ISSN 0189-2207

ANNALS OF BORNO

VOL. XXV (2020)

UNIVERSITY OF MAIDUGURI PRESS

SPONSORED BY

tetfund
TERTIARY EDUCATION TRUST FUND

(TETFund/DESS/UNI/MAIDUGURI/ARJ/2017-2024/1)

Review of Geothermal Energy Technology and its Potential for Power Generation in Borno Basin, Nigeria

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Abstract
A review of Geothermal Energy technology and assessment of boreholes in Borno Basin was carried out in order to determine the potentials of geothermal power generation. Temperatures of 180^{o}C and 280^{o}C between the depths of 4000m and 4500m have been identified in the three geothermal anomalies of the Basin. In addition to the gravimetric analysis of the Chad Basin formation, various methods of geothermal exploitation have been surveyed and Binary Power plant have been proposed for the purpose of electricity generation in these areas.

Keywords: Geothermal Energy, Geothermal gradient, Borno Basin, Binary power Plant,

INTRODUCTION
A large population in the world are still not being serviced with energy needs at the minimum level even in the 21st century (Dassappa, *et al*, 2004). Only about 35% of Nigerians have access to electricity compared with 95% in Egypt and 75% in South Africa. On the overall, energy consumption in Africa is less than 5% of the global use, though 13% of the world's populations and 10% of the world crude oil-reserves are in Africa. Nevertheless, 85% of the people in Africa still live in rural areas without access to electricity. Nigeria, the most populous country in Africa is herself facing an irony of sort; being the sixth largest world producer of crude oil, but yet facing very serious energy Crisis for over a decade (Bugaje, 2008). Heat from the earth can be used as an energy source in many ways, from large and complex power stations to small and relatively simple pumping systems. This heat energy, known as geothermal energy, can be found almost anywhere—as far away as remote deep wells in Indonesia and as close as the dirt in our backyards. Tapping geothermal energy is an affordable and sustainable solution to reducing our dependence on fossil fuels, and the global warming and public health risks that result from their use (Crissie, 2003). Geothermal is the only form of 'renewable' energy that is independent of the sun, having its ultimate source within the earth. It is a comparatively diffuse resource; the amount of heat flowing through the earth's surface, 10^{21} joules per annum, is tiny in comparison with the massive 5.4 x 10^{24} Joules per annum solar heating of the earth which also drives the atmospheric and hydrological cycles. Fortunately, there are many places where the earth's heat flow is sufficiently concentrated to have generated natural resources in the form of steam and hot water (180-250 ^{o} C), available in shallow rocks and suitable for electricity generation (Brown and Ganish, 2004). Unfortunately, geothermal wells of commercial proportions have not yet been investigated in Nigeria; a market for geothermal energy may emerge only when the existence of a significant resource based can be established (ECN, 2007). This paper is aimed at assessing the potentials of electricity generation from geothermal energy in the Nigerian part of the Lake Chad Basin (Borno Basin) and establishing reliable data that can be incorporated into the national renewable energy master plan.

MATERIALS AND METHOD

The Geothermal Resource

Under the earth's crust, there is a layer of hot and molten rock called magma. Heat is continually produced there, mostly from the decay of naturally radioactive materials such as uranium and potassium. The amount of heat within 10,000 meters (about 33,000 feet) of Earth's surface contains 50,000 times more energy than all the oil and natural gas resources in the world (Twidell and Weir, 2006).

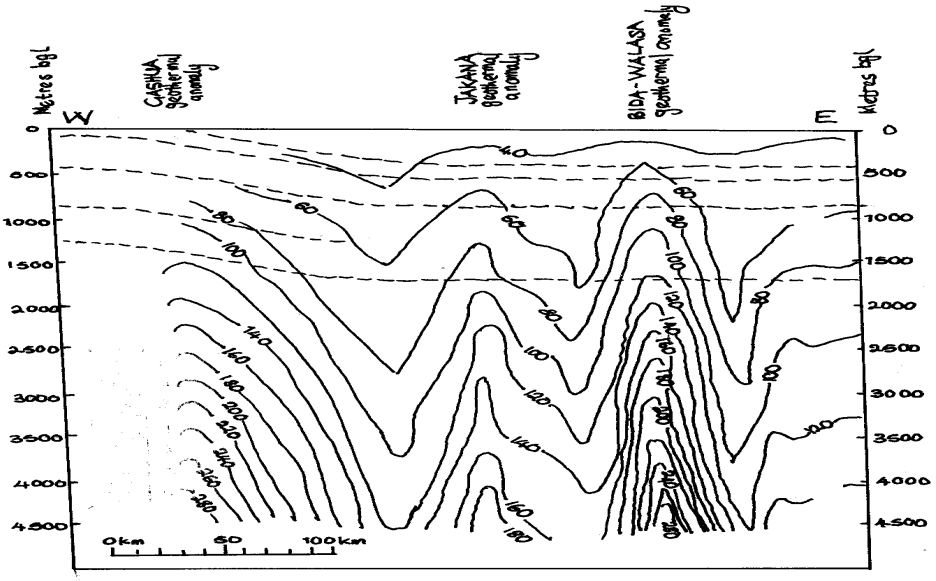

Fig.1a: Cross section of geothermal temperatures of the three potential sites

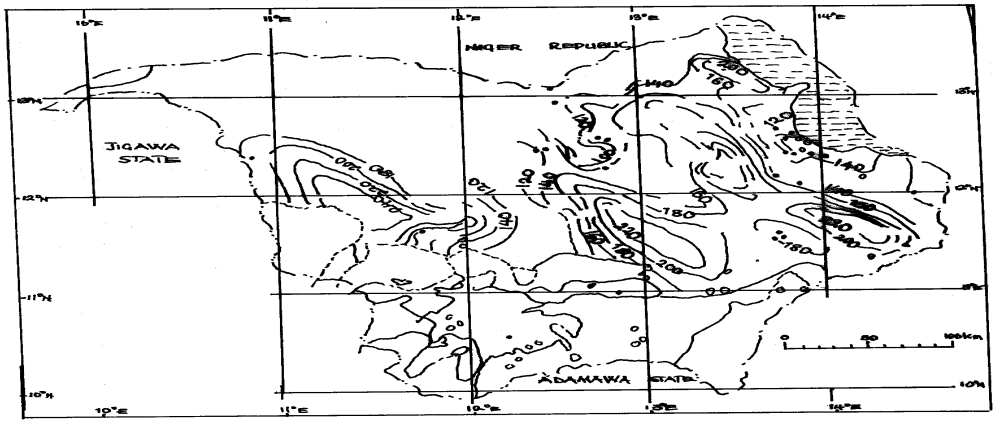

Fig.1b: Water temperatures at the depth of 4500m.

Occurrence of warm water in artesian boreholes drilled in Chad Formation of Borno Basin for the first time appeared in Barber and Jones (1960) and Barber (1965). Borno State Water Corporation embarked on systematic measurement of water temperature at the end of pumping test in its newly drilled boreholes. In 1987, Askira, carried out field measurements from 64 wells produced the first set of geothermal maps for Borno Basin. In the same year Schoeneich and Askira at the international conference on Chad Basin presented improved version of these maps, based on 48 boreholes. The maps show three warm geothermal anomalies up to 5^{o}C/100m trending NW – SE, above the 3^{o}C/100 m geothermal background of the Basin. Then in 2005 Kwaya updated these maps using temperatures from over one hundred water wells drilled by Borno State Water Corporation and by Chad Basin Development Authority (USDOE, 2006). Table 1 shows extract of wells having geothermal gradient of more than 3^{o}C/100 m (Kwaya *et al*., 2004). Fig1(a) and 1(b) shows the cross section of geothermal temperatures of the three potential sites and water temperatures at the depth of 4500m, respectively.

The sedimentary fill of Chad Basin, is estimated on the basis of gravimetry to be over 7,000 m, with the exception of the Pindiga Formation which is highly porous, moderately permeable and contains 9,530 km^3 of salty and fresh water, about 27% of all salty and fresh water in Nigeria. However fresh portable water, some 1,713 km^3 or 15% of all Nigeria's fresh water, is confined only to the uppermost 500 m of Chad Formation. This is mostly fossil water, accumulated during the Pleistocene time. Since about 20,000 years, these fresh water aquifers of the Chad Formation are not recharged by rain, at least in the northern part of the Basin. Sedimentary rocks below Chad Formation, down to the base of the Basin, are saturated by salty connate water of stagnant belt, with mineralization increasing from about 1 g/l in Kerri – Kerri Formation to about 320 g/l at the depth of about 3,000 m. This chlorosodic water is very hot, up to water critical temperature of 374.2 ^{o}C and under high hydro geological pressure. On warm geological anomalies, at depths below 6,500 meters in sedimentary rocks water exists only in gaseous form, as superheated steam. Salt water and steam of stagnant belt in Borno Basin amount to 7,817 km^3 or 33% of Nigeria's salt water (Kwaya *et al*., 2004).

Table 1: Geological information of wells with geothermal gradient of more than 3^{o}C/100m.

S/No	Borehole number / name	Coordinates Lat North. Long East	Depth to Mid screen.(m)	Ground water temp. (^{o}C)	Ground surface temp (^{o}C)	Geothermal gradient ^{o} C/100m
1	25/143/DC	11.41 11.20	154	39	28	5.84
2	9/DA	11 46 15 11 58 25	172	34.5	28	3.08
3	1/BA	11 30 56 13 40 37	150	35	28	3.33
4	7/DA	11 45 28 11 57 44	170	35.5	28	3.23
5	6/DA	11 44 32 11 57 46	131	36	28	4.58
6	8/DA	11 45 15 11 58 57	127	34	28	3.14
7	25/155/GJB	11 30 38 11 58 03	109	33.5	27	4.12
8	1/BM	12 18 42 13 24 28	315	50.5	30	5.87
9	8-DA	11 45 18 11 58 57	126.8	34	28	3.15
10	1/GZ	12 39 45 13 17 40	366	44	30.5	3.68
11	1/BD	12 18 27 13 24 34	330	51	30	5.75
12	16/62/WAL	11 34 20 14 14 20	146	32	27	4.72
13	27/512/KDG	11 39 13 25	188	36.9	28.5	3.40
14	26/281/JK	11 50 39 12 46 35	187	38.9	29	4.22
15	CB-11	12 35 13 06	346	43	30.5	3.03
16	Kemar	12 06 29 13 37 56	458.7	60.5	31.5	5.88

17	Kasade	12 55 50	13 26 23	121.7	76	31	3.53
18	Ngamma	12 23 59	12 39 17	152.5	81.4	30.5	3.20
19	245	11 55 10	13 10 01	477.54	50	29	3.98
20	268/MA	11 55 05	13 10 00	472.15	47	28.9	3.41
21	P267	11 55 10	13 10 01	465.34	50	29	4.08
22	266/MA	11 55 10	13 10 03	501.40	47	29	3.19
23	27/513	11 39 05	13 25 02	200.47	38	28.3	3.84
24	15/321Tb	12 30 00	13 55 00	311.87	45	30.3	4.07
25	15/224 Kum	12 34 15	13 24 50	338.09	48	30.6	4.56
26	15/339AB	13 50 00	13 35 40	352	50	32	4.56
27	16/95 DL	12 30 05	13 27 15	310	48	30.3	5.06
28	28/142GL	11 39 11	14 05 00	150.66	37	28.3	4.45
29	25/190FUN	11 40 05	11 45 00	155.5	35	27.8	3.34
30	18/158DBZ	11 28 00	12 28 00	186	36	27.8	3.33
31	27/527/KDG	11 39	13 25	192	37.8	28.5	3.80
32	Kanadi I	12 25 02	13 13 49	1782	103.4	30.5	3.97

Source: Kwaya *et al*. (2004)

Techniques for Geothermal Energy Exploitation

The techniques for exploiting the resources are very simple in principle, and are analogous to the well-established techniques for extracting oil and gas. One or more boreholes are drilled into the reservoir, the hot fluid flows or is pumped to surface and is then used in conventional steam turbines or heating equipment (Brown and Garnish, 2004).

Geothermal springs for power plants. The most common current way of capturing the energy from geothermal sources is to tap into naturally occurring "hydrothermal convection" systems where cooler water seeps into Earth's crust, is heated up, and then rises to the surface. When heated, water is forced to the surface, it is a relatively simple matter to capture that steam and use it to drive electric generators. Geothermal power plants drill their own holes into the rock to more effectively capture the steam (USDOE, 2006).

Dry Steam Power Plant

Steam plants use hydrothermal fluids that are primarily steam. The steam goes directly to a turbine, which drives a generator that produces electricity. The steam eliminates the need to burn fossil fuels to run the turbine. (Also, eliminating the need to transport and store fuels) This is the oldest type of geothermal power plant. It was first used at Lardarello in Italy in 1904, and is still very effective. Steam technology is used today at The Geysers in northern California, the world's largest single source of geothermal power. These plants emit only excess steam and very minor amounts of gases which contribute to global warming. The turbine blades which come into direct contact with the steam are subjected to chemical attacks from the impurities within the water which result into corrosion and erosion of the blades.

Flash Steam Power Plants

Hydrothermal fluids above 182°C can be used in flash plants to generate electricity. Fluid is sprayed into a tank held at a much lower pressure than the fluid, causing some of the fluid to rapidly vaporize, or "flash." The vapour then drives a turbine, which drives a generator. If any liquid remains in the tank, it can be flashed again in a second tank to extract even more energy. This method is not recommended because hot water is saline and with its mineralization of up to 320g/l, after cooling cannot be disposed and will pose serious environmental problem to the area

Binary-Cycle Power Plant

Most geothermal areas contain moderate-temperature water 204.4^{o}C. Energy is extracted from these fluids in binary-cycle power plants. Hot geothermal fluid and a secondary (hence, "binary") fluid with a much lower boiling point than water pass through a heat exchanger. Heat from the geothermal fluid causes the secondary fluid to flash to vapour, which then drives the turbines (Figure 2). Because this is a closed-loop system, virtually nothing is emitted to the atmosphere and hence the problem of global warming is not a case. Moderate-temperature water is by far the more common geothermal resource, and most geothermal power plants in the future may adopt binary-cycle plants. This is the one recommended for the area under study, because the temperatures at the three sites are between 180^{o}C to 280^{o}C (Table 1).

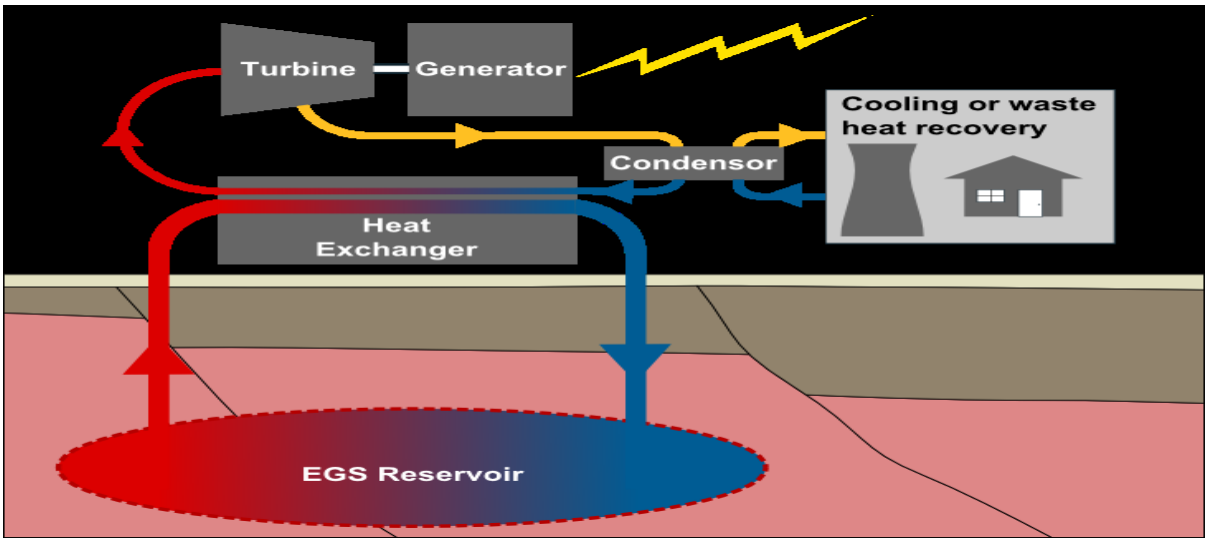

Fig. 2: Schematic showing key components of a geothermal power generation system. (Holmes and Hayward, 2011).

The power extracted from a single well is given by equation 1:

$$MW \approx C_P \times F \times \Delta T \times (\eta - P) \quad \text{.....(1)}$$

where Cp is the specific heat of the working fluid; F is the flow rate from the production well; ΔT is the sensible heat that can be extracted from the fluid produced by the production hole ($T_{reservoir} - T_{rejection}$); η is the efficiency with which the heat energy can be used, and P is the parasitic losses (Holmes and Hayward, 2011).

Technical Characteristics of Geothermal Energy Technologies

Geothermal power plants tend to be in the 20 MW to 60 MW range and the capacity of a single geothermal well usually ranges from 4 MW to 10 MW. Typical minimum spacing of 200 m to 300 m is established to avoid interference. Geothermal power plants have an average availability of about 90% compared to 75% for coal. The Olkaria I Geothermal Power Station in Kenya has been in operation for over 20 years and has consistently maintained an availability factor of about 98% (Holmes and Hayward, 2011).

Economic Competitiveness of Geothermal Energy Technologies

The economics of geothermal energy is highly variable depending on applications and site-specific conditions. The dominant costs are capital costs, especially for boreholes whose costs increase exponentially with depth. Since temperature increases with depth, and the value of the energy increases with temperature, most scheme settle on optimum borehole depth of approximately 5km
(Twidell and Weir, 2006). The costs of steam or hot water for direct applications will depend on geothermal steam/hot water temperature and the distance from the well to the point of use. The cost of geothermal power production varies from US5-7/kWh for plants less than 5 MW and US2.5-5/kWh for large plants of more than 30 MW for high quality reservoirs. Direct capital costs also vary significantly. Large plants in high quality sites can be as low as US$750/kW and as high as US$2300/kW for small plants (ECN, 2007).

Avoided Costs and Environmental Impact

Worldwide, direct uses of hot water reduced dependence on fossil fuels equivalent to burning of 830 million gallons of oil or 4.4 million tons of coal per year. Worldwide electrical production from geothermal reservoirs avoids the combustion of 5.4 billion gallons of oil or 28.3 million tons of coal. Based on the potential for U.S. geothermal power production from enhanced technologies cited above, the opportunity to avoid or offset over 74 million tons of CO_2 emissions annually from fossil fuel power generation and thereby significantly reduce greenhouse gas emissions in the country. In addition to these global emission reductions of a coordinated Federal/State/Industry geothermal power initiative, regional and local emissions will also be significantly reduced. Substituting 18,880 MW of geothermal power for an equivalent amount of power from the most advanced gas fired power plants would avoid over 5,000 tons of NO_x, 8,000 tons of CO, 5,000 tons of PM_{10}, and 2,000 tons of VOC's annually in the western skies even though air pollution does not respect international borders. Thus, increased reliance on geothermal energy will not only provide reliable baseload power but also enhance environmental quality making geothermal an integral component of the comprehensive national energy plan (Long and Shenenell, 2001).

The Future of Geothermal Electricity

Steam and hot water reservoirs are just a small part of the geothermal resource. The earth's magma and hot dry rock will provide cheap, clean, and almost unlimited energy as soon as we develop the technology to use them. In the meantime, because they're so abundant, moderate-temperature sites running binary-cycle power plants will be the most common electricity producers (USDOE, 2006). Obviously, electricity is a more valuable end-product than hot water, so most attention tends to be focused on those resources capable of supporting power generation, i.e. hot enough to make electricity generation economical. In 2004, over 9,000 megawatts of electricity were produced from some 250 geothermal power plants in 22 countries around the world. These plants provide reliable base-load power for well over 60 million people, mostly in developing countries. African countries with geothermal energy potential are those that are traversed by the East African Rift Valley. These countries include Djibouti, Eritrea, Ethiopia, Kenya, Tanzania and Uganda. Two known geothermal resources exist in Nigeria: Ikogosi Warm Springs in Ondo State (*sic*) and the Wikki Warm Springs in Bauchi (ECN, 2007).

Benefits and Limitations of Geothermal Energy Technologies

Where the resource exists, geothermal energy is a secure energy source. It is available 24 hours a day all the year round. Geothermal plants have high availability factors. Geothermal energy is also environmentally benign and releases minimal emissions. While the running costs of geothermal plants are low, initial costs of well drilling, pipeline construction, resource analysis of drilling information, design of plant and power plant construction is high. Steam or hot fluid cannot be transported efficiently over long distances. Therefore, the choice of the location of power plants is restricted to where reservoirs exist (Long and Shenenell, 2001).

CONCLUSION

From this research work it can be concluded that there is high potential of exploiting geothermal energy resource using Binary power cycles, especially in the three geothermal anomalies of Bida Walasa, Gashua and Jakana. Temperatures of 280^{o}C, 180^{o}C and 280^{o} C can be obtained in the three geothermal anomalies between the depths of 4000 m to 4500 m respectively, these temperatures are high enough to run a binary power plant. Even though the initial cost of drilling deep wells and setting the power plant is high the cost benefit is realised over time because of its high availability factor and environmental friendliness.

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Design, Development and Testing of an Automatic Hydraulic Car Jacking System

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Abstract
The typical hydraulic jack is a small usually cylindrical lifting device. The typical jack whether mechanical or hydraulic is usually actuated by a handle on up and down motion or in a circular motion. This paper presents the design and construction of an automated portable hydraulic jack that will enable easy and a faster operation of carjacking for preventive or routine maintenance work. It is powered by 12V, D.C motor with a remote control and has an overall efficiency of 90.75%. The car jack was able to raise 5000 kg weight of vehicle for replacement of bad tire or maintenance. This system provides ease of operation for pregnant women, elderly and physically challenged individual. It also eliminates the challenges of bending and squatting position of the operator for long duration as in the case of the manually operated hydraulic car-jacking system. The jacking system is recommended for motorist and auto mechanics.

Key words: Car Jack, Hydraulic System, Electrical, lifting, Repair

INTRODUCTION
The applied science of hydraulic system using fluid power have been developed over several decades and many applications of this science are now in use in our day-to-day lives. One of such application is found in the automotive industry such as car hydraulic jacking systems. Available car jacks such as screw jacks, bottle jacks, service jacks, stand jacks, floor jacks etc, are typically operated manually and therefore require substantial physical effort applied on the part of the user. Such jacks present difficulties for the elderly, handicapped, pregnant women, and takes more time for its operation even by an automobile mechanics or experts. Looking at the conventional manual type of jacks, there is a lot of human stress involve in its operation. Due to this effect, the regular use of the jack could damage or cause severe implications to the human body. This work provides the concept of an automatic hydraulic carjacking (AHCJ) device. The lifting of car for repair and maintenance by an auto-mechanic(s) or an individual is achieved with almost an effortless, faster and easier operation of the hydraulic car jack component that is driven by a 12V, D.C motor.

DESIGN METHODOLOGY

Design considerations
The materials for constructing of the machine were chosen based on their availability, required properties and economic considerations. The following were put into consideration while designing the machine, efficient, portability, ease of operation and the force required to operate the machine. The properties of the materials are chosen for strength, lightness of the material, Machinability, availability of the material and it costs (Ibhadode, 1997). The above qualities of materials were considered and chosen in the selection of material used in the design and construction of the automatic hydraulic car jack components. The hydraulic jack, circuit board

and the electric wiper motor were purchased. Slider-crank mechanism, the link, the base support was fabricated after their design.

Design Analysis and Calculation

Design Analysis of the Hydraulic Jack Unit

Mathematically, Pressure transmitted in the hydraulic system (P) = $P_1 = P_2$ in N/m^2

According to Pascal's law (*Louis, 2006),* pressure is uniformly distributed in a confined incompressible fluid).

where,

P_1 = Pressure in the large hydraulic cylinder

P_2 = Pressure intensity in the small hydraulic cylinder

$$P = \frac{\textbf{Force}}{\textbf{Area}} = \frac{\textbf{F}}{\textbf{A}}$$

The internal area of the large cylinder (m^2),

$A_{L1} = \pi D_{L1}^2/4$ (Kraige, 2002) ……. …….1

The internal area of the small cylinder (m^2),

$A_{s1} = \pi D_{s1}^2/4$ ……. ……2

where the desired internal diameter of the large hydraulic cylinder, D_{L1} = 0.03 (m) and the desired internal diameter of the small hydraulic cylinder, D_{s1} = 0.012 (m).

1 and 2 represent internal and external measurements, while L and S represent large and small measurements of the components respectively.

Therefore, the pressure exerted on the internal area of the large hydraulic cylinder (A_{L1}),

$P = F_2/A_{L1}$ ……. 3

where; F_2 = Maximum load to be lifted by the hydraulic Jack (Load on large cylinder),

Similarly, according to Pascal's law, pressure is distributed undiminished throughout a closed container.

Therefore, the effort or force on the small hydraulic cylinder, F_1 (N),

$F_1 = P \times A_{s1}$ …… 4

For the Large Cylinder:

The yield stress of the cylinder material (mild steel), δ_y = (480 MN/m^2),

$\delta_y = P\times [(D_{L2}+ D_{L1})/(D_{L2} – D_{L1})]^2$ (Essien and Nsikan, 2008) ……. 5

Where D_{L2} = External diameter of the large hydraulic cylinder (m).

The thickness of the large hydraulic cylinder (m),

$t_L = (D_{L2} – D_{L1})/2$ ……. 6

For the Small Cylinder:

$\delta_y = P\times[(D_{s2}+ D_{s1})/(D_{s2} – D_{s1})]^2$ ……. 7

where D_{s2}= External diameter of the small hydraulic cylinder (m).

The thickness of the small hydraulic cylinder (t_s) (m),

$t_s = (D_{s2}–D_{s1})/2$ ……. 8

The Hydraulic Reservoir:

To find the internal diameter of the reservoir:

D_{r1} = the internal diameter of the hydraulic reservoir (m) and

The desired external diameter of the hydraulic reservoir = D_{r2} = 70 (m).

$\delta_y = P \times [(D_{r2} + D_{r1})/(D_{r2} - D_{r1})]^2$ ……. 9

The thickness of the reservoir, $t_r = (D_{r2} - D_{r1})/2$ …… …….10

Volume of the reservoir, V_r = Area of the hydraulic reservoir (A_{r1} in m^2) × Desired length of the reservoir (L_r = 0.135m).

But $A_{r1} = \frac{\pi}{4} D_{r1}^2$ ……. ……11

Therefore, $V_r = A_{r1} \times L_r$ ……. ……12

The Slider-Crank Mechanism:

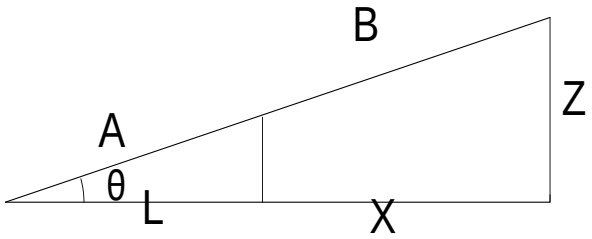


Fig. 1 Analysis of the Slider Crank Mechanism

Using trigonometric ratios;

where A = 0.07 m (at 30^o to the horizontal),

B = 0.128 m (at 30^o to the horizontal) from A and

θ = Desired angle of maximum displacement to the reference point = 30^o

Total length of the sliding lever pipe, F,

$F = (A+B) \cos \theta$ ……. .13

The length of the sliding lever pipe from the pivot to F_1, L,

$L = A \cos \theta$ …… .14

The crank length Z will be:

$Z = (A+B) \sin \theta$ …….. 15

To determine the angular velocity, ω of the Crank arm, we use Klein's analytical method,

where; N = Speed of Motor = 27 rpm

The ratio n,

$n = (A+B) / Z$ …… ..16

The angular velocity of Connecting rod in rad/s, (ω_c), is obtained from:

$\omega_c = \frac{2\pi N}{60}$ (Meriam and Kraige, 2002) ……. 17

The angular velocity of Crank arm in rad/s, ω,

$\omega = \frac{n \times \omega c}{\cos \theta}$ (Meriam and Kraige, 2002) …… ……18

The speed of rotation of the crank arm in rpm, N',

$N' = \frac{60 \times \omega}{2\pi}$ …….……19

The Sliding Lever:

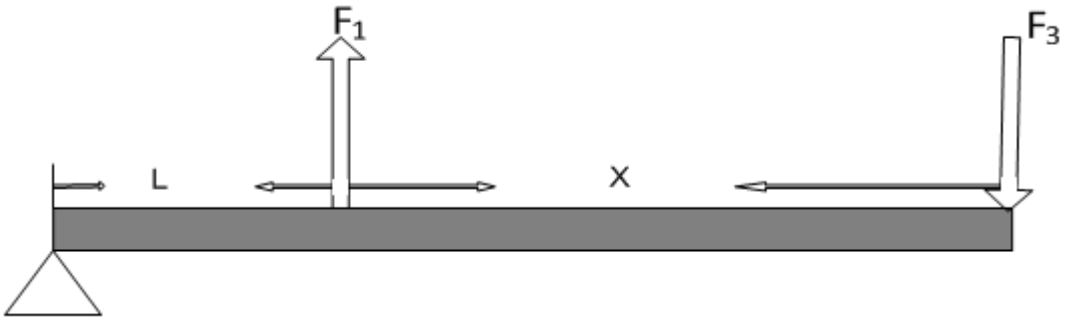


Fig. 2 Diagrammatic Representation of the Slider-Crank Mechanism

Taking moment about the pivot; + ΣMA =0;

$F_3 = (L*F_1)/ (F)$ …… 20

To determine reaction at the pivot, RA

Σ Fv = 0; summation of vertical forces equal to zero (0).

$RA = F_1 - F_3$ ……. ……21

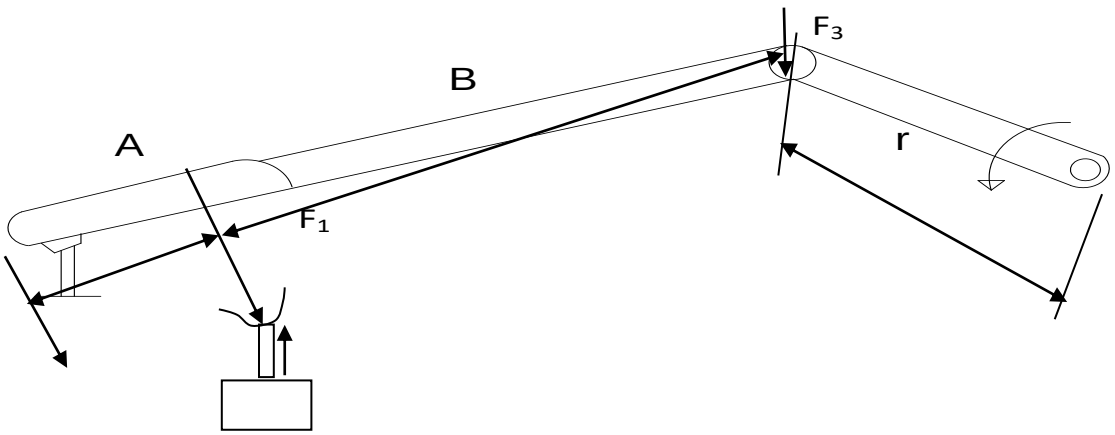


Fig. 3. The Slider Crank Mechanism.

The power required, P

$P = T \times \omega$ ……..…… 22

where, the torque on crank arm, T (Nm) and r = Radius of the crank arm (m).

$T = F_3 \times r$ …….. ……...23

Mechanical Advantage (M.A)

Mechanical Advantage = M.A = $\frac{\textbf{Load}}{\textbf{Effort}}$

For the Jack Unit

Maximum load capacity the hydraulic Jack can sustain = F_2

Applied effort on the hydraulic Jack = F_1

$M.A = F_2 / F_1$ …… ……24

For the Slider-Crank Mechanism

The load on the slider crank member = F_1

The applied effort on the slider crank member = F_3

$M.A = F_1 / F_3$ ……. 25

Velocity Ratio (V.R)

For the Jack Unit

where;

L_1= Desired length of the small hydraulic cylinder = 0.035 (m).

L_2= Desired length of the large hydraulic cylinder = 0.127(m).

L_3= Displaced length of fluid in the large hydraulic cylinder (m).

$L_3 = (A_1 / A_2) \times L_1$ ……..…….26

The number of stroke (N_c) by the piston to fill the large hydraulic cylinder is given by,

$N_c = L_2 / L_3$. …….……..…….27

V.R = $\frac{\textbf{Distance moved by effort}}{\textbf{Distance moved by the load}}$

$V.R = L_1 / L_2$ ….…….28

For the Slider-Crank Mechanism

V.R = $\frac{\textbf{Distance moved by effort}}{\textbf{Distance moved by the load}} = \frac{\textbf{Z}}{\textbf{C}}$ ..……..……29

where, c = Desired maximum height of the piston head displacement = 0.035 m

The Valve Unit

The desired diameter of the valve spring, D = 10 m.

Then, the twisting moment on the wire diameter, T (Nm),

$T = F_2 \times \frac{\textbf{D}}{\textbf{2}}$ …….……..…… 30

The diameter of the spring wire, d (m),

$d = \sqrt[3]{(\frac{\textbf{16T}}{\boldsymbol{\pi\tau}})}$ …….……...…….31

where the allowable shear stress on the wire diameter, $\tau = 420$ (MPa)
The spring index, C

$$C = \frac{D}{d} \qquad \text{……..……32}$$

Determination of the Efficiency (η)
For the Jack Unit and For The Slider-Crank Mechanism

$$\eta = \frac{M.A}{V.R} \times 100 \qquad \text{…….……33}$$

Overall Efficiency η_o
η_o = Efficiency of the hydraulic Jack × Efficiency of the slider-crank mechanism x 100

From the analysis conducted, the following results were obtained:
The maximum load to be lifted by the hydraulic Jack = F_2 = 49050 N
The internal area of the large (A_{L1}) and small (As_1) cylinder are = $7.0695\times \mathbf{10}^{-4}$ m^2 and $7.855\times \mathbf{10}^{-5}$ m^2 respectively.
The pressure exerted on an area, A_{L1} of the large hydraulic cylinder = 69,382,558.88 N/ m^2
and the force on the small hydraulic cylinder = 5,450 N
The external diameter and thickness of the large cylinders are 66.8 mm and 18.4 mm respectively.
For the Small Cylinder, they were obtained as 22.3 mm and 61.5 mm respectively.
For the Hydraulic Reservoir, the internal diameter and thickness of the reservoir are
= 31.43 mm and 19.3 mm respectively.
Volume of the reservoir (V), = $1.0475 \times \mathbf{10}^{-4}$ m^3

The Slider-Crank Mechanism
Total length (L) of the sliding lever pipe is 171.5 mm while the length of the sliding lever pipe from the pivot to F_1 = 60.62 mm and the crank length Z is 0.099 m.
The angular velocity (ω) of the Crank arm is = 6.5305 rad/s from the speed of electric motor of 62.354 rpm.
Reactions at both ends are 1,926.41 N and 3523.59 N
The power required (P) is = 566.13W = 0.7592 h.p
Mechanical Advantage (M.A) for the jack unit and the slider-crank mechanism are 9 and 2.83
The Velocity Ratio for the jack unit and slider-crank mechanism are 9.009 and 2.57.
Finally, the overall efficiency of the system (η_o) is = 90.75 %

3.0 FABRICATION PROCESSES

In the fabrication process, care and precision was top priority, ensuring that the correct dimensions, the materials and the right fabrication methods were used to give the desired result at the end of the construction process. The bottom of the component part (hydraulic jack and electric motors) were drilled to a diameter of 40 mm to allow the fasting together by a bolt and nut with the respective positions on the base support. The link mechanism was assembled by drilling a hole in the compressed end of the link to fasten by means of a bolt to the arm. The link is then made to slide freely in the hollow of jack plunger which allows it to do its job. This arrangement makes up the link mechanism, which converts rotary motion of the electric motor to linear movement used in operating the lift lever arm of the hydraulic jack. The electric wiper motor is hooked using a bolted to its support stand. Its position is horizontal and fastened to the

base support. With a pre-drilled hole in the base, under the stepper motor, a housing to hold firm in place the motor was secured in position on the base support. The motor which is responsible for the link which opens and closes the relief valve of the hydraulic jack causes the jacking up and lowering of the hydraulic jack as commanded. The electric circuit and the remote sensor are secured in position on a stand above the stepper motor and the connection of harness to the electric motors were safely run so as not to cause short circuit. The cables that supply power were secured in place and a battery clip was used to connect it to the car battery. Extra holes were made to allow for a fitting of two manual buttons used as a back-up system in case of automatic failure. The whole system was enclosed in a casing.

The Link Mechanism

For this mechanism, processes such as marking out, filling, grinding, drilling and welding were employed using Venire callipers, drilling machine, hack saw and welding machine (arc welding machine). These were used in making up the link mechanism that is the slider link and the link arm by allowing the slider link to move freely in the steel pipe welded to the jack lift arm, while the link arm is welded to the rotating rod of the electric motor armature. The link arm was joined to the slider link by means of bolt and nut.

Relief Valve Open and Close Mechanism

This also involved the process of marking out, cutting, filling, grinding, drilling and welding using tools and machines that include venire calliper, hack saw, drilling and welding machine.
The steel bars were welded to the relief valve of the hydraulic jack and the other to the electric stepper motor while the aluminium link joins the two steel bars by means of bolt and nuts. The arrangement is such that, when the lift or the drop down command is initiated, the motor moves the rod after a time, t, to cause the aluminium link to either lock or un-lock the relief valve; consequently, inducing pressure in the jack or relieving the jack of it. This creates the necessary lift or drop down by the weight or force of the car.

The Base Support

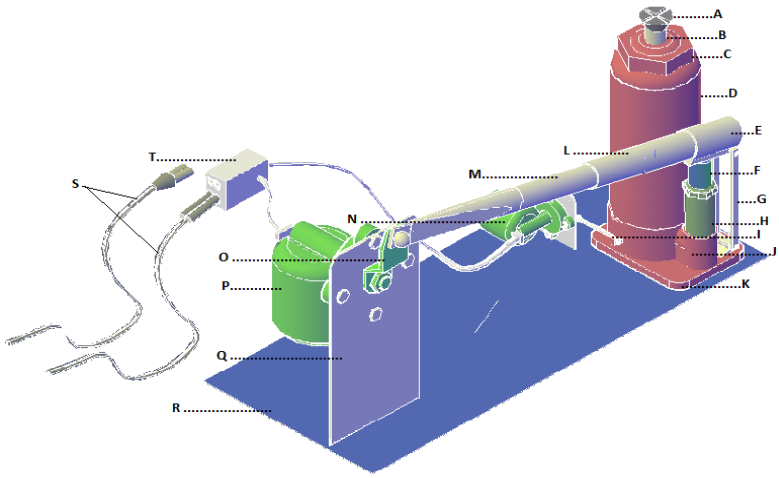
The process of marking out, cutting, filling, drilling, threading and welding were involved. Tools and machine used were scriber, caliper, rule, hacksaw, drilling machine, welding machine and tape. In this, a sheet metal of thickness 4 mm is marked out to the required dimension and cut to shape. Hole of 40 mm in diameter were then drilled into it as dimensioned to allow for proper fitting of the component parts on it. Angle bars of 4 mm thickness were also welded to corners of the plate. The angle plates were then drilled and tapped so that of the casing so as to fit it rigidly by bolt and nut.

The Overall Casing

The casing was produced from the process of marking out, cutting, folding, drilling, welding, grinding. Tools and machine used were scriber, caliper, rule, hacksaw, filling machine, drilling machine, welding machine. It involved marking out a metal sheet of desired specification and dimensions, folded to the required shape. The corners were then welded together. Holes were drilled on two opposite sides of the plate to give room for ventilation. A larger hole bore at the top end of the cover to allow the jack piston to move up for lifting and smaller hole for fastening the cover and the base support and to allow electric cable for power and bulge out of the slider link.

