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Original Article

RELATIONSHIP BETWEEN BASIC MORPHOMETRIC MEASUREMENTS, GROWTH PATTERN AND GROSS CARCASS VARIATION IN PROXIMATE COMPOSITION OF THE BODY PARTS OF ELECTRIC FISH (*Malapterurus electricus)* FROM AGAIE- LAPAI DAM, NIGER STATE, NIGERIA

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ABSTRACT

A total of one hundred and twenty (120) electric catfish (*Malapterurus electricus*) specimens, a commercially important freshwater fish inhabiting Agaie-Lapai dam, Niger state, Nigeria were collected to evaluate the relationship between basic morphometric measurements, growth pattern and gross carcass variation in proximate composition of its body parts. Fish samples were collected forth-nightly with artisanal fishing gears (gillnets, cast nets and seine nets) for a period of seven months. The results of the biometrics showed that the fish sample had a standard length of 12-19.93cm with mean value of 15.76 $\pm$2.08, with total length ranging from 14.30 – 21.59 cm with a mean value of 17.97 $\pm$ 2.22 and the body weight ranging between 26.1- 106.50g. The growth pattern analysis depicted that the fish was positively allometric with b value of 3.14 and condition factor "K" ranged from 1.13 – 1.93 with a mean value of 1.48$\pm$0.22. The results of the whole body proximate composition and gross carcass composition of its body parts showed that there was an inverse relationship between the body lipid and moisture in the whole body composition and that moisture was highest in the fish body in October and lowest in July while lipid was highest in June and lowest in October. Gross carcass variation of various parts of the fish showed that moisture content ranged between 55.99 and 64.42% and was significantly higher in the skin than other regions examined. The crude protein value ranged between 19.74 and 23.08% and the skin also had the highest significant value. The lipid and ash ranged from 4.63 and 9.17% and 1.34 and 4.66%, respectively. The fillet region had the highest significant lipid, while the head region had the highest significant value in ash content. It could be concluded that the *M. electricus* of Agaie-Lapai depicted a strong significant correlation between the length and weight and the growth exponent "b" indicated a positive allometric growth pattern with a (K) value index above 1. Proximate analysis showed that the lipid and moisture were inversely proportional in the body of the fish while other nutrients in the body of the fish did not fluctuate significantly over time and nutrients were not evenly distributed among the body parts.

Key words: K value; Length –weight relationship, Snout length, head length, *Malapterurus electricus*.

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INTRODUCTION

Eating fish is good for your health, however there are not enough wild fish and shellfish to meet existing demand. To meet this need, sustainable fishing will have to go hand-in-hand with fish farming. Only together can they produce enough fish to meet the demands of the growing global population without jeopardizing the long term future of our wild fish stocks. Morphometric data are useful standard results of fish sampling programs (Morato *et al*., 2001) and one of the most commonly used analyses of fisheries data is length-weight relationship (Mendes *et al*., 2004). In fish, size is generally more biologically relevant than age (Bake and Sadiku 2012), mainly because several ecological and physiological factors are more size-dependent than age-dependent. Consequently, variability in size has important implications for diverse aspects of fisheries science and population dynamics (Artgues *et al*., 2003). Length-weight regressions have been used frequently to estimate weight from length because direct weight measurements can be time-consuming in the field (Sinovcic *et al*., 2004; Oscoz *et al*., 2005). It is evident that fresh water systems in Africa frequently experience changes in food composition, environmental variables and spawning conditions. Hence morphometric data is very essential for their effective management, since morphometric data of fishes can be used to assess the influence of these factors, also the relative well-being of the fish can be known through these relationships. (Kulbicki *et al.,* 2005, King, 2007).

