

Growth Determination of Selected Fish Species in River Hadejia, Jigawa State, Nigeria

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Abstract

The work was designed to investigate the various ages of selected species of fishes in River Hadejia with the use of opercula and scales. The growth marks were laid annually. The growth rate did not exhibit Rosa Lees phenomenon. The asymptotic length L_{∞} had higher values in the males than the females except in *Tilapia Zilli* from site B. K (rate at which L_{∞} is approached) and t_0 (time at which the fish would be zero sized) did not show any consistent pattern of difference between the sexes. Growth performance index (d) was similar for the different species and sexes in all the sites, $S.D = 0.103$. The places show the growth marks on the opercula bones and scales of some selected fishes.

Keywords: - Growth, Opercula, Scales, River

Introduction

Growth in fishes is relatively indeterminate and do not follow a definite pattern of attaining a maximum size over a specific period of time (Bennett 1970). Several factors affect the rate of growth of fishes. These include population density which has inverse relationship with rate of growth (Wazmick, 1966). Other factors include genetic composition and length of growing season. The rates of metabolism of fishes vary with water temperatures change and the rate of metabolism change. This also affects rate of growth. Peek (1966), observed high growth rates in local situations among small mouth bass in certain localized situations, because of some unusual source of available food, a local population of fishes is growing more rapidly than the same species in less favoured environment. Bennett, (1937), observed this situation among small mouth bass in Arkansas and large mouth bass in Wisconsin respectively. According to Bennett (1970), a continuous study of the ecology and growth of one or several species making up a small fish population will show that there are times when certain types of food are abnormally abundant and that this abundance is often reflected in unusual growth.

In growth studies, age, length and weight data are very important tools to fishery biologists, since details of species growth mortality rates, age at maturity and life span can be determined from such information.

Ricker, 1975, Gulland, 1983). Although numerous methods have been used to age fishes (Nielson and Johnson 1983), three general methods predominate. The first is mark and recapture method, second is Peterson method, which involves the comparisons of length frequency distribution of fish population samples (Ricker, 1975). This method requires measuring the lengths of a large number of fish in a population. The third method is to count growth marks that develop periodically in various hard parts of fishes is the most commonly used method. This involves the use of several kinds of hard parts of fishes, is the most commonly used method in determining age (Nielson and Johnson, 1983). Otoliths, opercula and scales are the hard parts most often used, but in elasmobranchs and some and some other bony fishes, the vertebrae have been used for age studies as well. The use of annual marks on opercula fin rays and other calcified structure of bony fish. In many species these marks represent seasonal variations.

If isometric growth is assumed (all parts of the animal enlarge at similar rates) the pattern of growth of fish could be described by the relationship:

$$W = aL^b \text{ (Everhart et al, 1975)}$$

Factors relating to energy requirements in fishes. In general, the requirements for energy are somewhat greater for carnivores than herbivores because more energy is needed to eliminate high levels of nitrogenous wastes that build up when animal protein is digested than those resulting when dietary protein comes primarily from plants.

Characteristically all fish growth is ‘indeterminate’ in which growth is continually slowing down but apparently does not seem to stop and continues after sexual maturity is achieved. However, it is not a general rule amongst the cichlids whose growth rate declines after maturity, for example, *Sarotherodon galilaeus* (Fryer and Lles, 1972). In this respect, fish differs from mammals where growth virtually ceases at maturity.

Growth is a specific adaptive property ensured by the unity of the species and its environment. Slow growth and

small size of individual is enables several populations of fishes to exist on comparatively restricted food supplies but at the same time, small size is connected with an increased rate of consumption by predators and therefore should be some compensatory increase in the reproductive capacity of the population. Fast growth and large size ensures that the fish will have some protection against predators but this is only possible in the presence of an abundance food supply.

Growth is influence by many physical factors like temperature, food, length of daylight, salinity, pH and generic factors. The effect of temperature and food on growth is pronounced among fish species present in the temperature regions of the world producing rapid growth during the summer months and reduction of cessation of growth during the winter months, this is so because seasonal rise in temperature coincides with an increase of natural food for fishes, temperature also affects metabolism.

In tropics the temperature varies only slightly during the year. For example, the surface during the year (Haruna 1992: Hamisu, 1993), this favours primary production and the growth of the fish species. The daylight hours extends for about twelve hours each day making primary productivity possible all the year. The rather uniform temperature coupled with availability of food makes for uninterrupted growth during the year while in the temperature regions, during winter, there is shorter hours of daylight which reduces primary production.