Description of the machine

The automatic hydraulic car jack was designed to ease operation and to be able to raise and lower a 5000kg weight of vehicle to the required height for repairs or maintenance. It enables easy and a more faster operation of carjacking for preventive or routine maintenance work. Furthermore, it helps to eliminate the bending and squatting position of the operator for a long time, which always occur when using a manually operated hydraulic car jack. This makes the equipment user friendly. It is power by 12V, D.C motor and an attached remote control.



A	SADDLE
B	PLUNGER
C	RESERVOIR CYLINDER HEAD CAP
D	RESERVOIR CYLINDER
E	LINK ARM
F	PISTON
G	LINK SUPPORT
H	SMALL CYLINDER
I	VALVE LEVER
J	BASE SUPPORT
K	FLANGE (BASE SUPPORT)
L	LEVER LINK
M	SLIDER LEVER LINK
N	WIPPER MOTOR (FOR VALVE CTRL.)
O	CRANK
P	WIPPER MOTOR (FOR JACKING)
Q	MOTOR SUPPORT
R	BOTTOM CASE
S	HARNESS (FOR POWER & REMOTE CTRL.)
T	CIRCUIT BOX

Fig. 4: Isometric view of automatic hydraulic car jack.

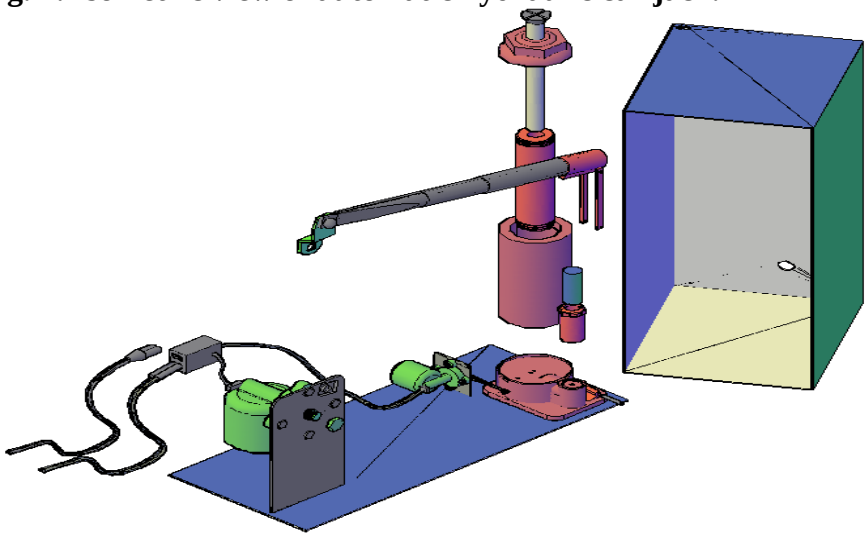


Fig. 5: Exploded 3D view of the automatic hydraulic car jack.

Principle of Operation

The machine is simple to operate requiring only one operator at a time. Before it is operated, all the parts must be properly set and fixed together. The slider crank mechanism is to be connected to the lever of the hydraulic jack using a mild steel pipe welded to the lever arm and the other end of the mechanism attached to the shaft of the electric motor by the use of a crank radius for easy rotation of the motor and the transmission of power to the crank mechanism to pump the

hydraulic jack for the lifting operation. The second motor is to be fixed to the relief valve of the hydraulic jack by a link mechanism to control the closing and opening of the valve. The electrical circuit as provided in figure 3, which consists of set of relays which helps to control the movement and sequence of operation of the motors, the circuit also connects the wired remote control with switch buttons used to control the operation of the device. The unit has been coupled and assembled together, to ensure that all the component parts are firmly and properly connected. The two wire terminals of the device to be connected to the terminal of the car battery ensuring that the positive cable was connected to the positive terminal and the negative cable to the negative terminal of the battery thus ensuring that the circuit is protected from damage. The jack to be positioned under a car that does not exceeds 5000 kg which is the limit of this design. The remote-control button is then pressed for the jacking action to start. As soon as the required height has been reached, the button is again pressed to stop the lifting action. To lower the car, the release button is pressed to release the pressure built up in the jack gradually, the process is repeated until the jack has been relieved completely of its built-up pressure and consequently the lowering of the jack by the weight or force of the car on the jack.

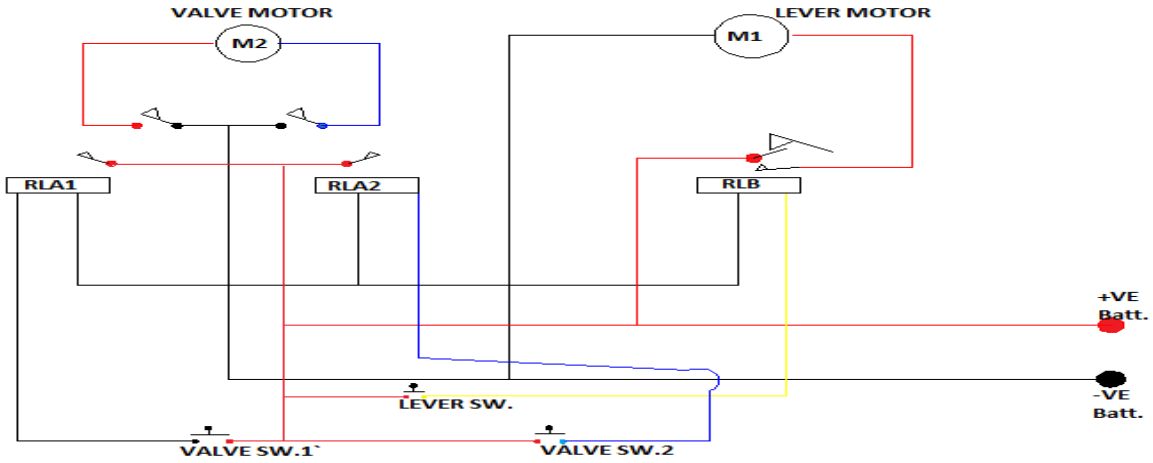


Fig. 6: Circuit Diagram of the Control Mechanism(s) of the Automatic Hydraulic Car Jack.

RESULTS AND DISCUSSION

The results obtained as provided in the preceding section helped in achieving the designed objectives of the work. The efficiency of the machine clearly shows the effectiveness of the machine in its operation and its ability to meet its designed considerations. The equipment will go a long way in revolutionizing the process of vehicle maintenance for all categories of people and workshops.

CONCLUSION

The development of an automatic hydraulic car jack system is an improvement on the existing manual and electronically-controlled hydraulic car jack. Thus, the project provides a more convenient and stress-free aid to lift cars in order to perform maintenance work, since it makes use of a remote control and a little manual effort.

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Evaluating the Effect of Tamarindus indica L. and Duration of Exposure in the Control of Tribolium castaneum (Coleoptera: Tenebrionidae), in Polished and Milled maize flour in Maiduguri, Nigeria

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ABSTARCT
The experiment was conducted in the University of Maiduguri, Faculty of Agriculture, Entomology Laboratory (30-35^{0}C and 55-67% RH), in 2008 and 2009 to find out the effect of *Tamarindus indica L.* in the control of *Tribollium castaneum,* reddish-brown flour beetle in polished and milled maize flour. The treatments consisted of control (0g), 10g, 20g, 30g, 40g, and 50g of *Tamarindus indica* pods each placed in 1000ml (1lt) in which 200g of maize were placed, except in that of the control. Twenty five (25) *T. castaneum* adults were added into each of the six bottles containing the maize flour and this was replicated three times over a period of two (2) years. Data capture was done at ten (10)-day intervals up to the 80th day after inoculation of *T. castaneum.* The results showed a better control at higher doses of *T. indica* (30g, 40g and 50g) and at longer periods(50, 60, 70 and 80 days) after inoculations. The mortality rate was significantly higher in those of the control, 10g and 20g and live insects ranging from 100% in the control to zero in the 50g treatment after 80 days of exposure. *Tamaridus indica* is known to be useful in human diet, and this work has shown that it is also useful in the control of *T. castaneum* in stored grains and flour. Therefore, humans can make good use of this technology in storing their cooking flour and grains.

Keywords:*Tamarindus indica*, *Tribolium castaneum*, Stored, Polished/Milled Maize Flour, Duration, Mortality.

INTRODUCTION
Tamarind (Arabic: *tamarhindi*=Indian date) is native to tropical Africa in Sudan and Madagascar (Morton, 1987). It is widely cultivated and to some extent commercialized in the Americas, Asia and Africa. It is grown in the wild in Nigeria and indeed in all the climatic zones of the country. The plant is a traditional food plant in the Philippines and Africa as culinary and has the potential to improve nutrition, boost food security, foster rural development and support sustainable land care (NRC, 2008). The fruits are used as flavouring and spices in food drinks in food industries. The fruits are also used in making syrups by pharmaceuticals and as well in the cleaning industries for cleaning of dulling and other unwanted marks or stains on materials, equipment or facilities such as furniture. *T. indica* medicinal ability is seen when the pulp, powders made from leaves and barks of trunks, are used as herbal tea for reducing malaria fever (due to the acidic nature of the pulps) in Philippines and as Ayurvedic medicine in gastric and or gastric digestion problems in Thailand. In Nigeria, the leaves are useful in treating gangrene (ulcer, wounds), particularly those caused by guinea worms, leprosy and boils.

Tribolium castaneum, origin of India, but now all over temperate and tropical countries (Haines, 1991), is a 2-4mm long, reddish-brown in colour and similar to the confused flour beetle, *T. confusum,* except for the eyes and antennae. *T. castaneum* has cannibalistic tendency (Via 1999)-males have predilection for pupae, while females feed on eggs (Howe, 1956). The insect is polyphagous in nature, has a long life span and has a long reproductive period (Dawson 1977), which give this insect the ability to be a successful competitor due to its high fecundity rate and veracious predatory habits (Howe, 1963; Weston and Rattingourd, 2000).Various studies have proved that *T. casteneum* has high and veracious feeding habits, destroying up to 100% of stored products. It is polyphagous, feeding on various cereals and food crops in store, and because of its feeding pattern, contaminates products with its dead carcasses, cocoons and excreta (Haines, 1991). Direct use of chemicals for the control of pests in stored products has many times proven lethal (Hills 1983) to humans, (Zettler and Cuperus 1999, Ruberrio 2003). The aim and objective of this study is therefore, to use *T. indica,* with its acidic pod, a plant derivative (Lale 1995, Talukder and Howe 1995, IJPM 1999), to control insect pests. Due to its importance in human diet, harmless fumes, has medical potential, it is cheap to obtain, safe, low cost, environmental friendly, useful as horticultural and as orchard plant (Avav and Oluwatoyo, 2006). The authors wish to use its pods and pulps as pest control materials in stored polished and milled maize flour which can be of use and of benefit to rural and urban women in Maiduguri, and Borno State of Nigeria in general.

Although, the scope of this study is limited to the control of *T. castaneum,* adults in polished and milled stored maize flour, the various stages of the insect were also affected, because the population of live *T. castaneum* adult which were products of eggs, larvae and pupae were reduced with increasing *T. indica* concentrations, suggesting the effectiveness of the *T. indica* even on the various stages of development. Pests of *T. indica* include the groundnut *bruchids, Caryedon serratus,* but not *T. castaneum* and that is why this study was conducted to ascertain its level of protection to polished and milled maize flour, being the commonly used dietary flour for many families in this part of the region. However, the detailed effects of *T. indica* on eggs, larvae and pupae forms another study entirely, as it has not been proven to have ovicidal, larval or pupacidal characteristics.

MATERIALS AND METHODS

Experiments on the use of *Tamarindus indica,* harmless and colourless fumes to control *Tribolium castaneum* in polished and milled maize flour (using big grinding machine to polish and remove grain husks and later grinding it into fine flour) was conducted in the Entomology laboratory, Faculty of Agriculture, University of Maiduguri ($11^0$50'N, 13^0 15'E), Nigeria in the year 2008 and 2009.About 3.6kg of the polished and milled maize flour was obtained from Maiduguri local market. The *Tamarindus indica* pods were also from the local markets in Borno State as well the required quantity of *T. castaneum* were also obtained from Maiduguri local grain market. Other materials were 18 (1000ml)-capacity bottles, tray, bowl, 48mm wire mesh, weight balance and chicken feather for separation and removal of *T. castaneum* from the grain flour during data capture.Two hundred (200g) grams each of the flour were poured into each of the 18 (1000ml)-bottles whose lids were perforated to allow for air circulation. Into each bottle, 25 *T. castaneum* adults were introduced (inoculated) and the ripe, pilled, brown *T. indica* placed directly into each bottle as follows: - control (0g), 10g, 20g, 30g, 40g, and 50g. These were replicated three times to give a total of 18 bottles. The 2008 and 2009 results were merged and

means obtained for analysis, since lab conditions do not vary significantly. *T. castaneum* completes its life cycle in 20-30days, therefore, 10-day intervals were allowed for data capture starting from 20 days after infestation and subsequently 30, 40, 50, 60, 70 and 80 days after infestation. This arrangement was chosen to allow for eggs to be laid, hatch, pupate and mature up to two generations. Data collection was made by counting the dead and live insects at an interval of ten days to ensure that dead insects available were removed even before the next data collection. This interval of time can also allow for maximum population saturation point to be reached. It allows the insect to mature and become visible to the researchers' naked eyes, because the adults are those that breed and increase the population of the insects. Data collected were recorded for each of the years and analysed using Analysis of Variance (ANOVA) and means, separated by Least Significance Difference (LSD), (Steele and Torrie 1980, Osuala 2005, Akindele 2004).

RESULTS AND DISCUSSION

Tribolium castaneum takes between 20-30 days to complete a cycle and an adult may live for only 6 months (Howe, 1967). Allowing twenty days after infestation before data capture was to ensure emergence of young adults of the first generation. The subsequent ten (10)-day intervals were to ensure that dead carcasses were removed constantly to prevent death of the insects from contamination of flour and overcrowding rather than the effect of *T. indica* pods introduced into the bottles.

Table 1, shows the mean mortality rate increase for the two years and for each of the treatments, control (0.29), 10g (1.14), 20g (2.05), 30g(4.91), 40g (5.52) and 50g (6.48), which were significantly different ($p < 0.05$) from each other, except for treatment 30g and 40g which were not significantly different ($p > 0.05$) for number dead (ND) and number alive (NA) for each treatment. There was no significant ($p> 0.05$), LSD 0.09230 and SE 0.4641 for treatments LSD 0.9969 and SE 0.5013 for duration, while interaction between treatments and duration, LSD 2.4420 and SE 1.2280.Mortality by duration were observed to be significantly different ($P<0.05$) between (60) days (7.06) and seventy (70) days (4.22), while due rest were not significantly different ($P>0.05$) from one another: control (2.67), 10g (2.94), 20g (2.72), 30g (2.11) and 50g (2.06), with LSD 2.44, SE 1.23. In all the treatments there was an increase as from 30g to 50g in the durations of exposure and a decline as from the 70^{th} day due to the fact that only few number of live *T. castaneum* were left. Mortality increased as one moves from control (0g) on day 20 to 13.67 on day 60 at 50g treatment which was significantly higher ($p<0.05$). This trend was similar all through the treatments and duration such that it was in 13 groups out of 42 were not significantly difference ($p>0.05$), while the remaining 29 groups out of 42 were significantly different ($p<0.05$) indicating the effectiveness of *T. indica* at higher concentration (weight) and longer duration of exposure.

Table 1: Dead *Tribolium castaneum* observed at the end ten- day interval of exposure to five levels of *Tamarindus indica* treatment

	TREATMENTS						
Duration (days)	Control	10g	20g	30g	40g	50g	Treatment Mean
20	0.00	0.33	1.33	3.33	5.00	6.00	2.67c

30	0.00	1.00	1.33	4.00	5.33	6.00	2.94c
40	0.00	0.67	1.00	3.33	5.00	6.33	2.72c
50	0.00	0.33	1.00	3.00	4.00	4.33	2.11c
60	0.33	2.33	3.00	11.00	12.00	13.67	7.05a
70	0.67	1.67	4.00	5.33	5.67	8.00	4.22b
80	1.00	1.67	2.67	4.33	1.67	1.00	2.05c
Mean	0.29b	1.14cd	2.05c	4.91b	5.52b	6.48a	

Means with different letters are significantly different.

Table 2, shows the live insect, *T. castaneum* remaining after the dead ones were removed after exposure to five *T. indica* treatments and data collected and recorded after every period of ten days. The live insects were counted after separation from the dead ones, whose numbers were also recorded. Mean live insects were significantly different ($p<0.05$) from each other in all treatments, with number reducing from, control (33.62), 10g (19.24), 20g (17.52),30g (12.43), 40g (10.14) and 50g (6.29) declining from highest in the control (33.62) to lowest in the 50g (6.29) treatment, (LSD 1.1298, SE 0.5681). This indicates that there is an increasing effectiveness of the *T. indica* with weight (concentration) of the pods introduced. It is also observed that the mean number of live insects was declining generally with duration of exposure and increasing weights of pods in all the treatments, i.e. 20 days (23.22), 30days (19.94), 40days (17.39), 50days (15.94), 60days (15.33), 70days (12.61) and 80days (11.33), (LSD 1.2203, SE 0.6136), were all significantly different ($p<0.05$) except in the 50days (15.94) and 60days (15.33), which were not significantly different ($p>0.05$) from each other. This shows that interaction between weights and duration seem to indicate that the higher the doses (weights) of *T. indica* and the longer the duration of exposure, the more effective the control. It is a clear indication that the *T. indica* efficacy depends on the length of exposure and concentration (weight) of *T. indica,* (LSD 2. 9890, SE 1.5031). Using the LSD for the mean separation, twenty-two (22) out of 42 groups were not significantly ($p>0.05$) different, while the remaining 20 groups were significantly ($p<0.05$) different from each other.

Table 2: Live *Tribolium castaneum* observed at the end of each ten-day interval after exposure to five levels of *Tamarindus indica* treatments.

	TREATMENTS						
Duration (days)	Control	10g	20g	30g	40g	50g	Treatment Mean
20	28.33	24.33	24.00	21.67	22.00	19.00	23.22a
30	29.33	23.33	22.33	17.67	14.67	12.33	19.94b
40	30.33	22.67	21.33	14.33	9.67	6.00	17.39c
50	34.00	22.33	20.33	11.33	6.00	1.67	15.94d
60	35.00	17.00	14.00	11.67	10.33	4.00	15.33d
70	36.67	14.33	11.33	7.33	5.00	1.00	12.61e
80	41.67	10.67	9.33	3.00	3.33	0.00	11.33e
Mean	33.62a	19.62b	17.52c	12.43d	10.14e	6.29f	

Means with different letters are significantly different.

Table 3 show the mortality rate of *T. castaneum* with time lapse, while mortality in the control showed no significant difference (P > 0.05) with duration as indicated by similar letters 'be' attached to each figure ranging from 0.0 in the 20 – 30 days to 0.33 in the 70–80 day time-lapse. However, significant difference (P < 0.05) was observed in those with various treatments of 10g - 50g as indicated by the letters attached to them with duration. Means for all treatments with duration show that means of control (0.28),10g (- 0.28), 20g (-0.56) are not significantly different (P > 0.05), 40g (-2.83) and 50g (-2.17) are also not significantly different (P >0.05) however, 30g (4.67) showed significant difference (p< 0.05) from all the rest of the treatment. (LSD 1.3135, SE 0.6589).This means that there was high mortality at 30g treatment, particularly during the 50–60 day time-lapse. This was highly positive, an indication that the critical and most effective point to achieve the best control is between 50 – 60 days after infestation of the flour as it can be observed during the highest deaths in the control (0.33), up to the 80th day.

Treatment mean gave no significant difference (P > 0.05) among the treatments with the time lapse, 20 – 30 days and 50 – 60 days (0.17), 30 – 40 days and 40 – 50 days (0.22) and 60 – 70 days (- 0.83) were not significantly different (P > 0.05). (LSD 1.3135, SE 1.3135). This indicate that the different treatment did not have any effect on mortality with time lapse, unlike those in the Table 1 (dead) and Table 2 (live) *T. castaneum* with duration of exposure to treatments. Treatment (weight) and duration showed that means for treatment shows that five (5) groups with homogeneous means were not significantly different (P >0.05) while the remaining groups i.e. thirty-six (36), were significantly different (p < 0.05) from each other (LSD 3.2174, SE 1.6140).

Table 3: Mortality of flour beetle *Tribolium castaneum* in *Tamarindus indica* treated with polished and milled maize flour with time lapse, treatment over a period of eighty (80) days

	TREATMENTS						
Duration (days)	Control	10g	20g	30g	40g	50g	Treatment Mean
20 – 30	0.00bc	0.67	0.00	0.67	0.33	0.00	0.17a
30 – 40	0.00bc	-0.33	-0.33	-0.67	-0.33	0.00	0.17a
40 – 50	0.00bc	-0.33	0.00	-0.33	-1.00	-1.67	0.22a
50 – 60	0.33bc	2.00	2.00	8.00	6.33	9.33	0.17a
60 – 70	0.33bc	-0.67	1.00	-5.67	-6.33	-5.67	0.83a
70 – 80	0.33bc	0.00	-1.33	-1.00	-4.00	-7.00	-0.83a
Mean	0.28b	-0.28b	-0.56b	4.67a	-2.83c	-2.17c	

Means with different letters are significantly different.

The two-year experiments on the control of *T. castaneum*, in polished milled maize flour in Maiduguri, using mature and ripe *Tamarindus indica* pods proved successful with increasing weight of pods and duration, (from mean of 0.29 to 6.48). *Tribolium castaneum* mortality increased from mean of one (1) in the control to 4.33 in the 30g treatment with increasing *T. indica* pods and with increasing duration of exposure. The mean total of one (1.00) death recorded in the control may have been due to overcrowding and also possible saturation point, cannibalism and exhaustion of the available meal, poisoned meals due to contamination of the

flour from dead larvae, pupae, egg shells and insect deposits and cocoons. The effect of duration was observed to fluctuate, although not significantly different ($P > 0.05$) from the 20^{th} – 50^{th} day. However, death rate increased sharply from the 60^{th} to 70^{th} day, but dropped sharply at the 80^{th} day, maybe because no other live insects remained. The longer the period of exposure, to *Tamarindus indica*, the higher the mortality rate observed. It is advisable that using the *Tamirindus indica* pods to store milled maize flour before consumption will need at least three months, if a good result is to be achieved.

It was also observed that number of live insects increased in the control from the 20^{th} to the 80^{th} day after inoculation – an indication that without control measures, whether in large stores with large quantity of products or in small house holding, the insects would multiply unabated. The levels of damage by these insects in stores due to the increasing population can render the products unfit for consumption, resulting in wastage. At this time, natural control may take place due to the exhaustion of the good part of the meals, suffocation from overcrowding and death from poisoned meals - as a result of contamination from dead eggs and egg shells, dead pupae from cocoons, contest, competition and cannibalism. These are natural control methods which seem to be the only means that can reduce the insect pest populations without artificial methods of control. Without the natural, there is an eminent reduction in the quality and quantity of the stored products. Therefore, the few deaths recorded in the control (Table 1) could not have been possible if not because of the several reasons advanced above.

Live insects were exterminated by the 80^{th} day after inoculation, which shows the highest mean mortality of 6.48 (Table 1) and the highest treatment of 50g. The highest mortality rate of 13.67 after the 10 days interval was on the 60^{th} day and at 50g of *Tamarindus* treatment. These two periods could be regarded as the peak period of *Tamarindus indica* action on *T. castaneum*, since the highest mean mortality was recorded during these two periods. However, mean live insects increased in the control from 28.33, on the 20^{th} day to 41.67 on the 80^{th} day, suggesting that the insects can increase to intolerable population levels when no control measures are taken, showing significant difference ($P<0.05$) with durations of exposure (Table 2). The mean total for live *T. castaneum* decreased sharply with increasing *Tamarindus* from 33.62 in the control to only 6.29 in the 50g treatment, also suggesting that *T. indica* was very effective in controlling *T. castaneum* if left over a period of time (e.g. 3 months or more), as observed in this experiment when the *T. indica* is increased both in weight and quantity to keep concentration constant.

CONCLUSION

As far as time lapse is concerned, as indicated in Table 3, the rate of deaths per day had significantly fluctuated in the mean mortalities observed with the different treatment levels. It is also clear from the table that time lapse also played a critical role in the mortalities of *T. castaneum*, as well as the duration of exposure and treatment levels, which are the major factors considered in this study. However, the negative indicator observed in the time lapse table suggests that the number of insects which died before the expiration of sixty days were fewer than those which died after that period. The positive signs mean that the mortality figures recorded during the 50-60-day time-lapse indicate the critical period for *T. indica* effectiveness after inoculation. It is therefore, recommended that both the rural and urban women who need to store their cereal flour in pots or polythene bags for future use may need to put enough amount of *Tamarindus* pods into the stored flour. It is safe, leaves no residual effect, good and effective in

pest control, medicinal in action and does not discolour products. For storage which takes more than three months, more *T. indica* pods need to be added before the three – month period lapses to keep the *T. indica* concentration at constant level. This is because of possible fresh infestation due to weakening effectiveness of the *T. indica* pods with time. To have more effective and long–time control therefore, 40g and 50g at 50 to 80-day period is recommended for 200g of grain flour. But the more the product to be stored, the higher the doses of *T. indica* required

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Analysis of Socio-Economic Determinants of Beehive Crops Production Among Apiaries in Adamawa State, Nigeria

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ABSTRACT

This study examined the socio-economic characteristics that influenced beehive production in Adamawa State, Nigeria, taking cognizance of bee baiting, beehive placement (position) and types of beehives used. Data were drawn from 120 apiarists and analysed using descriptive statistics which revealed means of 6, 13 and 45 years for beekeeping experience, years of formal education and age of apiarists, respectively. While means of 41m^3 was recorded for beehive size, 24 for number of beehives used, and 8 for household size, the distance between beehives and number of workers per apiarists accounted for 9 km and 2 persons, respectively. The dominant beehives used include the tree-trunk/log (67.42%) and woven straw (29.83%), with the majority (97.42%) of the beehives placed high in trees. Nine (9) bee attractants were used in bee baiting out of which perfume (Binta Sudan®) accounted for a larger proportion (48.33%). Of the eight (8) socio-economic variables selected, beehive size and number of beehives per apiarist significantly ($P<0.01$) correlated with the beehive crop yield. It was therefore, concluded that the beehive size and number of beehives used were the most influential determinants of beehive crop yield.

Keywords: Adamawa, Apiarists, Beehives, Beekeeping, Crops, Variables

INTRODUCTION

Apiculture (Beekeeping) which is one of the oldest branches of Agriculture and a form of animal husbandry plays a crucial role in the economies of both developing and developed nations (Ayodele and Onyekuru, 1999). Beside the beehive products (honey, beeswax, *probolis*, bee venom, royal jelly) which serve as major sources of raw material in industries such as pharmaceuticals, confectionaries, tobacco, breweries etc, bees also pollinate the flowers of numerous species of plants, thus contributing immensely to agricultural production and the conservation of environment and biodiversity (Dukku, 2001).Similarly, for countries that export beehive products, the venture serves as a potent additional source of foreign exchange (Anonymous, 1997).

While Bradbear (1994) observed that about 30% of human food is derived from bee pollinated plants, LaSalle and Gauld (1992) affirmed that the value of crops pollinated by bees exceeds the value of honey by a factor of 50.In the United State of America (USA), beekeeping industry contributes to the nation's food supply by producing honey and providing pollination services to 3.5 million acres of fruits, vegetable, oilseed and legume seed crops that are depended on insect pollination (Holf and Phillips, 1990). Further, the authors noted that insect pollination increases yields on another 63 million acres of crops. Although modern techniques of beekeeping were introduced in Zaria, Nigeria, as early as 1914 (Ojeleye, 1999), apiculture is still largely a traditional occupation in the country (Dukku, 2011). This trend is greatly attributed to the fact that there is very little sustained research and publications on beekeeping in the country. Crane (1990) reported that, in the edition of 1960 World Bee Research Directory, only one worker was listed for Nigeria. Most scholars who conducted pioneering studies on beekeeping in Nigeria concentrated mainly on how to tame the wild insects for proper management, whereas the later generation concerned themselves with improvement of breeding of the honeybee and processing of the main beehive crop (honey), which is mainly on the technical side. Meanwhile, the analysis of the economic aspect of this farming enterprise among smallholders has largely been neglected.

This study therefore, examined the socio-economic determinants of beehive crops production among apiarists in Adamawa State, Nigeria. It is an attempt towards paving way for further in-depth analyses or evaluation of the enterprise to reveal the simplicity of apiculture/beekeeping and the benefits derivable from it in order to promote knowledge and improve the subsistence farmers more economically.

METHODOLOGY

The Study Area

The study covered eight Local Government Areas (LGAs) of Adamawa State, namely Fufore, Girei, Ganye, Gombi, Hong, Jada, Lamurde and Shelleng, respectively. Adamawa State lies between latitude 7^0 and 11^0 N of the Equator and between longitude 11^0 and 4^0 E of the Greenwich Meridian. The Statehas a tropical climate marked by dry and rainy seasons. The rainy season commences in April and ends late October. The average rainfall is 759mm in the northern parts and 1011mm in the southern parts. The wettest months are August and September. The driest months are January and February when relative humidity is 13%. Temperature varies from place to place. The minimum temperature for the State is 15.2 ^{0}C while the maximum is 39.7 ^{0}C. Majority of the people are farmers with hunting, fishing, livestock rearing and beekeeping as other secondary economic activities. Cash crops produced include groundnuts, cowpea and cotton. Food crops include cassava, maize, yam, sorghum, millet and rice. The Fulani are the renowned cattle-rearers, whereas village communities living on the banks of Gongola and Benue rivers engage in fishing.

Sampling Procedure and Data Collection

Purposive and simple random sampling techniques were adopted for the selection of the LGAs and respondents, respectively. The State was divided into four agricultural zones based on soil, climate and vegetation. These zones are Northeast, Northwest, Central and Southwest. In spite of the fact that the whole State has great potentials for beekeeping, this study concentrated specifically on the main producing areas. In this regard, two (2) LGAs were selected from each zone thereby making the total of eight (8) LGAs studied in the State. Fifteen (15) apiarists were drawn from each LGA using simple random sampling, thereby making a total of 30 apiarists from each agricultural zone and 120 apiarists in the whole study area. The respondents were grouped into three (3) categories namely: small-scale (hobbyist), medium and large-scale producers. This was based on the classification of apiarists by Dedej *et al.* (2000), in which apiarists owning 1-10 beehives are termed small-scale/hobbyists, 11-29 beehives are intermediate and 30 and above beehives as professional, commercial or large-scale producers. There were a total of 48 apiarists each in the categories of small-scale/hobbyist and intermediate producers, whereas the large-scale producers were 24 in number. Data for the study were collected in a field survey conducted during the 2002/2003 cropping season (October, 2002 – June, 2003) through a well-structured questionnaire that was supplemented by oral interviews. The data were generated with the assistance of trained enumerators. These are staff of the forestry section of the LGAs involved in the survey. Each LGA was assigned an enumerator with the researchers supervising the data collection. Information on selected socio-economic characteristics of apiarists were gathered specifically on the age, gender, household size, number of beehives used, beehive size, beekeeping experience, years of formal education, distance between beehives, number of workers per apiary and beehive yield.

Data Analytical Techniques

Descriptive statistics were used to analyse the data. These include means, frequency distribution and percentages. In order to determine the relationship among the selected socio-economic variables, the generated data were subjected to correlation analysis.

RESULTS AND DISCUSSION

Selected Socio-economic Variables of the Apiarists in Adamawa State

The selected socio-economic variables are in a summary of minimum, maximum; mean and standard error of mean values, which are presented in Table 1. The latter reveals that the whole apiarists (100%) were males, with the minimum age of 18 years, 90 years as maximum and mean years of 45. This is an indication that beekeeping is exclusively carried out by males in the area studied, as against the finding by Chale (1995) and Hussein (2000), that majority of Kenya top-bar beehives were owned by women in Zimbabwe and Kenya, respectively. Also, both the young and old persons can keep bees. The lack of participation in beekeeping by the women in the study area could be attributed to the method of beekeeping on one hand, and the fear of bees on the other. Beehives were mostly kept on top of trees in the bush or forest usually from a height of four to ten metres, and beehive inspection and harvesting of the beehive products were carried out at night. Tree climbing and night outing are considered odd engagement for women in the area. In contrast, places like Kenya, Tanzania, Zimbabwe, etc. where modern beekeeping is practiced, beehives are placed on stands as low as 2ft above ground level. Apiarists use protective materials (bee suit) to guide against bee stings, while inspection and harvesting are done in the daytime.

Table 1 also shows the beehive size and the number of beehive owned by the apiarists. A minimum of beehive size of $2.2m^3$ and maximum of $491.4m^3$ with the mean of $41.3m^3$ were used by the apiarists. These are summation of all sizes of beehives used by an apiarist. Values of 2.0, 326 and 24 were the minimum, maximum and mean numbers of beehives owned by apiarists, respectively. Other variables reflected in the Table 1include beekeeping experience, years of formal education, household size, distance between beehives and number of workers per apiary.

Table 1: Selected Socio-economic Variables of Apiarists in Adamawa State, Nigeria

VariablesMinimum		Maximum	Mean	SE.mean
X_1 = Beehive size (m^3)	2.2	491.4	41.3	6.07
X_2 = Age of apiarist (yrs.)	18.0	90.0	45.0	1.07
X_3 = Beekeeping experience (yrs.)	1.0	70.0	6.0	0.98
X_4 = Years of formal Education (yrs.)	0.0	17.0	6.0	0.52
X_5 = Number of beehives/household	2.0	326.0	24.0	3.72
X_6 = Household size (persons/family)	1.0	21.0	8.0	0.42
X_7 = Distance between beehives (km)	0.2	164.89	9	1.97
X_8 = Number of workers per apiary	1.0	5.0	2.0	0.07

S.E = Standard Error

Source: Field survey (2002/2003)

In the aspect of experience with regard to beekeeping, the minimum recorded for the apiarists was one year, with the maximum of 70 years and mean of 13 years. This is an indication that traditional beekeeping has being in practice for a very long time in the area. The 17 years of

formal education attained by some beekeepers in Table 1 shows that some graduates also partake in the act of keeping bees in the State. While some household could own as many as 326 numbers of beehives, the minimum recorded was 2.0 with about 24 as the mean. The maximum cumulative distance between beehives per apiary was 326km. The minimum and mean per apiary were 2km and 24km, respectively. The latter result indicates that beekeepers kept their beehives in different trees of choice regardless of the distance between these trees. With regards to number of workers per apiary, values of 1.0, 2.0 and 5.0 accounted for minimum, mean and maximum number of persons, respectively.

Methods of Beekeeping in the Study Area

The type of beehives used and their placement determine the method of beekeeping, and largely indicate the level of technology applied by the apiarist in a locality. Table 2 indicates the number of beehives per household and the location of beehives from the surface of ground by the three categories (small-scale, intermediate and large-scale) of apiarists. Further, it shows that there were four (4) different types of beehives used in the area surveyed. These comprised the log or tree trunk, woven straw, clay or pot and the gourd beehives. Furthermore, Table 2 reveals that majority (68.81%) of the beehives used among the large scale apiarists were the log or tree trunk. The percentage of woven straw beehives ranked as the next highest with 58.99% in the same category. The placement of the beehives as shown in the Table 2 indicates that most (65.82%) of the beehives were placed high in trees among the large-scale producers. The majority (68.97%) of small-scale (hobbyists) used pits. Based on the result available, it could be said that the method of beekeeping in practice in the area surveyed was absolutely traditional, implying that the apiarists were not well-informed about modern methods of keeping bees. These findings agreed with Dukku (2001) who reported that beekeeping in the rural communities of Sokoto, Yobe, Jigawa, Bauchi, Plateau and Taraba States in Nigeria, are basically traditional.

Table 2: Distribution of Beehives According to Types and Placement among Apiarists in Adamawa State, Nigeria

Item	Small-scale beekeepers	Intermediate beekeepers	Large-scale beekeepers	Total
1.Types of beehives				
● Tree trunk (log)	178 (9.07)	434 (22.12)	1350 (68.81)	1962 (100)
● Woven straw	74 (8.53)	282 (32.49)	512 (58.99)	868 (100)
● Clay pot	23 (31.94)	24 (33.33)	25 (34.73)	72 (100)
● Gourd or calabash	1 (12.50)	2 (25.00)	5 (62.50)	8 (100)
2. Placement of beehives				
● High in trees	253 (8.92)	716 (25.26)	1866 (65.82)	2835 (100)
● On the ground	3 (6.52)	23 (50.00)	20 (43.48)	46 (100)
● In pits (below ground)	20 (68.97)	4 (13.79)	5 (17.24)	29 (100)

Note: Value in parentheses show percentage of the total
Source: Field survey (2002/2003)

The Number, Size and Colour of Beehives Used by the Apiarists in Adamawa State

In beekeeping, the beehive and its construction specification determine the adaptability and performance of the honeybees and consequently the honey yield (Mutsaers, 1993). The majority (62.65%) of respondents were large-scale apiarists, whereas the small-scale and intermediate categories accounted for 9.55% and 27.80%, respectively (Table 3). The category of large-scale farmers as per *apriori* expectation was having the highest size in terms of percentage of 61.28%. Accordingly, apiarists in categories of small-scale and intermediate producers accounted for 10.00% and 28.72% of the overall total size. The mean sizes of beehives of 10.44m^3, 29.98m^3 and 127.92m^3 were recorded for the three (3) categories of apiarists in the ascending order. The dominant colour of beehives based on their frequencies, were black, white and brown with 65.57%, 15.98% and 14.33%, respectively (Table 3). However, most of these colours were so due to either the nature of the wood or the duration of usage. For instance, a new beehive made from a neem tree (*Azadaricta indica)* is white initially, but on prolonged use turns to brown colour. On the other hand, a beehive made from a mahogany (*Khaya senegalensis*) wood is completely dark brown in colour, and on prolonged use, turns to black.

Table 3: Distribution of Apiarists According to the Number, Size and Colour of Beehives Owned in Adamawa State, Nigeria

Item	Small-scale Beekeepers	Intermediate beekeepers	Large-scale beekeepers	Total
1. Number of beehives	278 (9.55)	809 (27.80)	1823 (62.65)	2910 (100)
Mean	6 17	76	24	
2. Size of beehives (m3)	500.97 (10.00)	1438.52 (28.72)	3069.99 (61.28)	5009.48 (100)
Mean	10.44	29.97	127.92	42.45
3. Colour				
● White	64 (13.37)	103 (22.15)	298 (64.09)	465 (100)
● Black	169 (8.86)	465 (24.37)	127 (66.77)	1908 (100)
● Brown	33 (7.91)	164 (39.33)	220 (52.76)	417 (100)
● Red	11 (10.19)	67 (62.04)	30 (27.78)	108 (100)
● Green	-	12 (100)	-	12 (100)

Note: Values in parentheses show percentage of total
Source: Field survey (2002/2003)

The Types of Bee Attractants Used in the Area Surveyed

The success of beekeeping depends on the ability to attract bee swarms into the beehives using materials known as attractants. The result in Table 4 shows that nine (9) bee attractants were used in the study area. These include beeswax, perfume (Binta Sudan®), scented herbs, honeycombs, decomposed small animals (lizards, rats, fish etc.) and cow dung. Others were local brew brand (*burkutu*), goat fatty tissues and fruit juice. Table (4) shows that perfume (Binta Sudan®) was the attractant of choice among the apiarists, with 52.08% in the small-scale category being the majority. Accordingly, 45.83% was recorded each for intermediate and large-scale categories. The second most popular baiting material, the scented herbs, accounted for 25.00% for each of the small-scale and intermediate categories, respectively.

What the above result implies is that the apiarists are fast adopting the conventional (use of scented materials) way in baiting bees rather the old method (use of decomposed materials), which is unhygienic.

