Growth of *Clarias gariepinus* in Lake Sibaya, South Africa

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Pectoral spines from 750 *Clarias gariepinus* (Pisces:Clariidae) from Lake Sibaya were used for age and growth determinations. The spines have clear rings in the bone matrix. Rings formed on otoliths, vertebrae and opercula were less useful. A close correlation between ages determined from length frequency data and ages obtained by back-calculation of lengths for different ring classes exists. Spine rings are laid down annually, except in the first year. *C. gariepinus* in Lake Sibaya grow rapidly and remain in good condition to a length of about 500 mm (age 3+ years) but of the larger catfish, few exceed 650 mm (7+ years). Males grow slightly faster than females, and modal sizes are 580 – 590 mm TL, and 540 – 550 mm TL. Over one third of the adult population measures between 500 and 600 mm TL due to the sharp deceleration of growth rate after 500 mm TL. Modal length and growth rate of Sibaya catfish is equal to that of other *C. gariepinus* populations, but the number and condition of larger individuals is lower, probably because of inadequate food resources in deep water.
S. Afr. J. Zool. 1980, 15: 7 – 15

Pektorale stekels van 750 *Clarias gariepinus* (Pisces:Clariidae) in Sibayameer is vir groei- en ouderdombepalings gebruik. Dié toon sigbare ringe in die beenmatriks wat gevorm is. Ringe op otoliete, werwels en operkula is van minder waarde. 'n Goeie korrelasie bestaan tussen ouderdomme bepaal uit lengtefrekwensie inligting en berekening vanaf lengte by verskillende ringklasse. Stekelringe word jaarliks gevorm behalwe in die eerste jaar. *C. gariepinus* in Sibayameer groei vinnig en bly in 'n goeie kondisie tot 'n lengte van ± 500 mm (ouderom 3 + jaar). Min word groter as 650 mm (7+ jaar). Mannetjies groei vinniger as wyfies, en groottes is gemiddeld 580 – 590 mm TL, en 540 – 550 mm TL. Modale lengte en groeitempo van Sibaya babers is dieselfde as ander *C. gariepinus* bevolkings, maar die aantal groter individue is laer en hul kondisie is swakker, waarskynlik as gevolg van onvoldoende voedselvoorraad in diep water.
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The sharptooth catfish *Clarias gariepinus* (Burchell 1822) is a common omnivorous scavenger in rivers, swamps, impoundments and lakes from the Zambezi River southwards to the eastern Cape in Southern Africa (Jubb 1967, 1978). *C. gariepinus* feeds on a wide variety of organisms, from zooplankton to fish, and may grow to a large size (> 20 kg; Bruton 1976, 1979a). *C. gariepinus*, and the closely related species *C. mossambicus*, *C. lazera* and *C. anguillaris* of east, north and west Africa respectively, are important sources of food in rural areas although their aquaculture potential has only recently been realized (Van der Waal 1974; De Kimpe & Micha 1974; Micha 1975; Richter 1976, Hogendoorn 1977).

Knowledge of age and growth is fundamental to the understanding of a fish population in both artificial and natural environments before rational exploitation can take place. Previous studies on the growth of *C. gariepinus* have been made by Pivnicka (1974, for catfish in Lake Kariba, Zambia), Van der Waal and Schoonbee (1975, eastern Transvaal, South Africa), Willoughby and Tweddle (1978, Shire River, southern Malawi) and Van der Waal (1976, Lake Liambezi, Caprivi Strip, South West Africa). These studies have indicated that *C. gariepinus* may have markedly different growth rates in different waterbodies.

The present study on growth was part of a wider investigation of the habitat preferences, breeding and trophic ecology of *C. gariepinus* in a natural freshwater lake in South Africa (Bruton 1978, 1979a,b,c).

Study area

Lake Sibaya (32°40′E, 27°25′S) is a freshwater lake on the coastal plain of north-eastern Zululand. The lake has an area of 65 km², with mean and maximum depths of 13 and 40 m (Hill 1975). The lake is moderately clear (secchi disc readings 3,0 – 3,5 m) and has a well-illuminated, shallow littoral zone which ends abruptly in a steep slope into deeper water. The slope is vegetated with macrophytes to a depth of 7 – 9 m but the profundal zone is barren. Most food organisms occur in the littoral and well-vegetated slope zones. Open water temperatures range seasonally between 18 and 28 °C. In shallow water (< 10 cm) temperatures may reach extremes of 13 and 41 °C. Further details on Lake Sibaya are given by Allanson and Van Wyk (1969), Boltt, Hill and Forbes (1969), Hill (1969, 1975), Allanson, Bruton and Hart (1974) and Bruton (1978).

Methods

Collection and measurement

Small *C. gariepinus* (< 200 mm total length) were collected using rotenone, traps and seine nets, and large specimens using longlines, gillnets and traps described by Bruton (1978). All lengths given are total lengths (TL). Voucher specimens of *C. gariepinus* from Lake Sibaya have been lodged in the Albany Museum and the JLB Smith Institute of Ichthyology, both in Grahamstown.

The main spawning season of *C. gariepinus* in Lake Sibaya extends from November to February although some fish spawn in September and October or as late as March (Bruton 1979b). As *C. gariepinus* is fast-growing, well-defined length distribution peaks can be expected in younger age-groups as a consequence of the clearly-defined spawning season. *C. gariepinus* up to 300 mm TL mainly occupy marginal and littoral habitats in Lake Sibaya (Bruton 1978), and intensive sampling was therefore carried out monthly in these areas from October 1974 – January 1975 and from October 1975 – May 1976 to determine growth rates from length frequency modes in juveniles.