Mabaye (1981) reported that low pH reduces the appetite of *T. rendalli*. It would therefore seem that acid waters have an effect on fish growth but little is known of the actual effect on the fish. Canagaratnan (1966) demonstrated that *S. mossambicus* grew better in a saline medium with the highest rate being recorded at 50% seawater. Lagler (1977) reported that some selected strains of the brown trout *Salvelinus fontinalis* and the carp (*Cyprinus carpio*) have growth that is decidedly superior to that of the other strains.

Fish growth usually slows down after the onset of sexual maturity when large amount of nutrient materials periodically go into egg or sperm formation. The size differences between the sexes, which affects growth rates, and growth pattern may be due to generic factors, often correlated with inherited behavior patterns.

For a meaningful fishery management, knowledge of the growth rate can only be achieved from the increase in length with time, which can be derived from the age determination. In many fishes, aging is correlated with morphological changes. A characteristic feature of the growth of fishes as in all poikilothermic animals is its periodicity. In certain seasons of the year, the fish grows rapidly, in others, it grows slowly. This inequality in the growth rate throughout the year is well reflected on the various bones of the skeleton and the scales. The period of slow growth is unprinted on the skeleton in the form of rings or stripes, which are pale in reflected light. These stripes consist of small-flattened cells and they appear dark in direct light. Conversely, the periods of faster growth are characterized on the scales and skeleton by wide fields or rings, which are dark on, reflected light and pale in direct light. The first to state the rings on scales and bones of fishes correspond to period of retarded and accelerated growth and that the age of the fish could be read from these rings, Van et al (1947).

Fagade (1974) observed that opercula marks were laid twice in a year in the Lagos lagoon while Hamisu (1993) states that the marks were laid annually in the fishes from Watari lake. Since the annual marks are produced as the result of changes in the growth rate, the problem naturally arises as to whether annual rings could not possibly be formed several times in the year, not only as the result of the cessation of the feeding but also as the result of fasting, for instance, during the spawning period. For example, in the Caspian shad at the time of spawning the scales begin to break down which leads to the formation of definite type of mark. In the Caspian roach, the study of the scales of fish, which have been recaptured after being marked, has established (Chugunova, 1959) the existence of another three types of supplementary rings besides of larval and spawning rings. Naturally, there arises the question of whether the occurrence of supplementary rings on the scales, bones and otoliths of fishes does not make the whole method of determination of age from annual rings fallacious and how to differentiate between the annual and the supplementary rings. This work was designed to investigate the various ages of selected species of fishes in River Hadejia, with the use of opercula and scales.

Materials and Methods

Age estimation were also carried out, using where applicable, scale of fish and opercula bones are described in Hynes (1950), Bagenal (1978), and sparred et.al. 1991 and in conjunction with von Bertalanffy growth model available in LFSA/FISAT computer programmes.

The growth rate of fish is related in many ways to the growth of the hard part like scales, opercula bones etc. A scatter diagram of fish length against scale/opercula bone radius was plotted and the relationship was found to be

linear conforming to the equation:

$$L_n = \frac{S_n L}{S} \text{ (Lee 1920)}$$

Where L_n = Length of fish when mark “n” was formed
 L = Length of fish when scale was removed
 N = radius of mark “n”
 S = Total scale/opercula radius

The length of fish at each mark radius was calculated as well as the mean back calculated length for each age group.

Fish growth was described by the equation:

$$L_t = L_{\infty} (1 - e^{-k(t - t_0)}) \text{ (as described by von Bertalanffy 1957)}$$

Where

L_t = Predicted length at time t .
 L_{∞} = Asymptotic length or maximum attainable length
 e = Base of the natural log t .
 Time = Time

t_0 = The size at which organism would theoretically have been age 0

K = Instantaneous growth rate or growth coefficient

Values of length at infinity (L_{∞} parameter of the von Bertalanffy growth formula (VBGF) expressing asymptotic length i.e. the mean length the fish in a population would reach if they were to grow indefinitely), K (growth curvature factor), t_0 (size at which organism would theoretically have been at age 0) and

$\Phi = \text{Phi} - \text{Prime}$ (i.e. length based index of growth performance)

$\Phi = \text{Log}_{10} K + 2 \text{Log}_{10} L_{\infty}$) were estimated.

