A comparison of the otolith and scale methods of ageing, and the growth of *Sarotherodon mossambicus* (Pisces:Cichlidae) in a Venda impoundment (Southern Africa)

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Otoliths and scales were used for age and growth determinations of *Sarotherodon mossambicus* in the Luphephe-Nwanedzi impoundment, a subtropical man-made reservoir in Venda, northern South Africa. Two rings are deposited annually on the otolith whereas only one ring is deposited on the scales. Using otoliths the growth of *S. mossambicus* is described by $L_t = 27{,}3\,(1 - e^{-0{,}425(t+0{,}299)})$ cm and using scales by $L_t = 26{,}8\,(1 - e^{-0{,}389(t+0{,}045)})$ cm. These two curves differ significantly (P<0,01). The adequacy of these curves was tested by means of Ford-Walford plots. It is postulated that otoliths provide a more reliable estimate of age and growth than scales in subtropical and temperate regions. Males grow faster than females. Based on otoliths the growth of male *S. mossambicus* in the Luphephe-Nwanedzi impoundment is described by $L_t = 27{,}0(1 - e^{-0{,}417(t+0{,}504)})$ cm SL and that of females by $L_t = 25{,}8(1 - e^{-0{,}370(t+0{,}497)})$ cm SL. The growth of *S. mossambicus* in the Luphephe-Nwanedzi impoundment is compared to other *S. mossambicus* populations in South Africa.

S. Afr. J. Zool. 1980, 15: 222 – 228

Otoliete en skubbe is gebruik vir ouderdom- en groeibepalings van *Sarotherodon mossambicus* in die Luphephe-Nwanedzi-dam, 'n subtropiese dam in Venda, in noordelike Suid-Afrika. Twee ringe word jaarliks op die otoliet neergelê, terwyl net 'n enkele ring op die skubbe neergelê word. Met die gebruik van otoliete kan die groei van *S. mossambicus* deur die formule $L_t = 27{,}3(1 - e^{-0{,}425(t+0{,}299)})$ cm SL beskryf word en as skubbe gebruik word deur $L_t = 26{,}8(1 - e^{-0{,}389(t+0{,}045)})$ cm SL. Hierdie twee kurwes verskil betekenisvol van mekaar (P<0,01). Die toereikendheid van die twee kurwes is ook deur middel van Ford-Walford-kurwes getoets. Die afleiding word gemaak dat otoliete groter betroubaarheid as skubbe verleen vir die vasstelling van ouderdom en groei van visse in subtropiese en gematigde klimaatstreke. Mannetjies toon 'n vinniger groeitempo as wyfies. As otoliete gebruik word kan die groeitempo van mannetjies van *S. mossambicus* in die Luphephe-Nwanedzi-dam deur die formule $L_t = 27{,}0(1 - e^{-0{,}417(t+0{,}504)})$ cm SL aangegee word. Die ooreenstemmende formule vir wyfies is $L_t = 25{,}8(1 - e^{-0{,}370(t+0{,}497)})$ cm SL. Die groei van *S. mossambicus* in die Luphephe-Nwanedzi-dam word vergelyk met dié van ander bevolkings van *S. mossambicus* in Suid-Afrika.

S.-Afr. Tydskr. Dierk. 1980, 15: 222 – 228

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Submitted 11 March 1980; accepted 14 June 1980

The Cichlidae form the basis of many of the major inland fisheries on the continent and are the most important freshwater food fishes in Africa (Fryer & Iles, 1972). In temperate and subtropical waters the ageing of cichlid species is less problematic (Le Roux 1961, Van Rensburg 1966, Du Toit, Vermeulen & Schoonbee 1972, Bruton & Allanson 1974, Potgieter 1974) than in tropical regions (Mohr 1921, Chevey 1934, Lowe 1952, Lowe-McConnell 1957 and 1958, Garrod 1959, Fryer 1961, Fryer & Iles 1972, Tweddle & Turner 1977).

Some of these authors discuss the validity of annuli on scales, opercula, vertebrae and otoliths. In tropical waters they attribute ring formation more to a 'physiological winter', due to a scarcity of food and to the periodicity of spawning than to a climatic winter. Bruton and Allanson (1974) found that ring deposition on *Sarotherodon mossambicus*[a] scales was caused by a short period of rapid growth due to active feeding after spawning activity had ceased. Similarly De Bont (1967) has made reference to food and feeding patterns as being responsible for annulus deposition on scales.

