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The Structural and Functional Morphology of the Hard Parts of *Brycinus nurse* (Pisces: Cypriniformes, Characidae), From Asa Reservoir, Ilorin, Nigeria

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Abstract

The structural and functional anatomy of the scale, operculum and otolith of 980 specimens of *Brycinus nurse* Paugy, from Asa reservoir was investigated within the period November 1991 to October 1993. The physicochemical parameters of the reservoir were also investigated within the same period. The scale, opercula bones and otoliths all showed growth markings. However the growth marks on the opercula bones and otoliths could not be interpreted and were not reliable in estimating the age of the species. 91.94% of the opercula bones examined had no growth marks and the phenomenon of false marks was a common occurrence in a great majority. 7.96% had only 1 growth mark and 0.10% had 2 complete growth marks. One growth mark was laid down annually on the operculum. Both the cyclical and daily growth marks were recorded on the otolith; however the daily growth marks showed a marked disparity when compared with the days of the observed age of the fish. A maximum of 4 growth marks were recorded on the scale of a female specimen of 15.10 cm TL This growth marks were produced by cutting over. Two growth marks are laid down annually on the scales. The first growth mark was laid down between January and February coinciding with a drop in temperature while the second growth mark was formed between July and August coinciding with the period of flooding in the lake. The growth marks on the scale, were clear, reliable and easy to interpret making the scale of *B. nurse* the most popular and reliable means of estimating the age and calculating the growth of the fish.

Key Words: morphology, otolith, *Brycinus nurse*, Asa reservoir, Nigeria.

Introduction

Hard parts have been used frequently and successfully in estimating the age and growth of temperate fish species. Yilmaz and Polat (2002) analysed the scale, vertebrae, otolith, opercle and subopercle of *Alosa pontica* and concluded that the vertebrae was the most reliable for ageing the species. The otolith has been used for ageing, *Sardinella aurita* (Pawson, 1990) and *Promethicthys prometheus* (Lorenzo and Pajuelo, 1999). Few such records exist for tropical species. They are the use of otoliths in ageing *Tilapia guineensis* (Fagade, 1980a) and in *Chrysichthys nigrodigitatus* (Fagade, 1980b).

The tropical fish *Brycinus nurse* (Paugy, 1986) is of great commercial importance, because it is eaten widely locally. The species is particularly fatty and has food value (Reed *et al*., 1967). However not much is known about the age and growth of the species using hard parts. Most existing records indicate that length frequency plots are commonly used in the age determination of the species.

Johnnels (1952) and Bank *et al*. (1965) initially reported the presence of scale rings on *B. nurse*. These rings were used to determine the size of fish, when the rings appear, the annual growth pauses and disparity in growth of the sexes (Johal, 1980 and Paugy, 1980b). Sellick (1976) working on a population of *Alestes* sp in Kainji, observed that more than one ring was formed in a year on the scale.

Age and growth of other Alestin species have been investigated by researchers in West and East Africa and these include (Daget, 1952; Paugy, 1982; Fasedimi, 1984; Ekpo, 1993) on the age and growth of *B. macrolepidotus* (Durand and Loubens, 1969; 1971; Hopson, 1972; 1975; Paugy, 1977; 1978) on *Alestes baremose* while those of *A. macrophthalmus* and *A. imberi* have been documented by (Bow maker, 1965; 1969; Marshall and Vanderheiden, 1977; Paugy, 1980a) respectively.

The work aims at providing information on the structural and functional anatomy of the hard parts (scale, opercula bones, and otolith) of *Brycinus nurse* and also ascertains which is the most reliable in age and growth determination.

Materials and Methods

980 specimens *B. nurse* were collected biweekly from November 1991 to October 1993 in Asa reservoir using a fleet of gillnets with stretched mesh size ranging from 3.81 to 5.00 cm. The surface water temperature was estimated using Mercury in glass thermometer calibrated in °C. The light extinction coefficient as described by Idso and Gilbert (1974) was estimated from transparency readings taken by a Secchi disc. pH and conductivity readings were obtained from a pH meter model E 512 and

conductometer model CM 25, respectively. The dissolved oxygen was estimated by the Winklers titrimetric method while the relative humidity and rainfall values were obtained from the meteorological office of the airport.