Fish is one of the main food constituents in our diet as it includes essential fatty acids, amino acids and some of the principal vitamins and minerals in sufficient amounts for healthy living (FAO, 2003). Fish meat contains significantly low level of water and lipid than beef or chicken and is preferred over white or red meats (Nestel, 2000). The nutritional value of fish meat comprises the constituents of moisture, dry matter, protein, lipid, vitamin and minerals plus the caloric value of the fish (Mozaffarian *et al*., 2003; Foran *et al*., 2005; Steffens, 2006). The human body usually contains small amounts of minerals and the deficiency in these principal elements induces a lot of malfunctioning; as it reduces productivity and causes diseases (Mills, 2001). Furthermore, some nutritional components of fish have functional effects on human health. For example, fish oil is one of the most important natural sources of polyunsaturated fatty acids including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which have been proven to have useful effects on human health (Rafflenbeul, 2001; Saoud *et al*., 2008). In addition, fish oil is a rich source of vitamins including vitamin A, D, E, and K, which are soluble in oil and must be taken on a regular basis because of their key roles in human health and metabolism (Saoud *et al*., 2008). Since chemical composition can vary widely, not only from fish to fish of the same species, but also within an individual fish, precision is impossible. The processor, the nutritionist, the cook and the consumer all have a direct interest in the composition of fish. While the consumer is interested mainly in the edible part of the fish, that is the flesh or muscle, the fish meal manufacturer is concerned with the composition of the whole fish (Abdullahi and Abolude, 2000).

Electric catfish is the common name for the catfish in the Order Siluriformes and Family Malapteruridae. This family includes two genera, *Malapterurus*, and *Paradoxoglanis* with three species. Several species of this family have the ability to produce an electric charge of up to 350 volts using electro plaques of an electric organ. Electric catfish are found in tropical Africa and the Nile River. Electric catfish are usually nocturnal and feed primarily on other fish, incapacitating their prey with electric discharges. The genus Malapterurus is found throughout Western and central tropical Africa and the Nile River. *Malapterurus electricus* is restricted to the Nile River and Lake Chad (Moller, 1995; Olaosebikan and Raji 2013). There are currently three species of Malapterurus (Moller, 1995; Olaosebikan and Raji 2013). *Malapterurus minjiriya* is known from the Niger River and Lake Kainji and *M. microstoma* is known from the Zaire River basin.

Agaie-lapai dam is a man-made earth-filled dam in Niger state of Nigeria, created solely for portable water production and irrigation. Human activities have fragmented and simplified the tropical wetland habitat.

The processing and preservation of fresh fish are of utmost importance since fish is highly susceptible to deterioration immediately after harvest and also to prevent economic losses (Okonta and Ekelemu, 2005). Rasheed (2011) stressed that since chemical composition of fish can vary widely, information on such subject are important to the fish processors, the nutritionist and the consumers. Therefore, information about the morphology and the proximate composition of fishes especially in man-made dams is of paramount importance for adequate sustainability and proper management of the bio resources. Very few information on the seasonal variation in the nutritive values of *Malapterurus electricus* exist, furthermore there is lack of information about some basic morphometric measurement and proximate composition of different body parts of *Malapterurus electricus* found in man-made dams in the North-central zone of Nigeria. It is in this view that this study was carried out; hence the main objective of this study was to investigate the relationship between some basic morphometric measurements and cross carcass variation in the body parts of *Malapterurus electricus* from Agaie-Lapai dam.

MATERIALS AND METHODS

Sampling area

Agaie – Lapai dam is located at the boundary between Lapai and Agaie Local Government Areas of Niger state, Nigeria. It is a man-made earth-filled dam across River Jatau at Bakajeba with a reservoir capacity of 147×10^6 cubic meters. The dam is of rolled heterogeneous embankment type with a crest length of 1193.87m, maximum height of about 16m and about 38 Mm^3 capacities. It also has part of its components about 750 m Spill channel with 3m free board. Accessibility is through a 2.5km-untarred road, off Paiko-Lapai tarred road. The dam lies to the North-East of Lapai town and East of Bakajeba town. The dam is geographically located at Latitude $9^0 14^1$North of the Equator and Longitude $6^0 30^1$East of Greenwich. The major source of the dam is River Jatau, which is a tributary of River Kaduna. The main purpose of establishing the dam was to provide portable water for Abuja metropolis and also to supply water for irrigation to Agaie, Lapai and its environs. The dam site has typical tropical climate characterised by seasonal changes: rainy and dry seasons. The rainy season is usually from April to October having its peak within the month of August and September while the dry season covers the remaining months of November to March. Maximum and minimum mean temperatures between: 28.33^0C – 38.89^0C and 19.44^0C – 26.67^0C, respectively. Before the construction of the dam, the major occupation of the people was farming and fishing around the dam site.

