Age and growth of *Clarias gariepinus* (Pisces : Clariidae) in the P.K. le Roux Dam, South Africa

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Pectoral spines from 350 *Clarias gariepinus* from the P.K. le Roux Dam were sectioned near the distal end of the basal groove. There was a linear relationship between spine diameter and fish length. Of the spine sections 86% had clear growth checks, which were laid down annually in winter. Age and growth were back-calculated from spine sections. No sexual dichotomy was found in growth. *C. gariepinus* in the P.K. le Roux Dam have two growth stanzas, the first in fish <500 – 600 mm and the second in fish >500 – 600 mm. It is postulated that these stanzas may be caused by a switch in diet from invertebrates to fish, although the second stanza is probably accentuated by the methods used, which selected for faster growing, larger individuals. The length and mass frequency distribution, condition, size at sexual maturity and growth of *C. gariepinus* in the P.K. le Roux Dam are compared to those of *C. gariepinus* populations from other localities.
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Pektorale stekels van 350 *Clarias gariepinus* vanaf die P.K. le Rouxdam is vir die groei- en ouderdomsbepalings gebruik. Dwarssnitte van die stekels is by die distale ent van die basale groef gemaak. Daar was 'n lineêre verhouding tussen stekeldeursnit en vislengte. Van die stekelsnitte het 86% duidelike jaarlikse wintemeerleggings getoon. Ouderdom en groei is terugbereken deur middel van stekelsnitte. Geen geslagtelike digotomie, wat groei betref, is opgemerk nie. *C. gariepinus* in die P.K. le Rouxdam het twee groeifases: een by visse <500 – 600 mm en die ander by visse >500 – 600 mm. Daar word voorgestel dat hierdie groeifases veroorsaak word deur 'n omskakeling in dieet van ongewerwelde na vis, alhoewel die verskynsel van die tweede fase moontlik deur die tegnieke wat gebruik is, geaksentueer is, omdat hulle vir groter, vinniger groeiende vis selekteer. Die lengte- en massavoorkomsverspreiding, kondisie, grootte by geslagsrypheid en groei van *C. gariepinus* in die P.K. le Rouxdam word vergelyk met bevolkings van *C. gariepinus* wat elders voorkom.
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The first recorded use of checks in the calcified tissues of fish for age and growth studies was in 1759 (Hederstrom 1959). Ricker (1975) reviewed the history of age determination from scales, vertebrae and other bones of fishes. Today, age and growth studies using checks in calcified tissues are an integral part of fishery science (Weatherley 1972; Bagenal 1974). The various techniques for age determination, and their validation, are covered in detail by Bagenal & Tesch (1978).

Growth zones and growth checks are formed during periods of faster or slower growth (or no growth at all), and reflect various environmental or internal influences (Bilton 1974; Simkiss 1974). The rate of bone growth affects the optical properties of the bone, slower growing bones being optically less dense, due to variations in calcium metabolism (Simkiss 1974) or protein deposition (Casselman 1974). Seasonal variations in growth can therefore be interpreted from optically distinct zones in the calcified tissues.

Age determination of catfish (Siluroidea) has usually involved the analysis of growth rings in vertebrae (Marzolf 1955; Willoughby & Tweddle 1978; Bruton & Allanson 1980; Clay & Clay 1981; Clay 1982), spines (Hall & Jenkins 1952; Marzolf 1955; Donnelly & Caulton 1969; Gaigher 1969; van der Waal & Schoonbee 1975; Bruton & Allanson 1980; Clay 1982) or otoliths (Warburton 1978; Hecht 1980).

The growth of *C. gariepinus* has been studied in Lake Kariba, Zambia, by Pivnicka (1974), in the eastern Transvaal by van der Waal & Schoonbee (1975), in Lake Sibaya, KwaZulu, by Bruton & Allanson (1980), in the Shire River, southern Malawi, by Willoughby & Tweddle (1978), in Lake Liambezi, Caprivi Strip, by van der Waal (1976) and in the Hendrik Verwoerd Dam by Hamman (1981). These studies have shown that the growth rate of *C. gariepinus* varies markedly in different water bodies, and that this species may grow to a large size (Bruton 1976). The aim of this study was to determine the age of *C. gariepinus* collected over 19 months in the P.K. le Roux Dam, South Africa, using the growth checks in pectoral spine sections. The growth rates of male and female catfish could then be calculated using the back-calculation technique (Bagenal & Tesch 1978). The length and mass frequency, condition, size at sexual maturity and growth rate could then be compared with other populations.

Study area

The wall impounding the P.K. le Roux Dam (25°45'E/30°15'S) was completed in September 1976 and is situated 120 km downstream of the Hendrik Verwoerd Dam on the Orange River.

The P.K. le Roux Dam has a surface area of 128 km^2, with mean and maximum depths of 23 and 91 m (Allanson 1981), and is characterized by a steep, sparsely vegetated shoreline. The dam is situated in an arid region (rainfall approximately 350 mm per year, mainly in summer) and therefore receives most of its water via the Orange River from the Hendrik Verwoerd Dam (Kriel 1972). The flow rate of the 30 – 40 km riverine section between the two dams is highly regulated.

The P.K. le Roux Dam usually receives cool hypolimnetic water from the Hendrik Verwoerd Dam due to the position of the hydro-electric turbine intakes (Tomasson 1983). When the water level in the Hendrik Verwoerd Dam is low, warm epilimnetic water may be released. Figure 1a shows that open water temperatures in the P.K. le Roux Dam vary seasonally from 10° to 25 °C.

