GROWTH RATE AND GROWTH MARKS OF POND RAISED AND WILD POPULATIONS OF AFRICAN CAT FISH, *Clarias gariepinus* (BURCHELL, 1822), (PISCES, CLARIDAE)

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ABSTRACT

One hundred and twenty specimens of *Clarias gariepinus* collected from the wild and cultured populations from Plateau and Niger States of Nigeria respectively were analyzed for growth rates and growth marks. The hard structures examined for growth marks include the vertebral bones, pectoral spines, hypural bones and saggitta otoliths. All the hard structures examined showed distinct growth marks except the hypural bones. Growth marks were laid down seasonally and one wet and dry season growth marks were interpreted as one annulus. There was no significant difference between growth rate of wild and cultured populations ($P>0.05$). Males had higher growth rate in both wild and culture conditions. Back calculations of annulus radii of vertebrae and otoliths of the fish indicated that growth was faster during the first year of life. There was high correlation and linear relationship between body length and body weight ($P<0.05$). There was also high correlation and positive linear relationship between standard length and otolith radii and between standard length and vertebral radii ($P<0.05$).

Keywords: Fish, Age, Growth marks.

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INTRODUCTION

African catfish (*C.gariepinus*) is widely distributed throughout Africa. In the northern and central part of Africa it has been described as *Clarias lazera*, in the Eastern part as *C.senegalensis*, in the Western part as *C.mossambicus* and in the Southern part as *C.gariepinus* (Viveen, 1986). All these have been reclassified as one species, *Clarias gariepinus* (Teugels, 1986). It is named after its common locality, the Gariep River, a hotentot name for Orange River S. Africa (Teugels, 1986).*C.gariepinus* inhabits tropical swamps, lakes and rivers, some of which are subject to seasonal drying. Under favourable conditions the adult fish can grow to 32 – 40cm in length and weigh between 3 – 16kg (Viveen, 1986).

Knowledge of age and growth of fish is important in fisheries management and is of great biological interest. Age and growth studies provide means of estimating time taken by fish to attain a certain length or weight, sexual maturity and also to estimate how soon a fish stock of young ones can start to reproduce or reach table size (Lagler, 1956). Data on fish growth in relation to age has application in fisheries management for evaluation of population changes over time. It is also useful in determining and improving the culture potential of fish species (Tsang *et al,* 2007). Information on age and growth rate studies of fish stock is also relevant for ascertaining its optimum environmental requirements, feeding regime and stocking density.

A lot of studies have been carried out on ageing and growth rate of various species of fish. Records of these studies have shown that structures that show growth marks in one species in a particular area may not be useful for age determination in another species or even the same species in another place. For example Vandar Waal and Schoonbee (1975) found the pectoral spines most suitable for age determination in *C.gariepinus* in Transvall, South Africa, while Willoughby and Tweddle (1978) reported that vertebral centrum was most suitable for *C.gariepinus* and *C.ngamensis* in Malawi. These indicate that environment probably influences the laying down of growth marks in different structures in tropical fishes (Fagade, 1974). The works of Van Dar Waal and Schoonbee (1975) and Willoughby and Tweddle (1978) also showed that growth in Clarias in species dependent. Fernandez and Herrera (1995) studied the age structure, growth and reproduction of *Leuciscus pyrenaicus* (Gunther) in Guadalquivir river basin, Southern Spain using scale annuli to determine age. They observed six scale annuli in a male of 160mm fork length and a female of 171mm fork length age 7+. They also observed that males and females matured in their third and fourth years of life respectively. Friedland and Haas (1996) studied the post smolt growth and age at maturity of marine Atlantic Salmon using circuli spacing patterns on the scales which showed considerable variations between age groups. They also observed that spring or summer growth was greater than winter growth. Rodin *et al.* (1996) carried out growth ring detection on fish otoliths by graph construction and produced an algorithm for detection of growth rings on fish otolith based on graph construction method.

This study was therefore conducted to determine the body structures most suitable for age determination in *C.gariepinus* from Plateau and Niger states of Nigeria and also to determine any relative growth deterioration with regard to ageing in *C.gariepinus.*

Age of fish can be determined by interpretation of annual growth marks laid down on hard structures during periods of fast and reduced growth rates. These structures include otolith, opercular bone, vertebral centrum, spiny fin rays, the hypural bone, scales and cleithrium (Bagenal and Tesch, 1978). Seasonal changes in environmental and internal conditions such as temperature, food, day length, salinity, pH etc influence the laying down of growth marks.