From the von Bertalanffy growth equation.

$$L(t) = L_{\infty} \times \{ 1 - \exp(-k \times (t - t_0)) \} \dots \dots \dots (1)$$

A series of algebraic manipulations gave

$$L(t - \Delta t) = a + b \times L(t) \dots \dots \dots (2)$$

(Sparre and Venema 1992)

$$a = L_{\infty} (1 - b) \text{ and } b = \exp(-k \times \Delta t) \dots \dots \dots (3)$$

Since k and L_{∞} are constants, a and b also become constants

If Δt is a constant

The growth parameters k and L_{∞} were then derived from

$$K = 1/\Delta t \times L_n b \text{ and } \Delta t = a/1 - b$$

a and b were obtained from carrying out the regression analysis for the Ford – Walford plot. The Ford – Walford plot was

Results

Due to the similarity in climatic conditions and geographic location of the study sites, (A, B and C) studied and Hadejia wet land earlier studies by Gardo (1999), it was assumed that the periodicity of formation of growth marks on the opercula bone was annual in nature as described by Gardo (1999). The relationship between the Oral opercula scale and the standard length (mm) in the fishes from the study sites are described by the equations in Table 1 and illustrated graphically via figures 1 to 3. It is apparent that the relationship using the least square linear regression had positive intercept in sites A and C and negative intercept in Site B of River Hadejia.

Plates show the growth marks on the opercula bones and scales of some fishes in River Hadejia.

Table 1 shows Oral Opercula radius/standard length relationship with least square linear regression analysis data of *Sarotherodon galileaus* in study sites (A,B and C) of River Hadejia.

Study Site	Slope	*y intercept	N	R
A	108	+1.650	44	0.890
B	116	-4.045	37	0.957
C	117	+0.28	51	0.908

Note: * y intercept (y when X = 0)

P value < 0.0001

Oral opercula radius (ORR) = Slope (SL) + y – intercept

Therefore,

Site A ORR = 108 (SL) + 1.650
 Site B ORR = 116 (SL) + 4.045
 Site C ORR = 117 (SL) + 0.289

