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Growth of *Oreochromis mossambicus* (Pisces, Cichlidae) as Evidence of Its Adaptability to Sri Lankan Reservoirs

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Abstract

The introduced cichlid *Oreochromis mossambicus* (Peters) continues to play an important role in Asian fisheries, most notably in Sri Lanka. The growth parameters of 12 reservoir populations were determined using samples from the commercial gillnet fishery.

The parameters L_∞ and K ranged between 267 and 393 mm (TL) and 0.32 to 0.70 $year^{-1}$ with mean values of 311 mm and 0.50 $year^{-1}$, respectively. The von Bertalanffy growth function growth parameters indicate that *O. mossambicus* growth in Sri Lankan reservoirs compares well with African populations.

L_∞ was significantly correlated to the maximum size L_{max} (mean of largest 10 fish) and mean size at capture. M was correlated linearly to K (but not to L_∞), and L_{max} to length at maturity (L_{mat}). The ratio of L_{mat} to L_∞ indicates that the *O. mossambicus* populations are not stunted. Evidence is brought forth to highlight the adaptability of *O. mossambicus* populations to Sri Lankan reservoirs.

Introduction

The cichlid *Oreochromis mossambicus* (Peters) was introduced into Asia in the first half of this century (Ling 1977), with a view to its use in intensive culture. Its importance in intensive culture has declined markedly in recent years, its place being taken mostly by the Nile tilapia, *O. niloticus* (Linné). On the other hand, *O. mossambicus* remains an important constituent species in the capture fishery of reservoirs in tropical Asia, such as in Sri Lanka (Fernando and Indrasena 1969; De Silva 1983, 1985a; Amarasinghe and Pitcher 1986).

O. mossambicus is the dominant species of the reservoir fisheries in Sri Lanka which annually yield 27,000-30,000 t $year^{-1}$ or about 280 kg ha^{-1} $year^{-1}$ (De Silva, in press). This species constitutes on average 90% of the inland production. It is expected to retain its dominance in the fishery (Fernando and Holcik 1982; De Silva 1985a, in press). The commercial fishery essentially is a gillnet fishery which utilizes gillnets of stretched mesh 7-12 cm.

In recent years aspects of the biology of *O. mossambicus*, in particular feeding (Maitipe and De Silva 1985; De Silva et al. 1984) and reproductive biology (De Silva and Chandrasoma 1980; De Silva 1986) have been studied to learn the reasons for the success of this species in the reservoirs of Sri Lanka and its ability to sustain an intensive small-scale fishery.

Little is known on its growth, mortality and recruitment pattern, knowledge of which is important to bring about effective management of the stocks (Gulland 1977). Moreover, studies on growth, mortality, recruitment and other related factors on Asian tropical fish populations are few. As for cichlids, African populations are better known (see Iles 1973; Tweedle and Turner 1977; Trewavas 1983; Moreau et al. 1986).

In the present paper aspects of growth of *O. mossambicus* populations of 12 reservoirs, which are intensively fished (De Silva 1985a) and belonging to five different irrigational systems, are presented. Interrelationships amongst von Bertalanffy growth function (VBGF) parameters and other population characteristics were also investigated.

Materials and Methods

The reservoirs were selected for their accessibility, proximity to laboratories and/or field stations and the availability of statistics of the commercial fishery. These reservoirs also represent a good cross-section of the vast number of reservoirs in Sri Lanka (Fernando 1980; De Silva, in press). Some of the morphometric characters of these reservoirs and the status of their commercial fisheries are summarized in Table 1.

Table 1. Some morphometric characters of the reservoirs, the mean fishing pressure operating on the reservoirs and the yield of *O. mossambicus* (updated from De Silva 1985a). Fishing pressure is calculated assuming 300 days of fishing per year (cd = craft-day).