Table 4[*]: Distribution of Apiarists, Based on the Materials Used in Baiting Bee Swarms in Adamawa State, Nigeria

Attractants	Small-scale beekeepers (n= 48)	Intermediate beekeepers (n= 48)	Large-scale beekeepers (n= 24)
● Beeswax	3 (6.25)	1 (2.08)	1 (4.17)
● Perfume (Binta Sudan®)	25 (52.08)	22 (45.83)	11 (45.83)
● Scented herbs	12 (25.00)	12 (25.00)	10 (41.67)
● Honeycomb	6 (12.50)	5 (10.42)	4 (16.67)
● Decomposed small animals (lizards, rats etc)	10 (20.83)	17 (35.42)	6 (25.00)
● Cow dung	2 (4.17)	14 (29.17)	9 (37.50)
● Local brew brand (*Burkutu*)	7 (14.58)	3 (6.25)	2 (8.33)
● Goat fatty tissues	1 (2.08)	1 (2.08)	1 (4.17)
● Fruit juice	1 (2.08)	-	-

Note: Values in parentheses represent the percentage of the total apiarists in each category (n)
[*]**:** Multiple responses were recorded
Source: Field survey (2002/2003)

Correlation Matrix Showing the Relationship between the Selected Socio-economic Variables and Beehive Crops Yield in the State

The correlation matrix shows that all the selected socio-economic variables were positively correlated with the output except for the level of formal education, which was negative (Table 5). However, only two (2) variables were highly significantly correlated with the beehive yield. These were beehives size (X_1) and the number of beehives (X_5) kept by the apiarists. But another variable (X_7) also shows a slightly high level of significance among the selected ones. Of the three (3) significant variables, the number of beehives kept by individual apiarists had the highest influence on the yield with a correlation coefficient of 0.991, whereas the beehive size and distance between beehives had 0.969 and 0.743, respectively.

A negative value in the level of formal education implies that, as the level of formal education increases, the output decreases. It was found out in the study area that government employees, who were in the majority that kept lower number of beehives, do so probably as a result of their official engagement and also the rigours involved in the farming practice. Therefore, lower yield/output was experienced in their category. This trend was contrary to *apriori* expectation, which is supposedly that beehive crops yield would correlate with a rise in the level of education of the apiarists. However, the latter were discovered to have acquired formal education but with no skills or knowledge of modern apicultural practice.

Table 5: Correlation Matrix Showing the Relationship between the Selected Socio-economic Variables and the Dependent Variable among the Apiarists in Adamawa State, Nigeria

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8

● Beehive size (X_1)	0.969**							
● Age (X_2)	0.037	0.058						
● Experience (X_3)	0.258**	0.249**	0.649**					
● Level of Edu. (X_4)	-0.115	-0.107	-0.429**	-0.394**				
● No. of beehives (X_5)	0.991**	0.972**	0.063	0.274	-0.135			
● Household size (X_6)	0.259**	0.311**	0.470	0.349	-0.314**	0.299**		
● Dist. b/w beehives (X_7)	0.743**	0.747**	0.064	0.241**	-0.089	0.783**	0.386**	
● Workers/apiary (X_8)	0.373**	0.381**	0.132	0.212**	-0.145	0.387	0.301**	0.292**

****:** Significant at P<0.01
***:** Significant at P<0.05
Y **:** Beehive crops yield (honey and beeswax)
Source**:** Field survey (2002/2003).

CONCLUSION

From these findings, it could be concluded that the method of beekeeping in Adamawa State was traditional, and the number of beehives owned and beehive size were the most significant socio-economic variables in influencing the beehive yield. Therefore, improving the beekeeping practice in this area will, among other things, call for encouraging apiarists to own larger number of beehives and also maintain appropriate beehive size during the latter's construction.

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Morphormetric Development in Free-Range and Caged Cattle Egret (B*ubulcus (Ardeola) ibis L.*) Chicks in the Arid Zone of North-eastern Nigeria: A Comparative Study

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ABSTRACT

The growth and development of twelve free range and twelve caged (confined) one day old cattle egret chicks were described and their Morphormetric growth monitored for ten weeks until they fledged as independence chicks (able to leave nest). These were obtained from Mbodewa (12º 24'N, 11º 36'E) breeding site in Yobe State of Nigeria after hatching. One chick was left in the field (nest) to grow under parental care (free-range or under natural conditions). Monitoring and data capture were done at weekly intervals to reduce chick disturbance. The objective was to find out if differences occur between the free-range and confined chicks in their course of development into matured cattle egret adults. The mean growth in body weight (g) was (214.9; 199.7); bill length (cm) (5.8; 5.7); bill to foot length (cm) 41.0; 37.9 and bill to tail length (cm) (36.3; 32.6), for free-range and confined chicks respectively. These were similar in trends up to week four in the two categories of chicks. However, there was 7.1% slow in growth rate in the caged chicks than in the free-range (parent raised) and were significantly different from each other, may be due to lack of 'Crop Milk' in the confined chicks. Bill length had its peak by the seventh week, while bill to foot length showed S-shaped curve, similar to that of bill to tail length. The prominences of these curves began on the tenth day in bill to foot and on the 15th day in bill to tail lengths. Continuous increase began as from week four to week eight. It is therefore, possible to raise the cattle egret chicks under confinement (by an artificial feeding at ad lib) as seen in this study. The need to domesticate and conserve these birds, which consume 88.4% of insect pests of field crops and being a single most important biological pest control agent of agriculturally dangerous insects cannot be over-emphasized. It is also proven that those birds reared in confinement mixed freely with those in the field when they were finally released into the open field after the ten weeks of confinement.

Keywords: - Cattle egret chicks, Caged, Free-range, Crop milk, Food delivery, Growth rate, Morphormetric development.

INTRODUCTION

Cattle egrets (*Bubulcus ibis*) are colonial wading birds and terrestrial foragers with complete snow-white plumes and buff-colored filoplumes on breasts, back and crown (head) during breeding seasons. Several authors have described the nesting, breeding colonies and feeding behaviours as being similar with other ardeids, (plumage development of ibises, while others described interactions between hand-reared (caged) and free-range nestling White ibises (Elgood 1979, Coleman and Richmond 2007, De Santo 1990, Hammerkops *(Scopus umbretta*), Wilson *et al.* 1998, Michealmore and Oliver 1982, Kushlan 1974, 1977 and Sharah *et al*. 2007, 2008). French and Haverschmidt (1970), reported on behaviour, growth of soft body parts, changes in behaviour and development of plumage, changes in plumage of nestling Scarlet ibises, (*Egretta (Eudocimus) ruber*), pointing out that the nestlings had "white tufts" on their crowns. Thomas (1984), Luthin (1983) and Svagelj and Quintana (2007), compared the appearances of nestling

Bare-faced ibis (*Phimosus infuscatus*), Green ibis, (*Mesembrinibis cayennensis* and the Scarlet Ibises, showing general similarities and sexual dimorphism in breeding Imperial shags, *Phalacrocorax atriceps.*

Hancock and Eliot (1978) and Lowe and Richards (1991), in their separate reports described chick growth, pterylosis, skin colors, locomotory development, agonistic, vocal, comfort and breeding behaviours of the Intermediate egret, (*Egretta intermediata*) in eastern Australia up to chick independence (fledging). They reported that using morphological variation in the Scarlet ibis, helped in identifying three and the most prominent species of the Scarlet ibis viz:- *Threskiornis aethiopicus*, *T. melanocephalus* and *T. moluccus.*Werschkul (1979), listed some factors limiting growth in Little Blue Heron, such as the ability to distribute food equally among chicks, food quality and pattern of development which was dominated by rapid growth of the feet and ambulatory skills at the age of thirteen days. The diet of the cattle egret contains 88.4% crop pests (Sharah *et al.,* 2008), which were abundant during rainy season. It is its ability to supply, deliver and distribute the food equally, that result in such rapid development. The population of any organism depends on increased rate of food supply and delivery, increased food consumption and decreased predation. The pattern of development was therefore, viewed as a pre-adaptation to large body size, as it allows a longer nestling period (increased time for growth), than would be expected if off-springs were dependent only on adults for protection from predators.

This study was meant to compare the morphormetric growth and development of free-range and caged (confined) cattle egret chicks and advance the possibility of successfully raising the cattle egrets in confinement. At the end of the study, those chicks reared in confinement mixed freely with their colleagues reared in the free-range, when finally released into the open field?

MATERIALS AND METHODS

Study Site

Mbodewa site (12º 24'N, 11º 36'E), 79km along Damaturu- Gashua road in Yobe State of Nigeria, was selected out of three sites for the detail study in 2008 and 2009 breeding seasons.

Stock and Management

Twelve nests were marked out with full clutch of two eggs each and with equal weight, age and size and were marked with similar identification marks and numbers (1 and 2). One chick was removed from each nest and taken into a 2m × 2m size cage and were fed at ad-lib with similar diet to those reared in free-range (parent reared). Diet types for caged chicks, were captured from the same foraging sites where the parents foraged to serve as inference to the diet type to be fed to the confined chicks.

Insect preys, frogs and wet-land faunas were in abundant and catching them to feeding the confined chicks was not a problem because it was rainy season. Many a time boluses were collected from nests cared for by parents to identify diet types as an inference for diet to be caught and used in feeding the hand-reared. Chicks were initially fed with slurry diet (crashed preys) and smaller size (3.9cm - 21.5cm) grasshopper nymphs and other smaller insects, such as beetles and bugs caught from the foraging sites. Initially, feeding was done four times a day until food was left (ad-lib or un-ingested) before feeding stopped.

Experimental procedure for diet identification

In order to identify the diet type consumed by the cattle egrets, thirty-six birds per development stage were collected from field and dissected, gut contents removed and contents placed in 96% alcohol for preservation. Preys were grouped into like groups and classes and later identified in the Taxonomy Department, IAR ABU Zaria. Observations and data collection took eighteen days from middle August to early September (a period of abundant insect prey species) and the period when the cattle egrets had no prey scarcity. The second sample was done for roosting birds from November to December (dry season, a period of prey scarcity), to compare prey species variation with seasons, taking the same eighteen-day period of time as in the first sample. Seven groups of prey were later identify: - Vertebrate, Orthoptera, other Invertebrates, Isoptera, Acarina, Vegetables and Unidentified Animal Remains (UAR).

Preys consumed had sizes measured using linear meter rule (cm) to determine the most common prey sizes ingested by the various cattle egret development stages. Percent pest status was also determined from the already identified prey groups to know the roles and levels these birds played in biological control of these insect pests of field crops. To have the knowledge of these two would make the feeding of the cage (confined) chicks much easier and less cumbersome since their diets and agricultural importance as pest control agents are known.

Data collection

Each of the chicks from the free-range and confined had its initial body weight recorded using field scale (gm) and data on bill length, bill to tail length and bill to foot length was measured by using linear meter rule (cm), taken on weekly intervals throughout the ten weeks of breeding period. At the age of one week chicks spend the whole of the day sleeping and had to be stimulated by tickling on their anus to wake them from sleep for feeding. The number of feeding per day was increased from four to five times by week three and to six times a day by week five. This was to meet with the mean number of feeding visits, which was over four times per day as recorded for the free-range chicks. Fresh water was kept in drinking containers in the cage throughout the entire period of study (rearing), to ensure drinking at ad-lib.

At three weeks, the confined chicks were transferred into a wider and spacious cage (50m × 20m) size, to allow the juveniles probe the surroundings, which was full of grass and shrub coverage. This was where their juvenile behaviours were monitored and observed more closely. To ensure consistency in data capture, data for the two categories of chicks were taken on the same day and from 8am to 10am. Feeding the confined juveniles was now difficult and not without injuries from bill stabs. At ten weeks the chicks were finally released to the open field, where the free-range reared chicks were roosting and the threads tied to their legs snipped off, but the marking tags on their wings were left in order to monitor and observe their behaviour as they mix with their free-range reared colleagues through binocular observations. These caged chicks that were released disappeared within the larger roosting free-ranged reared population crèches in the field. The data collected was analyzed using analysis of variance (ANOVA) and means separated by least significant difference and standard error at 5% level of significance.

RESULTS AND DISCUSSION

Table 1 shows the body weight, bill length, bill to foot and bill to tail lengths for the free-range and caged chicks. The differences between those figures are also shown. Significant ($P<0.05$) difference occurred in the body weights, bill length and bill to tail lengths. However, no

significant (P>0.05) difference between the bill to foot lengths were observed in the free-range and the difference. Significant (P<0.05) difference were however found with the caged chicks.

Table 1. Morphormetric growth in the free –range and caged *Bubulcus ibis* L chicks observed for ten weeks in Mbodewa site

Age	a			b			c			d		
In	Body Weight			Bill Length (cm)			Bill to Foot Length (cm)			Bill to tail Length(cm)		
days	Free	Caged	Diff	Free	Caged	Diff	Free	Caged	Diff	Free	Caged	Diff
7	38.5	34.6	4.0	2.1	2.0	0.1	24.0	24.0	0.0	17.0	16.8	0.2
14	106.3	103.5	2.8	3.6	3.6	0.0	26.4	25.1	1.3	21.1	20.1	1.0
21	165.5	163.0	2.5	5.7	5.6	0.1	30.6	28.3	2.3	24.1	23.3	0.8
28	201.3	194.4	6.9	6.6	6.5	0.1	39.5	36.7	2.8	28.1	26.5	1.6
35	238.5	222.2	13.3	6.6	6.7	-0.1	43.6	40.1	3.5	31.5	30.2	1.3
42	260.2	235.2	25.0	6.6	6.7	-0.1	46.4	43.2	3.2	36.5	35.1	1.4
49	280.1	249.9	30.2	6.6	6.8	-0.1	48.0	45.1	2.9	43.8	42.3	1.5
56	285.1	263.5	21.6	6.8	6.8	0.0	49.0	48.3	0.7	49.9	47.8	2.1
63	285.2	263.9	21.3	6.8	6.0	0.8	50.5	50.0	0.5	54.5	51.2	3.3
70	288.2	264.1	24.1	6.8	6.8	0.0	52.1	50.0	2.1	56.0	51.2	3.8
Mean	214.9	199.7	15.2	5.8	5.7	0.1	41.0	37.9	1.93	36.3	32.6	1.7
SE =	49	6.21	34	1.18	1.27	0.04	0.93	6.31	0.8	0.47	3.6	0.47
LSD=	232.22	29.68	162.52	5.68	6.06	0.19	3.03	20.50	2.60	2.23	17.21	2.23
P=0.05	*	*	*	*	*	*	NS	*	NS	*	*	*

* Significant
NS = Not Significant

The body weight

Fig 1 shows the difference in the body weight of (gm) of the two categories of chicks showing prominence from the 30th day after hatching. Free – range chicks showed 8.4% increase (288.2g less 246.1g = 24.1g higher) in body weight at the age 70days (i.e the independence age), than the confined chicks. This showed significant (P<0.05) difference, because the mean difference was 15.2g and followed similar trend when tested. Fig 2 shows food consumption per gram of body weight for the chicks from the three sites and showed significant (P<0.05) difference with age. There was more food consumed per gram of body weight from ages one to four weeks (the juvenile stage), than from ages five to ten weeks (the maturity and independent stage). The figure also shows that the food supply by parents declined with increase in age and maturity. Number of feeding visits by the parent birds in the free-range reared chicks, determined the number of feeding given to the caged chicks, because food is the major determinant factor in the growth and development of any organism. Therefore, the number of feeding made to the caged chicks and food delivery by parent birds had to be same in the two categories of chicks.

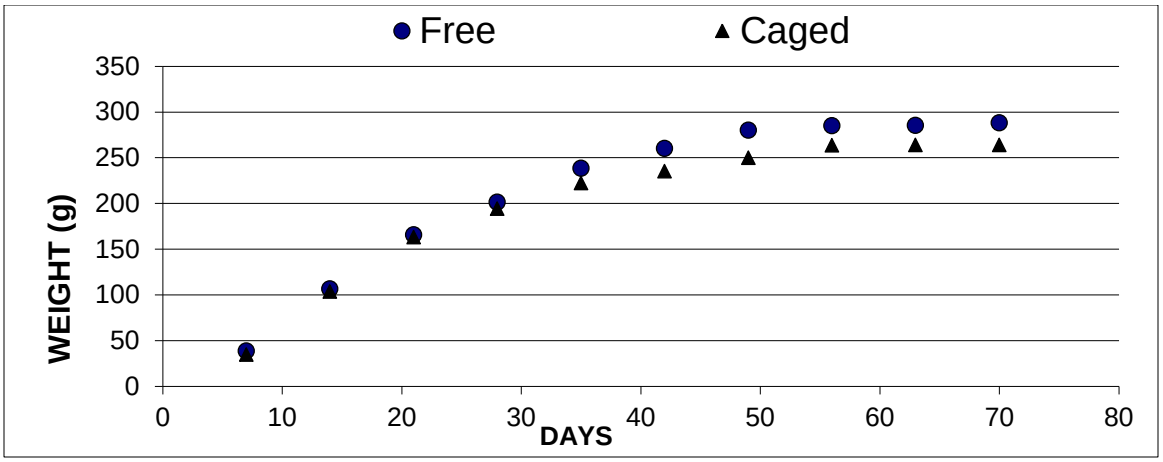

Fig. 1. Graph of body weight of free-range and caged *Bubulcus ibis* L. chicks reared and observed for ten weeks during the breeding season

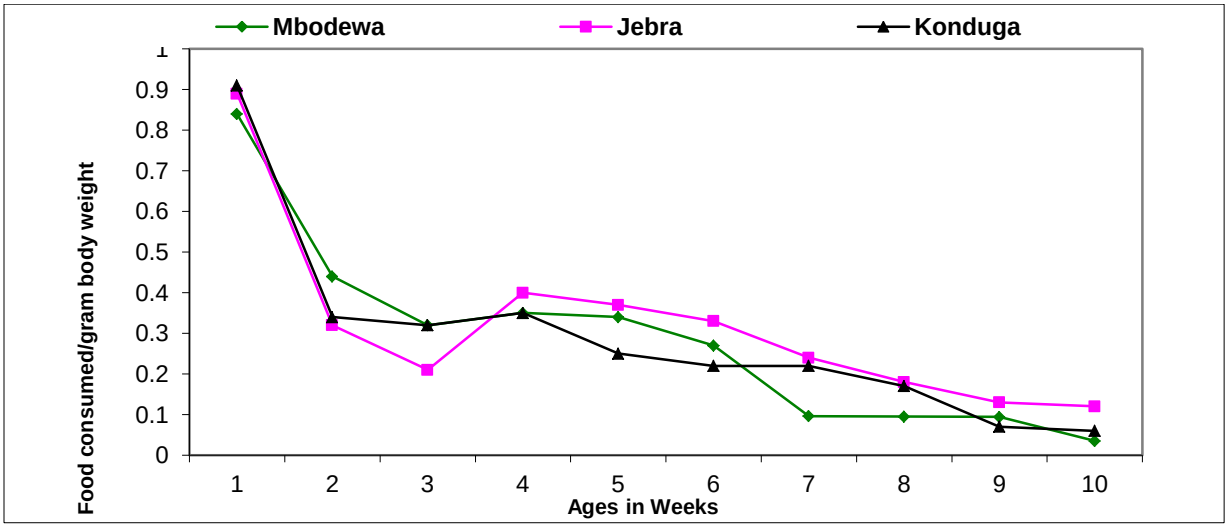

Fig. 2. Mean food consumption per gram of body weight of *Bubulcus ibis* L. chicks till maturity during the breeding season

Table 2 shows the mean number feeding visits by parent birds and number of feeding made to the caged chicks per day. This figure indicates the mean minimum number of feeding and feeding visits for each category per day. This also suggest that mean food delivered by parent bird at each feeding visit, number of feeding made to caged chicks and food consumption per day doubled by the age of two weeks after hatching and gradually declined to almost zero by the age of 70 days (10 weeks), when these birds were fledged. Food begging even at the foraging and nest sites made up the number below one at the 70th day after hatching and before dispersal.

Table 2. Mean food delivery to free-range and caged chicks of *Bubulcus ibis L.* per day and at weekly intervals over a period of ten weeks in Mbodewa breeding site

	CHICK NUMBER

Time in day	FR_1+CG_1 (mean)	FR_2+CG_2 (mean)	FR_3+CG_3 (mean)	Mean	SD	SE	CV(%)	P=0/05
Mean initial wgt.(g)	38.50	37.20	37.80	37.83	0.00	0.00	0.00	NS
7	5.50	5.30	5.10	5.30	0.20	0.12	2.18	NS
14	9.70	10.40	10.60	10.23	0.45	0.27	2.67	NS
21	8.50	7.80	8.30	8.20	0.36	0.21	2.54	NS
28	5.10	4.70	3.90	4.57	0.61	0.35	7.72	NS
35	5.30	5.80	7.60	6.23	1.21	0.70	11.24	*
42	3.10	3.00	2.40	2.83	0.36	0.22	7.72	NS
49	2.80	0.70	0.30	1.27	1.34	0.78	61.05	*
56	0.70	3.60	2.60	2.30	1.47	0.85	36.98	*
63	0.01	0.07	1.60	0.77	0.80	0.46	59.78	*
70	0.40	0.70	0.50	0.53	0.15	0.09	16.65	NS
Mean	4.11	4.27	4.29	4.22	0.10	0.05	1.35	NS
SD	4.40	4.90	4.00					
SE	1.40	1.60	1.30					
CV(%)	58.70	62.80	65.40					
LSD (nest) = 0.792		DF = 9						
P = 0.05		*	*	*				

FR_{1-3} = Free – range chicks on three nests and reared by parent under natural environment
CG_{1-3} = Caged chicks taken from three nests and caged under confined environment

Table 3 shows the daily increase of weight for attended and unattended chicks, which were distinct in trends over days. The attended chicks gained weight while the unattended lost weight with time. Regression analysis proved that the rate of increase and decrease in weight per day for attended and unattended chicks showed no significant difference ($P>0.05$), but was significant ($P<0.05$) in the mean difference. Similar trends were observed with bill length, bill to foot and bill to tail lengths. This indicates that environment did not affect chick development as did food supply. However, there was more environmental influence on the bill length than other parameters, because the R^2 was low in the free – range and caged chicks and declined further in the mean difference.

Table 3. Simple regression analysis table for changes in weight, bill length, bill to foot and bill to tail lengths for free-range and caged *Bubulcus ibis L.* chicks observed in Mbodewa site

Parameter	Chick weight (g) increase	$R^{2(\%)}$	Bill length (cm) increase	$R^{2(\%)}$	Bill to foot length (cm) increase	$R^{2(\%)}$	Bill to tail length (cm) increase	$R^{2(\%)}$
Free-range chicks	3.79	84.30	0.07	61.20	0.47	91.00	0.67	98.70
Caged chicks	3.36	82.20	0.06	61.70	0.47	94.50	0.61	98.10
Mean diff.	0.43	72.80	0.01	8.80	0.16	52.10	0.06	76.80

R^2= regression squared in percent

Bill length (cm)

Fig. 3 shows the bill length for the two categories of chicks (free-range and caged chicks), which reached their peaks after the 21st day of hatching and there after assumed almost constant growth rate up to the 70th day, giving the U-shaped graph. This suggests that after the 3rd week (21 days), the growth pattern of the body weight and bill length assumed similar trends as both of them slowed down tremendously. The difference in the growth rates of the bill length for the two categories of chicks showed significant ($P<0.05$) difference, because the mean difference was only 0.1cm (Table 1b). Similarly, the trends showed significant ($P<0.05$) difference when tested.

The Bill to Foot Length (cm)

Fig 4 shows an S-shaped curve as the differences in the bill to foot length between the two categories of chicks became prominent by the 10th day after hatching, with a 1.93cm mean difference (Table 1c) and increase over the caged chicks at 70 days was 2.1cm (4.03%) and was significantly ($P<0.05$) different. By the 49th day the gap had closed to almost equal length.

Bill to Tail Length (cm)

Fig 5 also shows an S-shaped graph resembling that of bill to foot. The sigmoid shape began to show by the 15th day up to the 49th day, and the gap widened again, although almost constant growth was experienced in the two categories of chicks. Significant ($P<0.05$) difference were observed between the two categories (Table 1d). The continuous and sharp increase from the 5th to the eight 8thweeks, had coincided with the period of high food demand by the juvenile chicks, which the parents had to struggle to supply. The mean difference was 1.7cm and was significantly ($P<0.05$) different with 3.8cm (6.8%) increase over caged chicks at 70 days and showed significant ($P<0.05$) difference when the trends were also tested.

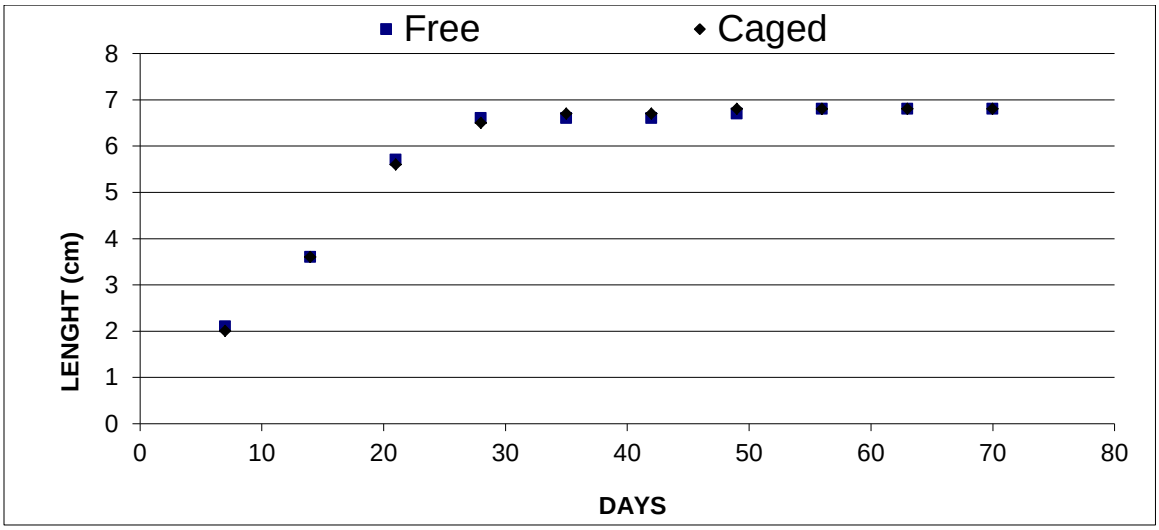

Fig. 3. Graph of bill length of free-range and caged chicks of *Bubulcus ibis* L. reared and observed for ten weeks during the breeding season.

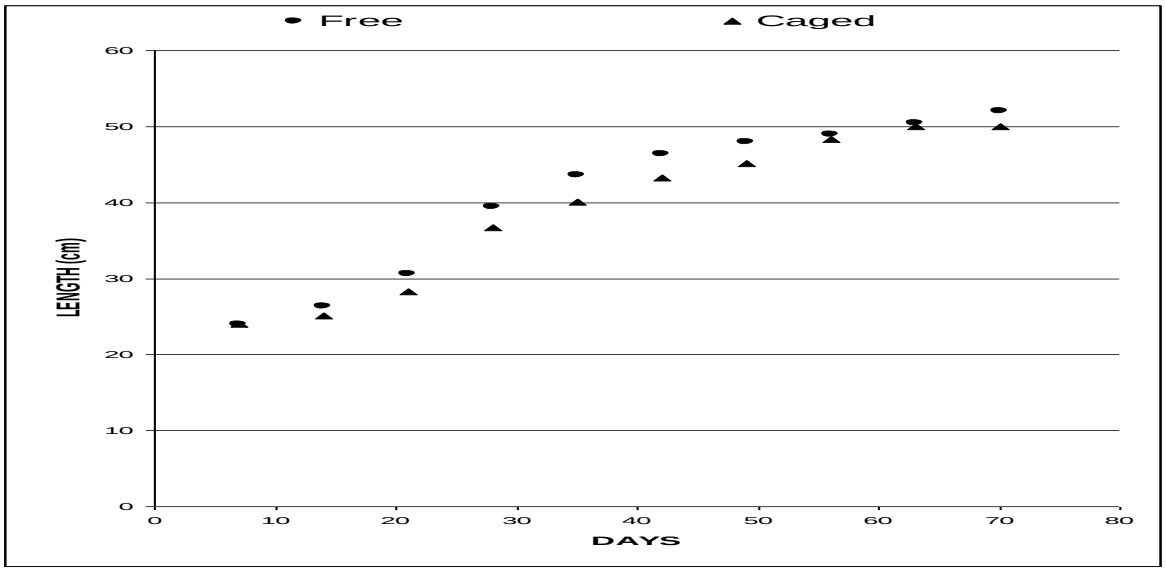

Fig. 4. Graph of bill to foot length of free-range and caged chicks of *Bubulcus ibis* L. reared and observed for ten weeks during the breeding season

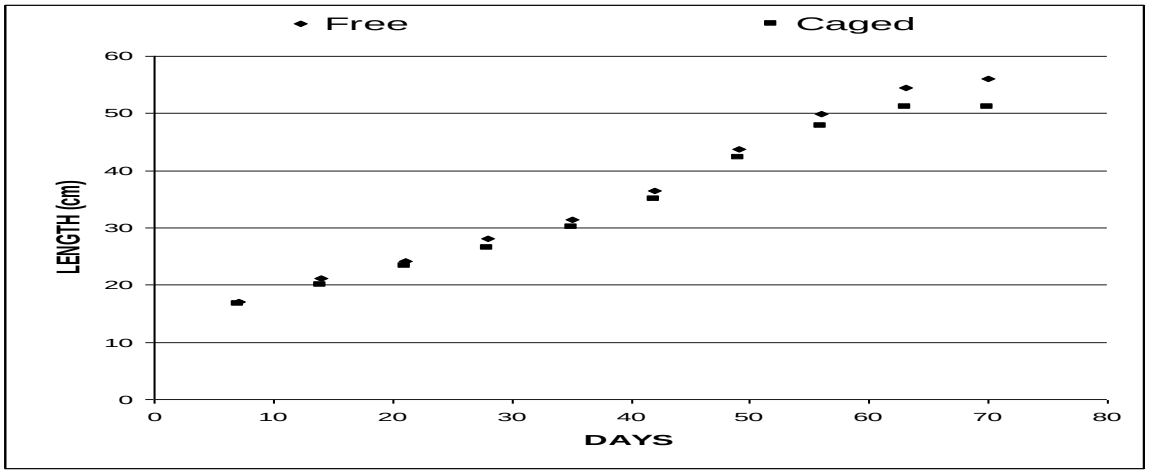

Fig. 5. Graph of bill to tail length of free-range and caged *Bubulcus ibis* L. chicks reared and observed for ten weeks during the breeding season

The two categories of chicks showed only slight difference in the growth and development of morphological parts of the body and appendages, which showed some increases per day and week which were significantly ($P<0.05$) different from each other. There was slow growth rate in body weight, bill length and bill to foot lengths as from week four. However, in bill to tail length the growth was on the continuous increase up to the tenth week for free-range and constant for caged chicks. The body parts which have now reached constant growth rate at this age ingest food only for development and maintenance of body metabolism. Food consumption per gram of body weight was high for the first four weeks and declined with age as bird reach maturity and can now fend for themselves. Environment had little effect on the growth and development of these chicks as did food supply, since the regression squared was higher in all parameters, except for the mean difference in bill length, which had low (8.81%) regression squared, which was not

significant. The food stabbing method of feeding using the bill, which was practiced by both categories of chicks was a stereotype behaviour, whether confined or not, hence the non-significant difference.

Crop milk, an important integral part of food supplied to chicks, is known to be present in the crop of pigeons (Young 1981), similar substance (Immunoglobulin) occurs in mammal (Eckert *et al*., 1988). However, it is not yet known whether 'Crop milk' do exist in the crop of the parent *Bubulcus ibis L.,* if it does exist, then the caged chicks were deprived from such nutritious part of food supply. Crop milk is known to contain all the necessary ingredients needed by avian chicks to grow healthy and strong. Consequently, the caged chicks, which were deprived of these nutrients from the first day after hatching till independence, may have lost other nutrients, hence the significant difference in the parameters. Those reared in free-range however, had all the nourishments from the parents' birds, which fed them directly through regurgitation of foods into chick mouths and the nest floor from which the chicks fed by stabbing. It is also known that confinement have negative effects on feeding habits, behaviour and development of living organisms, particularly wildlife, like the cattle egret which has no record history of domestication and reproduction in confinement, except for the Bare-faced Ibis, *Phimosus infuscatus*, (Michealmore and Oliver 1982). Despite the long confinement, the caged egret however mixed freely with their free-ranged colleagues after they were finally release to the open field. Suggesting that the ten weeks of confinement did not instilled permanent acclimatization and changes in behaviour in the egret chicks to the confined environment. The wildlife character did not change because of the short (ten weeks) duration, so the significant differences in the growth of appendages, body weight and plumage of the free-ranged and confined chicks also did not change their natural behaviour and character in the field. It is therefore, an uphill task to confine, reproduce, rear and release these agriculturally beneficial birds in large population required to control insect pests in farmers` fields.

The study has also revealed that the cattle egrets nest and bred in conserved areas and friendly ecosystem and occupy niches suitable for insect multiplication. However, their aggressive behaviour when defending their nests, pose threats and danger to predators, enemies and climbers who may wish to interfere with the nests and nest contents. Therefore, providing good niches and ecosystems, particularly in game reserves will attract these birds to nest securely, multiply and provide the high population needed to control insect pest outbreaks in the arid zone. It is also recommended that more studies be carried out to elucidate more on the presence of **'**Crop milk' in the crop of the *Bubulcus ibis L.,* since there was significant ($P<0.05$) differences in the body weight and other appendages in the two categories of birds, although fed with the same diet and rate per day. The 'Crop milk' once present, could be mimicked (through artificial and by synthetic means) by chemical industries to assist in large scale rearing of these agriculturally important, effective and environmental friendly biological insect pest control agent.

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Nutritive Value of Some Range Grass Species in the Semi-Arid Region of Nigeria

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ABSTRACT

The study was aimed at determining the nutritive value of some important range grass species of the semi-arid region of Nigeria. The study covered a period of two growing seasons in 2014 and 2015.Samples were collected from *Andropogon gayanus, Cenchtus biflorus, Paspalum conjugatum, Pennisetum pedicellatum, Setaria pallidefusca* and *Schoenefeldia gracilis* as they were the most abundant grass plants grazed by animals in the region. These samples were clipped in $1m^2$ quadrats and analyzed for crude fibre, crude protein, ether extract and ash. Some species were significantly higher than others in the constituents analyzed and lower in others. Some components were fairly uniform among species (e.g. ether-extract and ash) but crude protein was quite variable. *Andropogon gayanus* ranked high in crude protein but least in ether-extract and ash. *Setaria pallidefusca* ranked high in protein and ash, and third in ether-extract. *Cenchrus biflorus* was low in protein, ether-extract, ash and high in crude fibre. In range livestock management, one objective is to supply needed nutrients for livestock during the critical period in the dry season until new growth occurs. Forbs such as *Tridax procumbens* and *Sida acuta* grow during the dry season when soil moisture is available but they do not provide sufficient forage for livestock.

Keywords: Grazing, Grasses, Phenology, Protein, Ether-extract and Ash

INTRODUCTION

Range forages are the common feed source animals have in the region and management is exclusively by the extensive system. Chemical composition of range plants are often used to estimate the nutritive value of forages available to grazing animals. Many variables affect chemical composition of range vegetation. These variables are plant species, rainfall, and season of growth, soil fertility, temperature, weathering patterns of plant material and grazing intensities. Without supplemental feed, herbivores must select their diet from the available species. Hence, the chemical composition of their diet is directly related to the chemical content of the species on the range as animals are selective based on availability. Forage availability is a major factor that determines forage preference by grazing animals on rangelands (Mbaya *et al*, 2011). Van soest (1982) also stated that forage preference is based on palatability which is a subjective concept and refers to the assumed reason behind an animal's choice of one source of feed over another. Selection of forage variability is a function of available forage quantity and quality, plant structure and nutrient deficiencies (Gammon and Roberts, 1980 and Davies, 1982). Phenological stage of growth pattern is the most important variable controlling seasonal changes in chemical composition in forage plants (Watkins and Repp, 1964). The primary objective of this study is to determine the chemical composition of some important range grass species representative of ranges in the semi-arid region of Nigeria

MATERIALS AND METHODS

Study Area

The semi-arid region of Nigeria is located in the north-eastern part of the country and geographically located between Latitude 11^o 00"-12^o 30" N and Longitude 13^o 30"-15^o 00" E'. It has an annual rainfall of 280mm-320mm with duration of 3-5 months and with high amounts in July, August and September (BOSG, 2014). Mean temperature and relative humidity of 24^oC and

49.50% respectively were recorded (BOSG, 2014). The soils are characterized by sandy texture with low organic matter content, low cation exchange capacity and inherent low fertility status (Shuaib *et al*, 1997).

The vegetation is characterized by extensive grassland interspersed with tree species of drought resistant and fire tolerant. The tree species include *Acacia spp, Balanites aegyptiaca, Faidherbia albida, Ziziphus mauritiana, Adansonia digitata* and *Gueira senegalensis*. Dominant grasses are annuals such as *Cenchrus biflorus, Setaria pallidefusca, Pennisetum pedicellatum, Digitaria spp.,Aristida spp.* and *Schoenefeldia gracilis*. Perennial grasses are represented by few stands *of Andropogon gayanus, Hyparrhenia rufa* and *Sporobolus pyramidalis* along river courses and farm boundaries. Important forbs include *Cassia tora, Sida acuta, Aeschenomene indica, Tridax procumbens* and *Hyptis suaveolens*. Uncontrolled burning is common in the region and because it is not planned, it constitutes wildfire which becomes destructive to vegetation cover, soil and animal resources (Akosim, 2012). Two forms of land use are common in the region, pastoralism and sedentary agriculture. Pastoralism is the major occupation of the people of the region and management is largely by the extensive system (Famure, 1985). This implies that the animals depend on natural pastures for 80% or more of their food (Alao *et al*, 1994).

Data Collection

The study covered a period of two growing seasons in 2014 and 2015. During the two years of the study, the following grass species were selected*: Andropogon gayanus, Cenchrus biflorus, Paspalum conjugatum, Pennisetum pedicellatum, Setaria pallidefusca* and *Schoenefeldia gracilis.* These species were selected because they were abundant and form the bulk of forage plants grazed by animals in the region. Samples were collected at approximately monthly intervals during the growing season (July, August and September) and during the dormant season (November) from two locations in Borno state starting July, 2014 and ended in November, 2015. Samples in a $1m^2$ quadrat were clipped and composited in plastic bags. Phenological stage at time of collection was recorded for each species. The samples were sundried to constant weight and taken to the laboratory for chemical analysis.

Crude protein, crude fibre, ether extract and ash were determined by procedures of the Association of Official Agricultural Chemists - AOAC (2007). Data reported were averages of the two years for each month even though the plants may have been in slightly different growth stages at corresponding collections during different years. The averages of chemical compositions and seasonal differences are adequate for making generalizations about the species.

Data Analysis

Descriptive statistics using tables, charts and percentages were used in presenting the results. The data were analyzed by appropriate analysis of variance procedures with years used as replications. The main effects tested were species and months within years, hence, only species and collection month means were presented. Duncan's multiple range tests was used to compare individual means.

RESULTS AND DISCUSSION

The phonological stages of each species at the time of collection were from bloom to dormant stages of growth. July collections were made on most species in vegetative stages before development of inflorescence, although there were variations between years especially for *Schoenefeldia gracilis*. August collections were made when most of the species were in flowering stage and varied less among years than the July collections. August collections were in

mid-to-late bloom stages with the exception of *Schoenefeldia gracilis* which were in late-bloom to maturity stage. September collections were generally in mature stages, past seed development with the exception of *Schoenefeldia gracilis* which was in dormant stage with stems and leaves dried up. Plants collected in November were generally dormant and this stage prevailed through to May. Differences in phonological stages especially during July and August undoubtedly contributed to the variation in chemical compositions among species and years.

Crude fiber content of the species was presented in Table 1. The result shows that the crude fibre contents of the species were lower at the early stages of growth in July. *Cenchrus biflorus* had the highest average crude fiber content (46.50%) and Pennisetum *pedicellatum* had the least, 38.25% (Table 1). Protein is the basic structural material from which all body tissues (muscles, nerves, and blood cells) are formed. It is therefore essential for production and maintenance and cannot be replaced by other nutrients in the feed. Seasonal changes in protein content of all the grass species were similar. Crude protein was highest in samples collected in July and generally decreased through to November (Fig. 1). Most significant differences in crude protein content occurred during the first three months of collection with significant changes during the November collection when the samples were in dormant stage (Table 2*). Cenchrus biflorus* contained the least protein. This may be related to its nature of fast growth to production of culms and the almost complete shattering of seeds at mature and dormant stages. Average yearly protein content was highest for *Andropogon gayanus, Setaria pallidefusca* an*d Paspalum conjugatum* (Table 2). The crude protein content of these three grasses was relatively high well into the dormant stage. In the November collection, they were above 4.0%, which was higher than that of the other species e.g. *Cenchrus biflorus* ,2.4% and *Pennisetum pedicellatum*, 3.3%.