Asa reservoir is located 4 km South of Ilorin Township (80′28″-80′52″ N and 40′35″-40′45″ E) Nigeria (Figure 1). When full Asa reservoir has surface area of 302ha (Ita *et al*., 1985) with a maximum length of 18km and a maximum depth of about 14 meters at the dam site. It can hold 45.44 million litres of water.

Specimens collected were put in an ice chest and then transferred to the laboratory and stored in a deep freezer pending analysis. Each specimen was given a registration number, the total length in centimeters, the total weight in grammes and the sexes were recorded. The length-weight relationship was computed from the formula described by LeCren (1947).

$$W= a L^b$$

Where W= Total weight of fish (g)
L=Total length of fish (cm)
b= growth exponent or regression coefficient
a = constant, (intercept on the x –axis)

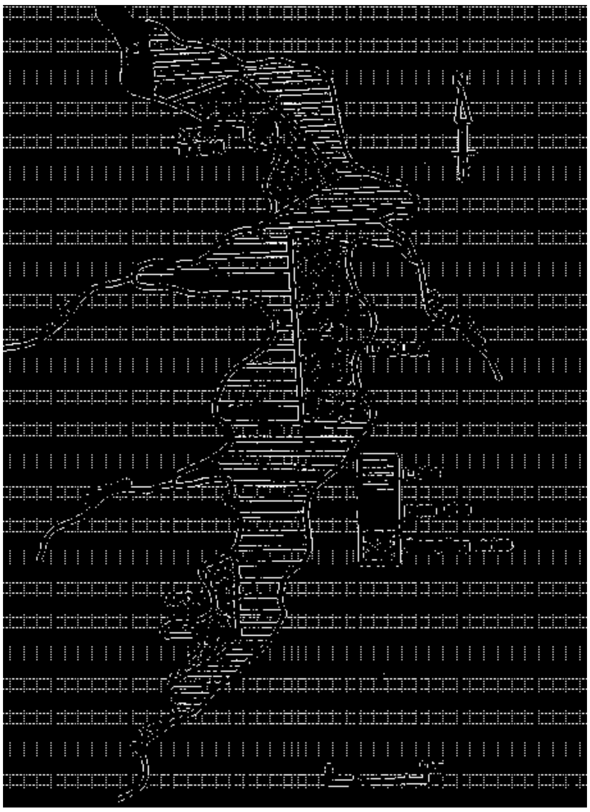


Figure 1. Asketch of Asa Lake showing the dam and sampling sites (Source: Kwara State Utility Board, Nigeria).

The scales used in age studies were removed from the region beneath the dorsal fin and above the lateral line. They were cleaned in dilute aqueous ammonia solution, rinsed and then dried. The dried scales were mounted on microscope slides and the growth marks read under a Carlzeiss projector at magnification X20. The new scale growth as described by Pollock (1981) was determined.

The opercula bones were removed by cutting away the pre sub and inter opercula and then soaked in warm water rinsed and dried and the growth marks read at a magnification of X10.

The lapillus otolith was removed by making a horizontal cut across the head just above the eye, exposing the brain. Otoliths were removed from grooves lying beneath the hind brain and kept for future examination. Subsequently, the otolith was polished, analyzed and read at magnification X40 as described by Fagade (1980 a; 1980b). Each hard part was read four times and only those readings where three or all four corresponded were regarded as valid for age and growth calculation. The otolith and opercula bone rings were counted without knowledge of scale ring counts so as to avoid possible bias. The scatter plot of scale radius, opercula size, otolith radius and otolith weight against total length was also made.

Results

A summary of the environmental factors of Asa reservoir between November 1991 and October 1993 is as illustrated in Figures 2 and 3.

The length weight relationship computed for 352 males and 628 females are as shown in Figure 4 and they are represented by the following regression equations:

Males: $Y = 1.78641 + .284202x$, $(r = 0.73)$
Females: $Y = 1.99874 + 3.03040x$, $(r = 0.89)$
The length-weight regression coefficient is 3.012

A scatter plot of scale radius, opercula size, otolith radius and otolith weight against total length is shown in Figures 5, 6, 7 and 8. These indicate a linear relationship and are represented by the following equations:

i). $Y = 5.81315 + 24.44856x1$, $(r = 0.68)$
ii). $Y = 3.83909 + 19.68352x2$, $(r = 0.69)$
iii). $Y = 0.003310 + 0.00804x3$, $(r = 0.80)$
iv). $Y = -0.00695 + 0.00072 x4$, $(r = 0.72)$.