MATERIALS AND METHODS

One hundred and twenty fresh samples of *C. gariepinus* (60 from the wild and 60 from culture) were collected from Plateau and Niger states of Nigeria. Cultured samples were obtained from Rockwater fish farm, Jos and Panyam fish farm, Panyam, both in Plateau state of Nigeria. The wild samples were obtained from fishermen from Nanko (Doko) perennial pool, Niger state. Samples were transported iced in cold box to the Hydrobiology and Fisheries laboratory University of Jos and preserved in deep freezer.

Prior to examination, samples were thawed thoroughly and all the water was mopped out with towel. Specimens from each sampling site were treated separately. Each specimen was given a serial number and its standard length and total length were measured using fish measuring board. The total body weights were measured using Metler P. 1210 balance. After this, specimens were dissected to determine sex and gonad maturity stages. The range, mean and standard deviations of standard length, total length and total body weight for male and female samples from each station were determined. All structures that are likely to show growth marks were removed from each specimen. These were the vertebral bone, pectoral spines, hypural bone and the saggitta otoliths. The first six vertebrae were removed by cutting across the flesh through the vertebral joints. The pectoral spines were removed by loosening them from their sockets. Hypural bone was removed by cutting and boiling the caudal peduncle ant caudal fin with electric hot plate to remove the flesh. The otoliths were dissected out from their grooves beside the hind brain.

All structures removed were kept in paper envelops and dried under the sun. Each envelop was labeled to reflect the serial number of the specimen and sample station. The vertebra and otolith were used for age determination. The vertebras were thoroughly cleaned and all flesh washed off. They were then viewed under reflected light on dark background using stereo dissecting microscope. The vertebral radius and radius of each annulus were measured transversely from the centre to the lateral edge of the centrum (Fig 1) using graticle micrometer eyepiece calibrated against stage micrometer to the nearest mm under reflected light on a dark background on dissecting microscope. The measurements were used for back calculations of the fish's length when the growth marks were formed using Lea's modified formula proposed by Frazer (1916).

$$In = sn / s (L-a) + a$$

Where Sn = radius of annulus (n)

S = total vertebral radius

L = standard length

a = the intercept on the ordinate

In = length at (n^{th}) annulus

The relationship between vertebral radius and standard length of fish were computed using the regression coefficient analysis and correlation co-efficient (r). The third and fourth vertebrae were used throughout as they are more regular in shape than the first two.

Photomicrographs of a few vertebrae showing growth marks were prepared.

The saggitta otoliths were used for validation of the fish's age determined from the vertebrae. One otolith from each sample was used to validate age determined from the vertebrae. Each was carefully grinded on glass slides treated with carborundum powder of 500 and 800 grit sizes respectively. Each grinded otolith was then washed in soap solution, eched in N/10 HCL for three minutes, transferred into 25% ammonia solution for about three minutes and then cleared in tap water. Each was then mounted on a slide and viewed under low power on a binocular light microscope.

The ololiths total radii and annulus radii were measured using the graticle micrometer eyepiece. Measurements were taken transversely form the nucleus to the lateral edge of the longest side of the otolith (Fig 2). Photomicrographs of a few otoliths showing growth marks were prepared. The measurements were then used to determine the regression coefficient of the otolith radius and standard length relationship, and correlation coefficient (r) and later for back calculations of standard length when growth marks were formed on otolith using Lea's modified formula. From back calculation the mean standard length at the formation of each annulus was determined and mean length at the formation of the annulus for each specimen were determined. Significant differences between mean standard length at formation of annulus for both the otolith and the vertebra were tested using t – test.

RESULTS

Forty specimens of varying sizes were purchased from each of the three sample sites. A total of 120 specimens ranging from 25.00 to 67.00 cm total length and 107.25 gm to 2.32 kg total body weight were examined. Varying sizes occurred among both male and females. Table 1 shows the size ranges, mean $\pm$ standard errors and standard deviations of both male and females of the sample populations. The vertebrae and saggitta otoliths showed distinct growth marks (Plates 1 & 2). The vertebrae (Plate 1) showed opaque and translucent prominent growth marks with numerous less prominent growth marks occurring in between the prominent marks. These represent growth marks laid down at irregular intervals due to changes in the fish's condition. The whole otolith was opaque and growth marks were not visible until when grinded. Each grinded saggita otolith showed distinct opaque and hyaline growth marks (Plate 2). These include prominent growth marks regarded as annulus and numerous less prominent growth rings in between which are regarded as daily or weekly rings or rings laid down due to changes in condition. A few sections cut from decalcified pectoral spines also shoved prominent and numerous less prominent growth marks. The hypural bones showed no distinct growth marks (Plate 3) and could not be used for age determination.