The ether-extract portion of plants contains fats and related compounds which may be sources of energy for herbivores (Ball *et al*. 2001) Generally, ether-extract of the six grass species declined from the second collection period (August) through the dormant season (Fig.2). The ether-extract content *of Paspalum conjugatum* was consistently above 2.0% for the three-month collection and *Cenchrus biflorus* contained above 2.0% only in July collection (Table 3). The yearly averages for *Andropogon gayanus* (1.48%) and *Pennisetum pedicellatum* (1.78%) were lower than for the other species. There were no differences in yearly average ether-extract content among *Paspalum conjugatum, Setaria pallidefusca* an*d Schoenefeldia gracilis* (Table 3). The ash content of plant contains the minerals. Ash determination provides a measure of total mineral content but not of the quantity of individual minerals (Collins, 1988). The ash content decreased from vegetative stages through maturity with slight increase at dormancy in *Cenchrus biflorus* and *Paspalum conjugatum* (Table 4). However, there were seasonal variations in ash content among species with the exception of *Andropogon gayanus* in which there was a gradual decrease in ash content from July to November collections. The decrease in ash content was not nearly as apparent as for protein content. The ash content of *Cenchrus biflorus, Pennisetum pedicellatum* and *Setaria pallidefusca* were fairly high in July, low in August and high again in September; in other species (*Cenchrus biflorus* and *Paspalum conjugatum*), ash content increased at the dormant stages. The average ash content was highest for *Setaria pallidefusca* (9.6%), followed by *Pennisetum pedicellatum* (9.4%) *and Paspalum conjugatum* (8.90%) and lowest for *Andropogon gayanus* (7.25%) as shown in Table 4.

Table 5 shows the ranking for chemical composition of the six grass species. The result showed that *Andropogon gayanus* ranked first in crude protein followed by *Paspalum conjugatum.*and least in *Cenchrus biflorus*.The highest crude fibre content was obtained in Cenchrus biflorus and least in *Pennisetum pedicellatum*. From the rankings, *Cenchrus biflorus* may be regarded to be less nutritive than the other species. This agrees with the report of Van Beest et al. (2010) that annual plants provide quality forage to grazing animal decreases as the growing season progresses. The nutritive value of the grasses decreased throughout the growing season (July-September) and the early dormant season (November). Crude protein, ether-extract and ash declined as the plants matured with increase in crude fibre The average crude protein content of the grasses decreased from 11.97% (July) to 3.85% (November) and the ether-extract content decreased from 2.38% (July) to 1.40% (November) and ash from 10.30% to 8.21%. The results conform with the findings of van Beest *et al.* (2010), that during periods of initial plant growth in the rainy season, all forage species are high in nutrient content although moisture content may also be high and limit dry matter intake. However, as plant matures, the nutritional difference among forages becomes more evident especially during the late growth stage. Reduced leaf-to-stem ratio is a major cause of the decline in forage quality with maturity (Collins, 1988; Ball *et a*l., 2001). Grasses show rapid decline in crude protein content as they mature as nitrogen from above-ground parts available to grazing animals to storage organs (Ruyle, 1993)

Table 1: Two Year. **Average Crude Fibre Content (%) of Six Grass Species by Month of Collection**

Month	An.ga.	Ce.bi.	Pa.co.	Pe.pe.	Se.pa.	Sc.gr.	Average
July	37ab	44a	43a	37ab	40b	38 ab	39.83c
August	39c	46a	44a	38c	42b	40ab	41.50ab
September	40c	47a	46a	39c	44ab	43ab	43.17b
November	46b	49a	46b	39c	46b	45ab	45.17a
Average	**40.50ab**	**46.50a**	**44,75a**	**38.25b**	**43.00b**	**41.50ab**	

An.ga.=Andropogon gayanus; Ce.bi.=Cenchrus biflorus; Pa.co.=Paspalum conjugatum; Pe.pe.=Pennisetum pedicellatum; Se.pa.=Setaria pallidefusca and Sc.gr.=Schoenefeldia gracilis. Means followed by different letters are significantly different ($p \geq 0.05$)

Table 2: Two Year Average Crude Protein Content (%) of Six Grass Species by Month of Collection.

Month	An.ga.	Ce.bi.	Pa.co.	Pe.pe.	Se.pa.	Sc.gr.	Average
July	11.6c	10.5c	11.7c	12.2bc	13.3a	12.5ab	12.0a
August	10.5a	8.2c	9.2bc	9.7ab	10.2a	9.0bc	9.5ab
September	7.5a	5.5b	7.5a	6.0b	6.2b	6.4b	6.5b
November	4,2a	2.4c	5.2a	3.3b	4.4a	3.6ab	3.9c

Average	**8.5a**	**6.7c**	**8.4a**	**7.4b**	**8.5a**	**7.8b**

Means on followed by different letters are significantly different ($p \geq 0.05$)

Table 3: Two Year Average Ether-Extract Content (%) of Six Grass Species by Month of Collection

Month	An.ga.	Ce.bi.	Pa.co.	Pe.pe.	Se.pa.	Sc.gr.	Average
July	1.77c	2.32ab	2.55a	2.17b	2.73a	2.63a	2.38a
August	2.02cd	1.85d	2.74ab	2.23b	3.02a	2.72ab	2.43a
September	1.09d	1.94ab	2.66a	1.51c	1.41c	1.89b	1.75b
November	1.05	1.64a	1.53a	1.23bc	1.20b	1.76a	1.40c
Average	**1.48c**	**1.93a**	**2.37a**	**1.78b**	**2.09a**	**2.50a**	

Means followed by different letters are significantly different. ($p \geq 0.05$)

Table 4: Two Year Average Ash Content (%) of Six Grass Species by Month of Collection

Month	An.ga	Ce.bi.	Pa.co.	Pe.pe.	Se.pa.	Sc.gr.	Average
July	10.92b	9.18c	8.29d	10.41b	12.95a	8.45cd	10.30a
August	7.57b	8.41a	8.35ab	8.20ab	6.58a	8.41a	7.92c
September	6.19d	8.74bc	9.20B	10.12a	10.35a	8.36c	8.83b
November	5.52d	9.17a	9.85ab	8.85ab	8.33b	7.53c	8.21c
Average	**7.25c**	**8.88b**	**8.90b**	**9.40a**	**9.60a**	**8.19ab**	

Means followed by different letters are significantly different ($p \geq 0.05$)

Table 5: Grass Species Ranking for Chemical Composition (%)

Species	Crude Protein	Crude Fibre
Andropogon gayanus	1	5
Cenchrus biflor	5	1
Paspalum conjugatum	2	2
Pennisetum pedicellatum	4	6
Setaria pallidefusca	1	3
Schoenefeldia gracilis	3	4

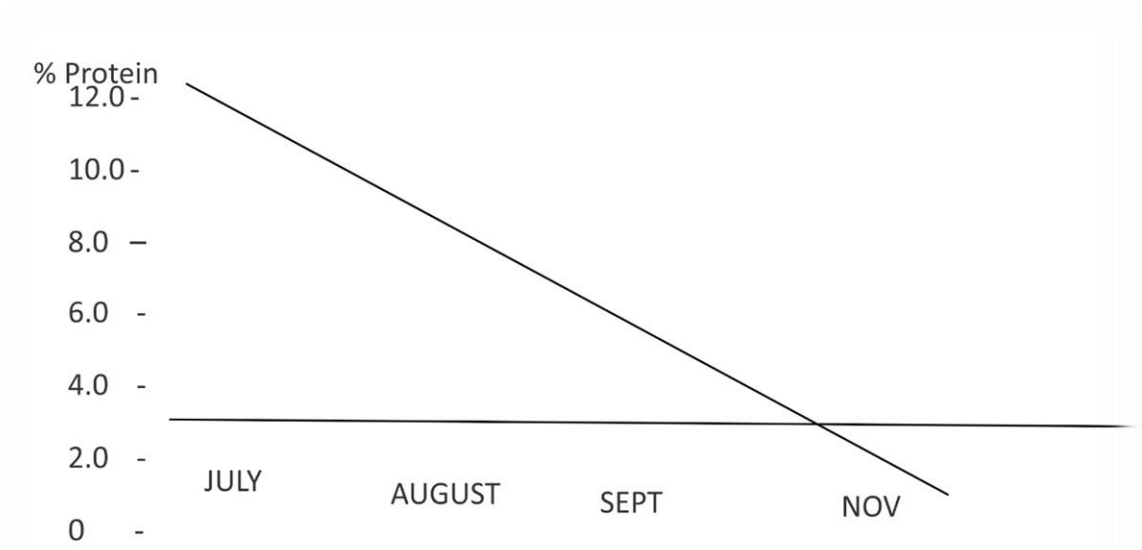

Fig. 1: Average crude protein content of thesix grass species

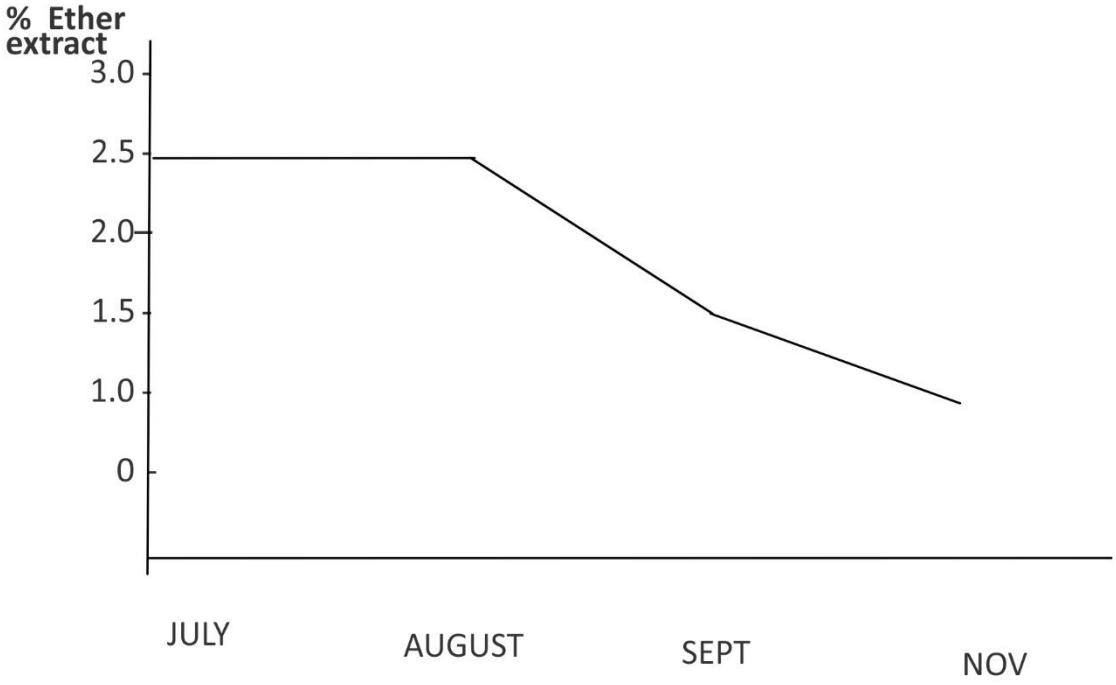

Fig. 2: Average ether- extracts content of the six grass species

CONCLUSION

The semi-arid region of Nigeria supports large number of domestic animals (sheep, goats, cattle, donkeys, camels and horses) which are normally reared under extensive system of management and mainly depend on natural pastures or rangelands. It also supports many wild animals such as antelopes. The forage quantity and quality falls below maintenance levels of the animals in the dry season which last for about 7-9 months in a year. The region has a high diversity of trees, shrubs and herbs which are used as sources of feed for animals. Many of these browse species provide protein and minerals for herbivores in the dry season when the natural pastures are devoid of such nutrients. Seeding the rangelands with adapted perennial herbs such as *Stylozanthes hamata* and *S. gueinnensis* to augment the nutrients needed by animals when the grass species are in dormant stages is highly recommended.

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The Role of Crude Apitherapy in Individuals' Consumption Patterns of Beehive Crops in Adamawa State, Nigeria.

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ABSTRACT
The individuals' consumption patterns of beehive crops were assessed in the month of February, 2007, in Adamawa State, Nigeria. Of the 397 respondents encountered at the point of beehive crops sale in six (6) major markets spread across the State, 240 were selected and interviewed using a systematic sampling method on official market days. Analysis using descriptive and t-test statistics showed that adults (97.92%) married (77.92%) males (78.33%) who were educated (80.83%) and employed (77.08%) were in the majority. A sign ($P< 0.05$) consumption rate of honey among the males with a mean of 2.48 lures per month was recorded as the highest. About 96.67% of the respondents consumed beehive products for medicinal (Apitherapy) reasons. Increased energy/libido among males was responsible for 70.45%. While the majority (72.23%) applied therapy through oral route and a larger proportion (49.12%) claimed absolute efficacy of the beehive products in treating their ailments, 67.20% attributed resorting to Apitherapy on advice from friends/people. Constraints reported in the use of beehive products include adulteration (60.20%) and high cost of crops (20.00%) among male and female respondents, respectively. The study recommends a thorough empirical investigation of these claims by experts to either dispute or endorse the usage of these products for the wider global readers, and the rural populace who are the majority.
Keywords: Apitherapy, beehive, consumption, crops, crude, patterns.

1.0 INTRODUCTION
Under a modern method of beekeeping, beehive crops include honey, beeswax, Probolis, royal jelly and bee venom. However, some apiculturists add bee broods and pollination services, due to the roles they play in the provision or generation of income to the producer. These crops are more pronounced in the advanced countries where transitional beehives like the langstroth and top-bar are used on a large scale. In most developing countries and Nigeria in particular, only honey and beeswax are harvested. In fact, studies (Ja'afar-Furo, 2006; Ja'afar-Furo *et al*., 2006) earlier conducted documented honey and beeswax as major beehive crops, with very negligible Probolis in Adamawa State in Nigeria. Similarly, a survey (MMAL, 2007) conducted in Tanzania on beekeeping reported honey and beeswax as the beehive crops in a value chain analysis.
The utilization or consumption of these products differ from one area to another and specifically, among various communities with different traditions and cultures. While countries like the USA, France and Britain, for instance, have the bulk of their beehive crops produced or imported for industrial uses, a report (Ingram, 2009) noted that a developing nation like the Cameroon is striving now to improve her honey quality through the efforts of a non-governmental organisation (NGO), the Guiding Hope, in collaboration with the Cameroonian Union of Apicultural Exporters. This is also taking into account the organic nature of the honey which attracts higher price, and preference in terms of consumption by the locals. Similarly, in Nigeria

and other neighbouring countries like the Niger Republic, the efforts and concern are still toward improving the purity of these beehive crops collected from the wild in preparation for the global markets and very little for local needs.

A few studies conducted in the southern part of the country show that apart from consumption as food, honey can be used specifically in the treatment of septic and surgical wounds, burns and bed sores (Fasika *et al.*, 1996; Lawal and Banjo, 2007). However, in the western world, extensive studies have been documented with regards to the healing effects of honey, beeswax, bee venom and Probolis in various ailments. Prominent among these cases are burns, fungal infections, herpes, seborrheic dermatitis, skin graft donor sites, dental decay and surgical wounds (Hutton, 1966; Forest, 1982; Zumla and Lulat, 1989; Anonymous, 1993; Sela *et al*., 2000; Al Waili, 2001; Misirliogu and Eroglu, 2003; Al-Waili, 2004a and Al-Waili, 2004b).

In an articulated report on apicultural development (Wilson, 2006), the scanty research attention the field of apiculture has received in Nigeria and other third world nations (Africa), was the major limiting factor in determining the actual production and consumption levels or patterns of beehive crops in these areas. The bulk of honey and beeswax come from hunting which is considered unlawful in most countries involved. And since record keeping is absent in such activities, it becomes increasingly difficult for beekeepers and the government agencies to keep track of yield and utilization of these products.

With these impressive findings from the western countries, it then became imperative to the tropical developing world to investigate the consumption patterns of these beehive crops with particular reference to the crude therapeutic uses which is fast becoming popular among consumers worldwide. Pure natural honey and other beehive products abound in Nigeria in the wild where the environment (bee flora) is perfect for their production. But the utilisation has not been properly defined. Since poverty is very much pronounced among the majority of the populace where access to good nutrition and medical facilities are problems, this survey then becomes appropriate, to serve as remedy and base line information.

It is hoped that the study on the individuals' consumption patterns of beehive crops in Adamawa State in Nigeria will serve as a stepping stone to, what the Waikato Honey Research Unit in New Zealand regards as (Bulman, 1955; Cavanagh *et al* 1970), the re-discovery of honey as topical antibacterial agent for the treatment of wounds, burns and skin ulcers, and other related developing countries' ailments. This will surely reduce the over-crowding of the few medical centers available and the huge financial burden on the teeming poor.

1.1 SPECIFIC OBJECTIVES OF STUDY

The specific objectives of the study were to: (i) examine the socio-economic characteristics of individual consumers; (ii) describe the individuals' consumption pattern of beehive crops by socio-economic characteristics; (iii) investigate the purpose for which beehive crops are utilised; and (iv) describe the constraints associated with the use of beehive crops in the area.

2.0 METHODOLOGY

The survey was conducted in Adamawa State in Nigeria. It is located between latitude 7^0 and 11^0N of the equator and longitude 11^0 and 14^0 E of Greenwich meridian. The State has 21 Local Government Areas (LGAs) with Yola as the State capital.

Primary data were collected from the respondents through the application of structured questionnaires aided by interviews by trained enumerators under the supervision of the researcher. Six major markets (Table 1) spread across the four agricultural zones of the State were selected for the study. These markets were Jimeta, Yola, Numan, Ganye, Mubi and Michika main markets. About 72, 66, 68, 70, 59 and 62 buyers, respectively, were encountered at selected major honey shops in the markets. Forty respondents were selected and interviewed through a systematic sampling method in the month of February, 2007, at point of beehive crops sale in each market on official market days, spread in four visits (i.e. 10 respondents per visit per market). The variations in the number encountered per market had to do with refusals of some buyers to respond to enumerators. Therefore, the stated figures were attained before the required number (40) of respondents was achieved.

Information sought from the respondents include the socio-economic characteristics (gender, age, marital status, education and employment status), the purpose for which beehive crops were utilised by individuals, the monthly consumption rates of beehive crops, modes of consumption and constraints encountered in the course of utilisation of same.

Data for the study were analysed using descriptive and t-test statistics. The former specifically include means and percentages. Since each of the socio-economic variables was measured in two groups, the latter tool of analysis was employed to find out if significant differences exist in the consumption rate of beehive crops between the groups.

3.0 RESULTS

Table 1: The Location (GPRS) of Surveyed Markets, the Official Market Days and the Respondents Interviewed in the Study Areas

S/N	Name of Market	Latitude	Longitude	Total No. Of buyers encountered at point of sale	Total No. Of buyers inter-viewed	Official market days
1.	Jimeta	09.2660N	12.4610E	72	40	Daily®
2.	Yola	09.2045N	12.4845E	66	40	Friday
3.	Numan	09.4663N	12.0371E	68	40	Friday
4.	Ganye	08.4315N	12.0547E	70	40	Saturday
5.	Mubi	l0.2703N	13.2669E	59	40	Tuesday
6.	Michika	10.6310N	13.2669E	62	40	Sunday
Total				**397**	**240**	

® The day selected for data collection was Saturday
Source: Field Survey, (2007).

Table 2: Distribution of Respondents Based on Selected Socio-economic Characteristics in the Study Areas. (n: 240)

Socio-economic Characteristics of Individuals	Frequency of Respondents	Percentage (%)
Gender/Sex		
• Male	188	78.33
• Females	52	21.67
Age		
• 1 – 17 years	05	2.08
• 18 years & above	235	97.92
Marital Status		
• Married	187	77.92
• Singles	53	22.08
Education Status		
• Educated	194	80.83
• Illiterate	46	19.17
Employment Status		
• Employed	185	77.08
• Unemployed	55	22.92

Source: Field Survey, (2007).

Table 3: Individuals' Monthly Average Beehive Crops Consumption by Selected Socio-Economic Characteristics in the Study Areas Selected

Socio-economic Characteristics of Individuals	Honey (liters)	Beeswax (kg)	Bee venom (mg)	Royal jelly (mg)	Probolis (kg)
Gender/Sex					
• Male	2.48	0.18	0.00	0.00	0.02
• Females	0.87	0.11	0.02	0.00	0.03
t-test statistics	2.17	1.03	-	-	-0.80
Age					
• 1 – 17 years	1.00	0.00	0.00	0.00	0.00
• 18 years & above	1.69	0.16	0.00	0.00	0.00
t-test statistics	1 .65	-	-	-	-
Marital Status					
• Married	1.78	0.18	0.00	0.00	0.02
• Singles	1.29	0.11	0.00	0.00	0.03
t-test statistics	-2.27	0.03	-	-	0.80
Education Status					
• Educated	1.74	1.74	0.00	0.00	0.02
• Illiterate	1.38	1.38	0.00	0.00	0.03
t-test statistics	-1.73	-1.73	-	-	0.87
Employment Status					
• Employed	1.86	0.19	0.00	0.00	0.02
• Unemployed	1.03	0.05	0.02	0.00	0.02
t-test statistics	4.12	-2.86	-	-	0.09

Source: Field Survey, (2007).

Table 4: Purpose for Which Beehive Crops are Utilised by Individuals in the Areas Surveyed.
(n:240)

Purpose for Use	Males' Percentage of Total Respondents	Females' Percentage of Total Respondents
• Medical	75.00	21.67
• Sweetener	25.50	2.08
• Medium for Preservation	0.83	0.00
• Spiritual	0.42	0.00
• In Enterprise (As raw material)	1.25	4.17

Source: Field Survey, (2007).

Table 5: Health Problems for Which Crude Apitherapy Was Made for by Individuals in the Study Areas. (n:240)

Health Problems	Beehive Crops Used as Remedy				
	Honey	Beeswax	Bee venom	Royal jelly	Probolis
• **Low Libido Among Men**	70.45	20.20	0.00	0.00	15.05
• **Abdominal Disorders**	68.29	5.02	0.00	0.00	0.00
• **Eye Sight**	62.90	0.00	0.00	0.00	0.00
• **Ulcer**	54.18	10.20	0.00	0.00	0.00
• **Cough**	50.50	12.19	0.00	0.00	13.00
• **Sour Throat**	22.95	9.12	0.00	0.00	4.05
• **Infertility in Women**	14.50	8.25	0.83	0.00	5.50
• **Burns**	18.17	15.16	0.00	0.00	0.00
• **Pile**	9.05	8.02	0.00	0.00	3.16

Note: Values are Percentage of Total Respondents
Source: Field Survey, (2007).

Table 6: Methods of Application of Crude Therapy and the Success Rates Claimed byRespondents in the Study Area. (n: 241)

Item	Male Respondents	Female Respondents
Mode of Application of Therapy		
• Oral	72.23	19.15
• Nasal	23.36	19.41
• Tropical	20.00	7.22
• Rectal	15.20	5.03
• Virginal	0.00	6.55
Success Rates of Therapy		
• Absolute Cure	49.12	5.42
• Moderate Improvement	10.21	6.25
• Mild Improvement	5.40	2.31
• Just Commerce Therapy	10.00	6.10
• No Improvement	3.60	1.59
Advice on Which Therapy was made		
• From People/Friends	67.20	19.00
• Traditional Healer	42.56	10.20
• Religious Books/Believe	39.92	15.00
• Literatures	24.09	9.25
• Medical Personnel	2.08	0.42

Note: Values are Percentage of Total Respondents
Source: Field Survey, (2007).

Table 7: Percentage Distribution of Respondents Based on Duration of Application of Crude Apitherapy and Constraints Experienced in the Study Areas. (n: 240)

Purpose for Use	Males' Percentage of Total Respondents	Females' Percentage of Total Respondents
Duration in Use of Crude Apitherapy		
• Less than a Month	8.50	1.65
• Month – 1 Year	19.83	5.15
• 2 - 5 Years	20.00	9.80
• 6 - 10 Years	16.40	3.05
• Above 10 Years	13.60	2.02
Constraints in the Use of Crude Apitherapy *		
• Adulteration of Beehive Crops	25.50	17.00
• High Cost of Beehive Crops	32.45	20.00
• Scarcity	25.50	17.00

*Multiple responses were observed.
Source: Field Survey, (2007).

4.0 DISCUSSION

4.1.1 The Location of Markets and Number of Respondents Interviewed

The six markets where the study was conducted and the locations are shown in Table 1. Also reflected in the Table (I) are total number of buyers of beehive crops encountered and the actual respondents interviewed in the study area. Of the 397 buyers that were met at the point of sale, 240 responded positively.

4.1.2 Selected Socio-economic Characteristics of the Respondents

Table 2 shows some of the relevant socio-economic characters of the beehive crops consumers in the area surveyed. These include the gender/sex, age, marital status, education and employment status of the respondents. Gender wise, males were the majority (78.33%) of the buyers of honey and other beehive crops on individual basis in Adamawa State. The females were in the minority (21.67%). This trend might be attributed to culture on one side, and the economic aspect on the other. As women movements are largely restricted in the northern parts of Nigeria where males head families with absolute control of the household resources, the limited population of females visiting markets is justifiable. A similar finding was reported by some scholars [Babatunde *et al.*, 2008] who found out that poverty was more pronounced among women and households headed by women in the south-western Nigeria. The Table (2) also reveals that adults accounted for 97.92% of the respondents studied, with only 2.08% as teenagers, thereby indicating that beehive products were mostly consumed by adult males. This contradicts an earlier survey (Bianka and Marghitas, 2003) which declared that a larger proportion (17.00%) of females in households/families in Romania consumed honey more than males. However, the difference in the approach is that while the latter survey considered household consumption as entity, this study reports the utilisation on individual basis.

Most (77.92%) of those that consumed beehive crops in the area were married individuals. Singles (unmarried) only recorded 22.08%. In spite of the fact that the married group is considered as being established economically, they are also matured individuals and consumption of honey and other beehive products are common among them. The education status of the respondents is also indicated in the Table (2). The bulk (80.83%) of the individuals' consumers had attained western education ranging from Primary to tertiary levels, confirming a report [Bianka and Marghitas, 2003] that honey consumption increases with level of education in Romania. Similarly, majority (77.08%) of those interviewed were gainfully employed either in the public or private sector, with only about 22.92% as unemployed. The latter category of beehive crops consumers was constituted by students, housewives or applicants.

4.1.3 Average Monthly Beehive Crops Consumption of Individuals by Socio-economic Parameters

While there are about five major beehive crops (honey, beeswax, Probolis, royal jelly, bee venom) in standard apiaries where improved beekeeping is practiced using modern beehives, only two major products (honey, beeswax) with negligible aspect of Probolis, in the area surveyed were reported (Ja'afar-Furo, 2006). Royal jelly and bee venom were virtually none existing. This had to do strictly with the processes of the extraction which require skills to perform appropriately but absolutely lacking among the beekeepers. The consumption patterns were therefore, centered on these three (honey, beeswax, Probolis) products. Table 3 indicates the mean consumption of these beehive crops by socio-economic parameters selected. Males

were said to consume a significant ($P<0.05$) quantity of honey and beeswax than females, with 2.48 liters and 0.18 kg per month, respectively. However, females recorded insignificant higher quantity (0.03 kg) of Probolis over their males (0.02 kg) counterparts. The result also shows that honey consumption vary significantly between the adults and teenagers. Average individual consumption of 1.69 liters per month was recorded for the former, whereas the teenagers had 1.00 liter per month. Only the adults seemed to consume beeswax (0.16 kg) in the area of study.

The consumption of honey, beeswax and Probolis by marital status shows no much significant difference (0.49 liters) in Adamawa State. Values of 1.78 and 1.29 liters of honey were for married and single individuals, respectively. About 0.18 kg of beeswax was consumed by married respondents and 0.11 kg was accounted for by single/unmarried individuals. Probolis was rarely consumed by married (0.02 kg) and single (0.03 kg) respondents. It was observed that educated individuals consumed (1.74 liters) honey higher than illiterates (1.38 liters) with a margin of 0.36 liters per month. This was also reflected in the consumption of beeswax in which the educated individuals accounted for 0.17 kg as against the illiterates with 0.11 kg. Even though illiterates slightly consumed (0.03 kg) Probolis higher than educated individuals (0.02 kg), this was absolutely negligible. As expected, respondents on employment consumed honey (1.86 liters) more than the unemployed (1.03 liters), giving a difference of 0.83 liter per month. Similarly, the employed individuals had increased consumption rate of beeswax of 0.19 kg per month over their unemployed counterparts with only 0.05 kg. Both the two categories (employed, unemployed) of respondents consumed 0.02 kg of Probolis each, per month on the average. It is evident from the results that unemployed females were the only consumers of bee venom with estimated quantity of 0.02 mg per month. Further investigation revealed that the respondent received bee stings (four) and not the prepared bee venom for her ailments.

4.1.4 Purpose for Utilisation of Beehive Crops in the Area

About four purposes of utilisation of beehive crops were reported by the respondents in Table 4. These include the uses as medicinal, sweetener, medium for preservation, spiritual and in enterprise as raw materials. Various uses to which beehive crops are put were earlier documented (Lawal *et al.,* 2003; Mahawar and Jaroli, 2008; Fakuda *et al.,* 2009). But of all the uses observed, the role of beehive crops as Apitherapy was the most reported since time immemorial. For instance, honey has been known to treat or cure ailments like arthritis, hair loss, bladder infections, toothache, cold and chronic cough, infertility, upset stomach and low libido/impotency among several others. While beeswax is specifically used to heal burns, wounds and hemorrhoids, the Probolis is used in alcohol tonic to refortify the heart good pumping actions. Related to these findings, the utilisation of these beehive crops in this survey was classified under males and females. About 75.00% of the males' percentage of the total respondents consumed honey and beehive products for medicinal purposes, whereas only 21.67% of their females' counterparts acted the same. As source of sweetener in beverages and related foods, the males' percentage of total respondents accounted for 25.50% as against the females' 2.08%. The sweetening aspect referred to in this study relate to consumption on individual basis, and males of diabetic problems were said to be responsible for this. For the purposes of medium for preservation and spiritual use, only the males recorded 0.83% and 0.42%, respectively. The utilisation of beehive crops as raw materials in enterprises was more (4.17%) pronounced among the females than males (1.25%). It was discovered that females used

mainly honey in baking special cakes for weddings and birthdays, and very few on personal requests.

4.1.5 Ailments for Which Beehive Crops were Used for Crude Treatment/Cure.

Table 5 gives the ill-health conditions on which respondents used beehive crops for alleviating or curing such problems. In this study, these include low libido/impotency among males, abdominal disorders, eye sight, ulcer, cough and sour throat. Others are infertility in women, burns and cases of pile. Of these cases, the problem of low libido/impotency among the men accounted for 70.45%. The males interviewed revealed that a sustained consumption of honey specifically in tea improves or even cure severe depressed libido/impotency. But for males that suffer from exhaustion, its consumption prior (at least 30 minutes) to love making increases erection of the penis. However, the use of beeswax and Probolis for this purpose has to be in mixture of some herbs which could not be ascertained at the point of this report. These accounted for 20.20% and 15.05%, respectively. The consumption of honey in the crude treatment of abdominal disorders ranked second with 68.29% in the areas surveyed. Although beeswax was used as remedy for this condition, it was negligible (5.02%).

Only honey was used for the crude treatment of problems arising from eye sight with about 62.90% of the respondents reporting this. They attributed success to continual consumption of this product for a long period of time. About 54.18%, 50.50%, 22.95% and 14.50% of the beehive crops consumers used honey for ill-health conditions that associate with ulcer, cough, sour throat and infertility in women, respectively. The Table 5 also indicates that the respondents made use of beeswax in the treatment of same ailments with values of 10.20%, 12.19%, 9.12%, and 8.25%, respectively. While they consumed only pure natural honey for medication in these stated cases, beeswax was mixed with variety of herbs, olive oil and onion juice in some instances in curing the same problems. In the aspect of crude treatment of burns or dressing wounds for which honey was known for, for centuries, only 18.17% of the beehive crops users practiced it. Similarly, 15.16% used Probolis for the same purpose. Up to 9.05%, 8.02% and 3.16% of the respondents applied honey, beeswax and Probolis to treat pile cases, respectively. Women were the only (0.83%) category of respondents that utilised bee venom in attempt of reversing the anomaly of infertility among them. However, it was not in the extracted form but few physical stings from the bees. A peculiar mixture of Probolis with garlic and olive oil was reported to have been used by the respondents for correcting the anomalies of cough (13.00%), infertility in women (5.50%), sour throat (4.05%) and pile (3.16%). The use of this particular preparation was adopted by beehive crops consumers for its efficacy in the crude treatment of these conditions as was claimed.

4.1.6 Modes of Application of Crude Therapy, Success Rates and Sources of Information on Crude Apitherapy in the Areas

The method of application of crude apitherapy, the successes claimed and sources of information on same are documented under two categories (males, females) in Table 6. Majority (72.23%) of males' percentage of total respondents used oral route for consumption of beehive crops for cure of their ill- health conditions. Application through nasal (23.36%), topical (20.00%) and rectal (15.20%) methods followed in descending order. In the females' category, oral route also accounted for the larger proportion with a value of 19.41%. About 19.15% of the total respondents used nasal method, 7.22% applied their medication through topical and 6.55%

through virginal route. Only 5.03% of the females' respondents subjected themselves to curing their ailments by applying beehive crops through the rectum.

In order to determine the success rates of these crude therapies among the respondents in the study areas, responses of the consumers are also recorded in Table 6. A combined (males, females) majority (54.54%) reported absolute cure of their health problems. While 16.52% of the two categories had moderate improvement of their ailments, 16.10% had just commenced crude therapy at the time of this study. Beehive crops consumers who claimed they had mild and no improvements were 7.71% and 5.19%, respectively.

Sources of information through which respondents became aware of crude apitherapy with multiple responses are also shown in Table 6. Most (86.20%) of the total beehive crops users in the areas surveyed got to know of the medicinal uses of these products through associates and friends. Those who were advised on crude apitherapy by the traditional healers recorded 52.76% of the consumers studied. Of the remaining three sources, medical personnel, literature and religious books or believes accounted for 2.50%, 33.34% and 54.92% in ascending order.

4.1.7 Duration of Use of Crude Apitherapy and Constraints Experienced among the Respondents

The length of period employed for crude apitherapeutical use and the constraints experienced among the respondents are stated in Table 7. It could be observed from the results that a larger proportion (29.80%) of the respondents used beehive crops for curative purposes between two and five years. This was followed by those (24.98%) who applied apitherapy from one month to a year. Respondents that used honey and other beehive products for medicinal purposes between 6 and 10 years and above 10 years accounted for 19.45% and 15.62%, respectively. The beehive crops consumers who utilised the products as remedy for their ailments for less than a month constituted the minority (10.15%). The implication of these findings is that the bulk (64.87%) of the subjects surveyed have had knowledge of using crude apitherapy for not less than two years in the areas, indicating that it was not exactly a new practice among the respondents.

Also shown in Table 7 are the constraints to utilisation of beehive crops in Adamawa State, Nigeria. Three worrisome problems that thwart the consumption or application of crude apitherapy were noted among the respondents. Foremost of all is the complaint of high cost of beehive crops. There were about 52.45% of honey and other beehive crops users who reported this aspect. Although beehive crops abound in Adamawa State, further investigations revealed that the bulk of the supply comes from hunters rather than producers. The processes in collecting these products from the wild which involve going out in the night, climbing trees, subjecting self to bees stings, risking reptiles' bite and armed bandit attack (Ja'afar-Furo *et al.,* 2009) contribute to hiking the prices. Other problems of concern include adulteration and scarcity of these products. Both incidences recorded 42.50% each among the respondents in the areas of study. In spite of the fact that beehive crops are noted for their potency in curing several ailments, respondents strongly believe that the products should be of pure and natural origin for efficacy to occur. However, a large proportion of thc consumers find it difficult to differentiate between pure and adulterated honey, for instance. Therefore, this lead to creation of scarcity of "pure" honey in the market, as a result consumer usually identifies some specific "honest" sellers.

5.0 CONCLUSION

From the findings of this survey, it can be concluded that adult married males who were educated and gainfully employed were the majority of the respondents that consumed beehive crops in the study areas. Major purpose for which products were utilised was basically medicinal with increased energy/libido among the males as the most reported reason for crude therapy. The crude apitherapy was widely applied through the oral route and the pure natural honey and other beehive products were found to be efficacious. Identified constraints to consumption of these products include their adulteration, high cost and scarcity.

6.0 RECOMMENDATION

The study therefore, recommends among others, consumer education on simple methods of identification of pure natural beehive crops to eradicate the issue of adulteration, intensify extension services on improved methods of beekeeping in order to raise production and consequently the supply in the markets, encourage the sustained consumption of pure products both for prophylactic and curative purposes in uncomplicated cases, and finally, the medical expert to conduct further studies for the purpose of validating or disproving these claims.

7.0 ACKNOWLEDGEMENTS

The author wishes to thank Mallam Abubakar S. Tahir, Department of Livestock Production, Ministry of Animal Health and Production, Headquarters, Yola, Mallam Muhammad I. Adamu, Health Department, Michika Local Government Area, Michika and Mallam Shehu Ahmad, Ministry for Livestock and Nomadic Settlement, Mubi, all in Adamawa State, Nigeria, for their contribution towards the successful collection of data.

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Citation Analysis of Doctoral Theses in Education, University of Maiduguri, Nigeria

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ABSTRACT
This study presents citation analysis of thirty-one doctoral theses in education accepted by the school of postgraduate studies, University of Maiduguri, between 1987 and 2007. The title pages, abstracts and references of each thesis were photocopied and examined thoroughly in terms of name of the researcher, title of thesis, year of award, subject area covered, number of citations, types of works cited and the total of each cited work. Bibliometric techniques were used in the analysis, which involves counting and categorising works cited in each thesis according to the following: books and monographs, journal articles, theses and dissertations, conference proceedings, unpublished materials, reports, newsletters and online sources. The information gathered was collated and analysed using frequency counts and percentage scores, presented in tables. Findings of the study reveal that Curriculum and Instruction ranked highest as the most researched subject area, while Educational Psychology was the least researched subject area. Books and monographs were cited more than other forms of library materials in the theses analysed. Similarly, out of the 912 journals cited, eighteen were identified as the most frequently cited. Most of the works cited by the researchers fall between 1980 and 1989.

Keywords: Citation, Doctoral Theses, Education

INTRODUCTION
The Department of Education was one of the few departments that started with the establishment of the University of Maiduguri in 1976. Since then, it has grown in staff strength, student population and academic programmes. The Department of Education pioneered postgraduate education in the University of Maiduguri with the establishment of M.Ed. and Ph.D. degree programmes and by the end of 1988/89 session; thus graduating one Ph.D. and thirty M.Ed. candidates. The Department offers several Ph.D. Programmes among which are: Educational Administration and Planning, Educational Administration and Management, Curriculum and Instruction, Educational Psychology, Educational Measurement and Evaluation, Guidance and Counselling, Philosophy and Foundation of Education. Every Ph.D. Students must submit to the school of postgraduate studies, a thesis as part of the requirements for the award of Doctor of Philosophy of the University of Maiduguri. This thesis must have been orally defended before a panel of internal and external examiners. (Faculty of Education Prospectus, 2010).

