Vidyodaya J., Sci., (1991) *Vol.* 3 *No.* 1 pp. 91-98

THE ROLE OF TILAPIA SPECIES (FAMILY CICHLIDAE) IN THE FISHERY OF THREE UPLAND, DEEP RESERVOIRS OF SRI LANKA

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Abstract

The fish catches of three upland reservoirs, namely, Kotmale, Victoria and Randenigala reservoirs, were studied for periods of 8, 18 *and* 9 *months, respectively. Tilapia species formed* 60-70% *of the catch of all three Reservoirs. Three species of tilapia, namely,* Oreochromis mossambicus, O. niloticus *and* Tilapia rendalli were present in *Victoria* and *Randenigala* reservoirs *but the last species was not caught in Kotmale reservoir. The three species formed, respectively,* 50.8%, 49.2% *and* 0% *of the tilapia catch of Kotmale reservoir,* 71.5% 26.6% *and* 1.9% *of that of Victoria reservoir and* 96.2%, 2.6% *and* 1.2% *of that of Randenigala reservoir. The relative abundance of the three species in the three reservoirs is discussed in relation to that of the three species in other reservoirs in Sri Lanka.*

Key words : *Tilapia* spp., Reservoirs of Sri Lanka.

1. Introduction

SRI LANKA, an island with no natural lakes, contains a large number of reservoirs most of which had been created 800 to 2500 years ago in the lowlands of <200 m elevation in the dry zone (Fig. 1A) for irrigating the rice fields. The exact number of these reservoirs is not known but estimated to exceed 10,000 (Abeywickrema, 1955), of which at least 7000 are usable today (De Silva, 1988). Most of these are small and seasonal, drying up completely or almost completely during the dry season by the end of the rice growing period. Of the perennial reservoirs, a few are large and exceed 300 ha at the full supply level (FSL), and others are of medium-size (10-300 ha). The total area covered by the irrigation reservoirs is about 162,000 ha of which about 122,;000 ha are perennial reservoirs. In addition to these, a few deep reservoirs have been created recently in the uplands (200-1000 m about MSL) and highlands (>1000 m) primarily for hydroelectric purposes. The area of these reservoirs is about 9000 ha.

The fisheries and the limnology related to fisheries of some of the lowland reservoirs have been studied, a few of them in detail, by several workers (Fernando, 1965; Mendis, 1965; Fernando & Indrasena, 1969; Costa, 1980;

Chakrabarty & Samaranayake, 1983; De Silva, 1983; Schiemer, 1983; De Silva, 1985; Chandrasoma, 1986). These and other works on the Sri Lankan reservoir fisheries have been recently reviewed by De Silva (1988). However, not much information is available on the limnology and the fishery of the upland deep reservoirs (de Silva, 1990; 1991; de Silva & Somarathna, 1990). Present paper reports on a 18 months study of the fishery of three of the upland reservoirs, namely the Kotmale, Victoria and Randenigala reservoirs.

2. Kotmale, Victoria and Randenigala Reservoirs

The three reservoirs (Fig. 1B) were created during the period of 1984-86 by impounding the river Mahaweli at different elevations. Of the three reservoirs, Kotmale reservoir is situated at the highest elevation (Table I). It is an inverted L-shaped reservoir (Fig. 1B), which is created by the damming of one of the uppermost branches of the river, the Kotmala Oya. Victoria reservoir, a W-shaped reservoir, has been built downstream of the point of confluence of the main branch of the river Mahaweli and a major tributary, the river Hulu. As a result, main branch of the river Mahaweli and the tributary Hulu join the reservoir at the two ends of the outer limbs of the reservoir (Fig. 1B). Victoria reservoir receives its water mostly from the Hulu branch, because water from the main branch of Mahaweli is usually diverted immediately upstream of the reservoir to the dry zone reservoirs. Randenigala reservoir is a hatchet-shaped reservoir (Fig. 1B), which is the third reservoir of Mahaweli river and is situated immediately below the Victoria reservoir. Although it has several streams flowing into it, its main supply of water comes from the Victoria reservoir. Therefore, the water level of the reservoir is mostly controlled by the outflow of the Victoria reservoir.

TABLE I. Important morphometric features of Kotmale, Victoria and Randenigala reservoirs.