The mean standard length obtained from backcalculations using the vertebrae and otoliths are presented in Tables II and III. The age of the fish populations from the three sample areas were estimated from the growth rings laid down on the vertebrae and otoliths. The otoliths were used for validation of age estimated from the vertebrae. The laying down of growth rings on the vertebrae and otolith appeared to follow seasonal changes because two prominent rings were noticed on fish known to be one year old (1+). Plate I shows vertebrae of fish under one year (1+) from Rock water fish farm showing one prominent ring and numerous daily rings. Thus two prominent rings represent one annulus and in this way the ages of all the samples were estimated. Frequency distribution of age group found and their percentages are presented in Table IV. Plate 2 shows grinded otoliths of a fish in its second year of growth (1+) showing two prominent growth marks. A few otoliths from Panyam samples were unreadable and could not be used for age determination.

Growth rings were consistently laid down on the vertebrae and otoliths of *C.gariepinus* examined. Measurements of the ring's radii showed wide rings followed by narrow rings indicating periods of fast growth and slow growth respectively. In majority of the specimens the last rings were found to be very close to the edge of the vertebrae and otolith.

The relationship between vertebral radii and standard length, otolith radii and standard lengths were determined by correlation coefficient (R) and regression coefficient (y=aLbx). The equations are presented in Table V while the figures showing linear relationships are indicated by Figs 3, 4,5,6,7 and 8. A high correlation ($P<0.05$) between standard length and vertebral radius and standard length and otolith radius were observed.

Table 1: Mean size range ± SD of Male or Female samples of *C.gariepinus* from three sample stations.

Station	Sex	N	Tl (cm)	Sl (cm)	TBW (G)
	Male	30	27.00-50-50	24.00 – 43.50	120.00 – 675.38
Rockwater			X= 34.89±4.87	X = 30.68±4.25	X = 280.68 ± 103.79
Fish Farm Ltd Jos.					
	Female	10	25.00 – 48.00	22.00 – 43.00	107.48 – 813.48
			x=36.01± 6.45	X = 32.72±6.51	X = 357.57 ± 197.46
	Male	17	26.50 – 41.00	22.50-35.50	119. 52 – 434.00
Panyam Fish farm			X = 29. 68 ± 3.37	X 25. 68 ±3.02	X = 168.22 ± 73.47
	Female	23	26. 00 – 49.00	22.50 – 43.00	123.66 – 802.40
			X = 32.22 ± 5.81	X = 28.00 ± 5.16	X = 251.95 ± 158.93
	Male	22	26.1,0 0 67.00	22.50-59.50	115.00-2318.29
Nanko			X = 40.19 ± 11.64	X 35.00 ± 10.45	X=517.89 ± 571.08
(Niger State)					
	Female	15	29.00 – 52. 80	23.50-46.50	107.25-1133.25
			X=35.37 ± 6.99	X30.67 ± 6.28	X=319.39 ± 289.08

TL = Total length SL = Standard length TBW = Total body weight

TABLE II: Mean Standard Length (SL) of *C. gariepinus* back- calculated from annual rings on vertebra.

Station	Mean SL (cm) 1st annulus	Mean SL (cm) 2nd annulus
Rock water	24.19 ± 4.402	-
Panyam	24.077 ± 3.814	-
Nanko	28.295 ± 6.676	37.633 ± 11.758

Table III: Mean Standard Length (SL) of *C. gariepinus* back- calculated from annual rings on otoliths.

Station	Mean SL (cm) 1st annulus	Mean SL (cm) 2nd annulus
Rock water	22.114 ± 3.281	-
Panyam	20.069 ± 5.708	-
Nanko	20.748 ± 5.245	39.048 ± 11.025

Table IV: Age group in years and percentage of *C. gariepinus* of three sample populations.

