered and 25ml of the filtrate was titrated with 0.1ml $KMnO_4$ while hot (80-90^oC) until a purple color was observed at end point.

Determination of phenols

It was determined by the Folin-Ciocalteu method (Singleton *et al.*, 1999). An extract of 0.1 g was dissolved in 100 ml methanol. An aliquot of 0.5 ml was mixed in an amber flask with 0.5 ml of the Folin-Ciocalteau reagent followed by 0.5 ml of 100 mg/ml sodium carbonate/distilled water (w/v). The mixture was allowed to stand for 2 h and the optical density measured at 765 nm in the visible spectrophotometer.

Determination of Saponin

Saponin content of the sample was determined by double solvent extraction gravimetric method (Harbone, 1973). Two grams of the powdered sample was mixed with 50mls of 20% aqueous ethanol solution. The mixture was heated with periodic agitation in water bath for 90 mins at 55^OC. It was filtered through filter paper through Whatman filter paper. The residue was extracted with 50mls of the 20% ethanol and both extracts were pooled together. The combined extract was reduced to about 40mls at 90^OC and transferred to a separating funnel where 40mls of diethyl ether was added and shaken vigorously. Separation was by partition during which the ether layer was discarded and the aqueous layer reserved. Re-extraction by partition was done repeatedly until the aqueous layer became clear in colour. The saponins were extracted with 60mls of normal butanol. The combined extracts were washed with 5% aqueous NaCl solution and evaporated to dryness in a pre-weighed evaporating dish. It was dried at 60^OC in the oven and reweighed. The experiment was repeated two more times to get an average.

Determination of Cyanogenic Glycosides (HCN)

10.0 g ground sample was weighted into an 800 ml Kjeldahl flask onto which 200 ml of distilled water was added and allowed to stand for four hours (for autolysis to occur). The mixture was steam distilled until about 150 -170 ml of distillate was collected into a 250ml conical flash containing 20 ml of 2.5 % NaOH and diluted to 250 ml. To 100 ml of the distillate, 2ml of 6 moldm-3 NH4OH and 2 ml of 5 % KI was added, the mixture was titrated with 0.02 M silver nitrate (AgNO3) using a micro-burette to a faint but permanent turbidity was obtained (1ml of 0.02 moldm-3 AgNO3 1.08 mg HCN) (AOAC, 2012).

Results

The nutritional composition of *Adansonia digitata* and *Parkia biglobosa* are presented in Table 1. The fruit pulp of *A. digitata* was high in moisture content and lower in protein, fat, fibre, and ash content compare to the seed, while the seed had higher protein, fat, fibre and ash content (Table 1).

Table 1: Nutritional composition of the fruit and seed parts of *Adansonia digitata* and *Parkia biglobosa*

FruitSpecies part	Fruit	Parameters Moisture (%)	Ash (%)	Fibre (%)	Fat (%)	Protein (%)
A.digitata	Fruit pulp	$10.47^{b} \pm 0.03$	$2.25^{c} \pm 0.14$	$4.84^{d} \pm 0.05$	$3.14^{c} \pm 0.11$	$5.17^{d} \pm 0.00$
	Seed	$5.39^{c} \pm 0.19$	$4.32^{a} \pm 0.14$	$7.52^{b} \pm 0.05$	$7.91^{b} \pm 0.34$	$16.29^{b} \pm 0.05$
P. biglobosa	Fruit pulp	$18.12^{a} \pm 0.12$	$3.59^{b} \pm 0.21$	$5.69^{c} \pm 0.24$	$3.39^{c} \pm 0.20$	$5.86^{c} \pm 0.17$
	Seed	$5.46^{c} \pm 0.05$	$4.57^{a} \pm 0.05$	$10.14^{a} \pm 0.42$	$12.7^{a} \pm 0.12$	$20.04^{a} \pm 0.25$

Notes: Each value is a mean of two replicates ± standard error. Means within the same column followed by the same letter are not significantly different ($p < 0.05$)

Similar trend was also observed in *Parkia biglobosa* pulp and seeds. The protein, fat and fibre content of the seeds were significantly higher ($P< 0.005$) than those in the fruit pulp. However, moisture content was higher in *Parkia biglobosa* pulp as compared to the seeds. The result indicates significant differences ($P< 0.005$) in all the nutritional composition of *Adansonia digitata* fruit pulp and seed. The ash content ranged (2 - 4%), fibber ranged (5-8%), fat ranged (3-8%) protein ranged (5- 16%) and were significantly higher, while the moisture content ranged (5-11%) and was significantly lower in *Adansonia digitata* seeds than the fruit pulp (Table 1). Similar trend was also observed in *Parkia biglobosa* fruit pulp and seed. Moisture content ranged (6-18%) and was significantly lower in the seeds than in the fruit pulp while the ash content ranged (4-6%) , fibre ranged (6-10%), fat ranged (3-12%) while protein ranged (6-20%) and was significantly higher in the seed of *Parkia biglobosa* than in the fruit pulp.

The results of the anti-nutritional factor showed significant difference ($p<0.05$) in some anti-nutritional content. Phytate ranged (0.10-0.78mgg^{-1}), tannin (0.01- 0.02 mgg^{-1}), saponin (0.80 - 0.97 mgg^{-1}) in *A. digitata* fruit pulp and seed. However, anti-nutritional content such as oxalate content (0.36 mgg^{-1}), Phenol (0.01 mgg^{-1}), HCN (0.01 mgg^{-1}) were the same in both fruit pulp and seed of *A. digitata*, hence it revealed no significant difference ($p<0.05$) (Table 2). For *Parkia biglobosa,* there were no significant difference ($p<0.05$) in the phenol content (0.01 mgg^{-1}) of both the fruit pulp and seed. However, phytate ranged (0.10-0.12 mgg^{-1}), Oxalate (0.86-1.13 mgg^{-1}), Tannin (0.01- 0.02 mgg^{-1}) and were higher in the seed compared to the fruit pulp of *P. biglobosa*, while saponin ranged (0.48 – 0.78 mgg^{-1}) and HCN (0.01-0.04mgg^{-1}) (Table 2).

Table 2: Anti-nutritional composition of the fruit and seed parts of *Adansonia digitata* and *Parkia biglobosa*

Fruit Species	Fruit/seed part	Parameters					
		Phytate (mg g^{-1})	Oxalate (mg g^{-1})	Phenol (mg g^{-1})	Tannin (mg g^{-1})	Saponin (mg g^{-1})	Cyanogenic glycosides (mg g^{-1})
A. digitata	Pulp	$0.78^{d} \pm 0.24$	$0.36^{c} \pm 0.00$	$0.01^{a} \pm 0.00$	$0.01^{b} \pm 0.00$	$0.80^{b} \pm 0.00$	$0.05^{d} \pm 0.19$
P. biglobosa	Pulp	$0.12^{b} \pm 0.00$	$0.86^{b} \pm 0.03$	$0.01^{a} \pm 0.00$	$0.01^{b} \pm 0.00$	$0.78^{c} \pm 0.12$	$0.04^{c} \pm 0.19$
A. digitata	Seed	$0.16^{c} \pm 0.48$	$0.36^{a} \pm 0.00$	$0.01^{a} \pm 0.00$	$0.02^{a} \pm 0.00$	$0.97^{d} \pm 0.17$	$0.08^{b} \pm 0.39$
P.biglobosa	Seed	$0.10^{a} \pm 0.24$	$1.13^{c} \pm 0.03$	$0.01^{a} \pm 0.00$	$0.01^{a} \pm 0.00$	$0.48^{a} \pm 0.00$	$0.01^{a} \pm 0.00$

Notes: Each value is a mean of two replicates ± standard error. Means within the same column followed by the same letter are not significantly different ($p < 0.05$)

Several tropical fruits are native to the savanna region in Nigeria and have contributed immensely to the diets of the rural dwellers. Quite a number of them are high in nutritional value and play important role in human nutrition (Bala and Bashar, 2017). The consumption of fruits has been effective in the prevention of chronic diseases and exerts a protective effect against the development of human diseases such as cardiovascular disease, diabetes, cancer etc. (Tekalign and Fistum, 2017). *Adansonia digitata* and *Parkia biglobosa* are among the widely consumed forest fruit species and has a long history of traditional uses. Both the pulp and seeds of the two species are edible. The seeds of *A. digitata* (baobab) are commonly used as coffee substitute and thickening agent in soup while *P. biglobosa* seed is used as condiment in soup (Abubakar *et al.*, 2015; Gernah *et al.*, 2007). The yellow fruit pulp of *P. biglobosa* (African locust bean) is sweet to taste, which indicates the presence of natural sugars and thus a potential energy source (Gernah *et al.*, 2007). Where about The baobab pulp is usually used in the preparation of fruit juice, snacks, sweets, as a fermenting agent in local brews and in food recipes (Sidibé & Williams, 2002; Gebauer *et al.*, 2014).

Moisture contents were higher in the fruit pulp of both species than in their seeds but considerably lower when compared to other commonly consumed indigenous fruits such as *Vitex doniana, Vitellaria paradoxa*, *Tamarindus indica* which are found grown in the same geographical locations (Bala and Bashar, 2017; Kinuthia *et al.*, 2017). The values obtained indicates that the seed has a good shelf life; hence it can be stored for a long time without spoilage. The moisture content of any food is an index of its water activity and is used as a measure of the stability and susceptibility to microbial contamination (Edem and Miranda, 2011). The moisture content in *Adansonia digitata* fruit pulp is lower when compared to *Parkia biglobosa* pulp; this is an indication of higher dry matter content and possibility of longer storage period. However, the value obtained for moisture content for *A. digitata* and *P. biglobosa* in this study is within the range reported by Muthai *et al.* (2017); Osman (2004) and Ndukwe and Solomon (2017). Generally nutritional composition of the seed of *A. digitata* and *P. biglobosa* was higher in the seed compared with the fruit pulp. Plant protein constitutes essential animal protein supplement, especially in the rural areas where animal protein is scarce and expensive (Onyekwelu *et al.,* 2015). *A. digitata* seed is a good source of protein, the protein content obtained in this study was within the range (16-29%) reported by Osman (2004) and Nour *et al.* (1980) but lower than the value (29.79%) obtained by Abubakar *et al.* (2015). Boateng *et al.* (2014) reported higher crude protein for raw *P. biglobosa* seed (26-28%) than was recorded in this study. However, Aremu *et al.* (2015) and Okai *et al.* (2014) obtained a range of (25-37%) for processed *P. biglobosa* seed hence, processing of African locust bean could therefore be used as an alternative source of protein in the diet.

Considerable high crude fiber content was discovered in the two fruit pulps and seeds. However, *Parkia biglobosa* seed is a better source of crude fibber. The high crude fiber found in raw *Parkia biglobosa* seed was comparable to (9-17%) reported by Aremu *et al.* (2015) and Ndukwe and Solomon (2017) but was higher than the fibre content of Garcinia kola, orange, African pea, pawpaw, pineapple, orange and pawpaw (Onyekwelu *et al.*, 2015; Udeme *et al.,* 3013). Crude fibre obtained for *Adansonia digitata* was within the range (6-9%) obtained by Muthai (2017) in six African countries. Dietary fiber plays an important role in the maintenance of internal distention in intestinal tract as its physiological effect. Hence, adequate consumption of dietary fibers from a variety of foods will help the protection against colon cancer and also help normalize blood lipids, thereby reducing the risk of cardiovascular diseases (Ogungbenle, 2006; Aremu *et al.,* 2015). The value of crude fat content of both species was considerably lower in the fruit pulp compared to the seed. This is in support of the assertion that fruits are not good sources of dietary fat and explains why fruits are usually recommended as part of weight reducing diets. However, the result obtained in this study was similar to those obtained by Okai, 2014 but higher compared to the range (1-7%) obtained by Gemmah (2007) and Aremu *et al* (2015). Crude fat content of *A. digitata* and *P. biglobosa* seed fall within the range (6-25%) obtained by Muthai *et al.* (2017) and Abubakar *et al.* 2015, hence the fruit seed maybe a possible source of oil soluble vitamins. The ash content, which is often regarded as an index of mineral content in biological mass was found low but higher than (0-2%) obtained in fruit and seed of *Chrysophyllum albidum* and *Garcinia kola* from rainforest eco system in Nigeria. (Onyekwelu *et al.,* 2015).

Antinutrients and phytochemicals found in foods have been categorized as having both adverse and beneficial health effects in humans. Their concentration in fruits differs and could be manipulated in such a way that advantage is taken from their health related benefits so that management of chronic diseases becomes possible (Shahidi, 1997; D'Mello, 2000).). The fruit and seed samples contain phytate, oxalate, phenol, tannin, and saponin in different proportion (Table 2). Anti-nutritional factor in both fruit pulp and seeds of *A. digitata* and *P. biglobosa* were relatively low. The phytate content ranged (0.10-0.78mgg^{-1}) for all the samples and are within the range (0.8-0.9mgg^{-1}) in guava, mango and pineapple (Tapiero *et al.*, 2002). The level of phytate in the fruits pulp and seeds were also within the global range of daily intake of (0.18-4.569g) (Reddy, 2002). However, Phytate content was higher in *Adansonia digitata* pulp hence, adequate consumption could enhance the activity of natural killercells and inhibit tumor growth. Research has found out that consumption of 1000-2000mg of phytic acid per day did not suffer from reduced mineral bioavailability (Hunt and Roughead, 1999). For decades phytate has been regarded as anti-nutrient because during gastro-intestinal passage, it may inhibit the absorption of some essential trace elements and minerals, which under certain dietary circumstances may lead to calcium, iron and zinc deficiencies. However, proper processing has been found to improve the bioavailability of essential trace elements and minerals. Over the years, the beneficial properties of phytate have been observed as antioxidant, anticancer and prevention of renal stone formation (Graf *et al.*, 1987; Shamsuddin, 1995; Schlemmer *et al.*, 2009). Oxalate content range (0.36- 1.13mgg^{-1}) in all the samples and were lower than the values reported for *Garcinia kola* and *Chrysophyllum albidium* in rainforest ecosystem of Nigeria (Onyekwelu *et al.*, 2015). Rahman *et al.* (2013) stated that plants with less than 2% soluble oxalate would not result in oxalate poisoning in ruminant animals.

The concentration of phenol and tannin in all the samples were low and are within standard safe limit (60.00mg/100g) (WHO, 2003) hence, consumption of the fruit pulp and seed may not lower the availability of protein in the body. Saponin content ranged (0.48-0.97mgg^{-1}) and is within the WHO recommended permissible limit of (48.50 mg/100g) (WHO, 2003). Therefore, the seeds and fruit pulp of the species are safe for consumption when use as food. The fruit pulp and seeds contain very low cyanogenic glycoside, ranged (0.01- 0.08mgg-1) but were higher in the seeds, though the concentration in the seeds were still within the lethal dose permissible recommended limit of (0.5- 3.5mgkg^{-1}), however adequate processing techniques will reduce the level of anti-nutritional composition of the seeds. Research (Siddhuraju *et al.*, 2001; Ugwu and Oranye, 2006) has found out that processing of raw seed have reduction effects on the level of anti-nutritional factors. This is in support of the findings of Ndukwe and Solomon (2017) that fermentation improves nutritional quality, and reduced the level of anti- nutrients factors of some local food condiment.

Conclusion

Indigenous fruits are the most essential nutrient source that contributes extensively to human diet. *Parkia biglobosa* and *Adansonia digitata* pulp and seeds are good source of protein and other essential nutrient that could be used to curb the problem of malnutrition and supplement protein in diet, most especially in areas where animal protein is scarce or unaffordable. There was variation in the anti-nutritional factors of the fruits pulp and seeds in all the samples and were within the acceptable and safe levels. However, the level of anti-nutritional content in the seeds were relatively higher compare to the fruit pulp. Hence there will be need for adequate processing method in order to reduce the level of anti-nutrient and make it safer for consumption

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Effects of Quarry Activities on Physical and Chemical Properties of Soils in Ondo State, Nigeria

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Abstract

Quarrying activities to obtain boulders, chips and stone dust for construction works, hard flooring and decorative polished slabs involve cutting or blasting rocks with explosives, crushing and haulage from the pit mines. The quarry is open to the air with the impacts of noise and vibrations and pollution from fumes, gases and dust particles which settle or are precipitated by rainfall on the adjoining area to alter the soil properties. This study was carried out to assess the effects of quarrying activities on the physical and chemical properties of soil samples collected at 0, 500 and 1000 m in cardinal directions around the quarry compared to samples from Aponmu Forest Reserve as the control. The soil samples were collected at 0-10, 10-20 and 20-30 cm depth for analysis using standard laboratory methods. The result shows significant differences in the properties of soil samples around the quarry from the soils in the natural forest. The clay content was not significantly different in all the directions, distances and depths. The silt was higher in the South direction at 0 m, 10-20 and 20-30 cm depths and the least value was recorded in the North direction at 1000 m and 0-10 cm depth. The sand portion was more abundant at the directions, distances and soil depths than the natural forest. Available macronutrients were higher at the sites than in the natural forest.

Keywords: Quarry, soil texture, available phosphorus, total nitrogen, exchangeable potassium,

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Introduction

The abundant mineral resources in Nigeria, on account of the solid geology, have attracted the establishment of petrochemical industries, iron and steel industries, science equipment centres and quarry industries (Adejuyigbe, 1995). The portion underlain by Pre-Cambrian Basement Complex igneous and metamorphic rocks consist of minerals which include granites, amphibolite, migmatite-gneisses, pegmatites, schists, granite-gneiss, quartzite etc (Oyinloye, 2011). The exploitation of these minerals necessitated opening up quarries to mine the materials needed in the construction industry and traditional hard flooring such as granite, marble and clay.

Quarry operations involve the removal of vegetation, alteration of slopes and creation of mine pits for excavation which affect the landscape and destroy wildlife natural habitats. The processes of rock cutting and blasting with powerful explosives for processing and sizing into boulders (large chunks of stones), slabs, slates, chips and stone dust produce local environmental impacts which include noise and vibration and the air pollution associated with the fumes, gases and dust particles released into the

atmosphere. These dust particles are numerous and varied due to the different sources of broadcast (Laj and Sellegri, 2003). Two types of particles are to be distinguished: the primary particles that are cleared directly in the atmosphere from the rock mining processes and dust raised from dry soil by haulage vehicles and the secondary particles formed in the atmosphere following chemical transformations. The deposition is complex and controlled by atmospheric stability, the surface roughness and diameter of the particles (Hosker and Lindberg, 1982). The atmospheric deposition of particulate matter will eventually occur usually after a supporting wind current or precipitation from rainfall causing the settlement of the particles on the surrounding land. Quarry dusts (predominantly particulates) vary in size and contain oxides of Ca, K, Si and Na which can enter into the soil as dry, humid or occults deposits to undermine its physical and chemical properties (Okafor, 2006). Since quarrying activities have the potential to cause significant impact on the environment (Okafor, 2006), the development of quarrying industries should be monitored and the negative externalities and environmental impacts assessed to avoid wrong attitude to industrial growth and maximize the benefits in the provision of natural resources for the development of socio-economic infrastructure (roads, buildings etc), creation of employment and source of revenue and foreign exchange (Hilson, 2002).

Akure North Local Government Area (LGA) is one of the eighteen (18) LGAs in Ondo State, Nigeria. It is characterized by undulating topography of mainly nearly level to gently undulating ancient plains with scattered hills, steep-sided rock outcrops and dome-shaped inselbergs as shaped by on the underlying Pre-Cambrian Basement Complex rocks (Facts and Figures about Ondo State" (2010). The rocks are sources of the raw materials that stimulated the location of many rock quarrying and crushing industries in the LGA. This study was carried out to assess the impact of rock quarrying activities at Stoneworks Industries Limited, Akure in Ondo State, Nigeria on the physical and chemical properties of soils in the adjoining land compared to the soils in Aponmu Forest Reserve far-removed from the operations area.

Materials and Methods

Study area

The study was carried out at Stoneworks Industries Limited, Akure along the Akure-Owo expressway within Akure North Local Government Area, of Ondo State. It is tucked within fairly massive porphyritic granite rock outcrops, as part of the underlying Pre-Cambrian Basement Complex rocks of Southwestern Nigeria, on latitude N 07º 16.5229′ and longitude E 05º 14.2754′ and the elevation is on 396 m above the sea level. The lithology is coarse porphyritic biotite-hornblende-granite as found in the massive outcrops of granitic rocks (Okoronkwo *et al .,* 2006) on all sides of the site. The study area is a built-up environment with several churches, market, schools, and commercial and residential buildings.

The soils samples studied were collected at 0-10, 10-20 and 20-30 cm depth within the vicinity of the quarry and at Aponmu Forest Reserve which served as the control. The reserves is about at about 20 km south of Akure on Latitude 70 18'N and Longitude 50 02'E. The samples were obtained at 0, 500 and 1000 m sequentially away from the quarry industry using the bulk sampling method at each sampling point. Triplicate samples were taken at each collection points. The sampling points were far enough from the expressway to avoid contamination that can occur through localized pollution from road traffic. The samples were bulked for each point, air-dried, sieved (< 2 mm) and stored for laboratory analysis.

The soils were analyzed for particle size distribution, pH, organic carbon, total N, exchangeable cations and available P using standard laboratory procedures (Udo *et al.*, 2010). The figures were subjected to Analysis of variance and test of significance were carried out.