	Kotmale	*Victoria*	*Randenigaal*
Year of impoundment	**1985**	**1984**	**1986**
Storage (10^6 m^3)	174	722	860
FSL (m above MSL)	703	430	232
Surface area at FSL (km^2)	6.3	23.7	23.5
Catchment area (km^2)	544	1891	2333
Maximum depth (m)	78	102	90
Mean depth (m)	27.6	30.8	36.6
Shore line (km)	32	115	73
Shore line development	3.96	6.66	4.25
Catchment area/Reservoir area	86.35	79.8	99.28
Littoral zone at FSL (<3 m depth) (km^2)	0.38	1.6	0.96
Lowest draw down level (m above MSL)	665	370	203
Useful storage capacity (10^6m^3)	152	688	565
Dead storage capacity (10^6 m^3)	22	34	295
Surface area at dead storage (km^2)	1.56	1.8	13.0

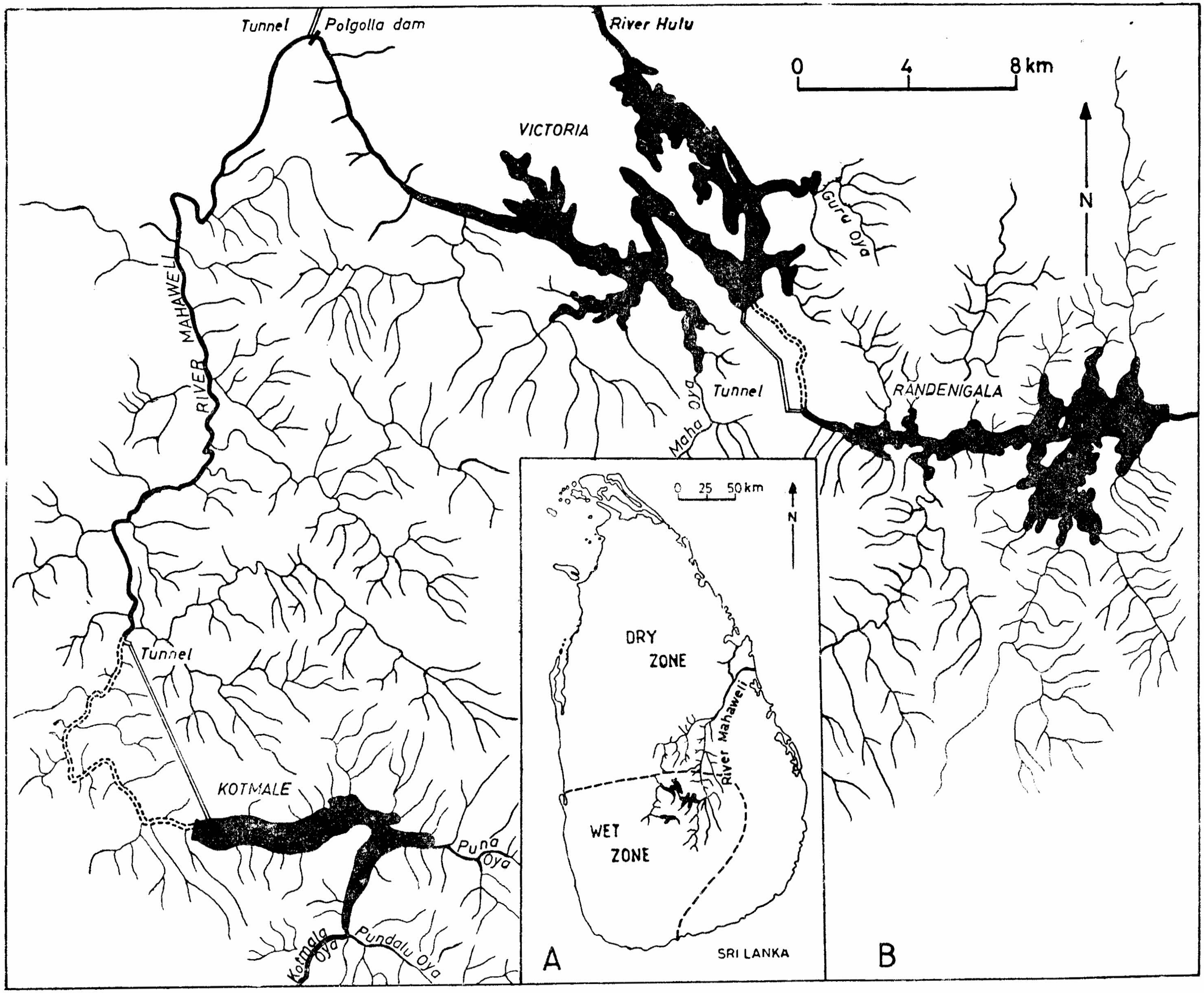

Fig. 1. (A) Sri Lanka showing the relative positions of the three reservoirs studied. (B) Kotmale, Victoria and Randenigala reservoirs in river Mahaweli.

As the three reservoirs are situated in the hill region, their banks are steep and the littoral zone is narrow in most parts of the reservoirs, in contrast to wide littoral regions of the shallow irrigation reservoirs in the dry zone. The frequent fluctuations of the water level, owing to high outflow rate when the power turbines are operating, change the position and extent of the reservoir littoral continually.

Major morphometric and hydrological features of the three reservoirs are listed in Table I.

3. Methods

Fishing was allowed in Victoria reservoir in January 1989 and in Kotmale reservoir in June 1989. The fish catch of Victoria reservoir was monitored several days a month during the period January 1989 to June 1990. The catch of the Kotmale reservoir was monitored at least once a month from September 1989 to April 1990. Fishing is still not allowed in Randenigala reservoir because the reservoir is situated within the boundaries of a wildlife sanctuary. However, illegal fishing has been continuing from the year of impoundment. Despite the difficulties encountered in meeting the fishermen because of the illegal nature of fishing, the catch was monitored at least once a month during the period August 1989 to April 1990. Species present in the catch of the three reservoirs were identified and suitable samples of each species in the monthly catch were measured for total length, weight, etc.