AGE GROUPS

	Rock water		Panyam		Nanko		
	+	2+	+	2+	+	2+	3+
Total	17	23	30	10	16	20	4
%	42.5	57.5	75.0	25.0	40	50	10

Table V: Regression and Correlation between SL/Vertebral radius and SL/Otolith radius of *C. gariepinus* of three sample populations.

Station	Coefficient	Vertebrae	Otolith
Rockwaterfish	Regression	V=3.712+2.726X	Y= 4.631+16.658X
farm	correlation	R = 0.953	R = 0.810
Panyam Fish	Regression	Y= 2.786 +2.429X	Y = -1.309 + 13.054X
Farm	Correlation	R = 0.943	R = 0.779
Nanko Pool	Regression	Y = 10.719 +17.003X	Y = -10.719 + 17.003X
	Correlation	R = 0.939	R = 0.939

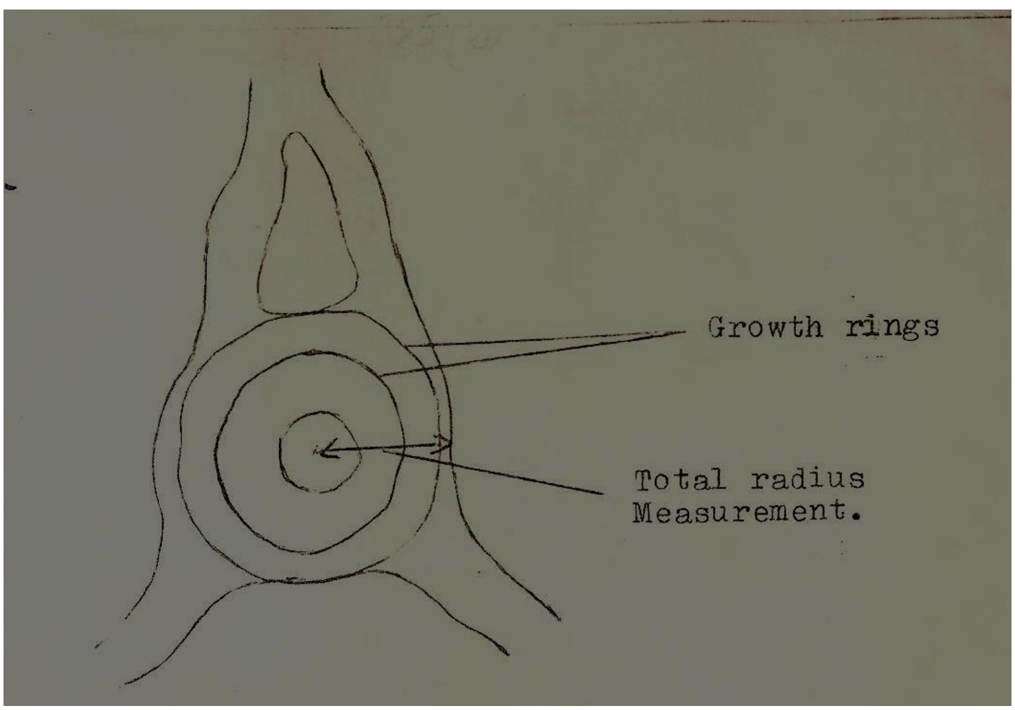
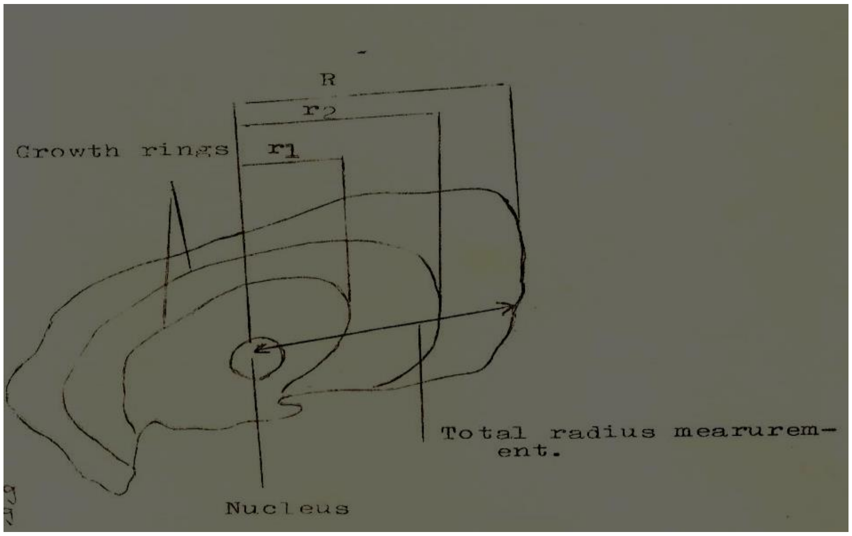


Fig. 1 Diagramatic representation of the Vertebrae showing direction of radius measurement and growth rings.