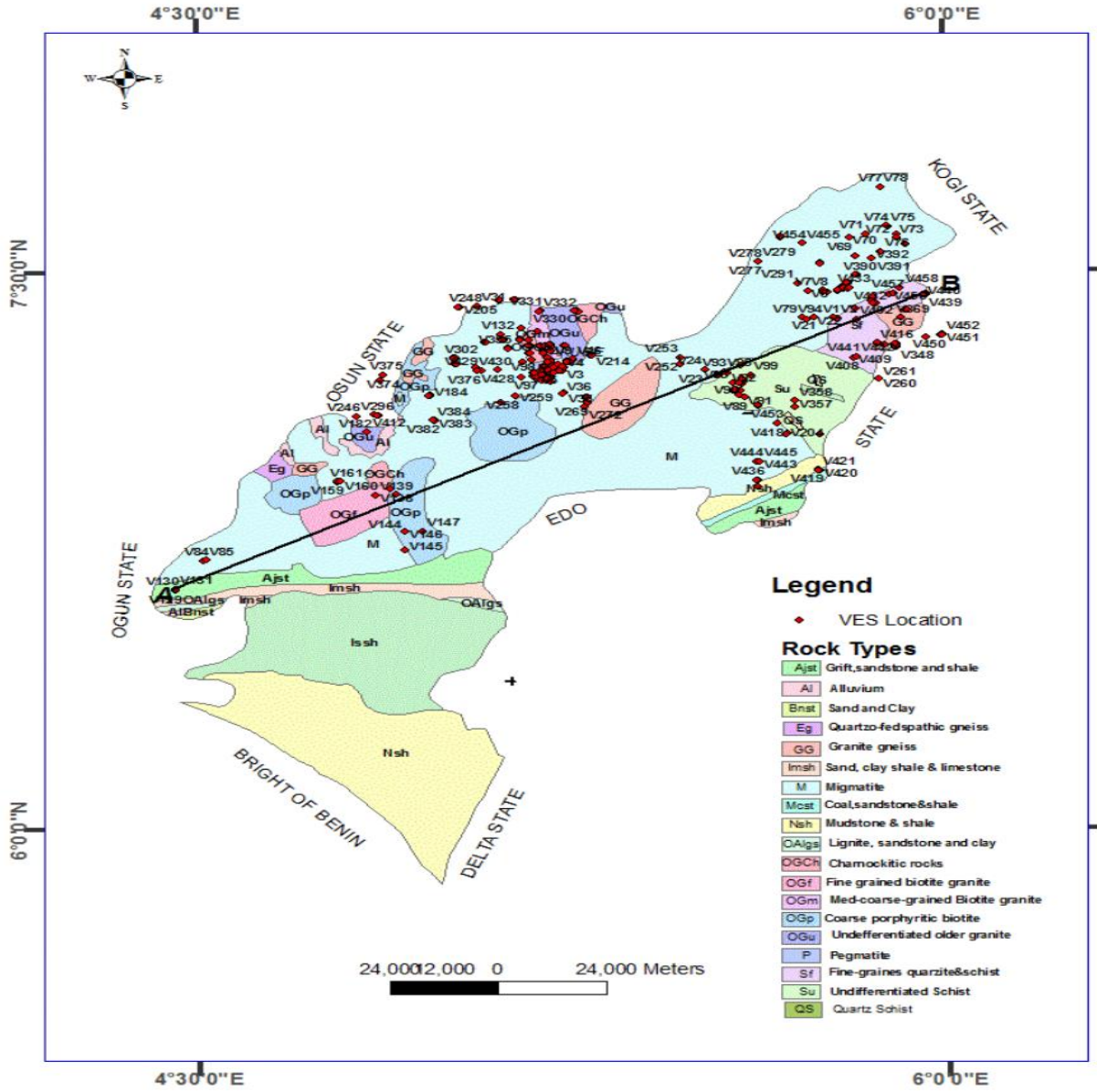

Fig. 1: Geological map of Ondo State (Adapted from NGSA, 2006)
Source: Mogaji, *et al.,* 2011

Data Analysis

Data obtained were analyzed using descriptive statistics that include the use of means and standard deviation. Also, one-way analysis of variance (ANOVA) was employed to test for the presence of significant difference. Where significant differences occurred, means separation was carried out with Duncan Multiple Range Test (DMRT).

Results and Discussion

The result in Table 1 shows that the farther the distance the higher the abundance of sand. The abundance of sand at 500 m and 1000 m is higher than that of the natural forest. The highest abundance of sand was 75.40 ± 5.00 at 1000 m North, while the lowest abundance of sand is 68.40 ± 2.00 in all directions at 0 m. The highest abundance of silt was 9.00 ± 1.73 at 0 m in the South, East and West directions, while the lowest abundance was 2.00 ± 1.00 at 1000 m northward. It's also shows that the lowest abundance of clay was 22.60 ± 2.65 and this was the same in all directions and distances, except at 0 m north which had the highest abundance of 23.10 ± 3.54 respectively. The

abundance of sand at all directions and distances was slightly lower than that of the natural forest. Table 1 below shows the result of organic carbon and it was recorded that the highest abundance of organic carbon was 1.91 ± 0.16 at 1000 m east, while the lowest abundance of 0.10 ± 0.02 was recorded at 0 m north. It also shows that the abundance was generally low at 0m compared to 500 m and 1000 m respectively. Abundance of organic matter was higher 3.22 ± 2.51 at 500 m west, while the lowest abundance was 0.35 ± 0.01 at 0 m north. It also shows that the abundance was high at 500m compared to 0 m and 1000 m respectively. From the table nitrogen was higher in all directions and distances (ranging from 0.24 ± 0.10 to 0.63 ± 0.05) than the abundance at the natural forest which is 0.17 ± 0.00. It also shows that the abundance was high at 500m compared to 0 m and 1000 m. Phosphorus was higher in all directions and distances (ranging from 3.11 ± 0.02 to 12.61 ± 0.02) than the abundance at the natural forest which was 2.88 ± 0.02. It also shows that the abundance of 5.37 ± 0.03/0.02 at 0m was same in all directions. Potassium was higher in all directions and distances (ranging from 0.09 ± 0.02 to 0.20 ± 0.02) than the abundance at the natural forest which was 0.07 ± 0.00. At 0 m West and 500 m south, the abundance was same at 0.16 ± 0.02.

Table 2 below shows that the farther the distance of the quarry, the higher the abundance of sand. The highest abundance of sand was 75.40 ± 0.00 at 1000 m north and 75.40 ± 2.65 at 1000 m west, while the lowest abundance was 66.40 ± 2.00 in all directions at 0 m. for silt the farther the distance, the lower the abundance of silt. The highest abundance of silt was 12.00 ± 1.00 in all directions at 0 m, while the lowest abundance was 2.00 ± 1.00 at 1000 m north and 2.00 ± 0.00 at 1000 m west. The highest abundance of clay was 22.60 same in all directions and distances with little differences in standard error, except at 1000 m north which had the lowest abundance of 22.00 ± 2.00. It also shows that the highest abundance of organic carbon was 1.70 ± 0.07 at 1000 m East, which was higher than the abundance at the natural forest, while the lowest abundance was 0.16 ± 1.12 at 0 m South. It also shows that the abundance was high at 500m compared to 0 m and 1000 m. The highest abundance of organic matter was 3.13 ± 0.01 at 1000 m east, which was higher than the abundance of 2.78 ± 0.01 at the natural forest, while the lowest abundance was 0.38 ± 0.11 at 0 m south. It also shows that the abundance was high at 500m compared to 0 m and 1000 m. Nitrogen was higher in all directions and distances (ranging from 0.31 ± 0.03 to 0.60 ± 0.01) than the abundance at the natural forest which was 0.19 ± 0.02, except at 1000 m West, where the abundance of nitrogen was 0.19 ± 0.05. At 500 m north and west the abundance was same at 0.34 ± 0.12. Phosphorus was higher in all directions and distances (ranging from 3.50 ± 0.02 to 7.39 ± 0.02) than the abundance at the natural forest which was 3.44 ± 0.02. It also shows that the abundance of 5.13 ± 0.02 at 0m was same in all directions. Potassium was higher in all directions and distances (ranging from 0.11 ± 0.02 to 0.18 ± 0.02) than the abundance at the natural forest which was 0.09 ± 0.02, except at 1000 m North, where the abundance of potassium was same as that of the natural forest.

Table 1: Mean Summary for Soil properties at 0 – 10 cm Soil Depth

	Direction	Sand (%)	Silt (%)	Clay (%)	Organic Carbon (%)	Organic Matter (%)	Nitrogen (%)	Phosphorus	Potassium
0m	North	68.40 ± 2.00^{a}	8.50 ± 2.12^{a}	23.10 ± 3.54^{b}	0.10 ± 0.02^{c}	0.35 ± 0.01^{c}	0.55 ± 0.01^{a}	5.37 ± 0.03^{a}	0.17 ± 0.01^{a}
	South	68.40 ± 2.00^{a}	9.00 ± 1.73^{a}	22.60 ± 2.65^{b}	0.20 ± 0.18^{c}	0.44 ± 0.16^{c}	0.54 ± 0.01^{a}	5.37 ± 0.02^{a}	0.16 ± 0.01^{a}
	East	68.40 ± 2.00^{a}	9.00 ± 1.73^{a}	22.60 ± 2.65^{b}	0.61 ± 0.89^{b}	1.18 ± 1.43^{b}	0.57 ± 0.05^{a}	5.37 ± 0.02^{a}	0.19 ± 0.04^{a}
	West	68.40 ± 2.00^{a}	9.00 ± 1.73^{a}	22.60 ± 2.65^{b}	0.67 ± 1.00^{b}	1.20 ± 1.47^{b}	0.46 ± 0.14^{a}	5.37 ± 0.02^{a}	0.16 ± 0.02^{a}
	Natural Forest (Control)	68.40 ± 3.00^{a}	6.00 ± 2.00^{a}	25.60 ± 2.00^{a}	2.25 ± 0.05^{a}	3.61 ± 0.01^{a}	0.17 ± 0.01^{b}	2.88 ± 0.02^{b}	0.07 ± 0.00^{b}
500m	North	74.40 ± 3.46^{a}	3.00 ± 1.00^{a}	22.60 ± 2.65^{b}	1.42 ± 1.14^{b}	2.51 ± 1.89^{b}	0.57 ± 0.04^{a}	6.53 ± 0.01^{a}	0.18 ± 0.01^{a}
	South	73.40 ± 3.00^{a}	4.00 ± 0.00^{a}	22.60 ± 2.65^{b}	1.24 ± 0.98^{b}	2.18 ± 1.61^{b}	0.58 ± 0.05^{a}	6.61 ± 0.01^{a}	0.16 ± 0.02^{a}
	East	73.40 ± 1.00^{a}	4.00 ± 1.00^{a}	22.60 ± 2.65^{b}	1.41 ± 1.13^{b}	2.50 ± 1.89^{b}	0.60 ± 0.06^{a}	6.14 ± 0.02^{a}	0.19 ± 0.02^{a}
	West	73.40 ± 2.65^{a}	4.00 ± 2.00^{a}	22.60 ± 2.65^{b}	1.84 ± 1.50^{b}	3.22 ± 2.51^{a}	0.43 ± 0.09^{a}	5.37 ± 0.01^{a}	0.13 ± 0.05^{a}
	Natural Forest (Control)	68.40 ± 3.00^{b}	6.00 ± 2.00^{b}	25.60 ± 2.00^{a}	2.25 ± 0.05^{a}	3.61 ± 0.01^{a}	0.17 ± 0.00^{b}	2.88 ± 0.02^{b}	0.07 ± 0.00^{b}
1000m	North	75.40 ± 5.00^{a}	2.00 ± 1.00^{b}	22.00 ± 2.00^{b}	0.95 ± 1.01^{c}	1.65 ± 1.71^{b}	0.53 ± 0.03^{a}	5.21± 0.02^{b}	0.14 ± 0.02^{a}
	South	73.40 ± 3.00^{a}	4.00 ± 1.00^{a}	22.60 ± 0.00^{b}	1.71 ± 0.07^{b}	2.93 ± 0.13^{b}	0.63 ± 0.05^{a}	12.61±0.02^{a}	0.20 ± 0.02^{a}
	East	73.40 ± 3.00^{a}	4.00 ± 1.00^{a}	22.60 ± 2.00^{b}	1.91 ± 0.16^{b}	3.11 ± 0.39^{a}	0.42 ± 0.16^{a}	3.97± 0.02^{b}	0.13 ± 0.04^{a}
	West	74.40 ± 3.46^{a}	3.00 ± 1.00^{a}	22.60 ± 2.00^{b}	0.99 ± 1.51^{c}	1.70 ± 2.60^{b}	0.24 ± 0.10^{b}	3.11± 0.02^{b}	0.09 ± 0.02^{a}
	Natural Forest (Control)	68.40 ± 3.00^{a}	6.00 ± 2.00^{a}	25.60 ± 2.00^{a}	2.25 ± 0.05^{a}	3.61 ± 0.01^{a}	0.17 ± 0.00^{b}	2.88± 0.02^{b}	0.07 ± 0.00^{a}

Note: *Note: Mean with the same letters in the same column is not significantly different*

Table 2: Mean Summary for Soil Properties at 10.1 – 20.00 cm Soil Depth

	Direction	Sand	Silt	Clay	Organic Carbon	Organic Matter	Nitrogen	Phosphorus	Potassium
0m	North	66.40 ± 2.00^{a}	12.00 ± 1.00^{a}	22.60 ± 1.00^{a}	0.83 ± 1.27^{b}	1.42 ± 1.91^{b}	0.39 ± 0.19^{a}	5.13±0.02^{a}	0.12 ± 0.04^{a}
	South	66.40 ± 2.00^{a}	12.00 ± 1.00^{a}	22.60 ± 1.00^{a}	0.16 ± 1.12^{b}	0.38 ± 0.11^{c}	0.50 ± 0.01^{a}	5.13±0.02^{a}	0.13 ± 0.03^{a}
	East	66.40 ± 2.00^{a}	12.00 ± 1.00^{a}	22.60 ± 1.00^{a}	0.20 ± 0.19^{c}	0.48 ± 0.27^{c}	0.52 ± 0.04^{a}	5.13±0.02^{a}	0.16 ± 0.04^{a}
	West	66.40 ± 2.00^{a}	12.00 ± 1.00^{a}	22.60 ± 1.00^{a}	0.62 ± 0.90^{b}	1.25 ± 1.62^{b}	0.43 ± 0.12a	5.13±0.02^{a}	0.13 ± 0.03^{a}
	Natural Forest (Control)	66.40 ± 2.00^{a}	9.00 ± 1.73^{b}	24.60 ± 0.00^{b}	1.62 ± 0.02^{a}	2.78 ± 0.01^{a}	0.19 ± 0.02^{b}	3.44±0.02^{b}	0.09 ± 0.02^{b}
500m	North	73.40 ± 3.00^{a}	4.00 ± 2.00^{b}	22.60 ± 3.00^{a}	1.34 ± 1.06^{a}	2.36 ± 1.71^{a}	0.34 ± 0.12^{a}	3.84 ± 0.02^{b}	0.12 ± 0.04^{b}
	South	72.40 ± 3.46^{a}	5.00 ± 2.00^{b}	22.60 ± 0.00^{a}	1.26 ± 1.00^{a}	1.07 ± 0.60^{b}	0.58 ± 0.09^{a}	7.23 ± 0.03^{a}	0.18 ± 0.02^{a}
	East	73.40 ± 0.00^{a}	4.00 ± 0.00^{b}	22.60 ± 0.00^{a}	1.24 ± 0.98^{a}	2.19 ± 1.56^{a}	0.40 ± 0.06^{a}	3.50 ± 0.02^{b}	0.12 ± 0.04^{b}
	West	71.40 ± 3.00^{a}	6.00 ± 2.00^{b}	22.60 ± 3.00^{a}	1.61 ± 1.30^{a}	2.85 ± 2.14^{a}	0.34 ± 0.12^{a}	3.97 ± 0.03^{b}	0.11 ± 0.05^{b}
	Natural Forest (Control)	66.40 ± 2.00^{b}	9.00 ± 1.73^{a}	24.60 ± 0.00^{a}	1.62 ± 0.02^{a}	2.78 ± 0.01^{a}	0.19 ± 0.02^{a}	3.44 ± 0.02^{b}	0.09 ± 0.02^{b}
1000m	North	75.40 ± 0.00^{a}	2.00 ± 1.00^{b}	22.00 ± 2.00^{a}	0.84 ± 0.94^{b}	1.46 ± 1.61^{b}	0.41 ± 0.14^{a}	4.87 ± 0.00^{b}	0.09±0.02^{b}
	South	72.40 ± 2.00^{a}	5.00 ± 0.00^{b}	22.60 ± 2.00^{a}	0.87 ± 0.84^{b}	1.02 ± 0.40^{b}	0.60 ± 0.01^{a}	7.39 ± 0.02^{a}	0.17±0.02^{a}
	East	73.40 ± 3.00^{a}	4.00 ± 0.00^{b}	22.60 ± 3.46^{a}	1.70 ± 0.07^{a}	3.13 ± 0.01^{a}	0.31 ± 0.03^{b}	3.58 ± 0.00^{b}	0.11±0.02^{b}
	West	75.40 ± 2.65^{a}	2.00 ± 0.00^{b}	22.60 ± 2.65^{a}	0.92 ± 1.27^{b}	1.61 ± 2.17^{b}	0.19 ± 0.05^{b}	5.06 ± 0.02^{b}	0.13±0.02^{b}
	Natural Forest (Control)	66.40 ± 2.00^{b}	9.00 ± 1.73^{a}	24.60 ± 0.00^{a}	1.62 ± 0.02^{a}	2.78 ± 0.01^{a}	0.19 ± 0.02^{b}	3.44 ± 0.02^{b}	0.09±0.02^{b}

Note: Mean with the same letters in the same column is not significantly different

The result on table 3 also shows the result of the soil parameters of both physical and chemical properties of soil as affected by the distance of the quarry and the result shows the soil depth at 20.1-30 cm respectively. The results revealed that the farther the distance of the quarry, the higher the abundance of sand (Table 3) below. The abundance of sand at 500 m and 1000 m was higher than that of the natural forest. The highest abundance of sand was 75.40 ± 1.73 at 1000 m west, while the lowest abundance of sand was 67.40 ± 0.00 in all directions at 0 m. silt was abundant 10.00 ±1.73 at 0 m in all directions, which was higher than the abundance of silt at the natural forest. The lowest abundance was 2.00 ± 1.00 at 1000 m west. The highest abundance of clay was 22.60 same in all directions and distances with little differences in standard error, except at 1000 m East and 500 m south which had the lowest abundance of 21.60 ± 2.00/3.00.

The abundance of sand at all directions and distances was slightly lower than that of the natural forest. Organic carbon has the highest at 1.63 ± 1.06 at 500 m west, while the lowest abundance was 0.27 ± 0.17 at 0 m south. It also shows that the abundance was low at 0m compared to 500 m and 1000 m. The highest abundance of organic matter was 2.81 ± 1.87 at 500 m west, while the lowest abundance was 0.64 ± 0.02 at 500 m south. It also shows that the abundance was low at 0m compared to 500 m and 1000 m. Abundance of nitrogen was higher in all directions and distances (ranging from 0.31 ± 0.08 to 0.54 ± 0.15) than the abundance at the natural forest which was 0.25 ± 0.02, except at 1000 m West, where the abundance of nitrogen was 0.20 ± 0.08. Phosphorus was higher than that of the natural forest (4.82 ± 0.02) in only three (3) locations, which were 6.84 ± 0.00 at 500 m north, 5.44 ± 0.02 at 500 m South and 14.58 ± 0.02 at 1000 m South. It also shows that the abundance of 3.73 ± 0.02 at 0m was same in all directions. potassium was higher than that of the natural forest (0.13 ± 0.02) in only four (4) locations, which were 0.17 ± 0.06 at 0 m East, 0.16 ± 0.05 at 500 m North, 0.20 ± 0.03 at 1000 m South and 0.16 ± 0.02 at 1000 m West. It also shows that the abundance of 0.13 ± 0.03/0.02 has more frequency at all the locations.

Table 4 shows the soil properties as affected by directions from the rock quarry. There was no significance difference in the sand and clay contents across the directions but the natural forest reserve contained the least amount of sand. The highest sand recorded at northern direction (720.7 g kg^{-1}) did not differ from the least obtained in the southern direction (707.3 g kg^{-1}). The clay and silt contents were highest in soils from the natural forest and significantly different from all the directions of the quarry site. Thus, the soils were sandy clay loams at the quarry site and natural forest. The quarry site contained significantly higher available P than the forest and differed across the directions with the highest value in the southern direction (7.57 mg kg^{-1}) and least in the east (4.38 mg kg^{-1}). The N content was highest in the southern direction (5.3 g kg^{-1}) which significantly differed from the other directions and the natural forest with the least value (2.0 g kg^{-1}). The exchangeable K in the southern direction was significantly higher than the other directions while the natural forest gave the least value (0.10 cmol kg^{-1}). The organic matter content was higher in the natural forest than all the other directions which gave similar values.

Table 5 shows the effects of sampling distance from the quarry on soil properties. The sand content was highest at 1000 m and did not differ from the value at 500 m while the natural forest had the least value. The silt was highest at 0 m in the quarry site and followed by the natural forest but least at 1000 m away from quarry site. The natural forest contained higher clay than the quarry site which had similar values at all the sampling distances. The available P was most abundant at 1000 m and differed significantly from other sampling distances while the natural forest contained the least amount. Total N and exchangeable K were significantly higher at all distances away from the quarry site than the natural forest but showed slight decrease with distance. The organic matter was highest at natural forest and differed significantly from all the distances but 0 m contained the least amount.