Secchi disc readings for the P.K. le Roux Dam from April 1977 to July 1981 are shown in Figure 1b. In late summer 1977/1978, there was a marked decrease in water transparency, but water transparency has subsequently increased steadily. In the unregulated Orange River, however, silt load varies with flow rate, which is seasonal. There is a decreasing turbidity gradient down the dam with water clarity being higher in the downstream basins (Tomasson 1983).

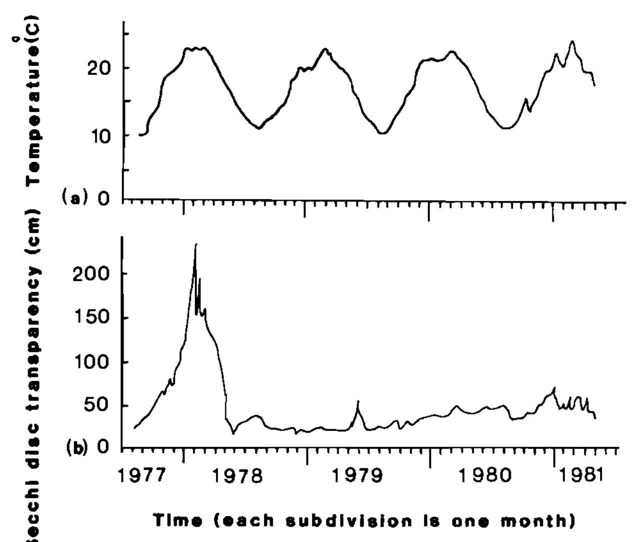

Figure 1 Seasonal variations in temperature (a) and water clarity (b) in the P.K. le Roux Dam, from July 1977 until April 1981 (From Hart 1981).

Materials and Methods

Catfish were collected in April, July and October 1980, and in January, April, July and October 1981 by Cape Provincial Administration Nature Conservation staff. The sampling gear used included gill-nets of seven mesh sizes (35; 45; 57; 73; 93; 118 and 150 mm stretched mesh) and longlines for catching fish >200 mm total length (TL). The largest catfish in the P.K. le Roux Dam were not caught as they straightened the longline hooks (T. Tomasson 1982, pers. comm.). One hundred meters of each mesh size of gill-net was set at 28 localities throughout the dam in each collection month. At each locality a single longline with 25 size 6/0 hooks baited with fish fillets was also set. Catfish <200 mm TL were collected by T. Tomasson using rotenone and a small beach seine (2 mm stretched mesh).

All catfish specimens were weighed, measured (total length: the shortest distance from the anterior tip of the snout to the posterior tip of the caudal fin in the midline), sexed and assigned an index of gonad maturity. Maturation indices were estimated subjectively in the field — a gonadosomatic index ⩾3 in males was given when the testes were fully developed, and sperm may or may not be released with the application of pressure. In females with a gonadosomatic index ⩾3 eggs vary in colour from white to green and may or may not be ejected by pressure on the abdomen (Nikolsky 1963, modified by Hamman 1981). The pectoral spines of each specimen were removed whole from the glenoid joint, cleaned and stored in marked envelopes. Utricular otoliths (lapillus) were removed (in April 1980 only) by cutting the cranium just anterior to the supra-occipital bone, and were stored with the pectoral spines.

The pectoral spines of *C. gariepinus* retain essentially the same form throughout life, but in older fish a progressive enlargement of the lumen takes place as a result of bone resorption (Bruton & Allanson 1980). They found that spines of fishes of all sizes gave the most reliable readings if they were sectioned at 5/7 of the spine length. Spines were therefore marked off from a nomogram at 5/7, and sectioned at this site on an Emco Unimat 3 lathe using a 24 mm diameter Dremel carborundum cutting disc. This is similar to the instrument recommended by Witt (1961) for sectioning spines and bones.

Sections of 1,2 mm were cut from the spines and polished on one side by moving the carborundum disc back and forth. A drop of cyano-acrylate adhesive was placed on a microscope slide and the spine section glued with the polished side down. The section on the slide was then ground on silicon carbide water paper (grit sizes 320 & 400) using water as a lubricant to a thickness of about 0,5 mm. A drop of methyl salicylate BP was then placed on the sections to improve the contrast between opaque and translucent zones, and the sections were examined by transmitted light in a microform reader (magnification × 24).

Growth checks in the spine sections took the form of translucent rings which contrasted with the opaque growth zones. Eighty-six percent of the spines of all fishes examined had clear rings ($n = 309$), but 73% of spines from fish >700 mm TL ($n = 51$) could not be used because of the resorption of one, two or possibly more rings.

The radius of the antero-lateral spine used by Bruton & Allanson (1980) for measuring growth was unsuitable for this population as the rings in that region were often unclear. A radius from the spine lumen centre to the ventral base of the anterior serrations of the spine was therefore used (Figure 2). T. Hecht (1982, pers. comm.) also found this position to be most suitable for ageing *C. gariepinus* in the Transvaal. The radius of the spine and the distances of the rings from the lumen centre were measured on the microform reader and recorded. These measurements were re-checked two or three

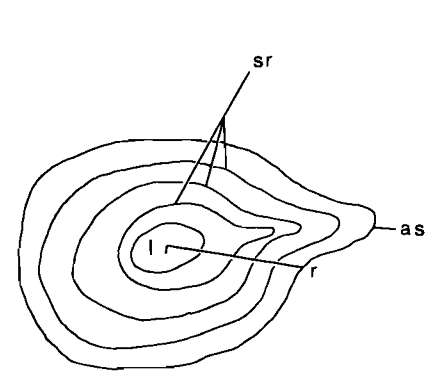

Figure 2 Diagramatic cross-section of a pectoral spine showing the lumen (l), spine rings (sr) and the radius (r) from the lumen centre to the ventral base of the anterior serrations (as).