Citation analysis according to Aina (2002) is a popular method in library and information science research in Africa, where references cited are statistically analysed in order to find out the common journals cited by researchers in a particular discipline. It is generally assumed to be part of bibliometric studies. Bibliometric study is usually applied to the quantitative analysis of

publications in a particular discipline. Mathematical and statistical techniques are used to study the documents and to measure the patterns of publications. It is also used to measure the impact of publications through citation analysis. Bibliometric study also helps to find out the publication productivity, examine the authorship pattern for publications, identify the channels of communications used and ascertain the journal and language preference of an author. (Kousar and Mahmood, 2010). There are literatures on citation analysis in different disciplines and have been growing fast in the field of library and information science. Sam and Tackie (2007) observed that citations drawn from student's dissertations or term papers were sources of checklist used in numerous studies, the earliest being that of Emerson's analysis of twenty- three engineering doctoral dissertations at the Columbia University between 1950-1954 to determine the percentage of references held or not held by the other campus libraries in the University. An earlier study by Iya (1996) on citation analysis of education dissertations at the University of Maiduguri, Nigeria revealed that out of the fifty-six (56) master dissertations analysed majority of the postgraduate students used textbooks (40.3%) more than any other forms of library materials in writing their dissertations. Furthermore, the Journal of the Science Teachers Association of Nigeria (STAN) was ranked first with 82 citations, followed by the West African Journal of Education (WAJE) with 35 citations. Similarly, Okiy (2003) conducted citation analysis of education dissertations at the Delta State University, Abraka, Nigeria which revealed that majority of postgraduate students in education used textbooks more than other forms of library materials in writing their dissertations. Egberongbe (2003) conducted a citation analysis of the literature used in political science doctoral theses in the University of Lagos from 1990-2000. The results showed that researchers cited more textbooks than journals in their research works, and observed that the researchers' use of journals at this level is rather inadequate. Also, Sam and Tackie (2007) conducted a citation analysis of dissertations accepted by the Department of Information Studies, at the University of Ghana, Legon, from 1998 to 2004, with a view to ascertaining pattern in the use of different types of information source formats, such as books, Journals, and so on. The study revealed that a total of sixty-seven (67) dissertations generated 2,212 citations. Books and monographs were cited more than journals (969 or 43:8%) of the citations were books and monographs, followed by journal articles (550 or 24.9%), and unpublished materials (4 or 0.2%) being the least cited materials.

METHODOLOGY

The study analysed thirty-one (31) doctoral theses in education accepted by the School of Postgraduate Studies, University of Maiduguri, between 1987 and 2007. It was limited to the theses housed in the Ramat Library, University of Maiduguri. The title pages, abstracts and references of each thesis was photocopied, and examined thoroughly in terms of the name of the researcher, title of thesis, year of award, subject area covered, number of citations and the total of each cited work. Bibliometric technique was used, which involves counting and categorising works cited in each thesis according to the following: books and monographs, journal articles, theses and dissertations, conference proceedings, unpublished materials, reports, newsletters and online sources. The data gathered were collated and analysed using frequency counts and percentage scores, presented in tables.

Analysis of Data

The results of the study are presented in tabular form below.

Table 1: Distribution of Theses by Subject Area.

Subject Area	Frequency	Percentage
Curriculum and Instruction	9	29
Educational Administration and Planning	8	25.8
Guidance and Counselling	7	22.6
Philosophy and Foundations of Education	6	19.4
Educational Psychology	1	3.2
Total	**31**	**100**

Table 1 shows the distribution of theses by subject area, ranked in the order of their scores from highest to lowest. Curriculum and Instruction ranked highest with nine scores, representing 29 per cent, Educational Administration and Planning followed with eight scores, representing 25.8 per cent, Guidance and Counselling recorded seven scores, representing 22.6 per cent, Philosophy and Foundations of Education recorded six scores representing 19.4 per cent, while Educational Psychology recorded one score representing 3.2 per cent.

Table 2: Format of Literature Cited in a Rank Order.

Format of Literature	Frequency	Percentage
Books and monographs	1511	51.2
Journals	912	30.9
Theses and Dissertations	175	5.9
Conference proceedings	110	3.7
Unpublished sources	93	3.1
Reports	75	2.5
Online sources	40	1.4
Newsletters	37	1.3
Total	**2,953**	**100**

Table 2 shows format of literature cited in the thirty-one theses analysed in the study in a rank order. Books and monographs were cited most frequently with 1511 scores, representing 51.2 per cent, followed by journal articles scoring 912, representing 30.9 per cent, theses and dissertations recorded 175 citations, representing 5.9 per cent, conference proceedings recorded 110 scores, representing 3.7 per cent, unpublished sources recorded 93 scores, representing 3.1 per cent, Reports recorded 75 scores, representing 2.5 per cent, online sources recorded 40 scores, representing 1.4 per cent, while, news-letters recorded lowest scores of 37 citations, representing 1.3 per cent.

Table 3: Top Eighteen Core Journals Cited in a Rank order.

S/N. Title of Journal	Frequency	Percentage
1. Journal of Counselling Psychology	40	18.9
2. The Counsellor	34	16.1
3. Nigerian Journal of Educational Psychology	17	8.1
4. British Journal of Educational Psychology	16	7.6
5. Journal of Research in Education	15	7.1
6. African Journal of Educational Research	13	6.7
7. Maiduguri Journal of Educational Studies	13	6.7
8. West African Journal of Education	12	5.7
9. Journal of Teacher Education	9	4.3
10. Nigerian Journal of Counselling and Devt.	7	3.3
11. Zaria Journal of Educational Studies	7	3.3
12. Journal of Educational Administration	6	2.8
13. Nigerian Educational Forum	4	1.9
14. Educational Forum	4	1.9
15. Nigerian Journal of Applied Psychology	4	1.9
16. Journal of Curriculum Studies	4	1.9
17. Journal of Research in Curriculum	3	1.4
18. Education Today	3	1.4
Total	**211**	**100.**

Table 3 presents the top eighteen core journals cited in a rank order. Out of the 912 journals cited, 18 journals were identified as most frequently cited. Journal of Counselling Psychology recorded highest scores of 40 citations, representing 18.9 per cent, while, Journal of Research in Curriculum and Education Today recorded the lowest scores of three citations each, representing 1.4 per cent respectively.

Table 4: Distribution of Citation by Decade.

Years	Frequency	Percentage
1960-1969	152	5.3
1970-1979	895	31.1
1980-1989	934	32.5
1990-1999	695	24.2
2000-2007	200	6.9
Total	**2,876**	**100**

Table 4 shows distribution of citations by decade. Majority of the works cited (934: 32.5%) fall between 1980-1989, followed by 1970-1979 with 895 (31.1%), The 1990s and 2000s recorded 695 (24.21%) and 200 (6.9%) citations respectively, while 152 (5.3%) works cited were from 1960-1969.

RESULTS AND DISCUSSION

The distribution of theses by subject area, ranked in the order of their scores from highest to lowest as shown in table 1 reveals that Curriculum and Instruction ranked highest with nine scores representing 29 per cent, while, Educational Psychology was the lowest recording one score representing 3.2 per cent. The distribution of format of literature cited in the thirty-one theses analysed in a rank order as shown in table 2 reveals that books and monographs were cited most frequently with 1511 scores, (51.2%), followed by journal articles scoring 912, (30.9%) while online sources and newsletters recorded lowest scores of 93 (3.1 %). and 40 (1.4%) each. Iya (1996) and Okiy (2003) found similar results in citation analysis of education dissertations at the University of Maiduguri and education dissertations at the Delta State University, Abraka respectively. These studies revealed that majority of postgraduate students used textbooks more than other forms of library materials in writing their dissertations. Thus, the use of journals and online sources by postgraduate students in their research works seem to been discouraging, considering the fact that these are the sources of information through which researchers particularly at the Doctoral level can get current research findings that would assist them in conducting their researches. Similarly, the predominance of textbooks and monographs usage among postgraduate students particularly at the Doctoral level at the expense of journals and online sources leave much to be desired in the quality of theses produced by the students in the university.

The top eighteen core journals cited in a rank order as shown in table 3 reveals that out of the 912 journals cited, eighteen were identified as most frequently cited. Furthermore, Journals of Counselling Psychology recorded highest scores of 40 citations, representing 18.9 per cent. While, Journal of Research in Curriculum and Education Today recorded the lowest scores of three citations each, representing 1.4 per cent respectively. This finding is consistent with the studies of Iya (1996) which revealed that 2, 377 citations recorded from master of education dissertations at the University of Maiduguri. Out of these, 959 citations were monographs while 553 citations were journal articles. Furthermore, the top ten ranked journals and their availability at the University Library shows that the Journal of the Science Teachers Association of Nigeria (STAN) was ranked first with 82 citations, followed by the West African Journal of Education (WAJE) with 35 citations. However, it was observed that these two journals that ranked first and second were not available in the University Library. Similarly, Educational Administration Quarterly that rank third was also found to be heavily used by students was absent from the University Library. This means that these students must have consulted the journals either from personal collections or other libraries. Thus, the finding of this study on the availability of the core journals cited is not different from the previous study by Iya (1996). Apart from Maiduguri Journal of Educational Studies and Educational Forum published by the Department of Education and Faculty of Education, University of Maiduguri respectively, majority of the core journals cited were not available in the University Library.

The distribution of citation by decade span a period of five decades as shown in table 4 reveals that majority (834:32.5%) of the works cited by the researchers fall between 1980-1989, while 152 (5.3%) of the works cited were from 1960-1969. Sam and Tackie (2007) in a citation analysis of 67 dissertations accepted in the Department of Information Studies, University of Ghana, Legon, from 1998 to 2004, reported that majority of the materials cited spanned a period over sixty years were from the mid-1990s to late 1990s, while (7.9%) of the citations were pre-1970. Thus, the result shows the currency of the materials cited in the dissertations is

encouraging. Also, Egberongbe (2003) reported the frequency level of the sources of information cited in political science doctoral theses in the University of Lagos, from 1999-2000, indicating that majority of monographs cited were between 1957 and 1989, while the intensity of citation was between 1976 and 1990. Furthermore, majority of journal articles cited were published between 1964 and 1997. This indicates that most of the journal articles cited were published within thirty years of the time of research.

CONCLUSION

The study analysed the citation pattern of Doctoral theses in Education at the University of Maiduguri, Nigeria. The major findings of the study revealed that Curriculum and Instruction was the most researched subject area, while Educational Psychology was the least researched subject area. Textbooks and monographs were cited more than journal articles and other forms of library materials in theses analysed.

Based on the findings and conclusion of the study, the following recommendations are made: -

- There is the need for University Library to improve on its journal collection in the field of education in particular;
- The University Library should subscribe to online journals, as the result indicated that the use of online journals by the postgraduate students in their research works does not seem to be encouraging, considering the fact that these are the sources of information through which researchers particularly at the Doctoral level can get current research findings that would assist them in conducting their research.
- There is the need for the Department of Education to encourage prospective candidates into Doctoral programme to take interest in conducting research in the less researched subject areas such as: Educational Psychology and Educational Measurement and Evaluation
- The University Library should ensure that one copy of each PhD thesis is deposited in the library by the School of Postgraduate Studies, University of Maiduguri for the purpose of reference and documentation.

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Relationship Between Resources Characteristic and Users' Satisfaction in Public Libraries in Borno State - Nigeria

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Abstract
This study determined the relationship between resources' characteristics and user's satisfaction in public libraries in Borno State. Five objectives, one research question and three null hypotheses guided the study. A survey research method was used for the study. The target population of 2,500 was from the branch libraries of Borno State Public Library. A sample of 250 users (i.e. 10%) was used for the study. The null hypotheses tested were analysed, using Pearson *r*. The findings of the study revealed that the overall level of users' satisfaction was very low. Also, there were no significant relationships between resource characteristics and personnel, while, there was a significant relationship between physical facilities and user's satisfaction. The study recommended among others, that Borno State Library Board should endeavour to provide enhanced quality and quantity collection to the branch libraries to promote users' satisfaction. The study concludes that the components of resource characteristics are the predictable factors responsible for users' dissatisfaction with public libraries in Borno State

Keywords: Survey Research, Population, Null Hypothesis, Physical Facility, Predictable Factors

INTRODUCTION
Users' dissatisfaction with public libraries has been a very great concern to public library librarians and information specialists in the Nigerian society. Aguolu and Aguolu (2002) noted that public libraries cannot fulfil their roles and carry out their responsibilities toward satisfying their users if the characteristics of their resources are not adequate. Public libraries, as observed by Father and Struges (2003), are made available for use of materials in printed, audio-visual and electronic formats in order to collect, preserve, organize, retrieve, disseminate and communicate information, ideas and the creative product of human imagination. Resource characteristics concept implies public library resources that constitute the library collections, personnel and physical facilities, which include books journals and non-print materials. It also includes the personnel (professional, para-professional and supporting staff). Others are physical facilities which include buildings, furniture, reading space, lightings, air-conditioners, fans, catalogue cabinets, etc. Users' satisfaction on the other hand, as explained by Applegate (1997), is a personal, emotional reaction to a library service or product. It is an innate expression of contentment by the library user, especially when his needs are adequately met by the library's offerings. In the same vein, Haruna (2002) opined that user's satisfaction refers to the extent to which library users' needs are fulfilled with the available service and information resource of a given library. User satisfaction is also regarded as a function of information availability, accessibility and relevance. Paradoxically, these two terms are related in the sense that users' satisfaction is regarded as a function of information availability, accessibility and relevance. In other words, it is not enough that the collection is made available to the user in the library but the characteristics of the resources should also be relevant to his needs with backup instruments of accessibility to satisfy him at all times. It is in this regard that studies of Besso (2001) affirm that users' satisfaction is a product of an information system made up of collections, personnel and physical facilities, which support satisfaction. The fact that there is no study establishing this

relationship between resource characteristics and users' satisfaction with Public Libraries in Borno State has generated the need for this study.

Father and Struges (2003) noted that it is a common knowledge that a public library as the name implies, renders information services to people across the society. It is in line with these reason that Vladimir Lenin, the great revolutionary of the former Soviet Union called it "the peoples' university". Fantor (1970) affirmed that public libraries contribute a lot to human development in general and information services in particular. They serve as community information centres where people of all works of life benefit from. Martin (1984) commented that community information has retained a place in the overall pattern of public libraries services not only among the literate, but also the no-literate society where information services are available in the non-print media. The relevance of public libraries in societies can never be over emphasized, since public libraries provide the opportunity for personal and community development in an artistic and scientific achievement through the selection preservation and dissemination of materials for education and for, lifelong learning, research, leisure and recreation. IFLA and UNESCO (2001) affirmed that the emphasis given to any one of these roles will vary according to the place and time the library is located and established. The relationship between resources' characteristics and user's satisfaction can be expressed by the role of public libraries in their communities which could only be achieved when quality and adequate resources are available and made accessible to them. Budd and Dicarlo (1982) pointed out that the library must make available a place for study and research, conducive enough to meet user's satisfaction through the availability for access to items owned by the library, and to ensure an organized collection. Isah (1997) affirmed that the availability of the library resources must be up-to-date both in quantity and quality to meet the satisfaction of the users. Users are dissatisfied whenever their required information resources are not adequate in the library

Harande (2003) argues that librarians simply assume that they know the needs of their users and are able to cater adequately for such needs even without the input of the users. The present-day problem created by information explosion demands relevant library resources to meet the precise needs of users. Okiy (2000) is of the view that periodic sampling of users' opinions on the characteristics of library resources is (inevitable) as these would help to check and find the relevance and appropriateness of library resources in meeting the satisfaction of users. As earlier mentioned, Applegate (1997) affirmed that users' satisfaction on the other hand, implies their personal emotional reaction to library resources. It is an innate expression of contentment by the library users, especially when their needs are adequately made available in the library. Users' satisfaction with public libraries depends on the characteristics of the resources provided. These characteristics are expressed in their adequacy, quality, relevance and quantity. When the resources' characteristics are of a high standard, users get what they need and also express satisfaction, while where the resources are below standard, the expected need of the users would not be met, and that leads to users' dissatisfaction in the library. This could be summed up that: users' satisfaction is a product of information system and support satisfaction. This explains clearly that users' satisfaction in libraries depends on the relationships between characteristics of library resources that could meet their information satisfaction. The ultimate objectives of libraries are to satisfy their users' needs and this is achieved through adequate characteristics of resources. This study is to determine the relationship between resource characteristics and users' satisfaction in the public libraries in Borno State. The works on characteristics of collections

shows the position of Aina (2004) and Hage (2003) who agree that libraries are expected to make available adequate and sufficient collections that would satisfy the needs of the users. Furthermore, these authors affirm that adequate availability of collections has been considered to be a major factor in the development of a society.

On characteristics of personnel in libraries, Library Association (2000) and Bankole (1981) assert that the success of any library depends on the effective utilization of its personnel, and that users' satisfaction is obtained through suitable assistance rendered to them by the personnel. Concerning the characteristics of physical facilities in libraries, it was observed by Budd and Dicardo (1989) and Amole (1986) that the services offered in libraries depend, to a large extent, on the physical facilities available. The adequacy and conduciveness of the library determine some level of users' satisfaction. On users' satisfaction with resource characteristics in libraries, Okiy (2002) and Besso (2001) agree that the satisfaction of users in libraries is based on the availability of efficient and effective service delivery, as well as adequate and up-to-date library resources in general, and that users' satisfaction surveys are used to measure the adequacy of the resources available in libraries. Finally, Aguolu (1986) and Okiy (2000) note that users' satisfaction is the product of adequate resource characteristics, which ensures users' need, and their comfort in using the libraries.

The specific objectives of the study are to determine:

1. Users' satisfaction with public libraries in Borno State.
2. The relationship between the quality and quantity of the characteristics of collection and users' satisfaction in public libraries in Borno State.
3. The relationship between personnel characteristic and users' satisfaction in public libraries in Borno State
4. The relationship between the characteristics of physical facilities and users' satisfaction in public libraries in Borno State.

Research Question

One research question guided the study:

What is the level of users' satisfaction with public libraries in Borno State?

Hypotheses

The following null hypotheses were tested:

1. There is no significant relationship between the quality and quantity characteristics of the collection and users' satisfaction with public libraries in Borno State
2. There is no significant relationship between the personnel characteristic and users' satisfaction with public libraries in Borno State.
3. There is no significant relationship between the physical facilities characteristics and users' satisfaction with public libraries in Borno State.

RESEARCH METHOD

Survey research design was used for this study. The target population of this study is 2500 registered users. While the sample of 250 (10%) was drawn using proportionate sampling techniques from the branch libraries under study as shown in Table 1:

Table 1: Population and sample of the study

S/N	Public Libraries in Borno State (Branches)	Year Established	No of Registered Users	10% sample population
1.	Askira	1991	250	25
2.	Bama	1979	300	30
3.	Biu	1978	400	40
4.	Gwoza	1985	350	35
5.	Konduga	1989	150	15
6.	Kukawa	1987	100	10
7.	Monguno	1989	150	15
8.	Maiduguri	1973	600	60
9.	Ngala	1989	200	20
	Total		2.500	250

The instrument, named "Questionnaire on Resource Characteristics and Users' Satisfaction" (QORCAUS), was designed by the researchers for the study.

The structured questionnaire used was divided into (three) sections: Section A, covers questions on demographic information of the respondents. Section B, covers the independent variables component of resource characteristics of collections, personnel and physical facilities. While, section, C, covers the dependent variable of users' satisfaction. To ensure the intensity of their feelings, the Likert scale of rank ordering was modified for use. It was modified through the omission of "undecided" which scored "0" since it had no value for statistical calculation. Thus, it was omitted from the instrument for scoring. The reliability of the test of the instrument was carried out through a pilot study at Yobe State Public Library, Damaturu, using test and re-test method on twenty (20) registered users of that library, who were not part of the population of the study. Correlation co-efficient of r=0.70 was obtained, which is valid and is an indication of high correlation. So, it was considered reliable as the instrument that would achieve the purpose of the study.

The questionnaire elicited response from the respondents, indicating their level of satisfaction or dissatisfaction on 5 negative statement items pertaining to the resource characteristic, whether they were

(a) Highly satisfied (HS)
(b) Satisfied (S)
(c) Dissatisfied (D)
(d) Highly dissatisfied (HD)

The third section enquires from the respondents their level of satisfaction or dissatisfaction on 5 positive statement items pertaining to their level of satisfaction, whether they were:

a) Highly satisfied (HS)
b) Satisfied (S)
c) Dissatisfied (D)
d) Highly dissatisfied (HD)

Scoring of questionnaire items

a) Resource characteristic variable (-)

	Highly satisfied	1
	Satisfied	2
	Dissatisfied	3
	Highly dissatisfied	4
b)	Users' satisfaction variables	(+)
	Highly satisfied	4
	Satisfied	3
	Dissatisfied	2
	Highly dissatisfied	1

Copies of the questionnaire were administered personally and the researcher was assisted by a trained member of staff in each of the libraries under study. The distribution of the copies of the questionnaire was carried out over a period of three weeks, with a follow-up after a week. The data collected were analysed using descriptive statistics of percentage and frequency counts for the research question. While the hypotheses were tested using Pearson (r) Product Moment Correction Coefficient (PPMC) to determine the relationship between resource characteristic and users' satisfaction

DATA ANALYSIS

The general background of respondent shows that out of 250 respondents 180 (72%) were males with 70 (28%) were females. This shows that majority of the users in the libraries under study were males.

On age group, the majority, that is 115 (46%) respondents, were within the age group of 21-30 years. This is followed by 60 (24%) who were within the age group of 31-40 years.

Occupation/profession of respondents indicated that the majority, 110 (44%) respondents, were students, followed by 85 (34%) respondents who were civil servants, 35 (14%) were in business, while the least was 2 (8%) respondents, who were farmers. Library usage indicated that majority of respondents 120 (48%) used the libraries occasionally 75 (30%) of them on monthly basis, 35 (14%) on weekly basis while the least 20 (8%) were on daily basis.

The result of the demographic information showed that the users of the libraries under study were more of males, who are within the age group of 21-30 years and were students who used these libraries occasionally when there was the need. These results imply that the level of frequency of usage was very low as indicated by the majority of respondents 120 (48%), who use these libraries occasionally while the least 20 (8%) of the respondents used these libraries daily.

The research question was answered using descriptive statistics of frequency and percentages.

Research question one: What is the level of users' satisfaction with Public Libraries in Borno State? The answer to this question is presented by the analysis of four indices of user's satisfaction components presented in Table 2.

Table 2: Level of User's Satisfaction with Public Libraries in Borno State

S/N	Users' satisfaction component	N	HS		S		Total satisfaction scores and %		D		HD		Total satisfaction	
			Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
1	Collections characteristics	250	10	4	50	20	60	24	160	64	30	12	190	76

2	Personnel characteristics		20	8	40	16	60	24	170	68	20	8	190	76
3	Physical facilities characteristics		15	6	70	28	85	34	140	56	25	10	180	66
4	Effect of Overall users' Satisfaction		10	4	15	6	25	10	180	72	45	18	223	4
	Average		16	6.4	41	16.4	57	22.8	161	64.2	32	12.6	193	77.2

Table 2, shows that collections characteristic scored 10 (4%) and 50 (20%) - a total of 60 (24%) respondents, were highly satisfied and satisfied respectively, while 160 (64%) and 30 (20%) - a total of 190 (76%) users- were dissatisfied and highly dissatisfied, respectively. This means the majority of the users were dissatisfied with the collections characteristic in these libraries. The analysis revealed collections characteristic in public libraries in Borno State did not satisfy the information needs of the users.

The personnel characteristic scored 20 (8%) and 60 (24%) users being highly satisfied and satisfied, respectively, while 170 (68%) and 20 (8%) - a total of 190 (76%) users- were dissatisfied and highly dissatisfied, respectively. This result revealed that a majority of the users were dissatisfied, which implies that the personnel characteristic did not satisfy their information need in the libraries under study. The physical facilities characteristic scored 15 (6%) and 70 (28%) – a total of 85 (34%)- who were highly satisfied and satisfied, respectively, while 140 (56%) and 25 (10%) - a total of 165 (66%) users-n were dissatisfied and highly dissatisfied, respectively. The analysis reveals that majority of the users were dissatisfied. This implies that the physical facilities in the libraries under study did not satisfy the users' needs. The effect of overall users' satisfaction with the resource characteristic in libraries under study scored 10 (4%) and 15 (6%) - a total of 25 (10%) users- who were highly satisfied and satisfied, respectively, while 180 (72%) and 45 (18%) – a total of 225 (90%) users- who were dissatisfied and highly dissatisfied, respectively.

The final analysis of the four users' satisfaction indices on the level of their satisfaction with the resource characteristic as indicated on Table 2 shows that the average score of 41 (16.4%) and 16 (6.4%) – a total of 57 (22.8%), who were highly satisfied and satisfied, respectively, while 16 (64.4%) and 32 (12.8%) - a total of 193 (77.2%) - who were, respectively, dissatisfied and highly dissatisfied with the resource characteristic. The result revealed that majority of users of these libraries under study were dissatisfied with the resource characteristic and so the level of users' satisfaction was low. This implies inadequate resource characteristic in public libraries in Borno State.

Testing of Hypotheses

Hypothesis one: there is no significant relationship between the quality and quantity characteristic of the collections and users' satisfaction in public libraries in Borno State. The result of the test is presented in Table 3:

Table 3: Relationship between the Quality and Quantity Characteristic of Collection and Users' Satisfaction with Public Libraries in Borno State

Variable	N	$\overline{X}$	SD	R-value	p-value	DF	Decision p<0.05
Quality and quantity characteristic of collection	250	9.704	1.002	0.143	0.0248	248	S
Users' satisfaction		9.416	0.470				

S= significant at P<0.05

Table 3 shows that the calculated mean for collection characteristic is 9.704 with standard deviation of 1.002, while users' satisfaction has the mean of 9.416 and standard deviation of 0.470, with an obtained calculated R-value if 0.143 with p-value of 0.024 at significant level of 0.05 with the degree of freedom of 248. Since the obtained R-value 0.143 is greater than the p-value 0.024, the null hypothesis is rejected. This implies that there is significant relationship between the collections characteristic and users' satisfaction in public libraries in Borno State.

Hypothesis 2: There is no significant relationship between the personnel characteristic and user's satisfaction in public libraries in Borno State.
The result of the test is presented in Table 4.

Table 4: Relationship between Personnel Characteristic and Users' Satisfaction with Public Libraries in Borno State

Variable	N	$\overline{X}$	SD	r-value	p-value	DF	Decision P<.05
Personnel characteristic	250	9.740	0.973	049	0.438	248	NS
Users' satisfaction		9.416	0.470				

NS-not significant at critical value P<0.05

Table 4 shows that the calculated mean for personnel characteristic is 9.740 with standard deviation of 0.973, while users' satisfaction has the mean of 9.416 with standard deviation of 0.470. The calculated R-value is 0.049 with p-value of 0.438 at significant level of 0.05 with a degree of freedom of 248. Since the obtained calculated R-value of 0.49 is not greater than the p-value of 0.438, the null hypotheses is accepted. This implies that there is no significant relationship between the personnel characteristic and users' satisfaction. Thus, personnel characteristic is adequate in the public libraries in Borno State. Therefore, the users' dissatisfaction might be attributed to factors other than the personnel characteristic.
Hypothesis Three: There is no significant relationship between the physical facilities characteristic and users' satisfaction with public libraries in Borno State.
The result of the test is presented in Table 5:

Table 5: Relationship between the Physical Facilities Characteristic and Users' Satisfaction with Public Libraries in Borno State

Variable	N	$\overline{X}$	SD	R-value	p-value	DF	Decision P<-05
Physical facilities	250	9.724	1.018	0.605	248	0.334	S
Users' satisfaction		9.916	0.470				

S=significant at P<0.05

Table 5: shows that the calculated mean for physical facilities characteristic is 9.724 and 1.018 for standard deviation, while users' satisfaction has a mean of 9.916 and 0.470 for standard deviation. The obtained calculated R-value is 0.605 with p-value of 0.334 at significant level of 0.05 with a degree of freedom of 248. Since the obtained R-value is greater than the p-value, the null hypothesis is rejected. This implies that lack of physical facilities might be attributed to user's dissatisfaction with the public libraries in Borno State.

DISCUSSION

The main objective of the study was to establish the relationship between resources characteristic and users' satisfaction in public libraries in Borno State. On the basis of the independent variables of resources characteristic: collections characteristic, personnel characteristic and physical facilities characteristic. One research question and three hypotheses were drawn to measure the dependent variable of users' satisfaction with public libraries in Borno State. The finding of the research question and null hypotheses tested formed the basis of the following discussions.

The research question analysed revealed the significance of the resources characteristic on users' satisfaction in the libraries under study – it found that there was low level of users' satisfaction. This implies that the resources are inadequate and do not satisfy majority of the users. Library resources, as a characteristic, have a significant relationship with users' satisfaction, as found in Okiy (2000) who affirmed that users' satisfaction is a product of the adequate resources that ensure what the users need, and their comfort in using such resources. Therefore, the negative response of the users could be interpreted to mean inadequacy of the resources characteristics in meeting their information needs which has significant relationship with their maximum satisfaction.

The findings revealed that there is significant relationship between collections quality and quantity characteristic and users' satisfaction. This finding agrees with Agoulu (1986) who affirmed that there is a relationship between the size of public library collection and its adequacy; and that the quantity of collections combined with its quality ensures adequacy. That is to say adequacy of library collection has both quantitative and qualitative dimensions in order to satisfy the needs of users, as noted by Besso (2001) and Aguolu (2002).

The findings of this study revealed that there is no significant relationship between personnel characteristic and users' satisfaction with public libraries in Borno State. This finding is in disagreement with that of Rowley (1978), which ascertained that the performance of both professional and non-professional staff determines to a large extent the level of users'

satisfaction experience from any library setting. At the same time Oregon Library Association (2000) affirmed that users' satisfaction cannot be possible without proposing suitable standard for quality and quantity of personnel in the library. Borman (1989) added that whatever the situation, library personnel standard must be observed, in order to have sufficient staff both in quantity and quality who will meet the users' satisfaction with the available resources. This contradiction of the finding of the present study to the earlier arguments might be attributed to the low-level educational background of the area of study as compared to the findings of other studies in more advanced educational background and setting. The findings also revealed that there was significant relationship between physical facilities characteristic and users' satisfaction in Public Libraries in Borno State. This study agreed with Amole (1986) who affirmed that the characteristic of physical facilities determines the users' satisfaction in their search and study in any library. Bud and Dicarlo (1989) added that libraries must make available a place conducive for study and reasoning. These findings therefore, have provided some relevant and useful information for the libraries under study in particular and other public libraries in general.

CONCLUSION

The study's findings provide evidence that in spite of the provision of resources for the users to carry out their study and research work in the libraries under study, users' satisfaction were low. The low level of users' satisfaction hinged on the characteristics of collection, personnel and physical facilities. The test of the hypotheses revealed that the collections' characteristic and physical facilities characteristic have relationship with users' satisfaction, while personnel's characteristic had no relationship with the users' satisfaction. The non-significant but low negative correlation of resources characteristic could be interpreted to mean inadequate resources. A significant relationship also exists between resources characteristic and users' satisfaction. In conclusion, the study concludes that the components of resources characteristic are the predictable factors responsible for the users' dissatisfaction with public libraries in Borno State.

Based on the findings of this study, the following recommendations are made for improvement:

1. The Borno State Library Board should endeavour to provide quality and quantity collection to the branch libraries to promote user's satisfaction.
2. Although, there were adequate personnel in the libraries under study, there is a need for the personnel to provide adequate users' information service.
3. The Borno State Government should provide adequate physical facilities for users' satisfaction in the libraries under study.

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Performance Evaluation of Continuous Oscillatory Baffled Reactor Arrangement on Production of Biodiesel from *Jatropha* Oil Using Heterogeneous Catalyst

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Abstract

The purpose of this work was to investigate the performance of the Continuous Oscillatory Baffled Reactor Arrangement on biodiesel yield from *Jatropha* oil using zinc oxide as a catalyst. The effect of various factors of reaction such as catalyst concentration, temperature, oil to alcohol ratio, mean residence time and frequency of oscillation on biodiesel production was studied. The results showed that the optimum catalyst concentration was 15%w/w of oil, optimum temperature was 65^{o}C, oil - methanol ratio of 1:12, best mean residence time was 5minutes and optimum frequency of oscillation was found to be 5Hz.The maximum biodiesel yield obtained from *Jatropha* oil using continuous oscillatory baffled reactor arrangement was 96%.

Keywords: Performance evaluation, COBRA, Biodiesel yield, *Jatropha* oil, Heterogeneous catalyst

INTRODUCTION

Due to the increase in the price of petroleum crude and products as well as environmental concerns about air pollution caused by the combustion of fossil fuels, the search for alternative fuels has been of paramount importance (Alamu *et al.,* 2007). Biodiesel derived from the transesterification of vegetable oils or animal fats with alcohol are potential substitutes for petroleum–based diesel fuels (Bugaje, 2006). Compared with conventional diesel, biodiesel has the advantages of being biodegradable, renewable and non-toxic and have low pollutant emissions (Sharp, 1998). Therefore, it is of utmost importance that the alternatives of petroleum fuels be explored to reduce environmental hazards. The degrading air quality, mainly in urban areas, further warrants the search into alternative clean fuels. With the stock of fossil fuels diminishing throughout the world and demands for energy based comforts and mobility ever increasing, time is ripe that we strike a balance between energy security and energy usage. Studies have shown that Nigeria currently imports about 80% of its petroleum product requirements and has been hard hit by rapidly-increasing cost and uncertainty (Alamu *et al.*, 2007; ECN 2005).

In the Niger Delta region, which is the centre of oil extraction in the country, severe environmental impact that has been ignored, has generated militancy from the local communities, making successful oil prospecting a near impossible task for the multinational companies involved if not for the Amnesty Programme. All these underline the urgency to find alternative renewable forms of energy. There is need to explore the production of biodiesel from non–edible oils such as *Jatropha* seed oil since production of biodiesel from edible oils will lead to high competition for food and biodiesel production (Umar *et al.,* 2006; Bugaje and Mohammed, 2008).

Batch processes have been used for the production of biodiesel but suffered several disadvantages compared to continuous processes. They require larger reactor volume, resulting in higher capital investment (Darnoko and Cheryan, 2000). Based on performances of a pilot plant for biodiesel production using a batch reactor, developed in Ahmadu Bello University, Zaria (ABUZ) and National Research Institute for Chemical Technology Zaria (NARICTZ). The product quality from these pilot plants is not very satisfactory and commercialization is yet to be commenced (Atadashi *et al.,* 2007). Subsequently continuous processes in producing biodiesel from vegetable oils have been developed by some researchers to reduce a high procurement cost and to enhance mixing of the reactants in order to improve the reaction rates (Darnoko and Cheryan, 2000). Hence the use of a continuous process tends to be more efficient and is therefore used on a larger scale. However, it is seldom used for long reaction time as conventional continuous reactor designs have certain draw-backs such as long reaction time systems: CSTRs have disadvantages of a broad residence time distribution, plug flow reactors (PFRs) require great lengths of narrow tubing, causing control, operability foot print and pumping problems and continuous stirred tanks in series tend to be expensive. Therefore, the aim of this work was to study the production of biodiesel using continuous oscillatory baffled reactor with the use of heterogeneous catalyst.

EXPERIMENTAL METHOD

The performance evaluation of the COBRA was carried out by determining the biodiesel yield from the transesterification reaction of *Jatropha* oil in the reactor at different factors that affect the reaction such as catalyst concentration, temperature, oil-methanol ratio, mean residence time and frequency of oscillation.

Experimental Materials

Refined *Jatropha* oil (NARICT) with a density and viscosity of 914 kg/m^3 and 31.2mm^2/sat 60^oC respectively was used as a source of triglyceride. The methanol and zinc oxide (ZnO) used are of analytical grades (Sigma –Aldrich).

Experimental Equipment

With stirrer for methanol/catalyst and $Tank_2$ for oil) using a twin-headed positive displacement metering pumps of 0.5 hp and the flow rates were monitored by flow meters. Temperatures were maintained in the feed vessels and supply lines by Eurotherm temperature controllers, regulating

the output to the hotplates beneath the feed vessels and the tapes around the supply lines respectively. The continuous oscillatory baffled reactor arrangement that was utilized in this work as shown in Figure1 was designed and constructed in the Department of Chemical Engineering University of Maiduguri, Nigeria. The device consisted of two vertically positioned jacketed stainless steel tubes of 1.4 m length and 0.1 m internal diameter, connected at the top by an inverted U-tube, fitted with manually operated purge valve of 0.21 m length. The overall internal volume of the reactor was 2.41×10^{-2} m^3. A series of orifice type stainless steel baffles with a diameter 0.05 m and baffle spacing of 0.15 m were welded to the tube wall. The baffle spacing was 1.5 times the tube diameter as suggested in the literature to achieve effective mixing over broad range of oscillation amplitudes and frequencies (Brunold, 1989). Both ends of the tubes were attached to an oscillation unit that consists of a pair of pistons. Pneumatically driven pistons that work in a push and pull sequence were used to oscillate the fluid within the COBRA at a frequency range of 1.0 to 10 Hz. Reactor temperature was maintained by a Haake F6/B5 heater /circulator unit. The net flow was provided by a liquid pumps from the feed vessels ($Tank_1$)

Fig. 1: Continuous Oscillatory Baffled Reactor Arrangement (COBRA)

RESULTS AND DISCUSSION

Transesterification reactions catalyzed by zinc oxide (ZnO) were conducted at different catalyst concentrations to determine the best catalyst concentration for biodiesel production. ZnO is one of the most commonly used due to its low cost and availability (Amish *et al.*, 2010). Figure 2 shows the different biodiesel yield resulting from the transesterification of the *Jatropha* oil using the heterogeneous base (ZnO) catalyst. It was observed that the optimum catalyst concentration was 15%w/w of oil. This is in accordance with studies on different FAME concentrations resulting from the transesterification of the refined *Jatropha* oil using the different heterogeneous base catalysts concentration (Amish *et al.*, 2010, Leon *et al.*, 2011). The effects of temperatures within the range of 40^oC-70^oC on transesterification reaction of *Jatropha* oil at oil - methanol ratio of 1:12, with the use of ZnO (15%w/w of oil) at residence time of 5 minutes were investigated and the observed effects are as shown in Figure 3.

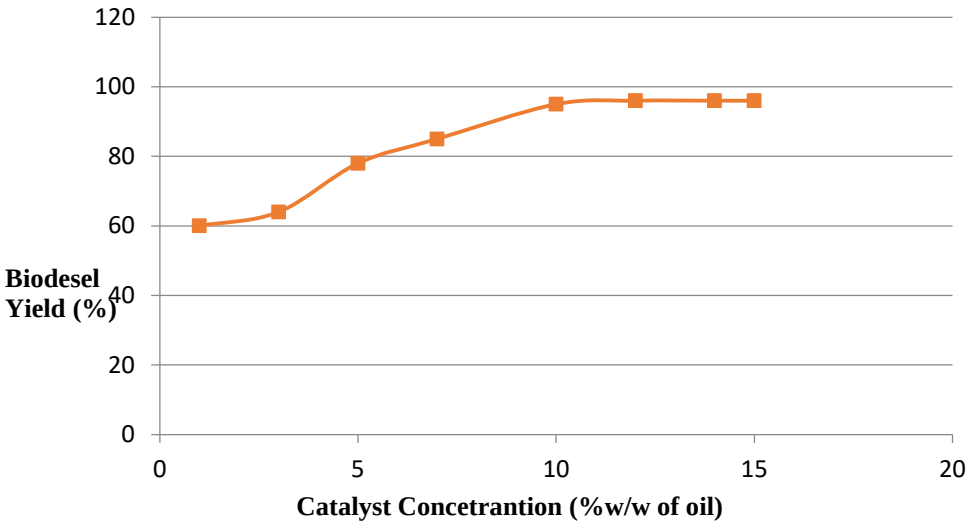

Fig. 2 : Effect of Catalyst concentration on Biodesel Yield

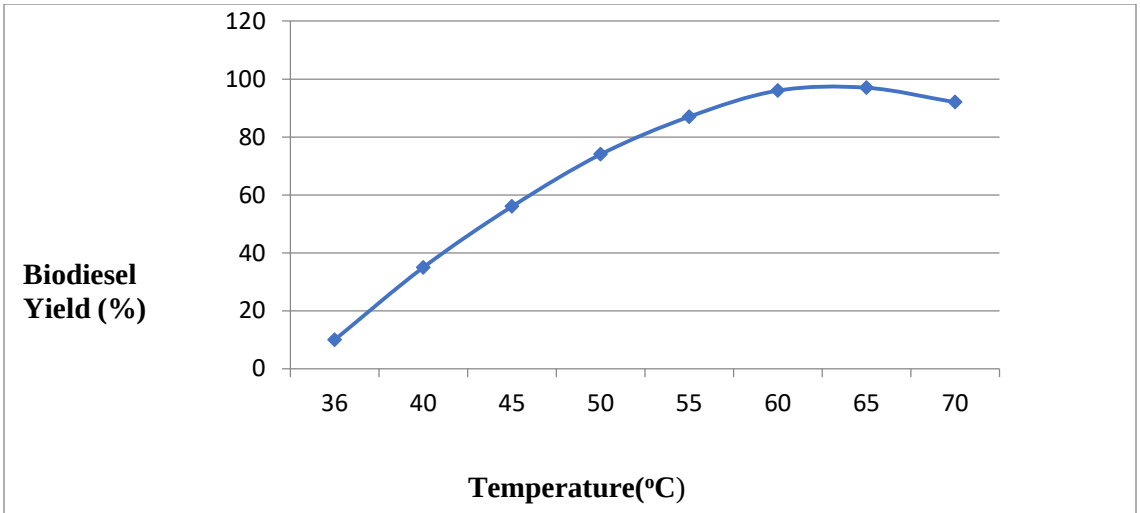

Fig. 3 : Effect of Temperature on Biodiesel Yield from *Jatropha* oil using ZnO (15w/w% oil)

The maximum equilibrium conversion was seen at temperature of 65^{o}C.This study is comparable to the work of Leon et al., obtained 84% conversion of *Jatropha* oil at 60^{o}C and oil-methanol ratio of 1:15 using Zeolite Y (10%w/w of oil) as heterogeneous catalyst [Leon, *et. al*, 2011]. Higher temperature above the boiling point of methanol was used to increase the rate of reaction as solubility of the reactants is increased and there is lower mass transfer resistance. The biodiesel yield generally increased as the reaction temperature was raised until 65ºC, which is the optimum temperature. Thus between the temperature range of 40^{o}C to 65^{o}C at every increase in temperature of 5^{o}C there is increase in equilibrium conversion of *Jatropha* oil of approximately 10%-20% At 65ºC, highest yield of biodiesel was achieved without having to operate at higher pressure. However, at temperatures above 65ºC, a drastic reduction in the biodiesel yield was observed. This can be due to the drastic loss of methanol (B.pt = 64.7ºC) that has escaped as vapour.