Where Y = Total length of fish (cm) and x1, x2, x3, x4 are scale radius, opercula size, otolith radius and otolith weight respectively.

Morphology of Hard Parts

a) Scale: The general feature of the cycloid scale of *B. nurse* is shown in Figure 10-A. The oral or

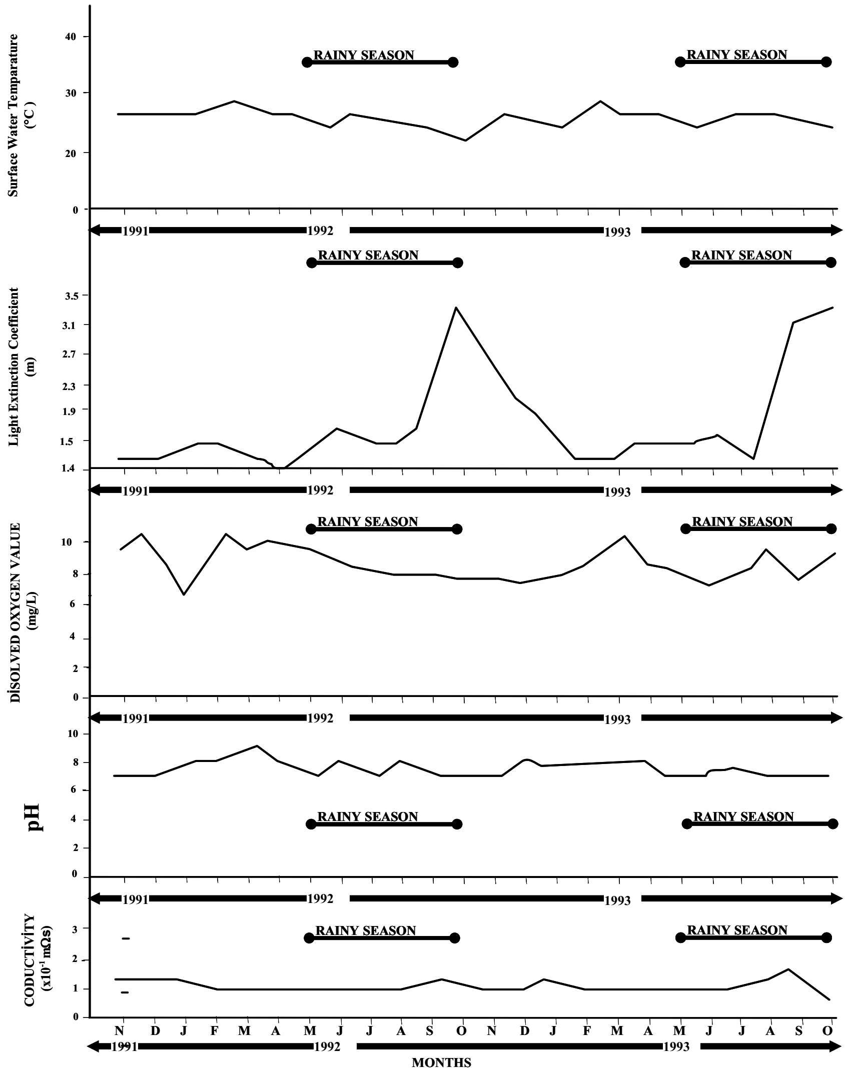


Figure 2. Monthly variation in pysicochemical factors in Asa reservoir, Ilorin, Nigeria.