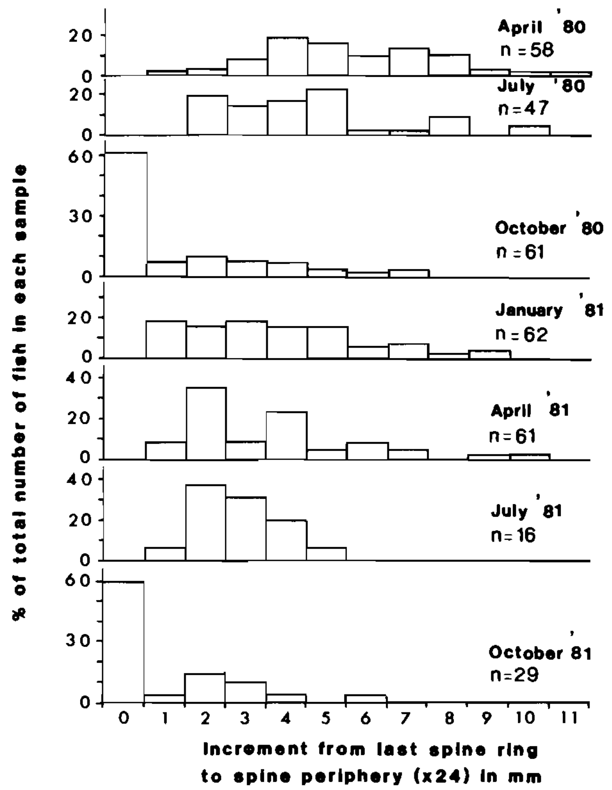

Figure 3 The increment from the last spine ring to the spine periphery for different months of the year in *Clarias gariepinus* from the P.K. le Roux Dam. The graphs show that growth checks occur during winter and become apparent in October.

times. The increment from the last spine ring to the spine periphery was plotted for different months of the year (Figure 3). The results in Figure 3 confirmed that rings were laid down annually after winter (October).

Otoliths were ground down to their nucleus by hand on a fine sandstone using methyl salicylate as a lubricant. The ground otoliths were then submerged in methyl salicylate in a black glass dish and examined in reflected light under a microscope. A pattern of translucent and opaque zones similar to that on the pectorals spines was observed. The otoliths were used to determine how many rings had been resorbed in the >700-mm specimens collected in April 1980.

Back-calculation of lengths from pectoral spine rings

To determine which method of back-calculation should be used, the radii of 309 pectoral spines were plotted against fish total length. No difference was found between males and females. The relationship is described by the regression $y = 135{,}1\,x - 12{,}2$ ($r^2 = 0{,}96$) where y = spine radius in mm and x = total length of fish in mm. The regression was linear and originated near the origin. Although the regression was almost directly proportional, Frazer's formula (Ricker 1975; Bagenal & Tesch 1978), which includes the intercept value on the length axis in the equation, was used:

$$L_n - c = \frac{S_n (L - c)}{S}$$

where

L_n = length of fish when ring 'n' was formed
L = length of fish at capture
S_n = radius of ring 'n'
S = spine radius
c = intercept on length axis.

Results

Age determination and growth in length

The length distribution of male and female *C. gariepinus* for different age groups is given in Table 1. There is considerable overlap between the lengths of consecutive age groups. The

Table 1 The length distribution of *C. gariepinus* from the P.K. le Roux Dam for different year groups as determined from pectoral spine rings (n = 306)

Total length group (mm)	Age groups (years)							
	1	2	3	4	5	6	7	8
80	2							
100	3							
120	5							
140	5							
160	14	1						
180	25	2						
200	22	7						
220	11	6						
240	20	5	1					
260	19	11	3					
280	7	15	5					
300	3	18	3	1				
320	3	17	9	1				
340	1	19	8	1				
360		13	7	2				
380		11	9	2				
400		12	9	2				
420		2	5	5				
440		1	6	3				
460		2	7	2				
480		1	11	3				
500			9	5				
520			2	2				
540			3	7				
560			1	2				
580			1	6				
600			1	4				
620			1	3	2			
640			1	2		1		
660				2				
680				1				
700					2			
720				1	1			
740					3		1	
760				1		2	1	
780						1		
800					1	1		1
820					2			
840					2	2		
860					2	2	2	
880					1	4	1	1
900						1	1	
920								
940							3	1
960						1	1	1
980							1	
1000							1	2
1020								
1040								
1060								
1080								1

estimation of age based on the movement of length frequency peaks (Petersen's method, *vide* Bagenal 1978) would therefore be inaccurate for this population.

The back-calculated total lengths and annual length increments of male and female catfish are summarized in Table 2 and Figure 4. Student's t tests for each age group showed that there was no significant difference in the growth rates of male and female catfish. Growth increments in both sexes are highest during the first year of growth, but there is another growth peak during the fifth year in males ($p < 0,05$ using a Student's t test).

A Ford-Walford plot of L_{t+1} on L_t (Figure 5) did not yield a straight line with a slope of less than one — a prerequisite if the data are to be fitted to the von Bertalanffy growth model (Everhart *et al.* 1975; Ricker 1975). Although the growth curve did not fit the von Bertalanffy model, the Ford-Walford plot can still be used to calculate asymptotic lengths (Ricker 1955, 1975), which were 1 150 mm TL for males and 1 020 mm TL for females. These asymptotic lengths correspond well with observed maximum lengths in the field. Males grew larger than females and in a sample of 788 *C. gariepinus* only 0,7% of males and 1,6% of females exceeded the postulated asymptotic lengths.