Fish sampling and Measurement

Specimens of *Malapterurus electricus* were collected from the fishermen at the two sampling sites twice a month for seven months. Gill nets, cast nets and seine nets of mesh sizes 50-55mm were used. A total of 120 fishes were collected at the upper and the lower site of the dam. Specimens collected were kept chilled in an ice chest to avoid post mortem damage. When the fishes were collected, they were washed, kept in the ice chest and quickly taken to the Department of Water Resources, Aquaculture and Fisheries Technology Laboratory Gidan Gwanu Main Campus.

In the laboratory, total length (TL) was measured from the tip of the snout (mouth closed) to the extended tip of the caudal fin. Standard length (SL) was measured from the tip of the snout to the caudal peduncle. Other basic morphometric features; head length, snout length and eyes diameter were measured with the aid of a measuring board and a mathematical set divider. The lengths were taken with measuring board to the nearest 0.1 cm. Body weight of individual fish was measured to the nearest 0.1 g with an electric balance (*CITIZEN MP-300*) model after removing the adhered water and other particles from the surface of the body.

Growth pattern and condition factor

Length-weight relationship was calculated using Le Cren (1951) equation; Linear regression was employed to determine the type of relationship between any given pairs of variables and their linear equation. Correlation analysis was used to ascertain the significance of this relationship a derivative of length weight study is the ponderal index denoted as:

$W= aL^b$

Where, W = weight (g), L= standard length (cm)

The length-weight relationship (LWR) was expressed by the equation:

$$\text{Log weight} = \text{Log a} + \text{b Log length}$$

Where, a and b are regression constants.

The condition factor was calculated using the formula:

$$K = [100\ W] / L^3$$

Where, K = condition factor, L = standard length (cm) and W = weight (g).

Proximate Composition Analyses

Proximate composition analyses were performed according to AOAC procedures (AOAC, 2000). Water content was determined by drying samples at 105±2°C until a constant weight was obtained. Dried samples were used for determination of crude fat, protein and Ash contents. Crude fat was measured by solvent extraction method in a soxhlet system where n-hexane was used as solvent. Crude protein content was calculated by using nitrogen content obtained by Kjeldahl method. A conversion factor of 6.25 was used for calculation of protein content (AOAC, 2000).

Data analyses

Data collected were analyzed using one – way analysis of variance (ANOVA) using statistica 6.0 (Stat-Soft, Inc., USA). Differences between treatments were compared by Tukey's test. Level of significance was tested at $P<0.05$.

RESULTS

Table 1 shows the results of biometrics of the *Malapterurus electricus* specimens. Total length of the specimens ranged from 14.05 to 22.43 cm with a corresponding body weight ranging from 27.21 to 100.00g and standard length ranging from 11.85 to 19.93 cm. The result of the morphometric measurements of *Malapterurus electricus* specimens examined provides the following information; the snout length ranged from 0.82 to 1.92 cm with a mean of 1.36±0.31, while the head length ranged from 2.15 to 4.18 cm with a mean of 3.43±0.53.

Relationship between the Morphometric Measurements

Standard length–head length relationship

Figure 1 shows the relationship between the head length and the body weight. It was observed that there was a positive relationship between the head length and the body weight correlation co-efficient r was 0.96 and was significant ($P<0.05$). This indicates that a proportional increase in the standard length can be associated with an increase in the head length.

Body weight – head length relationship

Figure 2 shows the relationship between the body weight and the head length. It was observed that there was a positive relationship between the head length and the body weight with Correlation co-efficient r 0.91 and was significant ($P<0.05$). This indicates that a proportional increase in the body weight can be associated with an increase in the head length

Standard length – snout length relationship

Figure 3 shows the relationship between snout length and the standard length. It was observed that there was a significant relationship between the snout length and the standard length as correlation co-efficient, r, was 0.79 and significant ($p<0.05$). This means that a proportional increase in the standard length was associated with increase in snout length.

