Available online at www.elixirpublishers.com (Elixir International Journal)

Applied Zoology

Elixir Appl. Zoology 79 (2015) 30438-30443

ISSN: 2229-712X

Analysis of the Fecundity and Gonadal stages of African carp, *Labeo senegalensis* (Valenciennes, 1842) from the White Volta, Ghana

Abobi S.M*, Alhassan E.H and Asare I.O

Department of Fisheries and Aquatic Resources Management, University for Development Studies. P.O. Box TL 1882 Tamale, Ghana.

ARTICLE INFO

Article history:
Received: 14 December 2014;
Received in revised form:
20 January 2015;
Accepted: 12 February 2015;

Keywords
White Volta, Condition factor,
Length weight relationship
Gonad,
Gonado-somatic index

ABSTRACT

One hundred and fifty specimen of *Labeo senegalensis* caught by gill nets from the White Volta at Yapei, Ghana were examined for the stages of gonad maturity, eggs, length-weight relationship (LWR) and condition factor during the dry season of 2013. Out of the 150 specimen, 89 were females and 61 were males. The sex ratio of males to females was thus 1: 1.5. Eleven out of the 89 females were found to contain gonads. The stages of gonad maturity ranged from immature stage to maturity stage. The total eggs found in the eleven female was 2,385 with a mean value of 217 eggs per gravid female of the species. The Gonado- Somatic Index ranged from 1.29 to 3.28 with a mean of 2.0 ± 0.57. The total length of *Labeo senegalensis* ranged from 9.5 cm- 24.6 cm with a mean of 16.0 cm ± 2.86 cm. The body weight of *Labeo senegalensis* ranged from 20 grams - 212 grams with a mean of 121.34 grams ± 93.89 grams. The LWR of species was highly significant ($P<0.001$) with r^2 of 0.907. The LWR of the *Labeo senegalensis* was $W = 0.180 \times TL^{2.66}$ with a slope *b* of 2.6 which indicated a negative allometric growth pattern ($b<3$) of the species. The Condition factor ranged from 0.93 to 2.90 and with a mean of 1.926 ± 0.61. The general wellbeing of the *Labeo senegalensis* was suitable during the study period.

Introduction

In Ghana, fisheries constitute an important sector in the national economic development and are estimated to contribute 4.5 percent of the total Gross Domestic Product (GDP) and 5 percent of the Gross Domestic Product (GDP) in agriculture in the year 2009. The fisheries (both marine and freshwater) sector employs an estimate of (2) two million people. The sector produces a total of 420,000tons of the 880,000 tons needed annually. Deficit of 460,000 tons is made up through fish import 2008-2009 (Kwadjosse*,* 2009).According to FAO statistics, inland capture fisheries contributed 27 percent of total Ghanaian fish production in 2009 (FAO, FishStat Plus). It is estimated that the Volta River provides 90 percent of national freshwater fish production (Abban, 1999).

The landings of freshwater fish in Ghana were officially estimated to be 75,000 tons in 2006 and formed 20 percent of the total fish landings from the country. The estimated landings for Lake Volta are probably greatly underestimated. The estimated catch is between 150, 000 and 200, 000 tones/year (De Graaf and Ofori-Danson, 1997). Other unpublished catch estimates based on reservoir-wide catch-assessment surveys and frame surveys proposed that the reservoir produced 217,000–251,000 tones in 2000 (Braimah, 2000, 2001, 2003). Abobi *et al.* (2014) reported *Labeo senegalensis* as one of the top 10 most abundant species out of 52 freshwater species the authors encountered at the Yapei stretch of the White Volta.

Freshwater fish is an essential irreplaceable source of highly quality cheap animal protein crucial to balanced diet in marginal foods. Fish contain important nutrients such as essential fatty acids, calcium, iron and vitamins (Paul and Southgate, 1978). Cyprinidae are highly important food fish and they make the largest part of biomass in most water bodies except for fast flowing rivers (Turan *et al*., 2013). According to Mayhew and Penny (1988), fish is quicker to cook and is more easily digested than meat of other animals. People in Yapei depend on the fisheries for their livelihood. The demand for fish and fishery product has put tremendous pressure on our oceans and fresh water bodies which are in many instances already strained to the limit. According to FAO (1991), fish production had risen almost five folds over the past 40 years from 20 million tones toover 100 million tonsin 2010.

There has been no appreciable increase in annual fish production over the years. In 2003, Ghana produced only 51.7 percent of its requirements from its domestic sources and in 2004, achieved 68.1 percent of its fish requirement through domestic production and imports. Tilapia is the major species farmed and constitutes over 80 percent of aquaculture production. The catfishes; (*Clarias sp*., *Heterobranchus sp*. and *Heterotis niloticus*) account for the remaining 20 per cent (FAO., 2005).