In order to determine whether resorption of rings in fish >500 mm TL had caused inaccurate results, the last annual increment for different length groups in different years was calculated (Figure 6). Using this method, most of the spines of fish >500 mm TL could be used because resorption did not affect the results as only the earlier growth increments are erased by resorption. The average annual increment was constant between length groups, about 80–106 mm. The only statistically significant difference between growth increments in different growing seasons was that during the clear water

Table 2 The average back-calculated lengths in mm (TL), standard error of TL (SE), annual length increment (ΔTL) and number of catfish in sample (n) for different year classes of male and female *C. gariepinus* from the P.K. le Roux Dam

Year	TL	SE	ΔTL	n
	Males			
1	213	5,7	213	77
2	321	7,0	108	79
3	413	11,4	92	59
4	520	15,4	107	30
5	683	22,1	163	26
6	803	22,6	120	16
7	903	39,4	100	6
8	964	46,6	61	5
	Females			
1	204	6,7	204	63
2	313	8,7	109	65
3	402	13,7	89	44
4	503	20,6	101	27
5	632	24,8	129	22
6	760	28,5	128	11
7	848	22,6	88	12
8	897	36,0	49	7

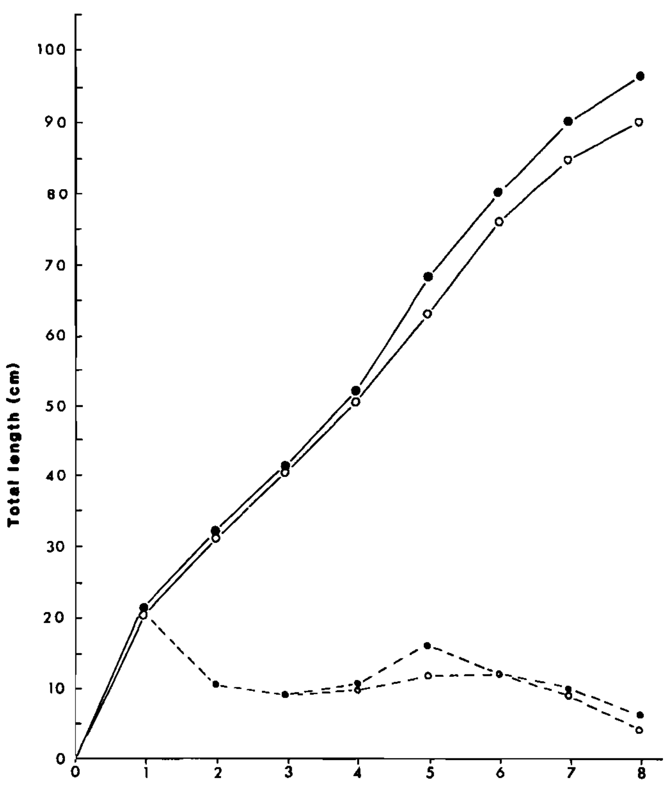

Figure 4 Growth in length of *Clarias gariepinus* in the P.K. le Roux Dam. Males – solid circles, females – open circles. The growth rate is in solid lines and annual length increments are in broken lines (n = 309).

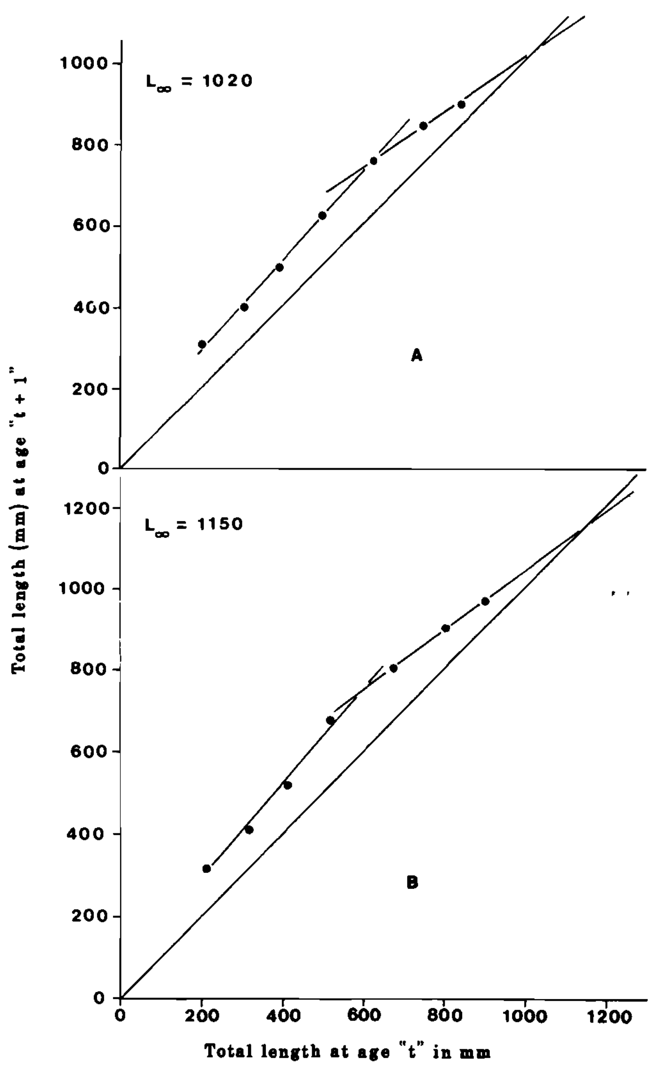

Figure 5 Ford-Walford plots for female (A) and male (B) *Clarias gariepinus* from the P.K. le Roux Dam. L ∞ = asymptotic length (intercept on the diagonal).