Table 3: Mean Summary for Soil Properties at 20.1 – 30 cm Soil Depth

0m	Direction	Sand	Silt	Clay	Organic Carbon	Organic Matter	Nitrogen	Phosphorus	Potassium
	North	67.40 ± 0.00^{a}	10.00±1.73^{a}	22.60 ± 0.00^{a}	0.79 ± 0.73^{b}	1.36 ± 1.24^{a}	0.33 ± 0.14^{a}	3.73±0.02^{a}	0.11 ± 0.04^{b}
	South	67.40 ± 0.00^{a}	10.00±1.73^{a}	22.60 ± 0.00^{a}	0.27 ± 0.17^{c}	1.06 ± 0.72^{a}	0.45 ± 0.06^{a}	3.73±0.02^{a}	0.12 ± 0.02^{b}
	East	67.40 ± 0.00^{a}	10.00±1.73^{a}	22.60 ± 0.00^{a}	0.46 ± 0.16^{b}	0.80 ± 0.26^{a}	0.50 ± 0.15^{a}	3.73±0.02^{a}	0.17 ± 0.06^{a}
	West	67.40 ± 0.00^{a}	10.00±1.73^{a}	22.60 ± 0.00^{a}	0.61 ± 0.42^{b}	1.05 ± 0.69^{b}	0.37 ± 0.07^{a}	3.73±0.02^{a}	0.13 ± 0.01^{b}
	Natural Forest (Control)	66.40 ± 1.00^{a}	9.00±1.73^{a}	24.50 ± 2.00^{a}	2.22 ± 0.02^{a}	3.53 ± 0.01^{a}	0.25 ± 0.02^{a}	4.82±0.02^{a}	0.13 ± 0.02^{b}
500 m	North	73.40 ± 0.00^{a}	4.00 ± 2.00^{b}	22.60 ± 3.00^{a}	1.59 ± 1.03^{b}	2.74 ± 1.81^{a}	0.54 ± 0.12^{a}	6.84 ± 0.00^{a}	0.16 ± 0.05^{a}
	South	71.40 ± 2.00^{a}	7.00 ± 1.00^{b}	21.60 ± 3.00^{a}	0.37 ± 0.03^{c}	0.64 ± 0.02^{a}	0.36 ± 0.04^{a}	5.44 ± 0.02^{a}	0.13 ± 0.03^{b}
	East	72.40 ± 3.00^{a}	5.00 ± 0.00^{b}	22.60 ± 2.00^{a}	1.13 ± 0.63^{b}	1.93 ± 1.11^{a}	0.38 ± 0.02^{a}	4.59 ± 0.00^{a}	0.13 ± 0.03^{b}
	West	71.40 ± 2.65^{a}	6.00 ± 0.00^{b}	22.60 ± 1.00^{a}	1.63 ± 1.06^{b}	2.81 ± 1.87^{a}	0.31 ± 0.08^{a}	4.12 ± 0.02^{a}	0.13 ± 0.03^{b}
	Natural Forest (Control)	66.40 ± 1.00^{b}	9.00 ± 1.73^{a}	24.50 ± 2.00^{a}	2.22 ± 0.02^{a}	3.53 ± 0.01^{a}	0.25 ± 0.02^{a}	4.82 ± 0.02^{a}	0.13 ± 0.02^{b}
	North	74.40 ± 4.00^{a}	3.00 ± 1.00^{c}	22.60 ± 3.46^{a}	1.14 ± 1.05^{b}	2.51 ± 1.08^{a}	0.52 ± 0.08^{a}	4.20±0.02^{b}	0.11 ± 0.05^{b}
	South	71.40 ± 2.65^{a}	6.00 ± 1.73^{b}	22.60 ± 1.00^{a}	0.55 ± 0.15^{c}	0.93 ± 0.29^{b}	0.54 ± 0.15^{a}	14.58±0.02^{a}	0.20 ± 0.03^{b}
1000 m	East	71.40 ± 1.73^{a}	7.00 ± 1.00^{b}	21.60 ± 2.00^{a}	1.22 ± 0.26^{b}	2.11 ± 0.42^{a}	0.31 ± 0.08^{a}	3.42±0.02^{b}	0.10 ± 0.02^{b}
	West	75.40 ± 1.73^{a}	2.00 ± 1.00^{c}	22.60 ± 0.00^{a}	1.04 ± 1.06^{b}	1.78 ± 1.82^{a}	0.20 ± 0.08^{a}	3.73±0.02^{b}	0.16 ± 0.02^{a}
	Natural Forest (Control)	66.40 ± 1.00^{b}	9.00 ± 1.73^{a}	24.50 ± 2.00^{a}	2.22 ± 0.02^{a}	3.53 ± 0.01^{a}	0.25 ± 0.02^{a}	4.82±0.02^{b}	0.13 ± 0.02^{b}

Note: Mean with the same letters in the same column is not significantly different

Table 4: Soil physical and chemical properties at different cardinal directions of the quarry site

Direction	Sand (g kg^{-1})	Silt (g kg^{-1})	Clay (g kg^{-1})	Textural Class	Available P (mg kg^{-1})	Total N (g kg^{-1})	Exchangeable K (cmol kg^{-1})	Organic matter (g kg^{-1})
North	720.7a	53.9^{d}	225.2^{b}	SCL	5.08^{b}	4.6^{b}	0.13^{b}	18.2^{b}
South	707.3a	68.9^{b}	224.9^{b}	SCL	7.57^{a}	5.3^{a}	0.16^{a}	11.8^{b}
East	710.7a	65.6^{bc}	224.9^{b}	SCL	4.38^{c}	4.5^{b}	0.15^{d}	19.4^{b}
West	715.1a	60.0^{cd}	226.0^{b}	SCL	4.40^{bc}	3.3^{c}	0.13^{c}	19.4^{b}
Natural Forest	670.7b	80.0^{a}	248.9^{a}	SCL	3.71^{d}	2.0^{d}	0.10^{e}	29.8^{a}
SE±	4.6	2.8	4.0		0.00	0.2	0.01	2.6

Mean values with the same letters are not significantly different (P<0.05)
SCL= Sandy clay loam

Table 5: Soil physical and chemical properties at various distances from the quarry site

Distance	Sand (g kg^{-1})	Silt (g kg^{-1})	Clay (g kg^{-1})	Textural Class	Available P (mg kg^{-1})	Total N (g kg^{-1})	Exchangeable K (cmol kg^{-1})	Organic matter (g kg^{-1})
0 m	673.3^{b}	98.3^{a}	230.9^{b}	SCL	4.54^{c}	4.1^{a}	0.14^{a}	12.0^{c}
500 m	716.7^{a}	53.3^{c}	229.9^{b}	SCL	5.02^{b}	4.0^{a}	0.14^{a}	24.6^{b}
1000 m	724.5^{a}	45.3^{d}	229.1^{b}	SCL	5.52^{a}	3.7^{b}	0.13^{a}	22.6^{b}
Natural Forest	670.7^{b}	80.0^{b}	248.9^{a}	SCL	3.71^{d}	2.0^{c}	0.10^{b}	29.8^{a}
SE±	3.6	2.2	3.0		0	0.1	0.00	2.0

Means with the same letters are not significantly different (P<0.05) SCL= Sandy clay loam

Table 6 shows the effect of quarrying activities of the properties of soils at various depths. The contents of the particle sizes differed significantly with sand highest at 0-10 cm depth which 10-20 and 20-30 cm contained the highest silt while clay did not differ with depth in the quarry site. The natural forest contained the least amount of sand but highest silt and clay but the values show that the quarry site and forest had sandy clay loams. The available P, total N and exchangeable K were more abundant at 0-10 cm soil depth and somewhat decreased with depth in the quarry site. The natural forest contained the least available P, total N and exchangeable K but had the highest amount of organic matter which did not differ significantly with soil depth in the quarry site.

Table 6: Soil properties at different depths in the quarry site and natural forest

Soil depth (cm)	Sand (g kg^{-1})	Silt (g kg^{-1})	Clay (g kg^{-1})	Textural Class	Available P (mg kg^{-1})	Total N (g kg^{-1})	Exchangeable K (cmol kg^{-1})	Organic matter (g kg^{-1})
0-10	713.3^{a}	54.3^{c}	231.9^{b}	SCL	5.31^{a}	4.4^{a}	0.14^{a}	21.8^{b}
10-20	701.3^{b}	71.3^{b}	229.6^{b}	SCL	4.69^{c}	3.7^{b}	0.13^{b}	17.8^{b}
20-30	700.0^{b}	71.3^{b}	228.4^{b}	SCL	5.09^{b}	3.7^{b}	0.14^{ab}	19.6^{b}
Natural Forest	670.7^{c}	80.0^{a}	248.9^{a}	SCL	3.71^{d}	2.0^{c}	0.10^{c}	29.8^{a}
SE±	3.6	2.1	3.0		0	0.1	0.00	10.2

Means with the same letters are not significantly different (P<0.05) SCL= Sandy clay loam)

Discussion

The physical properties of the soil at the quarry site of percentage sand, silt and clay that are present in the soil at the quarry site that were considered for this research, these parameters were measured and it was discovered that for percentage sand as reported in result of tables 4, 5 and 6 show that there is significant difference. The result shows that quarry activities affected the abundance of sand in the study area because sand was significantly lower than the natural forest when compared them in relation to their direction. Thus, it is therefore reported from the research that sand, silt and clay from the table 4, 5 and 6 above were significantly difference from the result of natural forest when compared. Bewekta and Stroosnijder (2003),

Martinez-Mena *et al.* (2008) showed the same results in their studies therefore the result of the two researchers agreed with the finding of this result. Also, the result of Kiakojouri and Taghavi, (2014) show a similar result with this research, in their own research, there is a shift from one agricultural system such as shifting cultivation, mixed farming to another in the level of the soil physical properties therefore, it can be justified that by decreasing the SOM and soil aggregate sustainability during the changes in the direction and distance to the soil surface, amount of erosion increases and consequently during the erosion clay and silt are separated and move to the downstream area (Celik, 2005;

Bewekta and Stroosnijder, 2003). Due to these reasons the physical properties in the west direction were completely higher than other direction this can be due to the movement of the erosion towards the west direction (Table 4) so that during the movement amount of clay at both of 0-10 cm and 10-20 cm as well as 20-30 cm depth have no significant difference but it increased with increase in depth in the quarry site (Kiakojouri and Taghavi Gorgi, 2014) Also, the result shows that quarry activities affected the abundance of clay and other physical properties as examined in this study. More so, this is similar to the result of (Paramesha *et al,* 2006 and Babitha *et al*, 2017) who reported that the substantial amount of coarse and fine sand is getting added into the soil by quarry activities this is due to the fact that during quarry, more particle were added when there is breaking of the rocks.

The result of phosphorus from this research is shown in tables 4, 5 and 6 above the results shows that there were significant differences in the abundance of phosphorus at the direction, distance away from the quarry site as well as soil depth. The result of the phosphorus was higher at southern direction. Also, the abundance of phosphorus was more at all the directions, distances and soil depths than the natural forest. Phosphorus was more abundant at the South direction, 1000 m away from the quarry site and at 0-10 cm soil depth respectively. The lowest abundance was at east direction, 0 m which was on the quarry site and 10.1-20 cm soil depth. Phosphorus (P) is also a key nutrient for agricultural yields and is essential in assessments of how soil is healthy.

Along with nitrogen, P is the main nutrient that limits the agricultural yields, especially in highly weathered, oxidic soils, where the major part of the total soil P is fixed in clay minerals and oxides. The available P in the soil solution is present as orthophosphates, but the microbial P and organic-P are also stocks that can rapidly become available. Procedures for assessment of P availability have been well established (Pankhurst *et al.*, 2003; Zhang *et al.*, 2006a). Though the available P mean value of 6 mg kg^{-1} was found in this research for surface soils though it is below the limitation as the value is below 15 mg kg^{-1} as recorded by (Holland *et al.*, 1989) and higher than the result of (Ezenwa, *et al.*, (2014);

Unanaonwi and Amonum (2017) in their experiment. There is significant difference in the abundance of nitrogen. Also, the abundance was more at all the directions, distances and soil depths than the natural forest ecosystem. Nitrogen was more abundant at the South direction, 0 m which was on the quarry site and at 0-10 cm soil depth respectively. The lowest abundance was at West direction, 1000 m away from the quarry site and at the 10.1-20 cm and 20.1-30 cm soil depth respectively. Though, nitrogen (N) is the most required plant nutrient, which is found in several chemical forms in soil (Cantarella, 2007), resulting in a very dynamic behavior. Soil nitrogen has been assessed mainly as mineral N, especially nitrate, organic N or potentially mineralizable N, as stored in the soil organic matter. There is significant difference in the abundance of potassium. Also, the abundance was more at all the directions, distances and soil depths than the natural forest. It was observed that there was slight difference in the abundance of phosphorus at all the directions, distances and soil depths. Potassium was more abundant at the South direction, both 0 m which was

on the quarry site and 500 m having same values and at 0-10 cm and 20.1-30 cm soil depth having same values. The lowest abundance was at West direction, 1000 m away from the quarry site and 10.1-20 cm soil depth. It was observed that the abundance of Phosphorus, Nitrogen and Potassium were higher than that of the natural forest.

More so, it was shown on tables 4, 5 and 6 there is significant difference in the abundance of organic carbon compared to the natural forest. Arif *et al.*, (2013) reported that quarry activities resulted in to loss of organic carbon and other vital nutrient in the soil. Though, there is no significant difference in its abundance in the directions and soil depth. It was recorded that soil organic carbon is also a key attribute in assessing soil health, generally correlating positively with crop yield (Bennett *et al.*, 2010). With this record it was revealed that this quarry site will not support the growth of crops compared to the forest soil and if the plants or crops were planted they will experience a stunted growth. As shown on Tables 4, 5 and 6 there is significant difference in the abundance of organic matter compared to the natural forest, but there is no significant difference in its abundance in the directions and soil depth, which further explains that the effect of the quarry activities on the percentage of organic carbon at the directions and soil depths was the same.

Conclusion

This study had revealed the impact of quarry activities on the physical and chemical properties of soil in the study site. Results from the study revealed the implication of the quarry activities based on the distance of the quarry as well as the depth of the soil on the impact of physical and chemical properties of the soil. The main impacts of the quarrying activities on the environment are the broadcasts of dusts and gases. These particles or dusts are very numerous and varied. Thus, quarry activities had significant effects on the on the soil properties of the study area. The top soil had more life form than the lower layers. The abundance of sand, phosphorus, nitrogen and potassium was higher at the quarry site than that of the natural forest. Quarry activities affect the abundance of organic carbon and organic matter.

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Climate Change Impacts on Ecosystem Services and Livelihoods of Fringe Forest Communities in Ondo State, Nigeria.

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Abstract

The changing climate from natural, but more from anthropogenic factors as indicated by global warming, unusual rainfall regimes and rising atmospheric carbon dioxide levels already affects agricultural production such that measures for climate change adaptation and mitigation are being emphasized. This study examined the impacts on of climate change on ecosystem services and livelihoods, and the adaptation and coping strategies in two forest communities of Ondo State, Nigeria. Primary data were obtained from 80 randomly selected respondents in four fringe communities of Ala and Akure Forest Reserves using a pre-tested and validated semi-structured interview schedule and subjected to quantitative statistical analysis. Sixty year-climate data obtained from Climate Research Unit of East Anglia, Norwich, UK showed that average temperature increased significantly while the increase in rainfall was insignificant and with high variability over the period for the study area. The forest communities derive provisioning, regulating, cultural and supporting services from the forest reserves with the most important ecosystem services being provisioning and supporting services at 63 and 53% ranking respectively. Almost all the respondents (95%) were aware of the changing climate and identified that crop farming was the livelihood most affected even as 49% attributed a reduction in soil fertility to it. Furthermore, climate change has reduced the natural ability of the forests to provide ecosystem services especially provisioning and regulating services in the study areas. Members of the forest communities have adopted various on-farm and off-farm adaptation strategies to cope with the changing climate and to improve their livelihoods.

Key words: Climate change, ecosystem services, forest communities, livelihoods, Nigeria

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Introduction

Climate change is a serious challenge facing the world today with its impacts felt in all facets of life. According to Staudinger *et al* (2012), climate change has documented impacts on biodiversity with a focus on genes, species, and assemblages of species, ecosystem structural elements and functions of various ecological systems. These impacts are expected to increase as climate change continues and perhaps even accelerates. Climate change may be due to natural internal processes, external forcing and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2014). However, human activities such as burning of fossil fuels, deforestation and growing world population are the main causes of the changes seen in the climate today (IPCC, 2007). The emission of greenhouse gases (GHG) and global warming largely result from the industrial activities in developed countries but the effects are felt in developing countries where the livelihoods of the poor are severely at risk (McGuigan *et al.,* 2002). The impacts of climate change in developing countries could be dramatic, particularly with regard to marginal regions and highly vulnerable poor communities

(Boon and Ahenkan, 2011). For example, over 250,000 Nigerians were displaced by flood disasters that ravaged many communities across the country in 2010 (NEMA, 2010).

Human well-being and progress towards sustainable development are vitally dependent upon the earth's ecosystem services (IPCC, 2007). According to MEA (2005), the ecosystem services are the benefits people obtain from ecosystems which include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational and other cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on earth.

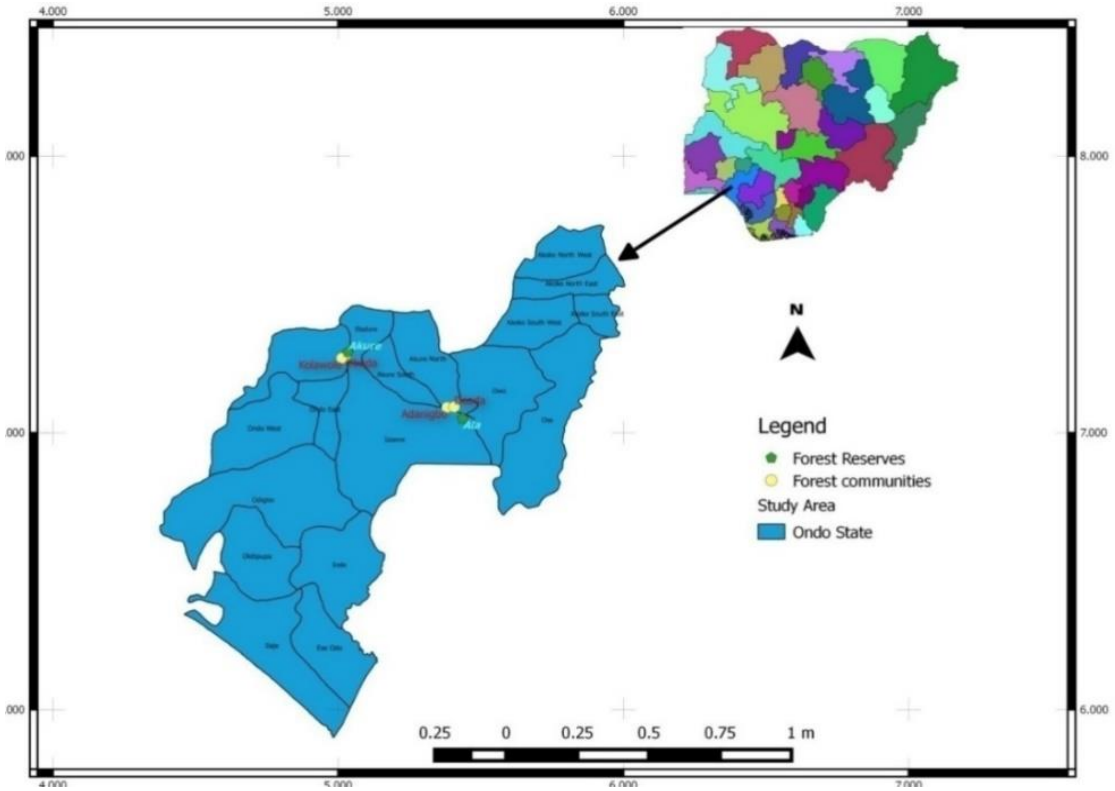

Fig. 1: Map of Nigeria showing the study area

Over one billion people rely heavily on forests and its services for their livelihoods (World Bank, 2004). The forests serve as carbon sinks and provide climate regulating services locally and globally (Bonan, 2008). However, the ecosystems, biodiversity and the services they support are intrinsically dependent on climate (Karevia *et al.*, 2012). The natural and agricultural ecosystems, including freshwater and coastal resources, are highly susceptible to the effects of climate change and the impacts of changing climate are already being experienced in Nigeria (NIMET, 2016). Ding *et al.* (2010) reported that the declining productivity and deterioration of forest ecosystems is a central concern to millions of people, whose livelihoods depend on them. There is the need to assess the impacts of climate change on the ecosystem services in order to explore the ecological, socio-cultural and economic values of the ecosystem services which, in turn, would facilitate planning and formulation of strategies and policies to safeguard valuable ecosystems, livelihoods, human well-being and environment at large (MEA, 2005). This study was carried out to assess the impacts of climate change on the ecosystem services and livelihoods in two forest communities of Ondo State, Nigeria, and the adaptation and coping strategies put in place to mitigate the negative effects.

Materials and Methods

Description of study area

This study was carried out in Akure and Ala Forest Reserves in Ondo State. The reserves are within the tropical rainforest ecosystem of Nigeria. Akure Forest Reserve (lat. 7.16°-7.29° N; long. 5.034°-

5.083º E) experiences humid tropical climate with seasonal variation. The mean annual rainfall is about 1600 mm with double maximum in July and September separated by a short relatively dry period in August while December-February constitutes the major dry season in which January and February as the driest months receive less than 30 mm rainfall (Akinyemi and Oke, 2014). Temperature ranges from about 20.6ºC to 33.5ºC which provides a conducive condition to the development of tropical rain forest. Ala Forest Reserve (lat. 6.75º-7.00º N; long. 5.00º-5.17º E) is 166 km^2 in size and divided into 100 annual coupes of productive forest for effective management (Adekunle, 2006). It was constituted as a government reserve by Order No.21 of 1950 and published in gazette No. 35 of 29th June, 1950.

