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THE RESERVOIR FISHERY: PRESENT STATUS AND FUTURE STRATEGIES

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The freshwater fishing industry of Sri Lanka is characterised by four unusual features, the combination of which perhaps makes the industry unique to the Island. Firstly, almost all the landings are from a single type of water body — the reservoirs; secondly, these water bodies are entirely man-made; thirdly, the fishery itself is by and large mono-specific and finally, the species which constitutes the back-bone of the industry is an exotic viz. *Sarotherodon mossambicus* (Peters) (Synonym : *Oreochromis mossambicus*).

Much has been written about the reservoir fishery of Sri Lanka (Fernando and Indrasena, 1969; Fernando, 1973; Mendis, 1977; Fernando and De Silva, 1984), and the role of exotics on the fishery (Fernando, 1971; De Silva, 1982). In the above considerations, catch statistics, the likely reasons for the success of the exotic *S. mossambicus* in the reservoirs and the aspects of the biology in outline, of the constituent species of the fishery, have been dealt with. In this presentation an attempt is made to review the data on available information from a management point of view, together with those aspects of the biology of the important species which have come into light recently and briefly survey qualitatively, the future strategies of the reservoir fishery with a view to optimization of its yield. The paper deals only with the fishery of reservoirs over 250 ha in surface area and their capture fishery only. The aquaculture potential of these reservoirs are not considered here (see Wannigama *et. al.*, 1982).

RESERVOIR FISHERY

Present Status :

The reservoir fishery, as at present, is a capture fishery, confined to the multitude of perennial man-made lakes, which range in size from a few hundred ha to 7,800 ha – the Senanayake Samudra. However, there are only 11 reservoirs which exceed a surface area of 2,000 ha. This number will increase to 17 on completion of the Mahaweli Diversion Scheme. Detailed classification of the reservoir resource has been attempted by Mendis (1977), De Silva (1982) and Fernando and De Silva (1984). The acreage of perennial reservoir over 250 ha of surface area is estimated to be around 126,000 ha. presently and is expected to increase approximately by another 24,000 ha, as a result of the Mahaweli Diversion.

Many characteristics of the reservoir fishery remain uniform throughout the Island. The craft is usually a dug-out canoe or a log-raft, operable by two men. These crafts, however, are being gradually replaced by fibre-glass crafts, similar in design to the dug-out canoe. The fishery is essentially a gill-net fishery, where the mesh size ranges from 8-12 cm. The gill-nets are laid in the early hours of darkness and hauled at dawn. In addition sporadic cast netting and hook and line fishing is also carried out but is not thought to contribute significantly to the fishery. The bottom topography as well as the numerous obstructions, particularly the tree trunks, prevent any other form of bottom gear being operable. Restrictions are imposed on the minimum permissible mesh size. Although the permissible mesh size is not scientifically determined this restriction, together with the complete prohibition of seining have imposed a certain amount of conservation of the fish stocks in the reservoirs.

The inland fish production which is essentially the reservoir fish production has been on the incline since the early 1950's (Table I) and is presently around 33.0 thousand tonnes; that is an overall yield of 267 kg ha^{-1} $annum^{-1}$, which is significantly higher than that recorded for most reservoir fisheries of the region (Fernando and Furtado, 1975).

The yields from individual reservoir fisheries is very variable, ranging from 710 kg ha^{-1} $annum^{-1}$ in Pimburettewa reservoir (1980 to 1982 data) to 101 kg ha^{-1}

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annum in Mahakandarawa (1977 to 1981 data). The data available for a few randomly selected reservoirs is given in Table II to emphasize the extent of this variability. The reasons for this variability is little understood. It is also evident from the Table that the fishery in all the reservoirs considered, is dominated by *S. mossambicus* and by and large the fishery is mono-specific. The main indigenous constituents of the fishery are *Puntius* (= *Barbus*) *sarana*, *Labeo dussumieri* and *Etroplus suratensis* — the last mentioned species being a typically estuarine species which has been transplanted to rivers and reservoirs (Willey, 1910). In addition certain carnivorous species occur in the catches sporadically. The contribution of the indigenous species to the fishery varies from reservoir to reservoir and from season to season. The two cyprinid species tend to contribute significantly during the rainy period, in most reservoirs (De Silva and Fernando, 1980; De Silva, 1983*a*).

Wijeyaratne and Costa (1981) using morphoedaphic indices (MEI) and catch data (C) for 1975 for seven reservoirs, of which three were omitted from the calculations on the presumption they were erroneous, derived the following relationship :

$$\text{Log C} = \log 19.0677 + 0.7050 \text{ lgo MEI}$$

Ryder (1982) the author of the MEI concept, has categorically indicated the precautions that have to be employed in the use of this concept. Sri Lankan reservoirs are characterised by a very heavy draw-down and as such do not meet a number of premises for the concept to be valid; that is the water body should act as a nutrient pool releasing its nutrients gradually from the deeper waters into the productive zone; secondly, it was emphasized by Ryder (1982) to use the average landings for a reasonable number of years to obtain any meaningful interpretations.

Recently, taking into consideration the catch and effort statistics of *S. mossambicus* for a three year period (79/82) for 18 reservoirs from widely different locations, and on the assumption that the fishing efficiency of the crafts are uniform and that a total of 300 days of fishing per annum is carried out by each craft, it has been shown by De Silva (1983*a*) that (a) the yield (in kg ha^{-1} $annum^{-1}$) is linearly related to the effort (craft-days ha^{-1} annum) in the following manner;

$Y = 4.0X - 53.98$ (d.f. = 18; r = 0.92; $p < 0.0001$) where Y = yield and X = effort. It was however, pointed out that there were indications of the yield levelling off at the extreme levels of effort, indicating that the effort cannot be increased indefinitely. Further, the relationship of yield per craft per annum to the number of craft-days operating per annum (=total effort) did not indicate any meaningful trend, a characteristic of an under-fished artisanal fishery. The yield per craft $annum^{-1}$ ranged between 0.62 to 9.58 m.t. $annum^{-1}$ with a mean of 5.43 ± 2.13 m.t. or 18.5 kg $craft^{-1}$ day^{-1} . De Silva (1983*b*) suggested that considering this value as a profitable amount for the fisherman to be indulged in this activity the total effort (craft $annum^{-1}$) which could be operable without detrimental effects on the population could be back calculated utilizing the earlier relationship; this computation is suggested as the first step towards scientific management of the fishery.

There is little to doubt that with increasing emphasis on the reservoir fishery and introduction of subsidy schemes (Anonymous, 1980*a*) there is a need for further evaluation of the yield data to arrive at management decisions, which are crucial for the sustenance and optimization of the yield.

THE EXOTICS

Upto 1982 a total of 18 exotic species have been introduced into Sri Lanka, since the first known introduction of *Salmo trutta* in 1882 (Table III). This number of exotics amount to more than one third of the recorded indigeneous fresh-water fish fauna (Deraniyagala, 1952; De Silva *et. al.*, 1981) of the Island. The role of the exotics, in particular that of *S. mossambicus* has been aptly documented earlier (Fernando, 1973; De Silva, 1982; Fernando and De Silva, 1984). This species undoubtedly is not only the most successful amongst the exotics but also forms the back-bone of the whole fishery.

Nevertheless, there have been erroneous indications, either directly or indirectly that *Tilapia rendalli* (Phillipart & Ruwet, 1982) and carps (Anonymous, 1980*b* — possibly referring to common carp) are either very well established or dominant in the fishery. There is no indication that either of these species contribute significantly to the reservoir fishery although there is increasing evidence to believe that common carp may be breeding in certain reservoirs (The Author has collected male and female *Cyprinus carpio*, weighing 3 to 5 kg., in running condition from Tissawewa in August 1982 and in July 1983).

It is also known that over the last one and half decades more than two million carp fry (including significant amount of grass carp fry) have been introduced into the perennial reservoirs, without significant returns. The possible reasons for the lack of success of these species will not be dealt with in detail. However, it is important to point out that for the multitude of perennial reservoirs which are relatively large (>250 ha.) extensive culture operations are unlikely to succeed, and their fishery potential lies in developing a capture fishery; a fishery which does not depend on continuous stocking and harvesting but relies on self-sustaining natural or quasi-natural populations.

The reasons for such a consideration is both biological and logistical. Biologically, the major carps are known to require considerable lengths of flowing waters with a variety of pre-determined conditions for spawning which are not completely understood (Sinha *et. al.*, 1974). In Sri Lanka the rivers are dammed at rather close proximity to each other and it may be that conditions suitable for spawning of the major carps do not prevail in such 'short river lengths'. Logistically, stocking and harvesting should ensure a return of at least 30 to 40% to make it viable and most preferably artificial stocking should be supplemented by natural recruitment. Past experience indicates otherwise. Moreover, in Sri Lanka the non-perennial reservoirs or the seasonal tanks, which approximates to nearly 35% of the available lacustrine waters in the Island provides an ideal resource for stocking and harvesting to be practiced. The return from this resource if properly utilized is likely to make a significant impact on the inland fish production, as evident from the preliminary trials (Thayaparan, 1982). As such utilization of the limited production of fingerlings to stock perennial tanks, presently, would be a blow to the whole industry.

ASPECTS OF THE BIOLOGY OF THE CONSTITUENT SPECIES

A substantial amount of information has been gathered on aspects of the biology of exotic species, *S. mossambicus* over the last 20 years, whereas that of the indigenous species of the fishery remain scanty. Fernando and Indrasena (1969) mapped the distribution of nests of *S. mossambicus* of the Parakrama Samudra and showed that the nests were essentially confined to the non-sloping west bank, between the high and low water marks; De Silva & Chandrasoma (1980) evaluated the reproductive biology of *S. mossambicus* and Chandrasoma and De Silva (1981) that of *Tilapia rendalli* of the Parakrama Samudra. More recently the fecundity of *S, mossambicus* populations of 12 reservoirs were investigated (De Silva-1984*b*). The overall fecundity of *S. mossambicus* was found to vary between 318 and 3,169, and fecundity was linearly related to body weight (*w*) and curvilinearly to body length (TL). The statistical relationship between these parameters were

to body weight — $F = 3.23w + 357.8$
($d.f.\ 203;\ r = 0.73;\ p < 0.001$)

to body weight — $F = 1.52\ L^{2.11}$
($d.f.\ 203;\ r = 0.68;\ p = 0.001$)

It was also shown that the fecundity of a standard individual was negatively correlated to the mean egg size of the mature individuals in stage V maturity and positively correlated to the mean fishing pressure operating in the reservoirs (De Silva, 1984*b*).

The respective relationships are as follows:

(*a*) Fecundity (FW_{200}) and Egg Diameter (Y)
$Y = 3487.4 - 1.14\ FW_{200}$ ($d.f.\ 10;\ r = 0.64;\ p < 0.05$)

(*b*) Fecundity (FW_{200}) and Fishery Pressure (X)
$FW_{200} = 10.24\ x + 896.8$ ($d.f.\ 9;\ r = 0.58;\ p < 0.05$)

The above relationships clearly indicate the adaptability and the responsiveness of *S. mossambicus* populations to man-induced changes. Aspects of the reproductive biology of *Puntius sarana* of the Parakrama Samudra was investigated by Chandrasoma and De Silva (1981) and De Silva *et. al.*, (1983*a*).

It is becoming increasingly clear that year — class abundance of many lacustrine species are related to fluctuations in the water-level as well as to other changes associated with flooding (Dudley, 1979; Marshall, 1982; Beam, 1983). De Silva (1984*a*) taking the Parakrama Samudra fishery into consideration showed that the yield in a particular year, which was considered as an index of abundance, was correlated to the degree of fluctuations of the water-level three years prior to that. Further, analysis of catch and water-level fluctuation data for other reservoirs could help to evolve managerial strategies, in conjunction with the irrigational authorities under whose jurisdiction the reservoirs are, to effectively use the fluctuations of the water levels which occur regularly to the benefit of the fishing industry without any negative influence on the rice paddy cultivation.

The fact that green and blue-green algae are common in the reservoirs and based on the finding of Costa and Abeyasiri (1978) that the young of *S. mossambicus* of the Colombo Lake fed mainly on green and blue-green algae as well as the likely ability of *S. mossambicus* like *S. niloticus* and other cichlids (Bowen, 1976; Caulton, 1975; Moriarty, 1973) to digest plant material was used by De Silva and Fernando (1980) to postulate that this could be a contributory factor for their unprecedented success in Sri Lankan reservoirs. However, a more detailed study carried out recently on 12 reservoir populations (Maitipe and De Silva, 1984) and that on the Parakrama Samudra populations (Hofer and Schiemer, 1983) some-what contradicts this hypothesis. It is now known that *S. mossambicus* adults and juveniles are predominantly omnivorous and that the omnivorous habit could vary from exclusive phytophagous, zoophagous or detritivorous habit to a mixture of two habits, depending on season and availability. In all cases, blue-green algae played only a minor role in the diet.

It has also been shown that irrespective of the qualitative make-up of the diet the food material devoured by *S. mossambicus* population from widely different reservoirs is nutritionally adequate to permit effective growth (De Silva, 1984*c*), where the Protein : Energy ratio required for effective growth exceeds 4 (Bowen, 1982). Furthermore, the dietary material devoured is known to be effectively digested (Hofer and Schiemer, 1983; De Silva *et. al.*, 1984*a*).

It is therefore, reasonable to assume that *S. mossambicus* primarily because of its non-catholic nature of the diet will not be limited by either a qualitative or a quantitative inadequacy of food material in Sri Lankan reservoirs.

Stunting or dwarfism is considered a major problem with respect to cichlids, especially in intensive culture (Noakes and Balon, 1982). De Silva and Fernando (1980) reported that in Sri Lankan reservoirs the mean size of landing of *S. mossambicus* of the Parakrama Samudra has declined from 34.2 cm. in 1957 to 21.8 cm. in 1978. It remains questionable whether this observed decrease is a true decrease in the mean size of the fishable stock or is a reflection of the increasing fishing pressure which is being exerted. The observations of De Silva and Fernando (1980), however, have been erroneously and prematurely interpreted as an incidence of stunting of the species in the reservoirs of Sri Lanka (Anonymous, 1980).

It has been suggested that stunting is also checked by the high predatory pressure on the juvenile population (Fernando and Indrasena, 1969). In Parakrama Samudra — a reservoir of 2662 ha at f.s.1 and on which the most limnological and fishery data are available, Winkler (1983) quantified that predation by birds account for approximately 254 tonnes annum ^{1} or 112-161 kg ha^{-1} annum^{-1} ,which is nearly 50% of the yield from the fishery. Apart from such predation, other factors such as the trapping of young fry and fingerlings in small pools in the littoral, which often occurs with the heavy draw down of these irrigation reservoirs could also contribute to minimise possible stunting of the population. In such pools the young are made increasingly vulnerable to predation, both avian and piscine and also to desiccation. Quantification of these aspects in relation to the fishery is an area which should be investigated in detail.

Strategies for the future :

In the foregoing section the present status of the fishery and aspects of the biology of the major constituent species were reviewed, briefly. It was evident that essentially the fishery remains uniform in the type of craft and gear utilized and is effective on a uniform size range of 16 to 35 cm on adult stock in the reservoirs. The reservoirs undoubtedly contain substantial stocks of indigenous minor carps and other species, in particular species such as for example *Puntius* (=*Barbus*) *dorsalis*, *P. filamentosus*, *Danio* sp. etc., which do not grow to a large size (Deraniyagala, 1952). The author has experienced, at least in two reservoirs, i.e. Mahavilachchiya and Nachchaduwa, where a gill net fishery for *S. mossambicus* and other species such as *P. sarana* etc., coexist with another fishery for the minor barbs, without apparent ill-effects on each other.

It is suggested that the minor barb resources remain very much underutilized and that in most reservoirs a secondary fishery could be developed for these species. However, as the effective mesh size of the gear — gill-net — have to be much smaller very effective and controlled management strategies have to be developed for such a fishery. This in the author's view is considered as an area of priority for research, whereby the timing, scale and the gear specifications should be determined before permitting commercial activity.

A similar strategy needs to be developed for the optimal utilization of the carnivorous species such as *Ophiocephalus*, *Wallago*, and *Anguilla* sp. Presently, the exploitation of these species is only accidental. Well-planned surveys using long lining is recommended to ascertain the likely fishable stock of carnivores. Based on these findings managerial decisions could be made to permit a specified number of fishermen to use long-lines in the reservoirs. Similarly investigations on the biology of *Etroplus suratensis* (De Silva *et. al.*, 1983) have suggested that this species would be more effectively exploited during dusk and dawn using a baited gear rather than by laying gill nets throughout the night.

It has often been suggested (Fernando, 1973) that a zooplankton feeder be introduced to fill this vacant niche with a view to developing an ancilliary fishery. The introduction of zooplankton feeding clupeids, specifically *Limnothrissa* sp. and *Stolothrissa* sp. into African lakes have yielded profitable results (Peter and Kapetsky, 1983). In the case of Sri Lankan reservoirs it is questionable whether sufficient quantities of zooplankters, particularly copeopods etc., are present. Fernando (1980) has reported on the paucity of large zooplankters both in species, number and biomass in the S.E. Asian region in general, while Duncan (1983) reported similar findings from the Parakrama Samudra. In contrast to the African Lakes which are very large by Sri Lankan standards, in the latter the draw-down is heavy and turn over rate of the hydrological cycle is considerably faster. This was postulated as a possible reason for the paucity of large zooplankton in Parakrama Samudra (Duncan, 1983). However, in the recent years it has become increasingly noticeable that *Hyporamphus* sp., which are typically coastal and estuarine species (Munro, 1955), populations are becoming increasingly prominent in some reservoirs, notably Udawalawe, Badagiriya, Kaudulla etc. In some of them very small scale fisheries have developed. The available information (personal observations) indicates that this species is primarily a zooplankton feeder. It may be that *Hyporamphus* sp. is gradually fitting into a vacant niche and in time to come may very well play an analogous role to the introduced clupeids in African Lakes.