Important physico-chemical characteristics (temperature, pH, conductivity, dissolved oxygen concentration, total alkalinity, turbidity and Secchi disc transparency) were studied in randomly selected 10 stations in Kotmale reservoir, 12 stations in Victoria reservoir and 12 stations in Randenigala reservoir by fortnightly sampling during the period January 1988 to December 1989. Subsurface phytoplankton was sampled quantitatively using an Apstein net with an attached flowmeter. Phytoplankton species were identified and the abundance of various taxa was estimated by counting them in sub-samples of water under an inverted microscope.

4. Results

Three species of tilapia, namely, *Oreochromis mossambicus*, *O. niloticus* and *Tilapia rendalli* were caught in Victoria and Randenigala reservoirs, but the last species was not caught in Kotmale reservoir. Tilapia species constituted, respectively, 67.5%, 59.4% and 69.2% (by weight) and 83.3%,82.5% and 83.8% (by number) of the respective catches of Kotmale, Victoria and Randenigala reservoirs (Table II). On the other hand, the indigenous species (mainly *Barbus sarana*, *Ompok bimaculatus* and *Tor khudree*) contributed only 10.5% 12.2% and 9.3% (by weight), while the stocked species (mainly *Cyprinus* *carpio*) contributed 22.0%, 28.4% and 21.5% (by weight) to the respective catches of the three reservoirs. The contribution by the individual tilapia species to the fish catch varied from reservoir to reservoir (Table II). The respective mean body length of each species in the catch was rather similar in Victoria and Randenigala reservoirs but was smaller in the Kotmale reservoir. The minimum, maximum and the mean total lengths of each of the three tilapia. species in the respective catches of the three reservoirs are given in Table III

Table II. (A) Catch composition of Kotmale (K), Victoria (V) and Randenigala (R) reservoirs. (B) Species composition of the tilapia catch in the three reservoirs.

(A)

Group	Catch Composition by weight			by number		
	K	V	R	K	V	R
Tilapia species	67.5	59.4	69.2	83.3	82.5	83.8
Stocked species	22.0	28.4	21.5	11.4	9.7	11.1
indigenous species	10.5	12.2	9.3	5.3	7.8	5.1
(B)						
O. mossambicus	50.8	71.5	96.2	49.6	78.5	97.0
O. niloticus	49.2	26.6	2.6	50.4	19.6	1.7
T. rendalli	0	1.9	1.2	0	1.8	1.3

Mean temperature, pH and the conductivity of the sub-surface waters of the three reservoirs are given in Table IV. The phytoplankton profiles of the three reservoirs were similar with Chlorophyta dominating species-wise as well as in numerical abundance.