Various authors have remarked on the different growth rates of some cichlids in different water bodies. Lowe-McConnell (1958) for example, found that *Sarotherodon niloticus* in Lakes George, Edward, Albert and Rudolf grows at different rates and Le Roux (1961) showed that *S. mossambicus* grows at significantly different rates in seven impoundments in the Transvaal Province, South Africa. Similarly Garrod (1959) points out that *Sarotherodon esculenta* populations in various parts of Lake Victoria show different growth rates. These examples should suffice to indicate that for the rational exploitation and management of cichlid populations it would be extremely dangerous to use growth data of one population for other populations in different water bodies.

Cichlid fishes also seem to be very sensitive to overpopulation which, caused by their prolific breeding habits, results in stunting (Coe 1966, Batchelor 1974, Bruton & Allanson 1974, Hecht, T. & Jackson, P.B.N., in prep. — Notes on a stunted population of mozambique tilapia *Sarotherodon mossambicus*).

S. mossambicus is indigenous to the coastal lakes and eastward flowing rivers of south east Africa (Jubb 1967).

[a]Previously *Tilapia mossambica* Peters (see Trewavas 1973 and Jubb 1974).

This species is of considerable commercial value and has been introduced into artificial impoundments throughout the world (Bruton & Allanson 1974). In the southern African region it is also one of the most sought after angling species. Du Toit *et al* (1972) mention that the number of licensed anglers in the Transvaal alone rose from 68 000 in 1968 to 95 000 in 1969. This figure has since risen to 142 000 (Salomon 1978). These figures indicate the need for intensified research into the dynamics of *S. mossambicus* and other fish populations.

Knowledge of age and growth is fundamental to the understanding of a fish population for management purposes. Most studies on the ageing of *S. mossambicus* in South Africa were conducted using scales (Le Roux 1961, Van Rensburg 1966, Du Toit *et al* 1972, Batchelor 1974, Potgieter 1974), although Bruton & Allanson (1974) also briefly investigated the possibility of using otoliths and opercula for ageing studies. Most of these authors experienced some difficulties in using scales for ageing. Similar problems were encountered during this investigation.

It was therefore decided to make a comparative study using scales and otoliths to determine which of these structures is more reliable and suitable for determining age and growth and also to test the reliability of each method. Hecht (1979) previously established that the otoliths of *S. mossambicus* show clear rings after being sectioned with a newly developed otolith saw (Rauck 1976) and postulated that they may successfully be used in ageing studies of this species. That otoliths have not previously been used to a greater extent is probably due to the time-consuming method of grinding them down by hand.

Study area

The Luphephe-Nwanedzi impoundment in Venda (northern South Africa, 30°25'E,22°39'S), is a man-made reservoir of approximately 250 ha. This impoundment and some of the surrounding area has recently (Jan. 1979) been proclaimed a nature reserve. In 1977 a research programme on the biology of the various fish populations in this impoundment was initiated to obtain information for the rational management of these fish stocks. Since its proclamation, the reserve has been opened to the public and it is expected that a large number of anglers will soon exert considerable pressure on the fish community. *S. mossambicus* is the second most dominant species after the butter catfish *Eutropius depressirostris* in this impoundment (Hecht 1980).

Material and Methods

General

The sagittal otoliths of 598 fish, ranging in length from 5,5 to 29,5 cm standard length (SL), were removed by cutting through the head approximately mid-way between the eyes and the first dorsal spine. Such a cut revealed the ventral lobes of the paired sacculi from which the sagittae could easily be removed. All otoliths were stored dry in numbered vials. In the laboratory they were imbedded in clear epoxy resin rods, whereupon highly polished 0,1 mm sections were cut through the nucleus with a specially developed otolith saw (Rauck 1976). These sections were then mounted between microscope slides with resin and each section given a serial number. Sections were best read under transmitted light at 6× or 12× magnification. All sections were read on four different occasions. Only those readings where three or all four corresponded were regarded as valid and used for age determination and growth calculations. Of the 598 otolith pairs examined, 92,6% could be read successfully.

Four scales were removed from 580 fish, in the same length range, from the pectoral region below the lateral line. Similar to the observations made by Bruton and Allanson (1974) it was found that the scales from this region were relatively uniform in size, showed distinct rings and also had a constant ring count. Scales were also stored dry. In the laboratory they were soaked in water for 24 hours, whereafter they could easily be cleaned by rubbing them between the fingers. The scales were then mounted between glass slides, given a serial number and also read four times with the aid of a scale projector. Of the 580 sets of scales examined, 82,6% were read successfully.