Sri Lanka possibly offers an unusual example of a case where at least some of the exotics have paid rich dividends, without any apparent detrimental effects on its indigenous aquatic flora and fauna. The 'era' of haphazard introductions has now disappeared, and introductions are now governed by strict rules and regulations, which are often arbitrarily determined (Pillay, 1971).

The Island is going through a number of major developmental projects which will have a direct influence on the natural aquatic habitats. For example, as a result of the Mahaweli Diversion Scheme its flood plain— the breeding grounds of some of the indigenous marsh-dwelling fish species — is estimated to be reduced by 50%, the river flow itself will be reduced by 50% and the duration of inundation of the flood waters of the 16,200 ha. of villus will also substantially decrease (Anonymous, 1980*b*). All such changes are likely to influence the indigenous flora and fauna in numerous ways, which are almost impossible to predict.

In the light of such changes Sri Lanka must be extra cautious with respect to future introductions, particularly piscine introductions. As indicated earlier there are numerous piscine resources which are underutilized. Evolving and adoption of managerial strategies for optimal utilization of these resources should take priority over hastened considerations for any further piscine introductions to the Island's meagre, indigenous fauna.

In the same token utilization of these reservoirs will depend on the initial stocking and possible natural recruitment of the different populations. Past experience clearly indicates that *S. mossambicus* has dominated, and is likely to dominate the reservoir fishery. It has also been argued earlier that a fishery based on periodical stocking is likely to be unprofitable and almost meaningless in the context of the Sri Lankan conditions. It is accepted that periodical stocking is unnecessary for those water bodies which have a self-sustaining population which permits a viable fishery (Welcome and Henderson, 1976; Bhukaswan, 1980). When stocking is carried out, for new reservoirs, it is also necessary to utilize individuals from parental stocks which are known to be disease resistant etc., as well as from populations which haven't been stunted for a long time. The latter will apply especially with respect to the tilapias which are more prone to the latter condition; for example, in the Sri Lankan context it will be ill-advised to utilize the Beira-Lake stocks for stocking.

Finally, a suggestion is made which undoubtedly would cause much concern to conservationist groups. The provision of a large number of lacustrine bodies, over the last 2000 years or so which are alien to the natural topography of the Island, is possibly responsible for the visible population explosions of cormorants, shags etc. Their impact on a sizeable portion of the protein resource of at least one reservoir is documented. It may be that careful studies be initiated on the extent of the avian fauna for reservoirs and evaluate the extent to which they could be cropped, a crop which could provide a meal-base for the expanding aquacultural practices in the country.

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Table I . The total yearly inland fish production (tonnes) from 1960 to 1982 and its percentage contribution to the total fish production (source Ministry of Fisheries)

Year	M.tonnes × 10^3	%
1960	3·3	6·2
1961	3·4	5·6
1962	3·8	4·7
1963	4·3	4·8
1964	5·4	5·4
1965	7·4	8·4
1966	9·2	8·9
1967	9·9	8·7
1968	8·6	6·1
1969	6·9	7·0
1970	8·2	8·5
1971	8·6	9·5
1972	8·3	8·3
1973	6·9	6·9
1974	7·5	6·9
1975	13·1	10·3
1976	12·3	9·2
1977	12·9	9·4
1978	16·4	10·6
1979	17·1	10·3
1980	19·9	10·8
1981	29·0	14·2
1982	33·4	15·9

Table II. Some morphometric features of individual reservoirs, the total annual production and *S. mossambicus* production (in metric tonnes).

Reservoir	Acreage ha	Catchment km^2	Production — Total			Production : Sarotherodon mossambicus			
			Years	Tonnes $annum^{-1}$	kg $ha^{-1}annum^{-1}$	%	Tonnes $annum^{-1}$	kg ha $annum^{-1}$	kg craft-day $annum^{-1}$
Badagiriya	482	346	80/82	199	413	94.3	188	389	7591
Chandrikawewa	729	164	81/82	69	153	68.0	46.6	104	3010
Giritale	310	28	80/82	31	101	63.5	19.7	63	3631
Kaudulla	2537	82	79/82	501	198	62.1	311	123	4960
Kiribbanara	367	28	81/82	84	231	69.5	59	160	3815
Minneriya	2550	24	76/82	510	199	67.0	342	134	5087
Parakrama Samudra	2662	1382	75/82	1020	383	67.0	684	257	8945
Pimburettewa	830	84	80/82	590	710	59.7	352	424	5430
Ridiyagama	888	31	81/82	169	190	92.8	157	177	3080
Tissawewa	234	38	81/82	234	1000	91.6	215	918	7956
Udawalawe	2382	1162	80/82	255	107	69.1	176	74	3695
Yodawewa	488	46	81/82	173	356	70.3	122	250	6412

Table III. Fish introductions into Sri Lanka with comments on their reproductive biology (updated from Fernando, (1971) *—re-introductions, **—transplantations).

Species	Origin	Date	Stocking	Breeding	Remarks
Salmo trutta	Europe	1882-1893	Hill streams	+(Fernando, 1971)	Stocks supplemented from the hatchery annually
Salmo gairdneri	N.America	1889-1893	— do —	+(— do —)	— do —
Cyprinus carpio (2 strains)	Europe	1915	streams/man-made lakes	+(Fernando,1971)	breeding not confirmed
Carassius carassius	Europe	1915	— do —	+(Fernando,1971)	
Osphronemus goramy	Indonesia	1909	— do —	+(Fernando,1971) (Ellepola & Fernando, 1963)	no longer important as a food fish
Ctenopharyngodon idella	China	1948/1975*	man-made lakes		bred in fisheries station, Udawalawe (Weerakoon, 1979)
Hypophthalamichthys molitrix	China	1948/1981			— do —
Aristychthys nobilis	China	1948/1975			
Catla catla	India	1942/1982*			reared in experimental stations
Cirrhinus mrigala	India	1981			
Labeo rohita	India	1981			
Trichogaster pectoralis	Malaysia	1951	Lagoons/marshes	+(Fernando,1971; Indrasena,1965	
Sarotherodon mossambicus	E.Africa	1952	Man-made lakes	+(Fernando & Indrasena,1969)	very important in reservoir fisheries
S. niloticus		1956/1975a	— do —	+(personal observation)	food fish common in certain reservoirs
Tilapia rendalli	E.Africa	1969	— do —	+(Chandrasoma & De Silva, 1981)	food fish
T. hornorumb	E.Africa	1969	experimental(?)		no data available on the present status of these introductions nor has any of the species reported in the inland fish catches.
T. zillib	E.Africa	1969	— do—		
Helostoma temmencki	Thailand	1951			
Puntius gonionatus	S.E. Asia				
Etroplus suratensis**	Lagoons	1910	Reservoirs/rivers	+(Willey,1910)	important catch in certain reservoirs
Chanos chanos**d	Lagoons				occasionally caught in reservoirs.
Mugil cephalus**d	Lagoons				

a — Mendis (1977); b — no records of these introductions are available; c — Jhingran & Gopalakrishnan (1974); d — no organised transplantation carried out.

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LIMNOLOGY AND FISH PRODUCTION POTENTIAL OF SOME RESERVOIRS IN ANURADHAPURA DISTRICT, SRI LANKA

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In the past, several large and small reservoirs have been constructed in Sri Lanka, mainly for irrigational and hydroelectric purposes. Subsequently they have also been used to develop inland fisheries. Not much research has been done relative to hydro-biological conditions and fish production of these reservoirs and as a result, our know-ledge about their biological productivity is very limited. So far a few accounts on the hydrobiology of some inland waters of Sri Lanka have been reported, (Holsinger, 1955; Mendis, 1964; Costa and de Silva, 1969; 1978 a, b, c). Scanty information however is available on connected aspects such as fish production (Mendis, 1965; Costa and Liyanage, 1978). Recently, attempts have been made to derive new methods for the estimation of potential fish production in inland water bodies with a view to improve the existing fishery resources (Welcomme, 1976; Wijeyaratne and Costa, 1981; Wijeyaratne and Amarasinghe in pre-paration).

Limnological conditions existing in water bodies are not uniform and tend to vary from one reservoir to the other and area to area. Hence it is necessary to carry out detailed limnological studies for as many reservoirs as possible, in order to obtain a general idea of the biological productivity of the reservoirs. The present study was under-taken to record the hydrobiological features and determine the fishery potential of seven man-made reservoirs in the north central province of Sri Lanka. A similar study has been carried out on the reservoirs of Ham-bantota district (Daniel, Costa and Wijeya-ratne, in preparation). These studies will provide base-line information for future studies regarding the development of inland fishery resources in Sri Lanka. The seven reservoirs studied were Hurulu wewa, Kala wewa, Mahakandarawa wewa, Mahawil-achchiya wewa, Nachchaduwa wewa, Nuwara wewa and Rajanganaya wewa. These are perennial tanks and except for Mahakan-darawa wewa. They also receive diverted water from the river Mahaweli. Except Nuwara wewa, in all the other reservoirs, there are decaying tree stumps. Among these tanks, the largest is Kala wewa and the smallest is Mahawilachchiya wewa. Table I gives the morphometric features of these reservoirs.

Materials and Methods :

Sampling was carried out once a month, for a period of 12 months, commencing from June 1980. Measurements for September 1980 were not taken due to unavoidable circumstances. Temperature was measured with a thermometer, accurate to 0.1 °C, between 10.00 a.m. and 3.00 p.m. Light penetration was determined with a standard Sechchi disc (diameter, 20 cm.) A "HACH" portable conductivity meter was used to measure conductivity, while a "Karl Kolb" portable pH meter was used to measure pH. Samples for the determination of dissolved Oxygen, total alkalinity and phytoplankton were taken with a Nansen's water sampler. For the determination of dissolved Oxygen, samples were taken both from the surface and the bottom, between 10.00 a.m. and 3.00 p.m. Dissolved Oxygen was measured by the Winkler method as described by Mackereth *et. al.*, (1978). Total alkalinity was determined by titrating the water samples with 0.01 N HCl (Golterman *et. al.*, 1978) and expressed as Calcium carbonate. Tem-perature, pH, dissolved Oxygen and total alkalinity were measured 3 times a day at 2 hour intervals and the mean values of the three measurements are given in Fig. 1 to 7. Primary production was estimated by the light and dark bottle method as des-cribed by Vollenweider (1974). Primary

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production at the surface and at the bottom were measured and the results are expressed as g C m $^{-2}$ day^{-1}

Phytoplankton were identified (Abeywickrama, 1979) and the cell counts were carried out as described by Vollenweider (1974). A single cell was considered as a unit for unicellular and filamentous algae, while a single colony was considered as a unit for colonial algae. Countings were done in triplicate and the average numbers for each genus were calculated. The results are expressed as number of cells/colonies per litre. The maximum sustainable fish yields (MSY) were calculated using morphoedaphic indices (MEI) and the regression equation calculated by Wijeyaratne and Amarasinghe (in preparation) which is as follows.

$$\log_e \text{ MSY} = 0.9005 \log_e \text{ MEI} + 1.9220$$

Results :

(A) Physico-chemical Factors :

Seasonal variation of physico-chemical factors for different reservoirs are graphically represented in figures 1 to 7.

1. Hurulu wewa (Fig. 1)

Temperature : Air and water temperatures varied from 20.4 °C to 31.8 °C and from 27.2 °C to 31.9 °C respectively during the period of investigation. Maximum air temperature was noted in April and the minimum in January. Maximum water temperature was observed in April and the minimum in August.

pH : The pH varied from 7.22 to 8.52 attaining a maximum in August and minimum in November.

Secchi disc visibility : This value ranged from 40 cm. to 111 cm. with a maximum in January and minimum in June and August.

Total alkalinity : This value ranged between 59.3 and 164.7 ppm., with a maximum in January and a minimum in February.

Dissolved Oxygen : The dissolved Oxygen concentrations of surface layers registered its peak value (10.5 mg/l) in July and the minimum 6.33 mg/l in November. Dissolved Oxygen concentrations of bottom layers ranged between 6.53 mg/l in November and 9.47 mg/l in July during the period of study.

Conductivity : Conductivity fluctuated between 140µ mhos per cm. in December and 300µ mhos/cm in November.

2. **Kala wewa (Fig. 2)** :

Temperature : Maximum air temperature (32.5° C) and water temperature (30.9° C) were noted during April and May respectively while the minimum air temperature was noted in December (28.8° C) and the minimum water temperature in October (27.2° C)

pH : This value fluctuated between 7.47 and 8.43 attaining a maximum in March and a minimum in October.

Secchi disc visibility : This value varied from 41 cm. to 94 cm.

Total alkalinity : The highest value (119.3 ppm.) was noted in March and the lowest (50.0 ppm.) in October.

Dissolved Oxygen : Dissolved Oxygen in the surface water layers varied from 9.4 mg/l to 7.87 mg/l, with maximum in July and March and minimum in December.

Dissolved Oxygen concentration of bottom layers ranged from 7.53 mg/l in December to 9.67 mg/l in July.

Conductivity : Maximum value (400µ mhos/cm) was noted in January and May and the minimum (82µ mhos/cm) was observed in August.

3. **Mahakanadarawa wewa (Fig. 3)** :

Temperature : Air temperature ranged from 29.3° C to 32.2° C and the water temperature ranged from 28.0 °C to 31.5 °C. The maximum air and water temperatures were recorded in August and in March respectively. Minimum air temperature was noted in November and the minimum water temperature was observed in July.

pH : It fluctuated between 7.90 and 8.45, with a maximum in August and a minimum in November.

Secchi disc visibility : The highest value (95 cm) was observed in January and the lowest (40 cm) in July.

Total alkalinity : This value varied from 107.0 ppm. in December to 189.0 ppm. in October.

Dissolved Oxygen : Dissolved Oxygen of surface water layers varied from 7.13 mg/l to 10.40 mg/l, with a maximum in July and a minimum in May. The maximum Oxygen concentration of bottom water layers (9.47 mg/l) was recorded in July and the minimum (7.27 mg/l) in February.

Conductivity : It showed an erratic fluctuation with a maximum of 910μ mhos/cm in February and a minimum of 420μ mhos/cm in August.

4. **Mahawilachchiya wewa (Fig. 4)** :

Temperature : Air temperature varied from 28.4° C to 33.8° C, attaining a maximum in June. The lowest value was recorded in January. The maximum water temperature (33.0 °C) was in June and the minimum (28.8 °C) was in January.

pH : The highest pH value (8.48) was noted in August and the lowest (7.50) in November.

Secchi disc visibility : This fluctuated between 42 cm and 78 cm.

Total alkalinity : It ranged from 81.0 ppm to 174.7 ppm. The maximum value was observed in July and the minimum in January.

Dissolved Oxygen : In the surface waters, maximum Oxygen concentration was 9.53 mg/l in June and the minimum was 7.33 mg/l in April. The Oxygen concentration of bottom water layers varied from 7.60 mg/l in February to 9.33 mg/l in July.

Conductivity : Conductivity ranged from 400μ mhos/cm to 800μ mhos/cm, with maximum in October and May and a minimum in June.

5. **Nachchaduwa wewa (Fig. 5)** :

Temperature : Air temperature varied from 28.6 °C to 32.9 °C. Water temperature recorded its maximum value (33.1°C) in November and the minimum (27.5°C) in July.

pH : Its highest value (8.50) was noted in January and the lowest (7.53) was observed in October.

Secchi disc visibility : It ranged between 40 cm and 90 cm.

Total alkalinity : These values varied from 45.3 pp, to 140.0 ppm.

Dissolved Oxygen : The peak value of dissolved Oxygen concentration in surface water (9.47 mg/1) was observed in June and the lowest value (7.07 mg/1) was noted in May. The maximum Oxygen concentration of bottom water layers was 8.60 mg/1 in May.

Conductivity : Conductivity was maximum (570μ mhos/cm) in August and minimum (350μ mhos/cm) in November.

6. **Nuwara wewa (Fig. 6)** :

Temperature : The maximum air temperature (31.3°C) was noted in April and the minimum (28.8°C) was in June. Water temperature ranged between 27.3 °C and 31.3°C, with a maximum in November and a minimum in July.

pH : It ranged between 8.20 and 8.60, attaining its maximum in July and its minimum in November.

Sechchi disc visibility : It ranged between 22 cm and 54 cm, the lowest recorded for all the reservoirs studied.

Total alkalinity : Total alkalinity varied between 74.7 ppm and 133.3 ppm.

Dissolved Oxygen : Dissolved Oxygen concentration fluctuated between 6.47 mg/l and 10.13 mg/l in the surface water, attaining its maximum in June and the minimum in January. The maximum dissolved Oxygen concentration of bottom water layers was 9.6 mg/l in June and the minimum was 6.27 mg/l in January.

Conductivity : Its peak value (840μ mhos/cm) was recorded in April and the lowest value (300μmhos/cm) was noted in July.

7. **Rajanganaya wewa (Fig. 7)** :

Temperature : The maximum air temperature (32.4°C) was noted in May and the minimum (26.5°C) was in December. The water temperature varied from 27.2°C to 30.5°C with a maximum in May and a minimum in December.

pH : pH ranged between 7.47 and 8.57.

Sechchi disc visibility : This value ranged between 65 cm and 151 cm.

Total alkalinity : The peak value (191.7 ppm) was recorded in August and its minimum, (124.7 ppm) was noted in November.