Table III. The maximum minimum and mean$\pm$standard error of the sizes in cm of the three species of tilapia in the respective catches of the three reservoirs.

	O. mossambicus	*O. niloticus*	*T. rendalli*
Kotmale			
Minimum	15.0	14.0	
Maximum	21.0	29.0	
Mean SE	17.84$\pm$0.300	17.42$\pm$0.051	
n	1015	1032	
Victoria			
Minimum	15.0	18.0	15.0
Maximum	34.0	35.0	28.0
Mean SE	22.23$\pm$0.048	25.67$\pm$0.080	21.23$\pm$0.286
n	2534	858	92
Randenigala			
Minimum	17.0	12.0	18.0
Maximum	32.0	28.0	25.0
Mean SE	21.57$\pm$0.067	23.57$\pm$0.532	20.83$\pm$0.737
n	1225	21	16

Table IV. Mean temperature, pH and the conductivity of the sub-surface waters of the three reservoirs during the study period.

	Kotmale	Victoria	Randenigala
Temperature (°C)			
Minimum	24.0	25.2	26.2
Maximum	27.6	24.8	30.6
Mean	25.61	26.92	28.32
pH			
Minimum	6.08	6.68	7.06
Maximum	7.19	7.82	7.72
Mean	6.61	7.13	7.40
Conductivity (μS^{25})			
Minimum	40.2	53.1	78.0
Maximum	54.3	92.2	99.3
Mean	50.7	77.4	90.1

5. Discussion

Reservoir fishery is the most important source of inland fish in Sri Lanka, a country which has no tradition of aquaculture. There is no commercial river fishery in the country and the reservoir fishery accounts for about 20% of the current total fish production, including that of the marine sector, of 27,000 to 30,000 t (De Silva, 1988).

The seasonal reservoirs in Sri Lanka are important in the culture fishery while the perennial reservoirs are important in the capture fishery. For the capture fishery, the reservoirs are generally stocked with fingerlings of the Chinese and Indian carps (Thayaparan, 1982; Chakrabarty & Samaranayake, 1983).

The inland fishery, specially the reservoir fishery, of Sri Lanka is dominated by *Oreochronus mossambicus* (Fernando & Indrasena, 1969; De Silva, 1983; Fernando & De Silva, 1984), which contributes 60-100% to the fish production of individual reservoirs (De Silva, 1988). This species was introduced to the island's freshwaters in 1952 (Fernando & Indrasena, 1969). Although four other tilapia species, namely, *O. niloticus*, *Tilapia hornorum*, *T. rendalli* and *T. zillii*, were introduced into the country, only *O. niloticus* and *T. rendall.* appear to have been established. Prior to the introduction of *O. mossambicus* in 1952, the fish production of the reservoirs was very low owing to the absence of true lacustrine fish species in the island. In a well documented case of Parakrama Samudra, a lowland reservoir situated in the north-east of Sri Lanka, the annual fish production has increased, beceuse of *O. mossambicus*, from less than 10 t prior to 1952 to more than 500 t by 1966 (Fernando and De Silva, 1984).

The fish catch of Kotmale, Victoria and Randenigala reservoirs is lower than that of lowland reservoirs. The fish production of Victoria and Kotmale reservoirs have been estimated as 70.1 and 38.0 kg ha^{-1} yr^{-1}, respectively, while Randenigala reservoir appears to have a fish production potential of 70 kg ha^{-1} yr^{-1} (de Silva 1990; 1991). Since the reservoirs are new these estimates of fish yield may be higher than what could be expected when the conditions are stabilized later. Among 19 lowland perennial reservoirs with surface areas ranging from 482 to 7825 ha only one reservoir has a fish production less than that of Victoria reservoir (De Silva, 1988). The average production of the 19 lowland reservoirs was 243.6 kg ha^{-1} yr^{-1}, which is about 3.5 and 6.5 times as high as those of Victoria and Kotmale reservoirs, respectively.