Examination of hard parts

Age determination in scaleless fishes has usually involved analysis of rings on other hard parts such as otoliths, vertebrae, cleithra, pectoral girdles and opercula (for reviews see Sinha & Jones 1967; De Bont 1967; Williams & Bedford 1974). In addition, dorsal and pectoral spines have been used to age *Ictalurus punctatus* (Sneed 1950; Marzolf 1955; Muncy 1959); *Pangasius pangasius* (Pantulu 1962); various Acipenseridae (Cuerrier 1951; Probst & Cooper 1955); *Eutropius depressirostris* (Gaigher 1969); *Heterobranchus longifilis* (Donnelly & Caulton 1969), and *C. gariepinus* (Van der Waal & Schoonbee 1975). Pectoral spines, otoliths, opercula and vertebrae were examined for possible use in age determination of *C. gariepinus* from Lake Sibaya.

Pectoral spines (Fig. 1) were removed from the glenoid joint whole, cleaned, and stored in envelopes cross-referenced to date of collection and fish number. The spine retains essentially the same form throughout life but in older *C. gariepinus* a progressive enlargement of the lumen takes place as a result of bone resorption. This enlargement proceeds towards the posterior side of the lumen, so that early growth rings may be resorbed, although they usually remain visible on an anterolateral side. To minimize this risk, a position on the spine was chosen for sectioning which gave reliable readings for all fish sizes. This position is at 5/7 from the distal end; all spines were therefore marked off from a nomogram at 5/7 and sectioned at this site (Fig. 1C).

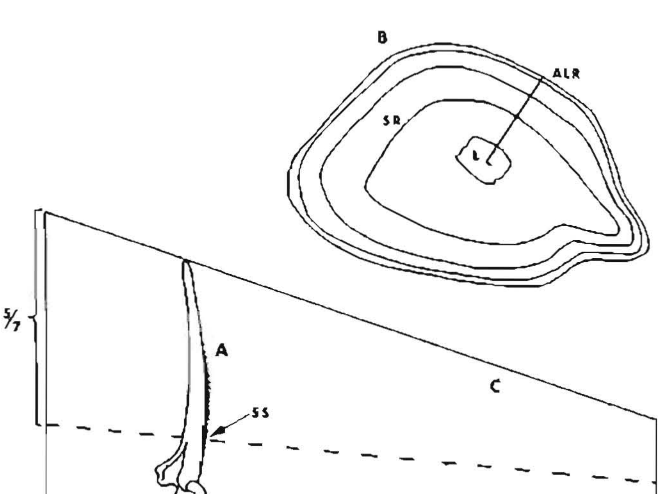

Fig. 1A Diagram of a pectoral spine of *C. gariepinus* (SS = sectioning site).
Fig. 1B Diagrammatic cross-section of a pectoral spine showing lumen (L), spine ring (SR) and antero-lateral radius (ALR).
Fig. 1C Nomogram for determining sectioning site at 5/7 spine length.

Spines were sectioned using a fine saw, and ground on the cut surface on silicon carbide water paper (grit sizes 100, 220 & 400) using paraffin as a lubricant. Small spines were ground manually by holding the bulb and rubbing the cut surface on firmly-fixed water paper. Larger spines were ground on water paper cut into discs and revolved on a sandpaper attachment to an electric drill. After polishing, a section about 2 mm thick was cut, cleaned and glued onto a microscope slide with the polished side down. The other side was then ground down to a thickness of about 0,1 mm, washed, labelled and examined under water or in glycerin in a black dish by reflected light. Clear subconcentric rings were usually visible (Fig. 2). Spine sections with indistinct rings were subjected to the following procedure: boil for 5 min (which removes the section from the slide and softens the tissue), decalcify in 30% nitric acid for 6 min, stain in alizarin red S for 40 min, dehydrate in 95 and 100% ethyl-alcohol for 30 min each, clear in xylol overnight and mount in Canada balsam under a cover slip. All spine sections were examined on a Fresnel screen mounted on a compound microscope.

Spine rings took the form of clearly-defined lines of denser tissue in the bone matrix (Fig. 2). Rings which did not extend from the anterior field across the lateral fields and into the posterior field were regarded as false rings, and were not used in age determination. True rings were counted on the anterior field to give the pectoral spine ring count. Spines were examined from 750 catfish collected in the summers of 1973/74 and 1974/75; 96% had clear rings, either before or after treatment.

Utricular otoliths (lapillus) were removed by cutting the cranium just anterior to the supra-occipital bone. The otoliths were ground to the plane of the nucleus on the convex side and etched using 1% aqueous hydrochloric

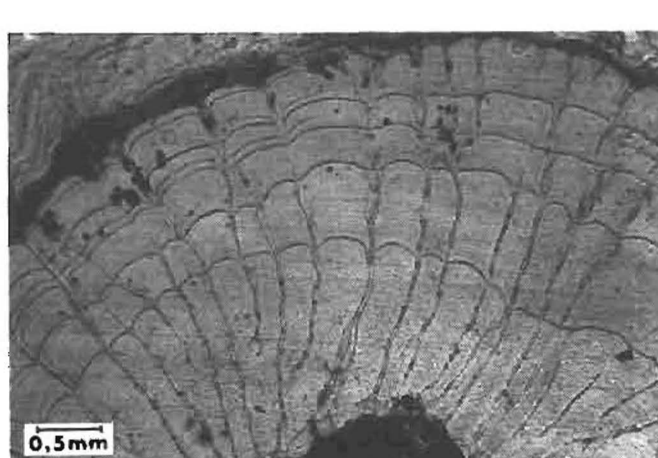

Fig. 2 Transverse section of the pectoral spine of *C. gariepinus* from Lake Sibaya showing clear spine rings in the anterior field. False rings can be seen in the top left hand corner.

acid. When examined under water in a black dish by reflected light, light and dark bands were visible on nine of the 36 otoliths examined. In addition 25 otoliths were ground to the plane of the nucleus and burnt over a cool flame. When examined dry by reflected light all these otoliths showed bands as well as minute rings (perhaps comparable to the growth patterns observed by Pannella 1974, and Brothers, Mathews & Lasker 1976).

Cleaned, dry whole vertebrae from 15 catfish were also examined, and all showed rings which were more distinct in decalcified samples. Opercula were almost opaque when untreated, but showed bands when decalcified. On the whole, otoliths, opercula and vertebrae were more time-consuming to prepare and yielded less distinct rings than did pectoral spines, which were therefore used in this study.