Dissolved Oxygen : Dissolved Oxygen of surface layers of the water body ranged between 4.80 mg/l in December and 9.60 mg/l in July. In the bottom layers, this value varied from 4.80 mg/l to 8.80 mg/l with a maximum in July and a minimum in December.

Conductivity : This ranged between 455μ mhos/cm and 650μ mhos/cm.

(B) BIOLOGICAL FACTORS :

Phytoplankton :

The main phytoplankton groups and their monthly fluctuations are shown in Figures 1 to 7.

Hurulu wewa :

Phytoplankton population in Hurulu wewa showed two pulses, one in July/August and the other in October. The dominant group of phytoplankton during the period was Bacillariophyceae.

Kala wewa :

Phytoplankton population in Kala wewa also recorded two pulses, one during August and the other during March/April. During August the most abundant group was Bacillariophyceae. It was also noted that the dominant group during March/April was Myxophyceae.

Mahakanadarawa wewa :

Phytoplankton density in this reservoir was comparatively low. A peak was recorded in April. During this time, diatoms predominated.

Mahawilachchiya wewa :

Phytoplankton density showed 2 peaks during the study period. Bacillariophyceae was the dominant group during August while Myxophyceae dominated in May.

Nachchaduwa wewa :

Phytoplankton was mainly made up of blue-green algae in July. Diatoms occur in large numbers in May.

Nuwara wewa :

Phytoplankton densities were relatively high and two pulses of Myxophyceae

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during January and March were noted. Two peaks of Chlorophyceae occurred in October and April.

Rajanganaya wewa :

Number of phytoplankton increased rapidly from June until August, followed by a decline. Myxophyceae and Chlorophyceae were the dominant groups during this period.

Primary Production :

Fluctuations of gross primary production (GPP) and net primary production (NPP) in the seven reservoirs studied are graphically represented in Figures 1 to 7.

Daily rates of gross primary production for Hurulu wewa, Kala wewa, Mahakanadarawa wewa, Mahawilachchiya wewa, Nachchaduwa wewa, Nuwara wewa and Rajanganaya wewa ranged between 1.20 - 5.40, 1.42 - 4.16, 1.42 - 4.16, 1.98 - 4.20, 1.73 - 3.67, 2.25 - 5.63 and 1.35 - 4.36 $g\,C\,m^{-2}\,day^{-1}$ respectively.

(C) **Potential Fish Production** :

Morpho — edaphic indices (MEI) and the maximum sustainable fish yields (MSY) were calculated and are presented in Table IV. Table V shows the present fish catches in the same reservoirs.

Disscussion :

Present study was undertaken mainly to acquire an idea about the prevailing limnological conditions and to assess the potential fish production of the major reservoirs of the north central province of Sri Lanka. Morphometrically, the seven reservoirs studied differ much from each other (Table I).

Mahawilachchiya wewa is fairly shallow while Rajanganaya wewa is relatively deep for its area. Degree of wind exposure and maximum depth influences the variation of water temperature (Hutchinson, 1957). Higher values were noted to occur in the shallow tanks such as Mahawilachchiya where the water temperature ranged from 28.7°C to 33.0°C. All the waters are slightly alkaline with most waters having pH values greater than 8.0. These reservoirs have high proportions of CO_3 and HCO_3 ions and it is apparent that the increasing total alkalinity influences the pH fluctuations. In the tanks which have high values for total alkalinity, pH fluctuates very little as the waters are considerably buffered. In all the reservoirs, total alkalinity values increase during dry seasons and during the months of low water levels, since evaporation exceeds inflow.

Sechchi disc visibilities were higher in deeper reservoirs, as for example, in Rajanganaya wewa this value ranged between 65 cm and 151 cm while it was often low in shallow tanks; in Nuwara wewa, it ranged between 22 cm and 54 cm. The lower values encountered in shallow tanks may be due to the turbulence caused by suspended particles and perhaps even due to the presence of large number of phytoplankton. These conditions were more pronounced in smaller reservoirs and were more commonly observed after heavy precipitation. Myxophyceae were the dominant phytoplankton in all reservoirs. Sreenivasan(1970 b) and Uhlmann *et.al.*,(1982) have stated that the dominance of blue green algae among the phytoplankton seem to be a feature of tropical reservoirs. The population densities of phytoplankton were directly correlated with the amounts of dissolved Oxygen which were rather high for both the surface and bottom layers in all the months except during the rainy season. This slight decline in rainy months may be due to, among other reasons, the decomposition of organic matter which gets drained into the water bodies with rain water. During dry seasons, phytoplankton increases rapidly in numbers so that increase in the amount of dissolved Oxygen during this time is mainly due to phytoplankton photosynthesis. In most reservoirs, however, except Mahakanadarawa wewa, the water levels do not markedly recede during the dry season because of the diverted Mahaweli water into these reservoirs. This diversion may tend to decrease the residence time of the water, making the nutrients in water bodies to get diluted as is reflected by the lower values for conductivity in certain reservoirs. In Mahakanadarawa wewa which receives only rain water on the other hand, there is a close relationship between total dissolved solids and rain fall.

Results showed that the production was moderately high throughout the year with little fluctuations in the rates of primary production. It was observed that higher primary production rates are related to high phytoplankton densities (Fig. 1 to 7). Various authors (Sreenivasan, 1964, 1965, 1966, 1970a 1974, Vijayaraghavan, 1971, Costa and de Silva, 1978 c) have shown that primary production in tropical waters is moderately high throughout the year with little fluctuations. Productivity values of waters in major reservoirs in Anuradhapura district (5.63 — 1.20 g C m^{-2} day^{-1}) are similar to those of that of Indian and other Sri Lankan water bodies. When considered seasonally, the values for production decline during the rainly seasons and increased during the dry seasons. These results also indicate that the community respiration resulting in low primary production was high during the rainy seasons.

Potential fish yields were calculated and they indicated that under optimum conditions, a potential fish yield of 5,881,384 kg/yr of fish could be harvested from these reservoirs if proper management measures are taken. According to the present catch statistics maintained by the ministry of fisheries, the present total fish catch from all these reservoirs is 2,854,002 kg/yr. It appears that the potential fish yield for Rajanganaya wewa (409 kg ha^{-1} yr^{-1}) and Mahawilachchiya wewa (630 kg ha^{-1} yr^{-1}) are almost similar to the present fish catches (442 kg ha^{-1} yr^{-1} and 583 kg ha^{-1} yr^{-1} respectively), so that it could be hypothesized that the fish stocks in these two reservoirs are being intensively exploited. Assuming the efficiency of all the crafts and fishermen in all the reservoirs were the same, values for catch per unit effort (CPUE) were estimated to compare the stock abundance (Table V). The CPUE values for Hurulu wewa and Kala wewa which have the same range of MEI values as Rajanganaya wewa, are a little lower than the CPUE for Rajanganaya wewa. When compared with Mahawilachchiya wewa the fish yields appear to be very low in Mahakandarawa wewa, Nachchaduwa wewa and Nuwara wewa although they have high MEI values. Correct management measures should be taken to increase the fish stock sizes of the reservoirs, namely, Hurulu wewa, Kala wewa, Mahakandarawa wewa, Nachchaduwa wewa and Nuwara wewa. This should be done by taking steps to stock more fish fingerlings in these reservoirs and by increasing the fishing effort.

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TABLE I. Morphometric data of the reservoirs studied

(From Register of Irrigation Projects in Sri Lanka.)

Name of the reservoir	Area ha.	Capacity $m^3 \times 10^4$	FSL m MSL	FSD m
1. Hurulu wewa	2125·5	6796·6	132·4	8·4
2. Kala wewa	2583·3	8981·2	128·2	9·2
3. Mahakandarawa wewa	1457·6	4479·6	94·9	5·8
4. Mahawilachchiya wewa	971·8	4016·2	53·8	6·7
5. Nachchaduwa wewa	1784·8	5579·1	101·8	7·6
6. Nuwara wewa	1196·9	4454·8	87·5	7·0
7. Rajanganaya wewa	1599·4	10083·8	68·4	10·7

FSL — Full Supply Level

MSL — Mean Sea Level

FSD — Full Supply Depth

TABLE II. Morpho- edaphic indices (MEI) and maximum sustainable fish yields (MSY) of the reservoirs :

Reservoir	Mean depth m	Conductivity µmhos per cm.	MEI	MSY kg yr^{-1} ha^{-1}	MSY kg yr^{-1} whole tank
Hurulu wewa	3·1	197	61·73	280	594970
Kala wewa	3·4	318	91·57	399	1031434
Mahakanadarawa wewa	3·0	651	211·95	850	1239149
Mahawilachchiya wewa	4·1	628	151·99	630	612383
Nachchaduwa wewa	3·1	461	147·59	613	1095350
Nuwara wewa	3·7	483	129·69	546	653831
Rajanganaya wewa	6·3	593	94·07	409	654267

TABLE III. Fish catch statistics for some major reservoirs in Anuradhapura district. (1980—1981)

Reservoir	Catch* kg yr^{-1}	Catch ha^{-1} yr^{-1} kg	Mean No. of crafts	Catch $craft^{-1}$ day^{-1}kg	Catch ha^{-1} $craft^{-1}$ day^{-1} kg
Hurulu wewa	1,47,449	69	28	14·43	2·28
Kala wewa	4,83,476	187	66	20·07	2·84
Mahakanadarawa wewa	1,48,897	102	30	13·60	3·41
Mahawilachchiya wewa	5,72,073	588	59	26·49	9·95
Nachchaduwa wewa	6,14,139	344	78	21·61	4·42
Nuwara wewa	1,80,840	151	38	13·15	4·10
Rajanganaya wewa	7,07,128	422	126	15·35	3·56

* From the Statistical Division, Ministry of Fisheries.

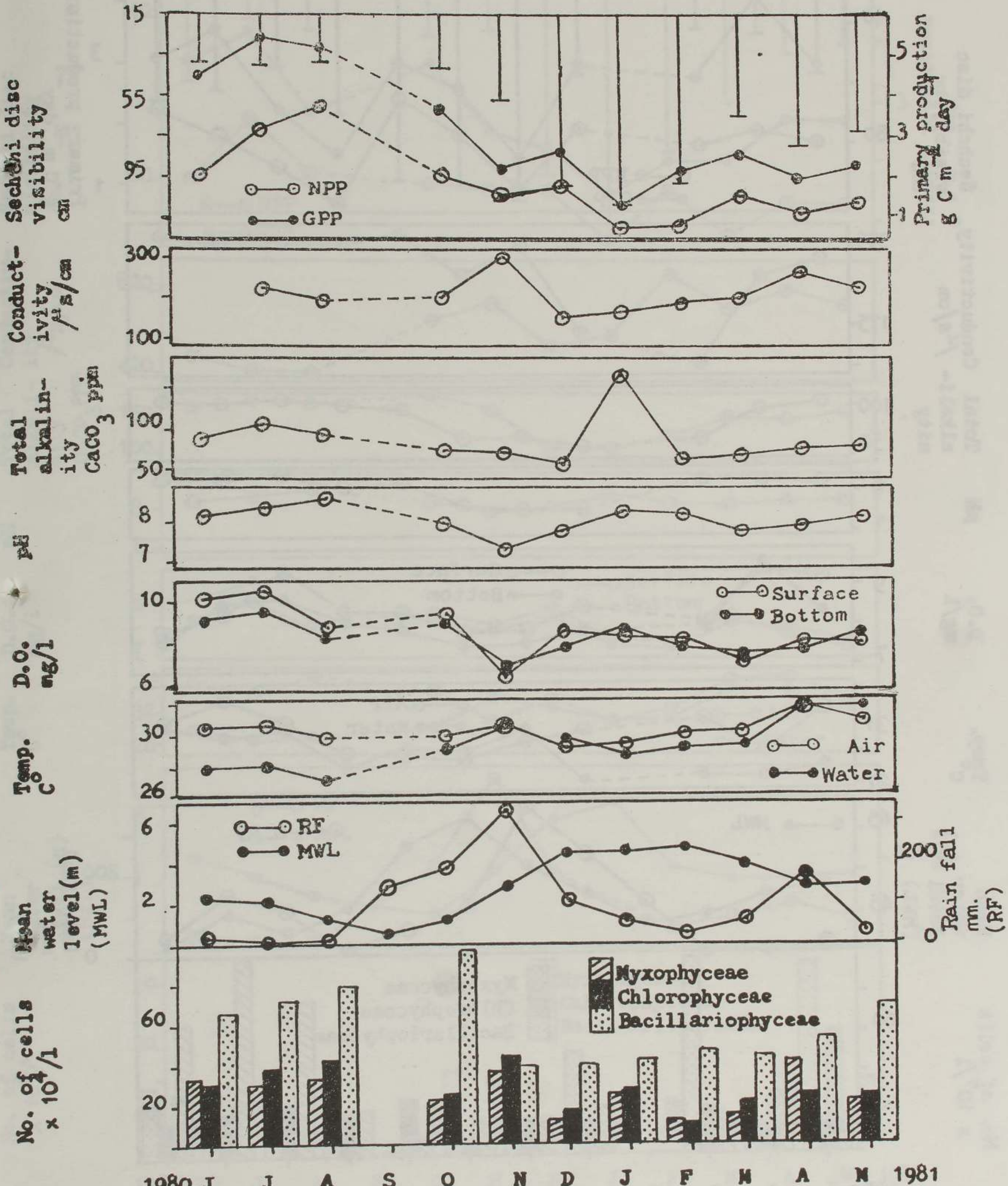

Fig. 1 Seasonal variations of hydrobiological conditions in Hurulu Wewa.