The contribution to the fish yield by *T. rendalli* is very low in the three reservoirs. The rarity of macrophytophagous *T. rendalli* is probably due to the lack of aquatic macrophytes in the reservoirs. The steep banks and the frequent changes of water level and extent of the littoral are unfavourable to the establishment of aquatic macrophytes. The absence of prolonged dry periods is unfavourable to periodic establishment of land grasses in the exposed littoral, which is characteristic of the littoral of lowland reservoirs. In Sri Lanka, *T. rendalli* was found to predominate the fishery of only the Mahagama reservoir situated in the southern lowlands, a reservoir which contains macrophytes (for instance, *Ipomea aquatica*) in abundance (Chandrasoma, 1986).

The only previously reported instance of *O. niloticus* predominating a reservoir fishery in Sri Lanka was that of Sorabora Wewa reservoir (Chandrasoma, 1986). The heavy stocking of this reservoir in 1978/79 with *O. niloticus* resulted in increasing of its importance in the fish catch from 0% to 95% while decreasing that of *O. mossambicus* from 100% to 5% within a period of four years (1979-82). However, a severe drought in early 1983, at the end of which the reservoir was reduced to a few pools, decreased the Nile tilapia percentage in the catch to 5%, although it showed signs of recovery subsequently (Chandrasoma, 1986). The success of Nile tilapia in this reservoir has been attributed to the dominance of its phytoplankton by blue-green algae and the ability of Nile tilapia to use this food source effectively (Chandrasoma, 1986). However, it has been pointed out that Java tilapia could also utilize blue-green algae, albeit not as effectively as the former species (De Silva, 1988). In the three upland Mahaweli reservoirs the dominance of *O. mossambicus* over *O. niloticus* increases with decreasing elevation. The phytoplankton profile of Kotmale reservoir is similar to that of Randenigala and Victoria reservoirs, with Chlorophyta dominating. The success of Nile tilapia in Kotmale reservoir does not seem to depend on the abundance of blue-green algae in the reservoir since the relative abundance of blue-green algae in Kotmale reservoir is not markedly different from that of the other two reservoirs. However, it has been shown that the lower temperature tolerance limit of Nile tilapia is lower than that of

Java tilapia (Balarin & Hatton, 1979). Since the temperature of Kotmale reservoir is lower than that of the other two reservoirs, the lower temperature tolerance of Nile tilapia could have been a contributory factor to its success in Kotmale reservoir.

All three reservoirs have been stocked for fishery purposes with fingerlings of Nile tilapla and/or exotic carps. Victoria and Randenigala reservoirs have been stocked with carps (mainly common carp and rohu) and Nile tilapia, while Kotmale reservoir has been stocked with common carp (according to stocking data of the Freshwater Fish Breeding and Research Centres at Ginigathena and Nuwara Eliya). However, only common carp shows a significant contribution in the catch.

Mean size at capture of all three species is markedly small in Kotmale reservoir. The smaller mesh size of the gillnets used in Kotmale reservoir appears to be the reason for this difference. Fishermen in Kotmale reservoir used 2 inch (5 cm) stretched-mesh nets (although it is illegal to use nets with mesh size below 4 inches (10 cm), whereas those in Victoria and Randenigala reservoirs used nets of stretched-mesh size of 4 inches (10 cm) and above.

In Sri Lankan reservoirs (both lowland and upland), the dominant fish species in the catch is the exotic *O. mossambicus*, which shows a high trophic plasticity (Maitipe & De Silva, 1985). If not for the introduction of *O. mossambicus* to the freshwaters of Sri Lanka, the fish potential of the lowland irrigation reservoirs as well as upland Mahaweli reservoirs would never have been realised to such a high degree. This shows the importance of having the "correct" species for the success of a reservoir fishery.

6. Acknowledgements

We wish to thank Mr. R. M. D. Somarathna for helping with sampling and laboratory analysis of reservoir water and plankton, and Messrs. U. Edirisinghe and D. G. Jayatissa for helping with collection of catch data. We are greatly indebted to the Manager and Chief Engineer of the Mahaweli complex of the Ceylon Eleetricity Board and the Engineers-in-Charge of Kotmale and Randenigala Projects of the Mahaweli Authority, for making available their boats for sampling and for providing some of the morphometric data of the reservoirs.

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