In Ghana, there are four (4) major inland water bodies namely, the Volta river (including Black, White, Red Densu, Oti and Pra river), Keta lagoon ($330km^2$), lake Bosomtwi ($49km^2$) and the Volta lake ($844\ km^2$) plus more than fifty (50) brackish water bodies dotting the coastline, most of which are RAMSAR designated sites (Ewer, 1966).The Volta River Basin occupies $417{,}382\ km^2$ in six countries .The basin drains 70 percent of Ghana. Basin elevation range from sea level to 920 m above sea level, with a mean elevation of 257m and correspondingly low channel grades. The lower Volta River is fed by three major tributaries. To the west, the Black Volta River or Nakambe River drains $147\ 000\ km^2$, mostly of western Burkina Faso with small areas of Mali and Cote d'Ivoire (Evans and Vanderpuye, 1973).The White Volta River or Nazinon River drains $10,\ 000\ km^2$ including much of northern and central Ghana and Burkina

Tele:
E-mail addresses: mabobi@uds.edu.gh

Faso. To the east, the Oti River drains 72 000 km^2 of northwestern Benin and Togo. The three tributaries join in northern Ghana to form Lake Volta. The basin is primarily underlain by a Voltarian formation consisting of sandstone, shale's and mudstones. Another formation is Precambrian classified into Birimain, Buem and Tarkwaian rocks (Dickson and Benneh, 1977). Currently, one hundred and twenty one (121) species have been identified in the Volta reservoir (Dankwa *et al*., 1999). It is also known that 32 fish species are present that were not recorded during the early stages of reservoir filling (Denyoh, 1969).

Cyprinidae are large family of freshwater fishes that comprise of the carp, the true minnows and their relatives commonly called the carp family or minnows (Holden and Reed, 1972). Its members are known as cyprinids. It is the largest fish family and the largest family of vertebrate animal in general. The family belongs to the order cypriniformes. The family is derived from the ancient Greek kyprinos (carp).*Labeo senegalensis* locally called Gbingbinifufu in the west Gonja District are extremely fecund by nature (Holden and Reed, 1972) and display a worldwide distribution in fresh waters with a maximum length 65.0cm and a maximum weight of close to 4Kg and maximum age of six (6) years (Lagler, 1971). *Labeo senegalensis* is a stomach less fish with a toothless jaw. It has a snout with tubercles slightly apparent, center of scales pinkish and surrounding zones lined with melanophores which form undulating longitudinal lines. *Labeo senegalensis* tolerate best in a temperature range of 22 -26^0C (Encyclopedia Britannica, 2006).Its distribution is known from Chad, Niger, Gambia and Volta as well as some coastal basins (Dankwa *et al*., 1999). According to Agyen-Tweneboah (2007) cyprinid dominated by *Labeo senegalensis* was abundant in the Yapei stretch with a relative abundance of 16.3%.The fecundity of *Labeo senegalensis* is particularly significant because of their vulnerability to overfishing. The total number of eggs laid during the spawning could thus be used in estimating fish population. In fisheries biology, absolute fecundity is defined as the number of ripe eggs in the ovaries prior to spawning of the individual female fish (Bagenal, 1978).This attribute is fundamental to the comprehension of reproductive life history of fishes and is useful in various applied aspect of fisheries biology and pisciculture (King, 1995).

Labeo species are food fishes and they also support fishing industry in Africa (Weyl and Booth, 1999). Gonads are the organs in the animal that produce the gametes. Female fish have paired ovaries that produce the eggs and the male fish have paired testes that produce the sperms which along with seminal fluid are termed as milt. When conditions are right, organisms can produce more species than it takes to replace themselves. Many factors control or regulate the growth of population.

In the Northern Ghana, rivers, dams, reservoirs and dug out are the main source of fish supply (Dankwa *et al*., 1999). Apart from farming, fishing is the next occupation that highly engages most of the habitant of Yapei.

The research was necessitated by the fact that, there is limited information on the fisheries of the Yapei stretch of the White Volta River unlike the Black Volta.

The studies on reproductive behavior of fish are important and a basic requirement for improvement and effective fishery resource management and conservation (Ali and Kadir, 1996).The study was initiated to give information on some aspect of reproductive biology such as fecundity and sex ratio which can be used to manage the fishery properly.

The study of fecundity and gonads contribute in no mean by providing a base line data for the development, planning and direct fish exploitation which will increase domestic food supply and consequently improve the livelihood of the fisher folks in Yapei and its neighboring communities.

Materials and Methods

Study area

The study was conducted at Yapeiportion of the White Volta River in the Central Gonja District of the Northern region of Ghana. Yapei is about 43 km south-west of the regional capital, Tamale.Yapei lies within latitude 9^0 $1^1$0''N and$1^0$$10^1$ 0''W (Figure 1). The White Volta river drains an area of about 92,000km^2 (Ewer, 1966). It passes through Yapei in a north-southward direction. The river is a perennial water body with an average width of about 150 m and headstream of the great Volta River in West Africa, which has maximum depth of 75 m, an average depth of 18.8 m and elevation of 85 m above sea level.