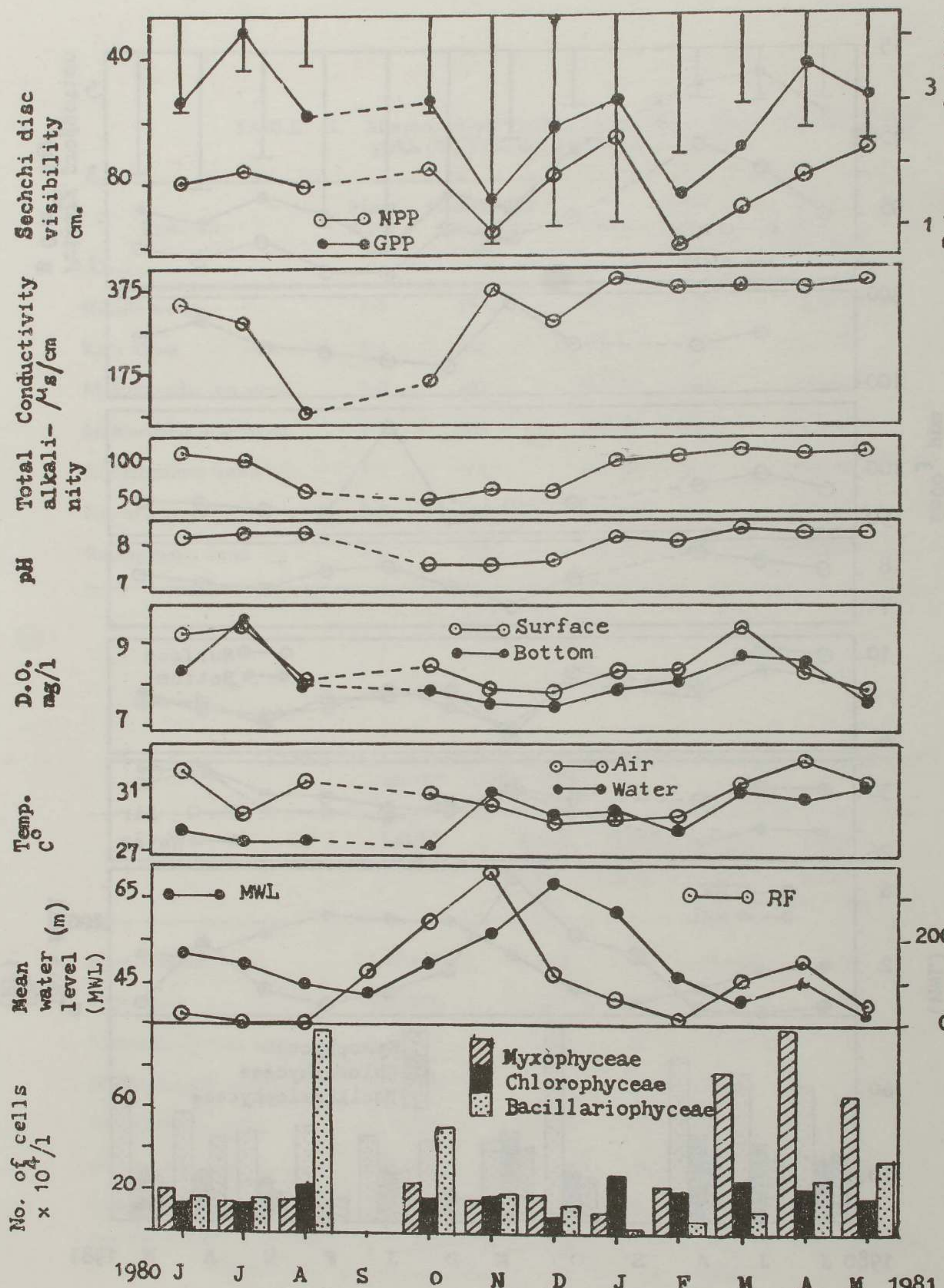

Fig. 2 Seasonal variations of hydrobiological conditions in Kalawewa

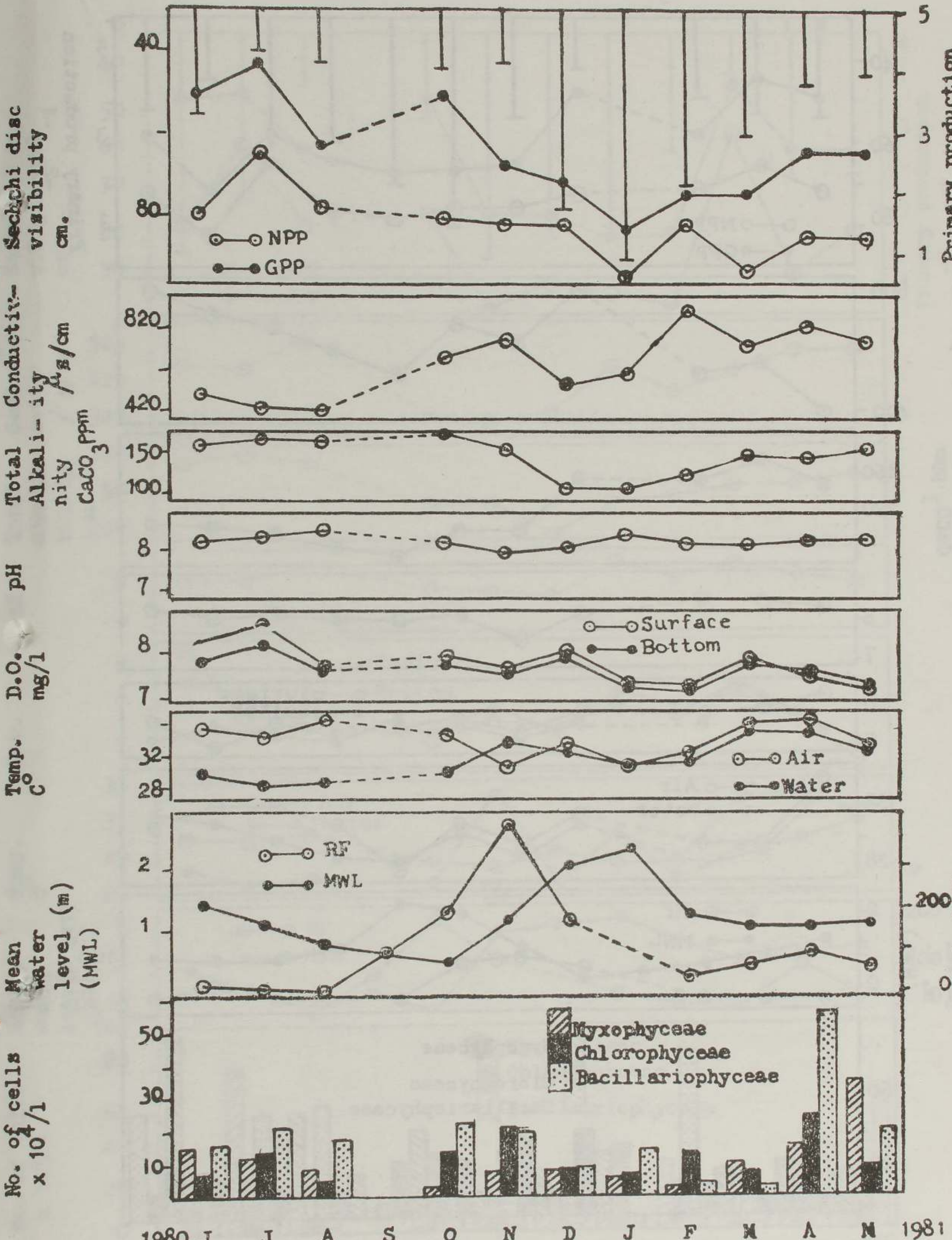

Fig. 3 Seasonal variations of hydrobiological conditions in Mahakanadarawa Wewa.

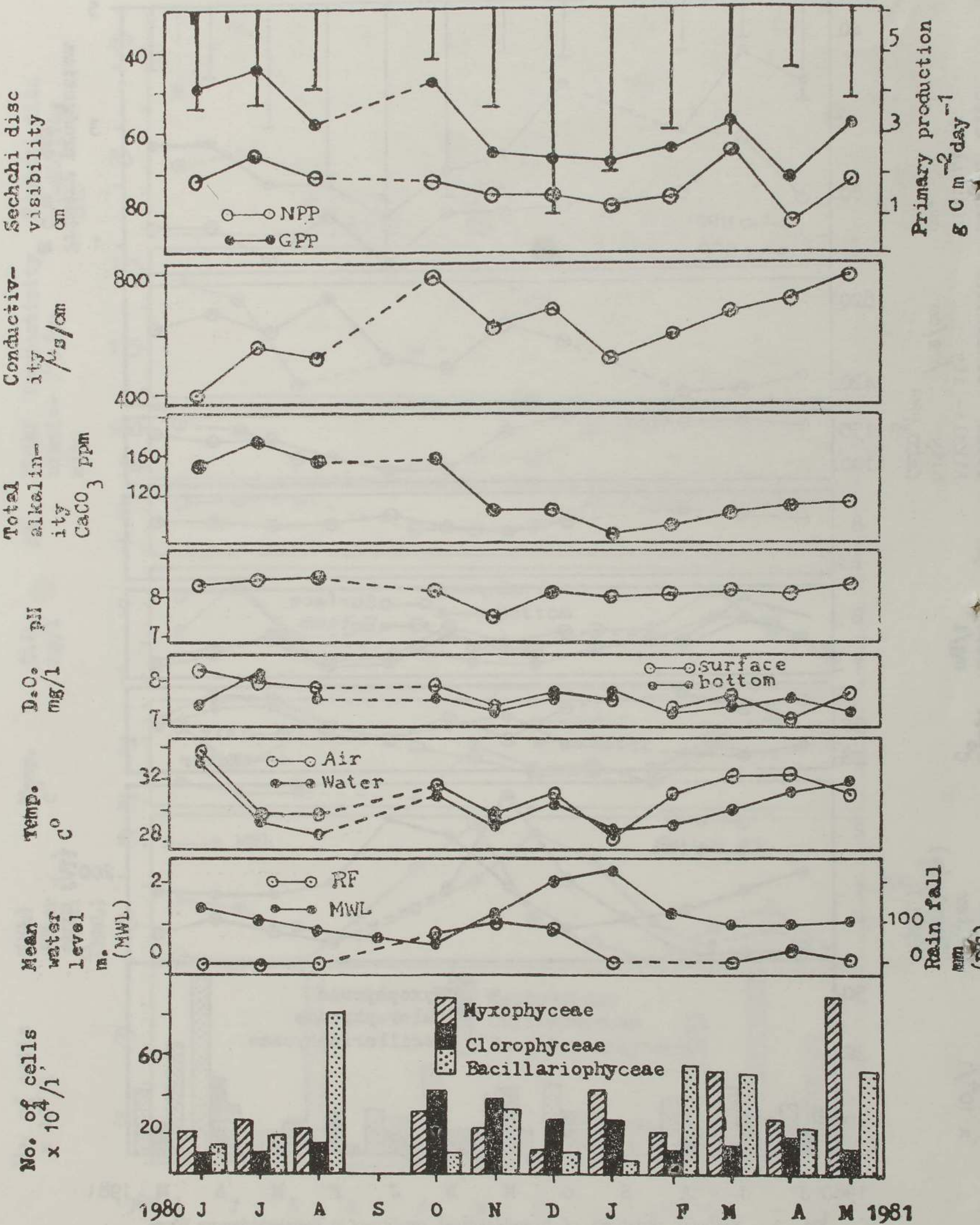

Fig. 4 Seasonal variations of hydrobiological conditions in Mahawilachchiya Wewa.

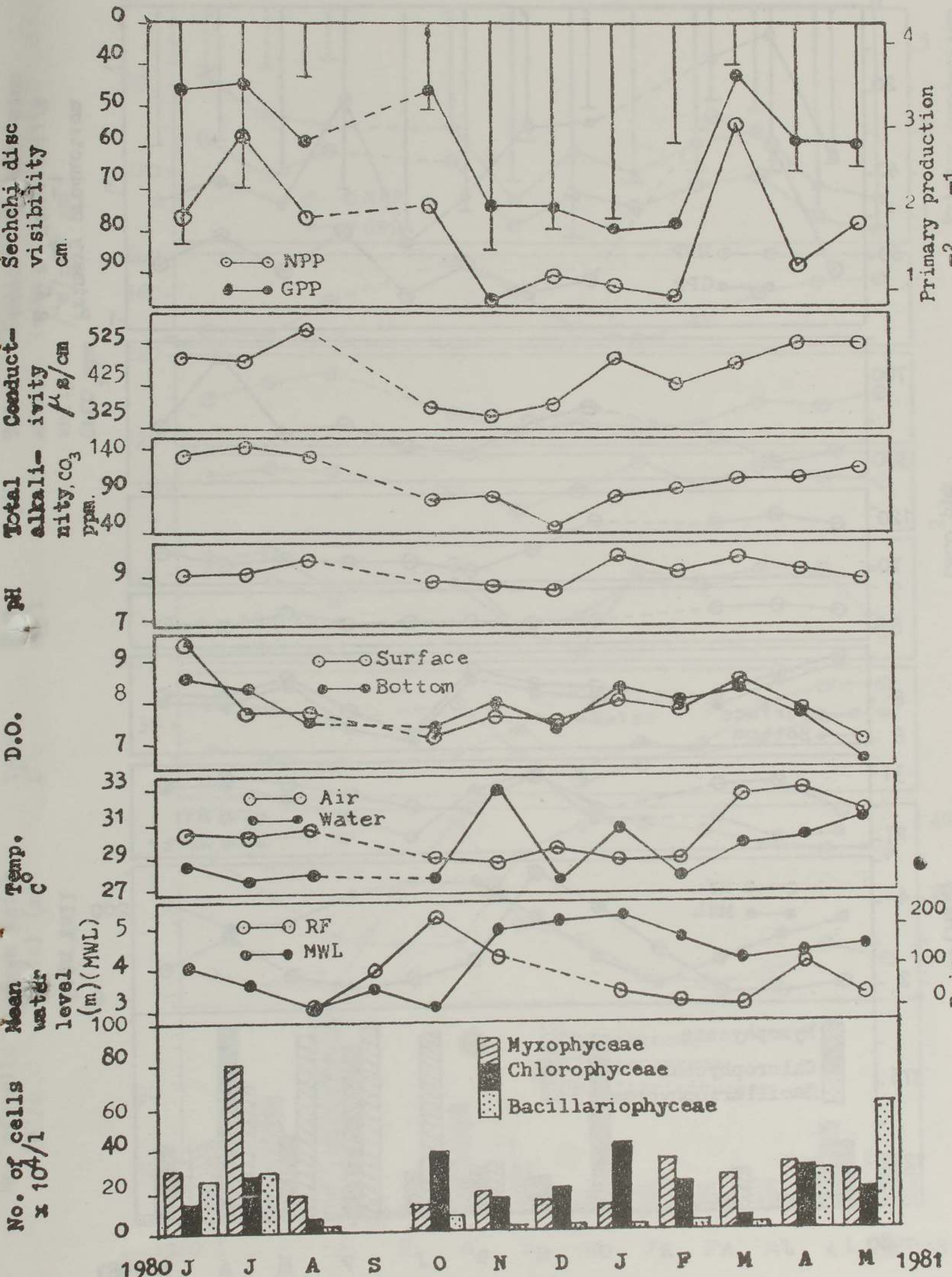

Fig. 5 Seasonal variations of hydrobiological conditions in Nachchaduwa Wewa.

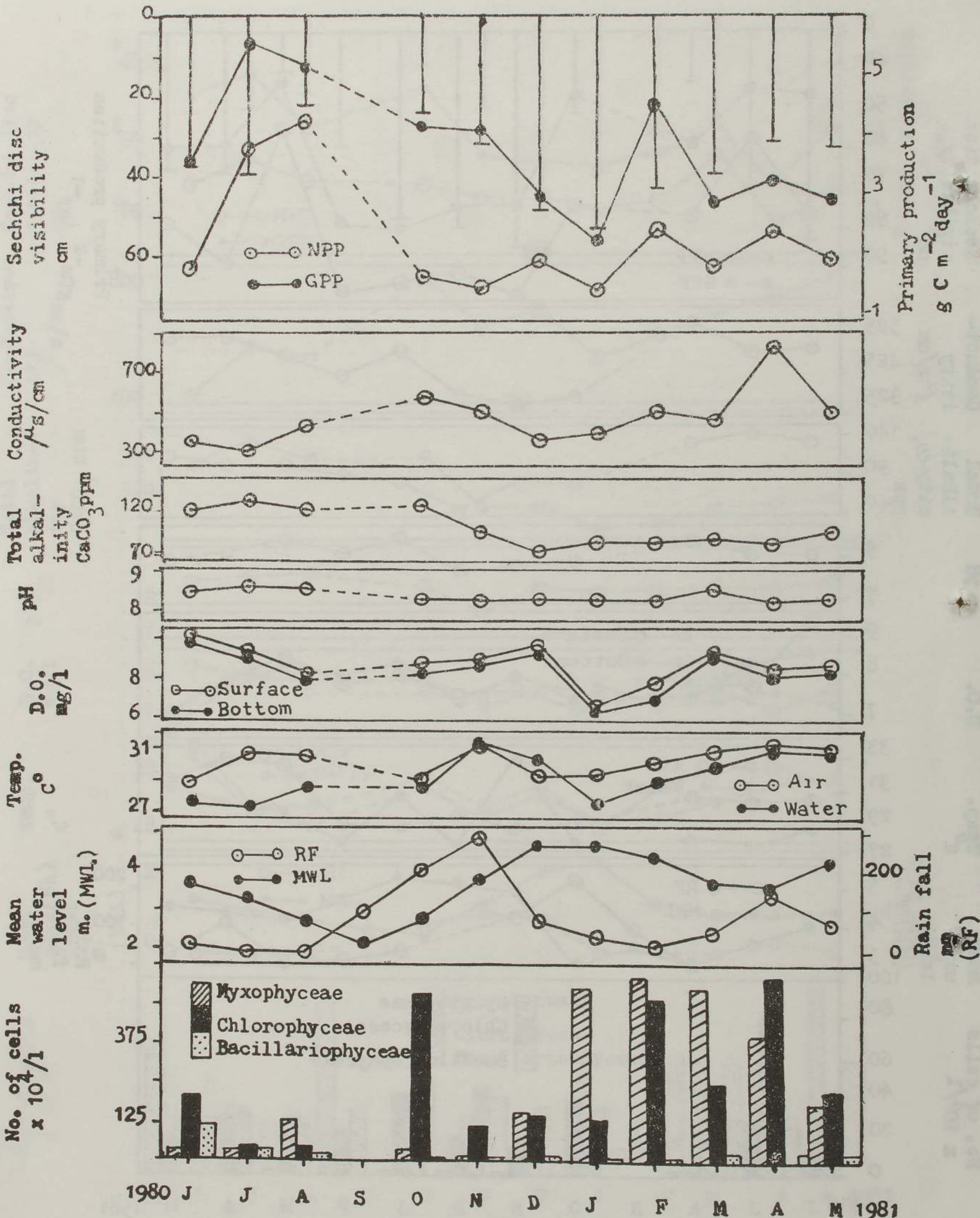

Fig. 6 Seasonal variations of hydrobiological conditions in Nuwara Wewa.

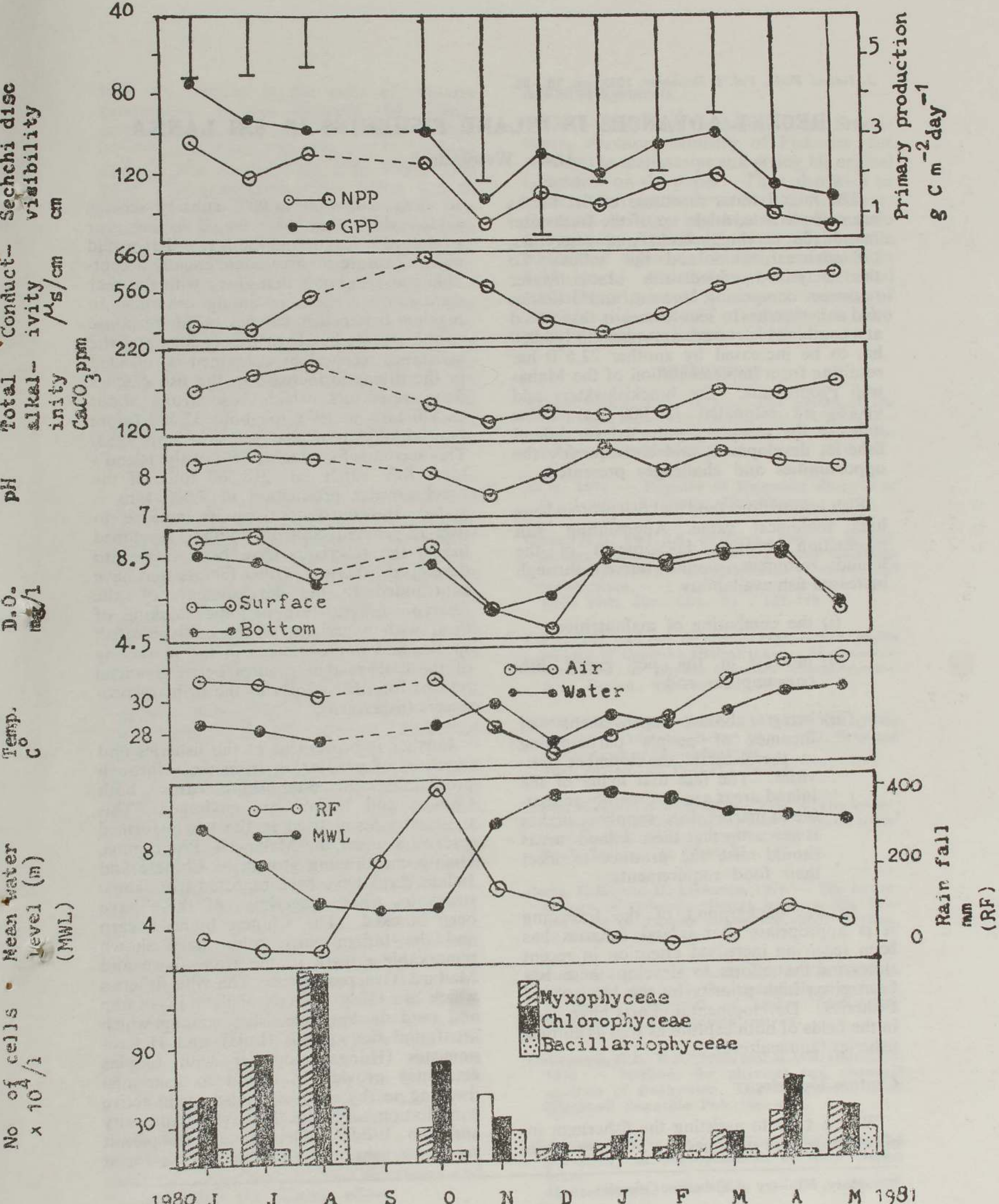

Fig. 7 Seasonal variations of hydrobiological conditions in Rajanganaya Wewa.