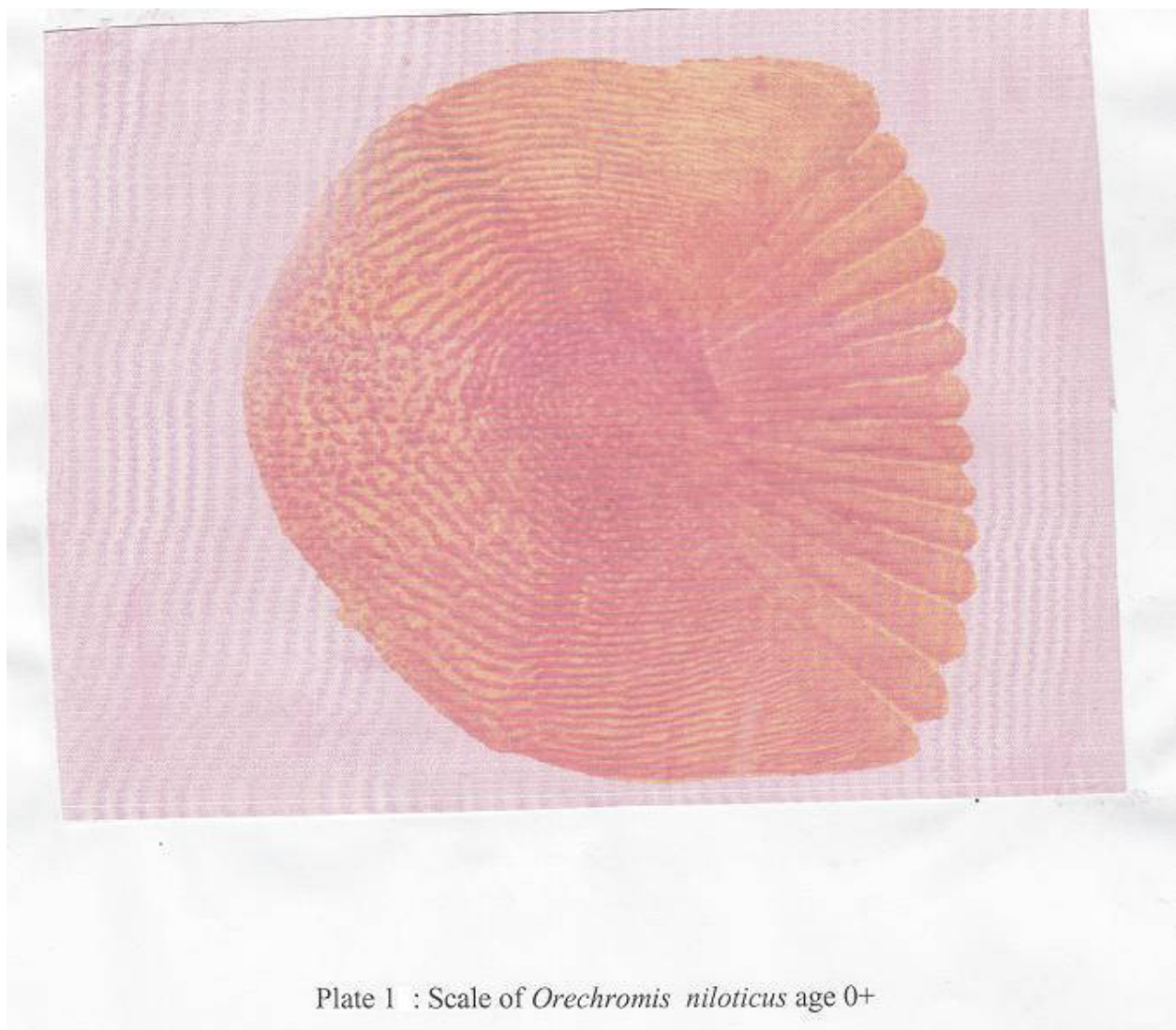




Plate 2 : Scale of *Oreochromis niloticus* age 1+



Plate 3: Opercula bone of *Clarias gariepinus* age 1+



Plate 4 : Scale of *Tilapia zillii* age 2+



Plate 5: Opercula bone of *Clarias gariepinus* age 3+



Plate 6 Scale of *Sarotherodon galilaeus* age 3+