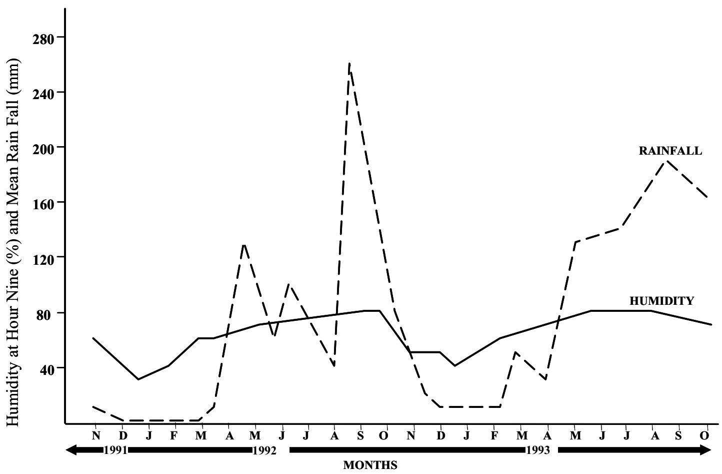


Figure 3. Monthly changes in relative humidity and rain fall in Asa reservoir, Ilorin (source: Ilorin Airport) Nigeria.

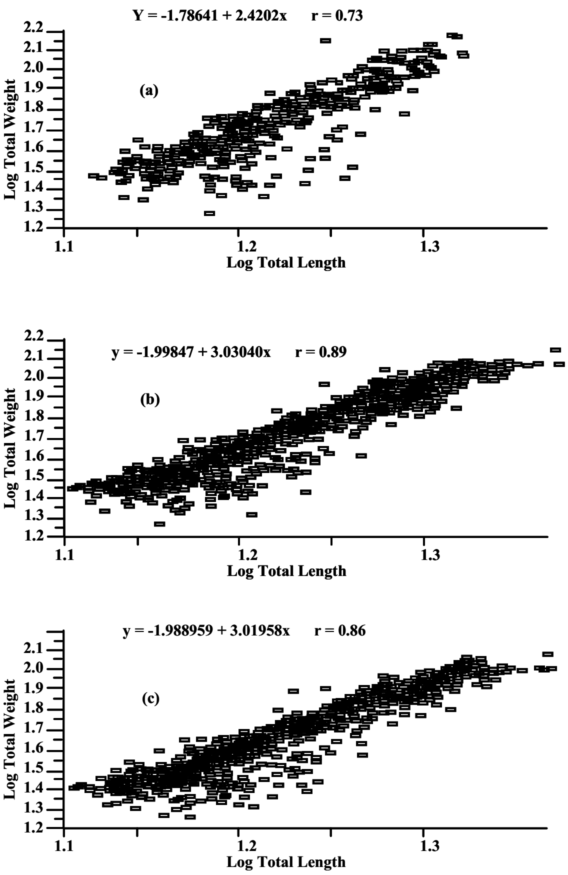


Figure 4. Relationship between total length and log total weight for a) male b) female and c) combined sex *B. nurse* in Asa reservoir, Ilorin, Nigeria.

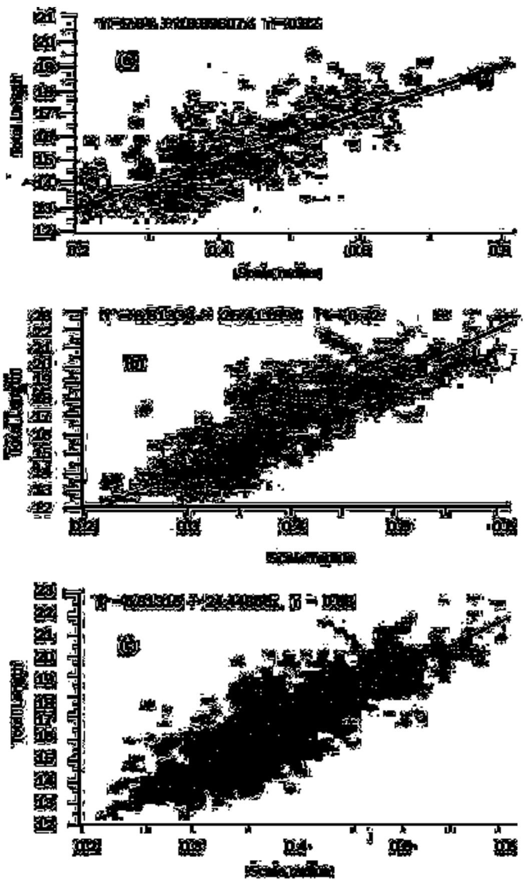


Figure 5. Relationship between total length and scale radius for a) male b) female and c) combined sex *B. nurse* in Asa reservoir, Ilorin, Nigeria.

anterior field of the scale is usually the most useful for identifying the annual growth mark. The production of one or two short fragmented ridges cutting over the other normal ridges indicates a growth mark (Figure 10-B).