R = Total radius r_1 = 1st growth ring r_2 = 2nd growth ring

Fig.2. Diagramatic representation of grinded Saggitta Otolith showing growth rings and radius measurement.

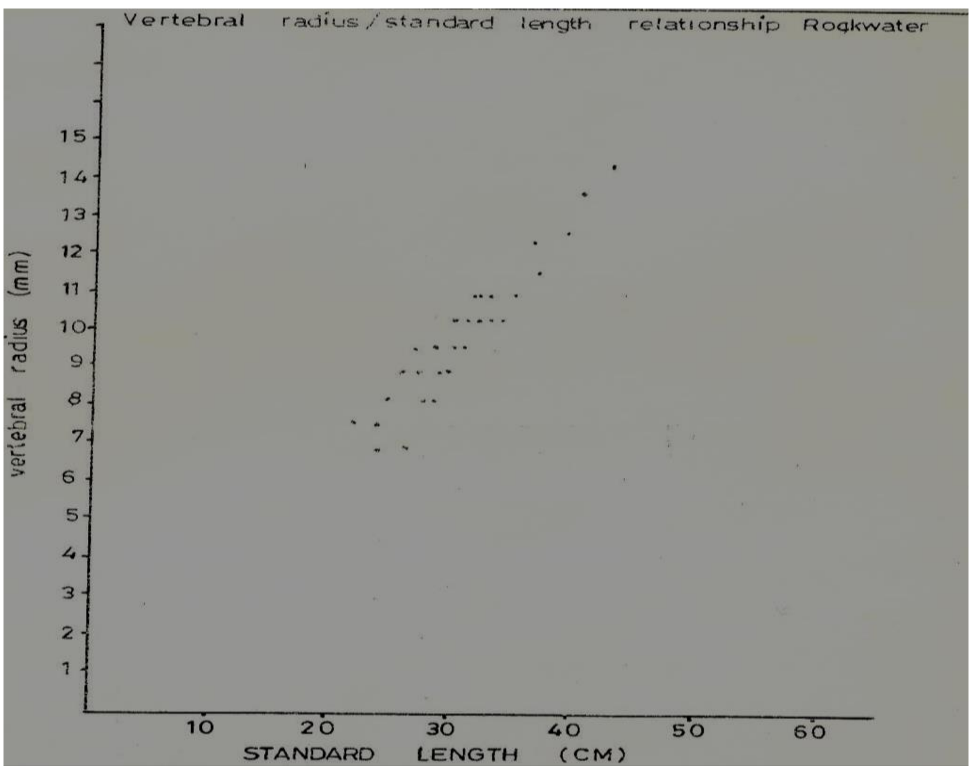


Fig.3. Vertebral radius / Standard Length relationship of *C.gariepinus* samples from Rockwater fish farm Jos.