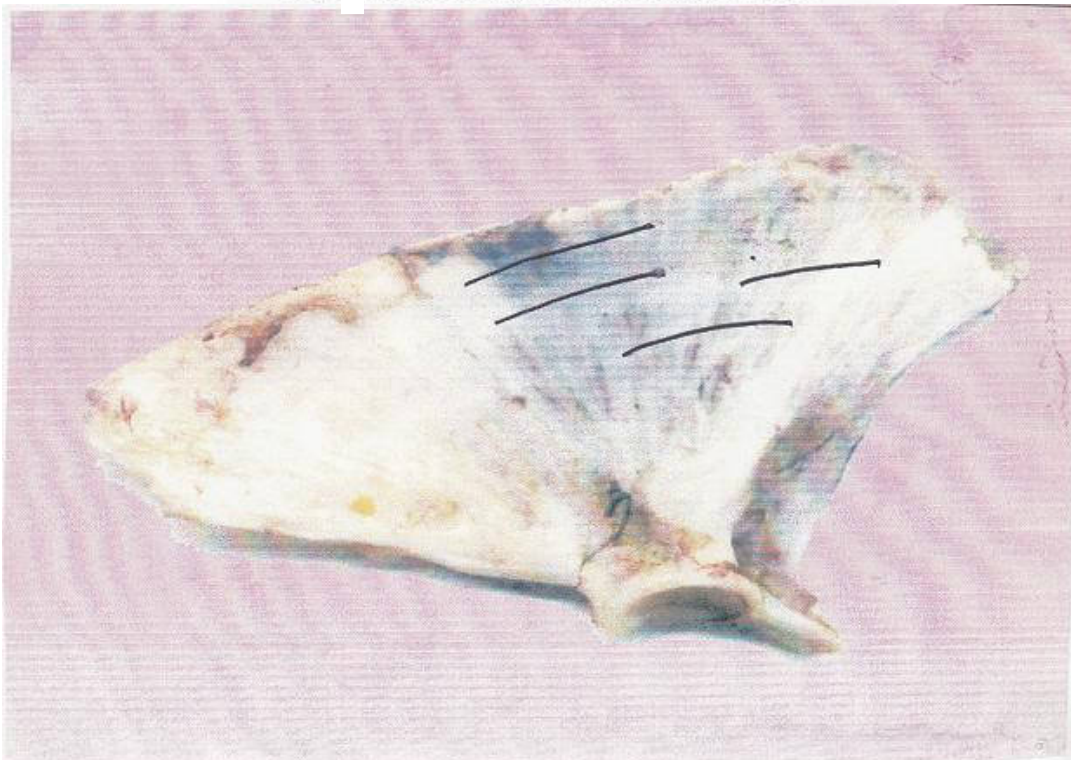


Plate 7: Opercula bone of *Barugus bayad* age 4+

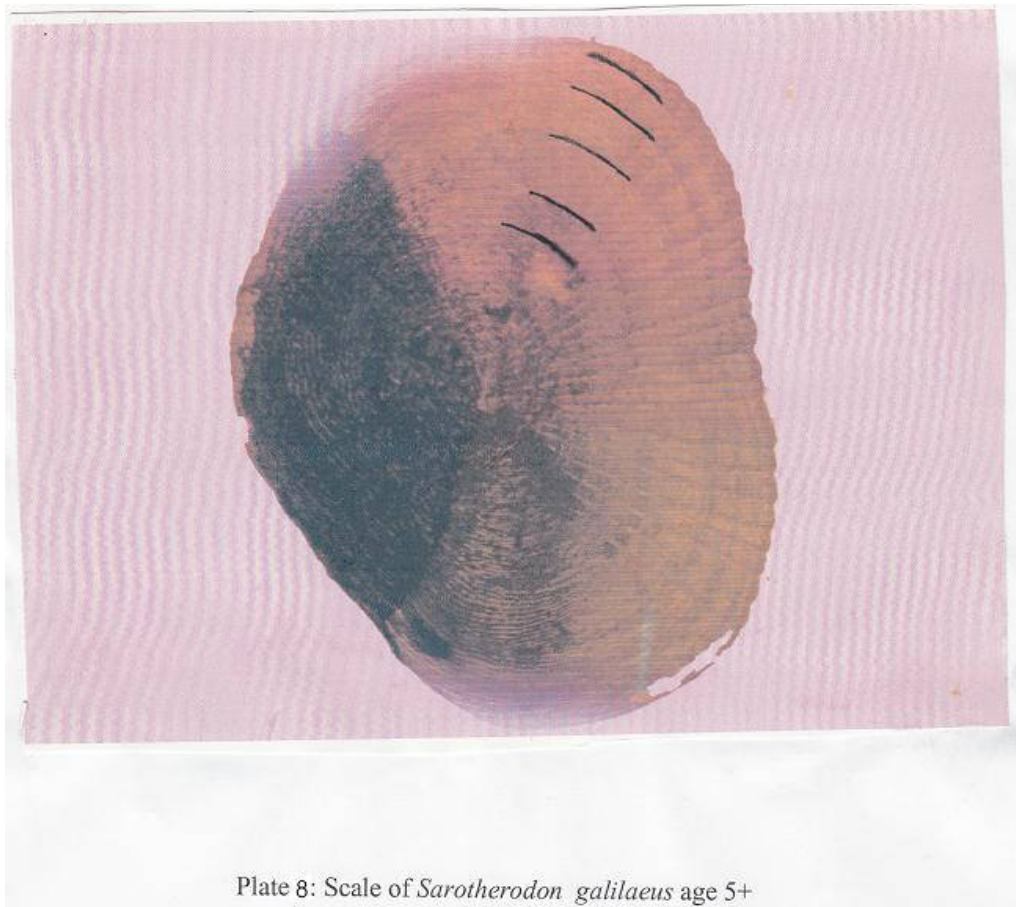


Plate 8: Scale of *Sarotherodon galilaeus* age 5+

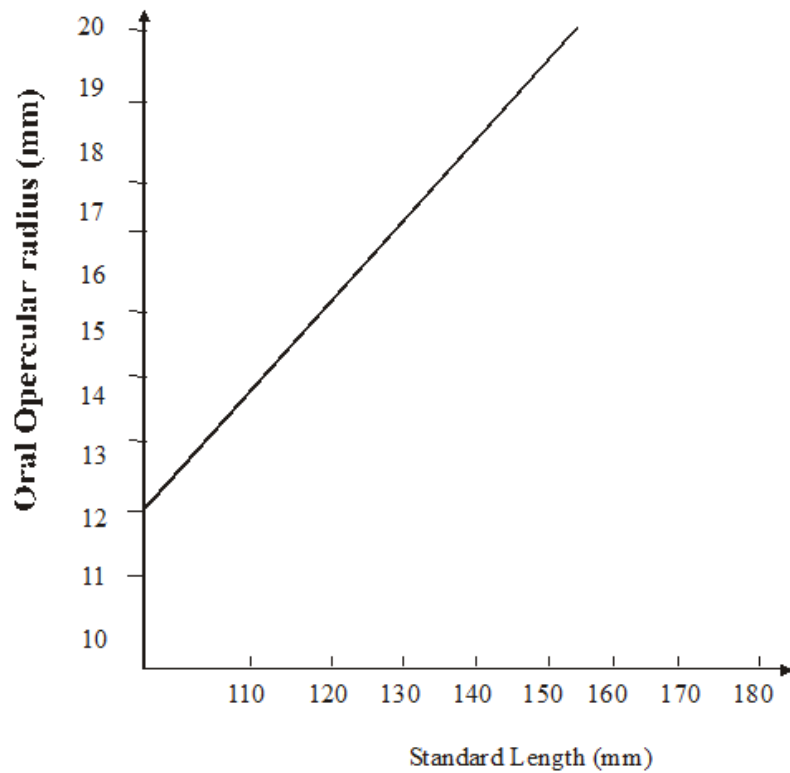


Fig. 1 Relationship between standard length and oral opercular in *O. niloticus* from Site A