Method of data collection

This study made use of primary and secondary data. The primary data were collected from stakeholders and community dwellers in the forest communities with the aid of a semi-structured questionnaire and focus group discussions. Two communities in each forest reserve were purposively selected based on proximity to the forest reserve and accessibility. In all, four communities: Adanigbo, Daada, Kolawole and Obada were selected from within and around the forest reserves. The coordinates of each forest reserve and selected communities were obtained using a hand-held Global Positioning System unit. Pre-tested and validated semi-structured questionnaire were administered to 20 dwellers in each community (at 10 to men and women) for a total of 80 interview schedules while two forest officials in each reserve were interviewed. Only community members who were above 40 years old were interviewed based on the assumption that younger people have less experience on climate change impacts.

The secondary data were in form of climate data, literature, research reports and published articles relevant to the specific issues of the study. Climate data on the spatiotemporal pattern of temperature and rainfall of Nigeria were obtained from the Global Gridded Climatology (CRU TS 3.21) presented at a new high resolution (0.5º latitude /longitude) and made available by the Climate Impacts LINK project, Climate Research Unit (CRU), University of East Anglia, Norwich, UK (Mitchell and Jones, 2005). The 0.5º-resolution dataset of monthly surface-based climate parameters covered the 1953-2012 period (60 years). The reference CRU grid stations used for this study were Oba-Ile (lat. 5.25º N, long. 7.27º E) and Deji Camp (lat. 5.78º N, long. 7.20º E) for Akure and Ala Forest Reserves respectively.

Data analysis

The interview schedules completed for each of the communities and respondents were scored to obtain quantitative values for statistical analysis. The quantitative information was analyzed using Statistical Package for Social Sciences (SPSS 16.0). Descriptive analysis in form of frequency, percentage distribution, tables and bar charts were used to analyze socio-economic and demographic variables of respondents. Quantum Geographic Information System (GIS) software package was used to produce the thematic maps of the study area. The climate data were subjected to time series and regression analyses using Microsoft Excel software. Temperature data were averaged while rainfall data for each gridded point stations were summed for the period of 60 years (1953-2012). The Mann-Kendall non-parametric test was used to analyze trends direction.

Results and Discussion

Long-term temperature and rainfall patterns

The temporal time series distribution and cumulative departures of mean annual temperature are shown in Fig. 2. There was a positive trend in annual temperature with ranges for the 60 year-period of 29.7º-31.9ºC and 31.4º-32.2ºC which indicate increases of 2.2º and 0.8ºC for Akure and Ala forest reserves respectively. Odjugo (2005) reported temperature increases of 1.2ºC in Port Harcourt, a coastal city in Rivers State, and 2ºC for Nguru, a semi-arid city in Yobe State, Nigeria between 1901 and 2005. This confirms the widespread increase in global temperature in recent decades but the values are higher than the global mean temperature increase of 0.74ºC recorded since 1860 when the scientific

measurement started (IPCC, 2007; Fan *et al.,* 2010) and exceed the increasing trend in air temperature of 0.036ºC in Nigeria from 1991-2000 (Akinsanola and Ogunjobi, 2014). There was no significant increase in the mean annual rainfall for the study locations. The minimum annual rainfall for Akure and Ala forest reserve was 1088.5 mm and 1231.3 mm respectively and the rainfall patterns showed very high variability in total precipitation volumes from year to year. The average negative deviation from the historical mean of 805.33 mm year^{-1} was -105.3% while the average positive deviation was 120.9 percent. Anuforum (2010) had indicated established cases of approximately 1.2ºC increase in temperature and rainfall variability in the Niger Delta region which includes parts of Ondo State.

The rising temperatures can have adverse effects on crop growth and the irregularity of rainfall, even if total precipitation is sufficient, can affect yields adversely if the rains fail to arrive during the crucial crop growth stage and consequently affect the livelihoods of the forest community dwellers.

Respondents' knowledge of ecosystem services

Out of the 80 respondents, 90% in Ala and Akure forest reserves had crop farming as the primary livelihood while 5 and 8% were into trading in Akure and Ala forest reserves respectively. The other primary livelihood activities in the study area were sales of Non-Timber Forest Products (NTFPs), sewing and teaching.

Ecosystem goods and services contribute significantly to the daily needs and livelihoods of the forest communities either directly or indirectly (Boon and Ahenkan, 2011). Table 1 shows the ecosystem goods and services identified to be very important to respondents in the study ar

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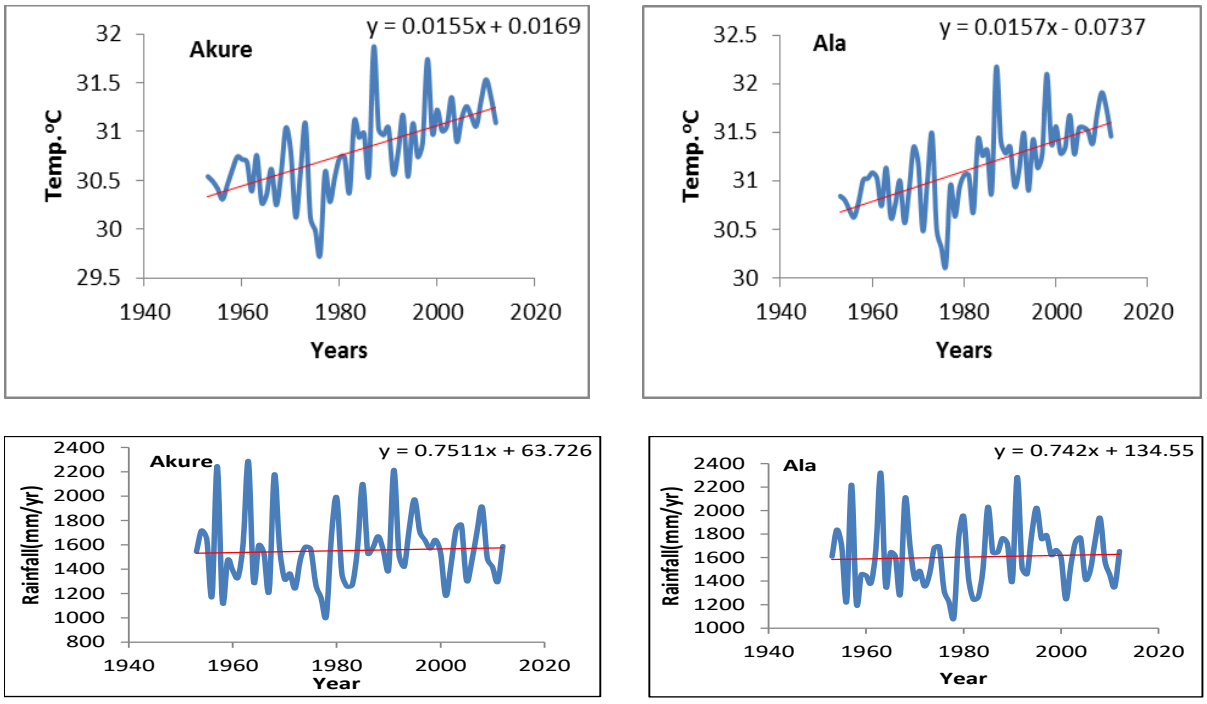

Fig. 2: Time series plot of mean annual temperature and rainfall between 1953 and 2012 for Akure and Ala forest reserves

Rain-fed agriculture (crop farming) constituted the primary and secondary sources of income in the forest communities indicating dependence on forest supporting ecosystem services for livelihoods which can be adversely affected by changes in the climate variables. Ozor (2009) noted that variations in rainfall pattern will affect crop production in different ways depending on the location and that changes in crop development and phenology as a result of climate change can

cause shortening or lengthening of crop cycles which could lead to decreases or increases in productivity.

Table 1: Ecosystem goods and services identified by the forest community dwellers

Provisioning Goods		
Foods	Medicine	Other goods
Bush meat	Barks	Fuel wood
Honey	Leaves	Timber
Wild fruits	Seeds	Grinders
Fish	Roots	Chewing sticks
Fresh water	Fruits	Building materials
Mushrooms	Animal products	Other goods
Snails		
Spices		
Kolanuts		
Regulating Services	Cultural Services	Supporting services
Air quality regulation	Spiritual values, Religious values	Photosynthesis
Local climate regulation	Recreation	Soil formation
Erosion regulation	Tourism	Nutrient cycling
Water purification	Habitats for Gods	
Pest and disease regulation	Coronation materials	

Use of provisioning ecosystem services

A high dependence on provisioning forest ecosystem services was observed in the study area (Fig. 3) at 70 and 60% of the respondents in Akure and Ala forest reserves respectively. The provisioning ecosystem services were utilized for domestic purposes only by 25 and 37%, and for commercial purposes only by 5 and 3% of the respondents in Akure and Ala forest reserves respectively. Boon and Ahenkan (2011) reported high utilization of forest ecosystem services for both domestic and commercial purposes. Mamo *et al.,* (2007) and Tesfaye *et al.,* (2011) noted this direct-use value of forest provisioning ecosystem services in households as a key determinant of their value, both in consumption and as a source of income

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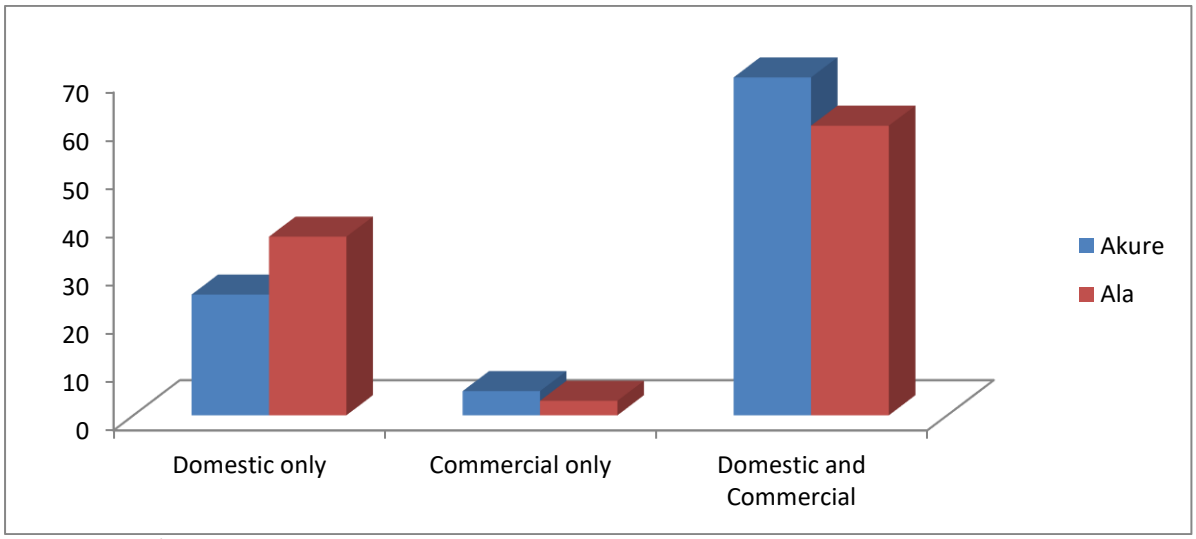

Fig. 3: Use of provisioning ecosystem service in the study area

Awareness of climate change impacts by respondents in the fringe forest communities

Majority of the respondents, almost all (98%) and 88% of the respondents in Ala and Akure forest reserve respectively, were aware of climate change in the study area (Fig. 4) and had observed the effects of increasing temperature, higher intensity of rainfall and seasonal change in rainfall patterns. This high level of awareness is similar to reports by Falola and Fakayode (2014) and Oluwatusin (2014) which indicated 80.8% and 96.9% awareness of climate change among cocoa farmers in Ondo State respectively. The World Bank (2007) had noted that most farmers in Africa are aware of the effects and existence of climate change occurrence in their areas.

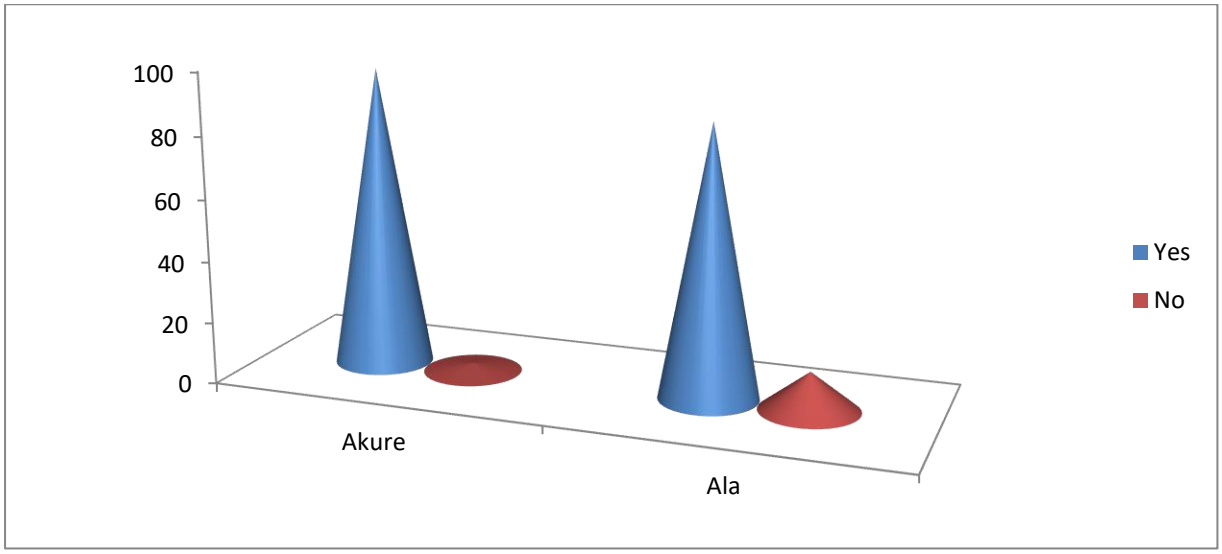

Fig. 4: Awareness of climate change in the study area

Perception of change in temperature by respondents

The results show that majority of the respondents in the study area were aware of temperature change in the study area (Fig. 5). A high proportion of the respondents (68 and 65%) perceived an increase in the average temperature in their communities but 30% and 22.5% perceived a decrease in the average temperature while 2.5% and 12.5% of the respondents did not observe any change in the average temperature in Akure and Ala forest reserves respectively. This is similar to the report of a study by Adekunle *et al.* (2011) carried out in South-west, Nigeria. Also, Lyimo and Kangalawe (2010) observed that 90% of the farmers in Shinyanga rural District, Tanzania acknowledged that there had been a change in climatic condition.

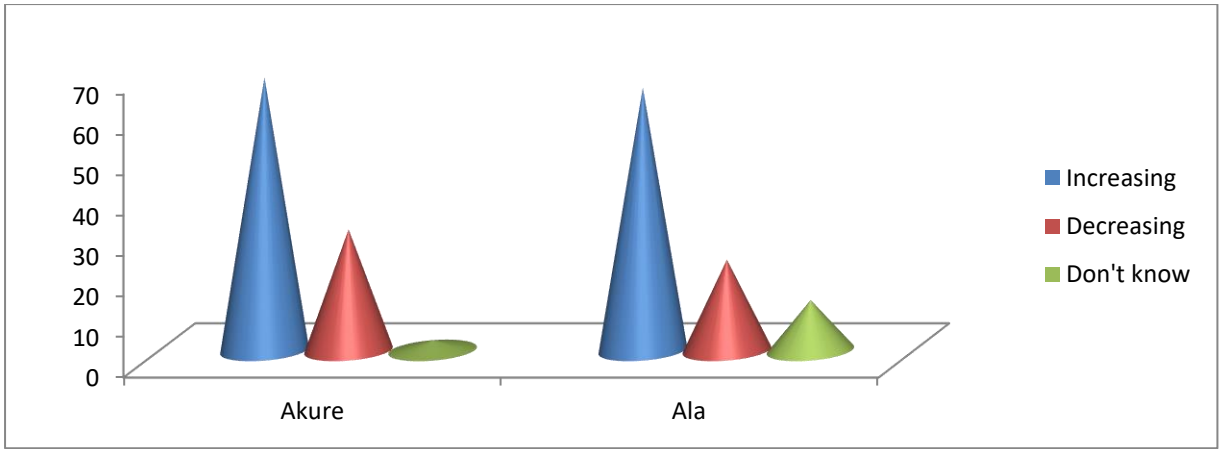

Fig. 5: Temperature change as perceived by respondents

Perception about length of rainy season and rainfall pattern

The perception of the length of the rainy season is presented in Fig. 6. A larger proportion of respondents (55% and 82.5%) claimed experiencing longer rainy seasons compared to 43 and 5% of the respondents who perceived shorter rainy seasons in Akure and Ala forest reserves respectively). The perception of changes in rainfall patterns (Fig 7) was irregular as indicated by 53 and 63%, regular by 45 and 25% while 3% and 13% could not clearly state the current rainfall pattern in Akure and Ala forest reserves respectively.

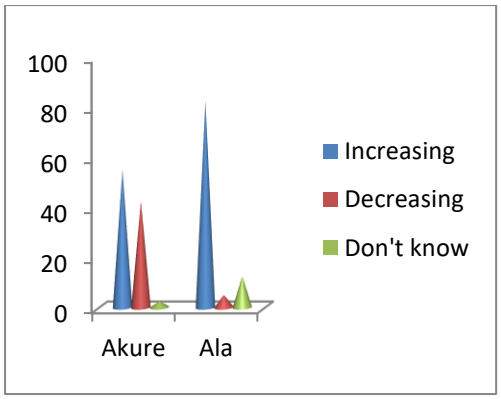

Fig. 6: Perception of rainy season lengths

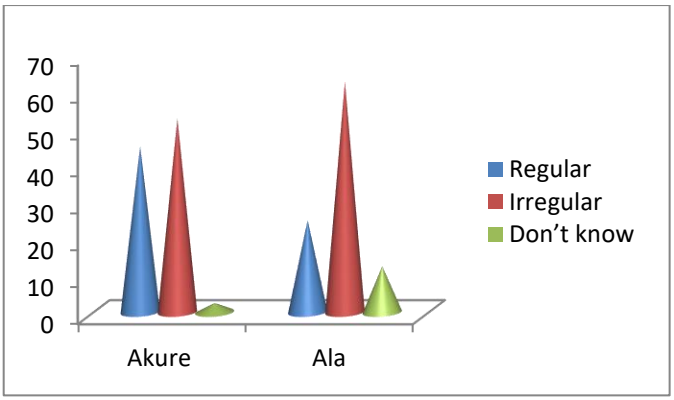

Fig.7: Perception of rainfall pattern

Perceived effects of climate change on ecosystem services in the study area

Table 2 shows the respondents' perception of the effects of climate change on ecosystem services in the study area. Majority of the respondents (53% and 55% in Akure and Ala forest reserve respectively) attributed reduced soil fertility to the change in climate. This could have resulted from the irregular rainfall and increase in temperature. Conant *et al.* (2011) noted that high temperature increases the decomposition rate of soil organic matter which on the long run will adversely affect soil fertility. The reduction in water availability was attributed to climate change by 3% of the respondents in both forest reserves while 7.5 and 10% of the respondents in Akure and Ala forest reserves reported increase in incidence of malaria fever attacks respectively. The increased incidence of pest and diseases due to climate change was reported by 10 and 8% of the respondents in Ala and Akure forest reserves respectively. Dhillon and Sharma (2013) had noted that temperature increases tend to extend the geographic range of some insect pests. However, 8 and 5% of the respondents perceived that the change in climate brought about reduced bush meat availability whereas 7.5 and 2.5% of the respondents in Akure and Ala forest reserve respectively did not perceive

any effect of climate change on ecosystem services in the study area

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Table 2: Perceived effects of climate change on ecosystem services

	Akure		Ala	
Effect of climate change	**Frequency**	**%**	**Frequency**	**%**
Reduced air quality	2	5	4	10
Increased incidence of pests and diseases	3	7.5	4	10
Reduced water availability	3	7.5	3	7.5
Reduced soil fertility	21	52.5	22	55
Reduced availability of bushmeat	3	7.5	2	5
Increased malaria incidence	5	12.5	4	10
No effect	3	7.5	1	2.5
Total	40	100	40	100

Perceived effects of climate change on livelihood activities

The livelihood activities of the forest communities are presented in Table 3. The most observed effect of climate change was crop failure which affected majority of the respondents which engaged in crop production as the main means of livelihood. Crop failure as a consequence of climate change was indicated by 18 and 30% of respondents while increase in the spoilage of stored produce was noted by 18 and 23 % of the respondents in Akure and Ala forest reserves respectively. The increased spoilage of crops such as cocoa and maize had a negative effect on the income generation of the forest community dwellers. A reduction in animal productivity was reported by 5 and 2.5% of the respondents in Akure and Ala forest reserves respectively while 17.5% of respondents in Ala forest reserve and 5% in Akure forest reserve attributed the decline in NTFPs to climate change effects. This crop failure and spoilage of stored produce were some of the deleterious effects of climate change on production reported by 80.8% of the cocoa farmers in Ondo State (Falola and Fakayode, 2014). The potential of climate change to bring about reduction in soil nutrient availability was reported by 10 and 17.5% of the respondents in Ala and Akure forest reserves respectively. Molua and Lambi (2006) had observed that performance of the agriculture sector depends largely on the return of good rains but which are not assured under changing climate scenarios in agreement with the projection of Assuncao and Feres (2008) that average agricultural output ha^{-1} in Brazil could decrease by 18% due to climate change by the year 2040.

Focus group discussions also revealed the impact of changing climate on the adequate processing and storage of some crop produce especially the drying of cocoa beans, maize grains and cassava mash thereby lowering the quality and quantity of output for sale such that income generation from such sales would decline. Nhemachena *et al. (*2010) and Deressa *et al.* (2009) had observed that climate change would have adverse economic impacts on crop and livestock production systems. About 13% of respondents in Akure forest reserve agreed that climate change caused increase in crop productivity while only 5 and 2.5% of the respondents in Akure and Ala forest reserves respectively stated that the changing climate had no effect on their livelihood activities.