The climate of the Central Gonja district lies within the tropical continental zone. The annual rainfall is unevenly distributed and limited to six months from May to October. The mean annual rainfall ranges between 1000-1500 mm with its peak in September. The relative humidity is between 70-90 percent during the long dry season. Temperatures are generally high and exhibit seasonal variation. The mean annual temperature of 35% with maximum temperature of about 40% is usually recorded in March to April.

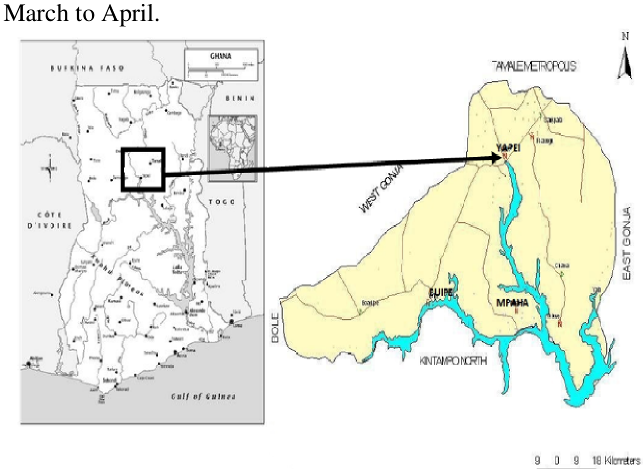

Figure 1. Map of Ghana with an insert showing Central Gonja District and study area Yapei

Data collection

Fish sampling

A total number of 150 *Labeo senegalensis* (plate 1) were collected from the landing site of the Yapei stretch from January to March 2013. The fish were caught by the gill net.

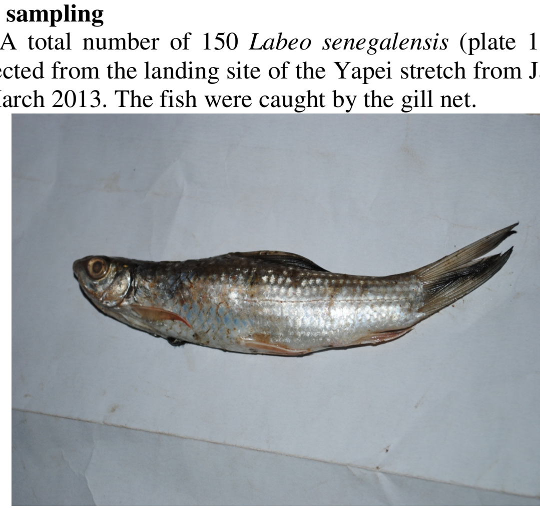

Plate 1. *Labeo senegalensis* from the White Volta, Yapei, Ghana

Measurement

Total length (cm) of each fish was taken from the tip of the fish mouth to the extended tip of the caudal fin using a measuring board and recorded to the nearest 0.1cm and the figure recorded. Standard length (cm) for each fish was recorded from the tip of the fish mouth to the caudal peduncle to the nearest 0.1 cm. The total body weight in grams was measured for each fish and recorded to the nearest 0.00 g using a weighing scale.

Laboratory analysis

The specimens were cut open on the ventral side and the gonads were carefully removed and weighed on the top of a loading electric balance. The sex of each specimen was recorded and the gonads were classified into gonadal stages of development according to Nikolsky (1963)

Length- weight relationship

Length-weight relationship provides information on growth patterns and growth rates of animals. During their development, fish are known to pass through stages in their life history which are defined by different length-weight relationship.

The length-weight relationship was estimated using the equation (Ricker, 1975):$W = a L^b$

The values of constant 'a' (intercept) and *b* (slope) were estimated from the log transformed values of length and weight, that is, linear regression equation: $\log W = \log a + b \log L$

Where a = intercept on y-axis; b = an exponent between 2.5and 3.5 (Bagenal and Tesch, 1978); W = Weight in grams; L = Total length in centimetres (cm).