The periodicity of ring formation

The nuclei of all otoliths examined were found to be opaque, followed by alternate light and dark zones. The outer perimeter of a minimum of 50 otolith sections was examined at monthly intervals. During this examination the presence of either an opaque or hyalin outer perimeter was noted and expressed as a percentage of the total sample. These findings are illustrated in Fig. 1, which clearly shows that two opaque bands are laid down annually, one during the period February/March and the other during the winter months July/August. Two opaque rings therefore represent one year of growth. Fig. 2 shows a scale (a) and an otolith (b) of a four year old male *S. mossambicus* (SL = 22,4 cm).

The rings on scales are formed by an interruption of the regular arrangement of the circuli in the anterior field of the scale. Only those rings which originated in the one lateral field and crossed the anterior field into the other lateral field were regarded as valid. Moreover, only those rings formed by widely spaced circuli were regarded as valid. Some rings were formed by closely spaced circuli. As this kind of ring rarely occured (0,5% of the total sample) they were not used for age determination. Bruton and Allanson (1974) also regarded such rings as invalid age marks.

The number of circuli in the marginal increment of the scale depends on the time of sampling. In fishes sampled immediately or shortly after ring formation the ring is found on the anterior margin of the scale and there are no or few circuli in the marginal increment. Bearing this in mind the marginal area of the scales of a minimum sample of 50 fish falling into the size class 14,0 – 15,9 cm SL was examined during seven different times of the year. During this investigation the number of circuli between the last ring and the anterior margin between two radii in the centre of the anterior field were counted. These data are shown in Fig. 3, from which it becomes evident that one ring is formed on the scale per year during the period February/March. This period coincides with the time of first opaque zone formation on the otolith (compare Figs. 1 and 3). The examination of the scales for the

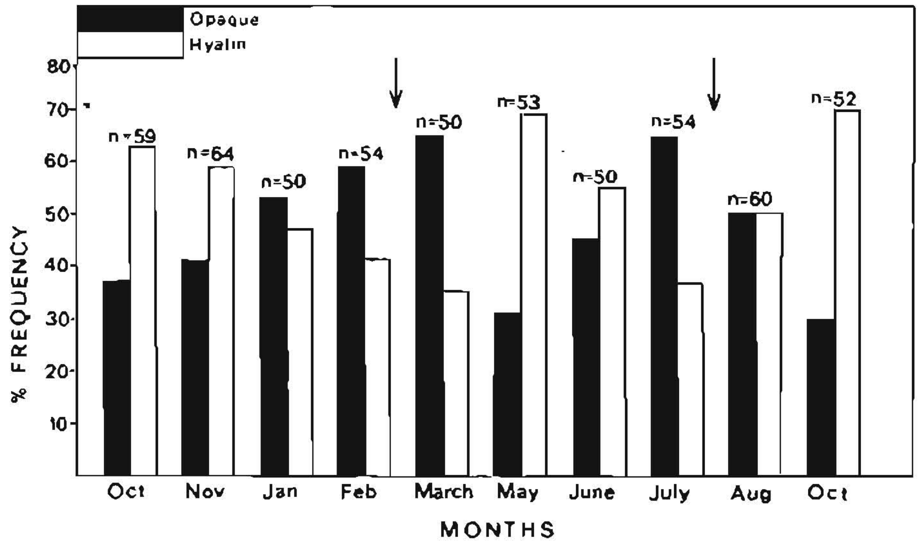

Fig. 1 The monthly percentage frequency of occurence of opaque and hyalin zones on the outer perimeter of *S. mossambicus* otolith sections. The arrows indicate the time of opaque zone formation (n = number of otolith sections examined).

