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The spawning pattern, length-weight relationship and condition factor of elephant fish, *Mormyrus rume* from the Bontanga reservoir, Ghana

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Abstract
A study was conducted into the Spawning pattern, Length-Weight Relationships and Condition factor of *Mormyrus rume* in a shallow reservoir in the Northern Region of Ghana. One hundred and sixty seven specimens were used during the study period. Males were 92 (55.1%) and females were 75 (44.9%) respectively. The reproductive pattern was studied within a specified period of five months (December 2010 to April 2011) by determining the sex ratio, gonadosomatic index (GSI), condition factor (K) and assessing the gonadal development of *Mormyrus rume*. Immature and maturing gonads were predominant in March and April respectively and gonads ripped in January and February. The patterns of gonad development in female the *Mormyrus rume* indicated that spawning was not synchronized. The gonadosomatic index (GSI) ranged from 1.29- 3.56 indicating that species were in good condition to grow and reproduce. Measurement of total length and standard length of each individual fish was taken to the nearest 0.10 cm. Total body weight of each individual fish was determined to the nearest 0.10 g. Counts of sexes were also determined for the sampled fish collected fortnightly by purposive sampling of the species from the fishermen's landing sites on the reservoir. It was revealed that *Mormyrus rume* has the allometric growth with b = 2.880 ± 3.092 and a = 0.031 ± 0.021 (n = 167). The condition factor (K) for the specimens ranged between 1.422 and 2.90 for females and 1.49 and 2.21 for the males. Males predominated over females with a sex ratio of 1.2:0.8 (male: female) and a chi-test (x^2) of 9.49 at $P<0.05$. Also, the relationship between the weight and the length was $W=0.0310L^{2.986}$ with coefficient of determination $r^2 = 0.8120$ respectively. There was no clear pattern in both growth parameters for the study period, indicating that there was no significant influence of high and low water levels on the growth performance of the fish. The best fish condition was recorded for those specimens with length of between 12.1 and 18.2 cm (SL) and 13.3 and 19.4 cm (TL) that was coincided with the maturation stage of the fish.

Keywords: *Mormyrus rume,* spawning pattern, length, weight, condition factor

1. Introduction
The reproductive pattern and Length-weight relationship of fish are crucial in fisheries biology and their stock assessment because they help in estimating the fish's average weight of a given length category by establishing a mathematical relation between the two [1]. The length-weight relationship can be used as a character to differentiate taxonomic units and the relationship changes with various developmental events in life of fish such as metamorphosis, growth and state of sexual maturity. Furthermore, the length-weight relationship can also be used in setting yield equations for estimating the number of fish landed and comparing the population in space and time [2]. Moreover, the empirical relationship between the length and weight of the fish species, improves the knowledge of the natural history of commercially important fish species, thus making conservation and utilization possible. Condition factor (k) is a quantitative parameter of the well-being state of the fish and reflects recent feeding conditions. This factor varies according to the influences of physiologic factors, fluctuating according to different stages of development [3]. Obviously, there are limited studies on the freshwater fishes in Ghana that emphasize on the importance of condition factor, sex ratio, gonad somatic index and their relations to the environmental condition.
Anderson OR and Neumann RM [4] reported that, length-weight data of population are basic

parameters for monitoring studies of fisheries, since it gives important information concerning the structure, growth and function of the populations. Presently, there are limited studies on the freshwater fishes in Malaysia, Ghana and other countries which emphasize on the length-weight relationships, condition factor and their relation to the environmental conditions. Most of the important reservoirs in Ghana such as Bontanga reservoir maintain good stock of freshwater fish mainly for human consumption and as a source of income for residents and traders in and around the region. Further, Length-weight relationships are of enormous importance in fisheries research because they provide information on population parameters [5]. Thus, a change in length and weight tells the age and year-classes of fishes, which is important in the fishery. Besides, the data can be used to estimate the mortality rate, and also to assess the sustaining power of the fishery stock. In addition, the data on length and weight can also provide clues to climatic and environmental changes. The growth of Mormyrid fish depends on many factors such as heredity, relative velocity of growth, ability to derive food and resistance to diseases, temperature, the quantity and quality of food, the composition and purity of chemical medium (available oxygen) and survival of fish in time and space [6].