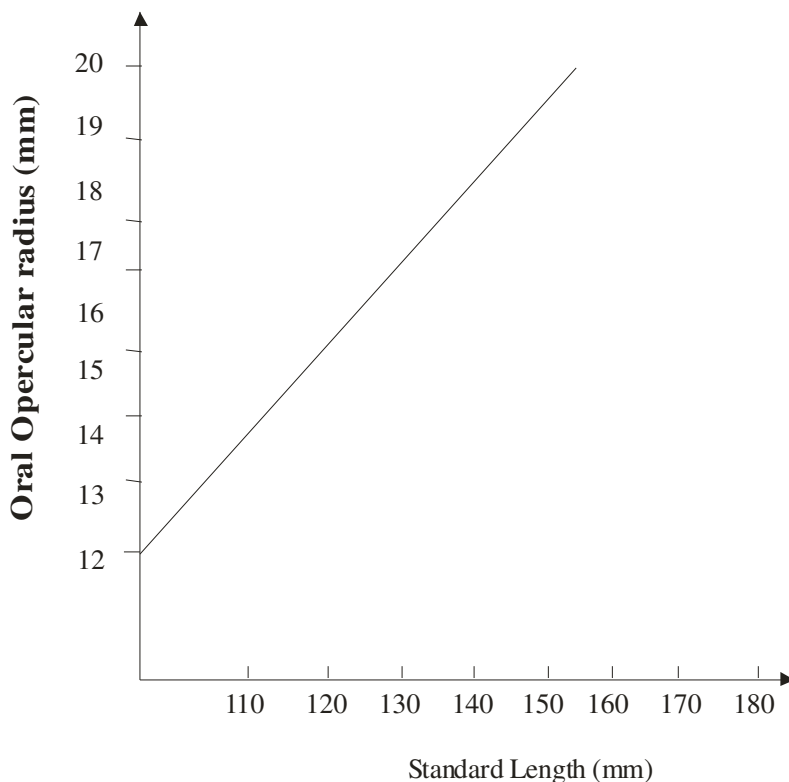


Fig. 2 Relationship between standard length and oral opercular in *O.niloticus* from Site C

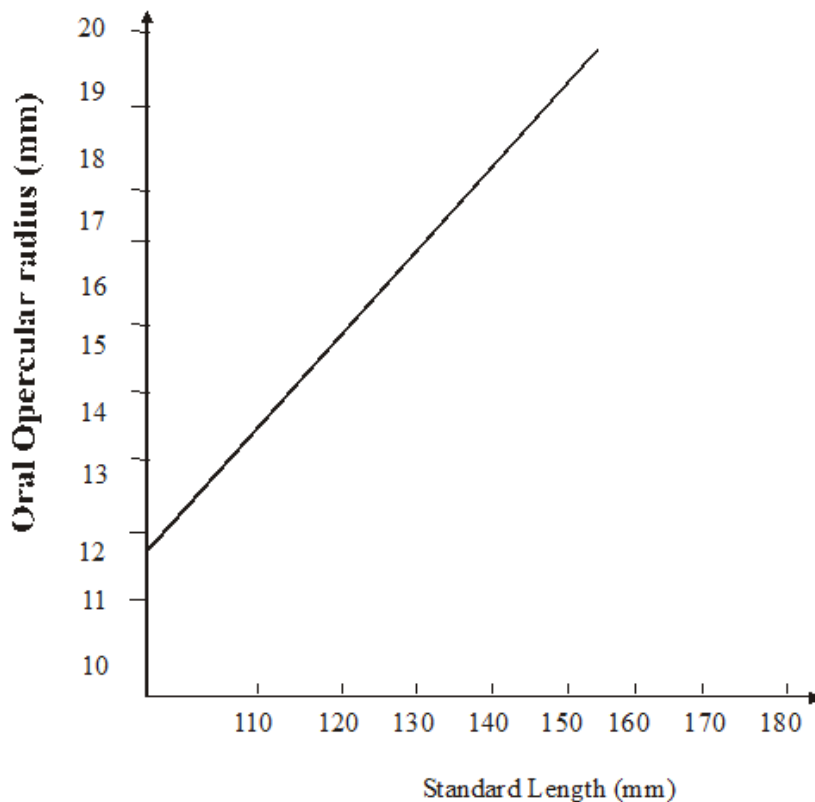


Fig. 3 Relationship between standard length and oral opercular in *O.niloticus* from Site B

Back Calculations

Table 2 gives the back – calculated standard lengths of *O.niloticus* in the sites of study in River Hadejia. Mean back calculated standard length if fish at age did not show any consistent pattern of difference between the sexes. Furthermore, phenomenon as back – calculated standard lengths from other fish were not significantly lower than values from younger fish.