The percentage mean new scale growth plotted against the month of sampling (Figure 9) Illustrates the formation of two annuli within a year on the scale of *B. nurse*. The first period of growth stoppage was between January and February while the second was between July and August. The two growth marks being similar to each other in form. Table 1 shows that the scales of a female fish of (15.10 cm). TL had the maximum number of 4 growth marks and that generally female fish had a higher number of growth marks than male fishes of the same length group. However male fishes within the length groups 15 – 17 and 18 – 20 cm, with 3 growth marks had a greater frequency of occurrence of growth marks than the females.

b) Opercula bones: The opercula bones are semicircular in shape and the detailed morphology is as seen in Figure 10-C. The opercula bone was not too reliable in determining the age of the species because most of them had no growth marks and they also showed numerous false rings. (91.94%) of the opercula bones examined had no rings. 78 (7.96%) had 1 ring only, while only 1 (0.10%) exhibited 2 complete rings.

c) Otolith: The 2 pairs of otoliths, the saccular and lapillus are well developed in *B. nurse*. The saccular is shaped like an anvil while the lapillus is horse shoe shaped (Figure 10-D). The lapillus bore 2 types of growth markings, the cyclical growth mark (CGM) and the daily growth marks (DGM) are as seen in plate 5 and 6. The cyclical marks, which were arranged in a definite pattern radiating from the nucleus in a regular cyclical manner while the daily growth marks are finer growth increments. Between successive cyclical rings were 14 DGM, this suggests that the cyclical rings were formed biweekly. Periods of fast growth (F–G) and slow growth (S–G) are indicated (Figure 10-F)

Discussion

Scale remains still the most popular and reliable means of estimating the age and calculating the

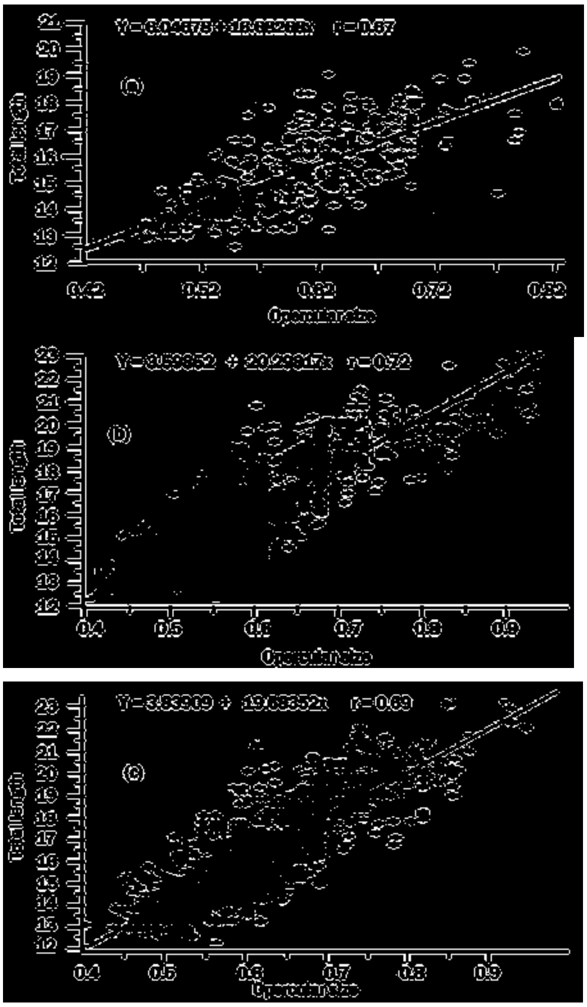


Figure 6. Relationship between total length and opercular size for a) male b) female and c) combined sex *B. Nurse* in Asa reservoir, Ilorin, Nigeria.