2. Materials and Methods

The study was carried out at the Bontanga reservoir in the in the Guinea Savannah ecological zone with extensive shrubby grasslands and few sparse populations of economic trees like *Vitellaria paradoxa* and *Parkia biglobosa* of the northern region of Ghana and characterized by a moderate annual rainfall pattern with varying temperature range occurring between November and March. The area lies between latitudes 9^0 30′ and 9^0 45′N of the equator and longitudes 10^0 00′ and 1^0 15′W. The reservoir has a distance of 30 km northwest of Tamale and is the largest in the northern region. It has a total surface area of 770 ha and average depths of 8 meters and 12 meters at the shallowest and deepest parts respectively. It has a developed area of about 570 ha and an irrigable area of 495.10 ha.

2.1 Fish Sampling

Fish samples were taken from commercial artisanal fishermen at five main landing sites every fortnight from December, 2010 to April, 2011 on the reservoir using identification keys by [7] Dankwa *et al.* Specimens were stored and placed in an ice chest to preserve them from deteriorating and transported to the laboratory for analysis. In the laboratory, species were sorted into males and females by observing the shapes of the genital papillae and genital openings with the help of a hand magnifying glass.

2.2 Length-weight measurement

The standard and total lengths of males and females of each fish were measured to the nearest 0.10 cm and recorded separately. Standard Length was measured from the tip of the fish snout to the point of flexure of the caudal fin while the total length was measured from the base of the fish's snout to the most posterior part of caudal fin using a measuring board. Each fish was weighed separately to the nearest 0.10 g on an electronic weighing scale and recorded. Length weight relationship was calculated thus: $W = aL^b$.

Since the bodyweight increased more rapidly than total length, the formula was logarithmically transformed for the purpose of data analysis according to [8] Nwani CD *et al*.

Thus: Log W = Log a + b Log L. Where 'a' was the proportionality constant, 'W' was the weight of fish in grams (g), 'L' was the total length of fish in millimeters (mm) and '*b*' was the allometric growth coefficient. Where b = 3.0, if the fish is growing isometrically (without changing shape). If the fish change in shape as it grows (allometric growth), *b* would differ from 3.0 and if the fish gets relatively thinner b < 3.0 and finally if they get plumper b > 3.0. The length-weight relationship was calculated as exponential formula by using Microsoft Excel program. The condition factor (K) otherwise known as the wellbeing of the fish was calculated according to [3] Le Cren. Thus, $K= 100W/L^3$. Where K = Condition factor, L = Standard length of fish in cm, and W = Body weight of fish in grams.

2.3 Gonad Study

Species were grouped separately into males and females by observing the shapes of the genital papillae and genital openings with the help of hand magnifying glass. Larger and pointed papilla represents that of male whilst smaller and rounded papilla indicates female *Mormyrus rume.* Sampled female fishes above 80.0 g were each dissected to remove the gonads. The colors of the gonads were recorded separately for each female fish to determine their levels of maturity; white, yellow and pale red representing immature, maturing and matured gonad respectively. The gonads were each put in separate plastic container and placed inside an ice-chest container with ice-block with them for analysis in the Spanish Laboratory, University for Development Studies, Nyankpala Campus.