Table 1: Summary of biometric measurements and K value of 120 *M. electricus* samples from Agaie-Lapai dam, Niger State from April to October 2012

Measurement	Range (cm)	mean±SD
Total length (cm)	14.05 - 22.43	18.49±2.27
Standard length (cm)	11.85 -19.93	16.06±2.25
Body weight (g)	27.21 - 100	63.20±12.28
Eye diameter (cm)	0.36 - 0.42	0.39±0.02
Body girth (cm)	2.04 -3.55	2.86±0.46
Head length (cm)	2.15 - 4.18	3.43±0.53
Snout length (cm)	0.82 -1.92	1.36±0.31
K value	1.13-1.98	1.48±0.22

Table 2: Temporal variation in proximate composition (%) of whole body of *M. eletricus* samples from Agaie-Lapai dam, Niger State

Months	Moisture	Lipid	Protein	Ash	Crude fiber
April	58.17 ± 2.13^{b}	9.14 ± 0.34^{b}	17.41 ± 1.32^{a}	4.06 ± 0.08^{a}	1.98 ± 0.08^{a}
May	57.06 ± 2.16^{c}	9.56 ± 0.22^{b}	17.24 ± 1.03^{a}	4.11 ± 0.12^{a}	1.81 ± 0.12^{a}
Jun	57.44 ± 1.13^{c}	10.57 ± 0.31^{a}	17.35 ± 0.45^{a}	4.15 ± 0.24^{a}	1.65 ± 0.24^{a}
Jul	56.47 ± 1.52^{d}	10.86 ± 0.42^{a}	17.56 ± 1.25^{a}	4.09 ± 0.05^{a}	1.69 ± 0.05^{a}
Aug	56.55 ± 2.46^{d}	10.75 ± 1.02^{a}	17.73 ± 2.05^{a}	4.06 ± 0.56^{a}	1.66 ± 0.56^{a}
Sept	58.74 ± 1.32^{b}	8.98 ± 1.21^{b}	17.68 ± 1.45^{a}	4.11 ± 0.62^{a}	1.95 ± 0.62^{a}
Oct	59.16 ± 2.41^{a}	8.23 ± 1.32^{c}	17.56 ± 1.48^{a}	4.22 ± 0.31^{a}	1.97 ± 0.31^{a}

*1 Values in the same column with different superscript letters are significantly different ($p<0.05$) from each other (n=3).

Table 4: Proximate composition of various body parts of *M. eletricus* samples from Agaie-Lapai dam, Niger State

Body component	Crude protein	Lipid	Ash	Moisture
Fillet	20.17±0.80[b*]	9.17±0.92[a]	1.34±0.12[c]	60.51±0.66[b]
Skin	23.08±0.75[a]	8.40±0.51[b]	2.03±0.02[b]	64.42±1.64[a]
Head	19.74±0.95[c]	4.63±0.47[c]	4.66±0.03[a]	55.99±0.20[c]

*Values in the same column with different superscript letters are significantly different ($p<0.05$) from each other (n=3).