Back-calculation of lengths from pectoral spine rings

The antero-lateral radius of 630 pectoral spines with undamaged edges and easily-defined lumen centres was determined. There was no significant difference between the two sexes in the relationship of the spine radius to total length of the fish. This relationship is described by the regression $y = 0{,}131x + 2{,}559$ ($r^2 = 0{,}98$) where y = antero-lateral spine radius in mm; and x = total length of fish in mm in the TL range 300 – 700 mm.

The regression is linear but not directly proportional and back-calculations were therefore made using Fraser's formula as suggested by Ricker (1968):

$$Ln - c = \frac{Sn}{S}(L - c)$$

where

Ln = length of fish when ring 'n' was formed
L = length of fish at capture
Sn = radius of ring 'n'
S = antero-lateral radius of pectoral spine
c = intercept on length axis.

Results

Growth rate from length distribution modes

The length distribution of fingerling *C. gariepinus* caught monthly from December 1975 – May 1976 along one stretch of shore is given in Fig. 3. The collections were made at the site of a major spawning run which occurred on 3 – 4 December 1975. The first collection, made in late December 1975, therefore represented catfish approximately three weeks old. These catfish had a length mode of 18 mm TL (Fig. 3). This growth rate was confirmed in aquaria, and in gauze cages placed in known spawning sites, in which *C. gariepinus* fry reached 18,2 mm in three weeks and 22,2 mm TL in four weeks (Bruton 1979b).

Clear separation of size classes between different samples is apparent from the catches of fingerling catfish (Fig. 3) which indicate their growth rates in the lake. Monthly length increments ranged from 18 – 38 mm (mean 24 mm) and a modal size of 144 mm was reached after six months. These length increments extrapolate to about 250 mm TL at an age of one year.

Collections of one year old catfish were made in the midsummers (December/January) of 1974/75 and 1975/76 in marginal habitats. The length modes of yearlings were between 240 and 260 mm in both years (Fig. 4).

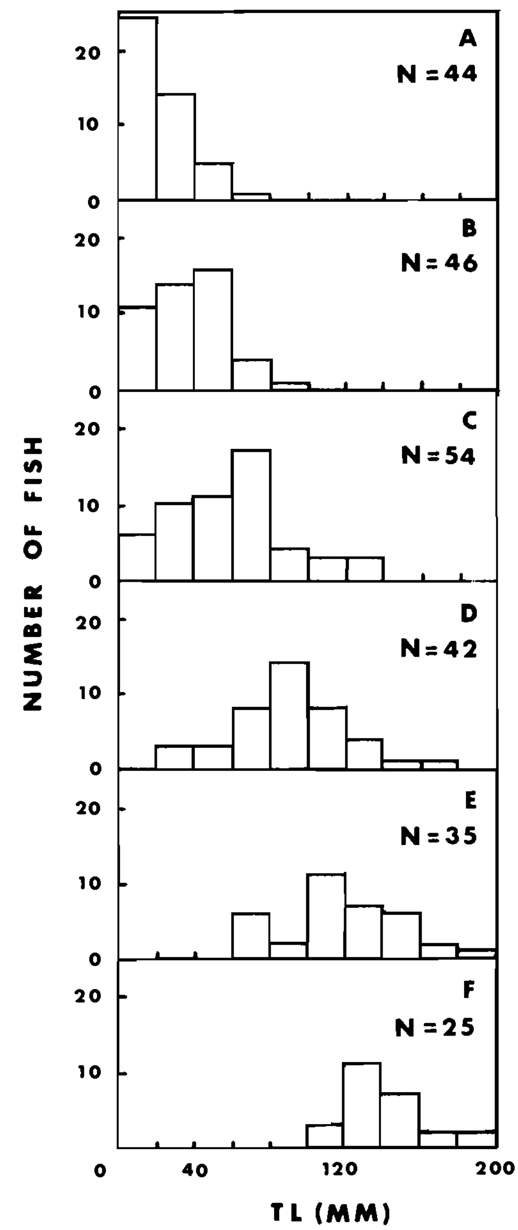

Fig. 3 Length distribution of fingerling *C. gariepinus* caught in the marginal shallows of Lake Sibaya, showing the growth rate by movement of the length mode. The juveniles for this sample were all collected at the same site monthly over a period of six months.
A: December 1975 – mean length 18 mm
B: January 1976 – mean length 43 mm
C: February 1976 – mean length 81 mm
D: March 1976 – mean length 102 mm
E: April 1976 – mean length 126 mm
F: May 1976 – mean length 144 mm.

Age determination from pectoral spine rings

The length distribution of male and female *C. gariepinus* for directly-read pectoral spine ring groups is given in Table 1. There is considerable overlap in consecutive groups, but clumping is evident at certain length groups.

Table 2 is a summary of the average back-calculated total lengths of both sexes for different spine ring counts. The lengths at each spine ring count in Table 1 correspond closely with those determined from observed data in Table 2, and confirm the accuracy of the directly-read lengths.

The first spine ring was formed at a modal length of 400 – 410 mm, and no ring was formed at a length of

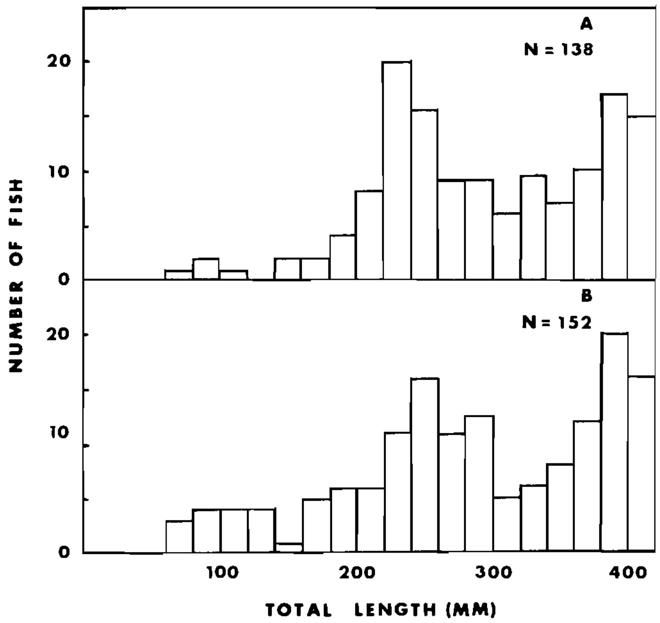

Fig. 4 The length frequency of *C. gariepinus* caught in shallow terrace and marginal habitats in Lake Sibaya, showing length modes of one year old fish. A: 240 mm in December 1974/January 1975; B: 260 mm in December 1975/January 1976.