Reservoir	No.	Surface area (ha)	Catchment (km^2)	Mean depth (m)	Fishing pressure cd ha^{-1} $year^{-1}$	Yield kg ha^{-1} $year^{-1}$
Badagiriya	1	482	346	4.3	15.4	476
Giritale	2	310	24	12.3	6.5	63
Kaudulla	3	2,537	82	9.2	7.4	211
Kiribbanara	4	366	18	3.2	12.6	160
Lunugamwehera	5	3,023	904	12.0	2.0	132
Minneriya	6	2,560	24	5.8	10.0	188
Parakrama Samudra	7	2,262	1,382	5.3	13.5	317
Pimburettewa	8	834	112	4.6	23.0	650
Ridiyagama	9	888	31	5.3	16.9	193
Tissawewa	10	234	38	5.0	34.6	918
Udawalawe	11	2,382	1,162	15.3	6.0	208
Yodawewa	12	488	46	4.0	10.5	157

Commercial catches were sampled as often as possible from July 1983 to December 1986. During each sampling, the proportion of *O. mossambicus* in the catches and the total length and body weight of a random sample of the catches were determined. (Details are given in De Silva 1985a; Maitipe and De Silva 1985).

The length-frequency data of each population were analyzed using the ELEFAN I program (Pauly and David 1981; Brey and Pauly 1986) using a Radio Shack Tandy 2000 microcomputer. The VBGF parameters, asymptotic length (L_∞) in cm (total or standard lengths as specified) and growth constant (K) on an annual basis, were computed. Also determined were the ϕ' growth performance index ($\phi' = \log_{10} K + 2\log_{10} L_\infty$) after Moreau et al. 1986); L_{max}, mean of the maximum recorded size of the largest 10 fish; L_{cap}, mean size of all fish captured in the gillnet fishery; and L_{mat}, size at which 50% of the population reaches maturity. Not all the above parameters were available for all the reservoirs.

Results and Discussion

The basic information obtained from ELEFAN analyses and the interrelationships is given in Tables 2 and 3 and Fig. 1. L_∞ and K of

Table 2. VBGF parameters computed from ELEFAN I analysis and other relevant parameters known for 12 Sri Lankan *O. mossambicus* reservoir populations. The ϕ' values are calculated for standard length. Estimates of longevity of the *O. mossambicus* populations were derived from the growth curves (a) and from the ratio 3/K (b).

Reservoir	L_∞	K	ϕ'	L_{mat}[1]	L_{max}	L_{cap}	Longevity (years) a	b
Badagiriya	267	0.59	2.48	165	270	165	07	05
Giritale	322	0.43	2.46	195	311	205	10	07
Kaudulla	292	0.70	2.59	210	285	168	06	04
Kirlibbanara	296	0.64	2.56	190	365	205	07	05
Lunugamwehera	327	0.40	2.44	-	345	183	-	08
Minneriya	306	0.40	2.38	195	350	207	11	08
Parakrama Samudra	290	0.55	2.48	170[3]	260	193	-	-
Pimburettewa	393[2]	0.34[2]	2.58	205	360	246	-	09
Ridiyagama	307	0.32	2.29	180	295.	193	14	09
Tissawewa	321	0.63	2.62	160	300	164	07	05
Udawalawe	322	0.70	2.70	190	380	177	06	04
Yodawewa	280	0.40	2.31	165	250	176	11	08

[1]Data from De Silva (1986).
[2]Amarasinghe (pers. comm.).
[3]De Silva and Chandrasoma (1980).

Table 3. Interrelationship between growth parameters L_∞ and L_{max}, and other population characteristics of *O. mossambicus* reservoir populations. All relationships are significant at least at the 5% level ($p < 0.05$).