Fecundity estimation technique

The eggs of the *Labeo senegalensis* are shown in plate 2. Fecundity estimation Technique was generally done by counting 100 eggs with the colony counter and the weight taken with the precision balance. The total weight of the eggs was then taken and the total number of eggs per berried female was estimated according to Baxter (1959) by the ratio:

$$\text{Fecundity} = \frac{\text{Weight of Total Eggs}}{\text{Weight of 100 Eggs}} \times 100$$

Gonado- Somatic Index

The Gonado- somatic index (GSI) is calculated as percentage (%) of the gonad weight to the body weight.

$$GSI = \frac{\text{Gonad Weight}}{\text{Body Weight}} \times 100$$

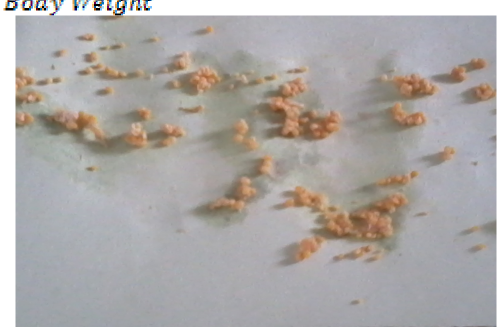

Plate 2. Eggs of *Labeo senegalensis* from the White Volta, Yapei, Ghana

Condition factor

The condition factor refers to the mathematical formula for determining the physiological state of a fish including its reproductive capacity. It is calculated by dividing the fish weight by the length cubed (W/L^3).The heavier a fish for a given length, the higher its condition factor (K).

$$\text{Condition Factor (K)} = \frac{\text{Weight (grams)}}{\text{Length (cm)}^3} \times 100$$

Data analysis

Data was analysed using the statistical packages: STATISTICA 8.1 and Microsoft Office Excel, 2013.Means were expressed with Standard deviations (± SD).Relationships between variables (weight vs. length, fecundity vs. body weight/ length) were carried out using the regression analysis.

Results

Length and weight distribution

Table1 shows the total number of specimen examined in each month while Table 2 shows the length-weight distribution of 150 (one hundred and fifty) specimens caught and examined. Eight-nine (89) were females representing 59.3% and Sixty one (61) were males representing 40.7%. Females of *Labeo senegalensis* dominated in the study than the male specimen. Eleven females were found to contain gonads in them. Three months namely (January, February and March) were used for the studies. January recorded, 52 fishes (20 males, 32 females and 3 gonads) whiles February recorded, 50 fishes (22 males, 28 females and 4 gonads) and March recorded 48 fishes (19 males, 29 females and 4 gonads)

Table 1. Monthly number of fishes sampled

Month/Year	No. of Fishes Sampled	Males	Females	Females with gonads
January 2013	52	20	32	3
February 2013	50	22	28	4
March 2013	48	19	29	4
Total	150	61	89	11

The total length of the 150 fishes ranged from 9.5 cm - 24.6 cm with a mean of 16.3 and a standard deviation of± 2.86 and the standard length ranged from 6.2 cm -20.7 cm with a mean of 13.0 and a standard deviation of± 2.27. The body weight of the 150 fishes ranged from 20 g- 212 g with a mean of 121.34 and standard deviation of ± 93.89.

Table 2. Total length, standard length and body weight distribution

Parameters	Total length (cm)	Standard length (cm)	Body weight(g)
Range	9.5-24.6	6.2-20.7	20-212
Mean (S.D(±))	16.3±2.86	13±2.27	121.34±93.89

S.D.: Standard deviation

Length -weight relationship

Figure 2 is a scatterplot showing the linear relationship between the weight and the length of *Labeo senegalensis* from the Yapei stretch of the White Volta. The length- weight relationship of the species had a fitted linear equation of $W = 0.180 \times TL^{2.66}$ ($r^2 = 0.907$) where W= body weight, TL = Total length and the exponential *b* value (slope) was 2.66.

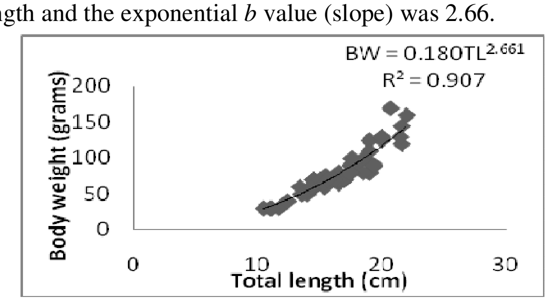

Figure 2. Length- weight relationship of *Labeo senegalensis* from the WhiteVolta.

Condition factor

The Minimum value of the condition factor was 0.93 and the maximum value was 2.90 with a Standard deviation of ± 0.61. A summary of the condition factor is presented in Table 3 below.

Table 3. Condition factor of *Labeo senegalensis*

Parameters	SL (cm)	TL(cm)	W(g)	Condition factor(K)
Min.	6.2	9.5	20	0.93
Max.	20.7	24.6	212	2.90
Mean	13	16.3	121.3	1.92
SD(±)	2.27	2.86	93.89	0.61

SL: Standard Length; TL: Total length; W: Weight; S.D.: Standard deviation;

Stages of gonadal development

Four (4) stages of gonadal development were observed from the eleven (11) female fishes as shown in Table 5. Immature specimen dominated the catch, mature females were found in March whiles mature males were found in the mid-January and February as shown in Table 4 below.