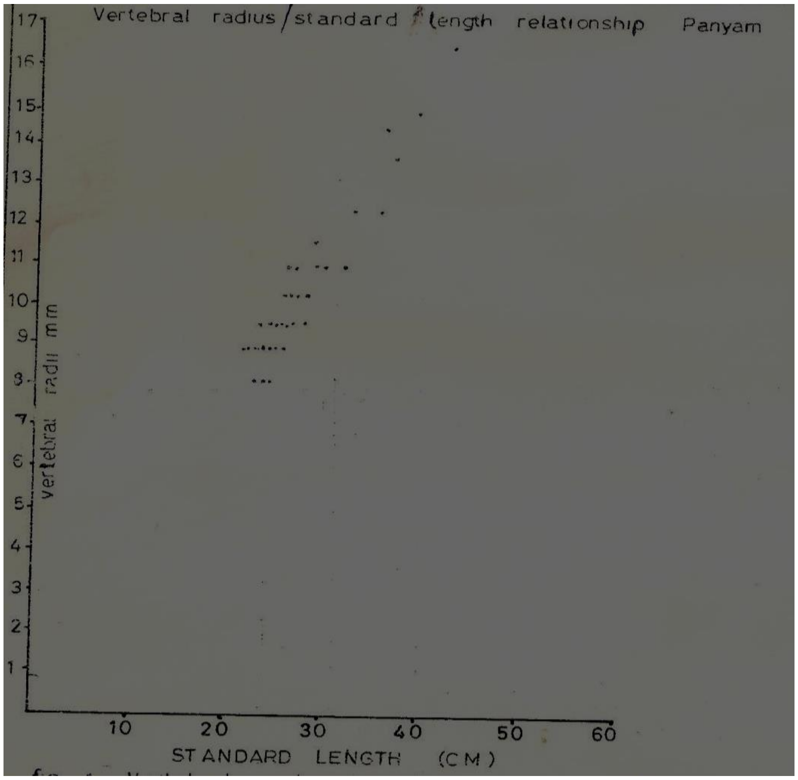


Fig.4. Vertebral radius / Standard Length relationship of *C.gariepinus* from Panyam fish farm.

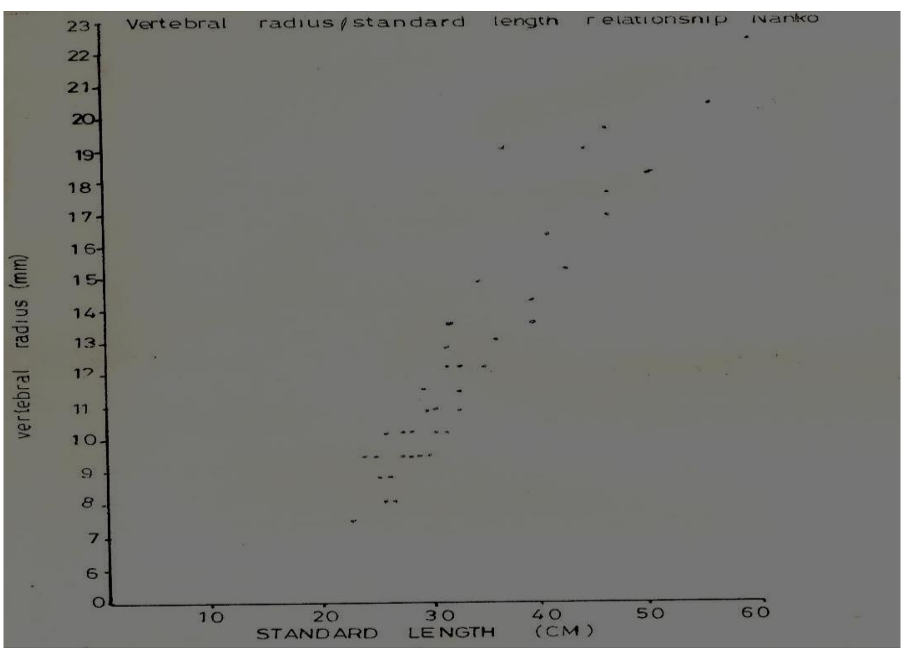


Fig.5. Vertebral radius / Standard Length relationship of *C.gariepinus* samples from Nanko pool (Doko Niger State).