Parameters	Relationship ($Y = mx + c$)	r	Slope	Intercept
L_∞ to mean length at capture (L_{cap})	$L_{cap} = 0.489 L_\infty + 37.965$	0.675	0.168	52.821
L_∞ to maximum recorded length (L_{max})	$L_{max} = 0.677 L_\infty + 96.24$	0.592	0.292	91.118
L_∞ to mean size at maturity (L_{mat})	$L_{mat} = 0.303 L_\infty + 87.159$	0.677	0.116	36.496
L_{max} to L_{mat}	$L_{mat} = 10.231 L_{max} + 111.932$	0.571	0.110	34.815
L_{mat} to L_{cap}	$L_{cap} = 1.32 L_{mat} - 4.636$	0.842	0.298	5.434

the *O. mossambicus* populations ranged from 267 to 393 mm (total length) and 0.32 to 0.70 $year^{-1}$ with means of 311 mm and 0.50 $year^{-1}$, respectively. The asymptotic length (L_∞) of the *O. mossambicus* reservoir populations was significantly correlated ($p < 0.05$) with the mean size of capture (L_{cap}) and the maximum recorded size (L_{max}). L_{max} was significantly related to L_{mat}. The ratio of L_{mat} to L_∞ of the different populations ranged between 0.49 and 0.72 with an overall mean of 0.60 (± 0.06). L_{mat} was very significantly correlated to L_{cap} (Fig. 1D and Table 3).

The growth curves (Fig. 2) of the different reservoir populations appear to indicate that the rate of growth of *O. mossambicus* populations of the downstream reservoirs was significantly lower but

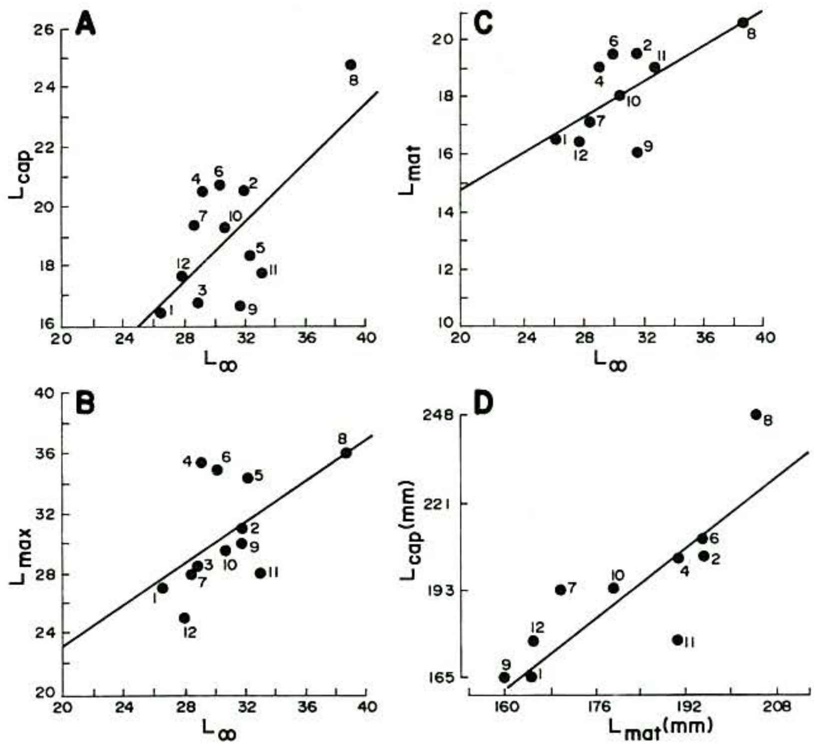

Fig. 1. The regressions relationships between VBGF parameters and other population characteristics. The numbers 1-12 denote each reservoir as per Table 1. A-D, respectively, indicate the relationship between (A) L_{cap} to L_∞, (B) L_{max} to L_∞, (C) L_{mat} to L_∞, (D) L_{mat} to L_{cap}.