Table 4. Monthly occurrences of stages of gonadal development

Months/ Gonad Stages	I Immaturity stage	II Resting stage	III Maturation stage	IV Maturity stage
Jan.	2	1		
Feb.	1	1	1	1
Mar.	1	1	1	1
Total	**4**	**3**	**2**	**2**

Gonad weight and total number of eggs

Table 5 presents the total number of eggs and weights of the 11 gravid females. The total number of eggs in the eleven (11) female fishes was 2,385 eggs with a mean of 216.8. The total weight of gonads was 21.89 g with a mean of 1.99.

Table 5. Gonads weight and their total number of eggs

Gonads	Weight (g)	Total Number of Eggs
Fish1	2.40	320
Fish2	1.60	197
Fish3	1.97	196
Fish4	1.88	210
Fish5	3.00	320
Fish6	1.76	172
Fish7	2.18	210
Fish8	1.54	135
Fish9	1.98	217
Fish10	2.14	263
Fish11	1.50	145
Total	**21.89**	**2,385**
Mean	**1.99**	**216.8**

Gonado- Somatic Index (GSI)

The GSI ranged from 1.29 to 3.28 with a mean and a standard deviation of 2.0 and ± 0.57 respectively. A complete summary of the GSI is shown in Table 6.

Table 6. Gonado-somatic index (GSI)

Fish	Gonad Weight (g)	Body Weight (g)	Gonado-Somatic Index (GSI)
Fish1	2.40	100	2.40
Fish2	1.60	74	2.16
Fish3	1.97	60	3.28
Fish4	1.88	110	1.71
Fish5	3.00	190	1.57
Fish6	1.76	85	2.07
Fish7	2.18	180	1.21
Fish8	1.54	70	2.20
Fish9	1.98	100	1.98
Fish 10	2.14	165	1.29
Fish 11	1.50	70	2.14
Mean	1.99	109.45	2.00
± S.D	0.436	47.056	0.573

Discussion

The overall sex ratio of males to females in this study was 1: 1.5. This is different from the expected ratio of 1 male to 1 female. The sex ratio of *Labeo senegalensis* is approximately 1: 1 which is different from the ratio of 1 male to 1.5 females observed in this study. Nilkosky (1963) revealed that the sex ratio varies considerably from species to species, but in most of cases it is close to one and may vary from year to year in the same population.

According to Holden and Reed (1972) *Labeo senegalensis* are extremely fecund in nature and display a worldwide distribution in freshwater with a maximum length of65 cm and a maximum weight of close to 4 kg but in this study, *Labeo senegalensis* attained a maximum length of 24.6 cm and a maximum weight of 212 g which are different from what Holden and Reed (1972) reported and it is possibly an indication of less matured/adult and less gravid populations during the study period. Again, Leveque and Daget (1984), confirmed unsexed *Labeo senegalensis* has maximum total length of65 cm and maximum weight of 3.8 kg which greatly above the maximum length of 24.6 cm and a maximum weight of 212 g recorded in this study. It implies that most of the *Labeo senegalensis* species sampled during the study might not have reached their full maturity.

The slope *b* for the length- weight relationship has a numerical value which is mostly between 2.5 and 3.5 and is often close to 3 (Bagenal and Tesch, 1978; Carlander, 1969).Even though the b value (2.6)from this study is within the acceptable range it exhibited a negative allometric ($b<3$). The negative allometric means the fish becomes more slender as its length increases.

A work carried on *Labeo senegalensis* from the tributary of the Volta river in Ghana by Entsua-Mensah *et al.* (1995), recorded *b* value of 3.08 (as presented in Table 7) indicating that species tend to become relatively fatter or have more girth as it grows (Murphy *et al.,* 1991) which is different from the obtained *b* value of 2.66 in this study which could be as a result of differences in ecological condition or some physiological parameters.

In the study, the mean condition factor (K) value was 1.92 with a standard deviation of ± 0.61 which is high and indicates favorable environmental conditions such as suitable habitat and prey availability which is comparable to the mean value of 1.87± 0.61 Blackwell *et al*. (2000) reported on *Labeo parvus* belonging to the same family with *Labeo senegalensis* (Cyprinidae).

Condition factor does not merely reflect the feeding condition of the adult stage, but includes the state of gonadal development based on the consumption of fat reserve during spawning period (Vazzoler and Vazzoler, 1965). The average value of gonado- somatic index (GSI) of the female fishes in the study was 1.9. According to Snyder (1983), the GSI range between 0 – 2 means that fishes are not preparing to spawn. It therefore implies that the female fishes in this study were not preparing to spawn. It is supported by the fact that Paugy (2002) reported *Labeo senegalensis* as a flood spawner and the study period was mainly during the dry season of the year which could not have triggered spawning. *Labeo senegalensis* as a benthopelagic species of freshwater body lays 50-2,000 eggs per year which is encompasses the range of 135-320 eggs estimated in this study.