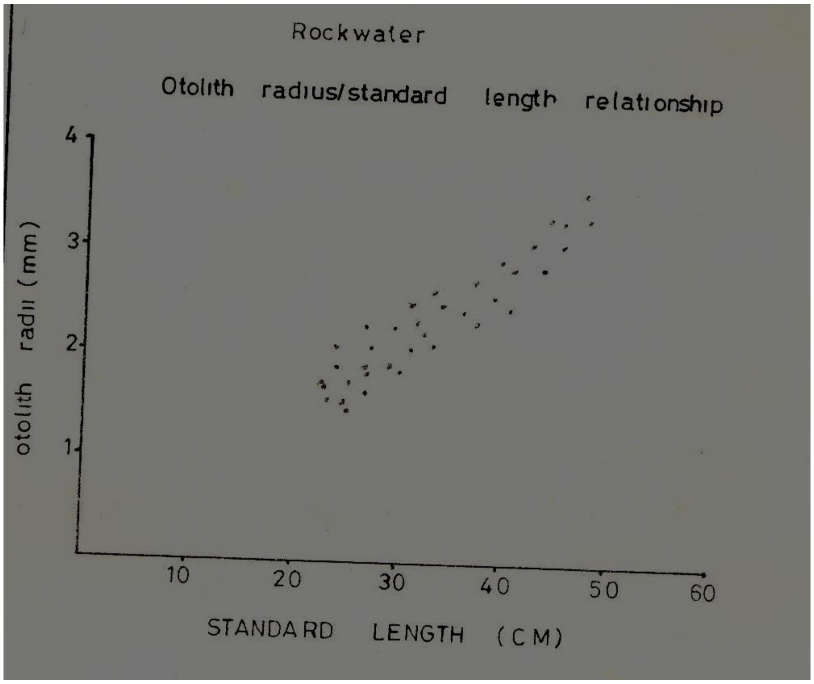


Fig.6. Otolith radius / Standard Length relationship of *C.gariepinus* samples from Rockwater fish farm Jos.

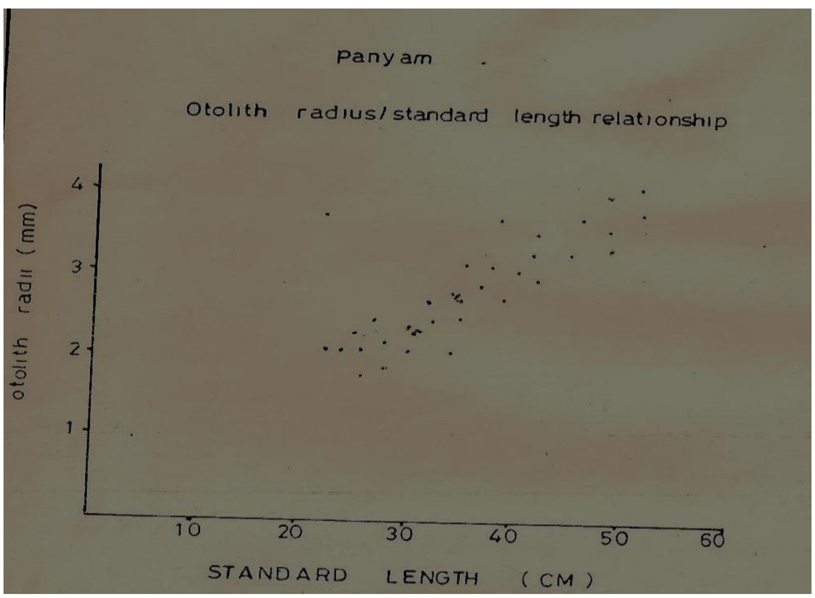


Fig.7. Otolith radius / Standard Length relationship of *C. gariepinus* samples from Panyam fish farm