Length at age of fish in the different sampling sites also did not seem to differ significantly Table 2. Only eight fish were used to back – calculate the lengths of *S.galilaeus* from Site C. No fish in 5⁺ and 6⁺ year class groups were represented in the sample.

Table 3 summarizes the von Bertalanffy growth parameters and growth index ϕ . The asymptotic length ranged from 116mm in the male *T.zillii* from site B to 228mm in the male *S.galilaeus* from site C of River Hadejia.

The males appear to have a higher Loo value than their female counterpart. However, female *T.zilli* from site B had a higher Loo is approached (K) ranged from 0.100 / year to 0.450 / year. The result did not show any consistent pattern of difference between the sexes (Table 3).

The time at which the fish would be zero (t_0) also did not show any consistent pattern of difference between the sexes and it ranged from 0.200 years to 0.677 years Table 3.

The growth performance index (ϕ) ranged from 3.65 to 3.97. It was similar for the different species and sexes in the sampling sites studied. Table 3.

Table 2 Back – calculated standard length of the endemic fish species in the River

Study Site (species No. of year fish)	L ₁		L ₂		L ₃		L ₄		L ₅		L ₆		L ₇		L ₈		
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
Site A <i>O. niloticus</i>	5	10	3+	80.0	76.4	90.6	90.0	102.9	102.4								
	1	6	4+	78.0	75.3	85.8	90.1	97.5	100.1	109.2	112.7						
	11	3	5+	83.6	73.7	92.4	86.2	101.5	97.4	111.1	108.5	121.7	118.2				
	7	0	6+	77.0	-	92.3	-	104.7	-	116.4	-	127.1	-	140.1	-		
	1	0	7+	89.7	-	97.5	-	106.0	-	114.2	-	130.5	-	146.8	-	154.9	-
			Mean	81.1	75.6	92.0	98.4	102.7	100.9	112.7	111.3	124.1	118.2	141.0	154.9		

Table 2 (cont'd)

Study Site (species)	No. of year fish	L ₁		L ₂		L ₃		L ₄		L ₅		L ₆		L ₇		L ₈			
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F		
Site C <i>O. niloticus</i>	0	2	2+	-	82.5	-	96.1	-	108.7	110.1	-	-	-	-	-	-	-	-	
	6	13	4+	81.5	83.1	86.5	88.2	108.8	108.2	119.4	113.6	-	-	-	-	-	-	-	
	8	1	4+	81.9	84.1	84.4	82.8	108.4	108.2	116.3	-	-	-	-	-	-	-	-	
	12	0	5+	82.3	-	84.4	-	108.4	-	116.3	-	-	-	-	-	-	-	-	
	8	0	8+	84.0	-	84.0	-	108.6	-	116.1	-	-	-	-	-	-	-	-	
	1	0	7+	84.8	-	110.4	-	127.3	-	135.0	-	-	-	-	-	-	-	-	
	Mean			83.1	83.1	85.0	87.5	107.4	109.7	117.5	113.6	126.9	-	-	136.6	-	154.9	161.3	
	Site B <i>O. niloticus</i>	7	12	3+	69.8	72.3	83.7	85.8	105.8	103.6	-	-	-	-	-	-	-	-	-
		12	3	4+	67.8	65.0	85.5	87.7	104.1	101.9	119.6	123.9	-	-	-	-	-	-	-
		2	1	5+	73.1	67.4	88.6	84.2	104.1	101.1	117.4	117.9	132.9	-	-	-	-	-	-
Mean				68.0	66.5	87.0	85.6	104.7	103.1	119.3	122.4	136.6	-	-	-	-	-	-	
134.8		134.8																	
Site A T. zillii	1	0	2+	82.4	-	92.7	-	-	-	-	-	-	-	-	-	-	-	-	
	2	1	3+	75.3	68.9	82.1	77.5	89.9	90.5	-	-	-	-	-	-	-	-	-	
	1	2	4+	83.6	70.1	84.5	78.4	108.2	91.4	118.1	103.4	-	-	-	-	-	-	-	
	Mean			79.2	69.7	86.8	78.4	96.3	91.1	118.1	103.4	-	-	-	-	-	-	-	
	103.4	103.4																	
Site B T. zillii	2	2	2+	50.9	50.4	64.8	71.6	-	-	-	-	-	-	-	-	-	-	-	
	2	2	3+	78.6	66.1	86.2	71.9	95.8	90.8	-	-	-	-	-	-	-	-	-	
	Mean			63.4	52.8	75.5	71.8	95.8	90.6	-	-	-	-	-	-	-	-	-	