On-farm adaptation strategies employed in the study area

Table 4 shows that various on-farm adaptation strategies have been employed by the respondents to cope with the changes in climatic conditions across the study area. Majority of the respondents (78 and 75% in Ala and Akure forest reserves respectively) changed the usual planting date of the main crops as a measure to cope with the impacts of climate change. Adekunle *et al* (2011) observed that the commonest adaptation method adopted by respondents in Southwest Nigeria was the choice of different planting dates for some crops

due to irregular rainfall. The control of pests and diseases through agrochemical sprays was adopted by 52.5 and 62.5% while fertilizer application was the practiced by 50 and 40% of the respondents in Akure and Ala forest reserves respectively.

Table 3: Effects of climate change on livelihood activities

Effects of Climate change	Akure Frequency	%	Ala Frequency	%
Crop failure	7	17.5	11	27.5
Increased spoilage of stored produce	7	17.5	9	22.5
increased disease spread	3	7.5	3	7.5
Decline in NTFP'S	2	5	7	17.5
Reduced Soil nutrient availability	7	17.5	4	10
reduced animal productivity	2	5	1	2.5
Increased productivity of crops	5	12.5	0	0
Inability to process farm produce effectively	2	5	4	10
No effect	5	12.5	1	2.5
Total	40	100	40	100

Agroforestry was adopted by 47.5 and 40% of the respondents in Akure and Ala forest reserves respectively while other on-farm adaptation strategies employed include application of manure, planting improved crop varieties, improved cultural services and mixed cropping. Ayanwuyi *et al.* (2010) and Falola and Fakayode (2014) observed that various on-farm adaptation strategies such as mixed cropping, planting different crop varieties, changing the planting and harvesting dates, crop protection with agrochemicals and water management among others are the practical measures used by farmers to mitigate the negative effects of climate change.

Off-farm adaptation strategies employed in the study area

Table 5 shows the off-farm adaptation strategies used by the forest community dwellers to cope with the impacts of changing climate. Half of the respondents in Akure forest reserve and 62% in Ala incorporated other non-farm income sources to their livelihood's activity as an adaptation strategy. About 25% and 58% of the respondents adopted local networks for exchange of useful on-farm adaptation techniques in Akure and Ala forest reserves respectively. Also, 23% and 43% of the respondents in Akure and Ala forest reserves respectively claimed to have temporarily migrated while 48 and 60% changed to other sources of income as adaptation measures to the climate change. Only 5% of the respondents in Akure forest reserve and none in Ala forest reserve tried to reduce household consumption as an adaptation strategy to climate change because many already have very little to feed on as the forest communities are home to some of the poorest and most vulnerable people (World Bank, 2001).

Table 4: On-farm adaptation strategies employed by forest community dwellers

Adaptation Strategies	Akure Frequency	%	Ala Frequency	%
Agroforestry	19	47.5	16	40
Fertilizer application	20	50	18	45
manure application	13	32.5	10	25
Improved cultural practices	20	50	14	35
Mixed cropping	9	22.5	10	25
Change in planting date	31	77.5	30	75
Planting improved crop variety	15	37.5	16	40
Use of agro-chemicals	21	52.5	25	62.5

Table 5: Off-farm adaptation strategies employed by forest community dwellers

Adaptation Strategies	Akure Frequency	%	Ala Frequency	%
Local networks for exchange of useful on-farm adaptation techniques	10	25	23	57.5
Temporal migration	9	22.5	17	42.5
Changes to other forms of non-farm income sources	27	67.5	24	60
Incorporation of other non-farm income sources with farming	20	50	25	62.5
Reduction of household consumption	2	5	0	0
Listening to information about climate change	5	12.5	5	12.5

Conclusion

Climate change is no doubt one of the greatest environmental threats with social and economic impacts on the livelihoods of people especially forest dependent communities in developing countries. The observed climate change from the statistical analysis of 60-year rainfall and temperature records for the study area was consistent with the forest community dwellers' perception of climate change and variability. The changing climate was identified by the rising temperature, higher amounts of rainfall and their variability. The study shows that the forest reserves are providing ecosystem services, especially provisioning services in the form of food, medicine, building materials etc. to the forest communities. The major source of livelihood in the forest communities was rain-fed agriculture whose productivity is determined by climatic factors such that climate change, especially reduction in amount and unusual distribution of rainfall, were associated with low yields and crop failure. It was revealed that climate change is impacting on rural livelihood activities as well as bringing about changes in the forest ecosystem. Although the forest communities have adopted various on-farm and off-farm adaptation strategies, they are still very vulnerable due to their high dependence on forest ecosystem services and their low capacity to adapt to climate change impacts. Further studies should be carried out to ascertain the factors that determine the choice of adaptation strategies being used to cope with climate change effects in the study area.

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Heavy Metal contents of Cocoa (*Theobroma cacao* L.)Beans and Plantation Soils in Ondo State, Nigeria

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Abstract

The use of pesticides to increase and stabilize cocoa production has become a global concern because portions applied to the foliage and pods end in the plantation litter and soils for uptake by the crop. The resultant heavy metal contamination of the soils has implications for product quality and food safety. This study assesses the heavy metal contents of surface layer (0-15 cm) and subsoil (15-30 cm) samples of soils in plantations and the parts of cocoa beans in Ondo State, Nigeria. The samples were collected from nine villages across three Local Government Areas and analyzed for the heavy metals using standard laboratory procedures. 90 copies of type 1 questionnaire were administered on 10 randomly selected farmers per village and 10 copies of type 2 questionnaire administered on 3 or 4 store keepers. Descriptive statistics of frequency counts, percentage, means and standard deviation were used to analyze the responses while data of heavy metals were subjected to analysis of variance. The average age, farm size and family size were 52±14 years, 9±13 acres and 6±2 persons, respectively. The farmers were males (87.8%) with formal education (91.5%), had used seeds harvested from plantations for planting (74.4%) and adopted 1111 seedlings ha-1 (90.3%). Only 47.6% used fertilizers and the main products were NPK 15-15-15 and NPK 20-10-10 mainly at 2 bags acre-1. The heavy metal contents of the soils were higher at 0-15 cm than 15-30 cm and the values significantly differed ($p<0.05$) among the locations. The order of abundance was Cu > Pb > Cd with Cu and Cd (detected in one location) above the permissible limits of 140 and 3 mg kg-1 respectively. The whole bean, testa and kernel were contaminated with Pb in all locations while Cu contamination of the whole bean and testa was in 3 and 2 locations respectively. The threat posed to market demand by quality and food safety concerns means that farmers should adhere to the recommended types and doses of pesticides to reduce heavy metal contamination while all stakeholders should monitor the cocoa from production through processing to packaging for the market.

Keywords: Cocoa beans, cocoa kernel, cocoa testa, heavy metals, Ondo State

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Introduction

The squash-like pods (fruits) of the cocoa tree (Theobroma cacao L) that grow proximal to the trunk and thicker branches contain the beans (seeds) which are extracted, fermented and sun-dried. The beans constitute an important agricultural commodity and key raw material in the food industry, mainly for the production of chocolates

(UNCTAD, 2006) and in the manufacture of pharmaceutical and cosmetic products (Mcshea et al., 2008; Fowler, 2009). Cocoa powder is used in confectioneries, production of cocoa wine and spirits (liqueur), and as flavour in biscuits, ice cream, and dairy drinks while cocoa butter is used in the manufacture of soaps and cosmetics. The nutritional value relates to the richness in energy and amino acids, high levels of mineral and vitamins while the flavonoids (polyphenols) account for the health benefits, especially in the suppression of cardio-vascular diseases, cancer and several age-related degenerative diseases (Cooper, 2008; Afoakwa, 2008).

Cocoa is crucial to the Nigerian economy as the leading non-oil (agricultural) export commodity and for poverty alleviation (Ibiremo et al., 2014). The estimated annual production was 420,000 tons (t) in the 1960s but with the advent of crude petroleum as highest source of government revenue, the cocoa output progressively declined to 170,000 t in 1999. Several initiatives and policies meant to address the problems of low agricultural expenditure and output, import substitution and adoption of modern best farm practices stimulated cocoa output which attained 485,000 t in 2006 but declined to 238,000 t in 2012/2013, 236,521 t in 2016 and 240,000 t in 2017/2018 as the 5th world producer (FAOSTAT, 2017; factfish, 2018).

The producers are estimated 300,000 dispersed small-scale farmers who own <2 ha holdings (farms or plantations) in the 14 cocoa-producing states but with two-thirds living in Ondo, Ogun, Ekiti, Oshun and Oyo States and accounting for 60% of national output (Adelodun, 2017). The yield is below 500 kg ha-1 of raw beans year-1 and the output declined progressively due to erratic rainfall from climate change, fire outbreaks, soil fertility depletion, ageing trees and farmers, labour scarcity and cost, poor adoption of improved plantation management strategies and pests and diseases (Cadoni, 2013). Phytophthora pod rot or black pod disease, caused by the fungus Phytophthora palmivora, is the most widely-distributed disease of cocoa in plantations established in wet humid areas which, if uncontrolled, can cause up to 75% yield loss (Akrofi et al., 2003). The major insect pests of cocoa are the mirids (capsids): brown mirid (Sahlbergella singularis and black mirid (Distantiella theobroma) and cocoa mosquito (Helopeltis bergrothi) which feed on pods, chupons and fresh shoots with the feeding injury acting as entry points to die-back fungus (Calonectria rigidiuscula) that causes the death of shoots from the tips (Opeke, 2003). The other insects are Earias biplaga whose caterpillars burrow into and destroy buds or eat some of the leaves during the rainy season and cocoa mealy bugs- Planococcoides njalensis, Planococcus citri and Ferrisiana virgata – which are vectors of the virus that cause cocoa swollen shoot disease. The commonest black pod disease control strategy among farmers in Nigeria is the monthly spray of copper-based fungicides (lime-bordeaux mixture, carbide-bordeaux mixture, cuprous oxide etc) and various insecticides whose amounts used have increased progressively since the 1950s (CRIN, 2003, Aikpokpodion et al., 2013). Asogwa and Dongo (2009) observed that the various pesticides used in cocoa production accounted for 31% of the total agrochemical market in Nigeria and this consisted of insecticides and fungicides at 35 and 65% respectively.

The use of pesticides to increase and stabilize crop production has become a global concern because of the issues related to sustainable environmental and food safety. A substantial portion of the foliar applied pesticides, enters the soil through spray drift and as wash-off from leaves and pods by rain and dew such that only 15% stays in the crop and taken up by the plant cells while the rest ends in the plantation litter and soils (Mabbett, 1984). The eventual accumulation of heavy metal impurities have impacts on the crop, animals and man through the food chain. The heavy metals are non-biodegradable and persistent environmental pollutants but at low concentrations, some- copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) - are essential for normal biochemical and physiological processes. Others- arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr), lead (Pb) etc- play no essential roles in plants and animals (Benavides et al., 2005) but can bio-accumulate to toxic levels. Reis et al. (2015) noted that stress from Pb toxicity led to structural changes of the mesophyll, cell membrane disorganization, unfavourable chloroplast development, changes in the mitochondria and outbreak of the nuclear membrane in root cells of cocoa plant. The heavy metals can accumulate in different human organs to produce deleterious/toxic effects. Exposure to excess Pb can cause hematic, renal and gastro-intestinal damages while effects on the nervous

system include headache, poor attention, spasm, irritability, dullness and memory loss (CDC, 2001). Cu poisoning symptoms include abdominal pain, nausea and non-persistent vomiting (ATSDR, 2008) while Cd can produce renal tubular dysfunction, formation of kidney stones, disturbance of calcium metabolism, and skeletal, endocrine, reproductive and respiratory defects (Järup and Åkesson, 2009; WHO, 2010). The toxic effects of heavy metals on human health have attracted global attention. The European Commission set maximum tolerance/permissible levels for contaminants and Cd in foodstuffs and a pronouncement to implement regulations governing chocolate and cocoa products that contain excessive Cd levels from 1st January 2019 (EU, 2014). The Codex Alimentarius Commission of the Joint FAO/WHO Standards Programme has a proposed draft on the maximum levels for Cd in chocolate and cocoa derived products which will have significant economic and social consequences on the cocoa producing and exporting countries.

The demand of the global community for cocoa products from Nigeria, reputed for the aroma is threatened by quality problems, especially the presence of heavy metals at elevated levels in the cocoa beans. There are continued efforts to raise the farmers' awareness in appropriate use of pesticides as part of improved farm practices, fermentation and drying, preparation and packaging which affect the flavour. Ondo State is the largest producer of cocoa in Nigeria with annual output of about 90,000 t (Cadoni, 2013) from plantations on which substantial amounts of pesticides are used to raise cocoa output for poverty alleviation. This study was conducted to evaluate the level of compliance of cocoa farmers and store keepers to the recommended pesticide dosages and the levels of heavy metals in the plantation soils and different parts of the cocoa bean in Ondo State, Nigeria.

Materials and Methods

Sample Sites

This study was carried out in three of the aforementioned Local Government Areas (LGAs) of Ondo State (Fig. 1); Akure South, Idanre and Ile-Oluji/Oke-igbo based on their high cocoa output. Three cocoa plantations were selected in each LGA namely: Akure South (Iwoye 7° 12 N 5° 6 E), (Ago Akure 7° 13 N 5° 6 E) and (Ago Store 7° 13 N 5° 2 E); Idanre (Owena - CRIN 7° 11 N 5° 5 E), (Oke Maye 7° 10 N 5° 2 E) and (Ola'nika 7° 10 N 5° 2 E); Ile-oluji/Oke-igbo (Oke'risa 7° 20 N 4° 55 E), (Agric. Farm Settlement 7° 17 N 4° 56 E) and (Eyin'gun 7° 16 N 5° 0 E). .

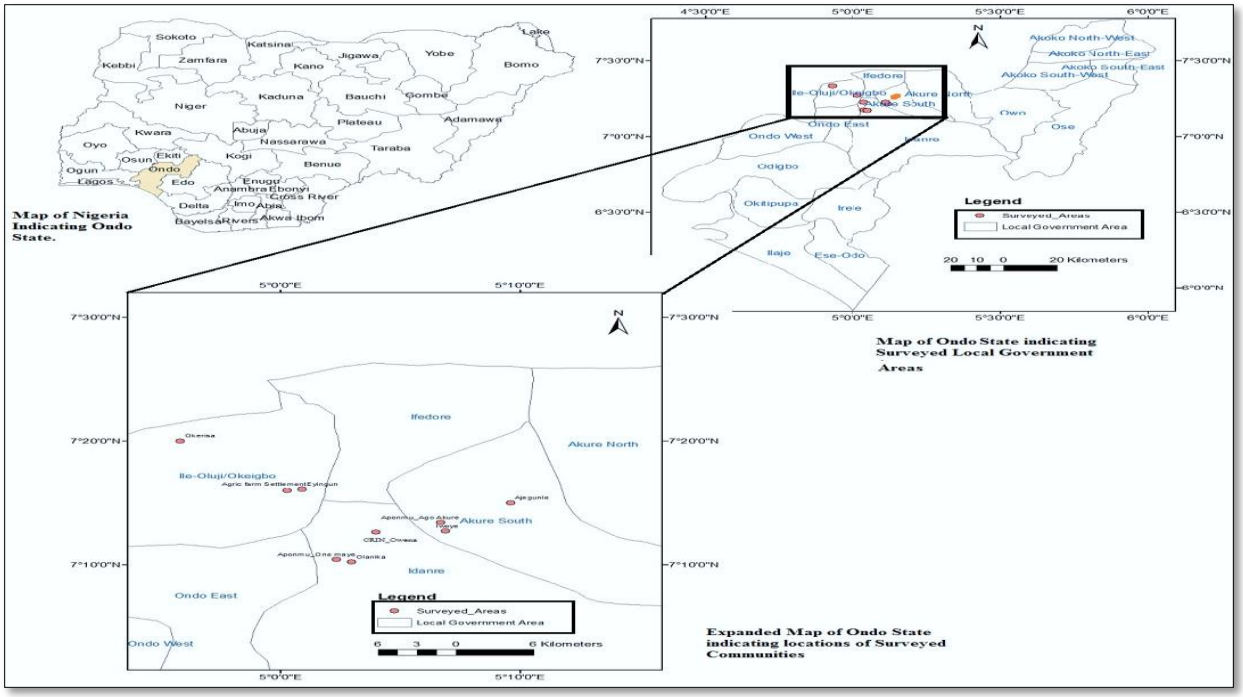

Fig. 1: Map of Ondo State indicating the surveyed Local Government Areas.

Data collection method

Two sets of well-structured and validated questionnaire were prepared for the study. The first set was administered on 90 randomly-selected farmers (10 per farming village or study site) to determine the attitude and perception towards pesticides usage and the level of compliance with the types and doses recommended by Cocoa research Institute of Nigeria (CRIN). The second type was administered on 10 store keepers at 3 per study site (except Ile-Oluji with 4). Out of the 100 copies only 82 were retrieved.

Collection of cocoa bean samples

Sun-dried cocoa beans were collected from 9 cocoa-growing villages. The cocoa bean heap from each farm was divided into three equal parts and three samples were collected from the top, middle and top portions, and bulked to form a 500 g composite sample from each of the 9 sites. The cocoa beans were further air-dried to constant weight at 84% relative humidity and stored in well-labeled sample bags.

Collection of soil samples from cocoa plantations

Soil samples were collected randomly less than 1 m away from cocoa trees at 0-15 and 15-30 cm depths in three points on each plantation using a calibrated Dutch auger. The samples were bulked to form a composite for each depth and from which 2 kg sub-sample was taken and kept in well-labeled sample bag. The soil samples were air-dried and stored for laboratory analysis.

Soil pH was determined with a glass electrode pH meter in 1: 4 soil: water paste.

Heavy metal determination in soil and cocoa bean samples

The soil samples were passed through 0.5 mm sieve and 1 g portion was weighed into 50 ml flask, digested in 20 ml of nitric acid and perchloric acid (3: 1 mixture) by boiling gently on a hot plate and 20 ml de-ionized water added followed by boiling again. The digest was cooled, filtered and make up to mark in a 25 ml standard flask with de-ionized water. The Cd, Cu and Pb were determined on Atomic Absorption Spectrophotometer.

Air-dried cocoa bean samples (whole bean, kernel and testa) were milled and homogenized, and 0.5 g samples were weighed into 30 ml porcelain crucibles and placed in muffle furnace set at 450-500^{o}C for 6-8 h. the ashed samples were cooled and 5 ml of 1N HNO3 added followed by evaporation to dryness on a hot plate at low heat. The samples were returned to the furnace and heated at 400^{o}C for 10-15 minutes until perfectly while or greyish ash was obtained. The samples were cooled and 10 ml of 1N HCl added to dissolve the ash, and followed by filtration into 25 ml volumetric flask. The crucible and filter paper were washed with portions of 0.1N HCl to make up to mark. The Cd, Cu and Pb were determined on the Atomic Absorption Spectrophotometer.

Statistical analysis

The questionnaire responses were analyzed for descriptive statistics of means, frequencies, percentages and standard deviation using IBM SPSS Statistical 20.0 Package. The data of heavy metals were subjected to Analysis of Variance (ANOVA) using DSAASTAT and the means were separated with Duncan's Multiple Range Test (DMRT).

Results and Discussion

Table 1 shows the demographic features of the respondents. The >53 years age bracket made up 50% of the respondents while the mean age was 52±14 years. This means that the respondents were beyond the active and productive ages in agreement with the ageing farmer population identified as one of the constraints of the cocoa industry (Nwachukwu et al., 2010; Cadoni, 2013). The mean age obtained in this study agrees with 51 years reported by Tijani (2006) as the age of cocoa farmers in Ondo State. Ayinde et al. (2013) noted that 58% of the cocoa producers in Obafemi Owode LGA, Ogun State aged between 61 and 70 years. The farmers were mostly male (87.8%) which agrees with dominance of males in cocoa production observed in Ogun, Osun, Edo, Kwara and Ondo States at 75.0, 97.5, 96.7, 83.3 and 88.0% respectively (Ogunjimi and Farinde, 2012; Mokwunye et al., 2012, Tijani, 2006). The farm size was mainly 1-13 acres (85.4%) and averaged 9±13 acres which confirm the small scale nature of cocoa production carried out at on atomistic farms (Tijani, 2006; Adelodun 2017) average farm size at 9±13 acres confirms that reports cocoa production is still largely on a small scale and carried out at the initiative of atomistic producers (Tijani, 2006; Adelodun 2017). The household size of 6-7 persons (46.7%) and average at 6±2 persons are low compared to household size of in Obafemi Owode

LGA, Ogun State. Almost all the respondents had formal education (91.5%) with 39% each at the primary and secondary levels. Tijani (2006) noted that cocoa farmers in Ondo State were literates with majority able to read and write in Yoruba language whereas Mokwunye et al. (2012) found low literacy levels among most cocoa farmers in Ogun, Osun and Kwara States.