GSI was calculated using the formula:

GSI = (GW/TBW) X 100. Where GW = Gonad Weight (g) and TBW = Total Body Weight (g)

3. Results and Discussion

3.1 Gonadosomatic Index (GIS)

The mean monthly changes in gonadosomatic Index (GSI) in females of *Mormyrus rume* during the study period ranged from 1.29 - 3.56. The maximum value of (GSI) which represents the peak spawning period was in January. This is in contrast with what [9] Elsayed AK and Mohammad MNA reported that, monthly variations in (GSI) for both sexes of *Mormyrus rume* followed nearly the same pattern and (GSI) showed higher values during the period from June to September with a peak in July, while the lower ones occur during the period from October to February. This is not the case in this present study since the sampling period was not all-year round.

3.2 Length-weight relationship

Length-weight relationships give information on the condition and growth patterns of fish [10]. Fish are said to exhibit isometric growth when length increases in equal proportions with body weight from constant specific gravity. There was a significant correlation between body weight and total length of specimens in this study, indicating that increase in length resulted in corresponding increase in weight. This assertion was supported by [8] Nwani CD *et al*.

The study revealed that out of 167 fish sampled, a total of 92

(55.1%) males were obtained which ranged in standard length from 11.2 cm in February, 2011 to 19.0 cm in March, 2011 with an average of 15.1 cm. The males total lengths ranged from 12.9 cm in February to 21.3 cm in March with an average of 17.1 cm. The mean body weight of the males ranged from 75.1 g to 102.8 g with an average of 88.95 g. The females were 75 (44.9%) which ranged in standard length from 12.2 cm in January, 2011 and April, 2011 to 19.0 cm in February with an average of 15.6 cm.

The total length ranged from 16.4 cm in December, 2010 and February, 2011 to 19.7 cm in April, 2011. The mean body weight of females ranged from 85.4 g in January to 96.3 g in February with an average of 90.85 g. The total length of gravid females ranged from 12.01 cm to 18.5 cm and standard length ranged from 9.2 cm to 15.4 cm.

The research revealed that the exponential power parameters of the length-weight relationship for males and females were 2.880 and 3.092 respectively with females having $W=0.039L^{2.880}$ and males having $W=0.031L^{3.092}$. The mean monthly total lengths (cm) and total weights (g) of both males and females recorded were $W=0.031L^{2.986}$ derived from the linear equation $W=aL^b$. Apparently, the exponent 'b' value obtained lies a little bit far from the ideal value which exhibited a negative allometric growth because they were less than 3. However, [11] Olele NF, Obi A reported positive allometric growth (3.1).

According to [12] Abdallah M, commonly seen in most fishes both of the tropical and temperate regions are their 'b' values ranging from 2.7 to 3.3. This means that the mean body weights of females are heavier than the males in the same length group. Males of *Mormyrus rume* caught in the reservoir throughout the study period were thinner than their female counterparts.

[6] Holden M and Reed W confirmed that, female Mormyrids usually grow in larger size than males and are highly prolific. Basically, for *Mormyrus rume* in particular, its pattern was mostly influenced by the local regular climatic variation. However, it was observed that relatively higher 'b' values were obtained at the beginning of the wet season between December, 2010 and March 2011, and right at the end of high water level in April, 2011.

Furthermore, the increase in weight of any individual was not due to a single factor but various factors [13]. The factors could be either intrinsic or extrinsic, or both and favored by the changes of the growth parameters (length and weight) of the fish [14].

3.3 Condition factor

The condition factor (index) of the fishes sampled, indicated that the fishes were doing well. Condition factor expresses the general well-being of a fish [10].

A condition factor of less than one (1) means the fish is elongated, starving and generally not in good condition. An index of 1- 1.2 means the fish is doing well. A condition index of 1.4 shows that, the fish is near spawning. The highest condition index recorded for females in this study was 2.90 in December, 2010 and the lowest recorded in April, 2011 was 1.422 whiles the males had the lowest condition factor of 1.49 in December, 2010 and highest condition factor of 2.21 in April, 2011.ranged from 2.21 in December 2010 to 2.16 and 2.09 in January to April, 2011 with the lowest condition factors of 1.49 and 2.02 recorded in March and February, 2011.