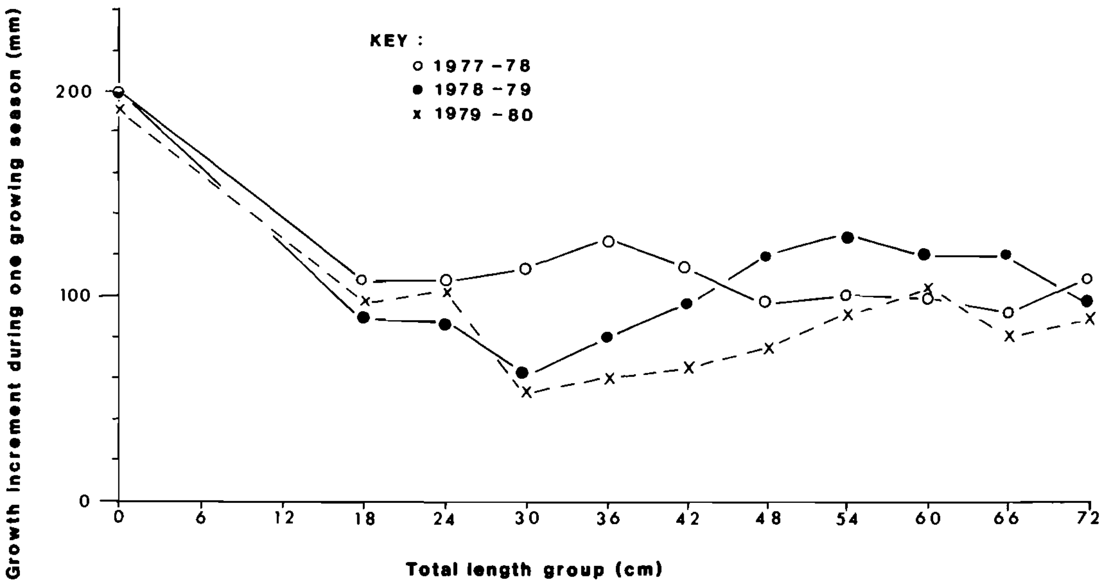

Figure 6 Annual length increments of different length groups of *Clarias gariepinus* from the P.K. le Roux Dam during the relatively clear 1977–78 and the relatively turbid 1978–79 and 1979–80 growing seasons (n = 468).

(Secchi disc transparency 50–230 cm) 1977–78 growing season the 300 mm length groups grew better ($p > 0{,}01$ using a Students t-test) than in the two turbid years (transparency 20–50 cm). In the 1978–79 turbid year the 540 mm length group grew better than the 240 mm length group ($p > 0{,}02$) and the 300 mm length group ($p > 0{,}0001$).

Length-mass relationship and growth in mass

Length-mass regressions were plotted separately for male and female catfish, but as these relationships were not significantly different, the data were combined. The relationship of length to mass is described by the equation:

$$y = 0{,}0000016\ x^{3{,}2284}$$

where y = mass (g) and x = total length (mm) (n = 242; $r^2 = 0{,}99$)

Growth in mass was calculated using the growth rate in Table 2 and the length-mass regression (Figure 7). The largest mass increments occurred in the sixth and seventh years of growth in both sexes. This contrasts with the largest length increment (Figure 4) which occurred in the first year.

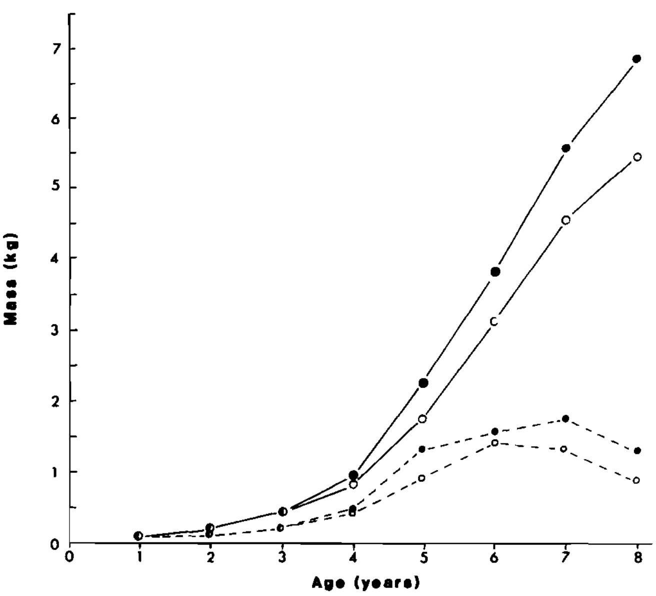

Figure 7 Growth in mass of *Clarias gariepinus* from the P.K. le Roux Dam. Males – solid circles, females – open circles. Growth rate is in solid lines and annual weight increments in broken lines (n = 309).

Population structure and size at sexual maturity

Population structure and size at sexual maturity were calculated from a sample of 1 148 *C. gariepinus*. In both sexes the length frequency distribution (Figure 8) was bimodal, at 360 and 740 mm for males and 310 and 720 mm for females. The lengths at which 50% of male and female catfish reached sexual maturity were 820–920 mm and >740 mm respectively (Figure 9).

Discussion

Ageing methodology

Van der Waal & Schoonbee (1975) and Bruton & Allanson (1980) found that spine sections were a simple and accurate method of ageing *C. gariepinus* in the Elands River and Lake Sibaya respectively. The present study shows that spine sections are difficult to use for catfish older than 4 years in the P.K. le Roux Dam due to lumen enlargement. Spine lumen enlargement was a problem as there was a much higher proportion of larger catfish (>700 mm) in the P.K. le Roux Dam than in the Elands River or Lake Sibaya (Figure 10 & Table 3).