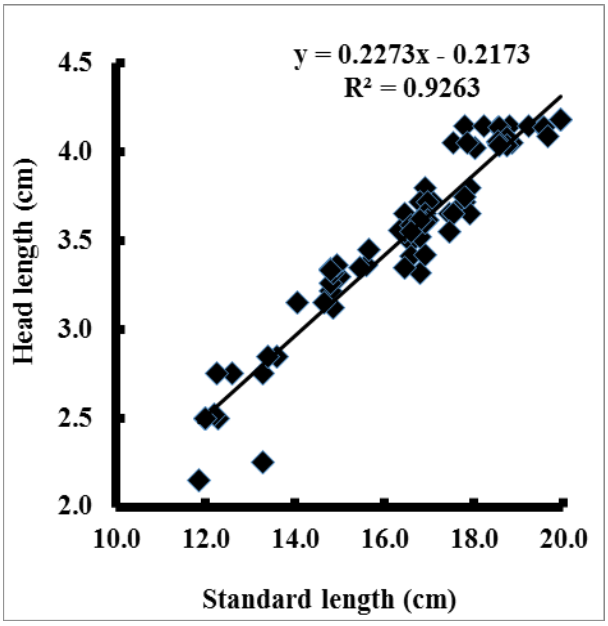

Figure 1: standard length-head length relationship

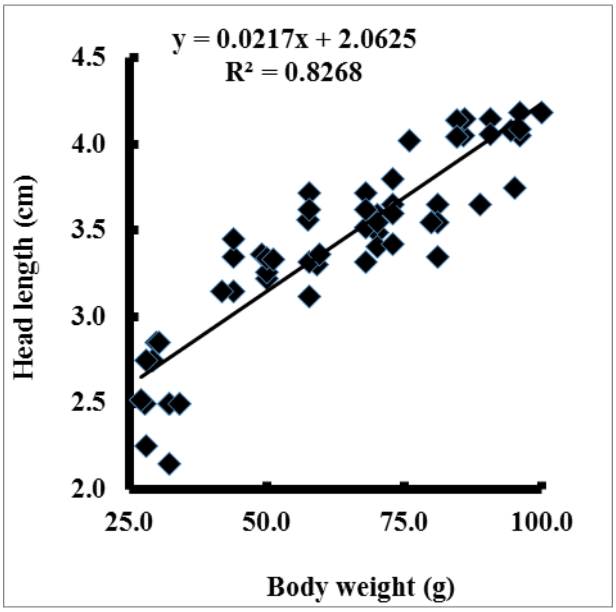

Figure 2: Body weight-head length relationship

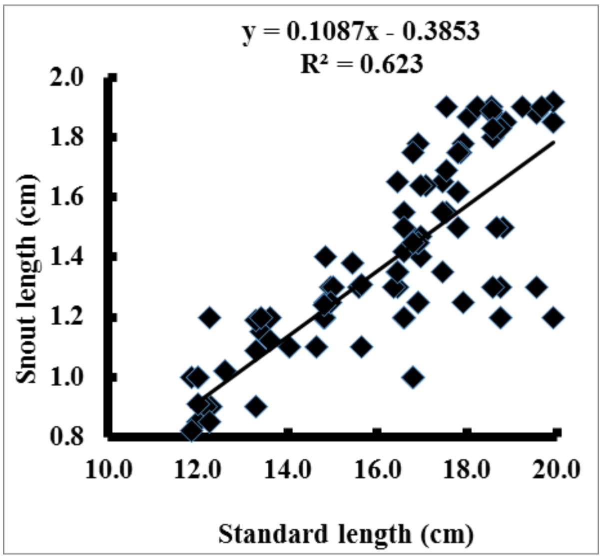

Figure 3: Standard length -snout length relationship

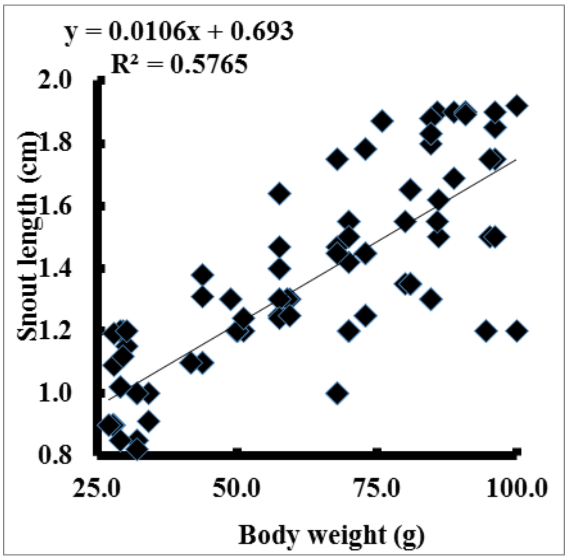

Figure 4: Body weight-snout length relationship

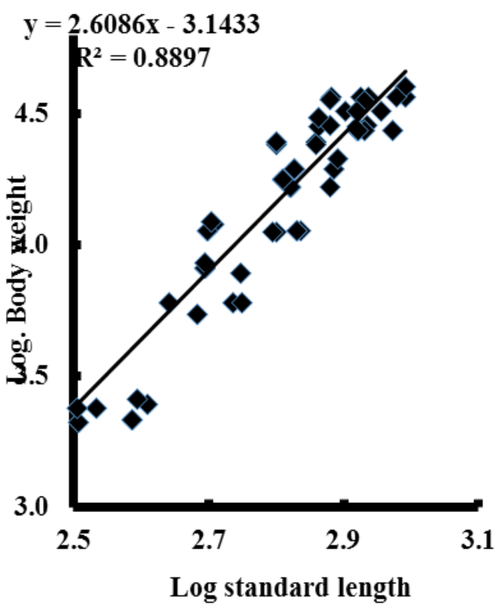

Figure 5: Standard length – Body weight relationship

Body weight-snout length relationship

Fig 4 shows the relationship between the snout length and body weight. It was observed that there was a positiverelationship between the snouts length and body weight as correlation co-efficient, r, was 0.76 and was significant ($P<0.05$). This means that an increase in weight was associated with an increase in snout length.