However, there was a steady increased in all the biological parameters (sex ratio, length and weight) from December, 2010 through to January, 2011. There was an increase in population of aquatic plants that supplied food and sufficient hiding places for the fishes in the water body. Many of the fishes could not be caught during this period. As the water level started reducing from January, 2011 onwards due to human activities such as farming, usage by animals as well as seepage and evaporation, the bigger fishes were exposed, resulting in continuous rise in sizes in catches from January, 2011 to March, 2011.

As a result of the massive capture of the bigger fishes during this study period, there was an over exploitation of the fishes which led to a drop in their numbers in March, 2011.

However, two good rains experienced in the middle of March, 2011 raised the water level to some extent, and this increased the population of the fishes from March, 2011 up to April, 2011.

Anibeze CIP [15] and Gomiero LM [14] and Braga FMS confirmed that better condition during the wet season was due to the availability of food and enhancement during their gonad development. However, Bontanga reservoir never experienced significant adverse environmental conditions such as drought throughout the study. The water level during the dry season was never below than one meter at the site studied. Thus, there should be no shortage of food (that is, detritus) available for the fish during the dry season and this fish growth was expected to be unaffected. Besides, there are suggestions that fish condition can be influenced by certain extrinsic factors such as changes in temperature and photoperiod [16]. The oxygen content, total suspended solid and macro nutrients in the water were among the physicochemical variables that appeared to be relatively high in the reservoir. However, those physicochemical variables might cause only a minor effect or no effects on the *Mormyrus rume* because it was found to be a dominant species especially in the middle segments of the reservoir.

Sufficient space area and abundant food supply were probably some of the main factors contributing to the steady increase in their weight and length growth throughout the study period.

3.4 Length-weight relationship and condition factor of specimens

One hundred and sixty seven (167) specimens, comprising 92 males and 75 females were examined. An overall proportion (92:75) of 1.2:0.8 male to female sex ratio was obtained. Monthly sex ratio data, together with their means, total lengths and mean body weight are shown in table 1. Features of *Mormyrus rume* involving body weight and total length were described by the correlation coefficient relationship transformed into logarithm and expressed as $\text{Log } W = aL^b$ where r^2 value for males was 0.7810 (Fig. 1) and that for females was 0.8590 (Fig. 2).

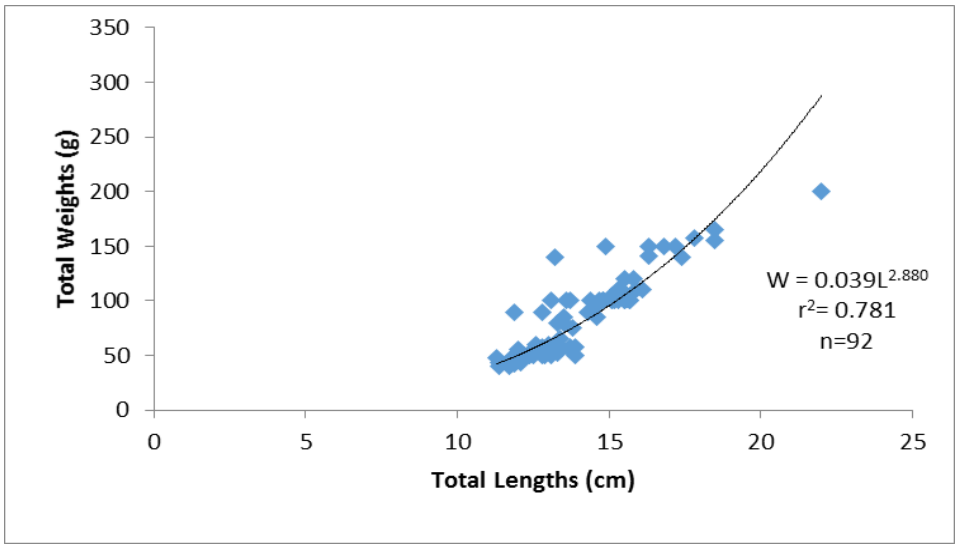

Fig 1: The monthly total lengths (cm) and total weights (g) relationship of males *Mormyrus rume* in the Reservoir at Bontanga.