T. Hecht (1982, pers. comm.) had similar problems with spine resorption in *C. gariepinus* populations in the northern Transvaal. He found that otolith sections cut to a thickness of 0,1–0,3 mm using an otolith saw developed by Rauck (1976) were more reliable for ageing large catfish. Clay (1982) compared the different methods used for ageing *C. gariepinus* and concluded that rings laid down in vertebrae are better indicators of growth (according to length frequency data) than those laid down in pectoral spines. An important recommendation for future *C. gariepinus* age and growth studies is that pectoral spines, vertebrae and otoliths should be collected until one or a combination of these structures is shown to provide reliable age and growth data. If possible a long term tagging programme should also be used to validate the accuracy of the cyclical growth checks.

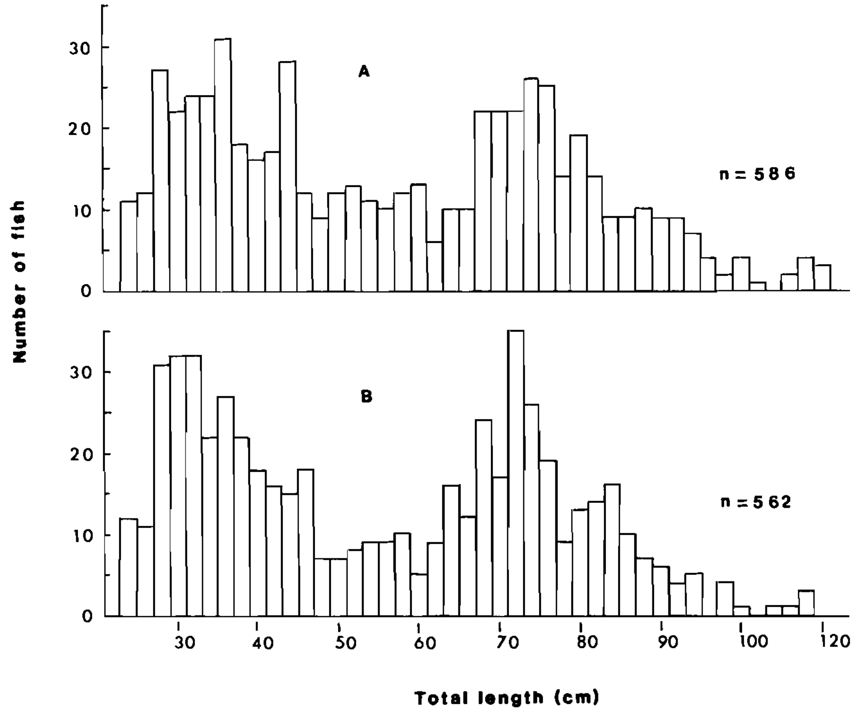

Figure 8 Length frequency distribution of male (A) and female (B) *Clarias gariepinus* from the P.K. le Roux Dam.

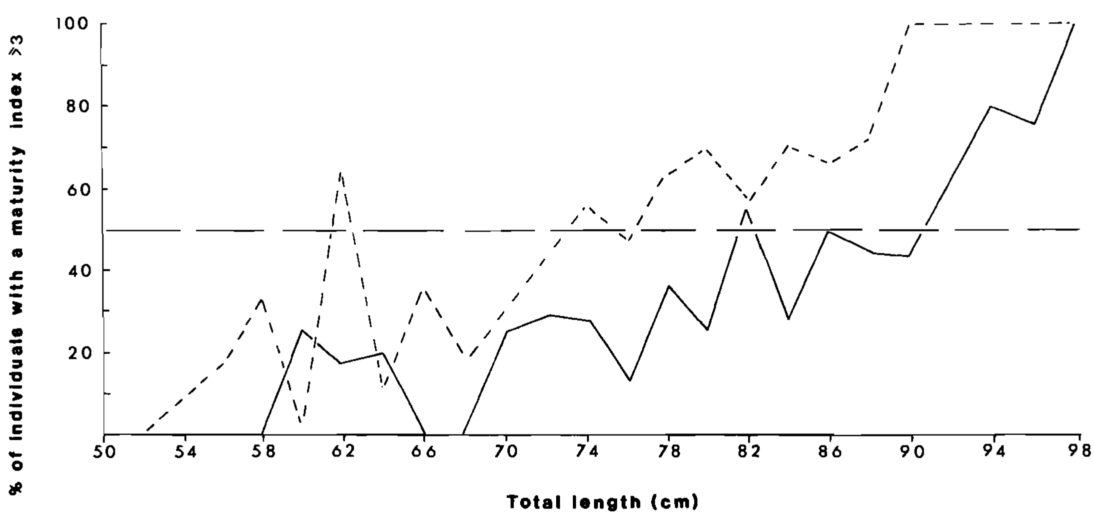

Figure 9 The percentage of the *Clarias gariepinus* population, caught in January 1979, 1980 and 1981, with a maturity index ⩾3. Males – continuous lines (n = 212), females – broken lines (n = 231).

Comparison of size frequency distributions, condition and size at sexual maturity

The length frequencies of six *C. gariepinus* populations are compared in Figure 10. Although these data should be interpreted with caution due to the effects of gear selectivity, it appears that the catfish populations in the P.K. le Roux, Verwoerd and Hardap Dams have a higher proportion of large fishes than in the other systems (Table 3).

The length-mass relationships of six *C. gariepinus* populations are compared in Figure 11. The Pongolo population has the highest ratio (presumably indicating good condition) with the P.K. le Roux and Verwoerd Dam populations in better condition than the other three. The relatively good condition of large catfish in the P.K. le Roux and Verwoerd Dams and the Pongolo floodplain is further emphasized in Table 4.