Table 1 The length distribution of *C. gariepinus* from Lake Sibaya for different pectoral spine ring counts

Total length group (mm)	Pectoral spine ring count 1	2	3	4	5	6	7
240	2						
260	2						
280	1						
300	3						
320	5						
340	8						
360	19	6	1				
380	24	1					
400	38	1	1				
420	29	13					
440	31	11	2				
460	6	11	2				
480	3	28	3	1			
500		52	8	1			
520	1	46	12	1	2	1	
540		40	14	2	2	1	
560		24	36	2	3	1	
580		9	33	13			
600		3	19	30	3	1	
620		3	11	23	5	1	1
640				10	8	3	1
660				2	11	1	
680				3	7	2	
700				1	5	5	2
720					1	3	3
740				1		2	4
760							
780							
800							
820							1

Table 2 Back-calculated total lengths (mm) for male and female *C. gariepinus* from Lake Sibaya, obtained from measurements of pectoral spine rings

No. of rings at capture	n	Length at age II	III	IV	V	VI	VII
				Males			
1	87	330					
2	122	368	473				
3	66	381	501	541			
4	34	387	529	553	623		
5	21	421	481	586	608	671	
6	10	382	517	551	630	635	697
No. of fish	340	340	253	131	65	31	10
Mean TL		378	500	558	620	653	697
				Females			
1	78	360					
2	98	378	483				
3	54	393	496	522			
4	41	371	532	558	608		
5	19	403	512	573	616	640	
No. of fish	290	290	212	114	60	19	
Mean TL		381	506	551	612	640	

240 − 260 mm at an age of about one year (Fig. 4), in the bulk of fish examined. If the first spine ring is assumed to be formed towards the end of the second year, a smooth curve is obtained which produces a good fit of Von Bertalanffy's growth equation (Von Bertalanffy 1957). This assumption was tested by calculating Von Bertalanffy's parameter, t_0 (the theoretical time when length is zero) using Ricker's (1975) method in which log $(L_0 - t)$ is plotted against age in years. L_0 is the final or asymptotic length obtained from a Ford-Walford plot (see below). Values of t_0 close to 0 indicate a good fit to Von Bertalanffy's growth model, and values approximating 1 or − 1 a poor fit. The values of t_0 when the first spine ring is assumed to be formed in the first, second or third years was calculated (Table 3). As shown in Table 3, t_0 closely approximated 0 if the first spine ring was laid down in the second year. This finding confirms that no spine ring is laid down in the first year.

The adequacy of the Von Bertalanffy growth model in this particular case was also tested using Ford–Walford plots (Ford 1933; Walford 1946). The data points occur in a straight line which bisects the 45° diagonal (Fig. 5), which is typical of a growth curve with an initial period of rapid increase and then a decrease. Walford (1946) pointed out that growth conforming to this pattern suggests a limiting

Table 3 The theoretical time when length is zero, t_0, for *C. gariepinus* from Lake Sibaya when the first pectoral spine ring is presumed to be formed in the first, second or third year of life

Year first ring formed	♂	t_0	♀
1+	−1,02		−0,88
2+	0,033		0,077
3+	1,033		1,077

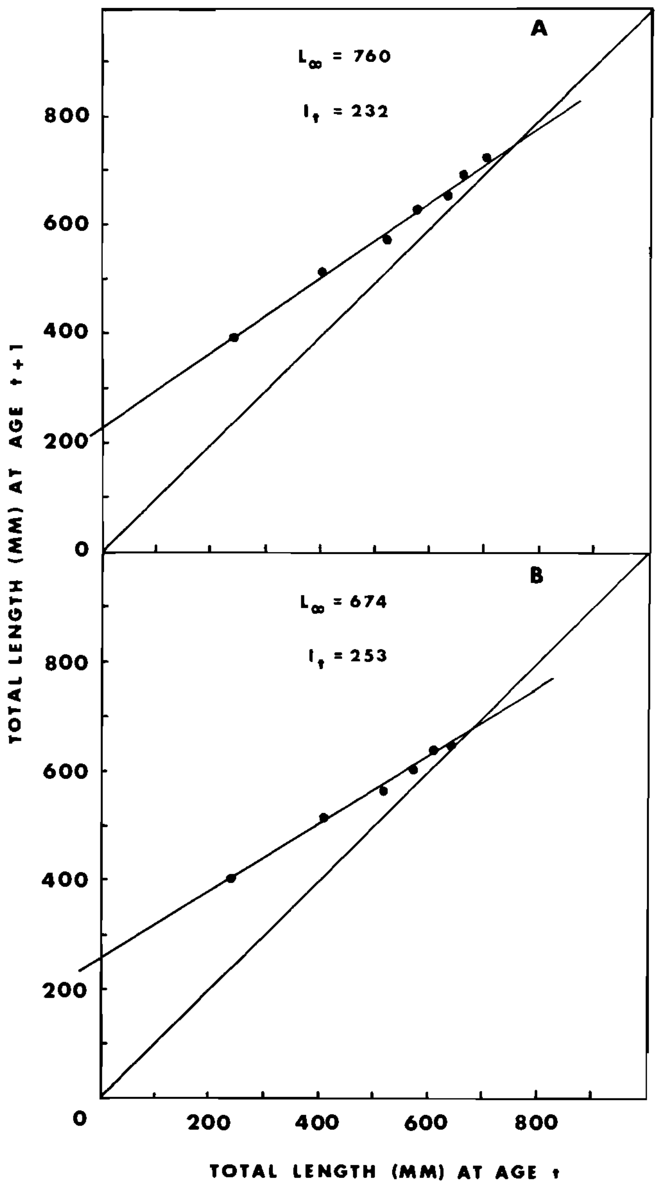

Fig. 5 Ford–Walford plots for male (A) and female (B) *C. gariepinus* from Lake Sibaya. L_∞ = asymptotic length (intercept on diagonal); l_t = length at one year (intercept on y axis).