One of the most important variables affecting the conversion of oil to biodiesel is the molar ratio of Oil to alcohol. The stoichiometric molar ratio for transesterification is three moles of alcohol to one mole of oil, to produce three moles of alkyl esters and one mole of glycerol (Amish *et al.*, 2010). The effect of molar ratio on transesterification reaction is associated with the type of catalyst used. Acid-catalyze transesterification requires a molar ratio of 30:1, while alkali-catalyzed reaction requires only 6:1 molar ratio to achieve the same equilibrium conversions (Canakci and Gerpen, 1999).

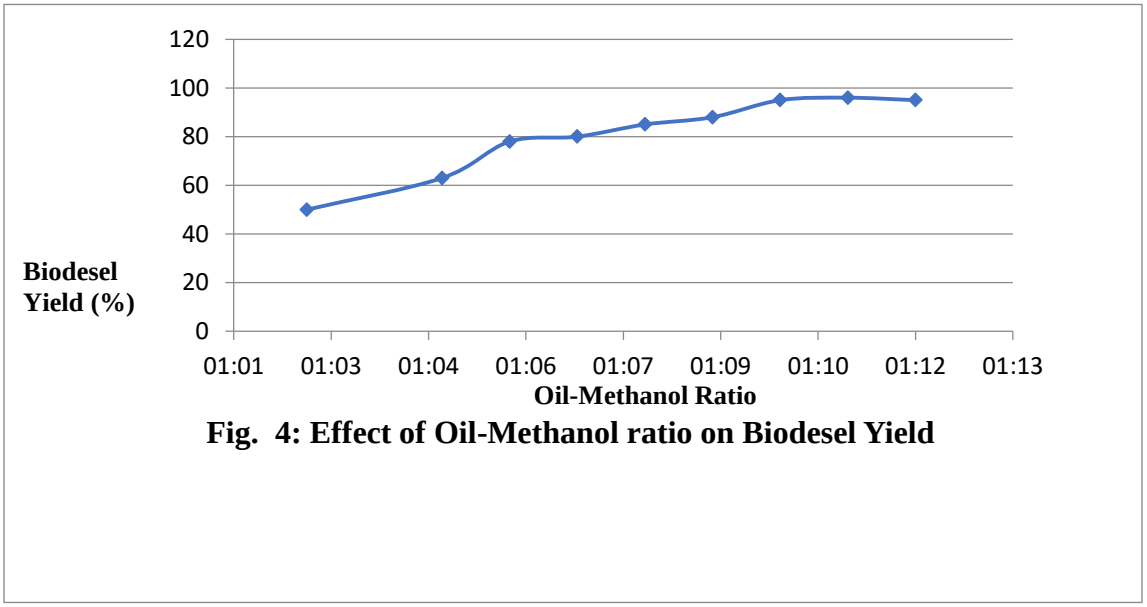

Fig. 4: Effect of Oil-Methanol ratio on Biodesel Yield

As can be seen from Figure 4, by the use of zinc oxide (ZnO) as heterogeneous catalyst maximum conversion of 96% was achieved at oil to methanol molar ratio 1:12 and reaction temperature of 60^{o}C. It is comparable to the work in which 90% conversion was obtained using methanol as an alcohol with triolein oil to alcohol molar ratio of 1:6 and KOH as a catalyst (Hanh *et al.*, 2007). Kumar *et al.*, have obtained above 98% yield using 1:9 *Jatropha* oil - methanol molar ratio and heterogeneous solid catalyst used was sodium silicate (Na/SiO^2) (Kumar *et al.*, 2010). The present study shows that with molar ratio of oil - methanol of 1:12, maximum conversion was achieved in 5 minutes only and after that it remained almost constant over an extended reaction time. Approximately 1-15% increase in equilibrium conversions were observed with an increase in molar ratio from 1:3 to 1:12. At higher molar ratios, the increase in the biodiesel yield was not as high due to the dilution of the reactive species, which in this case was the methoxide anion. Molar ratio of 1:3 and 1:6 were not showing appreciable results may be due to the predominance of esterification reaction at the initial phase, to transesterify the FFA present in the *Jatropha* oil, which can consume methanol present in the reaction mixture and hence, the amount of methanol available for transesterification may not be sufficient to drive the reaction forward for longer time. Figure 5 shows the effect of mean residence time of reaction on biodiesel yield from *Jatropha* oil in a COBRA. It was observed that as the mean residence time increased from 3 to 5 minutes, the equilibrium conversion increased from 64% to 96% though, the conversion was slow during the first and the last minutes due to mixing and dispersion of methanol. The results of this work were compared with the results of the study by Kumar *et al.*, (2010) on the effect of time of reaction on the transesterification reaction of *Jatropha* oil using sodium silicate as the heterogeneous catalyst in a batch reactor where 90% conversion was obtained in 2 hours. It can be seen from Figure 5 that in a continuous oscillatory baffled reactor arrangement, the maximum conversion of 96% of *Jatropha* oil was obtained at maximum reaction time of 5 minutes. This showed that reaction time has been reduced drastically from 2 hours as in the case of batch reactor to 5 minutes in a COBRA. The effect of oscillation conditions of the continuous oscillatory baffled reactor arrangement in the transesterification of *Jatropha* oil was studied. Figure 6 shows that the maximum frequency of oscillation is 5 Hz where the biodiesel yield increased to the maximum of 96%. At a frequency above 5 Hz no

significant increase in the biodiesel yields was obtained. This result was in agreement with the result of the study on the biodiesel screening using oscillatory flow meso reactors where the triglyceride conversion in the meso reactor was maximized at the frequency of oscillation of 6 Hz (Zheng *et al.*,2007).

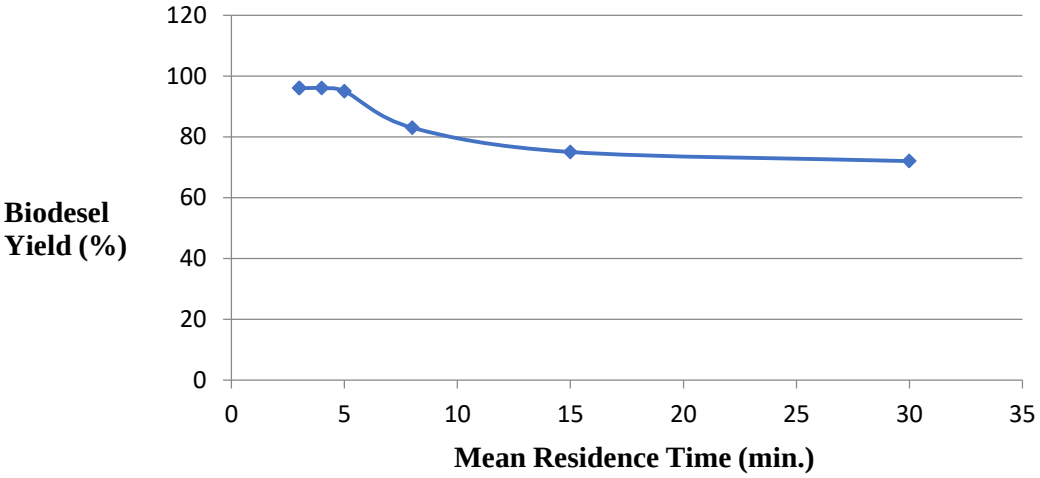

Fig. 5: Effect of Mean Residence Time on Biodiesel Yield

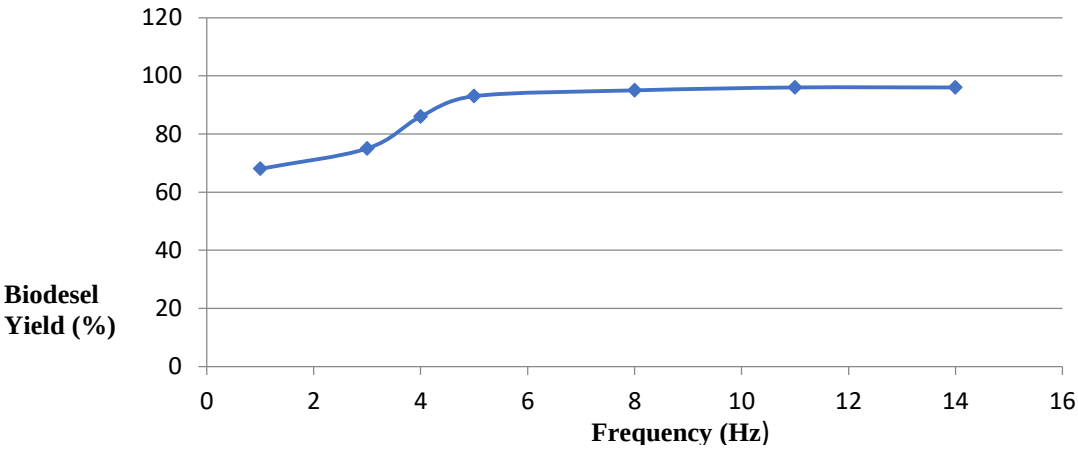

Fig. 6 ; Effect of Frequency of Oscillation on Biodiesel Yield

CONCLUSION

Performance evaluation of the developed COBRA was carried out to determine the biodiesel yield from transesterification reaction of *Jatropha* oil at different factors of reaction. The effect of heterogeneous catalyst (ZnO) concentrations on the production of biodiesel from *Jatropha* oil was analyzed. Effect of temperature on the production of biodiesel using COBRA was analyzed. The result showed that the optimum temperature that gave the highest yield of 97% was 65^{o}C. At

temperature of 70^{o}C, there was a drastic decrease in the yield to about 92%. Also, effect of oil-methanol ratio on yield of biodiesel from the COBRA was carried out. It was found that approximately there was 1-15% increase in biodiesel yield with an increase in oil-methanol ratio from 1:3 to 1:12. There was no significant increase in biodiesel yield at higher biodiesel ratios due to dilution of the species such as methoxide anion. The optimum mean residence time of reaction and frequency of oscillation of COBRA were found to be 5 minutes and 5 Hz respectively.

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The Effects of Aqueous Stem Bark Extract of *Ceiba pentandra L.* (silk cotton tree) on Ethanol and Indomethacin-induced Gastric Ulcer

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Abstract
The effects of aqueous stem bark extract of *Ceiba pentandra L.* (Silk cotton tree) on ethanol and indomethacin induced gastric ulcer were investigated. The first set of animals were divided into four (4) groups (n=5). Group 1 was treated with distilled water 10ml/kg. Groups 2, 3 and 4 were orally administered with 200, 400 and 800 mg/kg of the aqueous extract respectively. The second set were divided into five (5) groups (n=5), Group (I) was pre-treated with distilled water 10ml/kg. Groups 2, 3 and 4 were pre-treated with 200, 400 and 800mg/kg of the aqueous extract (orally) respectively. Group 5 served as positive control and was administered cimetidine 50mg/kg orally. Ethanol and indomethacin induced gastric ulcer were blocked by the plant extract in a significant and dose dependent manner ($p<0.01$). It was therefore suggested that the plant extract has anti-secretory and antiulcer potentials. It was inferred that the anti-secretory ability of the plant is via blockade of histamine and cholinergic pathways.

Key words: *Ceiba pentandra L.* (silk cotton tree), Ethanol, Indomethacin, Gastric ulcer

INTRODUCTION
Impaired gastrointestinal functions alter intestinal and mucosal physiology including gastric acid secretion, gastric metaplasia, immune responses, and mucosal defence mechanisms. It also changes metabolic processes, haematopoiesis, haemostasis, endocrine and nervous activities (Gilbert *et al*, 1991; DeCross and Peura, 1992; Paulev, 2000; Guyton, 2004). Gastric acid secretion is regulated by neural, hormonal, paracrine and intracellular pathways, deficiency of the acid interferes with the absorption of iron, calcium, vitamin B_{12}, and certain drugs (Schubert, 2006). It also predisposes the individual to enteric infection, bacterial or fungal overgrowth, and gastric malignancy (Schubert, 2004). Excess gastric acid secretion induces oesophageal, gastric, and duodenal injury. This injury is a major health problem that is responsible for morbidity in about 10 – 15% of the world population (Chaturvedi *et al.*, 2007; Schubert, 2004).

Hormones and certain chemicals such as gastrin, histamine, acetylcholine, and ghrelin stimulate gastric secretion whereas somatostatin, cholecystokinin, atrial natriuretic peptide, and nitric oxide inhibit acid secretion (Hou and Schubert, 2006). Certain diets and genes, age, bacteria, reactive oxygen species (free radicals and some medications to a large extent are implicated in the aetiology of various gastrointestinal malfunctions (Micheal, 2009). The Phytochemical constituents of the plant *Ceiba pentandra* (L.) silk cotton tree (Rimi in Hausa or Tom in Kanuri) include naphthoquinones with antimicrobial activities in the root bark, the leaves contain semi gossypol 1,4 – quinine, the stem bark contains flavonoids, beta sito sterol, lupeol, quercetin, terpenoids, saponins and hydrogen cyanide. The plant is used for waste management and bioremediation, as a diuretic, aphrodisiac and in the treatment of headache, dysentery, fevers, venereal diseases, asthma, menstrual bleeding and kidney diseases (Hidenori *et al.*, 2002). The stem bark extract of *Ceiba pentandra* is consumed for the treatment of diabetes in parts of

Cameroon and North-central Nigeria. The stem bark contains vavain and its glucoside content has inhibitory effects on cyclooxygenase-catalysed prostaglandin biosynthesis, an essential component of gastric mucosal defence (Pesker, 2001; Hidenori *et al.,* 2002). The leaves stimulate hair growth and facilitate shedding of placenta after delivery (Hidenori *et al.,* 2002; Saleem *et al*., 2003; Mpiana *et al*.,2007 and Djomeni *et al*., 2009)

This work will determine the effects of aqueous stem bark extract of *Ceiba pentandra L.* on ethanol and indomethacin induced gastric ulceration.

MATERIAL AND METHODS

Plant Materials

Collection of Plant Materials

The stem bark of *Ceiba pentandra L* (silk cotton tree) was collected from the residential area, University of Maiduguri campus in August, 2008. It was authenticated by Dr. E. Rabo of Botany Unit, Department of Biological Sciences, University of Maiduguri. A voucher number was obtained and a part of the plant was deposited in their herbarium. The stem bark was collected and shade-dried at room temperature (Tolu, 2008).

Aqueous Plant Extraction

The dried bark was made into fine powder by grinding with porcelain pestle and mortar. Aqueous stem bark extract was obtained by soaking 200g of the powder in one litre (1L) of hot distilled water 8.5^0C for one hour. The mixture was allowed to cool to 20-50^0C. It was then filtered through a cotton wool plug stuck in glass funnel. The filtrate was collected in a beaker and evaporated on a hot plate at 30^0C until dried residue was obtained. The residue was kept in a refrigerator until required. Stock concentration was prepared by weighing required quantity and dissolved in appropriate volume of distilled water.

For Example – Stock concentration of 100mg/ml = 1g of the residue to be dissolved in 10ml of distilled water.

New concentration is prepared from the stock using

$$\frac{NC \times VR}{SC}$$

where NC = New concentration desired, SC = Stock concentration and VR = Volume required
NOTE: Freshly prepared concentrations were used daily.

Animals handling

The animals used were obtained from the animal house, Department of Human Physiology, College of Medical Sciences, University of Maiduguri. They were kept in plastic cages and provided with regular supply of tap water. The rats were fed *ad libitum* with growers' mash (ECWA feed, Bukuru-JOs Plateau State). The animals were allowed uninterrupted 12 hours' day and night cycle.

Local strain of Rabbits (1.5-2.0kg) was obtained from Maiduguri, Monday Market. They were quarantined for 14 days in rabbit cages (2 per cage). They were fed with fresh green grass and dry groundnut leaves. The rabbits were allowed free access to tap water and uninterrupted 12h

day and night cycle. The animals were screened for possible diseases and found apparently healthy.

Experimental procedures on the animals used in the study were approved by the Pre-clinical, College of Medical Sciences, University of Maiduguri Animal Ethics Committee.

Induction of Gastric Ulceration in Albino Rats

Male rats (200-250g) were kept in cages with raised floors of wide wire mesh to prevent them from coprophagy (Mozafar and Hossein, 2006).

The rats were fasted for forty-eight hours (48hrs) to ensure an empty stomach. Water containing 8% sucrose in 0.2% sodium chloride was provided to the animal ad libitum to reduce dehydration and weight loss. Water was withdrawn an hour before induction of ulceration. The animals were later killed with overdose of anesthetic ether. The abdomen was cut opened through a midline incision. The stomach was isolated, washed with tap water, and cut opened through the greater curvature. The stomach was further rinsed under a stream of water and pinned flat on a corkboard. The stomachs were observed with a hand lens (x10). Erosions formed on the glandular portions of the stomach were counted and each given a severity rating on a 0 – 4 scales based on the diameter of the ulcer as follows.

(0)=normal grey stomach, (0.5)=pink to red coloration of stomach,
(1) Spot ulcer, (1.5) = haemorrhagic streak, (2) = ulcer<5mn; (3) = ulcer> 5mn, (4) = ulcer with bleeding.

The total lesion lengths in each group of rats were counted and expressed on the Ulcer scores. The ulcer score is used for the computation of ulcer index (UI). The ulcer index provides a better quantitative expression of ulcer severity (Nwafor, 2004).

$$\text{Ulcer index (UI)} = \frac{\text{Degree of Ulceration x Percentage of Group Ulceration}}{100}$$

$$\text{Preventive ratio} = \frac{\text{UI (Ulcerated group – Protected group) x 100}}{\text{UI (Ulcerated group)}}$$

$$\text{Degree of Ulceration} = \frac{\text{Total Ulcer Score}}{\text{Number of animals Ulcerated}}$$

Nwafor *et al.*, 2000).
At the end of the macroscopic evaluation, the stomach was photographed and fixed in 10% formol saline for histopathological studies.

RESULTS AND DISCUSSION

Effects of Aqueous Stem Bark Extract of *Ceiba pentandra* on Ethanol Induced Gastric Ulceration in Albino Rats.

Rats were divided into four (4) groups (n=5). Group 1 was treated with distilled water 10ml/kg. Groups 2, 3 and 4 were orally administered with 200, 400 and 800 mg/kg of the aqueous extract respectively. After one hour, rats in all the groups were administered with 1ml of 50% ethanol

orally. An hour after administrations of 50% ethanol, the animals were sacrificed and the ulcer score determined as indicated above.

Effects of Aqueous Stem Bark Extract of *Ceiba pentandra* on Indomethacin Induced Gastric Ulceration in Albino Rats.

Rats were divided into five (5) groups (n=5). Group (I) was pre-treated with distilled water 10ml/kg. Groups 2, 3 and 4 were pre-treated with 200, 400 and 800mg/kg of the aqueous extract (orally) respectively. Group 5 served as positive control and was administered cimetidine 50mg/kg orally, three hours after administration of indometacin (75mg/kg), the animals were sacrificed and the ulcer score determination as indicated above.

Statistical Analysis

Results were expressed as mean ± SEM. Statistical analyses were performed using one-way ANOVA (plus a post hoc Dunnett or Turkey tests). Values of $p<0.05$ were considered significant. Computer software GraphPad InStat$^{(R)}$ @ USA, 2003 was used.

Table 1 Effects of stem bark extract of *Ceiba pentadra* on Ethanol and Indometacin induced gastric ulcer in albino rats.

Experiment	Extract	Dose mg/kg	Ulcer Index	Preventive Ratio (%)
Ethanol 50%	N/Saline	10ml/kg	22.60 1.8	±0
	Aq Extract	400	15.2±2.8	33
		800	13.8 1.80*	± 39*
Indomethacin 75mg/kg	N/saline	10ml/kg	32.5±4.25	0
	Aq Extent	400	26.4±1.8	19
		800	18.4	± 43*
	Cimetidine	50	3.2* 8.4±0.25*	74***

*p<0.05, **p<0.01, ***p<0.001 Significant compared to control.

Plate 1: Gross presentation of rat stomach after oral administration of ethanol (50%).
Arrow indicate ethanol induced ulceration, haemorrhagic streak and reddining (x5).

The plant extract has conferred cytoprotection against ethanol induced gastric lesion when compared with control (plate 1). The noxious effect of the ethanol became manifest, but was reduced with administration of the plant extract. The mechanism of this cytoprotection exhibition by the plant extract in this study is not known. Although, gastric protection can be correlated to reduction in gastric acidity, gastric acid output, increased pH, reduced generation of free radicals and decreased lipid peroxidation alongside strengthening of mucosal barrier (Rachchh *et al; 2008).*

The plant extract may have provided cytoprotection against ethanol induced gastric ulceration through increased mucosal blood flow, scavenging of free radicals and prevention of peroxidation. Because, flavonoids, tannins, terpenoids are gastroprotective via increase in gastric mucus, activation of endogenous prostaglandins, generation of nitric oxide, antioxidant and anti-*Helibacter pylori* (Silveria, *et al; 2009).* The plant extract has reduced indomethacin induced gastric ulceration. This agrees with the findings of (Ibara, *et al* 2007). The mechanism of this protection may be unrelated to inhibition of isoenzymes cycloxygenase-1 (cox-1) and cycloxygenase -2 (cox -2). The stem bark extract of *Ceiba pentandra* contains vavain and its glucoside has cox-1 and cox-2 isoenzymes inhibitors, a combination that induces gastric damage (Pescar, 2001). These isoenzymes in the plant are expected to potentiate ethanol or indomethacin induced damage. Paradoxically, the plant extract in this study reduces gastric mucosal lesion invoked by ethanol and also prevented damage caused by indomethacin, a non-selective, non-steroidal anit inflammatory drug. This suggest that the concentration of inhibitors of cox-1 and cox-2 in the stem bark is either low or is superseded by an opposing or neutralizing phytocomponent of the plant in yet an undefined mechanism. Thus, providing protection to the gastric mucosa against necrotizing agent, ethanol and NSAIDS (indomethacin). On the whole, the extract by it possession of isoenzymes is expected to enhance damage to the gastric mucosa because the combination of the two isoenzymes (cox-1 and cox-2) inhibits the generation of precursors and synthesis of prostagalandin. This pro-inflammatory mediator (prostaglandin) reduces gastric acidity, increase mucus secretion, enhance bicarbonate release and protect gastric mucusa from damage. On the contrary, it seems likely that the cox-1 and cox-2 inhibitors did not block generation of prostaglandins and also did not potentiate the gastric damaging potential of

indomethacin in this study. Rather, the gastric mucosa was prevented from damage in yet an inconclusive mechanism.

The plant extract attenuates the mucosal aggressive factors by causing a decrease in gastric fluid volume, reduced acidity, decrease acid output and increased pH in a significant and in dose dependent manner (table I). These capabilities promote gastric mucosal integrity and probably explain partyl the cytoprotection potential of the plant extracts.

CONCLUSION

The aqueous plant extract has gastric antisecretory and gastric anti-ulcer potential. Inhibition of gastric secretion may be mediated via competitive blockade of histamine and acetylcholine receptors. The aqueous stem bark extracts can be used for the treatment of ulcer, gastritis and other disorders of the gastro-intestinal tract.

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The Effects of Aqueous Stem Bark Extract of *Ceiba pentandra* L. (Silk cotton tree) on Gastric Acid Secretion

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Abstract
Twelve (12) albino rats of wistar strain were used (220-280g) to study the effects of aqueous stem bark extract of *Ceiba pentandra*. Gastric acid secretion was stimulated using histamine and carbachol. The plant extract dose dependently blocked histamine (10mg/kg) and carbachol (60 μg/kg) induced gastric fluid volume; acidity, acid output and increased pH significantly ($p<0.01$) relative to control. It was therefore concluded that the plant extract has antisecretory and antiulcer potentials. It was inferred that the antisecretory ability of the plant is via blockade of histamine and cholinergic pathways.

Key words: *Ceiba pentandra*, gastric acid secretion, gastric ulcer

INTRODUCTION
Impaired gastrointestinal functions alter intestinal and mucosal physiology including gastric acid secretion, gastric metaplasia, immune responses, and mucosal defence mechanisms. It also changes metabolic processes, haemopoiesis, haemostasis, endocrine and nervous activities (Gilbert *et al.*, 1991; DeCross and Peura, 1992; Paulev, 2000; Guyton, 2004). Gastric acid secretion is regulated by neural, hormonal, paracrine and intracellular pathways, deficiency of the acid interferes with the absorption of iron, calcium, vitamin B_{12}, and certain drugs (Schubert, 2006). It also predisposes the individual to enteric infection, bacterial or fungal overgrowth, and gastric malignancy (Schubert, 2004). Excess gastric acid secretion induces oesophageal, gastric, and duodenal injury. This injury is a major health problem that is responsible for morbidity in about 10 – 15% of the world population (Chaturvedi *et al.*, 2007; Schubert, 2004).

Hormones and certain chemicals such as gastrin, histamine, acetylcholine, and ghrelin stimulate gastric secretion whereas somatostatin, cholecystokinin, atrial natriuretic peptide, and nitric

oxide inhibit acid secretion. (Hou and Schubert, 2006;Schubert 2007, 2008).Certain diets and genes, age, bacteria, reactive oxygen species (free radicals and some medications to a large extent are implicated in the aetiology of various gastrointestinal malfunctions (Masahiro and Takeo, 1987; Michael, 2009).The phytochemical constituents of the plant *Ceiba pentandra* (L.) silk cotton tree (*Rimi* in Hausa or *Tom* in Kanuri) include naphthoquinones with antimicrobial activities in the root bark, the leaves contain semi gossypol 1,4 – quinine, the stem bark contains flavonoids, beta sitosterol, lupeol, quercetin, terpenoids, saponins and hydrogen cyanide. The plant is used for waste management and bioremediation, as a diuretic, aphrodisiac and in the treatment of headache, dysentery, fevers, venereal diseases, asthma, menstrual bleeding and kidney diseases (Hidenori *et al.,* 2002; Duke, 2003).The Stem bark extract of *Ceiba pentandra* is consumed for the treatment of diabetes in part of Cameroun and North central Nigeria. The stem bark contains vavain and its glucoside content has inhibitory effects on cyclooxygenase-catalyzed prostaglandin biosynthesis, an essential component of gastric mucosal defence (Pesker, 2001; Hidenori *et al.,* 2002). The leaves stimulate hair growth and facilitate shedding of placenta after delivery. The metabolites of this plant may interfere with metabolic processes and modify physiologic activities. At present, most of the medicinal value of the plant remains speculative and there is paucity of physiologic data on the plant activities on gastrointestinal functions.

This work will determine the effects of aqueous stem bark extract of *Ceiba pentandra* (L.) on gastric acid secretion and gastric fluid volume in albino rats.

MATERIALS AND METHODS

Plant Materials

Collection of Plant Materials

The stem bark of *Ceiba pentandra* (silk cotton tree) was collected from the residential area, University of Maiduguri campus in August, 2008. It was authenticated by an Dr. E Rabo of Botany unit, Department of Biological Sciences, University of Maiduguri. A voucher number was obtained and apart of the plant was deposited their herbarium. The stem bark was collected and shade (air) dried at room temperature (Tolu, 2008).

Aqueous Plant Extraction

The dried bark was made into fine powder by grinding with porcelain pestle and mortar. Aqueous stem bark extract was obtained by soaking 200g of the powder in one litre (IL) of hot distilled water 8.5^0 c for one hour. The mixture was allowed to cool to 20-50^0c. It was then filtered through a cotton wool plug stuck in glass funnel. The filtrate was collected in a beaker and evaporated on a hot plate at 30^0c until dried residue was obtained. The residue was kept in a refrigerator until required. Stock concentration was prepared by weighing required quantity and dissolved in appropriate volume of distilled water.

For Example – Stock concentration of 100mg/ml = 1g of the residue to be dissolved in 10ml of distilled water.

New concentration is prepared from the stock using

$$\frac{NC \times VR}{SC}$$

Where NC = New concentration desired, SC = Stock concentration and VR = Volume required

NOTE: Freshly prepared concentration was used daily.

Animal Handling

The animals used were obtained from the animal house, Department of Human Physiology, College of Medical Sciences, University of Maiduguri. They were kept in plastic cages and provided with regular supply of tap water. The rats were fed *ad libitum* with grower mash (ECWA feed, Bukuru-Jos Plateau State). The animals were allowed uninterrupted 12-hour day and night cycle. Local strain of Rabbits (1.5-2.0kg) was obtained from Maiduguri, Monday Market. They were quarantined for 14 days in rabbit cages (2 per cage). They were fed with fresh green grass and dry groundnut leaves. The rabbits were allowed free access to tap water and uninterrupted 12h day and night cycle. The animals were screened for possible diseases and found apparently healthy.

Experimental procedures on the animals used in the study were approved by the Preclinical, College of Medical Sciences, University of Maiduguri Animal Ethics Committee.

Dissection of Anaesthetized Rats for Determination of Gastric Acid

The method of continuous gastric perfusion described by Gosh and Schild (1958) and modified by (Enyikwola, 1994) was used. Rats were deprived of feed for between 18 and 24h but allowed drinking water. The rats were anaesthetized with 0.6ml of 25% urethane (ethyl carbamate) per 100g body weight. The drug was administered intraperitoneally (ip). Corneal, withdrawal reflexes and other indicators of complete anaesthesia were adequately monitored before the commencement of operation. Depth of anaesthesia was checked throughout the experiment by the pedal withdrawal (toe pinch) reflex every 30-45minutes. If the pedal withdrawal reflex is observed, a supplemental dose of urethane (0.4g/kg, ip) was administered to maintain adequate anaesthesia. Animal body temperature was measured with a rectal thermometer inserted into the anus and maintained at 37^0c (Fatemeh *et al., 2002;* Mohammad *et al., 2004).* The ventral neck region of the rats was shaved with a pair of scissors and an incision was made to expose the trachea. The thyroid and thymus were carefully avoided. A small incision that allowed passage of polyethylene cannula (OD, 2mm) was made. The cannula was then introduced into the trachea for ventilation. After the trechaestomy, a laprotomy through the linea alba was also made. Duodenostomy was performed and after a complete gastric lavage, an outflow cannual was inserted through the pyloric sphincter into pyloric antrum of the stomach and ligated in place for collection of gastric effluents. The gastric perfusate was titrated against NaOH 0.02N to neutral pH 7.0 using pH meter (Hanna) (Enyikwola, *et al; 1992;* Enyikwola, 1994; Akinniyi *et al., 1995;* Eno *et al., 1998).*

Basal Gastric Acid Secretion in Urethane Anaesthetized Albino Rats

Twelve (12) albino rats of wistar strain were used (220-280g). The rats were dissected as above and perfused with normal saline at pH 7.0. A total of 10ml of perfusate was collected in every ten minutes for a period of 60 minutes. The perfusate was titrated against 0.01N of NaOH to a neutral point using pH meter (Hanna). The volume of base consumed was used to calculate titratable acidity.

Titratable Acidity = $\frac{\text{Volume of NaOH x Normality x 100 (mEq/1)}}{0.1}$ (Rajkapoor *et al., 2002)*

Effect of Aqueous Stem Bark Extract of *Ceiba pentandra* on Basal Gastric Acid Secretion in Urethane Anaesthetized Albino Rats

Twelve (12) male rats (230-260g) were anaesthetized, dissected and prepared for continuous gastric perfusion as above. They were perfused with normal saline (0.9% NaC1) pH 7.0 at 37^0c for sixty minutes. Ten (10) ml of effluent was collected every ten minutes to determine basal gastric acid secretion. At the end of the first hour, 50 mg/kg of the aqueous extract was administered through the tail vein. 10ml of effluent was collected in every ten minutes and titrated against 0.01N NaOH. The effect of the extract (50mg/kg) was flushed with normal saline (Gosh and Schild, 1958; Eno *et al* 1998; Modu *et al.*, 2003). The procedure was repeated with 100 and 150 mg/kg of the aqueous extract of the plant. At the end of every hour and six effluent collections, the effect of the extract was flushed with normal saline. The effluents collected were titrated against 0.01 N, NaOH to a neutral point pH 7.0 using pH meter (Hanna).

Effects of Aqueous Stem Bark Extracts of *Ceiba pentandra* on Histamine Induced Gastric Acid Secretion in Urethane Anaesthetized Albino Rats

Twelve (12) male rats (220-260g) were prepared for continuous gastric perfusion as in above. Basal secretion for one hour was obtained. Histamine 10mg/kg was administered intravenously through the tail vein. Gastric effluents were collected (10ml/10minutes) for one hour. Normal saline was administered through the tail vein to flush the effect of histamine. Thereafter, 50mg/kg of the aqueous stem bark extract was administered to the rat through the tail vein followed by administration of Histamine 10mg/kg through the same route. 10ml of perfusate was collected at 10minutes intervals for one hour. The combined effects of Histamine and aqueous extract were flushed with normal saline. The above procedures were repeated with 100 and 150mg/kg respectively of the aqueous extract along with the same dose of Histamine (10mg/kg). volume of base consumed for the titration of acid perfusate obtained was recorded and utilized for the determination of titratable acidity (Elsie *et al.*, 2007).

Effect of Aqueous Stem Bark Extracts of *Ceiba pentandra* on Carbochol Induced Gastric Acid Secretion in Urethane Anaesthetized Albino Rats

Male rats (n=12) that weighted between 240-280g were prepared for continuous gastric perfusion as in above. Basal secretion for one hour was obtained. Carbochol 60ug/kg was administered intravenously. Gastric effluents were collected (10ml/10minutes) for one hour. Normal saline was used and administered through the tail vein to flush the effect of carbachol (60ug/kg). Thereafter, 50mg/kg of the aqueous stem bark extract was administered to the rat through the same route. 10ml of perfusate was collected at 10minutes intervals for one hour. The combined effect of carbachol and aqueous extract was flushed with normal saline. The above procedures were repeated with 100 and 150mg/kg respectively of the aqueous extract along with the same dose of Carbachol (60ug/kg). volume of base consumed for the titration of acid perfusate obtained was recorded and utilized for the determination of titratable acidity.

Effects of Aqueous Stem Bark Extracts of *Ceiba pentandra* on Atropine and Cimetidine Inhibitory Action on Gastric Acid Secretion in Urethane Anaesthetized Albino Rats

Twelve (12) male rats (230 and 280g) were prepared for continuous gastric perfusion as above. Basal acidity was obtained with normal saline for one hour. Thereafter, Cimitidine (50mg/kg) was administered intravenously. Six effluents were collected and titrated against 0.01N NaoH. The Cimetidine was flushed with normal saline via the tail vein of the rat. Atropine (3mg/kg) was administered intravenously. Six effluents were also collected and titrated against 0.01N NaoH. The Atropine was flushed with normal saline via the tail vein of the rat. The aqueous stem bark extract of *Ceiba pentandra* (100mg/kg) along with Cimitidine (50mg/kg) were administered to the same rat intravenously. Six gastric effluents (10ml each) were obtained in one hour. The combined effects of plant extract and Cimetidine was flushed after an hour. Atropine (3mg/kg) and aqueous stem bark extract of *Ceiba pentandra* (100mg/kg) were injected intravenously. Perfusate (10ml in 10minutes) were obtained for an hour and titrated against a base.

Determination of Gastric Acidity and Gastric Fluid Volume in Conscious Rats

A modified method of Shay (1954) pylorus ligation was used. Rats (180-220g) were starved for forty-eight hours (48h) without feed but allowed drinking water *ad libitum* until an hour to the

commencement of the ligation. The drinking water contains 8% sucrose in 0.2% NaCl to prevent dehydration. At the end of the fasting period, the animals were randomly divided into groups (n=5).

Animals in all the groups were each anaesthetized with gaseous anaesthetic ether and their abdomen were opened through a midline incision and the stomach exposed. The pylorus of each animal was ligated with white thread. The abdomen was closed and stitched with black thread. The stitched area was smeared with bitter leaf juice to prevent the animals from gnawing, licking or severing the sutures. Thereafter, appropriate treatment (extract, drug) was given to each animal according to the experimental protocol. At the end of 120 minutes; the rats were euthanized with anaesthetic ether. The sutured abdomen was cut opened; the junction between the stomach and oesophagus was cut with pair of scissors and firmly held with forceps to prevent leakage of stomach content. The pyloric end with thread in position was also cut to remove the stomach from the abdomen. The stomach was rinsed in normal saline and then cut through the greater curvature. All its contents were emptied into a determined using pH meter (Hanna). The gastric fluid obtained was centrifuged for 5minutes at 1000 revolution per minute. The supernatant (0.5ml) was made up to 5ml with distilled water and transferred to a 25ml volumetric flask. This was then titrated against 0.01N NaOH to neutral point pH7.0 using pH meter. The titratable acidity expressed as mEq/I of hydrochloric acid (HCI) was calculated.

Acid output = Volume of Gastric Acid (ml/h) x Titratable Acidity (mEq/L)
It is expressed as uEq/h (Magaji, *et al., 2007)*

Effect of Aqueous Stem Bark Extract of *Ceiba pentandra* on Histamine Induced Gastric Acid Secretion in Conscious (Pylorus Ligated Rats)

The rats were divided into six (6) groups. Group 1 (control) was given distilled water orally (10ml/kg). Group 2 was given Histamine (10mg/kg) intramuscular (i.m). Groups 3, 4 and 5 were given 100,200 and 400mg/kg of the aqueous extract respectively in the presence of Histamine (10mg/kg) i.m. Group 6 was given Cimitidine 50mg/kg in the presence of Histamine (10mg/kg).

Effect of Aqueous Stem Bark Extract *Ceiba pentandra* on Carbachol Induced Gastric Acid Secretion in Conscious (Pylorus Ligated) Albino Rats

The rats were divided into seven (7) groups. Group 1 (control) was given distilled water orally (10ml/kg). Group 2 was given aqueous extract (200 mg/kg). Group 3, 4 and 5 were given 100, 200 and 400mg/kg of the aqueous extract respectively in the presence of Carbachol (60ug/kg). Group 6 was given Atropine 3mg/kg in the presence of Carbachol (60ug/kg). Group 7 was injected with Carbachol 60ug/kg.

Statistical Analysis

Results were expressed as mean ± SEM. Statistical analyses were performed using one way ANOVA (plus a post hoc Dunnett or Turkey tests). Values of $p<0.05$ were considered significant. Computer software Graph Pad In Stat$^{(R)}$ @ USA, 2003 was used.