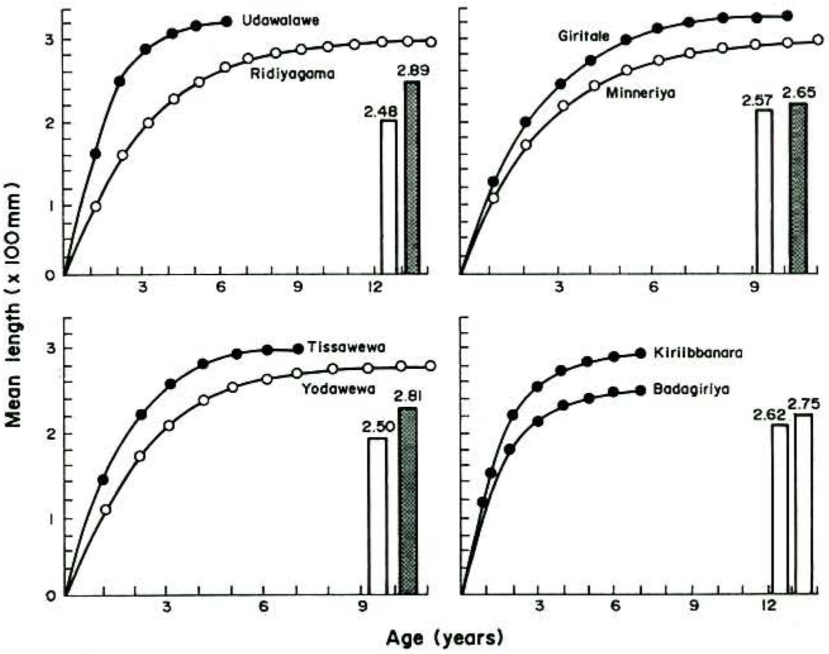

Fig. 2. Growth curves derived from ELEFAN I analysis. The upstream reservoirs in a system are shown in closed circles. Note that Badagiriya and Kiriibbanara reservoirs belong to two independent systems. The vertical bars indicate the ϕ' values (using TL) for each population (upstream hatched).

the longevity was higher. The values of ϕ', based on standard length, ranged from 2.31 to 2.70, comparable to populations of cichlid species which display a high growth performance (Moreau et al. 1986; De Silva and Senaratne, in press).

The longevity of the different reservoir populations inferred from the maximum observed length and the corresponding calculated age (see growth curves in Fig. 2) and from the ratio of 3/K (which implies that fish reach, on the average above 95% of their L_∞ values) is given in Table 2. The longevity derived from the two methods was 6 to 14 years and 4 to 9 years, respectively. Generally, for all populations, the "longevity" estimated from the ratio 3/K was lower, the difference being as high as 5 years in the Ridiyagama reservoir population. Also, irrespective of the method of computation, estimated longevities of the *O. mossambicus* populations of the more downstream reservoirs were higher than those upstream in the same irrigation system.

In recent years it has become increasingly apparent that growth performance of fish populations cannot be meaningfully compared by consideration of VBGF parameters singly; they are best compared by indices derived by incorporation of both L_∞ and K (Gallucci and Quinn 1979; Pauly 1979; Munro and Pauly 1983). Moreau et al. (1986) evaluated the merits and demerits of different indices and concluded that ϕ' is the most suitable index for natural fish populations. On the above basis De Silva and Senaratne (in press) compared the growth performance of the *O. mossambicus* reservoir populations of Sri Lanka. They were found to grow as well as populations in dams and ponds elsewhere.

Studies on interrelationships between growth and other population parameters are not common (see Beverton 1963). It is evident that in the *O. mossambicus* reservoir populations in Sri Lanka, growth is independent of the lake morphometry, in particular its size, depth and possible nutrient load and similar factors. It has been demonstrated that *O. mossambicus* switch their feeding habits (Maitipe and De Silva 1985) and that the predominantly ingested food material, detritus, is also nutritionally adequate (De Silva et al. 1984; De Silva 1985b). Bowen (1982) pointed out that tilapias tend to feed on food material that is most suitable for optimal growth.