Table 2 mt'd

Study Site /species	No. of year	Fish																
		L ₁	L ₂	L ₃	L ₄	L ₅	L ₆	L ₇	L ₈	L ₉	L ₁₀	L ₁₁	L ₁₂	L ₁₃	L ₁₄	L ₁₅		
Site C	<i>S. garwaensis</i>	2	4	3+	91.2	86.6	102.6	101.6	114.4	114.8								
		-	1	4+	-	86.2	-	103.4	-	112.0	-	125.0						
		-	-	5+														
		-	-	6+														
		-	1	7+	-	79.5	-	96.9	-	110.1	-	123.4	-	136.6	-	149.8	-	158.6
	Mean			91.2	85.3	102.6	101.1	114.4	113.6	-	124.2	-	136.6	-	149.8	-	158.6	
Site A	<i>S. galliaensis</i>	1	-	4+	79.5	-	102.9	-	112.3	-	126.3	-	121.2					
		-	1	5+	-	70.4	-	93.8	-	105.5	-	117.3	-					
			Mean			79.5	70.4	102.9	93.8	112.3	105.5	126.3	117.3	-	121.2			

Table 3 show Von – Bertalanffy growth performance parameters and the performance index (Φ) as described by sampling sites of River Hadejia.

Species (sites)	Sex	L ^a	K ^b	t ₀ ^c	Φ^d
<i>S. galileus</i> (A)	M	188	.190	.465	3.83
<i>S. galileus</i> (A)	F	184	.150	.448	3.71
<i>S. galileus</i> (C)	M	228	.100	.471	3.72
<i>S. galileus</i> (C)	F	216	.130	.426	3.78
<i>T. zillii</i> (B)	M	116	.450	.363	3.78
<i>T. zillii</i> (B)	F	135	.300	.301	3.74
<i>T. zillii</i> (A)	M	141	.290	.601	3.77
<i>T. zillii</i> (A)	F	137	.240	.525	3.65
<i>O. niloticus</i> (B)	M	160	.300	.283	3.89
<i>O. niloticus</i> (B)	F	152	.400	.120	3.97
<i>O. niloticus</i> (C)	M	200	.168	.299	3.83
<i>O. niloticus</i> (C)	F	166	.170	.677	3.83
<i>O. niloticus</i> (A)	M	170	.278	.299	3.90
<i>O. niloticus</i> (A)	F	155	.200	.527	3.68

Note;

- a = Asymptotic length in mm
- b = Rate at which L_∞ is approached per year
- c = Time at which the fish would have been zero sized in years.
- d = Growth performance index
 $= \log_{10} K + 2 \log_{10} L_{\infty}$

Discussion and Conclusions

The use of the hard parts like scales and opercula bones confirm the validation of the aging tropical fish species. Most of the fish species caught from River Hadejia fall within the range of 0⁺ to 5⁺ age brackets. The implication for the fishery is that many of the fish would enter the fishery at an early age and this could lead to the present experience of the fish reproducing early. This is in agreement with and Johnel (1952) associated annual rings with dry season. Spawning activity may also cause a decrease in the growth rate, which brings about the formation of growth marks on the hard parts. *O.niloticus* being a month brooder usually stops feeding after spawning; Fagade, (1979).

Fagade (1979) observed that growth rings were formed on the scales and opercula bones as a result of spawning in the mouth breeding *Tilapia* species. Condition associated with loud water and decreased area of inundation many also delay the resumption of rapid growth. This period is usually associated with the dry and warm season when the late of evaporation is high. Because the onset of warm weather spawning and low water level all occur at the same time the possibility that more than one of these three factors contribute to the formation of growth marks in on way detracts the validity of the growth marks (Haruna, 1992). Growth marks could therefore be laid yearly which agrees with the findings of Hamisu (1993) on Wateri Lake in Kano State (Olatunde, 1978). The result indicates low growth rate, which can be attributed to high fecundity. Pauly (1987) showed that the growth performance of most species they studied could be higher in cultured tanks than in wild although this was not so clear for species *O.niloticus*. This species showed the highest growth performance in index $+(ø)$ in wild populations but cultured palpations failed to fully realize their growth potential. Moreau et al (1986) found that $ø$ values have a normal distribution with a smaller standard deviation than the other growth performance indices, which have skewed distributions, since fish often lose weight but rarely lose length; this makes them less liable to biases. The growth performance index ($ø$) obtained in this study ranged for 3.60 to 3.97 which were within the limits 2.6 to 4.0 reported by Mathews and Samuel (1996).

Conclusions

Growth marks were laid annually on the opercula bones and scales that were used. The asymptotic length L_{∞} had higher values except in *tilapia zilli* from Site B. the growth performance index ($ø$) was similar in all the Sites (A, B and C). The plates show different years, ranging from 0 – 5 years.

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