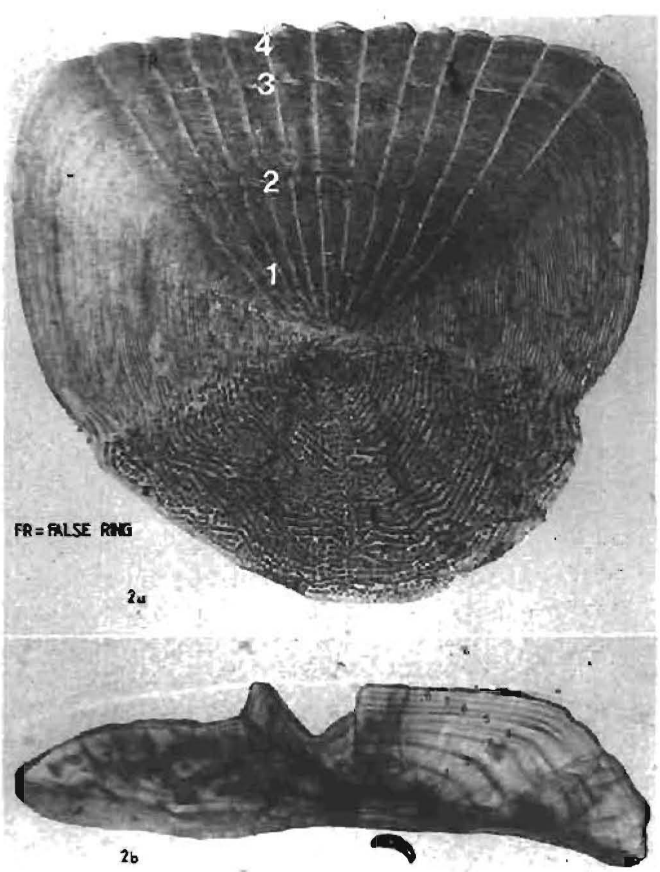

Fig. 2 A scale (2a) and a dorso-ventral section of a sagittal otolith (2b) of a four year old male *S. mossambicus* (SL = 22,4 cm) from the Luphephe-Nwanedzi impoundment. A false ring (FR) is shown on the scale. Four annual rings are visible on the scale whereas the otolith shows eight clear rings.

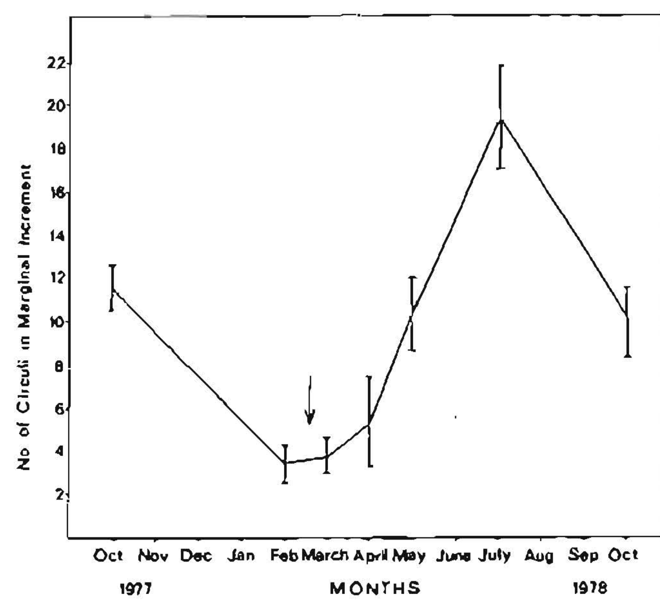

Fig. 3 Changes in the number of circuli (± SD) in the marginal increment of *S. mossambicus* scales from the Luphephe-Nwanedzi impoundment, showing the time of scale ring formation (indicated by the arrow).

determination of the periodicity of ring formation was restricted to the single size class as the number of circuli between annular rings decreases with increasing fish size. Had fish of all size classes been used for this purpose there would undoubtedly have been a considerable margin of error.

The time of scale ring formation coincided with the end of the peak breeding season of this species, which in the Luphephe-Nwanedzi impoundment is from October to January. Bruton and Allanson (1974) found a period of active feeding after termination of spawning activity. This period, they found, coincided with the deposition of a ring on the scale and they postulated that the irregularly and widely spaced circuli were caused by a temporary increase in growth due to active feeding. The present observations could be seen as substantiating their findings. Le Roux (1961), however, stated that ring formation on the scales of *S. mossambicus* in a number of Transvaal impoundments occurs in August i.e. towards the end of the winter. His estimation of ring formation in winter was determined by using the direct proportionality formula of Lea (1912). His calculations were, however, based on limited material which could possibly have caused an error in the estimation of the time of ring formation.

Difficulty was experienced in counting scale rings of fish larger than 22 cm SL. This was caused by their being crowded and not clearly separated. This problem was not encountered with otolith sections, where it was found that all rings, even of large fish, were clearly separated. Illegibility of otolith sections was caused mainly by the otoliths being either completely opaque or hyalin and therefore showing no rings at all.