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RECENT ADVANCES IN INLAND FISHERIES IN SRI LANKA

Anura Weeraratne*

The inland water resources of Sri Lanka are considerable, made up of the freshwater man-made perennial tanks and reservoirs, the seasonal tanks and the 'villus'. To this may be added the brackishwater resources comprising lagoons, and estuaries and salt marshes. The former is estimated at a combined hectarage approaching 140,000 ha. to be increased by another 22,670 ha. resulting from implementation of the Mahaweli Programme. The brackishwaters add up to an estimated 120,000 ha. These indicate the resources potential for inland fisheries development and consequently the opportunities and challenges presented.

Fish is nutritious food and fish protein have high biological value. Augmenting fish production through development of the inland resources would serve through increased fish availability :

(i) the combating of malnutrition;

(ii) increase in the per caput fish consumption and

(iii) bring about improvement of incomes of people participating in the fisheries development activities. The fact that many of the inland areas are not readily accessible to marine fish supplies makes it necessary that these inland areas should raise the produce to meet their food requirements.

In the background of the foregoing it is appropriate that inland fisheries has been receiving increased attention in recent times and that efforts to develop these has been given high priority by the Ministry of Fisheries. Developmental efforts have been in the fields of both capture as well as culture fisheries (aquaculture).

Capture Fisheries

With a view to assisting the fisherman in effective capture of fishes the Ministry came to their aid with a 90% subsidy scheme under which they were issued fishing gear of desirable length and mesh size that would ensure capture of sizes commercially acceptable and also boats that along with the gear were more efficient in aiding fishermen in making better fish catches. The response to the scheme has been tremendous and the assistance received by fishermen is reflected in the dramatic increase in the fish catches from reservoirs which rose from about 16,500 tons in 1978 to about 35,500 (more than doubled) in five years i.e. by 1983. This accounts for roughly 16% of the island's total fish catch of 218,500 tons. If the brackishwater production of 4,000 tons is added the contribution would increase to over 18 per cent. So from an underdeveloped fishery the reservoirs have been made into developed fisheries. Other factors that have contributed to the development of the reservoir fisheries are periodic stocking of these with fingerlings of the cultivable fish species and improvements in the marketing of the catches that ensures better financial returns for their efforts to the primary producers (fishermen).

Further improvement of the fisheries and increases of production from these through programmes of establishing carps, both Chinese and Indian, are envisaged. This is initially being tried in the newly formed reservoirs under the Mahaweli Programme. Highly encouraging growth of Chinese and Indian carps have been reported from some reservoirs where fingerlings of these have been stocked. The Chinese bighead carp and the Indian carp rohu have shown remarkable growth in the Udawalawe and Maduru Oya reservoirs. The villu fisheries which are fairly rich particulary in swamp and mud dwelling live fishes among which are found the murrels (Lula) and Heteropneustes (Hunga), together with tilapias etc., may provide livelihood to fishermen dwelling nearby and the Ministry is in active consultation with the Mahaweli Authority and the Wildlife Department to permit access to fishermen through reserve forest

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areas to exploit the fisheries resources of reservoirs and villus. Increased stocking with desirable fish species and additional water area resulting from the Mahaweli Programme raises further hope of increased fish productions from the reservoir fisheries.

Aquaculture

It is in the field of aquaculture that the most significant and far reaching developments have taken place. From virtually non-existing culture fisheries, fish culture today is spreading far and wide in the country. The limitations of the capture fisheries places upon aquaculture the need to play an increasingly important role in ensuring supply of food fish for the populace.

Aquaculture development is proceeding in a planned manner and the Ministry is building on information and experience gained and expanding the activities manifold. The two major areas where fresh-water aquaculture (culture fisheries) has made strides are the culture of fish in seasonal village tanks and raising of fish in ponds created under a subsidy programme of the Ministry.

Fish culture in seasonal tanks

Seasonal tanks situated mostly near villages and more common in the dry zone of the country have been identified as resources which can be used for growing food fish. Low investment, in terms of inputs, that make possible culture of fish in these naturally occuring water bodies that retain water seasonally, make the endeavour attractive. It has been estimated that around 10,000 eligible tanks with a command area of about 100,000 ha is available in the country. The Aquaculture Development and Co-ordination programme of the FAO indicated possibility of raising 25,000 tons of fish annually from these productive eco-systems, through appropriate management. These water bodies constitute a major fishery resource and experimental studies under a programme of the Ministry has yielded encouraging and valuable results that would guide the future development of these resources. Productions between 500—1,000 kg/ha. were recorded in a number of instances by culture of Tilapia and carps, in about 7—8 months.

The Asian Development Bank is financing a 6 year project of fish production mainly from the seasonal tanks. 20 million carp fingerlings will be raised in fish seed production facilities and 10,000 hectares of seasonal tanks will be prepared and stocked, yielding around 7,500 tonnes of fish, mainly carps. The Canadian International Development Agency (CIDA) is funding the establishment of a modern aquaculture facility in the Maduru Oya area to raise fingerlings for stocking of reservoirs and also development of fish culture through efforts of fish farmers in the Mahaweli Area.

Fish culture in ponds

Despite the favourable ecological conditions for growing fish in ponds, this method of raising fish has no history in Sri Lanka, unlike the age-old tried systems in many of the neighbouring countries of South and South-East Asia. To popularize this among people including small land holders, the Ministry introduced a pond subsidy scheme in 1980 under which pond construction efforts are assisted by the grant of cash subsidy. This is restricted to Rs. 10,000 for a pond of 2 acres in area, being less for ponds of smaller size. The Ministry also provides the fingerlings needed for stocking the ponds, in addition to pond site selection and imparting the fish culture know-how which is the scientific polyculture system. To create awareness of the scope of pond fish culture the Ministry produced a colour film and this was released for exhibition in 1982. Consequent to these promotional drives there has been considerable response, particularly in the Estate areas and people are taking to pond fish culture. Under this programme for fish culture water area created is about 475 acres till 1983, made up of 1575 number of culture units. Fish productions as high as at 1,000—2,000 kg/ha. have been raised in less than a year in a number of ponds through culture of tilapia and carps. To reduce cost but increase production pond fish culture is being integrated with poultry raising in which the bird excreta and other poultry shed washings serve to fertilize the fish pond and provide fish food organisms to the growing fish. Poultry shed construction is also partly subsidized by the Ministry. In an experimental study conducted in a pond of a fish farm of the Ministry fish production at over 4,000 kg/ha.

in 6½ months was obtained by fish polyculture being intergrated with duck raising.

Fish culture in paddy land, not used for rice cultivation, can give better financial returns than paddy and as such this can be recommended where such lands are not being actually made use of for growing rice.

Brackishwater Fish Culture

Despite the considerable potential with regard to this kind of aquaculture, coastal and brackishwater farming is not developed in Sri Lanka. Milkfish fry resources are sufficient to support commercial farming operations. The areas of fry availability, the seasons of abundance, method of collection and transport of the seed from the coastal areas to fish culture stations of the Ministry have been developed. In the recent past experimental trials to culture milkfish in brackishwater ponds have resulted in yields of over 1 tonne/ha. in 5 months. This augurs well for the development of this type of farming and is to be extended among fish farmers. Culture of milkfish singly or along with shrimps could be tried in brackishwater ponds.

The recent success achieved by the Ministry in breeding the giant freshwater prawn, *Macrobrachium rosenbergii*, under limited field facilities has opened up the possibility of raising seed of this commercial species for culture along with fin fish in ponds.

Availability of commercial species of shrimps, *Penaeus indicus, Penaeus monodon*. etc., in Sri Lanka has prompted private enterprise, involving foreign capital and expertise participation, to undertake the culture of shrimp on commercial scale. A modern shrimp hatchery in the Negombo area is nearing completion and over 1,000 acres is expected to be brought under cultivation shortly. The ADB's Aquaculture Development Programme for Sri Lanka has also a brackishwater component which includes establishing a shrimp hatchery, 50 ha. of demonstration ponds and pens and providing credit for development of about 200 ha. of commercial small-holder ponds.

New systems of fish culture

Culture of fish in cages is practised in many countries of South-East Asia and also in the West. The method makes possible raising of fish through individual effort in public waters, the ease of harvesting being particular incentive for such method of intensive farming. In Sri Lanka the Nile Tilapia was raised by culture in cages, in experimental studies, made of bamboo and nylon netting, fixed in reservoirs. The fish were fed with pelleted feed made from locally available low cost ingredients at the Ministry's Fish Feed and Nutrition Plant. Production at the end of six months were found to be around 60 kg per cu.m. of cage space used. The research project is funded by the International Development Research Centre (IDRC), Canada. Culture of the milkfish in bamboo made pens (enclosures) in coastal lagoons also under trial is another aspect of the research programme.

A pilot plant to fillet fish, mostly tilapias from reservoirs, has been set up by the Ministry at Minneriya with assistance from NARA. Apart from fish fillets, fish sausages and pastes are also being made. The products are marketed through Ceylon Fisheries Corporation retail outlets.

Fish culture stations

Thirteen freshwater fisheries stations and two brackishwater stations under the Ministry are engaged in raising seed fish that are required for freshwater and brackishwater aquaculture. Except the milkfish the seed of which is collected from coastal areas, the freshwater species i.e. the Chinese bighead carp, silver carp and grass carp and the common carp and the Indian carps rohu and mrigal (Catla recently bred) are bred at the fish culture stations and the fingerlings raised to stockable sizes and are then distributed for stocking reservoirs (large and medium tanks), seasonal village tanks and private fish ponds. The Chinese Silver carp and the Indian Major carps, rohu, mrigal and catla, reputed for their fast growth and high fecundity have been imported in recent years. Sometime earlier to this the Chinese grass carp and bighead carp also known for similar fish culture value had been imported. These valuable addition of exotic fish would help to develop scientific polyculture systems resulting in high fish yields. The milkfish fry collected from the North-western area are reared in ponds of the brackishwater fish culture stations to fingerlings before being supplied to private pond owners and for stocking community managed seasonal tanks. Apart from production of seed of culturable fish varieties the aquaculturists of the fish culture stations are engaged in research studies, related to culture of fish, fish diseases, fish feeds and feeding. The facilities at the stations have been considerably expanded in recent years and more scientific staff added to cope up with the increased work. An entirely new station which is a modern fish farming facility has been set up at Dambulla Oya in the Mahaweli 'H' area. Training programmes at national and international levels have been arranged for personnel of the Inland Fisheries Division.

International assistance in the aquaculture development programmes of Sri Lanka have come from the FAO/UNDP and UNICEF of the United Nations, the Asian Development Bank, the Canadian International Development Agency, the Governments of India, China, and Japan, the International Development Research Centre, Canada and the USAID Programme (shrimp culture).

Conclusion

Aquaculture is coming of age in Sri Lanka. The recent efforts and achievements and the future plans in inland fisheries makes one hopeful of significant augmentation of fish production in this sector.* Improvements in the reservoir fisheries, well managed seasonal tanks programmes through application of scientific fish culture methods, improved aqua-farming in freshwater and brackishwater ponds utilising more water areas and the integration of these efforts with poultry raising all lead to higher fish yields. The message of farming spread through extension officers and the practice of scientific aquaculture made possible through involvement of trained manpower would make possible realisation of our goal of a prosperous fish farming community contributing to upliftment of nutritional standards and the national economy.

*The Second Fisheries Master Plan, now being finalised for the period 1984—88 envisages a production of 64,000 tons from the inland fisheries sector *i.e.* about 20% of the targetted total fish production by 1988.

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FISHERIES DEVELOPMENT IN THE MAHAWELI RESERVOIR SYSTEMS

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and

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1. Introduction

Sri Lanka has about 140,000 ha. of "major, medium and minor" reservoirs and tanks, at present. Most of these except Senanayake Samudraya and the hill country reservoirs are not "high dams" but "tanks". However, the Mahaweli System will have the real "high dams" and the area of water spread in the accelerated Mahaweli System is expected to be over 20,000 ha. Developing the fisheries of these new reservoirs will be integrated into a System of River Basin Development — as in the TVA (U.S.A.), Delaware (U.S.A.), DVC (India), Mekong (Indo-China), etc. It is to be stressed that fisheries development is non-consumptive use of water as opposed to agriculture or animal husbandry. Protein supply is still deficient in the hinter lands, away from the sea and in rural areas and supply of fresh fish from reservoirs will raise the protein nutrition of the rural population, while providing income and occupation for inland fishermen. Reservoir fishing can become a full time occupation. Fisheries development in the Mahaweli System will be a tool for exploiting a resource which is untapped and which is non-consumptive use of the waters.

The Ministry of Fisheries have initiated advance action to develop the fisheries of the Mahaweli System. This is also beneficial to the fisheries because of its potential to produce fingerlings. Sizable quantity of fish could be produced by stocking the water bodies in the system. The additional fish production will provide the required animal protein for the colonists. The possible benefits are indicated elsewhere in this paper.

2.0 Freshwater Resources of Sri Lanka

It has been estimated (Thayaparan, 1982; Mendis, 1977) that there are 139, 271 ha. of freshwater bodies classified as follows:—

Major Irrigation Reservoirs	70,850	139, 271 ha.
Medium Scale Tanks	17,004	
Minor Irrigation Tanks	39,271	
Villus (Flood Plains)	4,049	
Upland Reservoirs	8,097	
Mahaweli System (expected)	22,670	
Total :	161,941 ha.	

It was indicated that the 'potential yield' from the 139, 271 ha. would be about 39,000t. (i.e. approx. 250 kg./ha.) Future development would take place in medium tanks and minor tanks connected to the new Mahaweli Reservoirs. This is possible through proper stocking and management. At present, it is not possible to quantify the yield from these, since limnological and productivity data are yet to be obtained. But a fair estimate based on previous experience could be attempted.

3.0 Location and Morphometry of the Reservoirs (See Figs. 1–5)

The "Big Five" of the Accelerated Mahaweli Project are Maduru Oya, Randenigala, Ulhitiya, Victoria and Kotmale (Moragahakanda is under consideration). Among them, Maduru Oya has already been completed and Victoria Dam is just being completed, while Ulhitiya was completed earlier by local engineers. Details of these are furnished in Table I.

In the near future other reservoirs like Moragahakanda, Rantembe, etc., are likely to come up and these will be part of the

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System and developed as such. Fisheries development in connected System, for e.g. System "B", "C" and "H" will be discussed seperately.

4.0 Strategies for the development of AMD Reservoirs

4.1 Pre-impoundment studies

Limnological studies have not been carried out on the reservoirs at the time of impounding but such studies are planned for the immediate future. As far as the fish fauna is concerned no major species of commercial importance is known to occur in the system. Fernando and Indrasena (1968) have listed a few species utilised as food fish but most of these are minnows and minor barbs. *Puntius sarana, Labeo dussumieri, Tor khudree, Wallago attu, Ophiocephalus striatus, O. marulius* and the estuarine cichlid *Etroplus suratensis* are the more desirable among the species, but their contribution as a major fishery is negligible. There is a moderate diversity of species but quantitatively of not much significance.

It is therefore imperative that new introductions are made into this system.

4.2 Water flow regime of the System

Though Maduru Oya has been completed first, it is the tail end reservoir of the AMD System. Kotmale Reservoir is at the top of the system from which water is conveyed to Victoria Reservoir through Polgolla (which is already existing). Victoria Reservoir will be sealed soon though Kotmale is not yet impounded. From Victoria, water is led into Randenigala, from where the water flows to Ulhitiya reservoir via the Minipe diversion wier, and into Rathkinda and later on through a tunnel to Maduru Oya. But the latter has its own catchment also. In the descending order the total dissolved salts and nutrients will increase from Kotmale to Maduru Oya. So also the temperature. It is expected that the water temperature of even Kotmale Reservoir will be suitable for tropical species. A one time estimation of conductivity (which indirectly measure total dissolved salts) indicates the following values :—

> Kotamale 33; Victoria 60; Randenigala 95; Ulhitiya 107; Maduru Oya 138; (μmhos/cm.) — the last nearly similar to Kalawewa.

Except Kotmale, Randenigala and Victoria the other reservoirs are expected to be moderate to high productive. The basic mineral in Kotmale being 'cavernous limestone', the water will be non-acidic.