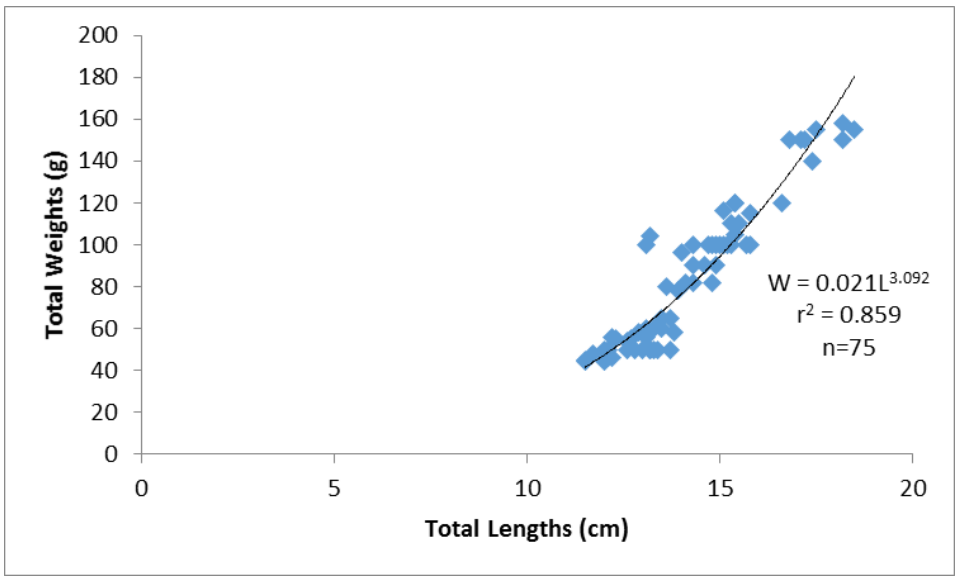

Fig 2: The monthly total lengths (cm) and total weights (g) relationship of females *Mormyrus rume* in the Reservoir at Bontanga.

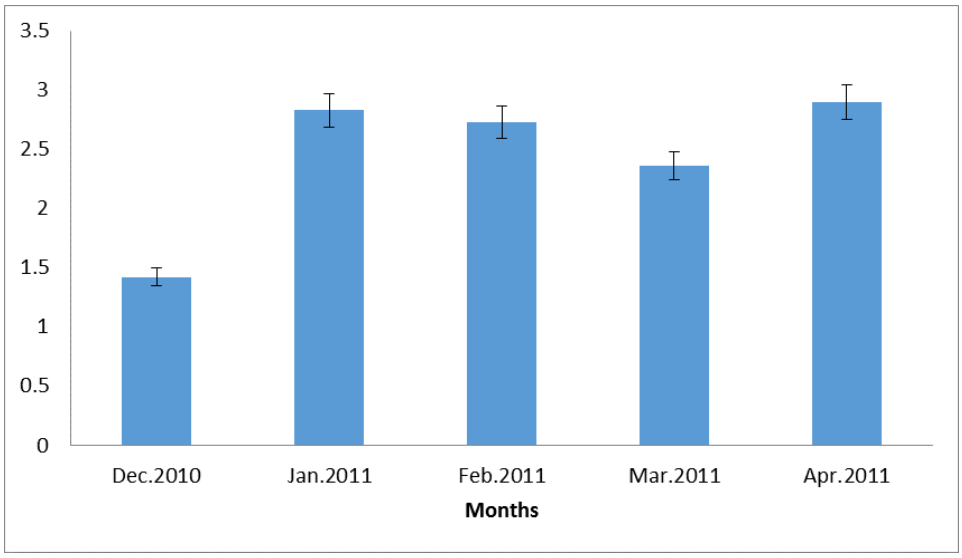

Fig 3: mean monthly variation of condition factor of male's *Mormyrus rume* from the reservoir with standard deviation bars.