Growth calculations

The relationship between otolith length as well as the anterior scale radius and the standard fish length was determined by the method of least squares and found to be SL(cm) = 3,174 OL(mm) − 4,222 and SL(cm) = 4,694 SR(mm) + 3,265 (OL = otolith length, SR = anterior scale radius). A better fit was obtained for the relationship between the antero-posterior otolith length and standard length ($r^2 = 0{,}93$) than between the anterior scale radius and standard fish length ($r^2 = 0{,}61$).

The observed lengths-at-age determined from scale readings were fitted by the method of least squares to the von Bertalanffy growth in length model in the form of $L_t = L\infty(1 - e^{-K(t-t_0)})$ (Ricker 1975). To standardize the data for comparison the observed lengths-at-age from otolith readings were treated similarly.

The adequacy of the von Bertalanffy growth models was tested using Ford-Walford plots (Ford 1933, Walford 1946). The straight line data points of the Ford-Walford line bisects the 45° diagonal. This is indicative of an initial period of fast growth followed by a decrease in the growth rate. Walford (1946) showed that growth conforming to this pattern indicates an asymptotic length which can be read off the Ford-Walford plot as the intercept on the 45° diagonal. The theoretical length at an age of one year can be obtained from the Ford-Walford plot as the intercept on the y axis.

Results and Discussion

The observed length-at-age data obtained from otolith and scale readings are shown in Table 1. Using otoliths, the growth of *S. mossambicus* is described by $L_t = 27{,}3(1 - e^{-0{,}425(t+0{,}299)})$ and using scales by $L_t = 26{,}8(1 - e^{-0{,}389(t+0{,}045)})$ cm SL. These data are illustrated in Fig. 4. The difference between these two equations was

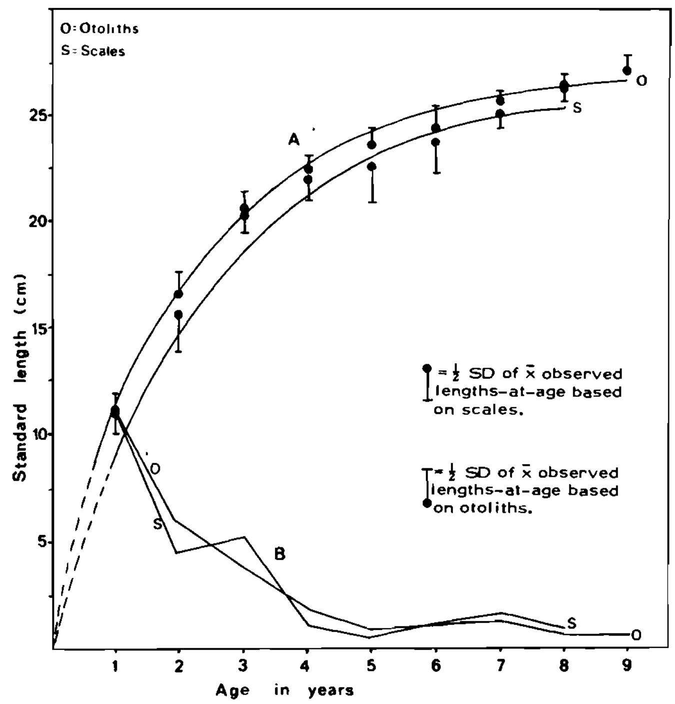

Fig. 4 Von Bertalanffy growth in length curves of *S. mossambicus* in the Luphephe-Nwanedzi impoundment, based on otolith (n = 554) and scale (n = 479) readings (data for males and females combined). A = growth rate, B = annual SL increment. Plotted points and vertical bars (½ SD) = observed data.

tested by means of the Student t distribution test. The difference was found to be significant ($t = 7{,}187$; $dF = 7$; $P < 0{,}01$). The differences between the observed lengths-at-ages as determined from otoliths and scales were also tested and found to differ only at the 5% level ($t = 3{,}254$; $dF = 7$).

Males of most cichlids have a faster growth rate than females (Fryer & Iles 1972). The results shown in Tables 2 and 3 clearly confirm this trend in the Luphephe-Nwanedzi impoundment and show that males already attain a greater length-at-age than the females after one year. In both sexes the growth rate was fastest in the first year and decreased progressively thereafter. This is common in most cichlids and occurs after sexual maturation (Lowe 1952, Fryer & Iles 1972). The growth of male fishes is described by $L_t = 27{,}0(1 - e^{-0{,}417(t+0{,}504)})$ cm SL and that of females by $L_t = 25{,}8(1 - e^{-0{,}370(t+0{,}497)})$ cm SL.