The lengths at sexual maturity of catfish in the P.K. le Roux (females >740 mm, males 820 – 920 mm), Verwoerd (females >900 mm, males 800 – 850 mm; Hamman 1981) and Hardap Dams (females 650 – 700 mm, males 650 – 750 mm; Gaigher 1977) are high relative to other populations and represent fish 4 – 6 years old. Their sizes differed markedly from

Table 3 The percentage of *C. gariepinus* greater than 2 kg in various lakes and dams in South Africa

Population	% *C. gariepinus* >2 kg	Reference
Lake Sibaya	4,1	Bruton (1979b)
Pongolo floodplain pans	17,4	Kok, in Bruton (1979b)
Hendrik Verwoerd Dam	44	Hamman (1981)
P.K. le Roux Dam	46,4	This study
Hardap Dam	62,8	Gaigher (1976, pers. comm.)

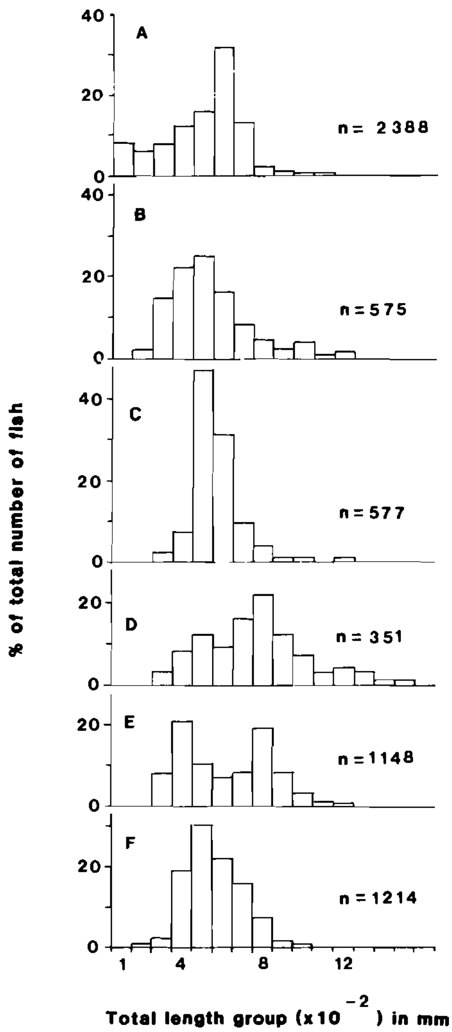

Figure 10 The length frequency distribution of five *Clarias gariepinus* populations. (A) Lake Sibaya (Bruton 1979b), (B) Pongolo floodplain pans (Kok, in Bruton 1979b), (C) Elands River (van der Waal 1972), (D) Hardap Dam (Gaigher 1976, pers. comm.) (E) P.K. le Roux Dam (this study) and (F) Hendrik Verwoerd Dam (Hamman 1981).

Table 4 The average mass (derived from length-mass regressions, Figure 11) of 1000 mm TL *C. gariepinus* from six populations in southern Africa

Population	Average mass at 1000 mm TL	% of B	Reference
A. Lake Sibaya	5539 g	57	Bruton & Allanson (1980)
B. Pongolo floodplain pans	9681 g	100	Kok, in Bruton (1979b)
C. Elands River	6971 g	72	van der Waal (1972)
D. Hardap Dam	17078 g	73	Gaigher (1976, pers. comm.)
E. P.K. le Roux Dam	7750 g	80	This study
F. Hendrik Verwoerd Dam	9052 g	94	Hamman (1981)

those recorded for *C. gariepinus* populations in Lake Sibaya, the Shire River and various lakes and rivers in the Transvaal and Zimbabwe where sexual maturity was reached at 250 – 450 mm TL after 1 – 3 years (Holl 1966; van der Waal 1972; Willoughby & Tweddle 1978; Bruton 1979a; Mabitsela 1981). Populations of *C. lazera* and *C. mossambicus* (= *C. gariepinus*; Teugels 1982) in Lakes Volta, Kyoga, Chilwa and Victoria also reached maturity at the relatively small size of 250 – 450 mm TL (Greenwood 1966; Kirk 1972; Loiselle 1972; Rinne 1975) whereas those in Lake Rudolph matured at 650 – 700 mm TL (Hopson 1975).

The relatively good condition of large catfish and their large size at first maturity in the large South African dams (le Roux, Hardap and Verwoerd) are as yet unexplained but may be the result of low catfish densities, high food availability to large fish and low water temperatures.

Growth

The reason why the growth curve of the P.K. le Roux Dam population does not fit the von Bertalanffy growth model is