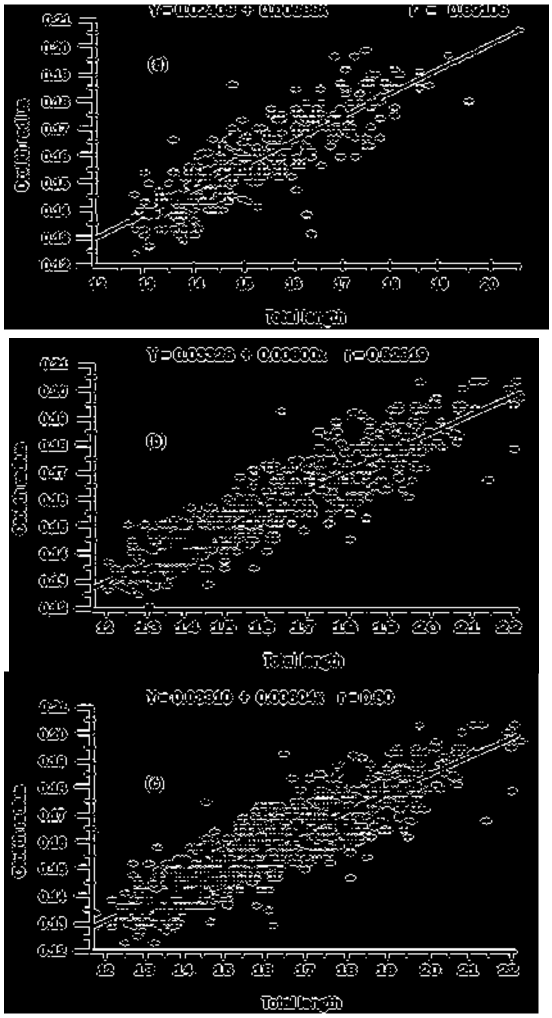


Figure 7. Relationship between otolith radius and total length for a) male b) female and c) combined sex *B. nurse* in Asa reservoir, Ilorin, Nigeria.

growth of most fishes (LeCren, 1947; Everhart *et al.*, 1957; Bagenal and Tesch, 1978). Over the years, they have been used more frequently than the other hard parts, partly due to the ease of handling and processing for age determination and also largely to the speed and ease with which the growth marks can be identified and interpreted.

In *B. nurse* although the opercula bones and otoliths showed growth markings, they could not be interpreted and as such could not be reliably used in estimating the age and growth of the species.

A great number of the opercula bones had no growth marks and a greater majority of those with marks showed false marks, hereby presenting an incomplete information picture. This obscured effective interpretation of the growth marks. However if was still possible to deduce that one growth marks was laid down annually on the opercula bone. This was in consonance with the study of Bruton and Allanson (1974) on. *T. mossambica* in Lake Sibaya where opercula counts were approximately equal to half the rings counted on the scale, suggesting that opercula rings were formed once a year, although rings on scales were laid down twice a year.

The otoliths were also not used in ageing despite observations of daily growth marks, because the daily growth marks showed disparity when compared with days of the observed age of fish. The reasons for such disparity have been proffered by Panella (1980) who stated that one source of misinterpretation about increment periodicity can be related to the fact that more than one increment (generally two) may be deposited in 24 hours or alternatively increments may not be deposited for one or more days, or in the later states of growth, increments already deposited may be eliminated by resorption. These three phenomenons produce variance in the growth record that result in a number of increments different from the actual number of days of growth.

Two growth marks were seen to be laid down annually on the scale (Figure 9). This same observation has been noted in other tropical fishes,