size, the asymptotic length, which is read off a Ford–Walford plot as the intercept on the 45° diagonal. Figures 5A and B give asymptotic lengths of 760 and 674 mm TL for male and female *C. gariepinus* from Lake Sibaya. In a sample of 1 156 *C. gariepinus* caught in all habitats in Lake Sibaya, only 1,7% of the males and 3,2% of the females exceeded these postulated asymptotic lengths. The theoretical length at one year is read off a Ford–Walford plot as the intercept on the *y*-axis. Once again, the values obtained (230 – 260 mm) correspond closely with observed values.

Description of growth

Growth rates were therefore calculated on the assumption that the first pectoral spine ring is formed at the end of the second year. Mean weight was determined from a length-weight regression based on 862 catfish, and is expressed as follows:

C. gariepinus juveniles 50 – 350 mm *TL*.
$W = 0{,}000006\ TL^{3{,}029}$ ($r^2 = 0{,}98$; n = 218)

C. gariepinus adult females > 350 mm *TL*.
$W = 0{,}00004\ TL^{2{,}705}$ ($r^2 = 0{,}90$; n = 289)

C. gariepinus adult males > 350 mm *TL*.
$W = 0{,}00004\ TL^{2{,}699}$ ($r^2 = 0{,}92$; n = 355).

where W = weight in grams; and TL = total length in mm.

The growth data are summarized in Table 4. The length at first maturity of *C. gariepinus* in Lake Sibaya (330 - 340 mm TL) was determined by Bruton (1979b).

Table 4 Mean observed total lengths in mm (TL), standard error of TL (SE), annual length increment (Δ TL), mean weight ($\bar{W}$) and number of catfish in sample (n) for different year classes of male and female *C. gariepinus* in Lake Sibaya. Mean length in the 1 + year class from Fig. 3

Year	TL	SE	Δ TL	$\bar{W}$	n
Males					
1+	240		240	97	
2+	399	0,49	159	419	81
3+	517	0,41	118	843	135
4+	575	0,53	58	1 123	67
5+	629	0,67	54	1 431	40
6+	659	1,06	30	1 623	24
7+	695	1,21	36	1 873	11
8+	726	1,47	31	2 107	10
Females					
1+	240		240	97	
2+	406	0,48	166	455	91
3+	512	0,45	106	852	110
4+	564	0,52	52	1 107	76
5+	608	0,41	44	1 357	50
6+	639	0,98	31	1 552	23
7+	648	2,46	9	1 612	12

Growth in weight was nearly linear in both sexes, but decelerated markedly after five years (Fig. 6). Annual weight increments were highest in the second and third years in both sexes. The mean weight after one year (97 g) was lower than that obtained by Van der Waal & Schoonbee (1975, about 450 g) but higher than the figure given by Pivnicka (1974, 6,8 g) and Willoughby and Tweddle (1978, about 36 g). The modal age of *C. gariepinus* in Lake Sibaya was 5+ years in males and 4+ years in females (Fig. 7). Few males exceeded 8+ years and few females 7+ years.

Growth in length for males and females was similar until 3+ years, after which males grow faster (Fig. 8). In both sexes, the annual length increment was highest in the first year, and then decreased progressively.

Large catfish (> 700 mm TL) are occasionally encountered in Lake Sibaya. Back calculations of growth rate from pectoral spine rings for four of these large catfish indicate that they attained a relatively high growth rate early in life which was maintained throughout life (Fig. 8). This phenomenon was also noted in aquaria where, as early as the second week, a small percentage of same-age catfish attain a larger size than the majority, and retained or increased this headstart in subsequent months (Bruton 1979b).