RESULTS AND DISCUSSION

Table I: Effect of graded doses of aqueous stem bark extracts of *Ceiba pentandra* on gastric acid secretion in urethane anaesthetized Albino Rats (n=12).

Treatment	Dose(mg/kg)	Titratable acidity (mEq/l/h)	pH
Basal (Control)	N/Saline	5.72±0.92	6.2
Aqueous Extract	50	4.86±0.39	6.8
	100	5.03±0.61	6.7
	150	4.56±0.23	6.9

*p>0.05, significant compared to control (n=12).

Table II: Effect of aqueous stem bark extract of *Ceiba pentandra* on Carbachol (60ug/kg) induced gastric acid secretion in urethane Anaesthetized Albino Rats (n=12).

Treatment	Dose (mg/kg)	Titratable (mEq/l/h)	Acidity	pH
Basal (Control)	N/Saline	5.11	± 0.91*	6.2
Carbachol	60ug/kg	8.86	± 0.14	4.8*
Carb + Aq Ex	50	5.42	± 1.26*	5.9
Carb + Aq Ex	100	5.06	± 0.61**	6.0
Carb + Aq Ex	150	4.89	± 0.88**	6.0
Carb + Atropine	3	4.84	± 1.98**	6.8
Carb + AqEx	100	3.70	± 0.43***	6.8

+Atropine (3mg/kg)				
Carb + AqEx+	100	2.96	± 0.72***	6.9
+Attropine (3mg/kg)	50			
+ cimitidine				

*p<0.05, **p<0.01, ***p<0.001 significant when compared to control (carbachol)

Table III: Effect of aqueous stem bark extract of *Ceiba pentandra* on Histamine (10mg/kg) induced gastric acid secretion in urethane anaesthetized albino rats (n=12).

Treatment	Dose (mg/kg)	Titratable acidity (mEq/l/h)	pH
Basal	N/saline	4.56***	6.3
Histamine	10	9.64	2.8**
His + Aq Ex	50	8.34	5.8
His + Aq Ex	100	7.52	5.8
His + Aq Ex	150	6.27*	6.0
His + Aq Ex Cim	50	5.84**	6.8

*p<0.05, **p<0.01, ***p<0.001 significant relative to control (Histamine) (ANOVA followed by Turkeys test)

Table IV: Effect of aqueous stem bark extract of *Ceiba pentandra* on Histamine (10mg/kg) induced gastric secretion in pylorus ligated albino rats.

Group	Dose (mg/kg)	Fluid Volume (ml)	Acidity (mEq/l/h)	Acid Output (ueq/l/h)
Basal	D/Water(10ml/kg)	1.8±0.36*	72±9.03***	43.4±3.42***
Histamine	10	4.0±0.81	144±12.46	191±8.75
Hist + Aq Ext	100	0.8±0.02**	90±5.80**	24±6.44***
Hist+Aq Est	200	0.7±0.06***	78±8.33**	18.2±2.86
Hist+Aq Est	400	0.7±0.03***	72±11.7***	16.8±1.12
Hist+Cimet.	50	1.2±0.44***	66±7.24**	26.4±4.2**

*p<0.05, **p<0.01, ***p<0.001 Significant when compared to control (Histamine)

Table V: Effect of aqueous stem bark extract of *Ceiba pentandra* on Carbachol (60ug/kg) induced gastric secretion in pylorus ligated albino rats.

Group	Dose (mg/kg)	Fluid Volume (ml)	Acidity (mEq/l/h)	Acid Output (ueq/l/h)
Basal	D/Water	2.0±086***	66.3±9.34**	44.2±6.4***
Aq Ex	200	0.9±0.21*	74.8±5.24*	19.9±3.12***
Carbachol	60ug/kg	3.4±0.94	108±11.6	115.2±9.9
Carb+Aq Ex	100	0.6±0.04**	82.4±6.22	16.5±2.87***
Carb+Aq Ex	200	0.6 ± 0.4 **	76.20± 5.40 *	15.2 ±1.80 ***

Carb+Aq Ex	400	0.7 ± 0.06 *	69.8 ± 2.13 **	13.96 ± 2.6 ***
Carb+Aq Ex	3	1.2 ± o.58	48.5 ± 6.8 ***	58.2 ± 7.7 ***
Atropine				

*P<0.5, **p<0.01, ***p<o.001 Significant compared to control (Carbachol)

In this study, the result of acute oral toxicity (LD_{50}) of aqueous stem bark extract of *Ceiba pentrandra* (L.) was greater than 4500 mg/kg body weight. There was no mortality or apparent sign of toxicity in all the groups examined. The non-lethal potential of the plant extract at 3000mg/kg was reported by (Ladeji, et al., 2004; Sarkiyayi et al., 2009; and Sule, *et al.*, 2009). Aqueous stem bark extract of *Ceiba pentandra* did not stimulate gastric acid secretion in urethane anaesthetized or pylorus ligated rats (Table I). The plant extract markedly inhibited histamine and carbachol induced gastric acid secretions in a significant, competitive and dose dependent manner. Gastric fluid volume, titratable acidity and acid output were attenuated while by pH was increased (Tables II, III, IV and V).The exact mechanism of the plant anti-secretory potential exhibited in this study is not fully established. It is assumed to be partially mediated via dual blockage of muscarine (M_3) and histamine H_2 receptors. Carbachol like acetycholine, stimulates gastric acid secretion via M_3 receptors and indirectly stimulates histamine through M_1 on enterochromaffin like cells (ECL) to secrete gastric acid (Prinz, 1992). The plant extract considerably antagonized the stimulating effect of carbachol probably like atropine by competitively acting on muscarine (M_3) receptors to directly reduce parietal stimulation and enhances somatostatin release.

The inhibitory actions of atropine on carbachol induced gastric acid secretion was potentiated by the plant extract further suggesting the implication of the cholinergic (M_3) pathways in the mechanism of action of the plant extract. Histamine induced gastric secretion was attenuated by the extract and cimitidine. The plant extracts potentiated the inhibitory action of cimitidine on histamine induced gastric secretion. This suggests that the plant extract may have a component that act on the H_2 receptor competitively, since the inhibition is in a dose dependent manner.

CONCLUSION

The aqueous plant extract has gastric antisecretory and gastric anti-ulcer potential. Inhibition of gastric secretion may be mediated via competitive blockade of histamine and acetylcholine receptors. The aqueous stem bark extracts can be used for the treatment of ulcer, gastritis and other disorders of the gastro-intestinal tract.

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Pebble Morphometric Analysis and Environmental Diagnosis: Case Study of the Bama Ridge, Borno Sub-Basin - Nigeria

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Abstract

Quartz pebbles of the Bama Ridge were systematically sampled and subjected to morphometric analyses. The mean sphericity value for the pebbles is found to be 0.67 with the oblate –prolate index averaging at 0.95, thus exceeding the set threshold value of -1.5. Furthermore, the flatness ratio and the mean form index were found to be 0.45 and 0.50 respectively. The mean roundness index averaged at 41%. These generally imply the impact of fluvial processes. Calculated morphometric parameters are evaluated also as dependent variables on scatter plots. Plot of maximum projection Sphericity index (M.P.S.I) versus Oblate-Prolate index (O.P.I) shows majority of the samples plotting within the river sector. The plot of roundness versus elongation ratio indicates transitional to fluvial environment and perhaps some beach influence. It is thus deduced that the pebbles of the Bama Ridge analysed were dominantly shaped in a fluvial environment.

Keywords: Ridge, Pebbles, Spericity, Fluvial Environment, Index

INTRODUCTION

The Bama Ridge is a long and narrow sand ridge. It is a prominent morphological feature overlying the Quaternary Chad Formation in the north-eastern part of Nigeria (Fig.1) and represents the ancient shoreline of the Mega Lake Chad (Durand, 1982). It was considered to have been formed during the Late Pleistocene when it was left as a distinct feature as the Mega Chad receded (Grove, 1959).

Regionally, the ridge trends roughly NW-SE in a somewhat discontinuous manner for about 160 km. It covers parts of the Cameroun plains, extending through the northern tip of the Mandara Hills in Nigeria, passing through Bama in Borno State to Gashua and Nguru in Yobe State. It ultimately flattens out beneath the sand dunes of the Republic of Niger. The relief surrounding the Bama Ridge (which rises for some 12 m through it) is relatively a flat plain (Seneviratae, 1983).

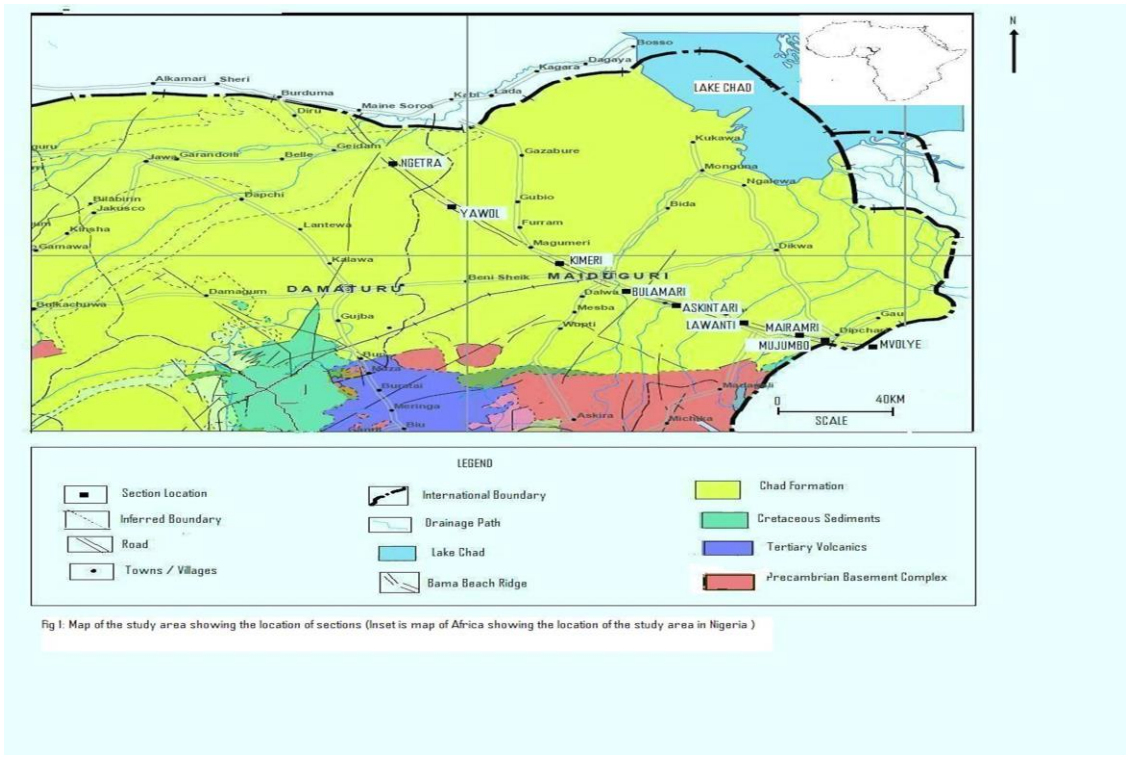

Fig 1: Map of the study area showing the location of sections (*Inset is map of Africa showing the location of the study area in Nigeria*)

The Bama Ridge in the Nigerian sector of the Chad Basin has not been studied in detail and existing literature only made reports of its existence from geographic and geomorphic points of view. Therefore, geological literature from published source particularly on sedimentology is very scanty. Available information on the geology of this feature is surrounded by a lingering controversy about its origin. Most workers (Mioged, 1924; Grove and Warren, 1968; Miller *et al.*, 1968; Iwuagwu, 1991 and Theimeyer, 1993) seem to associate the Bama Ridge with the shoreline of an ancestral Lake Chad. Durand (1982) however correlated the ridge to neotectonic processes. Workers want to know whether these deposits are constituents of the Chad Formation or a separate stratigraphic entity. Controversy on the origin of the Bama Ridge has thus lingered and only speculation exists as to whether these recent deposits, apparently younger, constitutes part of the Chad Formation or is a separate stratigraphic entity. The Bama Ridge being the most important source of sand for the catchment environment around Maiduguri, its use should be undertaken with caution. Many villages have been threatened with incessant undercutting as a result the exploitations of sand resource. This paper seeks to highlight the most probable depositional setting under which the sediments of the Bama Ridge formed. This shall contribute to the resolution of the controversies surrounding its origin.

MATERIALS AND METHODS

Reconnaissance

This was the first and preliminary stage of field studies, and was used as an aid to locate suitable sites for the field studies and also to determine the accessibility of the study area by locating foot

and truck paths. The Nigerian Federal Survey topographic map sheet 90 (Maiduguri / Mafa), the Agric, Livestock and Technical Services (ALTS, 1976) topographic map of the Ngadda and Yedzaram catchments were used and style proposed by Tucker, 1991 and Tucker, 2003 applied.

Sampling and Analyses

Systematic collection of samples of the Bama Ridge was undertaken with special attention on areas of concentrations of quartz pebbles. Pebble samples occurring as dispersed and in horizons were collected from the sandstone and granule stone facies of the Bama Ridge, across the study locations of Kimeri, Bulamari, Askintari, Lawanti and Mairamri (Fig. 1). These were studied, analysed and presented using procedure outlined by Okoro (2010). Some of these were excluded from studies on grounds of distinct fresh breaks, so as to assure determination of true roundness values. Also excluded are those that show strong lithologic inhomogeneity, as these are likely to affect the real values of the desired parameters (Sames, 1966; Els, 1988). The pebbles were then randomized and divided into batches following Sneed and Folk (1958). The three mutually perpendicular axes - Long (L), Intermediate (I) and Short (S) were measured using the Vernier calliper as suggested by Krumbein (1941), and described by Dobkins and Folk (1970). These were subsequently employed in the calculation of Flatness ratio (F R), Elongation ratio (E R), Maximum projection sphericity (MPS), Oblate-Prolate index (OPI) and Form (Appendix). These parameters are presented as independent single parameters and as dependent variables on graphical plots. The roundness of the pebbles was determined by visual comparison with chart images developed by Lutig (1962).

RESULTS AND DISCUSSION

The average values and computed indices of the pebbles as well as roundness values in each location/batch are presented as Appendix. The determined indices are further presented graphically in plots of Maximum Projection Sphericity versus Oblate-Prolate Index (Fig. 2); Sphericity-form diagram (Fig. 3) and as plot of Roundness versus Elongation ratio (Fig. 4).

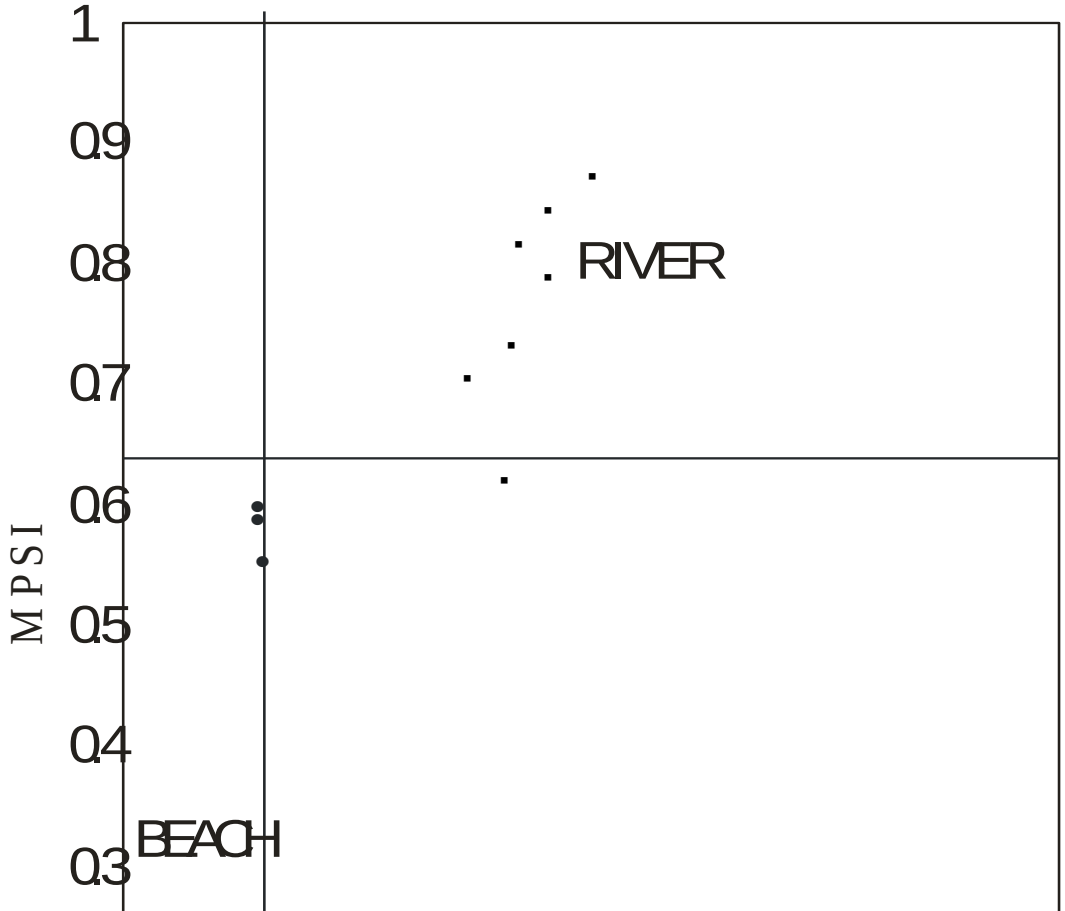

Fig 2: Plot of Maximum projection sphericity vs Oblate-prolate index (After Dobkin and Folk, 1970)

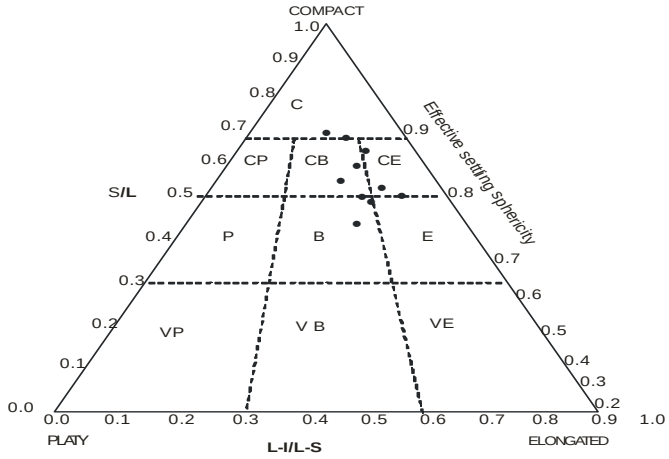

Fig 3: Plot of Sphericity- Form for paricle shapes (After Sneed and Folk, 1958)

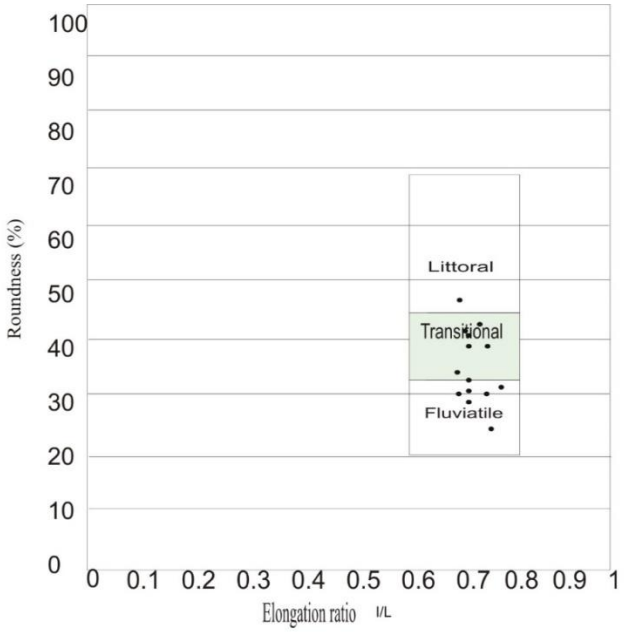

Fig 4: Plot of Roundness Vs Elongation ratio (After Sames, 1966)

Several authors have demonstrated the usefulness of pebble morphometry in palaeoenvironmental interpretations (Dobkin and Folk, 1970; Lutig, 1962; Sames, 1966; Nwajide and Hoque, 1982; Okoro *et al.* 2012). As independent functions, the flatness ratio, elongation ratio, maximum projection sphericity, oblate-prolate index, form and roundness have been used as indices for environmental diagnosis. Dobkins and Folk (1970) studied pebbles shaped by river and beach processes inTahiti-nui and noted that the mean sphericity of fluvial pebbles is 0.684 while that of pebbles in low energy and high energy beaches are 0.640 and 0.584 respectively. On this basis, they postulated that pebble suites with mean sphericity less than 0.65 indicate beach processes while those with values above 0.65 are shaped by fluvial processes. The mean sphericity value for the pebbles of the Bama Ridge (Appendix) is found to be 0.67, implying an interpretation as product of fluvial process. The O-P index of 0.76 also exceeds the threshold value of -1.5 (Dobkins and Folk, 1970) and points to a fluvial setting. The flatness ratio of 0.45 for the Bama Ridge also indicates fluvial environment as used by Stratten (1974), Sames (1966) and Omali *et al.* (2011). Dobkins and Folk, (1970) identified shape classes of Sneed and Folk (1958) that are diagnostic of certain environments. Compact (C), compact-bladed(CB) and compact- elongate(CE) are diagnostic of fluvial environments while platy(P), bladed(B), very bladed(VB) and very platy(VP) are more common in beach settings. A mean form index of 0.50 and predominantly compact bladed forms of the pebbles (Appendix) further support fluvial shaping. Although roundness of a pebble under hydrodynamic transport is a weak indicator of environment because it is a function of both inherited and environmentally acquired factors (Lutig, 1962, Sames, 1966, Dobkins and Folk, 1970; Okoro *et al*. 2012). Sneed and Folk (1958) observed that quartz pebble roundness increases from rivers to beaches. Sames (1966) placed an upper limit for roundness index in fluvial settings at 45%. The mean roundness index for the Bama Ridge is 41%. This also implies fluvial depositional environment.

Calculated morphometric parameters are evaluated also as dependent variables on scatter plots. Dobkins and Folk (1970) and Sames (1966) used plots of maximum projection sphericity versus oblate-prolate index and roundness versus elongation ratio to discriminate depositional environments. Plot of maximum projection Sphericity index (M.P.S.I) versus Oblate-Prolate index (O.P.I) shows majority of the samples plotting within the river sector (Fig 2).The plot of roundness versus elongation ratio indicates transitional to fluvial environment and perhaps some beach influence (Fig. 4). It is apparent that against the index of interpretation scales, all indices of pebble morphometry have indicated fluvial shaping. Although this is consistent with the findings of Obi (1996), it should be considered that the values here fell at marginal levels, in some cases, as in the plot of roundness versus elongation ratio, departure from fluvial setting is observed, tending towards transitional environment.

CONCLUSION

Quartz pebbles of the Bama Ridge were systematically sampled and subjected to morphometric analyses. Morphometric parameters evaluated which includes mean sphericity,oblate- prolate index, flatness ratio and mean form index as independent variables and maximum projection sphericity index vs oblate prolate index, roundness vs elongation ratio as dependent variables. The results of these generally indicate that the pebbles of quartz in the Bama Ridge were shaped in a predominantly fluvial setting.

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APPENDIX: Data of pebble morphometric analyses of the Bama Ridge
KIMERI 1

S/N	S	I	L	S/L	I/L	L-I / L-S	MPSI	O P INDEX	ROUNDNESS
1	1.10	2.11	2.69	0.43	0.78	0.35	0.65	2.88	40
2	0.90	1.85	3.29	0.27	0.56	0.59	0.50	3.65	40
3	0.70	1.15	1.50	0.47	0.76	0.43	0.65	-1.38	25
4	0.70	0.79	1.55	0.65	0.51	0.91	0.75	3.93	25
5	0.80	1.12	1.51	0.54	0.74	0.56	0.73	1.20	30

6	0.50	0.74	0.98	0.43	0.76	0.46	0.66	0.74	45
7	0.20	0.36	0.56	0.42	0.67	0.60	0.64	2.04	38
8	0.20	0.40	0.52	0.41	0.76	0.40	0.61	-1.65	53
9	0.20	0.40	0.54	0.39	0.76	0.41	0.58	-2.48	49
10	0.39	0.48	0.63	0.40	0.78	0.39	0.68	-2.84	36
11	0.20	0.45	0.64	0.35	0.72	0.45	0.67	-1.15	42
12	0.30	0.44	0.61	0.43	0.73	0.47	0.62	-0.66	57
13	0.40	0.58	0.80	0.46	0.72	0.51	0.68	0.38	40
MEAN	0.50	0.84	1.22	0.43	0.71	0.50	0.65	0.36	40

KIMERI 11

S/N	S	I	L	S/L	I/L	L-I / L-S	MPSI	O P INDEX	ROUNDNESS
14	0.30	0.50	0.60	0.41	0.76	0.32	0.67	0.36	42
15	0.20	0.44	0.56	0.46	0.72	0.37	0.68	-1.51	35
16	0.40	0.58	0.79	0.5	0.73	0.53	0.72	0.86	38
17	0.30	0.61	0.86	0.35	0.72	0.45	0.56	-1.31	42
18	0.30	0.44	0.61	0.50	0.73	0.54	0.78	0.75	28
19	0.30	0.48	0.63	0.40	0.70	0.39	0.59	3.13	46
20	0.70	0.92	1.37	0.53	0.69	0.67	0.74	3.11	45
21	1.20	1.55	2.25	0.53	0.70	0.65	0.74	2.95	38
22	0.00	1.39	2.11	0.49	0.66	0.34	0.71	3.26	43
23	0.90	1.90	3.34	0.28	0.56	0.59	0.50	3.65	52
24	0.70	1.19	1.54	0.48	0.77	0.43	0.65	-1.33	25
25	0.30	0.44	0.56	0.47	0.78	0.40	0.61	-1.65	53
26	0.80	0.83	1.59	0.48	0.52	0.91	0.75	3.93	25
MEAN	0.50	0.87	1.29	0.45	0.69	0.51	0.67	1.24	39

BULAMARI 1

S/N	S	I	L	S/L	I/L	L-I / L-S	MPSI	O P INDEX	ROUNDNESS
1	0.30	0.40	0.60	0.45	0.66	0.60	0.64	2.04	39
2	0.30	0.48	0.65	0.45	0.73	0.47	0.62	-0.66	42
3	0.20	0.44	0.58	0.42	0.75	0.41	0.58	-2.48	47
4	0.30	0.52	0.67	0.43	0.77	0.39	0.68	-2.84	36
5	0.30	0.49	0.68	0.38	0.72	0.45	0.67	-1.15	43
6	0.30	0.54	0.64	0.52	0.84	0.32	0.67	0.36	42
7	0.40	0.62	0.83	0.53	0.74	0.53	0.72	0.86	45
8	0.30	0.48	0.60	0.47	0.80	0.37	0.68	-1.51	38
9	0.30	0.52	0.67	0.43	0.77	0.39	0.59	3.13	46
10	0.40	0.65	0.90	0.39	0.72	0.45	0.56	-1.31	42
MEAN	0.30	0.52	0.68	0.45	0.75	0.44	0.64	-0.35	42

BULAMARI 11

S/N	S	I	L	S/L	I/L	L-I / L-S	MPSI	O P INDEX	ROUNDNESS
11	1.10	2.15	2.73	0.40	0.78	0.35	0.65	2.88	40
12	0.10	1.43	2.15	0.03	0.66	0.34	0.71	3.26	48
13	1.20	1.59	2.29	0.53	0.69	0.65	0.74	2.95	38
14	0.90	1.89	3.33	0.28	0.56	0.59	0.50	3.65	43
15	0.70	0.96	1.41	0.53	0.68	0.67	0.74	3.11	32
16	0.90	1.16	1.55	0.56	0.74	0.56	0.73	1.20	32
17	0.30	0.48	0.65	0.52	0.73	0.54	0.78	0.75	50
18	0.50	0.78	1.02	0.49	0.76	0.46	0.66	0.74	52
19	0.40	0.62	0.84	0.49	0.73	0.51	0.68	0.38	40
MEAN	0.70	1.23	1.78	0.42	0.71	0.52	0.68	2.10	42

ASKINTARI 1

S/N	S	I	L	S/L	I/L	L-I / L-S	MPSI	O P INDEX	ROUNDNESS
1	0.90	1.17	1.56	0.56	0.75	0.56	0.73	1.20	36
2	0.30	0.45	0.57	0.47	0.78	0.39	0.61	-1.65	53
3	0.30	0.50	0.69	0.39	0.72	0.45	0.67	-1.15	42
4	0.40	0.63	0.85	0.49	0.74	0.51	0.68	0.38	40
5	0.40	0.63	0.84	0.53	0.74	0.53	0.72	0.86	40
6	0.70	0.97	1.42	0.53	0.68	0.67	0.74	3.11	45
7	0.30	0.49	0.66	0.53	0.74	0.54	0.78	0.75	25
8	0.70	1.20	1.55	0.48	0.77	0.43	0.65	-1.33	28
9	1.20	1.60	2.30	0.53	0.69	0.65	0.74	2.95	38
10	0.10	1.44	2.16	0.03	0.66	0.34	0.71	3.26	43
MEAN	0.50	0.91	1.26	0.45	0.73	0.51	0.70	0.83	39

ASKINTARI 11

S/N	S	I	L	S/L	I/L	L-I / L-S	MPSI	O P INDEX	ROUNDNESS
11	0.20	0.45	0.59	0.42	0.76	0.41	0.58	-2.48	49
12	0.80	0.84	1.60	0.48	0.52	0.91	0.75	3.93	25
13	0.40	0.66	0.91	0.39	0.72	0.45	0.56	-1.31	47
14	0.30	0.53	0.68	0.44	0.77	0.39	0.59	3.13	46
15	0.50	0.79	1.03	0.49	0.76	0.46	0.66	0.74	26
16	0.30	0.55	0.65	0.52	0.84	0.32	0.67	0.36	42
17	0.30	0.49	0.66	0.45	0.74	0.47	0.62	-0.66	57
18	0.30	0.41	0.61	0.45	0.67	0.60	0.64	2.04	38
19	0.30	0.53	0.68	0.44	0.77	0.39	0.68	-2.84	36
20	1.10	2.16	2.74	0.40	0.78	0.35	0.65	2.88	40
21	0.20	0.45	0.59	0.42	0.76	0.41	0.58	-2.48	47
MEAN	0.40	0.71	0.97	0.45	0.74	0.47	0.63	0.30	41

LAWANTI 1

S/N	S	I	L	S/L	I/L	L-I / L-S	MPSI	O P INDEX	ROUNDNESS
1	0.50	0.79	1.03	0.50	0.768	0.46	0.66	0.74	47
2	0.30	0.41	0.61	0.46	0.674	0.60	0.64	2.04	38
3	0.30	0.49	0.66	0.46	0.744	0.47	0.62	-0.66	57
4	0.40	0.66	0.91	0.40	0.726	0.45	0.56	-1.31	42
5	0.30	0.55	0.65	0.53	0.847	0.32	0.67	0.36	42
6	1.10	2.16	2.74	0.40	0.789	0.35	0.65	2.88	40
7	0.50	0.63	0.84	0.54	0.751	0.53	0.72	0.86	30
8	0.30	0.49	0.61	0.48	0.805	0.37	0.68	-1.51	35
9	0.30	0.45	0.57	0.48	0.791	0.40	0.61	-1.65	53
10	0.80	0.84	1.60	0.48	0.526	0.91	0.75	3.93	28
MEAN	0.50	0.75	1.03	0.47	0.742	0.48	0.65	0.56	41

LAWANTI 11

S/N	S	I	L	S/L	I/L	L-I / L-S	MPSI	O P INDEX	ROUNDNESS
11	0.30	0.53	0.68	0.44	0.78	0.39	0.59	3.13	46
12	1.20	1.60	2.30	0.54	0.69	0.65	0.74	2.95	38
13	0.10	1.44	2.16	0.03	0.66	0.34	0.71	3.26	43
14	0.90	1.90	3.34	0.28	0.56	0.59	0.50	3.65	50
15	0.90	1.17	1.56	0.56	0.75	0.56	0.73	1.20	30
16	0.80	0.97	1.42	0.53	0.68	0.67	0.74	3.11	45
17	0.40	0.49	0.66	0.53	0.74	0.54	0.78	0.75	24
18	0.30	0.45	0.59	0.43	0.76	0.41	0.58	-2.48	36
19	0.40	0.63	0.85	0.50	0.74	0.51	0.68	0.38	40
20	0.30	0.50	0.69	0.39	0.72	0.45	0.67	-1.15	42
MEAN	0.50	0.97	1.43	0.42	0.71	0.51	0.67	1.48	40

MAIRAMRI 1

S/N	S	I	L	S/L	I/L	L-I / L-S	MPSI	O P INDEX	ROUNDNESS
1	0.40	0.62	0.77	0.51	0.80	0.39	0.68	-2.84	36
2	0.40	0.58	0.70	0.54	0.82	0.37	0.68	-1.51	35
3	0.50	0.75	1.00	0.45	0.75	0.45	0.56	-1.31	42
4	1.00	1.99	3.43	0.30	0.58	0.59	0.50	3.65	40
5	0.40	0.58	0.75	0.59	0.77	0.54	0.78	0.75	50
6	0.50	0.72	0.93	0.58	0.77	0.53	0.72	0.86	38
7	0.60	0.88	1.12	0.54	0.78	0.46	0.66	0.74	45
8	0.40	0.62	0.77	0.51	0.80	0.39	0.59	3.13	46
9	0.30	0.54	0.68	0.50	0.79	0.41	0.58	-2.48	49
10	0.80	1.29	1.64	0.51	0.78	0.43	0.65	-1.33	47
11	0.40	0.50	0.70	0.53	0.71	0.60	0.64	2.04	38
12	0.80	1.06	1.51	0.56	0.70	0.67	0.74	3.11	22
MEAN	0.60	0.84	1.17	0.51	0.75	0.49	0.64	0.40	41

MAIRAMRI 11

S/N	S	I	L	S/L	I/L	L-I / L-S	MPSI	O P INDEX	ROUNDNESS
13	1.30	1.69	2.39	0.55	0.70	0.65	0.74	2.95	38
14	0.40	0.59	0.78	0.46	0.75	0.45	0.67	-1.15	42
15	0.90	0.93	1.69	0.51	0.55	0.91	0.75	3.93	25
16	0.20	1.53	2.25	0.07	0.68	0.34	0.71	3.26	43
17	1.20	2.25	2.83	0.42	0.79	0.35	0.65	2.88	40
18	0.40	0.64	0.74	0.58	0.86	0.32	0.67	0.36	42
19	0.40	0.54	0.66	0.55	0.81	0.40	0.61	-1.65	53
20	0.50	0.72	0.94	0.54	0.76	0.51	0.68	0.38	40
21	1.00	1.26	1.65	0.58	0.76	0.56	0.73	1.20	30
22	0.40	0.58	0.75	0.52	0.77	0.47	0.62	-0.66	23
23	0.30	0.53	0.68	0.44	0.78	0.39	0.68	-2.84	36
24	0.80	1.20	1.55	0.49	0.77	0.43	0.65	-1.33	25
MEAN	0.60	1.04	1.41	0.48	0.75	0.48	0.68	0.61	36

X-Ray Diffractometry and Palaeoenvironment of Silty Clays in the Chad Formation, Borno Sub-Basin - Nigeria

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Abstract
The Chad Formation is a variable succession of sediments underlying the surface deposits in the Bornu sub-basin, Nigeria. It is in most places composed of thick clays separated by erinaceous horizons. Twelve samples of the Clays obtained from hand auguring and drilled boreholes were subjected to x-ray diffraction analyses. Results of the bulk samples show quartz as the predominant constituent with traces of potassium and plagioclase feldspars. Clay mineralogy generally indicates Kaolinite as the dominant Clay mineral species. An interpretation of these results implies derivation of these clays from a fluvio-lacustrine setting.

Keywords: Chad Formation, Silty Clay, X-ray diffraction, Quartz, Kaolinite, Fluvio-Lacustrine

INTRODUCTION

This is a variable succession that includes all Quaternary sediments underlying the surface deposits. The formation is a succession of lacustrine and fluviatile clays and sands of Quaternary/Pleistocene age (Carter *et al*., 1963; Dike and Bature, 1999; Dike, 2002a, b). Sediments of the Bama Ridge are considered by some authors (Carter *et al*., 1963; Matheis, 1976) as belonging to this formation with an average thickness of 400 m. With respect to water supply, this formation is of great economic significance. It has a thickness of over 700 m in Maiduguri and, in zones where the fluvio- lacustrine deposit is complete, water-bearing levels consisting mostly of sands and clayey sands are concentrated in three well defined aquiferous horizons (Dike and Bature, 1999; Dike 2002b). According to Dike (2002b), drilling in the basin has given an insight into the basin's subsurface stratigraphy and shows that large volume of water exists in the formation. According to data from NNPC boreholes in Maiduguri area (Dike, 2002b), the Chad Formation rests uncomfortably on the Fika Formation. This has been explained as due to the local uplift/erosion of the post Maastrichtian sediments which affected the northern Benue Trough prior to the sedimentation of the Chad Formation (Dike, 2002 a, b)
The Chad Formation in the Nigerian sector of the Chad Basin has not been adequately studied. Therefore; geological literature from published source is very scanty.

This work attempts to make a contribution to the scanty literature by studying the silty clays which constitute a prominent component of this Formation. The mineralogical analyses cannot be performed with routine thin section microscopy. This underscores the significance of the application of X-ray diffractometric in deciphering the clay mineral composition of this Formation.

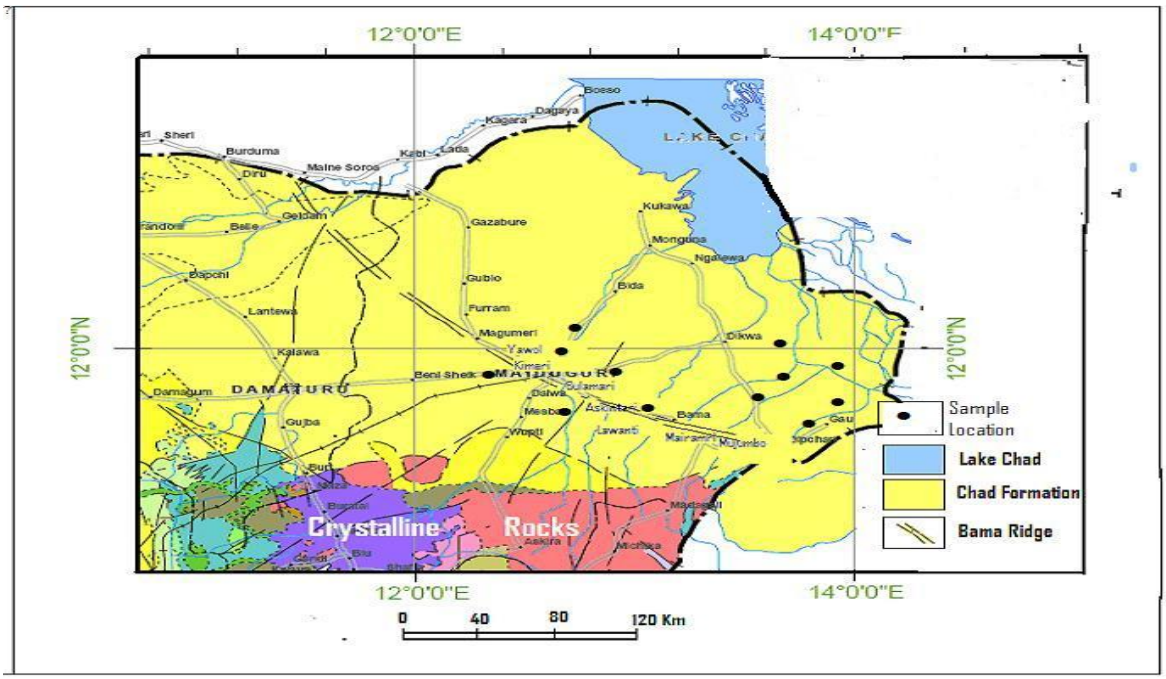

Fig 1: Geological map of the study area showing the location of samples (Modified after NGSA, 2006)

MATERIALS AND METHODS

Twelve samples were subjected to analyses which were performed using the BRUKER AXS D8 advanced diffractometer. Seven were obtained through hand auguring to shallow depths while five were sourced from sampling during water borehole drilling. The equipment was set at the following test conditions: Co radiation,40Kv, 35Ma; Regular scanning of step 0.02 degrees: step time, 0.2s, 2theta range 3-70°C with clay section scanning of step:0.01 degrees: step time 0.2 s, 2theta range: 3-40°C.; Regular scanning of step 0.02 degrees: step time, 0.2s, 2theta range 3-70°C with clay section scanning of step:0.01 degrees: step time 0.2 s, 2theta range: 3-40°C. Sample preparation involved the use of standard preparatory techniques, employing sodium hexametaphosphate as an agent of dispersion through decantation and centrifugation. Mounting of oriented samples dried at 60°C was then performed to obtain powder mounts. Each sample was ground thoroughly using mortar and pestle so that it was easily brushed through the sieve. The Sieve was then placed over the sample holder and brushed from the mortar. The Glass slide was used to pack the sample firmly enough into the cavity of the equipment. For treatment with ethylene glycol, the reagent was poured into a desiccator to about 1cm depth and oriented aggregate mounts were placed on the shelf of the desiccator. The desiccator was then placed in an oven at a temperature of 60°C for 5 hours. The Samples were removed at the time they were to be run on the X- ray diffractometer. Heat treatments were used to identify clay minerals by revealing changes in crystal structure spacing or loss of the structure. Oriented aggregate mounts were placed in the furnace using tongs and samples left therein for 1.5 hours at a temperature of 400°C. The mounts were then removed by pulling forward with the wire hook until the edge of the mount could be grasped with the tongs. The Mounts were removed when they were ready to be run on the diffractometer. Samples were X- rayed and the procedure repeated at 550°C.