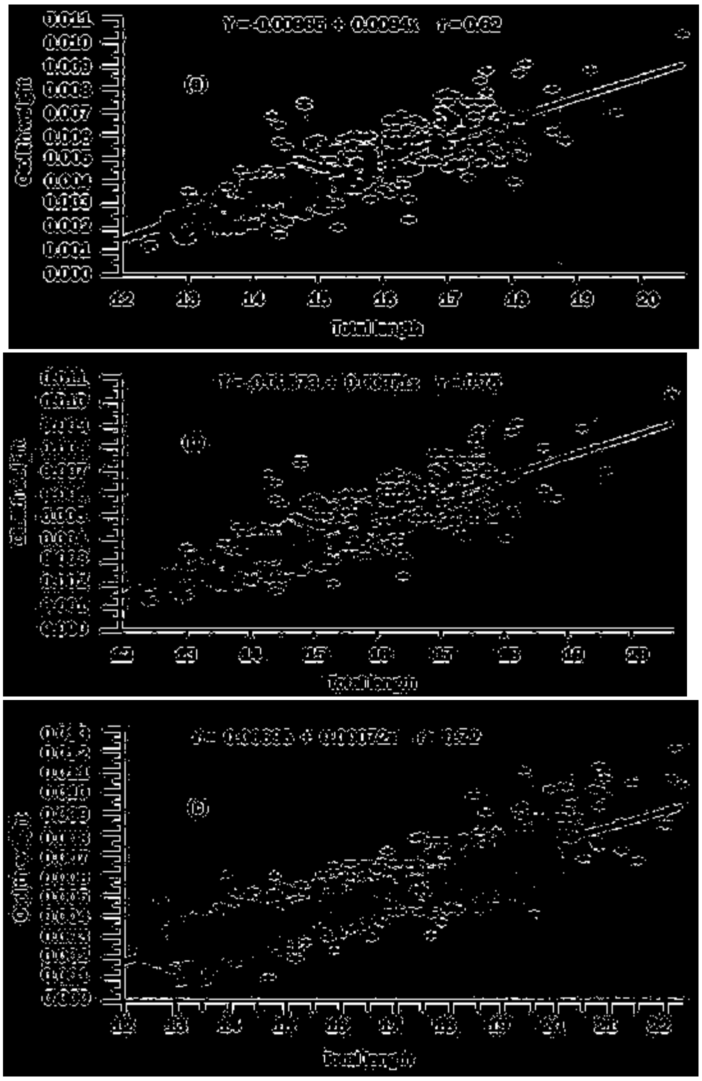


Figure 8. Relationship between otolith weight and total length for a) male b) female and c) combined sex *B. nurse* in Asa reservoir, Ilorin, Nigeria.

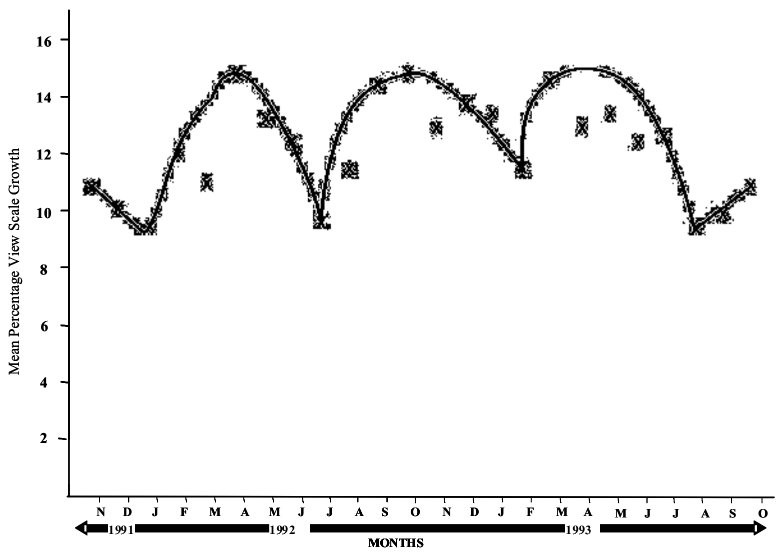
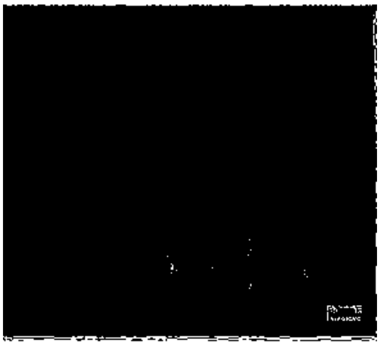


Figure 9. The timing of annulus formation on scale of *B. nurse* in Asa reservoir, Ilorin, Nigeria.

A
The general feature of
the scale of B. nurse (17.20 cm TL)
N-*R=Scale Radius*
1, 2, 3=1st, 2nd and 3rd growth marks.