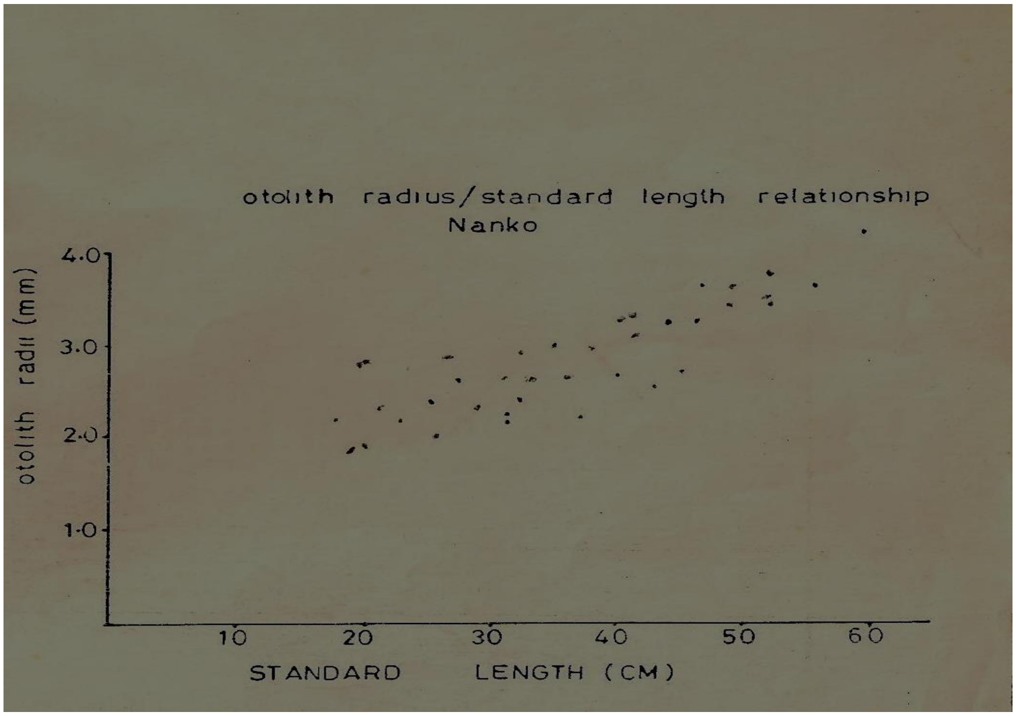


Fig.8. Otolith radius / Standard Length relationship of *C. gariepinus* samples from Nanko pool (Doko, Niger State).

Plate 1. Vertebral Centrum of *C. gariepinus* under one year (0+) showing one prominent growth mark.

Plate 2. Grinded Saggitta Otolith of *C. gariepinus* estimated to be one year old (1+) showing two prominent growth marks.

Plate 3. Hypural bone of *C. gariepinus* from Rockwater Fish Farm showing no growth mark.

DISCUSSION

Except for the hypural bones, all the hard structures examined showed growth marks indicating that the vertebrae, otolith and pectoral spines are all suitable for age determination of *C.gariepinus* in Plateau and Niger state of Nigeria. Fagade (1974), Ezenwa and Ikusemiju (1981) had also reported growth marks on otoliths, opercula bones and spines of fishes within Ibadan and Lagos Lagoons. Alternating wide and narrow growth rings were observed as similarly reported by Bagenal and Tesch (1978). Fagade (1974) and Pannella (1974) noted that the formation of broad wider ring correspond to the period of fast growth which occurs during the wet season, while the narrow rings correspond to period of reduced growth which occurs during the dry season.

Fagade (1974) and Panuella (1974) observed that in the tropics, temperature variation is very slight during the year and this results in formation of rings which are not necessarily annual. Ezenwa and Ikusemiju (1981) also observed that it is difficult to determine the age of tropical fishes due to little seasonal environmental changes under which they do not lay down definite annual rings. The results from age determination indicated that majority of the fish samples were in their first and second year of growth (age group 0 & 1+). A few specimens from the wild were in their third year of growth (2+). However, observations on the laid down growth rings and back calculations indicated that most of them had just entered their second or third year of growth because the last rings were very close to the edge. Data from back calculated standard length also indicated that the fish had their fastest growth rate during the first year of growth. This was also indicated by the radii of the rings near the nucleus being wider than the subsequent rings. This also provided information on the growth pattern of individuals. A similar observation was made by Fagade (1980) on *Tilapia guineansis.* Cheung *et al* (2007) studied growth impairment in three species: red drum *Sciaenops ocellatus,* grouper *Epinephelus coloides* and medaka *Oryzia melastigna* through scale circulus number and radius length measurement. They observed positive correlation between scale increment and growth. They also observed that scale circulus number is more consistently linked to fish growth than the radius length.

The consistent laying down of growth rings on the vertebrae and otolith indicated that growth was increasing with age. Plots of the otolith and vertebral radii against standard length (Figs 3 – 8) confirmed this. Van Dar Waal and Schoonbee (1975) also observed no visible decline in growth rate with increase in age of *C.gariepinus* in Transvaal, South Africa. Otoliths were found useful for validation of age determined from other structures but as rightly observed by Van Dar Waal and Schoonbee (1975) in their attempt to use otolith to age *C.gariepinus,* the otoliths were opaque and very brittle and rings could only be observed after fine grinding and polishing.

Conclusion

Age and growth rates of *C.gariepinus* from the cultured and wild populations from Plateau and Niger States respectively were determined from the annual rings on the vertebral and otolith bones. The hypural bones did not show growth marks. From the results of back calculation and mean standard length at annulus formation it could be concluded that there was no significant difference (P>0.05) in growth rate between the wild and cultured populations of *C.gariepinus*. There was high correlation (P<0.05) between length, weight and age and also between the standard length and vertebral and otolith radii of *C.gariepinus* samples studied.

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