Table 1 Calculated and observed standard lengths-at-age, standard deviation (SD) and annual standard length increments of *S. mossambicus* in cm, using otoliths (O) and scales (S)

Age (years)	$\bar{x}$ Observed SL (cm)		SD		n		Annual SL increment (cm)		Calculated SL (cm)		Difference
	O	S	O	S	O	S	O	S	O	S	
1	10,98	11,07	0,98	1,05	58	58	5,83	4,52	11,56	9,94	2,62
2	16,81	15,59	1,49	3,56	104	98	3,83	5,08	16,99	14,69	2,30
3	20,64	20,67	1,50	2,44	108	87	1,90	1,15	20,55	18,58	1,97
4	22,54	21,82	1,09	1,79	68	118	0,88	0,56	22,87	21,22	1,65
5	23,42	22,38	1,48	2,91	54	78	1,06	1,19	24,39	23,01	1,38
6	24,48	23,57	1,14	2,84	48	52	1,25	1,68	25,38	24,22	1,16
7	25,73	25,25	0,74	1,84	50	49	0,72	0,94	26,04	25,04	1,0
8	26,45	26,19	0,96	1,42	68	40	0,75		26,45	25,60	0,85
9	27,20		0,76		40				26,73		

Table 2 Calculated and observed standard lengths-at-age of male *S. mossambicus* based on otoliths

Age (years)	$\bar{x}$ Observed SL (cm)	SD	Annual SL increment (cm)	Calculated SL (cm)
1	11,64	1,20		12,58
			4,39	
2	16,03	1,84		17,49
			5,43	
3	21,46	1,04		20,74
			1,0	
4	22,46	0,99		22,87
			1,36	
5	23,82	1,19		24,28
			0,85	
6	24,67	1,34		25,20
			1,03	
7	25,70	0,74		25,82
			0,63	
8	26,33	1,15		26,22

Table 3 Calculated and observed standard lengths-at-age of female *S. mossambicus* based on otoliths

Age (years)	$\bar{x}$ Observed SL (cm)	SD	Annual increment (cm SL)	Calculated standard length (cm)
1	10,60	0,46		11,01
			3,44	
2	14,04	0,90		15,61
			5,69	
3	19,73	1,93		18,79
			1,47	
4	21,20	1,07		21,00
			1,10	
5	22,30	1,31		22,50
			0,92	
6	23,22	1,21		23,55
			0,75	
7	23,97	1,42		24,27
			0,84	
8	24,81	2,01		24,77

Table 4 Number and percentage of *S. mossambicus* of the same and of different ages using scales and otoliths for ageing

Age (years)	Same age No.	Same age %	Different age No.	Different age %
1	55	94,80	3	5,20
2	67	68,37	31	31,63
3	58	66,67	29	33,33
4	76	64,41	42	35,59
5	19	24,36	59	75,64
6	10	19,23	42	80,77
7	12	24,49	37	75,51
8	12	30,00	28	70,00

Table 4 shows the number and percentage of fish in each year class of the same and of different ages using scales and otoliths. From this table it becomes clear that both scales and otoliths can be used equally well for age determination up to four years. However, although scales could be read with ease up to four years it became increasingly difficult to distinguish between rings of older fishes. Otoliths were found to remain completely legible up to the maximum age. The data in Table 4 show that after four years the percentage difference between scale and otolith age readings increased significantly.

The reason for the difficulty in reading scales of four-year-old and older fish is that the rings become crowded in the anterior and lateral fields. This occurrence can be correlated directly with the progressive decrease in the growth rate after sexual maturation. The crowding of scale rings is probably also the explanation why the age group 9 was not picked up. This phenomenon is probably the biggest disadvantage of using scales for the ageing of older fishes. Fragmentation of the scale perimeter in fishes older than six years was also found to hamper the counting of rings. Bruton and Allanson (1974) encountered similar problems whilst ageing older *S. mossambicus* in Lake Sibaya.

A further factor hampering the ageing of fish in excess of four years was found to be the phenomenon of 'cutting over' of scale rings. This was first described by Le Roux (1961) in *S. mossambicus*. False rings may also be misinterpreted as annual rings and so may cause a considerable margin of error. False rings were also reported to appear on the scales of *S. mossambicus* in Lake Sibaya (Bruton & Allanson 1974) and were defined by them as rings which did not extend from one lateral field across the anterior field and into the opposite lateral field. Such false rings are illustrated in Fig. 2a.