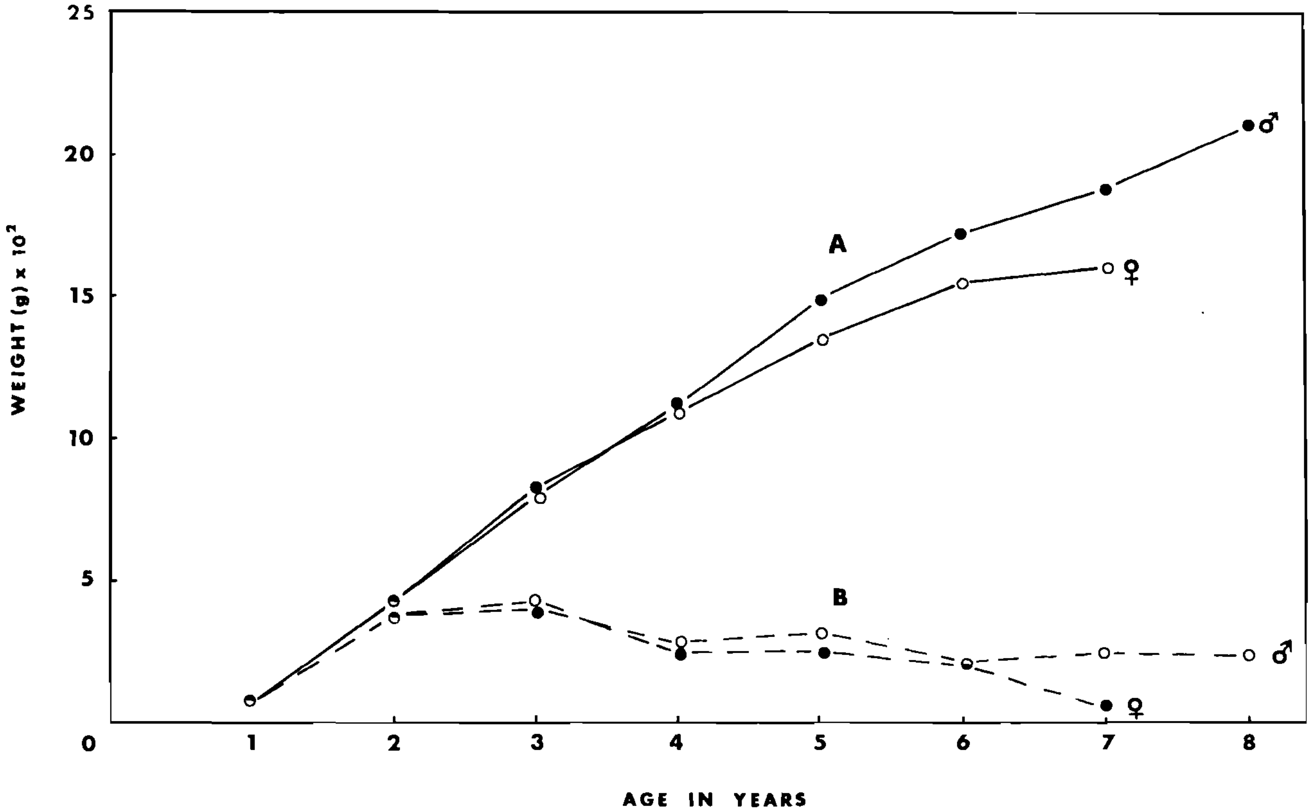

Fig. 6 Growth in weight of *C. gariepinus* from Lake Sibaya. n = 750, A: Weight increase, B: Annual weight increments.

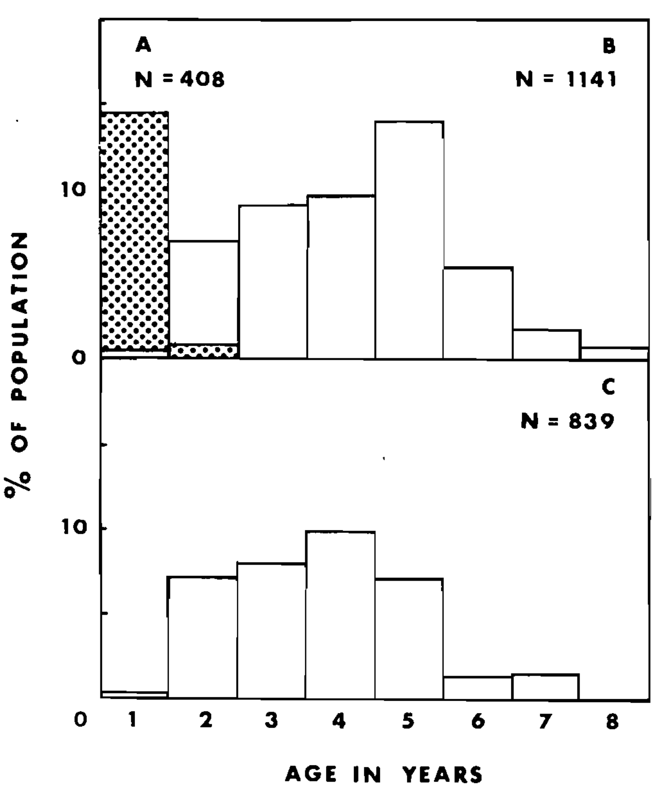

Fig. 7 Age structure of *C. gariepinus* in Lake Sibaya based on average length-at-age data. A: (Shaded) Juveniles, B: Males, C: Females.

The sizes of the largest male and female *C. gariepinus* caught in Lake Sibaya are given in Table 5. Bruton (1976) reviewed the size reached by *C. gariepinus* in other systems.

Population structure and sex ratio

The length frequency of 408 juvenile, 839 female and 1 141 male *C. gariepinus* caught in all habitats in Lake Sibaya is given in Fig. 9. The length mode in males was 580 – 590 mm TL and in females 540 – 550 mm TL. Over one third of the adult population measured between 500 – 600 mm TL. This marked clumping is explained by the sharp deceleration of growth rate between these lengths, as shown in Fig. 8.

The overall sex ratio of 1 980 *C. gariepinus* in Lake Sibaya was 1,36:1 in favour of males. Females exceeded males by a ratio of 1,13:1 to 500 mm TL but thereafter males were more abundant, and after 600 mm TL exceeded females by a ratio of 3,84:1. Males also exceeded females in large size groups of *C. gariepinus* in the Elands River (Van der Waal 1972), Pongola pans (H. Kok *pers. comm.* 1976), Hardap Dam (Gaigher 1977) and Lower Shire River (Willoughby & Tweddle 1978).

Discussion

The growth of other *C. gariepinus* populations

The growth rates of yearling catfish differ markedly in different waterbodies. *C. gariepinus* reached 37 – 48 mm after 65 days and 60 – 80 mm after 70 days in Zimbabwe Rhodesia (Holl 1968), about 144 mm after six months in Lake Sibaya (this paper) and 130 mm after nine months in Lake Kariba (Bowmaker 1973). Faster growth rates have been recorded for *C. gariepinus* in breeding ponds, with lengths of 39 mm after 40 days (Van der Waal 1972). The early development and first year growth rates of various *Clarias* species are reviewed by Clay (1977) and Bruton (1979b).