RESULTS AND DISCUSSION

Results of this analysis are presented in two subsets: bulk mineral composition and clay mineral composition (Table1). The results from the bulk samples indicate that quartz is the dominant mineral present in the Silty clay. Non-clay minerals include potassium feldspar and minor/trace amounts of plagioclase feldspar. The diffractograms of clay mineralogy (Fig.2) show that kaolinite was identified from reflection pattern around $7A^0$ which upon the effect of high temperature, the diffraction pattern began to disappear. No change occurred on the reflection pattern upon glycolation. Since these samples contain no chlorite, other treatments such as comparison of the $3.58A^0$ peak for kaolinite with 3.54^0A for chlorite as suggested by Biscaye (1965) were not done. Treatment with potassium acetate was similarly not undertaken.

Table 1: Summary of semi-quantitative X-ray diffraction results

Sample	**Major** (>30% Wt)	**Moderate** (10% -30% Wt)	**Minor** (2% -10% Wt)	**Trace** (<2% Wt)
(1) ***L2 S5***				
Bulk	Quartz	potassium feldspar	Plagioclase	*montmorillonite, *kaolinite, *illite
Clay Fraction	Kaolinite	Montmorillonite	Illite	*plagioclase
(2) ***L4 S4***				
Bulk	Quartz	potassium feldspar	plagioclase, calcite	*montmorillonite, *kaolinite, *illite
Clay Fraction	Montmori	Kaolinite	Illite, calcite,	*plagioclase
(3) ***L6 S2***				
Bulk	Quartz	potassium feldspar	plagioclase, kaolinite,	*illite
Clay Fraction	Kaolinite	Montmorillonite,	Illite	-
(4) ***L10 S6***				
Bulk	Quartz	potassium feldspar	plagioclase, kaolinite montmorillonite	*illite
Clay Fraction	Kaolinite	Montmorillonite,	illite,	
(5) ***L12 S1***				
Bulk	Quartz	potassium feldspar	plagioclase	*montmorillonite, *kaolinite, *illite
Clay Fraction	Kaolinite		I/M mixture, illite,	
(6) ***L15 S2***				
Bulk	Quartz	potassium feldspar	plagioclase	*montmorillonite, *kaolinite, *illite
Clay Fraction	Kaolinite	I/M mixture,	illite,	

(7) ***L18 S1***				
Bulk	Quartz	potassium feldspar	plagioclase, kaolinite	*montmorillonite, *illite
Clay Fraction	-	kaolinite, I/M mixture		
(8) ***L21 S5***				
Bulk	Quartz	potassium feldspar	plagioclase	*montmorillonite, *kaolinite, *illite
Clay Fraction	Kaolinite	Montmorillonite,	illite,	
(9) ***L23 S1***				
Bulk	Quartz	potassium feldspar	plagioclase, kaolinite	*montmorillonite, *illite
Clay Fraction	Kaolinite	Montmorillonite,	illite,	
(10) ***L25 S3***				
Bulk	Quartz	potassium feldspar	plagioclase	*montmorillonite, *kaolinite, *illite
Clay Fraction	-	kaolinite, montmorillonite,	illite,	
(11) ***L26 S4***				
Bulk	Quartz	potassium feldspar	plagioclase	*montmorillonite, *kaolinite, *illite
Clay Fraction	Kaolinite	Montmorillonite,	illite,	
(12) ***L8 S2***				
Bulk	Quartz	potassium feldspar	plagioclase	*montmorillonite, *kaolinite, *illite
Clay Fraction	Kaolinite	I/M mixture[(1)],	illite,	

Heat treatments were used to identify clay minerals by revealing changes in crystal structure spacing or loss of the structure The untreated oven dried sample of montmorillonite shows a peak centring on 14^0A. Upon glycolation, the peak shifted to $17A^0$ and at high heat treatment, the spacing shrank to 10 A^0 due to driving out of structural water from its lattice. The identification of illite was achieved by observing a basal spacing of about $10A^0$ in the oven- dried untreated samples. This showed no visible effect upon glycolation. Other samples indicate that illite and montmorillonite occur as mixed clay. The peaks are broad, ranging from $10A^0$ to $14A^0$ in the untreated oven-dried samples and showed a slight expansion upon glycolation. Heating to both levels of 400^0C and 550^0C shrank the spacing to < $10A^0$. Therefore, these minerals are probably interstratified. The semi- quantitative results (Table 1) indicate that all the bulk samples are dominated by quartz and K-feldspar in major (>30wt %) and moderate (10-30wt.%) proportions, and that except for two samples (L4S4 and L25S3) which contain montmorillonite in higher and equal amounts respectively, the clay fraction is dominated by kaolinite. Apart from the clay

minerals identified other minerals such as quartz and feldspars are also present in the clay fractions (<4 µm).

Most water-deposited clays and shales have their bulk composition dominated by quartz as shown by the samples of the silty clay lithofacies (Table 1). It reflects the presence of notable sand and silt sized materials usually quartzose and feldspathic. Kaolinite which tends to be coarser than other clay minerals also tends to be more abundant in the coarser muds (in shallow water, near shore). Keller (1970), in a review of the processes leading to the formation of clay minerals stated that presence of kaolinite suggests a continental provenance, because in the presence of sea (or lacustrine) water, this mineral transforms to more complex clays. Weaver (1960) however opined that kaolinites are associated with near shore sands. Kaolinite, observed to constitute more than 30% (Table 6) of the clay fraction of most of the samples might imply a high influx of continental sediments onto the shores of the mega Lake Chad. The illite and mixed layer illite are common weathering products and are expected from fluvial settings carrying weathered material from a variety of source rocks. The occurrence of mixed clay layer in the form of Illite-montmorillonite mixture presupposes that, due to temperature/pressure variations, diagenetic transformations may have played a part in their co -existence. Montmorillonite, marine related clay perhaps imply derivation of the silty clays in a lacustrine setting.

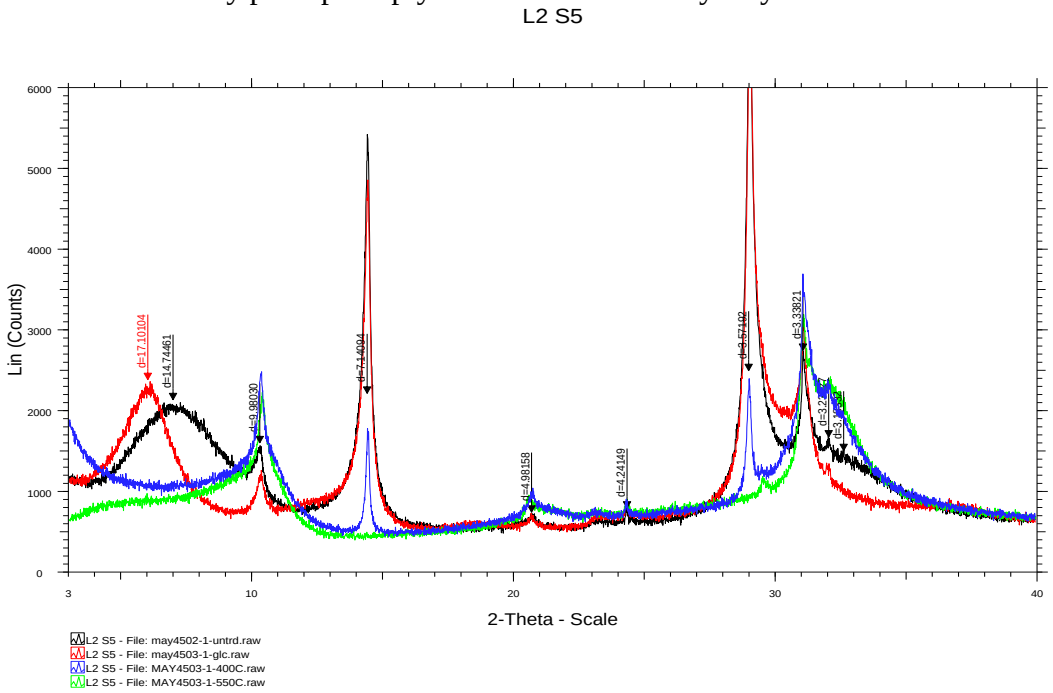

Fig 2: Typical Clay X-ray diffraction pattern showing the d-spacing values of the silty clays

CONCLUSION

Representative samples of the silty clay lithofacies of the Chad Formation in the Bornu sub-basin were sampled from hand auguring and water boreholes. X-ray diffraction analyses were performed using standard sample preparatory techniques and heat treatments. The results of semi quantitative data show that Quartz is the major mineral of the bulk samples, though moderate to trace amounts respectively of potassium and plagioclase feldspars are also notable. The Clay fraction yielded Kaolinite as its dominant mineral with traces of montmorillonite and Illite.

Analyses and interpretation of these imply formation of these sediments in a fluvio-lacustrine environment.

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In vitro Trypanocidal Efficacy of *Balanite saegyptiaca*Del. (*Zygophyllaceae)* Leaf Aqueous Extract

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ABSTRACT

The *In vitro* anti-trypanosomal activity of graded concentrations of *Balanites aegyptiaca* leaf aqueous extract was investigated using *Trypanosoma brucei* treated with graded concentrations of aqueous extract of *B. aegyptiaca* leaf by the test tube *In vitro* technique. A parasitaemia count ($x10^6$/ml) of 2.24 ± 0.09 was recorded for the untreated control, while graded extract concentrations of 0.875mg/ml; 1.75mg/ml and 2.5mg/ml indicated reduced parasite counts of 0.16 ± 0.13; 0.21 ± 0.09 and 0.0 ± 0.09 respectively ($p< 0.05$); proportionately represented as 0% inhibition for the control and 94.1%, 98.2% and 100% for 0.875, 1.75 and 2.5mg/ml extract concentrations. This study has shown that there is a positive correlation between the graded concentrations of the aqueous extract of *B. aegyptiaca* leaf and parasitaemia levels, and this concludes that *B. aegyptiaca* leaf has trypanocidal efficacy.

Keywords: Trypanocidal efficacy, *Balanites aegyptiaca, In vitro, Trypanosoma brucei.*

INTRODUCTION

Trypanosomiasis is an important protozoan disease of domestic animals and man (Esuruoso, 1973). The disease has been considered one of the major obstacles in livestock production in Africa (Wilson *et al*., 1983). *Trypanosoma brucei brucei,* the causative agent of Nagana is a unicellular parasite transmitted by the bite of tsetse fly and is closely related to *Trypanosoma brucei rhodesiense* and *Trypanosoma brucei gambiense* which causes human African

trypanosomiasis, also known as sleeping sickness. Sleeping sickness affects about half a million people in sub-Saharan Africa and an estimated 60 million people are at risk of contracting this disease, which is fatal if untreated (Warren, 1988; Kuzoe, 1993; WHO, 1998; Barrett, 1999; Welburn *et al.*, 2001). As a result, the importance of trypanosomiasis to human and animal health, nutrition and economy cannot be overemphasized. Unfortunately, existing treatment is beset with problems of toxicity, drug resistance and expensiveness while, the search for an effective vaccine remains elusive (Gutterridge, 1985; Aldhous, 1994; Onyeyili and Egwu, 1995; Atouguia and Costa, 1999).The possibility of sourcing for newer trypanocidal agents from plant extracts and plant derivatives have been receiving some consideration (Igweh and Onabanjo, 1989; Wosu and Ibe, 1989; Freiburghaus *et al.*, 1998; Atawodi *et al*., 2002). Some of these reports have indicated *In vitro* that some of the plants could be a good source of trypanocidal drugs (Freiburghaus *et al.*, 1998; Atawodi *et al*., 2003). In Nigeria, many plants believed to have medicinal properties are used against animal and human trypanosomiasis with little scientific information on their effectiveness. It was for this reason that this work was carried out to investigate the *In vitro* antitrypanosomal activity of graded concentrations of aqueous extract of *Balanites aegyptiaca* leaf.

MATERIALSAND METHODS

Plant collection, identification and extraction:Fresh matured leaves of *Balanites aegyptiaca* were collected from University of Maiduguri Campus, and were identified by a botanist in the Department of Biological Sciences, University of Maiduguri, Nigeria. The leaves were then air-dried under shade (to prevent solar leaching) at laboratory conditions for 14 days, hand crushed to obtain a 500gram powder, which was extracted in 700mls distilled water at 60^{o}C for 8hours using the Soxhlet extractor to obtain a 77.9% w/w yield. This was concentrated on an aluminium tray, dried in an oven at 60^{o}C overnight and stored at room temperature until used.

Trypanosomabrucei

This was obtained from stabilates maintained at the Nigerian Institute for Trypanosomiasis Research (NITR), Vom, Plateau State, Nigeria. The parasites were maintained in the parasitology laboratory of the Faculty of Veterinary Medicine, University of Maiduguri, Nigeria, by continuous passage in albino rats to establish sufficient parasitaemia for the *In vitro* testing. When parasitaemia levels have shown 16-32 parasites per field usually obtained at day 3-5 post infection, 1ml of infected albino rat blood in 0.2ml of phosphate buffered saline (PBS) solution (containing $1x\ 10^{6}$ parasites: which is a standard established by Herbert and Lumsden, 1976) was inoculated intraperitoneally (or intramuscularly) into each of five (5) albino rats that were male and 60 days old.

Determination of Parasitaemia

Parasitaemia levels were determined from blood obtained from the tail (sterilized using methylated spirit) of albino rats. Wet mount films placed onto clean grease-free slides under a cover slip were examined microscopically at x400 of the light microscope. The rapid matching technique of Herbert and Lumsden (1976) was used to obtain the absolute number of trypanosomes per ml of blood.

*In vitro*Assay

A serial dilution of the aqueous extract of *Balanites aegyptiaca* leaf extract to give 0.875mg/ml, 1.75 mg/ml and 2.5mg/ml graded concentrations in phosphate buffered saline solution was prepared into test tubes replicated 8 times for each concentration. Two drops of *T. brucei* infected blood obtained from parasitaemic donor albino rats were added to each test tube and incubated at 37^{o}C using a water bath. Also Glucose D® (Glaxo Nigeria Ltd) was added to each test tube which provided a source of energy for *T. brucei* survival. For reference tests, 2 control groups comprising of a negative control which had test tubes containing 2 drops of *T. brucei* infected blood in 1ml of phosphate buffered saline solution and without extract treatment to determine whether *T. brucei* mortality could be due to other factors, and a positive control group which had test tubes containing 2 drops of *T. brucei* infected blood in 1ml of phosphate buffered saline solution and treated with Veriben® (3.5mg/kg Diminazene aceturate, Eagle Chemical Company Ltd Ikeja, Nigeria) which represents the drug of choice for *T. brucei* and will allow the comparison of the efficacy of the extract and Veriben® .All tests were allowed to stand for a period of 15 minutes after which the improved Neubauer's Chamber was used to count the number of parasites per field under the light microscope at an interval of 5 minutes at 27^{o}C room temperature for 3 hours. Trypanocidal activity was determined by observing cessation of motility of the parasites (Atawodi *et al.*, 2003). It is to be noted that under *In vitro* tests parasites in the negative control could survive up to 4 hours. Percentage inhibition/cessation of motility was calculated as below:

$$\% \text{ inhibition} = \frac{\text{(Parasite count of negative control – Parasite count of extract treated)}}{\text{Parasite count of negative control}} \times 100$$

Data Analysis

In vitro data were expressed as mean ± standard deviation (SD) of parasite count x 10^6 and % inhibition in terms of cessation of parasite motility.

RESULTS AND DISCUSSION

Table 1 shows the antitrypanosomal activity of graded concentrations of *Balanites aegyptiaca* leaf aqueous extract on *T. brucei* in terms of mean ± SD of parasite count and percentage inhibition. Complete elimination of motility or reduced motility (inhibition) of parasites when compared to the control was taken as indices of antitrypanasomal activity. The negative control showed 2.24 ± 0.09 x10^6 parasite counts with reduction at 0.875mg/ml, 1.75mg/ml and 2.5mg/ml concentrations of the extract having 0.16 ± 0.13 x10^6, 0.21 ± 0.09 x10^6 and 0.0 ± 0.09 x10^6 parasite counts respectively. The percentage inhibition was 100$^{o}/_{o}$ at an extract concentration of 2.5mg/ml as all *T. brucei* showed complete cessation of motility under the light microscope at x100 magnification, and this compared favourably with Veriben®.

Table 1: *In vitro* antitrypanosomal activity of graded concentrations of *B. aegyptiaca* leaf aqueous extraction *Trypanosoma brucei*

Concentrations of extract (mg/ml)	Parasite count x 10^6/ml	$^{o}/_{o}$ Inhibition
Negative (Untreated) control	2.24 ± 0.09	0.0
Positive (Veriben®) control	2.24 ± 0.09	100.0
0.875	0.16 ± 0.13	94.1
1.75	0.21 ± 0.09	98.2

2.5	0.0 ± 0.09	100.0

The result of this present study showed that the aqueous extract of *Balanites aegyptiaca* leaf has antitrypanosomal activity *In vitro*. The results also showed that parasite counts ($x10^6$) decreased with increase in graded aqueous extract concentrations of *B. aegyptiaca* leaf with mean values of $0.16\pm0.13 \times 10^6$at 0.875mg/ml down to $0.0\pm0.09 \times 10^6$ at 2.5mg/ml (100% inhibition on *T. brucei* motility *In vitro*), thus indicating a positive correlation between extract concentration and percentage inhibition. This finding is in consonance with the findings of other authors (Asuzu and Chineme, 1990; Owolabi *et al.*, 1990; Nok *et al.*, 1993; Sepulveda-Boza and Cassel, 1996; Freiburghaus, 1998 and Biu *et al.*, 2015) who studied the antitrypanosomal properties of plants of different families and regions and related this property to the bioactivity of their alkaloid, flavonoid and terpenoid components. However, the mechanism of the trypanocidal action of aqueous extract of *Balanites aegyptiaca* leaf was not determined in this study, it was reported that the mechanism by which plant extracts exert their trypanocidal activity is through the interference of the redox balance of trypanosomes (Alli *et al.*, 2011), while others impede glucose catabolism and polyamine synthesis, and/or inhibit ornithine decarboxylase. Also trypanocidal activity of certain plants extracts have been attributed to the highly aromatic planar quaternary alkaloids, berberine and harmaine whose anti- protozoal action is through intercalation with the kinetoplast DNA of the parasite (Atawodi, 2005). These results suggest that *B. aegyptiaca* has trypanocidal potential, as such it is recommended that further bioassay techniques and spectroscopic methods be used to evaluate the active ingredients responsible for such activity. Previous reports have indicated that plant bioproducts such as alkaloids, tannins, and anthraquinones possess antiprotozoal and antitrypanosomal effects (Cowan, 1997; Atawodi and Ogunbusola, 2009).

In spite of the fact that bioactive screening *In vitro* remains a useful tool for pre-selection, isolation and identification of active principles of medicinal plants, it should not be the only yardstick for assessing the medicinal properties of plants. *In vivo* studies should be undertaken in order to obtain additional information and evidence for the presence of bioactive constituents.

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Effects of Pregnancy on Plasma glucose and Some Serum Metabolic Hormones in Sahel Goats

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ABSTRACT

Plasma glucose and some serum metabolic hormone levels of Sahel goats were investigated during pregnancy. Fourteen apparently healthy Sahel goats comprising six pregnant, six non-pregnant and two bucks were used in the study. Pregnancies were achieved following natural mating after estrus synchronization by intramuscular administration of *cloprostenol* (250 µg) to each animal twice at 11-day interval. Non-pregnant does with normal estrous cycle served as control. Blood samples were collected from day 0 in both groups and thereafter on biweekly basis for serum hormone assay (cortisol, thyroxine (T_4), triiodothyronine (T_3) and insulin) using micro plate Enzyme-Linked method. Glucose concentrations decreased significantly ($p < 0.05$) from 3rd to 5th months of gestation compared to control. Serum insulin levels did not vary significantly ($p > 0.05$) during pregnancy while significant ($p < 0.05$) increase in serum cortisol concentration was observed during late gestation. Serum T_3 (triiodothyronine) and T_4 (thyroxine) concentrations significantly ($p < 0.05$) increased during early gestation and thereafter attained normal levels during the later stages of gestation. This was probably a mechanism to reduce metabolic demands when catabolic functions are high during pregnancy. It was concluded that Sahel goats metabolically adapted to gestational changes as the low plasma glucose level decreased through the actions of metabolic regulatory hormones which probably stimulated glycogenolysis and gluconeogenesis from non-hexose source

Key words: Sahel goats, Pregnancy, Glucose, Hormones

INTRODUCTION

In the Savannah of West Africa, goats are essentially of two types: The Sudan or Sahel goats in the Sahel belt of Africa and the dwarf goats in tropical countries of Guinea coast, Congo and southern Nigeria (Epstein, 1971; Kwari, *et al.,* 2004). In the Sahel environment, Sahel goats seem to be one of the few species that thrive well (Peters, 1987; Nozawa 1991). One of the most important changes during pregnancy is the increase in metabolism, which is necessary to provide nourishment to the foetus (Ceylan*et al*., 2009). The important metabolic hormones include thyroid hormones (thyroxin (T_4) and triiodothyronine (T_3)), cortisol, insulin and growth hormone.

Thyroid hormones affect cellular differentiation, growth, and metabolism of protein, lipids and carbohydrate (Oppenheimer *et al.,* 1991), and are involved in the overall metabolic rate and oxygen consumption of the body (Klee, 1996). Thyroid activity undergoes significant changes during pregnancy resulting in increased concentrations of serum T_3, T_4 and thyroglobulin *(*Baxter and Webb, 2009). Cortisol is essential for the maintenance of homeostasis and regulates body metabolism through energy regulation and mobilization during pregnancy (Burton and Jauniaux, 2004). The physiological effects of insulin include maintenance of normal blood glucose levels by facilitating cellular glucose uptake, regulating carbohydrate, lipid and protein metabolism and promoting cell division and growth (Wilcox, 2006). Thyroid hormones and insulin usually work in concert to regulate metabolic process during pregnancy (Brenta, 2011). Analysis of Blood glucose and serum metabolic hormones during pregnancy provide information relating to the physiological status of the animal.

The objective of the present study was to evaluate plasma glucose and some serum metabolic hormone concentrations in pregnant Sahel goats.

MATERIALS AND METHODS

Experimental Animals

Fourteen apparently healthy adult Sahel goats comprising twelve Sahel does and two bucks were used for this study. They were managed intensively in the University of Maiduguri livestock research farm. Their feed rations consisted of wheat offal, cowpea husks, groundnut haulms and maize bran. Mineral salt licks and water were given *ad libitu*m. During the stabilization period, the animals were treated with oxytetracycline LA (Introxin-200®, Interchiemie, Venray, Holland) at 20mg/kg body weight and ivermectin (paramectin®, pharma Swede, Egypt) at 200µg/kg body weight. The males and the females were initially kept in different pens until the time of service. The does were 1½ to 2½ years of age, while the bucks were 2-3 years based on dentition (Dyce, *et al.,* 1987). The does weighed 20-25 kg and the bucks were 20-30kg.

Estrus Synchronization and animal grouping

The does were synchronized using a synthetic analogue of prostaglandin $F_2\alpha$, cloprostenol (Estrumate®, Schering-Plough Animal Health, Germany), at 250 µg administered twice to each doe intramuscularly at 11-day interval, as previously reported (Akusu and Egbunike, 1984; Akusu*et al*., 1989). The animals were teased with apronned males daily. The does that came into estrus after the second treatment were randomly separated into two groups of six each. Does in the pregnant (PGN) group were allowed to be served naturally by the males and were tagged as pregnant group. The days of service were considered as day 0 of the gestation. Pregnancies were later confirmed by failure to return to estrus and ultrasonographic examination of the doe using Draminski Ultrasound Pregnancy Detector (UPD-PD032013EX-1.2, Draminski Agricultural Engineering Co. Inc., Owocowa-Olsztyn, Poland). The animals in the non-pregnant (NPN) group were not served by the males.

Blood Sample Collection and Analysis

Blood samples were collected on day 0 in all groups and thereafter on biweekly basis throughout the period of the experiment. Blood sample (5 mls) was collected from each animal through jugular veinpuncture on the same day prior to feeding with minimal excitement. The blood sample from each animal was placed in two sample tubes (5ml each) without anticoagulant and with sodium oxalate fluoride respectively. The serum harvested from clotted blood were stored at -20^0C for hormone assay (cortisol, thyroxine (T_4), triiodothyronine (T_3) and insulin) using micro plate Enzyme-Linked Immuno Sorbent Assay (ELISA) with standard goat ELISA kits (Blue Gene, Bio Tech Inc., Shanghai, China). The second sets of the blood samples that were placed in sample tubes containing sodium oxalate fluoride were used for determination of glucose by enzymatic oxidation reaction in the presence of glucose oxidase using standard reagent kits, (*Randox Laboratory Limited, Ardmore, UK).*

Statistical Analysis

Data were summarized as Means ± S.D and analyzed using one-way analysis of variance (ANOVA) for significant variations among the different reproductive stages. The differences between pregnant (PGN) and non-pregnant (NPN) groups were evaluated using Student's t – test with computer software package (GraphPad Instate®, 2003). Significant differences were considered at ($p < 0.05$).

RESULTS AND DISCUSSION

Parturition occurred on day 147, 148 and 150 of gestation in one; two and three does respectively without complications. One doe given birth to twins, while a single kid was born to the remaining five does. All births were single except one and the average birth weight of the kids was 1.6 ± 0.2 kg.

Plasma concentrations of glucose and serum concentrations of insulin, cortisol, thyroxine (T_4) and triiodothyronine (T_3) in pregnant and non-pregnant Sahel does are presented in Table 1.

Table 1: Effects of Pregnancy on Plasma glucose and Some Metabolic hormones in Sahel goats

		Periods of observation (Months)		
Parameters	Groups*	0	1	2
Glucose	PGN	64.65±0.28	64.70±0.20	64.40±0.35
(mg/dl)	NPN	64.50±0.20	64.41±0.35	64.50±0.25
Insulin	PGN	2.75±0.14	2.80±0.04	2.81±0.11

(ng/ml)	NPN	2.80±0.10	2.82±0.11	2.79±0.30
Cortisol	PGN	13.83±0.30	13.77±0.18	13.83±0.12
(ng/ml)	NPN	13.88±0.38	13.86±0.25	13.82±0.32
T_3	PGN	1.12±0.09	1.66±0.03[ac]	1.70±0.01[a]
(ng/ml)	NPN	1.07±0.03	1.09±0.03	1.08±0.02
T4	PGN	3.60±0.17	4.65±0.30[ac]	4.66±0.22[a]
(µg/ml)	NPN	3.60±0.31	3.65±0.25	3.61±0.18

Table 1 cont'd

		Periods of observation (Months)		
Parameters	Groups*	3	4	5
Glucose	PGN	60.70±0.38[bd]	58.50±0.23[bd]	56.40±0.3[b]
(mg/dl)	NPN	64.60±0.38	64.50±0.33	64.43±0.37
Insulin	PGN	2.85±0.09	2.88±0.07	2.84±0.05
(ng/ml)	NPN	2.80±0.05	2.81±0.25	2.77±0.18
Cortisol	PGN	14.25±0.20[ac]	14.68±0.18[ac]	16.80±0.30[ac]
(ng/ml)	NPN	13.81±0.24	13.83±0.34	13.88±0.45
T_3	PGN	1.20±0.04[ad]	1.11±0.07[d]	1.12±0.01
(ng/ml)	NPN	1.10±0.01	1.07±0.04	1.13±0.01
T4	PGN	4.67±0.40[a]	3.63±0.19[d]	3.62±0.25
(µg/ml)	NPN	3.59±0.29	3.63±0.15	3.63±0.16

Keys: PGN = Pregnant; NPN = Non pregnant (Control); T_3=triiodothyronine; T_4= tetraiodothyronine
*N=6 for both groups; [a]=Significant ($p<0.05$) increase compared to respective control group
[b] =Significant ($p<0.05$) decrease compared to respective control group
[c]= Significant ($p<0.05$) increase compared to preceding gestational stage
[d] =Significant ($p<0.05$) decrease compared to preceding gestational stage

Significant ($p < 0.05$) decrease in plasma glucose concentration was observed in pregnant Sahel does from the 3rd to 5th of gestation. There were no significant ($p > 0.05$) variations in insulin concentrations in pregnant and non- pregnant does during the period of study. Cortisol level steadily increased significantly ($p < 0.05$) from the 3rd to 5th month of pregnancy (14.25 ± 0.20 ng/ml) up to the end of the experiment compared to control (13.81 ± 0.24 ng/ml). The serum concentrations of T_3 and T_4 increased significantly ($p < 0.05$) during the first two months of gestation and thereafter return to normal during the remaining period of the gestation compared to control.

Pregnancy, especially in the early stages, is a very demanding physiological state when nutritional requirements and utilization of the circulating metabolites are increased (Goff and Horst, 1997). Decreased plasma glucose levels in pregnancy as observed in this study are associated with considerable glucose requirements and utilization for nutrition of both the dam and the foetus (Bost and Magat, 1975; Jacob and Vadodaria, 2001). Utilization and partitioning of nutrients change drastically during pregnancy and lactation and both are controlled by endocrine status (Bines and Hart, 1982; Collier *et al*., 1984). Pregnancy did not affect serum insulin concentrations because of lack of increased stimulus from blood glucose which was not elevated. Elevated plasma glucose is a major stimulus for insulin secretion (Bowen, 2006). Suganya and Gomathy (2009) reported decrease in insulin concentration during pregnancy in Tellicherry goats and Khan and Ludri (2002) reported increase on day 15 prepartum in crossbred goats.

Increase in serum cortisol from the third month of pregnancy may be due to pregnancy related stress resulting from rapid foetal growth and increased maternal physiological changes during this period. The production and secretion of cortisol by the foetal adrenal glands increase at the final stage of gestation in preparation for parturition (Challis *et al.*, 1981; Bazer and First, 1983). The observed increase could therefore be the consequence of increased adrenal output from both the dam and the developing foetus as the pregnancy advanced. Increase in serum cortisol is consistent with the study by Suganya and Gomathy (2009) which observed elevated cortisol level during late pregnancy in Tellicherry goats. However, Khan and Ludri (2002) reported decrease in plasma cortisol concentration in pregnant goats.

The initial increase and subsequent return to normal of serum T_3 and T_4 concentrations during mid- and late gestation suggest increased consumption of T_3 and T_4or increased enzymatic conversion or deiodination of T_3 to T_2 in order to reduce metabolic demands when catabolic functions are high during pregnancy (Blum *et al.*, 1983). Similar observations were reported in Ossimi ewes and Tunji ewes by Soliman (2014) and Karapehlivan *et al*. (1997), respectively. The findings were also similar to the reports of Eswari*et al.* (1999) in Madras Red ewes and Nosratollah*et al.* (2005) Iranian women.

CONCLUSION

In conclusion, pregnancies in Sahel does were characterized by the decreased plasma glucose concentrations which probably stimulated glycogenolysis and gluconeogenesis through the

ACKNOWLEDGEMENT

We sincerely thank Mrs. Rhoda Genesis Chemical Pathology Department of University of Maiduguri Teaching Hospital (UMTH) and her team for their assistance during laboratory

works. We wish to appreciate and thank the animal care taker Mr. Bello Usman and his team for their contributions.

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Experimental Studies on the Life Cycle of *BOOPHILUS* (CURTICE 1891) Tick Species on Rabbits in Maiduguri, Borno State - Nigeria

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ABSTRACT
Ticks are notorious vectors of life threatening diseases and distressing pests of man and livestock. An experimental study on the life cycle *Boophilus* ticks was conducted in the Veterinary Parasitology Laboratory of University of Maiduguri, Nigeria. Two (2) sets each of 10 ticks were reared in glass test tubes under bell jar relative humidity (90%) and ambient (room) relative humidity of 85% until the end of egg hatch. Fully engorged adult female *Boophilus* indicated a shorter tick eclosion (pre-oviposition) period (mean ± SD) of 2.0 ± 0.00 days under bell jar than ambient conditions with 4.0 ± 0.70 days ($p<0.05$); a longer oviposition period of 15.8± 0.45 days under bell jar than ambient conditions with 13.2± 1.92 days ($p<0.05$).Egg eclosion (incubation) period was longer under ambient (12.0± 2.0 days) compared with bell jar conditions (4.4± 0.55days) ($p<0.05$). Total number of eggs laid was 2632.2 ± 198.91 and 745.8±125.94 under bell jar and ambient conditions respectively ($p<0.05$).The mean ± SD engorgement period for larvae, nymph and adult lasted 6.0 ± 1.2, 8 ± 1.7 and 6.0 ± 1.2 days respectively, while the moulting period for the larvae was 14.0 ± 2.1 days and nymph 10.0 ± 1.9 days.The mean duration of the life cycle of *Boophilus* was shorter (66.2days) under bell jar compared with ambient (73.2 days) conditions ($p<0.05$).

Keywords: Life Threatening Diseases. Oviposition period, Relative humidy, Engorgement period

INTRODUCTION
Ticks of the genus *Boophilus* are commonly found feeding on livestock especially ruminants, playing a vital role in the transmission of diseases ranging from viruses to helminths, mostly confined to tropical and sub-tropical countries (Fuente *et al.*, 2008) especially babesiosis tick

paralysis and anaplasmosis (Akinboade *et al.*, 1980; Tamirat *et al.*, 2009) and are known vectors of human zoonosis (Coon and Versalovic, 2002; Donovan 2002) leading to production losses and death (Irshad *et al.*, 2010). The development of various stages of these are influenced by important epidemiological factors such as relative humidity, temperature, and host availability (Tamirat *et al.*, 2009), and based on this fact an experimental study on the life cycle of *Boophilus* species was made to provide data for future control programmes.

MATERIALSANDMETHODS

Tick collection, identification and laboratory investigation

Fully engorged adult *Boophilus* ticks were collected manually from cattle sold at Municipal cattle market Maiduguri, Borno State, Nigeria. In the Veterinary Parasitology Laboratory of the University of Maiduguri, each tick was transferred to a Petri dish and examined under a stereoscopic microscope to confirm the genus, sex and stage of tick development, using the characteristics described by Soulsby (1982). A set of 5 ticks each put into a separate Petri dish and kept on the laboratory bench at ambient temperature (27-29^{0}C) and relative humidity of 85% to allow for oviposition. A similar set of 5 ticks preserved the same way were kept in a desiccator containing saturated solution of potassium chloride (KCl) in the lower chamber for controlled humidity of 90% for oviposition and relative humidity was measured using a hygrometer (D-3850, Bremer Haren, West Germany). The eggs from each tick in the desiccator were transferred to separate test tubes plugged with a cotton wool, kept still in the desiccator to allow for eggs to hatch into larvae.The duration of pre-oviposition and oviposition, number of eggs laid, and egg incubation period for each tick were recorded. The eggs were collected from each Petri dish since the day of the commencement of oviposition with the help of a clean needle, spread over a slide with square markings, and were counted using a stereoscope.

Experimentation on rabbits

A total of 10 rabbits were used for this study, and 20 larvae from each test tube were left for 4-5 days to become hungry and then fed on each rabbit. The larvae were put in a bag of cotton cloth, open at one end and a little larger in size than the ear of a rabbit (Basu and Haldar, 2008). One ear of each rabbit was inserted into the bag and the open end tied to the root of the ear so that larvae could not escape. The rabbits were prevented from scratching the ear by applying a plastic neck collar. Occasionally the ear bag was removed to observe for the development stages, and the larval and nymphal moults recorded.

RESULTS AND DISCUSSION

The results of this study as shown in Table 1 indicates the mean ± SD tick eclosion (pre-oviposition) period in days for *Boophilus* as 2.0 ±0.00 and 4.0 ±0.71 under bell jar and ambient relative humidity conditions respectively.The oviposition period lasted 15.8 ±0.45 and 13.2 ±1.92 days, number of eggs laid was 2632.2 ±189.91 and 745.8 ±125.94 and the egg eclosion period was 4.40 ±0.55 and 12 ±2.0 under bell jar and ambient conditions respectively.Table 2 shows the mean ± SD engorgement and moulting period, for the development of larval, nymphal and adult stages of *Boophilus*. The engorgement periods lasted for 6.0±1.2, 8.0±1.7 and 6.0±1.2 days, while the larval and nymphal moulting periods were 14.0±2.1 and 10.0±1.9 days respectively.

Table 1:Incubation and Oviposition Periods of *Boophilus* Tick under Bell jar and Ambient Conditions

	Mean ± Standard Deviation (SD)	
Parameters	Bell jar humidity (90%)	Ambient Humidity (85%)
Pre oviposition period (days)	2.0 ± 0.00	4.0 ± 0.7071
Oviposition period (days)	15.8 ±0.4472	13.2 ±1.924
Number of eggs laid	2632.2 ± 189.91	745.8 ±125.94
Egg incubation period (days)	4.4 ±0.5477	12.0 ±2.0

Table 2: Engorgement and Moulting Periods of *Boophilus* Tick on Rabbits under Laboratory Conditions

Parameters	Mean ± SD (days)		
	Larva	Nymph	Adult
Engorgement period	6.0±1.2	8.0 ± 1.7	6.0± 1.2
Moulting period	14.0± 2.1	10.0±1.9	-

In this experimental study, the entire life cycle of *Boophilus* ranged between a mean of 66.2 and 73.2 days under bell jar and ambient conditions respectively. This is in contrast with the reports by Soulsby (1982) and Urquhart *et. al.,* (1992) that indicated a period as long as 2 years under field conditions and explained that variations could be due to differences in environmental conditions of temperature and relative humidity with lower values prolonging the life cycle.Also in this study *Boophilus* laid a mean ± SD total of 2632.2 ±189.91 and 745.8 ±125.94 eggs under bell jar and ambient relative humidity conditions respectively. However, Ixodid ticks generally could lay 10,000 to 20,000 eggs under favourable conditions, and the number of eggs produced by a tick is influenced by temperature fluctuation, relative humidity, tick strain and body weight (Tamirat *et al.*, 2009; Binni *et al.,* 2010; Adejinmi, 2011; Adejinmi and Akinboade, 2011).
In summary, apart from photo periodicity, temperature has been reported as a major factor in oviposition of *Boophilus* ticks (Dipeolu *et al.,* 1989), and in addition, this study has observed positive correlation between relative humidity and number of eggs laid under ambient and bell jar conditions.

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