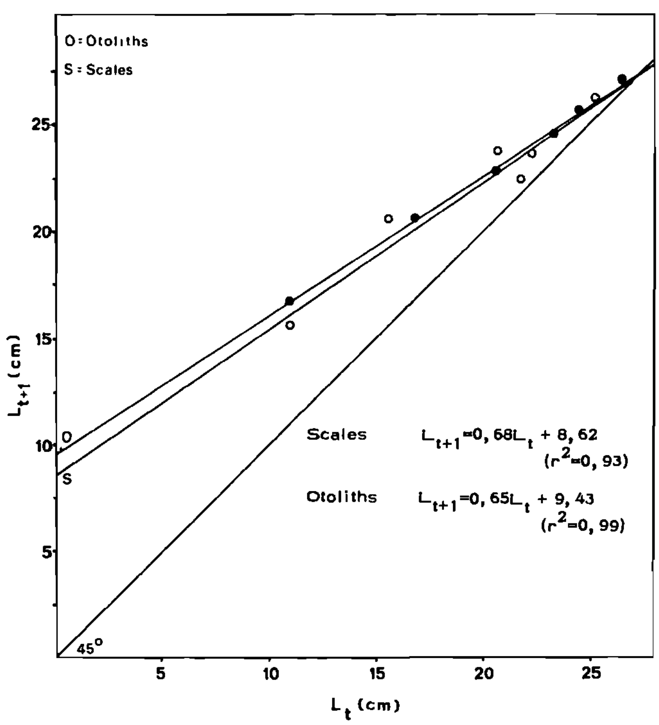

Fig. 5 Ford-Walford plots of otolith and scale length-at-age data of *S. mossambicus* (● = observed otolith data, o = observed scale data). From otolith data L_{t+1} = 9,6 cm and from scale data L_{t+1} = 8,6 cm.

From the data presented in Table 1 and Figs. 4 and 5 a further number of points can be mentioned which show otoliths to be more reliable than scales for age determination of *S. mossambicus*:

- The wide range of observed lengths-at-age and the subsequent comparatively high standard deviation of the mean standard lengths-at-age when scales are used for ageing.
- On fitting the von Bertalanffy equation to the scale length-at-age data it became evident that the calculated curve falls outside the standard deviation of the observed lengths-at-ages one, three and eight years. This is in contrast to the curve based on otolith readings where the calculated curve falls within the standard deviation of the mean observed

Table 5 Growth of *S. mossambicus* in various water bodies in South Africa. (All growth estimates are based on scale readings and all lengths are expressed as TL except for Bruton and Allanson's (1974) and the present studies data which are SL) (Tvl. = Transvaal Province).