Though two major reservoirs viz. Ulhitiya and Maduru Oya are filled by water through tunnels, they also have their own catchment and supply through Ulhitiya Oya and Maduru Oya respectively. This provides scope for potamodramous species to ascend the rivers to top waters for breeding purposes. This has to be watched and confirmed. The shape of reservoirs with many bays provides a large littoral area, making them productive (high "Shoreline development").

4.3 Stocking programme :

Reservoir fisheries could be developed on the principle of 'ranching' — stocking and harvesting. In as much as there is no indigenous or endemic species of high commercial value in Sri Lanka, stocking assumes great importance. Stocking is the major input in the development of reservoir fisheries. It remains the only successful means of maximizing fish production in reservoirs (Baluyut, 1982; Jenkins, 1961). This has been stressed by Sreenivasan (1984). While stocking, the population changes likely to occur have to be taken into account (Petr 1967; Sreenivasan, 1976). The criteria for selection of species have been enumerated by Sreenivasan (1982, 1984).

There is no doubt that Tilapia did serve the purpose of providing an increasingly large poundage of animal protein in the shallow man-made lakes of Sri Lanka. However, multi species fishery is desirable. The new Mahaweli Reservoirs are quite deep and cannot be compared with the shallow ancient tanks like Parakrama Samudra whose flow through rate is not high. Being a downstream migrant *T. mossambica* (*Sarotherodon / Oreochromis*) *mossambicus*), has been able to drift downstream and establish itself in the newer reservoirs too — for e.g. Ulhitiya, Maduru Oya, etc. For fuller utilization of food materials in the new reservoirs, other species also should be introduced.

The Indian and Chinese carps, would be the candidates for stocking the Mahaweli reservoirs. Indian carps are very easy to breed by estrualization and the Chinese carps have also been successfully spawned in Sri Lanka. A very notable feature has been the breeding of Rohu and Mrigal in the very first year of their maturity after rearing them from fry stage to breeder stage in Sri Lanka. Such ease of breeding and the high fecundity make them ideal for stocking reservoirs which need millions of fingerlings for planting. By the hormone breeding technique, the required numbers can be easily obtained. Rohu has been introduced into Thailand and the Philippines where it is reported to be doing well (Bhukaswan, 1980; Balayut 1983 and Pantulu, 1980). Zhiwan Song (1980) has shown that Mrigal is as good as the Silver carp and Bighead carp in growth. A very significant observation made in a few newer and old reservoirs of Sri Lanka is that Rohu stocked in them in modest numbers, started appearing in commercial catches within six months. The Chinese Bighead carp has also grown well in Sri Lanka reservoirs. In Maduru Oya it has started appearing in the commercial catches within five months of stocking and in reservoirs stocked earlier it has grown to big sizes. Its likelihood in breeding naturally in the reservoirs is however negligible. The Crucian carp or the English carp *Canassius vulgaris* would be suitable for the upland waters like Victoria, Kotmale, etc. *Etroplus suratensis* could be introduced into the reservoirs where it is likely to establish itself. The Milkfish **Chanos** which is available in plenty and which has not been utilized fully could be tried in some reservoirs where algal populations persist. It cannot breed in freshwaters and annual stocking is needed. So far there is no information about the commercial success of milk fish in reservoirs. However, a few of this species have been recovered from one or two reservoirs. Already the major indigenous species, *Labeo dussumieri* has been introduced into Maduru Oya.

It is essential to establish adequate breeding populations in reservoirs. In reservoirs like Ulhitiya and Maduru Oya, the original river systems still bring in flood waters in addition to the supply through tunnels. The breeding season and flood season coinciding, the major carps may breed in these reservoirs. Stocking would be justified if there is adequate recapture to make it profitable. The comparatively deep reservoirs in Sri Lanka are Kotmale, Randenigala and Victoria. Reservoirs deeper than these have been successfully stocked with Indian carps, Silver carp and Common carp with satisfactory results (Sreenivasan, 1984). A suggestion was made that *T. galilae* may be stocked in the deep Mahaweli reservoirs but after due experimentation. Common carp of large sizes have been caught in many Sri Lankan waters either downstreams or in connected shallow tanks. Hence stocking Common carp will benefit the fishery of the system. Grass carp is not likely to be of much use in the reservoirs where submerged vegetation is not likely to be present. It is also reported to be a carrier of diseases (Rosenthal, 1976).

While introducing new species, preference should be for species thriving in similar agroclimatic conditions or geographically proximal areas.

4.4 Conservation and Exploitation :

After stocking, the next important aspect in reservoir fisheries development is conservation. The fish that has been planted must be allowed to grow to a marketable size, before being caught. Knowledge of the biology of the species will enable us to prescribe the size at capture, which can be implemented by regulating the mesh size of the nets to be used in exploitation.

In some countries after a reservoir is filled, commercial fishing commences only after two or three years to enable the stocked fish to grow, attain maturity, breed and repopulate the waters where possible. Declaring certain areas as 'fish sanctuaries' (closed for fishing), prescribing a 'closed season' (breeding season), prohibiting destructive methods of fishing, regulating fishing effort are other essential means of conservancy aspects of reservoir fisheries management. Exploitation should be based on productivity, standing crop, recruitment, predator and trash fish removal and not the least important, economic yield. The maximum number of fishing units should be fixed on the basis of optimum (sustained) catch per unit, total yields and desirable size at capture. Conserving the indigenous species has to be kept in mind, when a reservoir is planned. Some local hillstream species, for e.g. *Labeo fischerei*, are likely to become 'endangered'. It should be possible to save them by breeding and stocking the streams. The mahseer (*Tor khudree*) is an economic food fish, which is also likely to be affected adversely by the construction of dams. Some of the fish breeding stations are taking up the task of breeding them in ponds for subsequent restoration in their native streams and rivers.

4.5 New Systems of fish culture in Reservoirs:

In addition to developing the capture fisheries or ranching, fish production could be enhanced by simultaneous adoption of culture methods. Cage culture would be suitable for exploiting the space in deep reservoirs. Currently, experiments are under way in Sri Lanka in the cage culture of *T. nilotica*. Attempts to culture in cages, species that show low survival must be made. For e.g. if net cage culture is found suitable for Chanos, Common carp, etc., it would throw open a vast potential for obtaining high catches from reservoirs. Seasonality in abundance of catches (as in capture fisheries) could be obviated and a sustained steady market could be secured for the fish.

Running water fish culture is another area requiring serious consideration. Since many canals and distributories are coming up in the Mahaweli System, fish culture could be practised in them. Stocking may be needed here. However, this would depend on the duration of water flow in the canals.

Where drastic draw-downs do not occur, pen culture, both for fry rearing and for table fish could be initiated. This would be most useful especially to raise stocking materials.

4.6 Clearing of Reservoir Beds :

Different opinions on the subject were discussed by Sreenivasan (1982). A definite view on the nature and extent of tree clearance has not crystallized because no specific study has been made and only *ad hoc* opinions have been expressed on the basis of post-factum observations. However, there is unanimity regarding the obstructional role of submerged tree stumps in fishing. Therefore, during the construction of the new Mahaweli Reservoirs, submerged trees have been partially removed.

4.7 Possibilities for fish culture as an alternative to paddy cultivation :

Chakrabarty *et. al.*, (unpub. 1983) have indicated that it is more profitable to culture fish in ponds than growing paddy in equal area. Rice fish culture is not likely to make much of an impact on fish yields but pond culture will give high yields of 5,000 kg/ha. (Chakrabarty *et. al.*, 1983 unpubl.). The Committee which examined this problem suggested that ½ acre out of the 3 acres to be allotted to new colonists, could be used for pisciculture and that the net benefit would be Rs. 5,000/- from the ½ acre pond as against Rs. 752/- from an equal area of land under paddy.

It is recommended that out of about 30,000 ha. under System 'B', at least 1/10th be utilized for pond fish culture and at a conservative estimate of 3,000 kg/ha., this 3,000 ha. would yield 9,000 tonnes of fish, generating an income of Rs. 90 million. This is part of the benefits of developing the fishery in the Mahaweli System.

5. Development of Fisheries in Systems B, C and H (Figs. 2—3)

System 'B' :

Maduru Oya is the largest man-made Lake in this System and at present the second largest in Sri Lanka. At present there is predominantly *Tilapia* fishery which has resulted from the escapement of this species from upstream reservoirs. Being the down stream reservoir, it has the advantage of having higher dissolved salts and nutrient status as well as the auto-stocking by upstream fishes. In such a large reservoir all the trophic niches must be utilized, which warrants regular stocking. At a modest rate of 250 fingerlings/ha., 1.57 million fingerlings are needed. A large fish breeding cum rearing centre could be established in this System. With a water supply all round the year, breeding activities could be carried out round the year. Catla, Rohu, Mrigal, as well as the Chinese carps could be spawned and reared in this Station. A whole complex of breeding ponds (with shower-spray arrangements, hatching units, rearing ponds, broodstock pond etc.) can be accommodated. A total water spread of about 20 to 25 ha. could be set apart for this. A conservative estimate of 5 million fingerlings could be raised here and with experience, this could be doubled. A major part of the freshwaters of Sri Lanka could be stocked from this proposed Maduru Oya Complex. Other important older reservoirs in this System are —Pimburettawa, Vakkaneri and Aralaganwila. These reservoirs have a high dissolved salts content (conductivity of 180—400μ mho/cm, hardness of 50—80 p.p.m). and are fairly productive. The fish yield from the above is expected to be 500, 350 and 50 t. respectively while Maduru Oya may yield about 900 t. a year. Taking into account smaller tanks like Dalikanawewa, Ambalankulam, Mahawewa, Ellawewa etc., and another 50 seasonal village tanks, the total output from System 'B' would be at least 2,000 t. valued at Rs. 20 million.

System 'C' :

The fingerlings required to stock these waters is about of 1.5 million. The European Economic Community had indicated interest in funding a small fish breeding station at Giranduru Kotte. This will be adequate to stock all types of waters in System 'C' and neighbouring areas too.

There are about 5,600 ha. of large and medium water bodies which are expected to yield about 1,380 t. of fish on full development.

The monetary value of the fish produced in this System would be about Rs. 13.8 million (at Rs. 10 per kilo).

System 'H' :

The water resources of this System are well documented. The large and medium tanks account for 6,804 ha. while the smaller village tanks account for 1,012 ha. At 200 kg/ha. in large tanks and 1,000 kg/ha. in village tanks the yield would be about 1,360 t. and 1,000 t. respectively, valued at Rs. 23.0 million.

Since, in two to three years, adequate fingerling supply (the major essential input) will be available to all the three systems enumerated above, the expected fish production may even be exceeded. Stocking, conservation and management are the key factors in developing the fisheries. In System 'H', strengthening Dambulla Fish Breeding Station will produce additional supply of fingerlings of major Indian carps and Chinese carps. Success has already been achieved with Indian carps, which have been bred, reared, stocked and recaptured.

The more important among the reservoirs and tanks in System 'H' are Kalawewa-Balaluwewa, Kandalama, Dambulla Oya, Mahailluppallama, Kattiyawa, Usgalasiyambalawa, Rajangana, Angamuwa etc.

Sketchy accounts of water quality of Kalawewa — Balaluwewa are available (Gunawardana *et. al.*, 1981). The parameters are Bicarbonates 1.19 — 2.49 m. vall Calcium 0.19 — 0.36; Magnesium 0.10—0.29; P_2O_5 8.38 to 15.72 p.p.m. TDS, 300 p.p.m. The pH value was 7.2 to 8.2. The high phosphate is noteworthy.

6. Fish Seed Farms in Reservoir Sites

It is an accepted principle that stocking source should be as close to the waters being stocked, as possible. This would reduce the mortality in transport and obviate the need to acclimatize the fingerlings before planting in the reservoirs. As far as possible a few of the larger reservoirs could have fish breeding and rearing station below the dam. Fish could be bred here by hypophysation, reared to appropriate size and stocked in the reservoir. By this, the stocking cost could be kept to the minimum. Hatcheries established at reservoir sites would supply all the fingerlings needed for stocking the reservoir, and in addition have surplus to stock other waters too. Fingerlings could also be reared in net cages in reservoirs. Since Sri Lanka has a good transport system, the fingerlings could be sent to receiving stations with ease — a few large breeding stations like Maduru Oya, Kalawewa, Dambulla etc., will be able to produce fingerlings for stocking other reservoirs — large and small.

7. Limnological Studies

Limnological studies are the key to the development of reservoir fisheries. The entire ecological spectrum of reservoirs has to be studied to evaluate the productivity. The assortment of planktonic and benthic organisms in the littoral as well as limnetic regions have to be evaluated. This will guide us in the stocking programmes. The thermal features, oxygen regime, nutrient cycling, organic inputs, primary production, dissolved solids, pH, etc., have to be monitored at regular intervals to determine seasonal variations, vertical stratification and diurnal variations. It would be very useful to work out the ecological energetics also. If adequate data is obtained, modelling could be attempted. The reservoirs that would need immediate attention are — Maduru Oya, Victoria, Dambulla Oya, Pimburettawa, etc. The little data available on a few of the pre-impounded streams is given in Table II.

8. Exploitation

In Sri Lanka, because of the proliferation of **Tilapia,** even new reservoirs (for e.g.. Ulhitiya, Maduru Oya, etc.) get populated by these species and fishermen immediately start fishing since these fish are available. Hence management measures like fishing holiday etc., are not relevant to these reservoirs. Capture of species like Common carp, Bighead carp, etc., in some reservoirs is reported to be difficult. Gill nets ('Rangoon nets' and 'Uduvalais') are operated in deeper reservoirs in India (Ranganathan and Venkataswami, 1962) successfully. If necessary it would be expedient to suitably modify the gill nets for the capture of Common carp and Bighead carp. The number of fishing units to be operated in a reservoir should be fixed with reference to the area of water spread, the standing stock of fish and the economic price for the fish.

9. Marketing

The profitability of reservoir fisheries depends on successful marketing. As producer, the fishermen would expect a reasonable price for his catch. The fishermen must organize a marketing co-operative, pool their catches and sell it through this Institution. Elimination of middlemen will naturally help the consumer also in getting fish at cheaper prices. It should provide for transporting fish over long distances. Transport such as three wheelers or small trucks must be made available to take the landed fish expeditiously to the markets, Drying of fish results in denaturation and reduced nutritive value. Hence, fish must be sold fresh to provide better nutrition to consumers. After selling the fish to the local population, the surplus may be taken to larger towns and cities. In the case of seasonal tanks, the fishing will be confined to a shorter period of one or two months only and it is in this sphere that proper arrangements are needed to market the fish in good condition and at remunerative prices.

10. Water Regulation

Sudden closure of sluices may lead to the fish below the dam getting stranded in pools and mortality may ensue or the fishes may be poached. These stranded fish must be 'rescued' and re-stocked in the reservoir or used to raise brood stock in the ponds. Reservoirs should have a 'dead storage' (or minimum conservation pool) so that the resident fish will have adequate living space till the reservoir again fills up. This will also provide water-supply to the fish farms sited below the dam.

11. Programme for the Development of Freshwater Fisheries

In order to raise the output of freshwater fish various programmes have been drawn up and these are expected to raise the present production, to about 64,000 t. by 1988. Under the U.N.D.P. Project for the development of seasonal tanks, a survey of these tanks was undertaken and after identifying suitable tanks for short term fish culture, they are being stocked with fingerlings of various species under a system of polyculture. The fingerlings of Chinese carps and Indian carps are produced on an increasing sacle in some of the breeding station which are already engaged in the production of *T. nilotica* and Common carp. There are 11 Freshwater Fish Breeding Stations at Muruthawela, Rambodagalla, Udawalawe Padaviya, Ginigathena, Inginiyagala, Panapitiya, Nuwara Eliya, Polonnaruwa, Beragala and Dambulla.

Among these the latest one at Dambulla is financed by MASL/UNICEF and it has a modern hatchery. The UNDP Project at Udawalawe is also involved in training programmes in freshwater fisheries for aquaculturists, fishery inspectors, extension officers, fish culturists, administrators, Bank officials, estate officers and others. The ADB project now initiated would be undertaking the major task of developing inland fisheries further by setting up hatcheries and rearing stations (to produce over 20 million fingerlings), organizing an Institute for training all types of personnel in Inland Fisheries Programmes and in stocking and developing fish culture in seasonal tanks. The project will also be involved in brackish-water fisheries A Canadian aided (CIDA) Project is also envisaged for the development of System 'B' with a large breeding and rearing complex near Maduru Oya. Programmes for the development of fisheires in this system when implemented through these two projects would supply most of the stocking material needed and lead to a fuller development of freshwater fisheries of Sri Lanka. This would be reflected in the reservoir fisheries. For example, the fingerlings of Indian carps stocked in certain reservoirs like Udawalawe, Kandalama, Tabbowa, Unnichchai etc., showed up in the catches in less than six months.

12. Conclusion

A phased development of fisheries in the Mahaweli Reservoir System will provide additional food fish for the people and also supply the stocking material for the entire country. Smaller reservoirs, seasonal tanks, and village ponds connected to the Mahaweli System will provide much more fish than the main reservoirs, by adopting intensive culture techniques. All these development measures are bound to create a big impact on domestic fish supplies and go a long way towards achieving self-sufficiency in Sri Lanka.

13. Acknowledgement

Our thanks are due to the Ministry of Mahaweli Development for the maps included in this paper which were obtained from various publications of the organizations under that Ministry.