K as a function of L_∞ for *O. mossambicus* natural populations in Africa was computed by Moreau et al. (1986). A majority of the *O. mossambicus* reservoir populations in Sri Lanka fall within the confidence limits and the others very close to the limits of ϕ' distribution given by these authors. This perhaps is indicative of the reliability of using ELEFAN analysis on samples obtained from a fishery based on a selective, uniform gear. Moreover, the sample size was kept comparatively low as the diversity in the catches was small. This also emphasizes the ability to use the ELEFAN package effectively on relatively small samples.

The interrelationship of L_{max} and L_{cap} to the asymptotic length is to be expected. It is well documented that one of the less desirable features of tilapiine species and in particular of *O. mossambicus* is its ability to stunt easily. Iles (1973) pointed out that although size reduction is the most immediately obvious feature of stunting, the marked acceleration of the life and growth cycles is more important. The latter is effectively measured by the ratio of the minimum size at maturity to L_∞. The mean size at maturity (L_{mat}) is always higher than the minimum size at maturity. In the present study the ratio of L_{mat} to L_∞ in *O. mossambicus* populations ranged between 0.49 and 0.72 with a mean of 0.60 (± 0.06). When compensation is made for the higher values of L_{mat}, the above results are an indication that the Sri Lankan populations are not stunted, as was inferred by De Silva and Senaratne (in press) from consideration of changes in the landing size over the years.

The very significant relationship between L_{mat} and L_{cap} may possibly be an indication of the adaptability of L_{mat} to fishing pressure (also see De Silva 1986). The latter is further proven by the relationship between L_{mat} and fishing pressure (Fig. 3). L_{mat} in *O.*

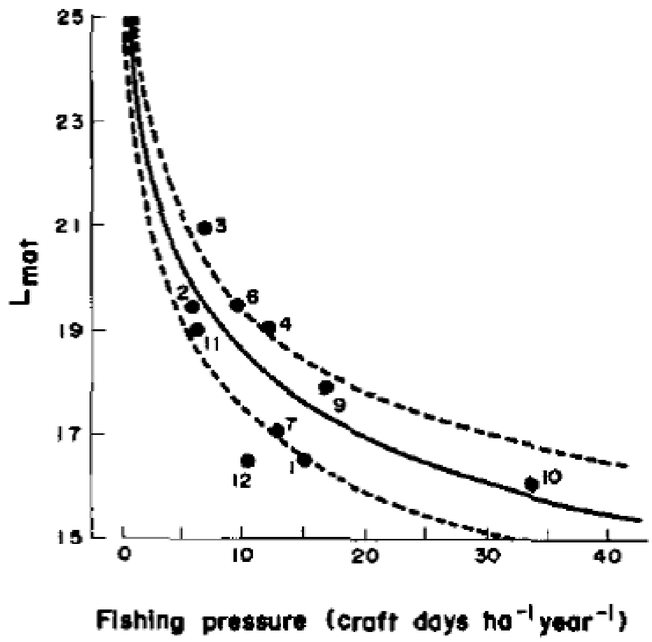

Fig. 3. The relationship of L_{mat} to fishing pressure in 12 Sri Lankan reservoirs. The numbers 1 to 12 denote each reservoir as per Table 1.

niloticus is known to be related to body condition in East African waters (Lowe-McConnell 1982). It has also been demonstrated that fecundity of *O. mossambicus* responds to available nesting area (De Silva, unpublished data). Generally, life history variations in response to environmental changes, either natural or man-induced, are found to occur in fish species (Noakes and Balon 1982; De Silva 1986; Goto 1987). *O. mossambicus* in this respect is one of the most adaptable species (Noakes and Balon 1982; De Silva 1986; Arthington and Milton 1987).

The longevity derived/computed from different methods differed for all populations, with values of 4 to 14 years. This range is within those recorded for tilapias (Iles 1971; Trewavas 1983). It is possible that for some reason, as the fish grow older they tend to move downstream. A possible cause of this could be water temperature (Caulton 1982), which in turn could be effected by depth.

Finally, the present findings provide further evidence of the adaptability of *O. mossambicus*, which presumably is a major factor underlying its success in Sri Lankan reservoirs.

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