Table 7. A summary of Length- weight relationships and condition factors of some selected studies

Species	Location	year	Number	Min. (L) cm	Max. (L) cm	b value	r^2 value	Mean C.F (K)	References
Labeo senegalensis	Ghana	2013	150	6.2(SL)	20.7(SL)	2.661	0.907	1.92	Present study
Labeo senegalensis	Ghana	1995	270	6.4 (SL)	28 (SL)	3.082	0.992	-	Entsua-Mensah *et al.* (1995)
Labeo senegalensis	Ghana	-	270	6.4 (SL)	28(SL)	3.082	0.984	-	Entsua-Mensah *et al.* (1995)
Labeo senegalensis	Benin	1999 - 2001	917	7.8 (TL)	40(TL)	2.999	0.984	-	Laleye (2006)
Labeo coubie	Ghana	1995	125	6.6(SL)	22.8(SL)	3.162	0.994	-	Entsua-Mensah *et al.* (1995)
Raiamas senegalensis	Ghana	1995	75	7.7 (SL)	18(SL)	3.233	0.979	-	Entsua-Mensah *et al.* (1995)
Labeo parvus	Ghana	1995	198	7.1(SL)	21.2(SL)	3.206	0.993	-	Entsua-Mensah *et al.* (1995)
Labeo rohita	India	2012	250	39 cm (TL)	70 cm (TL)	2.852	0.98	1.60	Prasad *et al.* (2012)

Key: Min.: Minimum; Max. : Maximum; SL: Standard length, TL: Total length; C.F: Condition factor

According to Entsua-Mensah *et al.* (1995), the minimum and maximum standard lengths ranged from 6.4 -28.0 cm respectively which is similar to 6.2 cm -20.7cm in this study. The correlation coefficient (r^2) value reported by the authors was 0.992 which is comparable to the obtained (r^2) value of 0.907 in this study. The weight-length model from this study is thus a good means of estimating the weight of *labeo senegalensis* from the length of the species. The authors further indicated that *labeo senegalensis* in Volta River, Ghana, had *b* value of 3.082 which is comparable to the obtained *b* value of 2.661 obtained in this study. Moreover, it is similar to *b* value of 2.999 reported by Laleye (2006) on *Labeo senegalensis* from the Ouémé River in Bénin (West Africa).

A work carried on *Labeo rohita* (a species belonging to the same family with *labeo senegalensis* Cyprinidae) from the Govinddgarh lake in India by Prasad *et al.* (2012), recorded *b* value of 2.852 which is comparable to the obtained *b* value of 2.661 in this study indicating an isometric growth pattern. According to Prasad *et al.* (2012), the minimum and maximum total length was 39 cm - 70 cm respectively (as shown in Table 7) which is larger than the obtained minimum and maximum total length of 9.5cm - 24.6 cm respectively in this study which could be to the differences in the fishing gears as fishermen on the White Volta at Yapei practice unregulated and unselective fishing with fishing net of small mesh sizes. According to the authors, the mean condition factor was 1.60 which is comparable to the obtained mean value of 1.92 in this study indicating a better state of wellbeing of *Labeo senegalensis* at Yapei stretch of the White Volta than what the authors reported.

Conclusion

The *b* value of the regression analysis showed that species of *Labeo senegalensis* sampled from January to March from the White Volta River exhibited an isometric growth pattern and was within the acceptable range of the *b* value of 2.5 – 3.5 for tropical fish stock.

The mean condition factor (K) of 1.92 in this study is high and shows a good state of wellbeing of *Labeo senegalensis* in the Yapei stretch of the White Volta.

The mean GSI had of 1.9 indicates that fishes were not preparing to spawn. The eggs estimated in this study were within an acceptable egg range of 50 to 2,000 eggs for the species.

Acknowledgements

We wish to express our profound gratitude to the staff of Spanish Laboratory, at the Nyankpala campus of the University for Development Studies for their assistance during the laboratory examination and analysis of our samples.