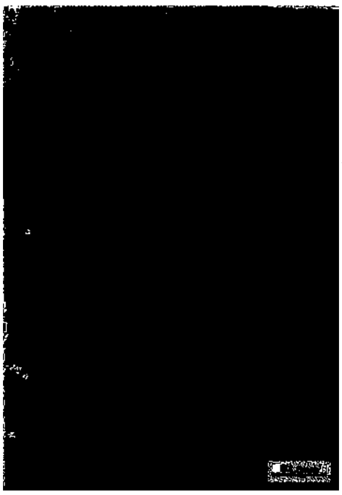
B
Scale of *B. nurse* showing
cutting over of growth mark.
NC=Normal circull,
GR=Growth mark



C
The general feature of the opercular bone of *B. nurse* (15.90 cm TL) showing 2 complete growth marks and 1 false growth mark.
N-R=opercular size
1, 2=1st and 2nd growth marks
In=false growth mark

Saccular (Anvil shaped) Lapillus (Horse shoe shaped)

D
The general features of the saccular and lapillus otolith of *B. nurse* (17.8 cm TL)
N=Nucleus
R=Radil
1&11=Growth marks



E
Lapillus otolith of *B. nurse* showing periods of fast and slow growth demarcated by cyclical marks.
F-G=Fast growth
S-G=Slow growth
CM=Cyclical marks

F
Lapillus otolith showing daily growth marks of *B. nurse*
DGM=Daily Growth Mark
CM=Cyclical marks

Figure 10. Otolith scale of *B. nurse* showing periods.

Hopson (1972) in *Alestes baremose* from Lake Chad, Willoughby (1974) in Synodontis species from Lake Kainji, Sellicks (1976) in *Alestes* sp from Kainji Lake and Paugy (1980b) in *B. nurse* from the river basins of Ivory Coast.

The first growth mark was laid between January and February coinciding with the peak of the harmattan period, when there was a general drop in temperature, subsequently leading to a process of overturn in the environment. Fagade (1980a) reported that noticeable changes do occur in some environmental factors especially at the turn of each of the two seasons of the year. Egborge (1978) remarked that such major changes include water transparency and changes in thermal stratification.

The second growth mark corresponded to the period of flooding in the lake. The increased turbidity during this period lead to decreased Phytoplankton production, ultimately affecting the food available to *B. nurse*. Flooding also brought about dramatic environmental changes leading to growth marks being deposited. It was also observed that the period of flooding also coincided with peak spawning among the species. Tweedle (1975) related the period of true annuli ring formation with the spawning period of some African species.

The greater number of growth marks observed on the scales of the female *B. nurse* was adduced to the process of spawning. It is a well known fact that growth marks are also laid down in response to physiological processes. Panella (1980) reported that growth marks are formed not only due to environmental fluctuations but also in response to physiological changes. He went on to state that structural and chemical variations in the bands on hard parts are controlled by changes in physiology due to seasonal environmental fluctuations. Similarly, Moe (1969) suggested that annulus formation in the sagittae of the red grouper, *Epinephelus morio* (Valenciennes) from the Gulf of Mexico, was the result of physiological changes associated with spawning time, increased photoperiod and elevated water temperature in the spring.

In specimens of *B. nurse* with 3 growth marks, males within the length ranges of 15-17 cm and 18-20 cm had a greater representation than their female counterparts (Table1). This could be explained by the fact that males had become sexually mature and the process of gonad formation had begun. The species of *B. nurse* were found to attain sexual maturity between 15.00 – 15.75 cm (TL), (Saliu, 1997). The growth of *B. nurse* is isometric as indicated from a length weight regression coefficient of 3.012.

This paper has shown the reliability of the growth marks on the scale and the ease by which they can be interpreted over the other hard parts.

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Table 1. The Frequency distribution of growth marks on the scale of *B. nurse* in Asa reservoir, Ilorin, Nigeria

Total length (cm)	Number of growth marks and Sex								Total
	1		2		3		4		
	M	F	M	F	M	F	M	F	
12-14	49	72	8	7	0	1	0	0	137
15-17	144	184	73	98	20	13	0	1	533
18-20	14	112	23	81	20	16	0	0	266
21-23	0	22	1	16	0	5	0	0	44
Total	207	390	105	202	40	35	0	1	980
% of each sex	21.12	39.80	10.71	20.61	4.08	3.57	0	0.10	100
% of combined sex	60.92		31.32		7.65		0.10		0

* (Note 2 growth marks are deposited annually)

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