Table 1: Demographic information of the respondents

Variables	Categories	Frequency	Percentage	Mean	SD
Age	25-38	13	15.9	52	14
	39-52	28	34.1		
	53 and above	41	50.0		
Sex	Male	72	87.8		
	Female	10	12.2		
Farm size	1-13	70	85.4	9	13
(acres)	14-26	11	13.4		
	27-39	0	0.0		
	40 and above	1	1.2		
Family size	2-3	5	6.1	6	2
	4-5	30	36.6		
	6-7	35	42.7		
	8-9	6	7.3		
	10 and above	6	7.3		
Educational	No formal education	7	8.5		
background	Primary education	32	39.0		
	Secondary education	32	39.0		
	Tertiary education	11	13.5		

Source: Field survey, 2019

Table 2 shows that 42.7% of the respondents had cultivated cocoa for 10-20 years, 54.9% cultivated the Amazon variety, 74.4% planted previously harvested seeds and 90.3% planted at the recommended 1,111 plants ha-1 population. Tijani (2006) noted that 58% of farmers in Ondo State had over 20 years of experience and Ayinde at al. (2013) reported 48 years of experience. These are in conformity with the average age of the farmers in each study. Most of the farms still contained the Amazon unlike in Ogun State where 78% cultivated the hybrid varieties which were attributed to farmers' attendance of agricultural extension and enlightenment programmes. More than half (52.4%) of the respondents did not use fertilizer. The most used fertilizers were NPK 15-15-15 and NPK 20-10-10 by 51.3 and 30.8% of those who applied fertilizers while manure and compost were not popular. Fertilizers were used mainly by 33.3 and 30.8% of respondents at 2 and 0.5 bags acre-1 respectively while only 2.6% used 4 and 10 bags

Table 3 shows that 80.5% of the respondents used manual weed control method, identified termites as the major pests (65.9%) and black pod was the main disease of cocoa (93.9%). Most respondents adopted chemical control for insects (85.4%) and other pests (98.8%). The fungicides used were ultimax plus (63.4%) and red force (45.1%) at 1 sachet in 15 l of water (70.7%) while the dominant insecticide was cypermethrin (68.3%) applied at 1 insecticide cap in 15 l of water (56.1%). Most of the fungicides are in the CRIN recommended list and doses. The ultimax plus used by most respondents is also approved by the Standards Organization of Nigeria whereas red force, a popular brand is not listed and should be screened for effectiveness by CRIN with a view to approving its adoption. Natural pesticides (bio-pesticides) are being developed and promoted because they do not leave deleterious residues in soils and plants or negative impacts on food and the environment (Asogwa and Dongo, 2009; Fayinminnu et al., 2017).

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Table 2: Enterprise characteristics of respondents

Variables		Frequency	Percentage
Period of cultivation cocoa	< 10 years	7	8.5
	10-20 years	35	42.7
	20-30 years	15	18.3
	30-40 years	11	13.4
	> 40 years	14	17.1
Variety of cocoa cultivated*	Amelonado	25	30.5
	Amazon	45	54.9
	Hybrib	35	42.7
Sources of cocoa seeds*	Previously harvested seeds	61	74.4
	Local seed retailers	12	14.6
	Imported seed	2	2.4
	CRIN	5	6.1
	ADP	3	3.7
Number of cocoa seedlings planted	< 1000	1	4.8
	1000	3	3.7
	1111	74	90.3
	1500	1	1.2
Fertilizer application	Yes	39	47.6
	No	43	52.4
Type of fertilizer*	NPK 15-15-15	20	24.4
	NPK 20-10-10	12	14.6
	Compost	2	2.4
	Farm yard manure	5	6.1
Quantity of fertilizer applied	One quarter bag	5	6.1
	Half bag	12	14.6
	1 bag	5	6.1
	2 bags	13	16.0
	3bags	2	2.4
	4bags	1	1.2
	10bags	1	1.2

Source: Field survey 2019

Table 4 shows the heavy metal contents at different soil depths in the cocoa plantations. The Pb and Cu were higher in the 0-15 cm depth except Pb at Eyin'gun while Cd was only detected 0-15 cm depth in Iwoye. Renan (1994) had reported higher values of Pb and Cu in the 0-15 cm than 15-30 cm depth which suggests the source of exposure to be anthropogenic. Savithri et al. (2003) noted that the build-up of Cu is more in the agricultural surface soil (0-15 cm) without evidence of its accumulation at depths below 25 cm within the profile. The Pb and Cu contents in the soils varied significantly ($p<0.05$) among the plantation sites. The 0-15 cm soil depth at Iwoye contained the highest Cu (363.55 mg kg-1) which differed significantly from Ago Akure (339.75 mg kg-1) and the highest Pb (79.31 mg kg-1) that was significantly higher than Owena (29.25 mg kg-1) and Ola'nika (29.00 mg kg-1). Ago Akure contained the highest Cu (122.40 mg kg-1) in the 15-30 cm depth, which differed from Iwoye (106.60 mg kg-1) while the highest Pb at Eyin'gun (33.55 mg kg-1) differed significantly from Owena (25.40 mg kg-1). The least Pb values in both soil depths were in Agric Farm Settlement and Cu in Oke'risa. The order of abundance at Cu > Pb > Cd is consistent with the copious foliar spray of Cu-based fungicides in the plantations which get deposited in the soil through rainfall and dew (Aikpokpodion et al., 2010). The soil Cu levels in Ago Akure, Ago Store, Iwoye, Okemaye and Owena are higher than the permissible level at 140 mg kg-1 and the Pb levels in all the plantations below the permissible level at 300 mg kg-1 while Cd at Iwoye exceeded the 3.0 mg kg-1 limit (EU, 2014).

Table 3: Types and level of pesticide use

Variables		Frequency	Percentage
Method of weed control	Weeding	66	80.5
	Chemical application	16	19.5
Associated pest affecting cocoa production*	Termites	54	65.9
	Rodents	30	36.6
	Fungi	21	25.6
Type of disease encountered*	Cocoa black pod	77	93.9
	Cocoa mired (capsid)	16	19.5
Method of insect control	Farm sanitation	2	2.4
	Trap setting	10	12.2
	Chemical method	70	85.4
Method of controlling other pest	Chemical method	81	98.8
	Gamalin	1	1.2
Type of herbicides used*	Glyphosate/touchdown/round up/clear weed	8	9.8
	Paraquat	13	15.9
	Atrazine	3	3.7
	None	59	72.0
Concentration of herbicides used	Half milk tin	1	1.2
	1 milk tin	8	9.8
	2 milk tin	1	1.2
	Half pesticide cap	1	1.2
	1 pesticide cap	10	12.2
	2 pesticide caps	2	2.4
Type of fungicides used*	Ridomil gold plus	29	35.4
	Red force	37	45.1
	Mackecknie gold	6	7.3
	Champ DP	2	2.4
	Kocide 2000	1	1.2
	Ultimax plus	52	63.4
	None	2	2.4
Concentration of fungicide applied per 15L of water	Half sachet	19	23.2
	1 sachet	58	70.7
	2 sachets	3	3.7
Type of insecticides used*	Actara 25 WG	22	26.8
	Proteus 170	1	1.2
	Cypermethrin	56	68.3
	Chlorpyriphos	3	3.7
	Gamalin	1	1.2
	None	3	3.7
Concentration of insecticides used	12g	1	1.2
	1 milk tin	9	11.0
	2 milk tin	2	2.4
	1 pesticide cap	46	56.1
	2 pesticide caps	4	4.9
	One sachet	16	19.5
	2 sachets	1	1.2

Table 4: Levels of heavy metals at different soil depths on cocoa farms from nine study areas in Ondo State

Heavy metals	Pb (mg/kg)		Cu (mg/kg)		Cd (mg/kg)	
Depth	15 cm	30 cm	15 cm	30 cm	15 cm	30 cm
Ago Akure	18.00d	17.70c	339.75b	122.40a	ND	ND
Ago store	26.20c	16.50c	174.30c	31.90f	ND	ND
Agric Farm S.	5.90f	5.35d	42.75g	30.90f	ND	ND
Eyingun	18.75d	33.55a	25.35h	19.35g	ND	ND
Iwoye	79.31a	16.65c	363.55a	106.60b	8.63	ND
Okemaye	12.30e	7.75d	154.65d	86.80d	ND	ND
Okerisa	12.80e	6.15d	18.45i	15.50h	ND	ND
Olanika	29.00b	16.30c	120.60h	95.10c	ND	ND
Owena	29.25b	25.40b	145.55e	69.05e	ND	ND
*EU STD	300	300	140	140	3	3

Values with the same letter within a column are not significantly different at $p<0.05$, *EU STD (2001) = European Union Standard, ND = Not Detected

Table 5 shows the Pb, Cu and Cd contents of the cocoa bean parts. The Pb content differed significantly among the plantations and the cocoa bean parts. The highest Pb values in the whole beans were obtained from plantations in Ola'nika (142.80 mg kg-1) and Owena (142.60 mg kg-1) which did not differ while Okemaye was below detectable level. The kernel Pb content was highest at Eyin'gun (72.85 mg kg-1) followed by Oke'maye (63.95 mg kg-1). The testa Pb was highest at Eyin'gun (465.70 mg kg-1) followed by the similar values at Agric Farm Settlement (342.35 mg kg-1) and Ago Store (342.20 mg kg-1). The testa contained the highest Pb in all locations except at Ago Akure, Ola'nika and Owena whose whole bean samples had the highest values. The concentrations of Pb in the whole bean, kernel and testa across the locations were higher than allowable maximum residue limit of 2.0 mg kg-1 (WHO/FAO, 2012). The source of contamination could have been through the soil, bioaccumulation on the farm and vehicular emission as sun-drying took place near high traffic roads (Rankin et al., 2005). The highest whole bean Cu was in Agric Farm Settlement (121.30 mg kg-1) which differed significantly from Ola'nika (105.00 mg kg-1) and other plantations. The kernel Cu was highest in Eyin'gun (26.85 mg kg-1) and followed by Agric Farm Settlement (21.30 mg kg-1) while Oke'risa contained the highest testa Cu. The bean contained highest Cu in Ago Akure, Agric Farm Settlement, Eyin'gun, Iwoye and Ola'nika while the testa contained the highest Cu in the rest location while the kernel Cu content was least across the locations. Cu was lower than the maximum residue limit of 30 mg kg-1 (WHO/FAO, 2012) in the kernel, higher in the whole bean from Agric Farm Settlement, Ola'nika and Eyingun, and higher in the testa at Oke'risa, and Ago Store. Cd was detected in the whole beans at Ola'nika (0.60 mg kg-1) and kernel from Ago Akure (0.65 mg kg-1) only and these are lower than 1.0 mg kg-1 maximum allowable limit (WHO/FAO, 2012). The order of abundance was Pb > Cu > Cd, similar to report by Naser et al. (2011) that plants contain higher levels of Pb than Cu.

The desire of farmers to maximize productivity in the cocoa plantations necessitated adhering to recommended farm practices which emphasize the use of fertilizer and pesticides. These activities have been indicted for heavy metal contamination in soils but the levels in the soils of the study sites were below the maximum allowable limits. The elevated Pb and Cu levels in the soils were reflected in the higher concentrations of the whole beans, testa and kernels of cocoa which exceeded the maximum allowable limits. The quality and safety concerns would pose threats to market acceptability of the products and eventually dampen local production. Therefore, farmers should adhere to the recommended dosages and types of agrochemical inputs while the concerned stakeholders should monitor the cocoa from on-farm through processing methods and packaging.

Table 5: Levels of heavy metals in cocoa beans from nine study areas in Ondo State

	Pb (mg/kg)			Cu (mg/kg)			Cd (mg/kg)		
Location	Bean	Kernel	Testa	Bean	Kernel	Testa	Bean	Kernel	Testa
Ago Akure	72.35c	15.50g	49.00f	23.70e	12.70g	14.95g	ND	0.65	ND
Ago store	76.15b	36.55e	342.20b	26.80d	17.85d	31.65b	ND	ND	ND
Agric Farm S.	25.60f	57.85c	342.35b	121.30a	21.30b	24.80e	ND	ND	ND
Eyingun	50.10d	72.85a	465.70a	30.45c	26.85a	24.15e	ND	ND	ND
Iwoye	41.25e	13.65h	54.80e	23.25e	12.90g	22.50f	ND	ND	ND
Okemaye	ND	63.95b	115.00c	16.35f	18.90c	24.70e	ND	ND	ND
Okerisa	7.95g	11.40i	58.40d	30.20c	13.60f	63.65a	ND	ND	ND
Olanika	142.80a	20.40f	34.90g	105.00b	14.90e	26.00c	0.60	ND	ND
Owena	142.60a	54.30d	6.80h	10.80g	12.55g	25.40d	ND	ND	ND
*WHO/FAO		2			30			1	

Values with the same letter within a column are not significantly different at $p<0.05$
*WHO/FAO, (2012) = Maximum Residue Limit for Heavy metals in food

Conclusion and Recommendation

Surface soils and cocoa beans from cocoa plantations are mostly contaminated with Cu but cocoa kernels were not, while Pb heavy metal was a major contaminant in cocoa beans (whole, kernel and testa) in Ondo State. This study and that of Aikpokpodion (2010) reported the high level of Cu contamination on cocoa plantation soils in Ondo State, Nigeria. This may be due to continuous application of Cu-based fungicides to control blackpod disease of cocoa and sun-drying of cocoa beans closer to the major roads thereby contaminated with tetra-ethyl lead additive in gasoline. The results indicated that concentrations of Cu and Pb in cacao beans were above tolerance limits, while the concentrations of Pb in plantation soils were below the permissible limits. Cadmium heavy metal however, was mostly not detected in plantation soils and cocoa beans. High levels of Cu and Pb in cocoa beans may hereby have implications on the quality and safety of this valuable crop and may pose a threat to cocoa production in Ondo State. It is therefore recommended that pesticides (especially fungicides) and fertilizers should be avoided and if they were to be used, farmers should adhere/comply strictly to their recommended usage. Planting selected cocoa varieties with low accumulation levels of contaminants. The concerned Cocoa Board/Agency should also monitor cocoa crop from on-farms through processing methods.

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Gender Role in Decision-making among Maize Farmers in Isaga-Orile Community of Ogun State, Nigeria

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Abstract

This study examined gender roles in decision making among maize farmers in Isaga Orile farming community of Ogun State. Data were collected through interview schedule from 60 male and 30 female farmers selected using a multistage sampling procedure. Data were analysed with the use of frequency counts, percentage, Chi-square, and Pearson's Product Moment Correlation. The result showed that 42.2% of the respondents were between the age range of 41 – 50 years, 87.8% were married, 77.8% and 22.2% were male and female respectively and 50% of the respondents had secondary school education. Considering gender role in decision making, the result showed that 87.8% of male farmers determined the utilization of returns accrued from sales of maize as against a joint decision made by 12.2% of male and female farmers. The results further showed that 84.4% of male farmers determined what to plant and when to plant. The major constraints encountered by the respondents in maize production were inadequate farm machinery to hire (98.9%), pest and disease outbreak (91.1%), and limited access to improved seeds (85.6%). There existed significant relationship ($p<0.05$) between land preparation ($r=0.333$), drying ($r=-0.304$), and value addition ($r=-0.319$), and maize production. It is therefore recommended that efforts should be made to improve maize farmers' accessibility to improve maize seed, pesticide, and chemical for disease control and farm machinery for hire.

Keywords: Constraints, activities, agro- service, participation, domination

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Introduction

Gender perception is a very significant part of agriculture which must be well-thought-out for any developmental contribution to be effective. It is the social variances between men and women (Oladeebo, 2012) which could manifest in the form of division of labour, roles and responsibilities, making a decision, and access and control of resources. In Nigeria, both men and women often have a balanced role in maize production, and in some regions, women have distinctly different tasks and responsibilities in maize production (Badmus et al., 2015). There are consistent gender disparities in accessing, and benefiting from agricultural technologies, services, and inputs in developing countries (World Bank, 2009).

Education, access to learning, employment, and decision making, among other things, are a number of the areas of gender disparity (Ajala and Alonge, 2013). Socio-economic characteristics of farmers among other factors also affect the decision-making process within the household in agriculture (Ogunlela and Mukhtar, 2009).

The long-term low socioeconomic status, render women generally unable to take key decisions

overuse of such resources and benefits accruing from farm production (Oyakhilome, 2013). Farmers make choices on several pre-harvest and post-harvest activities such as what to produce, input use, harvest, and post-harvest issues (Williams, 2003), which affect production, processing, distribution, prices, and cost (Umar, 2011). Available literature reveals that men have constantly in control farm decision-making despite the important role played by women in agricultural production, processing, and marketing in Nigeria, even in areas where women are the largest providers of farm labour (Amaechina, 2002). They, therefore, have not received equitable decision-making rights (Oyakhilome, 2013).

Maize (Zea Mays) also called corn, is the third most important cereal crop in the world after wheat and rice (Gaya *et al.,* 2017). Maize is a significant cereal crop that is grown in various ecological zones in Nigeria which can be eaten boiled, roasted, prepared into porridges, and processed into flour and used as feed for livestock (Badmus *et al.*, 2015). It is an arable crop, cultivated on subsistence and commercial scale, with abundant economic and medicinal values. The importance of maize farming in Nigeria cannot be over-stressed as the country produced about 43% of maize grown in West Africa (Olarinde *et al.,* 2007). Maize is now a commercial crop on which many agro-based industries hinged on as raw materials (Iken and Amusa, 2004). There has been a remarkable success in the efforts to improve and sustain maize technologies as improved maize varieties are now grown across all agro-ecological zones of northern and southern Nigeria (Olaniyi and Manyong, 2007). However, considering the teeming and ever-increasing population of Nigeria, maize production has not met fully with the industrial and consumption needs of Nigerians probably due to lack of gender equity in decision making at the household level.

In a Nigerian study, it was found that the level of participation of women in farm management decision making was quite low (Shou, 2011). Similarly, there has been increasing literature on gender issues in agricultural production on the other hand but there seems to be an information gap (Oyakhilome, 2013) on gender role in decision making among maize farmers in Isaga Orile community Ogun State. On this note, the study sought to (a) ascertain the personal characteristics of maize farmers (b) determine gender role in decision making among the respondents (c) determine farmers' participation in maize production activities (d) to identify constraints faced by the respondents in maize production. The study, therefore, hypothesized that (1) there is a significant relationship between farmers' characteristics and maize production (2) there is a significant relationship between maize farmers' farm activities and maize production.

Methodology

Study Area

This study was carried out in the Isaga Orile community of Abeokuta North Local Government Area of Ogun State, Nigeria. It has an area of 808 km and a population of 201,329. The average monthly temperature ranges from 23 °C in February. The distribution of rainfall varies from about 1000mm in the western part to about 2000mm in the eastern part. There are two distinct seasons in the State, namely, the rainy season which lasts from March/ April to October/ November till March/ April. The climate of Ogun State follows a tropical pattern with the raining season starting about March and ending in November followed by a dry season. People of Isaga-Orile are noted for practicing agriculture as their major occupation. They engaged in crop production at commercial and subsistence scale, such crops include maize, cassava, rice, cowpea, vegetables, yam, and water-yam.

Data Collection, Measurement, and Analysis

Multi-stage sampling procedure was employed in this study to select 60 male and 30 female farmers from the study area. Data was collected on farmers' characteristics, gender roles in decision making at the household level, farmers' participation in maize production activities, and constraints faced by farmers using a structured interview schedule. Constraints encountered in maize production was measured on two-point Likert-type scale as major constraint (2) and minor constraint (1) Gender role of decision making was measured as 'yes and no' to a set of questions provided on decision making. Farmers' participation in agricultural activities was measured on a 3-point Likert scale as always participate (3), occasionally participate (2) and do not participate (1). Scores obtained from respondents were aggregated and analysed using frequency count, percentage, Chi-square, and Pearson's Product Moment Correlation.

Results

The study revealed the personal characteristics of the respondents (Table 1). The findings from this study showed that 42.2% of the respondents fall

within an age range of 41-50 years. The majority (77.8%) of the farmers were male. Ninety percent of the respondents had the highest educational qualification of secondary school. The majority (87.85%) of the farmers were married and 65.5% were Christians.

Table 1: Personal characteristics of respondents

Variables	Frequency	Percentage (%)
Age		
21-30	4	4.4
31-40	35	38.9
41-50	38	42.2
51 and above	13	14.4
Sex		
Male	60	77.8
Female	30	22.2
Educational Qualification		
No formal	9	10
Adult education	4	4.4
Primary education	28	31.1
Secondary Education	45	50
Tertiary Education	4	4.4
Marital Status		
Single	3	3.3
Married	79	87.8
Widower	1	1.1
Separated	7	7.8
Religion		
Christianity	59	65.6
Islam	22	24.4
Traditional	9	10.0

Gender role in decision making is presented in Table 2. It was revealed that 87.8% of male farmers controlled and determined the utilization of returns accrued from sales of maize produce, 84.4% of men determined the variety of maize to plant and when to plant, also male farmers (41.1%) controlled what is to be consumed at the household level. However, male and female farmers (66.7%) jointly had control over sales of maize and the sales of maize produce (63.3%).

Table 2: Gender role in decision making among maize farmers

Variables	Male (%)	Female (%)	Joint decision (%)
Determination of what to plant and when to plant	84.4	0.0	15.6
Control and determination of what to consume at the household level	41.1	21.1	37.8
Control of sales of maize crop	34.4	2.2	63.3
Control of selling prices for maize commodities	32.2	1.1	66.7
Determination of utilization of revenue accrued from the sales of maize	87.8	0.0	12.2

Constraints Encountered by Farmers in Maize Production

The study shows the constraints faced by maize farmers (Table 3). The findings showed that the major constraints faced by the respondents in maize production were non-availability of farm machinery (98.9%), Outbreak of pest and diseases (91.1%) and limited access to improved maize seeds (85.6%) while their minor constraints were unfavourable weather condition (77.8%), unstable markets (74.4%) and theft (66.7%).