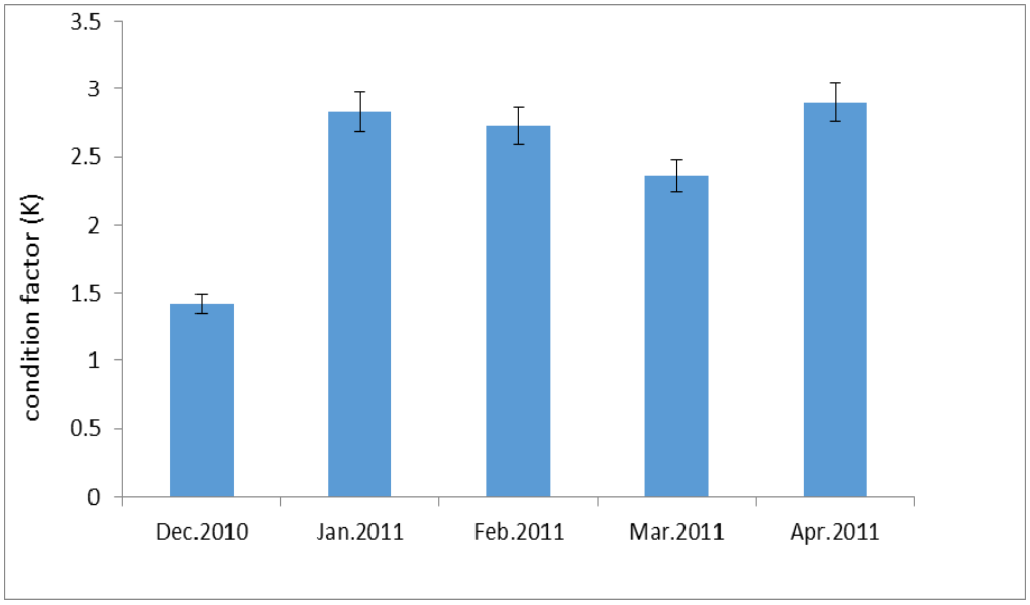

Fig 4: Mean monthly variation of condition factor (K) of female's *Mormyrus rume* with standard deviation bars.

Table 1: The relationship between mean Gonadosomatic Index (GSI) and Condition Factor (K) for female's *Mormyrus rume* with Range in parenthesis

Month	TF	GF	MTL ± SD (cm)	MTW ± SD (g)	MGW ± SD (g)	GSI	K
Dec. 2010	13	7	16.1 ± 0.9 (15.1-17.4)	98 ± 20.8 (62-122)	2.2 ± 1.5 (0.66-3.99)	2.35	1.422
Jan. 2011	10	7	15.8 ± 1.4 (14.1-17.5)	79 ± 26.1 (48-112)	2.4 ± 1.9 (0.56-5.10)	1.29	2.83
Feb. 2011	16	6	18.9 ± 1.3 (17.4-20.5)	133± 19.7 (105-155)	2.7 ± 1.8 (0.66-5.09)	1.51	2.73
Mar. 2011	12	6	16.9 ± 1.9 (14.1-19.1)	100 ± 44.7 (50-150)	1.4 ± 1.1 (0.60-3.44)	1.37	2.36
Apr. 2011	24	14	16.9 ± 1.9 (14-20.2)	100 ± 36.1 (50-158)	1.4 ± 1.3 (0.59-3.40)	3.56	2.90
Total	75		84.6	510	10.1	10.08	11.24