Munro (1965) used monthly length frequency peaks of *C. gariepinus* caught in commercial gillnets to describe the growth of modal groups in Lake McIlwaine, Zimbabwe

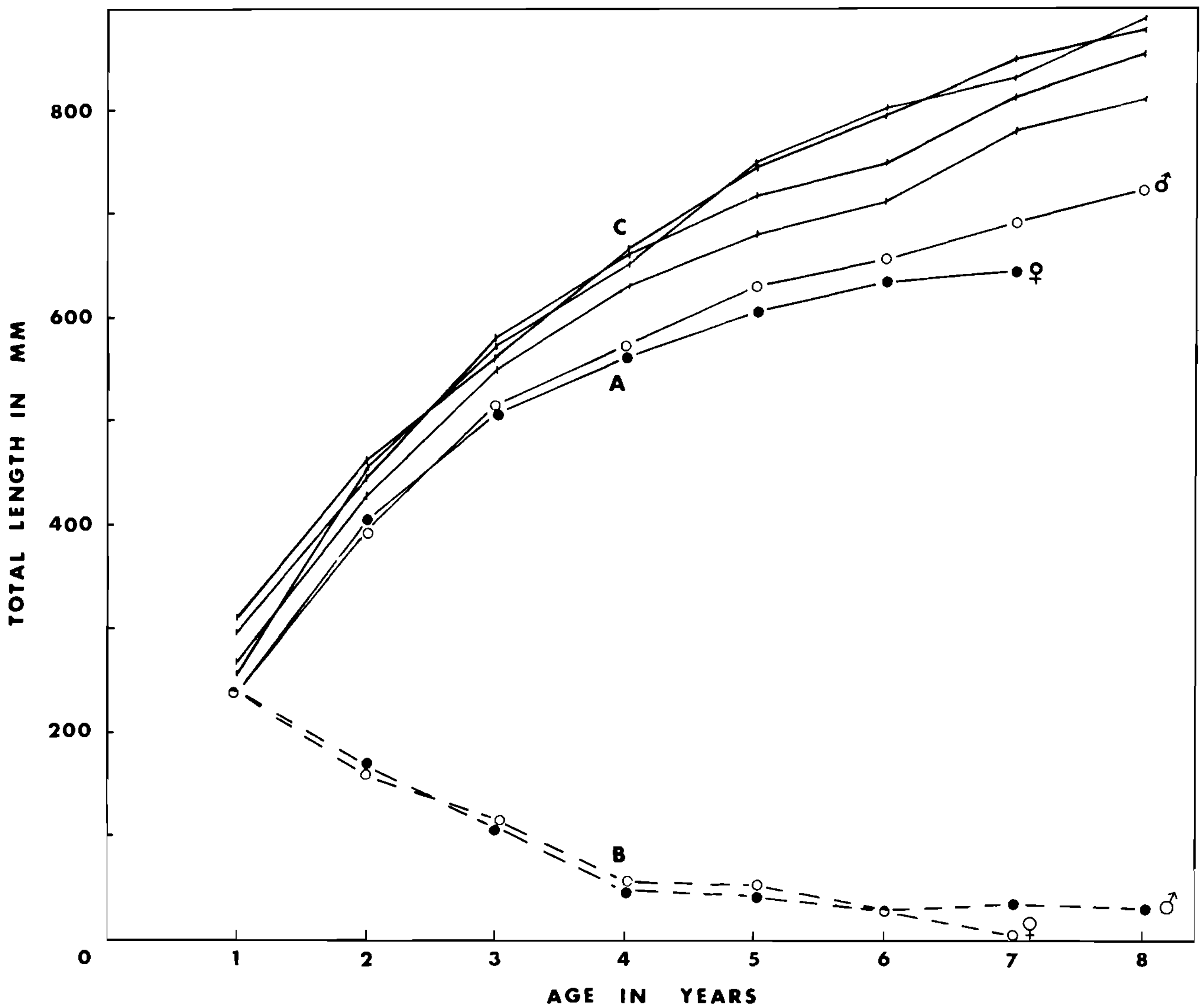

Fig. 8 Growth in length of *C. gariepinus* in Lake Sibaya. n = 750, A: Growth rate of individuals in the general population, B: Annual length increments, C: Growth rates of four fast-growing catfish.

Table 5 Sizes of the largest *C. gariepinus* caught in Lake Sibaya during the present study (1973 - 1976)

Sex	Total length (mm)	Weight (kg)
♂	1 088	8,79
♂	947	5,84
♂	916	5,52
♀	1 036	7,76
♀	1 005	5,68
♀	951	6,18

Rhodesia. He predicted total lengths of 300, 470, 600 and 720 mm in the first four years in males and 270, 370, 500 and 580 mm in females. These growth rates are high possibly due to the use of gillnets with a minimum stretch mesh size of 50 mm, which would not sample small (? first year) catfish.

Pivnicka (1974) established the growth rate of *C. gariepinus* from Lake Kariba using rings on the vertebrae. He assumed that vertebral rings were laid down once a year, and that the first ring was formed in the first year. An adequate sample (72) was available from only one locality. According to his back-calculated (standard) lengths, catfish were four years old at about 250 mm and six years old at about 380 mm. This growth rate is considerably slower than that reported here for *C. gariepinus* from Lake Sibaya.

The growth rate of *C. gariepinus* in the H.F. Verwoerd Dam on the Orange River was determined by Hamman (1974) on the basis of pectoral spine rings. He recorded average total lengths for males and females of 287, 425, 594, 633, 736 and 799 mm for the first six year classes. This growth rate is similar to that recorded in Lake Sibaya for the first two years, but more rapid thereafter.