References

1. Abban, E.K., 1999. Integrated development of artisanal fishes. Integrated Development of Artisanal Fisheries Project No. GHA/93/008, pp: 1-43. http://www.fao.org/docrep/015/i1969e/i1969e02.pdf
2. Abobi, S.M., E.H. Alhassan, E.D. Abarike, A. Ampofo-Yehoah, S. Atindana and D.N. Akongyuure, 2014. Species composition and abundance of freshwater fishes from the lower reaches of the White Volta at Yapei, Ghana. J. Biodivers. Environ. Sci., 4: 1-5. http://www.innspub.net/wp-content/uploads/2014/04/JBES-Vol4No4-p1-5.pdf
3. Agyen-Tweneboah, D., 2007. Fish species composition and abundance in the White Volta at Yapei in Central Gonja District, northern region of Ghana. B.Sc. Thesis, University for Development Studies, Tamale, Ghana.
4. Ali, A.B. and B.K.A. Kadir, 1996. The reproductive biology of the cyprinid, *Thynnichthys thynnoides* (Bleeker), in the Chenderoh Reservoir: A small tropical reservoir in Malaysia. Hydrobiologia, 318: 139-151. http://link.springer.com/article/10.1007/BF00016676#
5. Bagenal, T.B. and F.W. Tesch, 1978. Age and Growth. In: Methods for Assessment of Fish Production in Fresh Waters, Bagenal, T.B. (Ed.). 3rd Edn., Blackwell Scientific Publication, Oxford, UK., ISBN-13: 9780632001255, pp: 101-136.
6. Bagenal, T.B., 1978. Aspects of Fish Fecundity. In: Ecology of Freshwater Fish Production, Gerking, S.D. (Ed.). Wiley, Blackwell Scientific Publications, New York, ISBN-13: 9780632002566, pp: 75-102.
7. Baxter, I.G., 1959. Fecundities of winter-spring and summer-autumn herring spawners. J. Conseil Int. Explor. Mer., 25: 73-80. DOI: 10.1093/icesjms/25.1.73
8. Blackwell, B.G., M.L. Brown and D.W. Willis, 2000. Relative weight (Wr) status and current use in fisheries assessment and management. Rev. Fish. Sci., 8: 1-44. DOI:10.1080/10641260091129161
9. Braimah, L.I., 2000. Full frame survey at Lake Volta, Ghana-1998. Fisheries Subsector Capacity Building Project, IDAF Project, Integrated Development of Artisanal Fisheries (IDAF), Yeji, Ghana, pp: 1-196. http://www.fao.org/docrep/015/i1969e/i1969e02.pdf
10. Braimah, L.I., 2001. Volta Lake fisheries management plan. Fisheries Subsector Capacity Building Project, IDAF Project,