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TABLE I

Morphometric feature of AMD Reservoirs

Name	*Maduru Oya*	*Ulhitiya/ Rathkinda*	*Victoria*	*Randenigala*	*Kotmale*
1. Name of River on which dam is built/source of supply	Maduru Oya + Ambanganga/ Mahaweli	Minipe R. B.Canal Ulhitiya Oya	Mahaweli and Hula Ganga	Mahaweli	Kotmale Oya
2. Area at FSL(ha)	6280	2270	2270	2750	970
3. Volume at FSL millions m^3	596·6	146	730	860	174
4. Catchment area (sq. km.)	453	653	1869	233·3	210
5. Maximum depth (m)	21	6·1	30·4	31·27	42·1
6. Elevation above sea level (m)	+96·0	—	+438	—	+703
7. Mean depth (m)	9·5	6·43	32·2	31·3	17·9

TABLE — II

Hydrobiological parameters of Rivers/Streams that are being impounded

Parameters	*Mahaweli(a) Ganga*	*Nuwara(a) Eliya Maskeliya*	*Streams or Rivers*		*Amban Ganga*
			Kotmale Oya (b)	*Victoria dam site(b)*	
Elevation above sea (m)	2000	1000—1500	750	500	—
Temperature °C	15·3	15·3—20·8	—	—	—
pH	5·8	5·4—6·8	7·0	6·8	7·4
Oxygen absored ppm	17·3	9·2—28·8	—	—	—
Alkalinity m.va l/L	0·25	0·05—0·20	—	0·61	0·98
NO_3 — ppm.	0·07	0·045	—	—	—
P_2O_5 — ppm.	0·02	0·0—0·17	—	—	—
SiO_2 — ppm.	13·3	1·98—3·12	—	—	—
CaO. — ppm.	1·94	2·58	0·23	0·35	20·8
MgO — ppm.	1·64	1·70	0·06	—	3·36
Cl — ppm.	2·55	2·69	0·20	—	—
Conductivity µmho/cm.	26·3	8 — 25	33	60	169
Total Hardness (German)	0·65	0·08 — 0·45	1·05	—	—

(*a*) Weninger (1972)

(*b*) TAMS Report (1981)

TABLE II A

Expected production from the major AMD Reservoirs

Name of Reservoir	*Year of Sealing*	*Year of Stocking*	*Year of Breeding*	*Year Exploitation*	*Area at FSL(ha)*
Madurua Oya ...	1983	1983	1985	1984	6280
Victoria	1984	1984	?	1987	2270
Kotmale	1985	1985	?	1988	970
Randenigala	1986	1986	?	1989	2750
Ulhitiya	1982	1983	1985	1984	2270

TABLE II B : **Morphometric features and anticipated fish yields**

Reservoir	*(C) Catchment Area (ha)*	*(A) Area of water spread (ha)*	*(V) Capacity* $x10^6 m^3$	*C/A*	*V/A*	*Expected Production kg/ha.*	*(T) m. tons*
Kotmale	54,400	970	174	56	17·9	50	48·500
Victoria	187,000	2270	728	82	32·1	750	170·000
Maduru Oya	45,300	6280	467	7·2	7·4	150	942·000
Randenigala	233,300	2750	860	84·8	31·3	50	137·500
Ulhitiya/Rathkinda ...	28,000	2270	98	12·3	4·3	200	454·000
Moragahakanda ...	78,200	4050	686	19·3	16·9	150	607·50

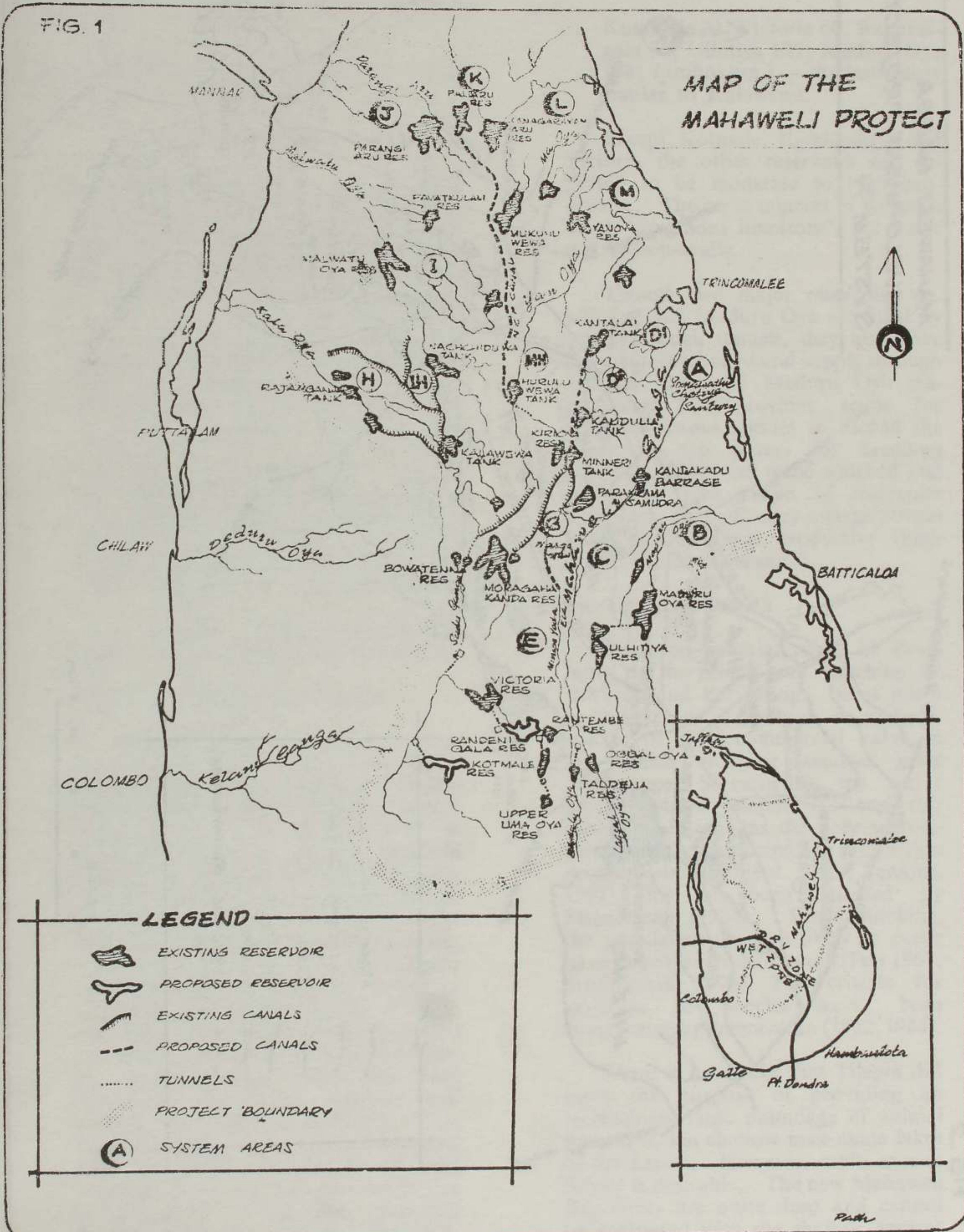
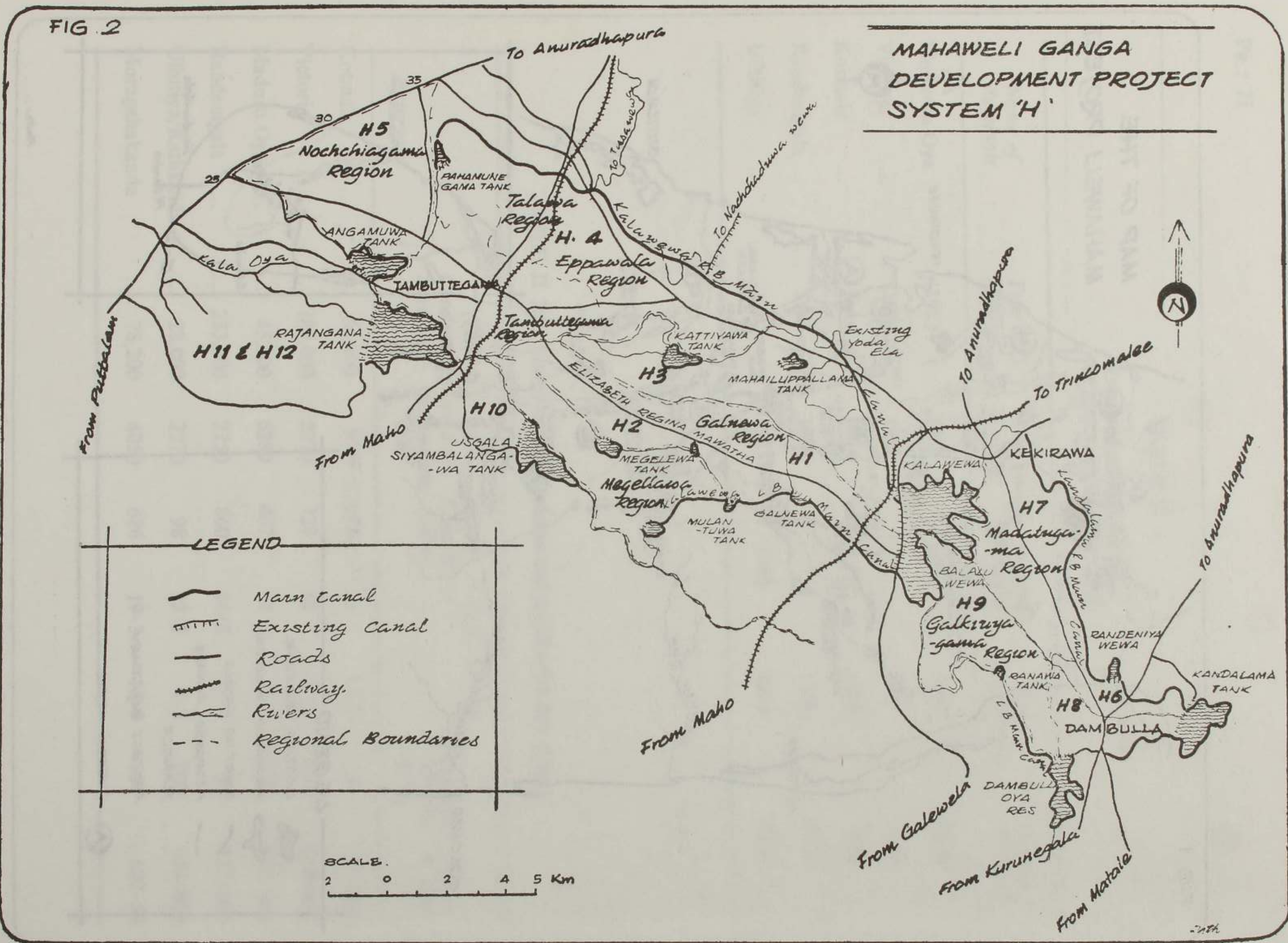


FIG. 1
MAP OF THE MAHAWELI PROJECT
MANNAR
PUTTALAM
CHILAW
COLOMBO
TRINCOMALEE
BATTICALOA
Deduru Oya
KANTALAI TANK
KAUDULLA TANK
MINNERI TANK
KANDAKADU BARRASE
BOWATENNA RES
MORAGAHA KANDA RES
MADURU OYA RES
ULHITIYA RES
VICTORIA RES
RANDENIGALA RES
RANTEMBE RES
KOTMALE RES
UPPER UMA OYA RES
TALDENA RES
KALAWEWA TANK
RAJANGANA TANK
HURULU WEWA TANK
YANOYA RES
MUKUNU WEWA RES
PARANGI ARU RES
MALWATU OYA RES
LEGEND
EXISTING RESERVOIR
PROPOSED RESERVOIR
EXISTING CANALS
PROPOSED CANALS
TUNNELS
PROJECT BOUNDARY
SYSTEM AREAS
Jaffna
Trincomalee
Colombo
Hambantota
Galle
Pt. Dondra
WET ZONE
DRY ZONE

FIG 2


MAHAWELI GANGA
DEVELOPMENT PROJECT
SYSTEM 'H'
To Anuradhapura
To Tissawewa
To Nachchaduwa wewa
To Anuradhapura
To Trincomalee
To Anuradhapura
From Puttalam
From Maho
From Maho
From Galewela
From Kurunegala
From Matale
H5
Nochchiagama Region
PAHANUNE GAMA TANK
Talawa Region
H. 4
Eppawala Region
ANGAMUWA TANK
Kala Oya
TAMBUTTEGAMA
Tambuttegama Region
RAJANGANA TANK
H11 & H12
Kalawewa R B Main
KATTIYAWA TANK
H3
MAHAILUPPALLAMA TANK
Existing Yoda Ela
ELIZABETH REGINA MAWATHA
H10
USGALA SIYAMBALANGA-WA TANK
H2
MEGELEWA TANK
Megelewa Region
Galnewa Region
H1
Kalawewa L B Main Canal
MULAN-TUWA TANK
GALNEWA TANK
KALAWEWA
KEKIRAWA
H7
Madatugama Region
Kandalama R B Main Canal
BALALU WEWA
H9
Galkiriyagama Region
RANDENIYA WEWA
RANAWA TANK
H8
H6
KANDALAMA TANK
DAMBULLA
L B Main Canal
DAMBULLA OYA RES
LEGEND
Main Canal
Existing Canal
Roads
Railway
Rivers
Regional Boundaries
SCALE
2
0
2
4
5 Km
35
30
25

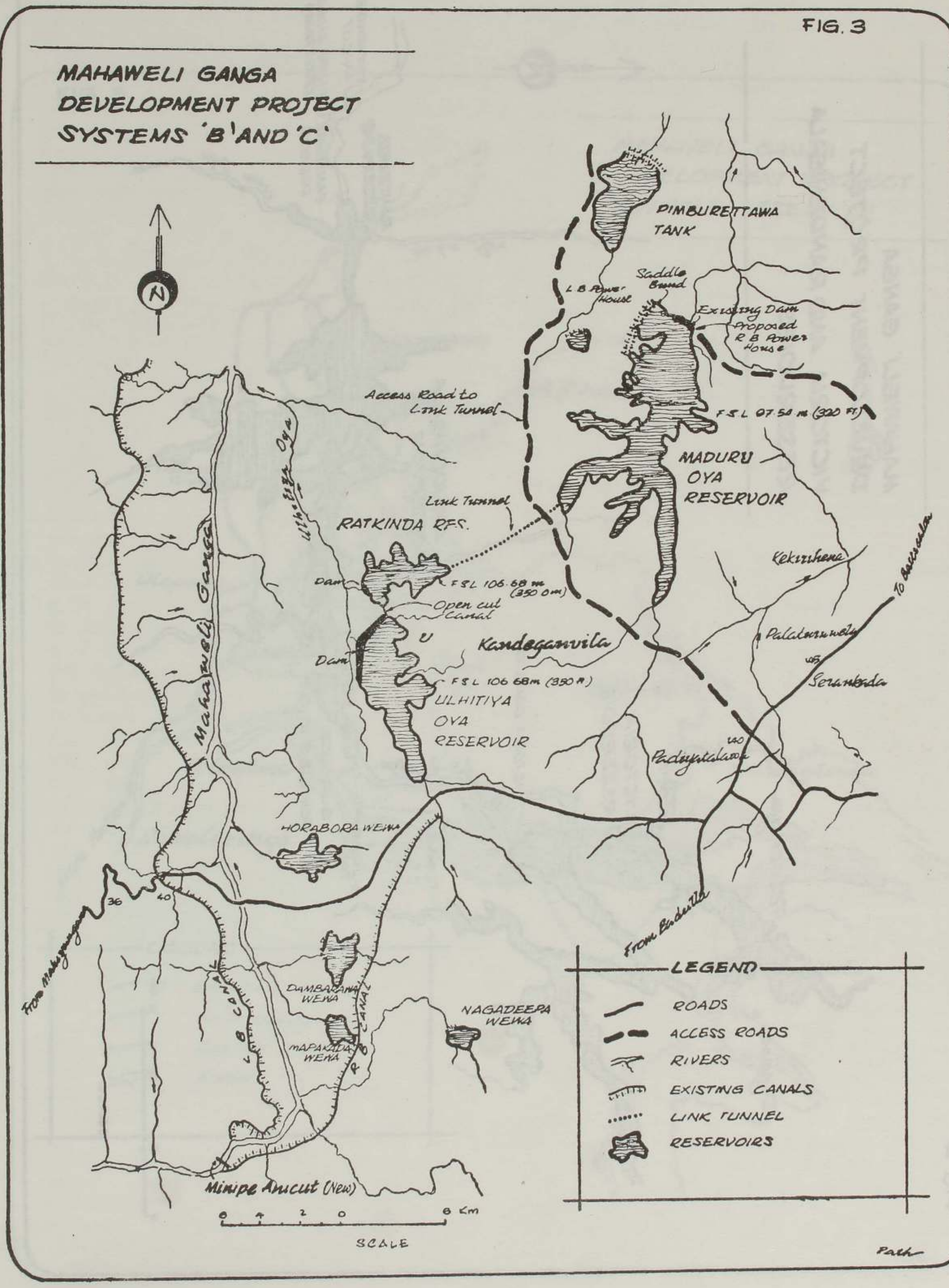
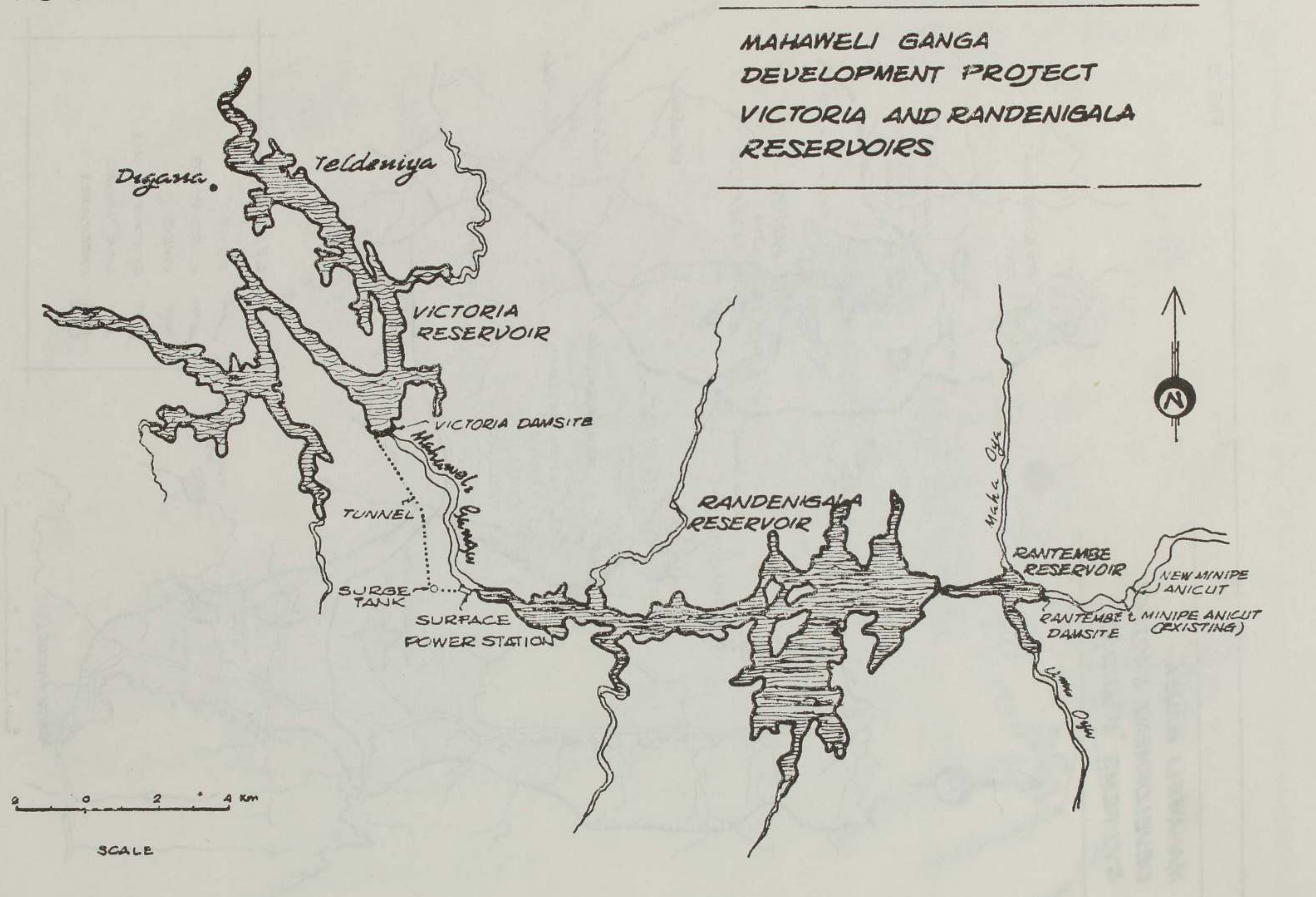