Table 3: Constraints encountered by farmers in maize production

Constraints	Major constraint	Minor constraint
1. Outbreak of pest and diseases	91.1	7.8
2. Inadequate funds	65.6	34.4
3. Transportation problem	36.7	63.3
4.Inadequate storage facilities	65.6	34.4
5. Inadequate farm machineries	98.9	1.1
6. Unstable markets	25.6	74.4
7. Limited access to improve seeds	85.6	14.0
8. Unfavourable weather condition	22.2	77.8
9. Problem of Weed	83.3	16.7
10. Labour shortage	61.1	34
11. Low soil fertility	76.2	23.3
12. Poor extension service	62.2	37.8
13. Theft	33.3	66.7

Participation of Farmers in Maize Production Activities

The study shows maize farmers' participation in maize production activities (Table 4). The findings showed that the majority of the respondents always participate in land preparation (85.6%), sowing (84.4%), and harvesting (67.8%). Also, maize farmers occasionally participate in value addition (57.8%), marketing (57.8%), drying (50%), and weeding (45.6%).

Table 4: Participation of farmers in maize production activities

Farm activities	Frequently Participate (%)	Occasionally Participate (%)	Do not Participate (%)	Mean ($\bar{x}$)	Rank
1. Land preparation	85.6	13.3	1.1	51.4	Ist
2. Sowing	84.4	13.3	2.2	36.2	2nd
3. Weeding	30.0	45.6	23.4	26.4	7th
4. Harvesting	67.8	30.0	2.2	34.1	3rd
5. Drying	35.6	50.0	14.4	28.4	6th
6. Value addition	41.1	57.8	1.1	30.8	4th
7. Marketing	41.1	57.8	1.1	30.8	4th

Relationship between Farmers' Characteristics and Maize Production

Table 5 shows the relationship between respondents' characteristics and maize production. The results of the findings showed that no relationship ($P>0.05$) existed between farmers' characteristics and maize production.

Table 6: Relationship between farmers' characteristics and maize production

Variable	χ^2	DF	p-value	Decision
Sex	3.82	3	0.282	Not Significant
Religion	6.70	6	0.349	Not Significant
Educational level	7.23	12	0.842	Not Significant
Marital status	2.60	9	0.978	Not Significant

Relationship between Maize Farming Activities and Maize Production

Table 7 shows the relationships between maize farming activities and maize production. The result of the finding showed that significant relationships ($p<0.05$) existed between land preparation, maize sun drying, and value addition and maize production.

Table 7: Result of Correlation Pearson Product Moment Correlation Analysis

Variables	R	P
1. Land preparation	0.333	0.001**
2. Sowing	0.088	0.407
3. Weeding	0.031	0.770
4. Harvesting	0.090	0.401
5. Drying	-0.304	0.004**
6. Value addition	0.319	0.002**
7. Marketing	-0.157	0.141

**0.05 level of significance

Discussion

The study showed that the majority of the respondents were male, suggesting male farmers' domination in the cultivation of maize in the study area. This result is higher than what (34.4%) was obtained by Badmus *et al.* (2015). The majority (90%) of the respondents acquired education in a formal setting, as against the highest secondary school education of 20.4%obtained by Adeola and Adetunbi (2015). Also, the majority of the respondents have established family, this could suggest the availability of family labour and that decision making among the respondents at the household level may be competitive. It could be inferred that female farmers had no complete control over decision making at the household level. The result of this study is similar to the assertion of Umar *et al.* (2011) who observed that men dominate decision-making process for activities like selection of enterprise, input procurement, input allocation, selling of produce and storing of produce in their study conducted gender analysis of labour contribution and decision-making role. Also, Ogunlela and Mukhtar (2009) reported that only 24% of women farmers took part in the final decision on the storage and marketing of farm produce.

Constraints encountered by maize farmers in the study area were farm machinery, the outbreak of pests and diseases, and limited access to improved maize seeds. This could imply that these constraints affect both categories of farmers. This result conforms with the report of the study conducted by Umar *et al.* (2011) Where access to farm inputs was ranked 3rd among the constraints facing respondents in a study conducted on gender analysis of labour contribution and decision-making role among maize farming households in north-central, Nigeria. Furthermore, respondents opined that unfavourable weather conditions, unstable markets, and problems associated with theft were minor constraints to maize production in the study area.

The finding further showed that the majority of the respondents always participate in land preparation, sowing, and harvesting. This could imply the significance of these activities in maize production. Also, maize farmers occasionally participate in activities like value addition, marketing, drying, and weeding. This could have resulted from the use of hired farm labour in maize production activities by the respondents.

The study hypothesized that maize production does not have a direct relationship with personal characteristics of the respondents such as sex, religion, educational level, and marital status, this means that maize production does not depend on the personal characteristics of the farmers. Also, the results showed that maize production has a direct relationship with land preparation, maize sun drying, and value addition.

Conclusion and Recommendations

The study examined the role of gender in decision making at the maize production household level. The result showed that male farmers had control over the decision made on the production of maize compared to the female counterpart. Constraints encountered by farmers were non-availability of farm machinery, pest and disease outbreak, rapid weed growth, and limited access to improved maize seed. Maize farmers always participate in land preparation, sowing, and harvesting. No relationship existed between the personal characteristics of farmers and maize production. However, a significant relationship ($p<0.05$) existed between land preparation, maize sun drying and value addition, and maize production.

The study, therefore, recommends that researchers should design an empowerment program aimed at educating male farmers on how to respect the opinions of their female counterparts because no one is an island of knowledge. Also, to boost maize production, the government should make available farm machinery for hire, improve seeds and pesticide for sale through agro service centres

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Evaluation of the Nutritional Qualities of Edible Portions of Two Commercially Important Prawns in Southwest Nigeria.

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Abstract:
The nutritional qualities of the edible portions of prawn: *Macrobrachium macrobrachion (M. macrobrachion)* and *Macrobrachium vollenhovenii (M. vollenhovenii)* collected from Oluwa Creek, Ondo State, and Asejire Reservoir, Oyo State respectively were evaluated for food security potential. Smoke-dried samples were selected for proximate and mineral analysis. The weight *M. macrobrachion* ranged from 0.93 to 2.9g (1.97±0.62) and *M. vollenhovenii* ranged from 5 to 24g (12.42±6.62). Standard procedures were used for biochemical and mineral analysis, and the data obtained were statistically analyzed. The values obtained for proximate and mineral analysis of *M. vollenhovenii* and *M. macrobrachion* were proteins (69.58±0.02 and 72.47±0.04%), carbohydrates (11.15±0.00% and 6.07±0.07%), fats (10.93±0.06% and 12.43±0.18%), moisture (4.79±0.01 and 5.49±0.15%), ash (3.21±0.01 and 3.17±0.01%) and crude fibers (0.33±0.01 and 0.37±0.01%), respectively. Significantly higher amount of magnesium (32.82±0.00mg/l), potassium (161.31±0.03mg/l) and sodium (90.17±0.04mg/l) were obtained in samples of *M. macrobrachion* while, *M. vollenhovenii*, showed higher amount of calcium (351.53±0.05mg/l), manganese (0.57±0.01mg/l), iron (4.32±0.04mg/l), zinc (1.12±0.00mg/l) and copper (0.38±0.00mg/l) The caloric energy value of 426.05kg/100g determined in *M. macrobrachion* was higher than the value of 421.29kg/100g for *M. vollenhovenii*. Values obtained for both species were significantly different ($P<0.05$) for the proximate and mineral compositions, except for ash, moisture, and crude fiber. The result affirmed that these shellfishes are nutritionally valuable, and are profitable for human consumption, not only as a delicacy, but also for their nutritive qualities which compare favourably with other animal protein sources.

Keywords: Asejire, reservoir, *Macrobrachium macrobrachion, Macrobrachium vollenhovenii,*

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Introduction

The continuous rise in the human population especially in the developing countries necessitates the search for additional sources of animal protein (El-Katcha *et al.*, 2015) to mitigate widespread deficiency in the diet. In Nigeria, the deficiency of animal protein security is indicated by the consumption put at 10 g/head compared to the minimum daily intake of 65 g recommended by the Food and Agricultural Organization (FAO) and the minimum requirement for the growth and development of the body (Adamu *et al.,* 2015; El-Katcha *et al.,* 2015). Shellfishes have been identified as an additional source of food derived from the aquatic environment. Shellfishes contain varying levels of high-quality protein rich in all the valuable dietary essential amino acids (Udo, 2004), and are

superior to those in meat and poultry (Ehigiator and Oterai, 2012). Shellfish is a fisheries and culinary term for exoskeleton-bearing aquatic invertebrates used as food. They can be divided into two groups, viz: molluscs and crustaceans. Crustaceans commonly eaten are shrimps, prawns, lobsters, crayfish, and crabs.

Prawn is one of the popular crustaceans widely consumed in Nigeria mostly among the middle and low-income groups (Abulude *et al.*, 2006). Prawns that are caught in Nigerian waters are transported and concentrated in open and organized markets, where they are sold as cheap and affordable delicacies eaten either whole (shell with flesh) after drying or are processed flesh only (Udo, 2004). Its neutral flavour makes it a natural additive in food, such as salads, pasta, curry, soups, stew, stir-fried dishes, and are traditionally used as a condiment. Apart from being a delicacy, they are valuable in the diet for the supply of good quality proteins and vitamins and are good sources of dietary minerals such as calcium, phosphorus, iron, magnesium, etc. which are beneficial to man and animals (Abulude *et al.*, 2006). Freshwater prawns of the genus *Macrobrachium* are decapods crustaceans in the family Palaemonidae; this family, together with the family peneidae (marine shrimps), has been globally acknowledged for recruitment into aquaculture (New, 2002). They are usually found in lakes, rivers, swamps, irrigation ditches, canals, ponds, and estuarine areas (New, 2002). Out of the 200 species that make up the genus; only four have been reported in Nigeria, and the two largest species of them, *Macrobrachium macrobrachion* and *Macrobrachium vollenhovenii*, are commercially important shrimps/prawns which are extensively exploited in Nigeria (Hu *et al* 2002; Willet, 2007).

Due to their economic importance, previous studies on these two species have been on the aspects of the abundance, meristic and morphological characterization, biology, food and feeding habits, and proximate and mineral composition of these Palaemonid prawns (Deekae and Abowei, 2010; Ehigiator and Nwangwu, 2011; Olawusi-Peters and Ajibare, 2014; Arazu and Udo, 2015; Udo, 2015).

The knowledge of the biochemical composition of any edible organism is extremely important since the nutritive value is reflected in biochemical contents, such as protein, amino acids, lipids, fatty acids, carbohydrates, vitamins, and minerals (Nagabhushanam and Mane 1978). Studies on the biochemical composition have focused on species from the Southern and Eastern parts of the country; there is the dearth of information on these species from Southwestern part, except the relatively few from Lagos Lagoon, hence, this study was conducted to provide information on the nutrient composition of the two Caridean prawns from other Southwestern parts of the country, Ondo and Oyo States.

Methodology

Sample Origin

Oluwa Creek in Igbokoda lies in Latitude 6.2833 and longitude 4.8167 . This area falls within the oil prospecting zone in Nigeria called the Oluwa region. The river is in the Ilaje Local Government Area, which is at the extreme southern part of Ondo State. It shares boundaries with Okitipupa Local Government Area in the North; the Atlantic Ocean in the South; Ijebu Waterside Local Government Area (Ogun State) in the West and Delta State in the East. This brackish watercourse is bounded by thick vegetation with a low occurrence of rhizoid plants and a higher profile of salt marshes and surface macrophytes that extend into the tributaries and mark the breeding grounds for the prawns. Asejire reservoir lies between longitudes 4^{E} and $4^{0}07^{E}$ and latitudes 7^{0N} and $7^{0}21^{N}$. The reservoir took its source from the Osun river and flows through Oluwo and Alaye-ala down to Asejire. Asejire reservoir is in Egbeda Local Government Area of Oyo State, Southwestern Nigeria. The reservoir supplies water to Ibadan in Oyo State and some towns and villages in Osun for domestic uses. The reservoir is bi-focated with two unequal arms surrounded by a large mass of land. The left longer arm is fed by Rivers Oba and Osun while the right arm is supplied by River Agboiro. The catchment area of the reservoir is $78km^2$ and the impounded area is 2,342 hectares. The reservoir has a normal pool elevation (water level) of 150m and maximum flood elevation of 152.4m. The reservoir has approximated gross storage of 7,403 million liters.

Collection of Samples

Thirteen and 12 prawn samples (*M. macrobrachion* and *M. vollenhovenii*) with weight ranging from 0.93 to 2.9g and 5 to 24g respectively were procured from prawn mongers at the landing sites at Oluwa Creek, Igbokoda, Ondo State and Asejire Reservoir, Oyo State. The prawn samples were transported to

the laboratory of the Department of Animal and Environmental Biology, Adekunle Ajasin University, Akungba-Akoko, for further analysis.

Sample Identification and Preparation

Samples were identified from taxa to species level using taxonomic keys from the Food and Agricultural Organization Identification sheets (FAO, 1981) and Powell, (1982). The meristic and morphometric features such as colouration, the shape of rostrum, and the number of spines on the rostrum of each species were used for the identification. The samples were further smoke-dried to constant weight and were separated into waste (head with carapace, all the limbs with the pleopods, exoskeleton (body sheath on the abdomen), and flesh. The prawn's flesh, whole body, and exoskeleton were weighed with a digital weighing balance "Scout *Pro*" to the nearest .01gram. The prawn's flesh was ground into a fine powder using a "MOERGOLD MGB—242" electric blender, packed in a hermetic nylon material with labels, and stored in the desiccator for biochemical analysis.

Proximate and Mineral Analysis

The proximate components of the samples were determined using methods described by the Association of Official Analytical Chemists (AOAC), (2005). Moisture was determined by drying of samples for 24hrs at 105^0C, ash was determined from the residue left after incineration of a weighed portion of the sample at 550 C using a muffle furnace, Carbohydrate content of the samples was determined as difference from the total percentage (100%). The energy values of the prawns were calculated according to Palani *et al.* (2014), using the crude values of protein, fat, and carbohydrate as obtained from the proximate analysis. Energy value kg/100g= P x 4.00 (protein) + C x 4.00 (carbohydrate) kcal/100g + F x 9.00 (fat) kcal/100g. Mineral components- Calcium, Magnesium, Potassium, Sodium, Manganese, Iron, Copper, and Zinc of the samples were determined by Atomic Absorption Spectrophotometric method at appropriate wavelengths. All analyses were done in duplicate, and all determinations were done on a dry weight (matter) basis.

Statistical Analysis

The statistical interpretation of the data was performed using Statistical Package for Social Sciences (SPSS version 21.0) for the mean and standard deviation. An Independent sample t-test at a confidence level of 95% was used to compare data to determine the significant differences between the values obtained from both species.

Results

Morphometric

The average weight composition of the prawn samples is presented in Table 1. For *M. vollenhovenii*, weight varied from 5 to 24g; 1 to 9g and 3g to 14g, respectively for the whole body, flesh, and waste; whereas, weights obtained for the whole body, edible portion (flesh), and waste for *M. macrobrachion* ranged from 0.93 to 2.9g; 0.29 to 0.88g, and 0.63 to 2.02g respectively.

Table 1: The Average Weight Composition of the Palaemonid Prawns (Mean ±SD)

Species	Whole prawn (g)	Edible portion (Flesh) (g)	Waste (g)
M. macrobrachion (n=13)	1.97±0.62	0.65±0.19	1.31±0.47
M. vollenhovenii (n=12)	12.42±6.62	4.35±2.52	7.92±4.18

Proximate

The proximate compositions (g $100g^{-1}$) of the prawn samples are shown in Table 2. Mean crude protein values of (69.58±0.02 and 72.47±0.042) were found to be the highest, and the least proximate values were obtained for crude fiber (0.33±0.01 and 0.37±0.01) in *M. vollenhovenii* and *M. macrobrachion* respectively. Values obtained for protein (72.47±0.042) and fat (12.43±0.18) were significantly higher in *M. macrobrachion* than in its freshwater counterpart. *M. vollenhovenii* had higher carbohydrate (11.15±0.00) and ash content (3.21±0.01), and lower moisture (4.79±0.01) and crude fiber (0.33±0.01) components than *M. macrobrachion.* However, statistically, there was no significant difference (P>0.05) in the moisture, ash, and crude fiber values, as observed to have existed

in other proximate parameters for both *Macrobrachium* species.

Table 2: Proximate Composition of Prawn Samples (g 100g-1)

Parameter %	*Macrobrachium macrobrachion*	*Macrobrachium vollenhovenii*
Protein	72.47 ± 0.04	69.58 ± 0.02
Moisture	5.49 ± 0.15	4.79 ± 0.01
Fat	12.43 ± 0.18	10.93 ± 0.06
Ash	3.17 ± 0.01	3.21 ± 0.01
Crude fibre	0.37 ± 0.01	0.33 ± 0.01
Carbohydrate	6.07 ± 0.07	11.15 ± 0.00
Dry Matter	94.51 ± 0.15	95.21± 0.01

Means ± SD are values of duplicate determination

Mineral Composition

In Table 3 are some macro and micro mineral components (mg/l) contained in the prawn samples. For macro minerals, the result showed that calcium had the highest mean values of (351.53±0.05 and 179.67±0.176mg/l), with magnesium recording the least values of (22.75±0.00 and 32.82±0.002mg/l) in *M. vollenhovenii* and *M. macrobrachion* respectively. Iron showed the highest values (4.32±0.04 and 3.02±0.035mg/l), and the values obtained for copper (0.38±0.00 and 0.24±0.001mg/l) were respectively the least for micro minerals. *M. vollenhovenii* showed statistically higher amount of micro minerals: Mn (0.57±0.01), Fe (4.32±0.04), Cu (0.38±0.00), and Zn (1.12±0.00); conversely, except for calcium, significantly higher macro minerals values for Mg (32.82±0.00), K (161.31±0.03), and Na (90.17±0.04) were obtained for *M. macrobrachion.*

Table 3: Mineral Contents of Prawn Samples

Minerals (mg/l)	*Macrobrachium macrobrachion*	*Macrobrachiun vollenhovenii*
Calcium	179.67 ± 0.17^{b}	351.53 ± 0.05^{a}
Magnesium	32.82 ± 0.00^{a}	22.75 ± 0.00^{b}
Potassium	161.31 ± 0.03^{a}	117.60 ± 0.02^{b}
Sodium	90.17 ± 0.04^{a}	55.68 ± 0.01^{b}
Manganese	0.37 ± 0.00^{b}	0.57 ± 0.01^{a}
Iron	3.02 ± 0.03^{b}	$4.32\pm0.04_{a}$
Copper	0.24 ± 0.00^{b}	0.38 ± 0.00^{a}
Zinc	0.93 ± 0.02^{b}	1.12 ± 0.00^{a}

Means ± SD are values of duplicate determination

Discussion

The protein content obtained in M. vollenhovenii and M. macrobrachion were high to other biochemical compositions, corroborating assertions by Yanar and Celik, (2005) that shrimp meat is an excellent source of protein, Dayal et al., (2013) that nearly 80% of the portion (dry matter) of prawns comprises of protein, and Dinakaran et al., (2009) which stated that protein is the most prominent biochemical component of crustaceans. However, the protein content of M. vollenhovenii (69.58%) was significantly lower compared to (72.47%) obtained for M .macrobrachion, ($p<0.05$). The protein content of both species compares favourably with Ehigiator and Oterai (2012) for M. vollenhovenii (71.37%), and Reddy and Reddy (2014) for cultured M. rosenbergii (72.24%), but is higher than Udo (2015) for M. vollenhovenii (22.63%) and M. macrobrachion (20.30%), Ehigiator and Nwangwu (2011) for edible portion of *M. vollenhovenii*

(53.85%) and *M. macrobrachion* (58.92%), Arazu and Udo (2015) for dried M .macrobrachion (27.68%), Dinakaran et al., (2009) for *M. idae* (57.32%), Fasakin et al. (2000) for *M. vollenhovenii,* (16.99%), M. rosenbergii (17.30%), Omomo et al., (2014) for Chokor smoke-dried (55.88%), and for the Altona smoke-dried (58.87%) M. vollenhovenii, and Asaikkutti et al., (2016) for edible portion of wild M. rosenbergii (52.74%).

Minerals make up the micronutrients that are necessary for physiological and biochemical processes by which the human body takes in and utilizes food to maintain health and activity (Mohapatra et al., 2009). The calcium content recorded for M. vollenhovenii (351.53mg/l) was significantly higher than that of M. macrobrachion (171.67mg/l). However, both species' calcium contents were lower than (Abulude, et al., (2006), Ekpenyong et al., (2013) and Arazu and Udo (2015). Nonetheless, the value obtained for M. vollenhovenii was higher than Arazu and Udo (2015) for fresh (33.0mg/100g) and dried (28.8mg/100g) samples of M. macrobrachion, Omomo et al., (2014) for Chokor smoke-dried (5.66%), and Altona smoke-dried (4.20%) M. vollenhovenii, and Ehigiator and Akise (2013) for M. vollenhovenii (8.86mg/100g).

Macro minerals: potassium, sodium, and magnesium obtained in M. macrobrachion were higher, statistically than what was contained in its freshwater counterpart. These are found to be lower than Abulude et al., (2006) for M. vollenhovenii (176mg/100g), (165mg/100g), and (330mg/100g) respectively. They are however, higher than Ehigiator and Akise (2013) for M. vollenhovenii (11.94mg/100g and 15.17mg/100g) respectively and Ehigiator and Oterai (2012) for M. vollenhovenii. Significantly higher micro minerals: Mn (0.57mg/l), Fe (4.32mg/l), Cu (0.38mg/l) and Zn (1.12mg/l) were obtained for M. vollenhovenii, when compared with values obtained for M. machrobrachion however, the values are still lower than Ehigiator and Akise (2013) that recorded Mn (4.33mg/100g), Fe (40.44mg/100g), Cu (2.22mg/100g), and Zn (11.93mg/100g) for flesh of M. vollenhovenii. Notwithstanding, the prawn samples contained considerable amount of essential minerals, and its consumption will help, among their numerous functions, regulate fluid balance (Sandstead, 1997), enzyme production, blood clotting (Abulude et al., 2006), metabolism of carbohydrates to produce energy (Hambidge, 2000), maintain blood pressure, transportation of oxygen, normal function of muscles, nerves, bones and promote good health.