Legend: TF = Total Females, GF = Gravid Females, MTL = Mean Total Length, SD = Standard Deviation, MGW = Mean Gonad Weight, GSI= Gonadosomatic Index, K = condition factor

Table 2: Mean monthly relationships for total length and Total body weight of *Mormyrus rume*

Month	No. of fishes: male	MTL (cm)±SD	MTW (g)±SD	No. of fishes: female	MTL (cm)±SD	MTW (g)±SD	Sex ratio M:F
December	14	15.6±3.9 (13.3-19.4)	91.3±35.4 (50-143)	13	15.6±3.2 (13.5-17.4)	82.9±29.8 (46-122)	1.1:0.9
January	10	14.8±3.6 (13.4-17.8)	67.0±34.8 (42-122)	10	15.6±3.4 (14-17.5)	75.0±28.9 (46-112)	1:1
February	14	16.3±3.5 (13.4-18.1)	82.7±27.7 (46-122)	16	16.9±4.2 (13.5-20.5)	95.6±17.6 (47-157)	0.8:1.1
March	27	16.9±4.0 (16.8-24.0)	94.8±44.6 (52-202)	12	16.4±3.7 (14.1-19.1)	87.0±42.9 (52-152)	2.3:0.4
April	27	16.0±5.6 (13.7-20.5)	85.4±37.9 (42-167)	24	16.4±3.7 (14.0-20.2)	90.1±36.2 (52-160)	1.2:0.8

TL = Mean total length and BW = Mean total body weight

Total lengths ranged between 15.45-20.5 cm, whiles total body weights varies from 79.0 to 212.0g

Condition factor: Revealed that male specimens (55.1), were in a better condition than the female specimens (44.9) based on their mean values calculated as fresh body weight.

Table 3: Mean monthly variation of condition factor of male's and female's *Mormyrus rume* with range in parenthesis.

Month	No. of fishes: Male	MTL(cm)±SD	MTW(g)±SD	K	No. of fishes: Female	MTL(cm)±SD	MTW(g)±SD	K
Dec.	14	15.6±3.9 (13.3-19.4)	91.3±35.4 (50-143)	2.21	13	14.1±0.9 (13.1-15.4)	82.9±29.8 (46-122)	1.422
Jan.	10	16.3±3.5 (13.4-18.1)	91.3±35.4 (50-143)	2.16	10	13.8±1.4 (12.1-15.5)	75.0±28.9 (46-112)	2.83
Feb.	14	16.3±3.5 (13.4-18.1)	82.7±27.7 (46-122)	2.02	16	16.9±1.3 (15.4-18.5)	95.6±17.6 (47-157)	2.73
Mar.	27	16.9±4.0 (16.8-24.0)	94.8±44.6 (52-202)	1.49	12	14.9±1.9 (12.1-17.2)	87.0±42.9 (52-152)	2.36
Apr.	27	16.0±5.6 (13.7-20.5)	85.4±37.9 (42-167)	2.09	24	14.9±1.9 (12.0-18.2)	90.1±36.2 (52-160)	2.90
Total	92	85.9	98.50	9.97	75	74.60	100.80	11.24

TF= total number of fish, MTL= Mean Total Length, MTW= Mean total body weight of fish, K= condition factor

4. Conclusion

Mormyrus rume belongs to the family Mormyridae which is one of the largest groups of fishes. Their ability to feed on a wide range of organisms at different trophic levels (food chain) was the possible reason for their fast growth rate, making them promising candidates for commercial culture. Since the species are widely accepted and used as human food throughout the area in which they occur, they could be easily incorporated into local polyculture systems with minimal inputs of expensive animal protein in their diet.

This was clearly revealed by the condition factor (K) of the fishes with respect to sustainability of fish well-being as indicated of fish samples collected with the highest value for males. The sex ratio of males to females (92:75) was 1.2:0.8 and this clearly gave an indication of lower reproduction efficiency since male population was higher than the female population.

5. Acknowledgement

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