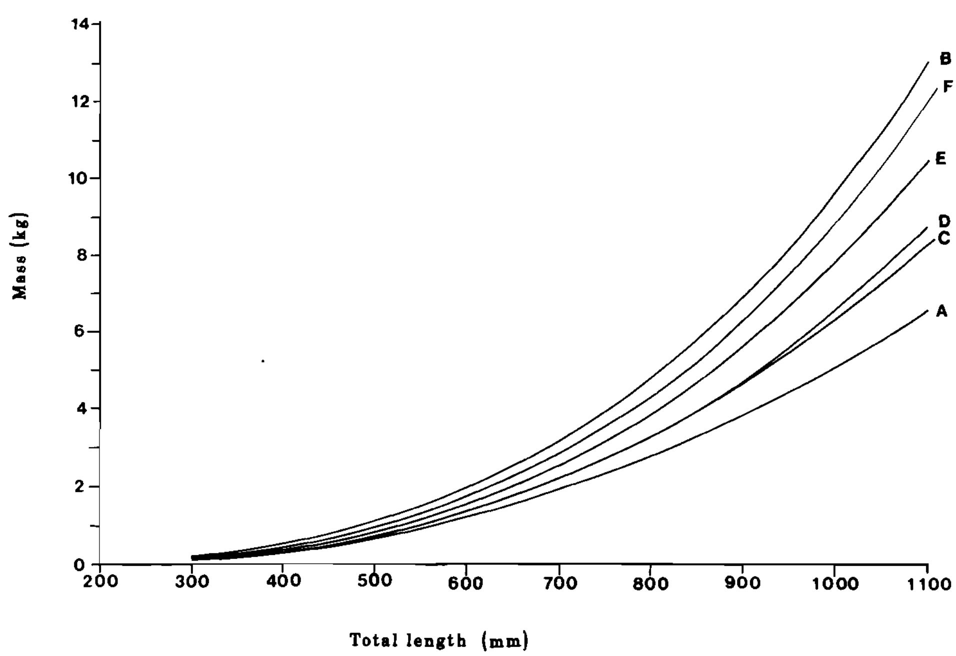

Figure 11 The length:mass relationships of *Clarias gariepinus* from six populations. (A) Lake Sibaya: M = 0,00004 TL^{2,699} (r^2 = 0,92; n = 355; Bruton 1979b). (B) Pongolo floodplain pans: M = 0,000003 TL^{3,169} (r^2 = 0,98; n = 165; Kok, in Bruton 1979b). (C) Elands River, Transvaal: M = 0,007308 TL^{2,9928} (TL in cm, males only, r^2 = ?; n = 605; van der Waal 1972). (D) Hardap Dam: M = 0,000004 TL^{3,071} (r^2 = 0,95; n = 139; Gaigher 1976, pers. comm.). (E) P.K. le Roux Dam: M = 0,0000016 TL^{3,2284} (r^2 = 0,99; n = 242; this study). (F) Hendrik Verwoerd Dam: M = 0,0028 TL^{3,2548} (TL in cm, r^2 = 0,99; n = ?; Hamman 1981). M = mass (g), TL = total length (mm) unless otherwise indicated.

that in both males and females the annual length increments decreased from years one to three, then increased markedly in years four and five. Ricker (1955) found a similar pattern for Spear Lake bluegills — the Walford plot had a slope >1 for the first two years of growth and a slope of <1 for later years of growth. Van der Waal & Schoonbee (1975) found a similar pattern for the first four years of growth of *C. gariepinus* in the Elands and Olifants Rivers in the Transvaal. The Walford plot for *C. gariepinus* older than four years in the Transvaal had a slope >1.

There are two probable reasons for the increased growth increment of 500 – 600 mm TL *C. gariepinus* in the P.K. le Roux Dam. After four years the problem of lumen enlargement becomes marked, and more than 50% of spines from fish of four years and older had to be discarded. Because faster growing fish have spines which are clearer to read, and early rings which are further from the lumen centre, the back-calculated growth for fish >4 years may be biassed towards faster growing individuals.

Secondly, catfish of 500 – 600 mm TL in the P.K. le Roux Dam change their diet from a predominantly invertebrate, low-fish diet to a predominantly fish diet (White & Bruton, in prep.). Ricker (1979) found similarly that a sudden increase in growth occurs in some perch (*Perca* spp.) when they shift from an insect to a fish diet, resulting in the start of a new growth stanza. In the P.K. le Roux Dam there appear to be two growth stanzas; the first occurs in fish up to 500 – 600 mm, and the second in fish $>500-600$ mm.

The growth rate of *C. gariepinus* in the P.K. le Roux Dam also appears to be affected by turbidity. In Figure 6 the *C. gariepinus* were grouped into length classes, and not year classes. This allowed the last annual increment of all length classes to be determined without being affected by inaccuracies caused by resorption. Parker & Larkin (1959) and Warren (1971) reviewed the use of size as a basic determinant of growth. They concluded that age is only a reliable index of growth rates in relatively constant environments, and suggest that size provides a better indication of the *ecological* and *physiological opportunities* for growth. In the previous paragraph we showed how size affected the *physiological opportunity* for growth resulting in the second growth stanza of the $>500-600$ mm fish. In Figure 6 we show how size affects the *ecological opportunity* for growth. In the turbid 1978 – 79 growing season there were massive fish kills (Tómasson 1983); these ecological conditions favoured the growth of the large piscivorous but not the small invertivorous catfish (White & Bruton, in prep.). This is reflected in the increased growth rate of the 540 mm length groups compared to the 240 mm and 300 mm length groups. There was no statistical difference in growth rates in the preceding clear (1977 – 78) and the following turbid (1979 – 80) growing seasons, in which there were no massive fish kills (Tómasson 1982, pers. comm.).

Growth rates were compared to those of four other catfish populations (Elands and Olifants Rivers, van der Waal & Schoonbee 1975; Shire River, Willoughby & Tweddle 1978; Lake Sibaya, Bruton & Allanson 1980; and Verwoerd Dam, Hamman 1981). A notable feature is that the length-at-age of the different populations varies considerably. The smaller catfish (<500 mm) in the P.K. le Roux Dam had a better growth rate than the Shire River population, but showed poorer growth than all the other populations whilst the larger catfish (>500 mm) had better growth than all the other populations except those in the Verwoerd Dam. This further supports the hypothesis that conditions in the P.K. le Roux Dam are unfavourable for small catfish (<500 mm) but favourable for larger catfish (>500 mm).

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