Conclusion

From nutritional perspective, these prawns' flesh are excellent sources of high quality protein which is superior to those in meat and poultry; other varying inherent and essential nutrients can also compete favourably with those in meat from other animal sources. They also contain considerable amount of macro and micro minerals. The result further showed Macrobrachium macrobrachion to be richer in protein, fat, and some macro minerals than Macrobrachium vollenhovenii. Conclusively, consumption of the prawns, apart from being a delicacy, could also enhance food security because of their nutritional value

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Poaching and its impact on Wildlife Population in Ise Forest Reserve, Ekiti State.

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Abstract

Poaching wildlife for food is a major threat to wildlife conservation in Nigeria where the demand for bushmeat is ever-increasing, decimating wildlife resources in the protected areas. This study examines poaching and its impact on wildlife populations in Ise forest reserve, Ise-Ekiti, Ekiti State. Twenty-one forest officials and 23 hunters were interviewed using pre-tested structured questionnaires. Market surveys and short reconnaissance surveys were also carried out to sample animal species being poached and data collected were analyzed using descriptive statistics. The results show that 90.5% of the respondents were married and 61.9 % had no formal education. The majority (85.7%) combined hunting with farming and 52.4% earned between ₦20,000 and ₦30,000 monthly while 43.5% used Dane-gun, snare (30.4%), and traps (23.9%) and 67.86% hunt at night with 74.1% hunting ungulates with at least 2 kills per week. However, 85.7% agreed to a sharp decline in species being hunted with habitat destruction (52%), habitat fragmentation (40%), and slash and burn (8%) being the major threat to wildlife population in the reserve. Additionally, the prohibition of the unauthorized entry (52.8%), issuance of a hunting license (41.7%), and regulating hunting seasons (5.6%) would curb illegal hunting in the reserve. There is the need for active participation of the communities around the forest reserve in the planning and implementation of forest policies for the conservation of the animal diversity within the reserve for posterity.

Keyword: Poaching, bushmeat, questionnaire, Dane-gun, respondents, posterity

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Introduction

Wildlife populations are declining at an unprecedented rate across much of the globe (Novacek and Cleland 2001). The world is currently experiencing a mass extinction event with the loss of large numbers of species as a direct result of human activities (Wake and Vredenburg, 2008). Of the world's 5,490 mammals, 79 are Extinct or Extinct in the Wild, 188 Critically Endangered, 449

Endangered, 505 Vulnerable and now 1,677 reptiles are listed on the IUCN Red List with 293 alone added in the year 2009 (IUCN 2009.

Rapid human population growth, climate change, and habitat conversion are causing the decline of many species (Thomas *et al.*, 2004) and hunting for meat and income is an additional key factor reducing wildlife across much of Africa, Asia and South America (Fa *et al.*, 2002). Evidence now exists that illegal hunting and the bushmeat trade also represent a severe threat to wildlife populations in the African region (Lindsey *et al.* 2011). Until recently the scale of the problem has not been adequately acknowledged and as a result, inadequate resources are available to address the issue.

Poaching, which involves the illegal killing, hunting, and capturing of wild animals for sale, is the biggest threat to wildlife after habitat destruction. Poaching is hunting without legal permission and the difference between poaching and hunting is the law (Worldanimalfoundation, 2017). Legal hunters also kill tens of millions of animals per year. For each of those animals, another animal is illegally killed. Whether done legally or illegally, all types of hunting have led to the extinction of species. If not controlled, many more animals will be doomed to extinction. The rise in human population has been accompanied by rapid economic growth in some parts of the world which has led to affluence and a huge and growing demand for a wild animal and animal by-products (Worldanimalfoundation, 2017)

Bushmeat hunting has been an important subsistence activity in many rural parts of Africa throughout history (Bowen-Jones *et al.*, 2003). Bushmeat serves as a key protein source and provides an alternative to livestock meat, especially in areas where tsetse flies are prevalent (Barnett 2000.). However, extensive bush meat hunting often causes pressures on various wildlife species, leading to their decline (Damania *et al.,* 2005) and frequently involves illegal hunting. In Central and West Africa, bushmeat offtake has been observed to occur at unsustainable levels, with harvest levels estimated to range from 1 to 3.4 million tons per year (Wilkie and Carpenter 1999). Increased and unsustainable levels of hunting have been a major cause of biodiversity loss and decline in wildlife populations throughout Africa (Redmond *et al.* 2006.) Poaching threatens not only wildlife but also local fish and plant populations. From an equity perspective, poaching deprives legitimate users, consumptive as well as non-consumptive, of resource utilization opportunities (Muth and Bowe 1998). Unregulated hunting may also increase the danger of transmission of zoonotic diseases (Karesh and Noble 2009). Despite existing laws and regulations regarding hunting in Africa, it is difficult to restrict the use of bushmeat, as many rural people depend upon it to meet their basic nutritional needs (Robinson *et al.,* 2002). Poverty is known to be a major driver for illegal hunting by people living around protected areas (Songorwa *et al.*, 2007). Increased human populations around protected areas often result in escalating pressures on wildlife resources, and greater population densities are known to exacerbate illegal hunting (Røskaft *et al.*, 2009). Since bushmeat hunting is typical of areas with low food security and few realistic alternative meat sources, understanding the social contexts of communities in rural areas is essential for developing strategies to reducing the problem (Westphal *et al.* 1999). To identify the drivers behind and levels of bushmeat hunting, consumption, and trade in the communities around national parks and game reserves, it is necessary to obtain a realistic picture of how local populations perceive and understand specific social issues and livelihood conditions. It is widely accepted that current biodiversity loss and poverty are interwoven and that poverty and conservation must be recognized and addressed as interlocking challenges (Wolmer *et al.* 2004). This study, therefore, seeks to assess poaching and its impact on wildlife population, identify various methods of hunting employed in the harvesting of wildlife resources, identify the species of animals most hunted and why this animal is preferred and identify factors encouraging the illegal killing of wildlife resources in Ise Forest Reserve.

Materials and Methods

Study Area

Ise forest reserve is located in Ise-Ekiti, Ekiti State, South-West Nigeria between the latitude of 7.38($7^0$22 60 N) and longitude of 5.37($5^0$22 E) with an elevation of 366 meters above sea level, covering 56.77 km^2. Sunrises at 6:21 am and set at 7:27 pm. The reserve can be accessed from Ise Ekiti town which is about 6 km in a straight direction to the northern edge of the reserve (Figure 1). The weather is warmest in March with an average temperature of 32.8 C at noon while December is

the coldest with an average temperature of 18.9 C at night. The wet season has a rainfall peak around July and the dry season is around January. The land area is not cultivated as most of the natural vegetation is still intact. The landscape is mostly covered with mosaic croplands/vegetation. The climate is classified as a tropical savanna (winter dry season), with a tropical dry forest biozone. The soil in the area is high in lixisols (lx), soil with the clay-enriched lower horizon; low cations exchange capacity (cec), and high saturation of bases.

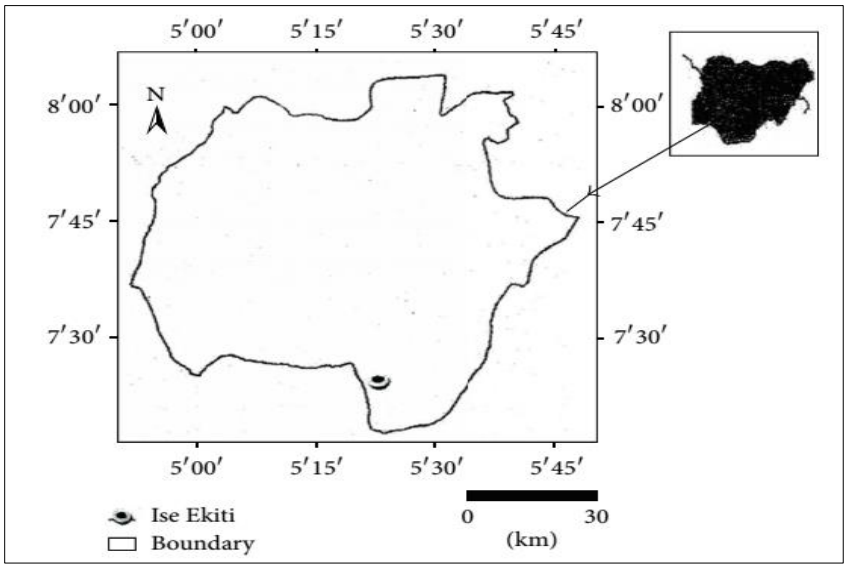

Fig 1: Map of the Study Area
Source: Orimaye *et al.,* 2016

Method of Data Collection

Data were obtained through the use of a structured questionnaire administered on hunters and forest officials. Market surveys and reconnaissance surveys were also carried out. Twenty-one (21) hunters were interviewed using a structured questionnaire on one to one basis. Questionnaire administration was done in the evening when they were found in a relaxation mood on one to one basis. The questionnaire was also administered on the forest officials in a common location in Ise-Ekiti and Ado-Ekiti during their monthly briefing. Questionnaires were administered to individual forest guards to be filled and returned immediately.

A market survey was also carried out three times during this time of visitation to the forest reserve. The area of the market visited were the bush-meat section of the market where animal killed by hunters were displayed for sale. Photograph of the commonly found animals on display was taken and the list of the animals was compiled.

Short forest reconnaissance (recce) surveys were carried out in the forest reserve. Hunter's trails and old logging routes were used in the forest reserves. Transect length surveyed ranges between 4 km and 7 km in the reserve. Transects were traversed twice daily each day between 07.00 – 9.00 and evening 15 – 17.30 hours. The adjourning forest was also searched out for animal activities such as feeding signs, nesting sites, and listening to their calling. GPS locations of activities were taken and recorded. Data obtained were analyzed using the descriptive statistical method. Simple percentages and frequency were presented in tabular form.

Results

Table 1 below shows the socio-economic status of the respondents. Hunters interviewed out of the seven adjoining villages shows that Edege village had the highest (33.3%) number of respondents, followed by Abdul, Oparun, and Orente villages with 14.3% each while Ojo-Akute village had the least (4.8%), respondents. The gender distribution of the hunters interviewed shows that all were male with the majority (81.0%) falling between the middle-class age of 21 and 40 years, 14.2% were between 41 and 60 years while 4.8% were below the age of 20 years.

Similarly, 90.5% of the respondents were married, while 9.5% were single in the study area. The educational status of the hunters reveals that 61.9% had no formal education, 33.3% had primary education while 4.8% had secondary education. Also, majority (52.4%) of the respondents earned between ₦20,000 and ₦30,000, 28.6% earned between ₦10,000 and ₦20,000, and 14.3% earned above ₦30,000 while 4.8% earned below ₦10,000. On the occupation of the respondents, the majority (85.7%) combined hunting with farming while only 14.3% of the respondents were hunters.

Moreover, the interview of forestry officials shows that all respondents are male and the highest percentages (69.6%) came from Ise-Ekiti, 26.1% from Ilawe-Ekiti, and 4.3% from Aba-panu. The age class of the respondents reveals that 60.9% were between 21 and 40 years while 39.1% were between 41 and 60 years of age with all of them happily married. Furthermore, 47.8% of the respondents attained secondary education, 39.1% had tertiary, and primary had 13.0%.

Table 1: Socio-Economic Status of Respondents

	Frequency	Percentage (%)
Hunters		
Village		
Edege	7	33.3
Abdul	3	14.3
Orente	3	14.3
Sunday	2	9.5
Panu	2	9.5
Oparun	3	14.3
Ojo-Akute	1	4.8
Sex		
Male	21	100
Age		
<20 years	1	4.8
21-40 years	17	81.0
41-60 years	3	14.2
Marital status		
Married	19	90.5
Single	2	9.5
Educational background		
No formal education	13	61.9
Primary	7	33.3
Secondary	1	4.8
Income (monthly)		
<10 000	1	4.8
10 000-20 000	6	28.6
20 000-30 000	11	52.4
>30 000	3	14.2
Occupation		
Hunting	3	14.3
Hunting & farming	18	85.7
Forest Officials		
Village		
Ise	16	69.6
Ilawe	6	26.1
Aba panu	1	4.3
Gender		
Male	23	100
Age		
21-40 years	14	60.9
41-60 years	9	39.1

Marital status		
Married	23	100
Educational background		
Primary	3	13.0
Secondary	11	47.8
Tertiary	9	39.1

Source: field survey 2014

Table 2 shows the methods and tools engaged in wildlife harvesting in the study area. The result shows that 85.7% of the respondents combined both hunting and farming as their major sources of livelihood while only 14.3% had hunting as their main profession. Similarly, a large percentage (67.86%) of respondents hunt at night, 25.0% combined both day and night hunt while 7.14% were involved in day-time hunting using individual hunting methods. The table further revealed that the majority of the respondents used Dane-gun (43.5%), snare (30.4%), and traps (23.9%) while 2.2% were involved in the use of catapult in harvesting wildlife from the reserve.

Table 2: The methods and tools engaged in wildlife harvesting in the study area

	Frequency	Percentage (%)
Full-time hunter		
Yes (Hunting only)	3	14.3
No (Hunting and Farming)	18	85.7
Hunting time		
Day-time only	2	7.14*
Night	19	67.86*
Both	7	25.00*
Method of hunting		
Individual hunting	21	100
Group hunting	0	0
Tools used for hunting		
Dane-guns	20	43.5*
Traps	11	23.9*
Snare	14	30.4*
Others	1	2.2*

** More than one response*
Source: field survey 2014

Table 3 shows the array of species being hunted and various reasons for hunting the species. The result shows that ungulates (74.1%,) were most hunted, followed by reptiles (18.5%), primates (3.7%), and birds (3.7%). Furthermore, 95.2% of the respondents assert that they hunt other species of animals while 4.8% hunted only the listed wildlife. On the sexual category of animals hunted, 50% agrees that they hunt both sexes, 38.10% hunted males while 11.90 hunted female. Likewise, 45.7% of the respondents claimed that they recognized the animals to be killed by their genital parts, 40.0% by their size (the males are usually bigger than the females) while 14.3% recognized the animals by colour. More so, the reasons for hunting wild-animals were identified. A large percentage (51.3%) hunt for their household consumption while commercial hunting had 48.7% of the respondents.

Table 3:Species of Animals Hunted and Reasons for Hunting

	Frequency	Percentage (%)
Species of animals hunted		
Primates	1	3.7
Ungulates	20	74.1
Reptiles	5	18.5
Birds	1	3.7
Other species hunted		
Yes	20	95.2
No	1	4.8
Sex of animals hunted		
Male	16	38.10*
Female	5	11.90*
Both	21	50.00*
Recognition of the animals		
Colour	5	14.3
Size	14	40.0
Genital parts	16	45.7
Reasons for hunting		
Subsistence	20	51.3
Commercial	19	48.7

** More than one response*
Source: field survey 2014

Table 4 shows the extent of Wildlife depletion due to poaching. The hunting experience of the majority (47.6%) of the respondents is between 5 -10 years, 28.6% is between 10-20 years, 14.3% is between 20 years above while 9.5% is below 5 years. However, most (76.2%) of the respondents engaged in hunting activities 2 times in a week, 19.0% between 3-4 days while 4.8% only once in a week. Furthermore, a large percentage (76.2%) of the respondents kill at least 2 animals per week, 19.0% up to 3 animals per week while 4.8% kill 1 animal per week. On the population status of the specie hunted in the forest reserve, the majority (85.7%) of the respondents agreed to a sharp decline in their population while 14.3% claimed a stable population. However, the majority (76.2%) of the respondents have their highest kill during the dry season, 19.0% during the raining season while 4.8% claimed that it is no difference in the two seasons. The table also shows that the majority (95.2%) hunt within the forest reserve with only 4.8% in other forests apart from the forest reserve.

Table 5 shows the opinion of Forest guards on the factors affecting the Wildlife population in the reserve. On other threats to Wildlife population apart from hunting, 52% of the respondents agreed that habitat destruction, 40% habitat fragmentation, and 8% slash and burn are the major threat wildlife population in the reserve. Unfavourable weather conditions (46.7%), Predation and Parasitism (36.7%), and Food scarcity (16.7%) were ranked as natural factors affecting the wildlife population in the reserve. However, 91.3% of respondents opined that wildlife population status is decreasing rapidly while 8.7% still believe that the wildlife population is still intact in the reserve. On the mechanism to check illegal hunting in the reserve, 52.8% of the respondents believe that prohibition of unauthorized entry would check illegal hunting, 41.7% believes that issuance of hunting license would curb illegal hunting while 5.6% opined that regulating hunting seasons would curb illegal hunting.

Table 4:Extent of Wildlife Depletion due to Poaching

	Frequency	Percentage (%)
Years of hunting		
Below 5 years	2	9.5
5-10 years	10	47.6
10-20 years	6	28.6
20 years and above	3	14.3
Hunting day(s) per week		
Once	1	4.8
Twice	9	76.2
3-4 times	11	19.0
Number(s) of kills per week		
One (1)	1	4.8
Two (2)	16	76.2
Three (3)	4	19.0
The population of the species hunted		
Decreasing	18	85.7
Constant	3	14.3
Season of the highest kill		
Rainy season	1	19.0
Dry season	16	76.2
Both	4	4.8
Hunting in other forests?		
Yes	1	4.8
No	20	95.2

Source: field survey 2014

Table 5: Opinion of Forest guards on the factors affecting Wildlife Population in the Reserve

	Frequency	Percentage (%)
Other threat to wildlife population apart Poaching		
Habitat destruction	13	52.0
Slash and Burn	2	8.0
Environmental pollution	0	0
Habitat fragmentation	10	40.0
Natural factors affecting wildlife Population		
Food scarcity	5	16.7
Unfavourable weather conditions	14	46.7
Predation and Parasitism	11	36.7
The population of wildlife as regard hunting		
Increases	0	0
Decreases	18	91.3
Balance	3	8.7
Mechanism to check illegal hunting		
Issuance of license	15	41.7*
Regulated harvesting period	2	5.6*
Prohibition of unauthorized entry	19	52.8*

**More than one response*
Source: field survey 2014

Table 6 shows the results species of animals sighted during a 56 km reconnaissance walk in the study area. A total of 3 primates (2 Mona monkeys and 1 Red-capped Mangabey), one Ungulate (Duiker) 5

reptiles, and 1, 367 bird species were sighted and recorded

.

Table 6

Species of animals hunted	Total Observed
Primates	3
Ungulates	1
Reptiles	5
Birds	1, 367

Perp. Dist = 30 meters

Discussion

The result shows that Edege village has the highest number of hunters using the forest while Ojo-Akute had the least. The reason could be the proximity of the Edege village to the forest reserve while Ojo-Akute village is the farthest village to the forest. All the hunters interviewed were male and of marriageable age which could be attributed to the belief in Africa that hunting is majorly for men folks. Hunting and gathering of wild animals have constantly been a significant part of life in rural African cultures. These observations agree with the observation of Lahm (1993), Nathalie van Vliet and Nasi (2008), and Adefalu *et al*., (2009) where all hunters they interviewed in their respective researches were male whose mean average age was 38.3 years similar to the age distribution of most of the respondents used in this research. This active age group falls within the dominant age group of between at 15-64 years in Nigeria (NMEC, 2008, Orimaye *et al* 2018). More so, most of the respondents had no formal education at all which signifies the low level of education in the rural area in Nigeria which corroborates the findings of Dadan *et al,* (2014) where he reported the existence of higher inequalities in educational achievement between rural and urban dwellers of China. McKenzie (2004) also opined that this inequality may be the distance of the available schools from home which may correspondingly affect attendance. However, most of the respondents combined hunting with farming, but their average income of ₦20,000 to ₦30,000 per month from hunting despite the use of primitive tools such as Dane gun, traps and snare is a clear signal that the population of wildlife within the forest reserve is negatively affected. This observation was equally noted by Okorafor *et al*., (2012) where he reported that all (100%) hunter interviewed used all the tools mentioned. IUCN (2000) and Fa *et al*., (2002) affirmed that hunting has been specifically identified as a threat for 84 mammalian species and subspecies from West and Central Africa.

The large percentage of respondents who prefer to hunt mammals to other species of animals could be that most mammals are large-bodied animals which pose an easy target due to their size and also means more money from their kill (Orimaye *et al*., 2017). This observation agrees with the studies of Peres (1990) and Bodmer (1995) that Neotropical hunters prefer large species, when these are available, for sale and their protein value. This trend was also corroborated by hunters with over 5 years' experience which have a particular species they hunt which have declined in population over the years. All these could have explained the reduction in the kill by the hunters over the years.

Conclusion and Recommendations

The results of this study revealed that wild animals are been hunted mostly for food (protein supplement) and to generate income. Most of the respondents claimed that they hunt for subsistence purposes. The study also showed that the species of animals most hunted were mammals and the majority of the respondents engaged in night hunting using primitive tools and equipment. Since these hunters hunt more than two times per week and almost all of them hunt exclusively within the reserve, the population of wild- animals have greatly declined. The rate of illegal exploitation can be attributed to poverty, the poor monitoring, and supervision of activities going on within the forest reserve.

Based on the findings of this study, the following are recommended.

- More personnel should be recruited to monitor and supervise the activities going on within the forest reserve.
- The government should discourage the indiscriminate logging and all activities of farmers who practice various farming activities within the reserve.
- Conservation education/program should be initiated through mass media especially radio programs to prevent over-exploitation of these animals by the grassroots dwellers.
- Strict policies or measures should be put in place to ensure adequate management by relevant government agencies.
- Active participation of the communities around the forest reserve should be encouraged in the planning and implementation of forest policies.

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