Van der Waal and Schoonbee (1975) reported a different growth pattern for *C. gariepinus* from the Elands River, in which water temperatures ranged between 12 — 28 °C (Schoonbee, *pers. comm.* 1976). Their first year length increment was 426 mm in males and 414 mm in females, which is about 40% higher than that given here. These very high initial growth rates may be due to the resorption of the first ring as the lumen of the spine enlarges with age as noted by Van der Waal and Schoonbee (1975), as well as Marzolf (1955) in *Ictalurus punctatus*. Furthermore, their technique relied partly on the use of known-age fish from production ponds some distance from the Elands River and partly on aquarium-reared fish to establish the age at which the first pectoral spine ring was formed. *Clarias* species are known to exhibit high growth rates in culture ponds e.g. *C. mossambicus* reached 900 and 2 400 g after one and two years respectively in culture ponds in Zambia (Mortimer 1964). Van der Waal and Schoonbee's known-age fish in

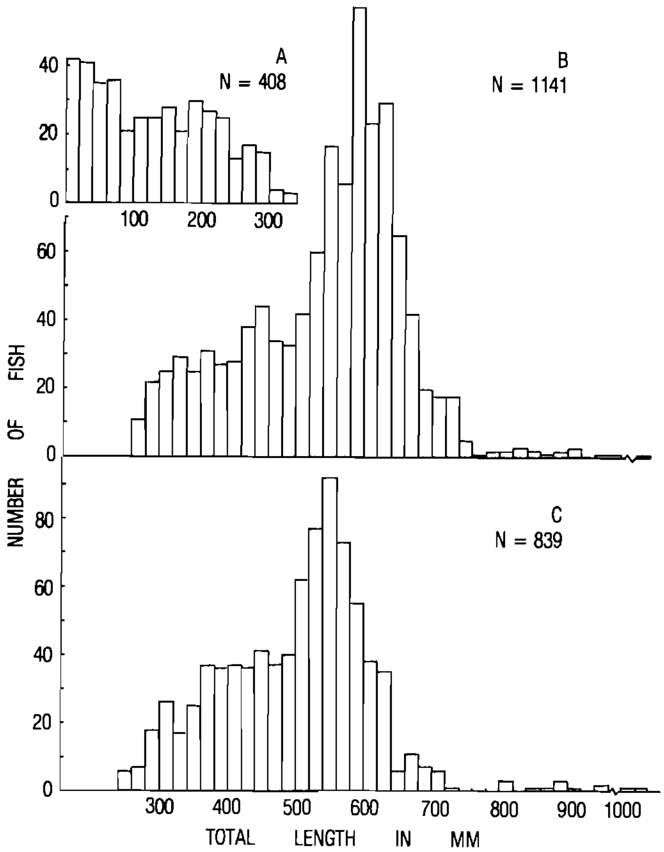

Fig. 9 Length structure of a sample of 2 388 *C. gariepinus* from Lake Sibaya caught throughout the study period (1973 – 1976). A: Juveniles, B: Adult males, C: Adult females.

ponds and aquaria may have grown faster than the catfish in the rivers. The first year ring in river catfish may not have been detectable, as in Lake Sibaya, so that the mean length at the first spine ring could be the length after two years. If so, their postulated growth rate would be similar to that in Lake Sibaya to 5+ years.

The growth rate of *C. gariepinus* in Lake Liambezi, Caprivi Strip, South West Africa, was determined by Van der Waal (1976) on the basis of vertebral rings. Both sexes reached approximately 480 mm TL in the first year, 510 mm in the second and 560 mm in the third. Females grew more slowly thereafter, and the majority of large specimens were males. The growth characteristics of this population were therefore quite different from those of all other studied populations of *C. gariepinus* except the population investigated by Van der Waal and Schoonbee (1975) in the eastern Transvaal.

Willoughby and Tweddle (1978) used vertebrae for ageing *C. gariepinus*. They based their determinations on 255 males and 223 females caught in the lower Shire River in Malawi. The pattern of growth of the Malawi catfish was very similar to that in Lake Sibaya, but the growth rate was slightly slower. Both sexes reached approximately 200 mm in their first year, 300 mm in the second and 380 mm in the third. Females grew more slowly thereafter, and the majority of large specimens were males.

The growth of *C. gariepinus* in Lake Sibaya

The rapid growth and good condition of yearling *C. gariepinus* in Lake Sibaya is readily explained by the diversity and quantity of food found in the shallow marginal areas which they inhabit (Bruton 1978). According to Allanson *et al.* (1974) the diversity of fauna in Lake Sibaya is greatest in sheltered marginal vegetation (83 taxa) and permanently sheltered plant beds (55) and least on the terrace (29) and in profundal and limnetic zones (24 & 16). Juvenile and small adult *C. gariepinus* (60 – 400 mm TL) preyed on a greater variety of prey (mainly invertebrates) and on a higher number of individual food items than larger adults (Bruton 1979a).

Intermediate-size adult *C. gariepinus* (400 – 600 mm TL) inhabit offshore zones but feed in the shallows, usually at night. In contrast to smaller catfish, their diet consists almost entirely of fish, mainly juvenile *Sarotherodon mossambicus* and juvenile and adult *Pseudocrenilabrus philander*, which are abundant in inshore areas. Adequate food quality and quantity result in sustained high growth rates during this period.

Large adult *C. gariepinus* (> 600 mm TL) enter shallow inshore areas less frequently, and feed mainly in offshore habitats (Bruton 1978). Besides a preference for deeper water, which is common in large fish, this offshore-feeding habit may be related to the size of prey chosen. The main fish prey of *C. gariepinus* in Lake Sibaya is *Sarotherodon mossambicus* which inhabits shallow terrace areas until a length of about 80 mm TL, and then moves into offshore areas (Bruton & Boltt 1975). The size of fish prey taken by *C. gariepinus* represents on average about 14% of the predator's length (range 5 – 21%, Bruton 1979a). A 600 mm TL *C. gariepinus* would therefore feed, on average, on *S. mossambicus* in the range 80 – 90 mm TL, and larger catfish would feed on larger prey, which are found in deeper water (except during the breeding season). Large *S. mossambicus* are in poor condition in Lake Sibaya, and attain a maximum size of only 260 mm TL (rarely 290 mm TL, Bruton & Allanson 1974). Their value as a source of food to large *C. gariepinus* is considerably less than the massive shoals of good condition juvenile *S. mossambicus* which intermediate-size *C. gariepinus* have available in shallow water. The only other prey available to large *C. gariepinus* in offshore zones consists of benthic crustaceans and molluscs which are either too small, unpalatable or sparse to sustain good growth in a large predator (Bruton 1979a). Poor food quality and low availability of large food items in deep water can thus be identified as the cause of decreased growth rates of large *C. gariepinus* in Lake Sibaya.

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