Length –Weight relationship and growth pattern of *Malapterurus electricus*

The condition factor and growth of the fish were derived from the standard length and body weight measurements of the specimens. Log weight was regressed against log length as shown in fig 5 and Table 1. It was observed that the growth of *Malapterurus electricus* was positively allometric with b value of 3.14. There was a strong relationship between the standard length and the body weight and the correlation co-efficient r was 0.94.

Table 1 also shows the condition factors otherwise called ponderal index denoted, as

K of *Malapterurus electricus* from Agaie-lapai dam and it ranged from 1.13-1.98 with a mean value of 1.48±0.22.

Proximate composition and Carcass variation of the body parts
Whole body composition

The results of the seasonal proximate composition of whole body of *Malapterurus electricus* specimens from Agaie- Lapai dam examined are shown in Table 3. There was a significant seasonal variation in the lipid and moisture values of the specimens. Lipid from the samples collected ranged from 8.23±1.32 to 10.86±0.42% and was significantly highest in July and lowest in October ($P<0.05$), while the Moisture content of the samples ranged between 56.47±1.52 and 59.16±2.41% and was significantly highest in October and lowest in July ($P<0.05$). The crude protein did not vary considerably over time, values ranged from 17.24±1.03 to 17.73±2.05% hence, there was no significant difference in the crude protein between April and October in all the samples analysed ($P>0.05$). The Ash content ranged from 4.06±0.08 to 4.22±0.31%. There was no significant difference in the ash content of the samples throughout the period of the study ($P>0.05$).

The results of the chemical analyses (proximate composition) of some of the body parts of *Malapterurus electricus* samples are shown in Table 4. The skin had the highest values of both moisture and crude protein and was significantly higher than other body parts examined ($P<0.05$) (64.42±1.64 and 23.26±0.75%, respectively) while the head region had the lowest moisture content and crude protein (55.99±0.20 and 19.74±0.95) and was significantly lower than other body parts measured ($P<0.05$). The fillet region had the highest lipid content value 9.17±0.92% and was significantly different from the than other body parts examined. The head region had the highest significant value of ash content 4.66±0.03%, while the fillet had the lowest ash content.

DISCUSSION

From the results of the basic mophormetric measurements of the *Malapterurus electricus* specimens examined, there was a strong positive relationship when the snout length, head length and body girth were regressed against the body weight, indicating that an increase in body weight leads to a proportional increase in snout length, head length and body girth. Also, when the snout length, head length and body girth were regressed against the standard length, there was a strong positive relationship, showing that an increase in the standard length leads to a proportional increase in snout length, head length and body girth. This finding was consistent with those of previous works on some freshwater fishes (Bake and Sadiku, 2012; Bake *et al.*, 2014) which is in line with the theory of proportionality of growth state of the organism (Mosby 2009).

In this study, sampling was carried out to include possible wide range of sizes which was generally obtained from the sampling. The differences in sizes obtained showed that the population at this period of research were majorly adult fishes with few small-sized individuals. This however can suggest variation in their growth (Frota *et al.,* 2004). The uniformity in size of the samples can also be related to the mesh size of the fishing gears used.

Growth was described as the change in the absolute weight (energy content) or length of fish over time (Wootton, 1998), Zafar *et al.* (2003) reported that fish weight is considered to be a function of length., while Sadiku and