Integrated Development of Artisanal Fisheries (IDAF), Yeji, Ghana. http://www.fao.org/docrep/015/i1969e/i1969e02.pdf
11. Braimah, L.I., 2003. Fisheries management plan for the Volta Lake, Ghana. Report Prepared for the Directorate of Fisheries, Ministry of Food and Agriculture (MAF), Accra, Ghana, pp: 1-77. http://www.fao.org/docrep/015/i1969e/i1969e02.pdf
12. Carlander, K.D., 1969. Handbook of Freshwater Fishery Biology, Volume 1. 3rd Edn., Iowa State University Press, Ames, USA., ISBN-13: 9780813807096, Pages: 397.
13. Dankwa, H.R., E.K. Abban and G.G. Teugels, 1999. Freshwater Fishes of Ghana: Identification, Distribution, Ecological and Economic Importance. Koninklijk Museum voor Midden-Afrika, Belgium, ISBN-13: 9789075894257, pp: 25-38.
14. De Graaf, G.J. and P.K. Ofori-Danson, 1997. Catch and fish stock assessment in stratum VII of Lake Volta. Integrated Development of Artisanal Fisheries Project/Technical Report No. 97/ I, FAO, Rome, pp: 1-96. http://www.fao.org/docrep/015/i1969e/i1969e02.pdf
15. Denyoh, F.M.K., 1969. Changes in Fish Populations and Gear Selectivity in Volta Lake. In: Man-Made Lakes: The Accra Symposium, Obeng, L.E. (Ed.). Ghana University Press, Accra, Ghana, pp: 206-219. DOI:10.1016/0165-7836(81)90039-4
16. Dickson, K.B. and G. Benneh, 1977. A New Geography of Ghana. Longman, USA. ISBN-13: 9780582603431, Pages: 173.
17. Entsua-Mensah, M., A. Osei-Abunyewa and M.L.D. Palomares, 1995. Length-weight relationships of fishes from tributaries of the Volta River, Ghana: Part I. Analysis of pooled data sets. Naga ICLARM Q., 18: 36-38. http://www.worldfishcenter.org/Naga/na_1448.pdf
18. Evans, W.A. and J. Vanderpuye, 1973. Early Development of the Fish Populations and Fisheries in Volta Lake. In: Man-Made Lakes: Their Problems and Environmental Effects, Ackermann, W.C., G.F. White and E.B. Worthington (Eds.). American Geophysical Union, Washington, DC., USA., pp: 114-120.
19. Ewer, D.W., 1966. Biological investigations on the Volta Lake, May 1964 to May 1965. In: Man-Made Lakes, Lowe-McConnell, R.H. (Ed.). Academic Press, New York, pp: 21-31.
20. FAO., 1991. Where are the best opportunities for fish farming in Ghana? The Ghana geographical information system as a decision-making tool for fish farming development. Field Technical Report 5, FI: TCP/GHA/0051, Food and Agriculture Organization (FAO), Rome, Italy, March 1991. http://www.fao.org/3/contents/d3117edd-0408-5852-9991-a3308fe8a087/AC106E00.htm.
21. FAO., 2005. Fishery Statistics: Aquaculture Production. Vol. 96/2, Food and Agriculture Organization (FAO), Rome, Italy, ISBN-13: 9789250053387, Pages: 195.
22. Holden, M. and W. Reed, 1972. West African Freshwater Fish. Longman Group Ltd., UK.,pp:68.http://www.scielo.sa.cr/scielo.php?script=sci_nlinks&ref=735392&pid=S0034-774420020002000270007&lng=en
23. King, M., 1995. Fisheries Biology, Assessment and Management. John Wiley and Sons, UK., ISBN-13: 9780852382233, Pages: 341.
24. Kwadjosse, T., 2009. The law of the sea: Impacts on the conservation and management of fisheries resources of developing coastal states-the Ghana case study.
25. Proceedings of the Asia-Pacific Meeting on the United Nations-Nippon Foundation of Japan Fellowship Programme, April 13-15, 2009, Tokyo, Japan, pp: 1-88. http://www.un.org/depts/los/nippon/unnff_programme_home/fellows_pages/fellows_papers/kwadjosse_0809_ghana.pdf
26. Lagler, K.F., 1971. Capture, sampling and examination of fishes. Int. Biol. Programme, 3: 7-44. DOI: 10.1577/1548-8659(1976)105411:AGAFOT2.0.CO;2
27. Laleye, P.A., 2006. Length-weight and length-length relationships of fishes from the Oueme River in Benin (West Africa). J. Applied Ichthyol., 22: 330-333. DOI: 10.1111/j.1439-0426.2006.00752.x
28. Leveque, C. and J. Daget, 1984. Cyprinidae. In: Check-List of the Freshwater Fishes of Africa, CLOFFA, Volume 1, Daget, J., J.P. Gosse and D.F.E.T. van den Audenaerde (Eds.). Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM)/Musee Royal de l'Mrique Centrale (MRAC), Tervuren, Belgium, pp: 217-342.DOI: http://dx.doi.org/
29. Mayhew, S. and A. Penny, 1988. Tropical and Subtropical Foods. MacMillan Publishers, London, UK., pp: 291.
30. Nikolsky, G.U., 1963. Ecology of Fishes Apl. Academic Press, London and New York, ISBN-13: 9780125197502, Pages: 352.
31. Murphy, B.R., D.W. Willis and T.A. Springer, 1991. The relative weight index in fisheries management: Status and needs. Fisheries, 16: 30-38. DOI:10.1577/1548-8446(1991)016<0030:TRWIIF>2.0.CO;2
32. Paul, W. and L. Southgate, 1978. Fish and Meat Consumption in the Tropics. Macmillan, London, UK., Pages: 287.
33. Paugy, D., 2002. Reproductive strategies of fishes in a tropical temporary stream of the Upper Senegal basin: Baoule River in Mali. Aquat. Living Resour., 15: 25-35. DOI:10.1016/S0990-7440(01)01144-5
34. Prasad, U., P. Satanand, P.D. Prasad and P. Amitabh, 2012. Length Weight Relationship and condition factor of <i>*Labeo rohita*</i> in Govindgarh Lake, Rewa (M.P.). Indian J. Res., 1: 185-187. DOI: 10.11609/JoTT.o2590.2333-42
35. Ricker, W.E., 1975. Computation and interpretation of statistics of fish population. Bull. Fish. Res. Board Can., 191: 291-382. http://www.dfo-mpo.gc.ca/Library/1485.pdf
36. Snyder, D.E., 1983. Fish Eggs and Larvae. In: Fisheries Techniques, Nielsen, L.A. and D.L. Johnson (Eds.). American Fisheries Society, Bethesda, USA., pp: 165-197.
37. Turan, D., F.G. Ekmekci, C. Kaya and S.S. Guclu, 2013. *Alburnoides manyasensis* (Actinopterygii, Cyprinidae), a new species of cyprinid fish from Manyas Lake basin, Turkey. ZooKeys, 276: 85-102. DOI: 10.3897/zookeys.276.4107
38. Vazzoler, A.D.M. and G. Vazzoler, 1965. Relation between condition factor and sexual development in *Sardinella aurita* (Cuv. & Val. 1847). Anais Academia Brasileira Ciencias, 37: 353-359. http://www.scielo.br/scielo.php?script=sci_nlinks&ref=7695365&pid=S0101-81752003000300008000058&lng=en
39. Weyl, O.L.F. and A.J. Booth, 1999. On the life history of a cyprinid fish, *Labeo cylindricus*. Environ. Biol. Fish., 55: 215-225. http://link.springer.com/article/10.1023/A:1007543319416