			Length (cm) at age (yrs)								
Locality	Reference	Sex	1	2	3	4	5	6	7	8	9
Njelele dam, Tvl. 30°07'E 22°44'S	Le Roux (1961)	M&F	12,7	19,1	22,9	25,4	27,5	28,5	30,2		
Lake Funduzi, Tvl. 30°20'E 22°50'S	Le Roux (1961)	M&F	8,1	10,4	13,5	16,5	19,3	22,9	25,4	27,9	
Albasini dam, Tvl. 30°06'E 23°06'S	Le Roux (1961)	M&F	8,4	12,7	17,3	20,3	24,1	29,9			
Rust de Winter dam, Tvl. 28°28'E 25°14'S	Le Roux (1961)	M&F	8,6	14,9	21,1	25,4	28,7				
Loskop dam, Tvl. 29°21'E 25°25'S	Le Roux (1961)	M&F	10,2	18,8	25,4	30,2	32,5	35,3	38,1		
Sheyo-lo-ngubu dam, Tvl. 31°20'E 25°43'S	Le Roux (1961)	M&F	12,7	20,1	24,9	25,4	29,9	32,3			
Hartebeespoortdam, Tvl. 27°50'E 25°44'S	Le Roux (1961)	M&F	9,7	17,0	22,9	27,4	30,5				
De Hoop Vlei, Cape Prov. 20°25'E 34°28'S	Van Rensburg (1966)	M&F	13,2	23,5	29,0						
Zeekoei Vlei, Cape Prov. 18°01'E 34°04'S	Van Rensburg (1966)	M&F	12,0	19,5	25,0						
Loskopdam, Tvl. 29°21'E 25°25'S	Du Toit *et al* (1972)	M	13,9	21,9	27,7	32,4	35,4	36,0	36,4	37,2	
Loskopdam, Tvl. 29°21'E 25°25'S	Du Toit *et al* (1972)	F	12,5	18,8	25,4	30,9	32,0	32,1	33,3		
Loskopdam, Tvl. 29°21'E 25°25'S	Du Toit *et al* (1972)	M&F	11,3	20,3	26,3	31,2	32,8	34,3	35,0	35,9	
Doorndraai dam, Tvl. 28°46'E 24°17'S	Batchelor (1974)	M	13,1	22,8	29,2	30,7					
Doorndraai dam, Tvl. 28°46'E 24°17'S	Batchelor (1974)	F	13,6	20,6	25,2	26,2	27,5	31,5			
Doorndraai dam, Tvl. 28°46'E 24°17'S	Batchelor (1974)	M&F	13,4	21,6	25,1	27,9	29,3	31,2			
Lake Sibaya, Zululand 32°40'E 27°25'S	Bruton & Allanson (1974)	M	8,5	12,4	14,8	17,7	18,7	19,4			
Lake Sibaya, Zululand 32°40'E 27°25'S	Bruton & Allanson (1974)	F	8,3	11,3	13,4	14,7	16,6				
Incomati-Limpopo river, Tvl.	Potgieter (1974)	M	16,2	22,4	26,9	30,1	32,9	36,1	38,4	40,3	41,8
Incomati-Limpopo river, Tvl.	Potgieter (1974)	F	16,2	21,4	24,7	27,3	29,2	30,6	32,7	34,3	
Luphephe/Nwanedzi, Venda 30°25'E 22°39'S	Present study	M	12,6	17,5	20,7	22,9	24,3	25,2	25,8	26,2	
Luphephe/Nwanedzi, Venda 30°25'E 22°39'S	Present study	F	11,0	15,6	18,8	21,0	22,5	23,6	24,3	24,8	
Luphephe/Nwanedzi, Venda 30°25'E 22°39'S	Present study	M&F	11,6	17,0	20,6	22,9	24,4	25,4	26,0	26,5	26,7

lengths at all ages, thus indicating a better fit.

- From the Ford-Walford plots in Fig. 5 which were constructed to test the adequacy of the von Bertalanffy growth models, the asymptotic lengths using scales and otoliths were found to be 26,7 and 27,3 cm SL respectively. The theoretical length at an age of one year can be read off the Ford-Walford plot as the intercept on the y axis. From scale and otolith readings these lengths were found to be 8,6 and 9,6 cm SL respectively. The asymptotic lengths as well as the length at an age of one year as read off the Ford-Walford plot based on otolith data was found to be in closer agreement with the observed lengths than those read off the Ford-Walford plot based on scale readings.

The only advantage of using scales for the ageing of *S. mossambicus* is that the fish do not necessarily have to be killed. However, if a population which is or will come under considerable fishing pressure is to be studied, it is imperative that ageing be done as accurately as possible as this is one of the most important parameters upon which recommendations can be based for the rational exploitation of a fish species.

From the results presented here it becomes evident that otoliths provide a better means of determining age than scales in the Luphephe-Nwanedzi impoundment. As this impoundment is situated north of the Tropic of Capricorn, and may therefore be regarded as sub-tropical it would be reasonable to assume that otoliths provide a better means for age determination in these and in temperate regions. It is, however, suggested that otoliths of fish from tropical regions should also be sectioned and examined for age marks. During the present study whole otoliths were also examined for age marks but these efforts proved to be entirely fruitless. Only after sectioning did the rings become clearly visible.

Table 5, showing the lengths-at-age of various *S. mossambicus* populations in South Africa, has been included for comparison and also serves to point out that this species grows at significantly different rates in different water bodies throughout the South African region. For easier comparison of the data presented here to those presented in Table 5 the standard length/total length relationship was found to be SL = 0,71 + 0,83 TL ($r^2 = 0,99$).

As regards longevity it is probable that this species in the Luphephe-Nwanedzi impoundment reaches a maximum age of nine years. The largest specimen obtained was a male measuring 29,5 cm SL.

Acknowledgements

This study was made possible by financial grants from the C.D.R. of the Department of Co-operation and Development and the research fund of the University of the North. These institutions are sincerely thanked for their support. Field assistance was provided by Prof. J.E. Saayman, Mr. L. Polling and Mr. R. Viljoen to whom I extend my thanks. I would also like to thank the Venda Division of Nature Conservation for their kind cooperation and permission to work at the Luphephe-Nwanedzi impoundments.

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