Oladimeji (1991), Bake and Sadiku (2012) summarized growth as a function of size. Wootton (1998), reported that fish grow in length as well as in bulk. Linear regression of log standard length and log weight gave useful co-efficient. Regression "b" = 3 is isometric; below this is negative allometric and above it is positive allometric (Tesch, 1978; Froese 2006). Fagbenro *et al.* (1991) stated that the growth pattern of majority of fishes especially freshwater fishes do not obey the cube law (isometric growth, b = 3). From the result of this study the growth pattern of *Malapterurus electricus* from Agaie – Lapai dam was positively allometric with "b" value of 3.14; hence showed a slight deviation from the cube law which is in line with the earlier report of Fagbenro *et al.* (1991). The result showed that the length growth rate is slower than the body weight growth rate (stout in nature). This result is similar to the findings of Offem *et.al.* (2009) from Cross River inlands wetlands, however Obasohan *et al.* (2007) reported that *Malapterurus electricus* from Ibiekuma stream Ekopama was negatively allometric. Abowei and Davies (2009) and Ikongbeh, *et al.* (2012) reported that the suitability of an aquatic habitat for fish growth is determined by the value of the condition factor. This study showed that the condition factor of *Malapterurus electricus* from Agaie - Lapai dam ranges from 1.13-1.98 with a mean value of 1.48±0.22. This result is similar to the findings of Offem *et al.* (2009) on *Malapterurus electricus* from Cross River inlands wetlands and Obasohan *et al.* (2007) from Ibiekuma stream Ekpoma, hence in this study the condition factor of *Malapterurus electricus* from Agaie – Lapai dam indicated that the fishes were in good condition and well-being since K-value was greater one.

The species investigated in this present study: *Malapterurus electricus* is a popular market fish in the rural and urban areas, and belong economically to different traditional grades, according to consumer and fishermen preference in Nigeria (Akinsanya *et al.,* 2007). In this study, protein, lipid, moisture and Ash were the major contents considered in evaluating the nutritional value of the fish studied. The proximate composition of *Malapterurus electricus* varies considerably between April-October. Many researchers have reported that variation in proximate composition of fresh fish may be due to species variation, season, age and feeding habit of the fish (Azim *et al.,* 2012). The result of the present study showed that there were fluctuations in moisture and lipid values of whole *Malapterurus electricus* from April-October. This variation in moisture and lipid content of the samples showed that with a gradual decline in moisture content, fat content gradually increased. This findings were consistent with results obtained by previous works on freshwater fisheries (Sadiku and Oladimeji, 1991; Bake and Sadiku, 2012; Bake *et al.,* 2014). Saoud *et al.* (2007), also reported that fat content shows inverse proportionality to water content in some semi fatty fish species muscle. This may be attributed to the seasonal differences in availability of food and changes in the reproductive cycle having considerable effect on tissue biochemistry of the fish, particularly, changes in the lipid and water content of their body system.

The nutritional elements showed variable values in the body regions of the species analyzed; Moisture and the crude protein content of the skin region had the highest values. This portrays *Malapterurus electricus* as an important aquatic living resource of dietary protein as other sea and freshwater fish

(Zuraini *et. al.,* 2006). The high crude protein in the skin may likely be attributed to some digestible and indigestible properties of protein which are usually built up in the skin of fishes (Choi and Regenstein, 2000). Gudmunsson and Hafsteinsson (1997) and Choi and Regenstein (2000) reported that the fish skin is a potential source of phosphorus, gelatin, melanin and keratin which at times are enzymatic in nature. High lipid fishes have less water and more protein than low lipid fishes. This is in-line with the report of Steffens (2006), that moisture forms the largest quantity of the wet-weight in fish. From our results the ash content of the head region was significantly higher than the other parts of the fish; this may be attributed to the concentration of inorganic materials present in it. Steffens (2006) stated that the head region of a fish is mostly bones which are very rich in inorganic materials. The variations recorded in the concentration of the different nutritional components in the regions of the fish examined could be as a result of the fish ability to absorb and convert the essential nutrients from the diet or surrounding water body (Agaie-Lapai dam) where they live. This is in agreement with the findings of Richardo *et al*. (2002), Adewoye *et al*. (2003) and Fawole *et al*. (2007).

CONCLUSION

This study showed that there is a proportionate growth and a positive relationship between the basic morphometrics parts of the fish measured. The high condition factor of the fish also reflects a good physiological state and well-being of the fish. The growth pattern of *Malapterurus electricus* from Agaie-Lapai dam is positively allometric, which is the normal growth pattern of the fish. The proximate composition of the fish showed that the fish is rich in protein hence can be a very rich source of protein to the rural populace and is a fatty fish because of its high lipid content. Further studies need to be carried out on the other properties and compositions of the fish.

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