FIG. 3
MAHAWELI GANGA
DEVELOPMENT PROJECT
SYSTEMS 'B' AND 'C'
N
PIMBURETTAWA
TANK
Saddle Bund
L B Power House
Existing Dam
Proposed
R B Power House
Access Road to
Link Tunnel
F S L 97.54 m (320 Ft)
MADURU
OYA
RESERVOIR
Link Tunnel
RATKINDA RES.
Dam
F S L 106.68 m
(350 0 m)
Open cut
Canal
Kandeganvila
Dam
F S L 106.68m (350 ft)
ULHITIYA
OYA
RESERVOIR
Mahaweli Ganga
Kekirihena
To Batticaloa
Palatanuwela
Serankada
Padiyatalawa
140
HORABORA WEWA
36
40
From Mahiyangana
From Badulla
DAMBARAWA
WEWA
NAGADEEPA
WEWA
MAPAKADA
WEWA
L B CANAL
R B CANAL
Minipe Anicut (New)
0 4 2 0 8 Km
SCALE
LEGEND
ROADS
ACCESS ROADS
RIVERS
EXISTING CANALS
LINK TUNNEL
RESERVOIRS

FIG 4


MAHAWELI GANGA
DEVELOPMENT PROJECT
VICTORIA AND RANDENIGALA
RESERVOIRS
Digana
Teldeniya
VICTORIA
RESERVOIR
VICTORIA DAMSITE
Mahaweli Ganga
TUNNEL
SURGE TANK
SURFACE
POWER STATION
RANDENIGALA
RESERVOIR
Maha Oya
RANTEMBE
RESERVOIR
NEW MINIPE
ANICUT
RANTEMBE DAMSITE
MINIPE ANICUT (EXISTING)
Uma Oya
0
2
4 Km
SCALE

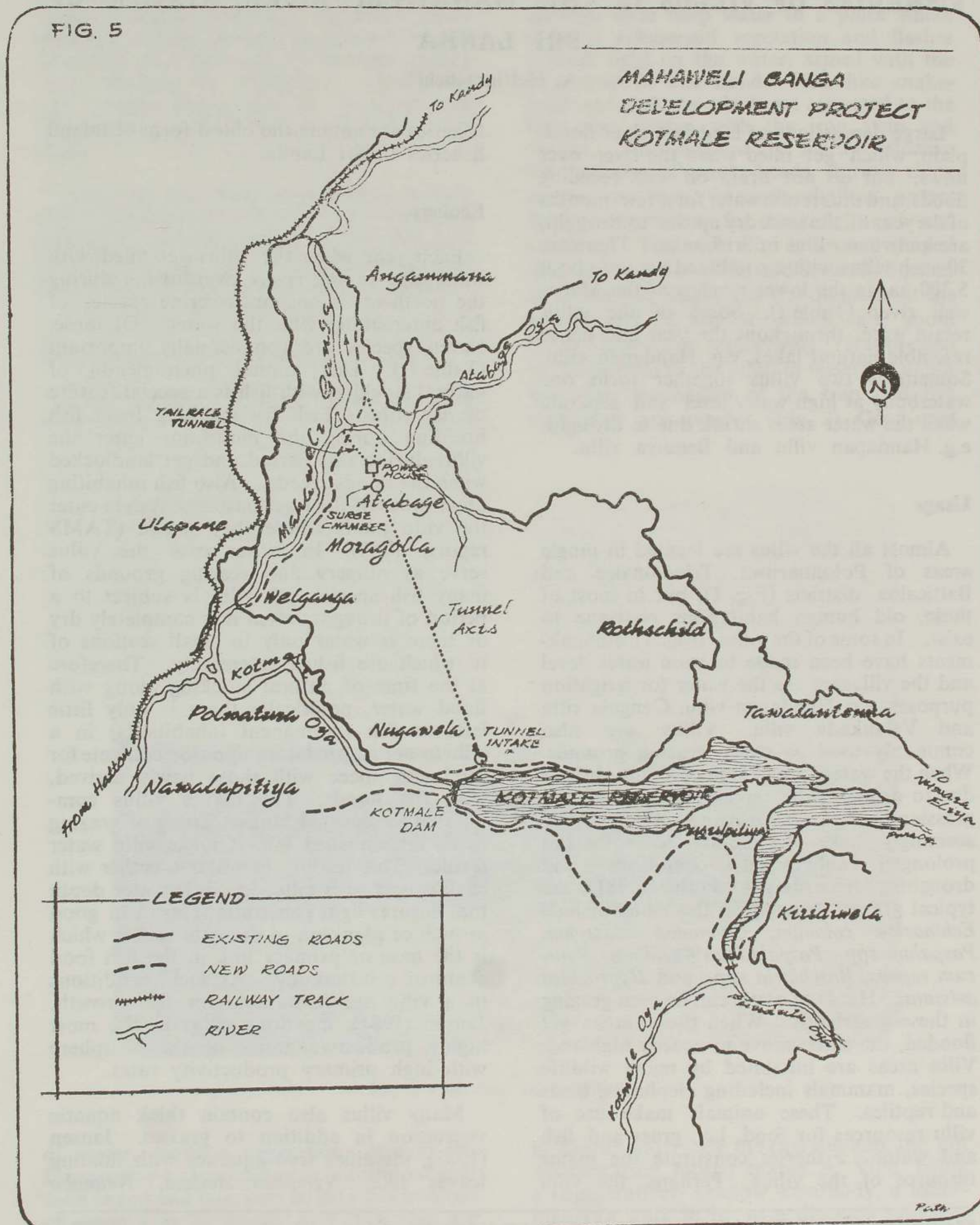


FIG. 5

4. இ.ஃ. 86189

J. Inland Fish., Vol. II, December, 1983, pp. 50—56.

FISHERIES OF VILLUS IN THE MAHAWELI RIVER SYSTEM OF SRI LANKA

A. Hettiarachchi*

Large depressions of land in a river flood-plain, which get filled when the river over flows, but do not drain off with receding floods, and thus retain water for a few months of the year till the same dry up due to drought, are known as villus in Sri Lanka. There are 30 such villus with a combined area of about 5,300 ha. in the lower reaches of the Mahaweli river (Table I). Some of the villus retain water throughout the year and hence resemble natural lakes, e.g. Handapan villu. Sometimes two villus together form one waterbody at high water level and separate when the water areas shrink due to drought, e.g. Handapan villu and Bendiya villu.

Usage

Almost all the villus are located in jungle areas of Polonnaruwa, Trincomalee and Batticaloa districts (Fig. 1), but in most of these, old human habitations continue to exist. In some of the villus, (Fig. 1), embankments have been made to raise water level and the villagers use the water for irrigation purposes, e.g. Handapan villu, Gengala villu and Velankadu villu. Villus are also commonly used as cattle grazing grounds. When the water spread area of a villu shrinks due to drought, the exposed area turns to a grassland. Grasses growing in the villus seemingly have the ability to withstand prolonged submerged conditions and droughts. According to Jansen (1981), the typical grasses growing in the villus include *Echinocloa colonum, Cyonodon dactylon, Paspalum* spp., *Paspaladium flavidium, Panicum repens, Brachiaria* spp., and *Hygrorhiza aristata*. Herds of cattle can be seen grazing in these grasslands. When these areas get flooded, the cattle move to nearby highland. Villu areas are inhabited by many wildlife species, mammals including elephants, birds and reptiles. These animals make use of villu resources for food, i.e., grass and fish and water. Fisheries constitute the major resource of the villus. Perhaps, the villu fisheries are among the oldest form of inland fisheries in Sri Lanka.

Ecology

Each year when the villus get filled with water due to the rivers overflowing during the north-east monsoon, riverine species of fish enter along with the water. Of these, eleven species are commercially important (Table II). This annual phenomenon of natural stocking with fish is a special feature of the villus. Fish fry resulting from fish breeding during the monsoons enter the villus during this period and get landlocked when the floods recede. Also fish inhabiting other areas of the river basin ecosystem enter the villu pools where they spawn (TAMS report, 1980). In either case the villus serve as nursery and rearing grounds of many fish species. A villu is subject to a period of drought, when it is completely dry or there is water only in small sections of it, which are fished extensively. Therefore at the time of natural stocking along with flood water, practically there is only little leftover fish (permanent inhabitants) in a villu to act as predators upon or compete for food and space with those newly arrived, with the floods. This makes villus comparable to seasonal tanks. Dung of grazing cattle etc., washed into it make villu water fertile. This fertility of water together with shallowness of a villu, i.e., low water depth that ensures light penetration, result in good growth of plankton in the villu water, which is the base or primary link in the fish food chain of a waterbody. As such, conditions in a villu are favourable for fish growth. Jansen (1981), mentions villus as the most highly productive zones of the biosphere with high primary productivity rates.

Many villus also contain thick aquatic vegetation in addition to grasses. Jansen (1981), identifies true aquatics with floating leaves like, *Nymphea stellata, Nelumbo*

*Freshwater Fish Breeding and Experimental Station, Polonnaruwa.

nucifera, Nymphoides spp., *Aponogeton natans* and *A. crispum*; submerged aquatics like *Ceratophyllum demersum* and *Hydrilla verticillata* and common floating plants like *Pistia stratoites, Salvinia molesta, Trapa bispinosa, Azolla pinnata, Neptunia oleracea, Spirodela polyrrhiza* and *Lemna* spp. among those forming the vegetation. During the dry season, the plants lie dormant and regenerate when the villus get filled with water.

Fernando and Indrasena (1969), remark that it is unfortunate that no study has been undertaken on the biology of the villus and further express that conservationists and freshwater biologists should join together in preserving these habitats.

Fishing methods and the fishery

Several types of fishing gear are used in the villus depending on the prevalent depth of water, aquatic vegetation present etc. Inexpensive and primitive or traditional gear such as rod and line, iron strip (a flat iron bar of about 1 m. in length) and stick trap are used in the shallow waters. Unlike the other fishing gear, which are used mostly during daytime, the iron strip is used exclusively at night. A fisherman wades through knee deep water to a place where there is submerged vegetation and flashes a torch light on the water, armed with the iron strip in one hand. Fish like snake-head and mahseer which get attracted to the light, are beaten with the iron strip and caught. This method is highly effective for capture of snake-heads during rainy season, as they frequent shallow waters having vegetation, for building nests and breeding. The stick trap is a cone shaped device made with sticks and secured together by twine, the height and the diameter at the bottom and the top of which, are about 0.7, 0.5 and 0.2 m. respectively. It is pressed to the bottom of the villu, in waters of depth less than the height of the trap and fish entrapped are caught (Fig. 2). Gear used in deeper waters are the cast net and the gill net capturing mostly tilapia. A Villu being a comparatively shallow waterbody, a fisher-man can walk in it, to a distance sufficient

Fig 2 Fish trap in operation

to lay a gill net or throw a cast net. But fishermen use outrigger canoes, especially during the flood season for fear of crocodiles. (A few months ago, a man while using rod and line in 'Gengala villu' was reportedly attacked by a crocodile. Fellow fishermen managed to drive away the crocodile by beating it with rods. Although his life was saved, the incident made him more or less permanently disabled).

During droughts when water is receding, scoopnets and seines are used. The scoopnet is about 1.5 m. 0.5 m. and 1.5 cm. in length, width and mesh size, respectively. It is used in the marginal waters of the villus. The scoopnet and the seine are effective in capture of almost all the fish species present in the villus. No limitation on the mesh size of nets is enforced in the villus. The main hindrance for the operation of nets in the villus is presence of aquatic vegetation, especially Salvinia.

Tables III, IV and V provide information on fish catches from the major villus. The annual catch depends mainly on the period of retention of water in the villus, which decides the period of growth of fish, and also determines the fishing method employed. In late 1980 and 1981 the amount of water the villus received from river overflows were less than in previous years, which possibly resulted in diminished fish stocking. On the other hand heavy rains from time to time during the year raised the water levels of the villus to higher levels at which, seining and other fishing operations were difficult. The foregoing may be attributed among the reasons for decline in the catches in 1981 and 1982 compared to those in 1980. The TAMS report (1980), estimates an average fish yield of 50 kg/ha/yr for all the floodplain areas and a total fish population of 300 to 900 kg/ha as supported by the villus.

The presence of submerged grasses and aquatic vegetation points to a suitable habitat for grass carp to grow and if advance fingerlings can be introduced when a villu is getting filled, fish production may possibly be increased. The grass carp excreta would serve as fertilizer and increase the production of fish food organisms, which consequently results in enhanced growth of fish. Chakrabarty *et al.* (1980), in carp polyculture experiments undertaken by them in India mention of likely benefits derived by the stocked species from the semi-digested excreta of grass capp.

Landed villu fish are traditionally smoked for marketing, owing to the location of the villus' in remote jungle areas, and the resultant difficulty to transport the catch in fresh form to consuming areas and procure salt required for salt-drying, but on the other hand, easy availability of firewood required for smoking have contributed to the development of this tradition. Also smoked fish fetches a higher price than salt-dried fish. Now since the areas are being populated due to colonization schemes and the demand for fish has increased, cycle vendors visit some villus, e.g. Gengala villu and Velankadu villu, and purchase part of the daily catch.

Future

The extent of the effect of dam construction on the Mahaweli river at five points, on the villus is dfficult to be presently predicted. Thayaparan (1982), says the villu fishery is generally on the decline due to diversion of rivers, construction of flood protection schemes and increased wildlife conservation measures. Cutting off water supplies to these floodplains adversely affecting the habitat and enforced prevention of fishing through its prohibition, if imposed, together would contribute to non-utilisation of these natural fishery resources.

If the productive villus at least, are not disturbed and judiciously exploited, and arrangements made to market the catch fresh, these waterbodies can contribute to national fish production and help improve living conditions of the fishing community dependant on the same for their livelihood.

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TABLE I

Villus in the Mahaweli river system

(Sri Lanka Survey Department 1972)

Villu	*Area at full water level (ha)*	*District located in*
		Polonnaruwa
Handapan villu/Bendiya villu	796	—do—
Gengala villu	264	—do—
Velankadu villu	679	—do—
Tamara villu	30	—do—
Karapola villu/Hewanpitiya villu	552	—do—
Mutugalla villu	453	—do—
Katuwanwila villu/Kanawadi villu	213	—do—
Kokku villu	40	—do—
Vandavettana villu	163	—do—
Uruadi villu	98	—do—
Kudapattu villu	62	—do—
Malwatta villu	149	—do—
Meen villu	285	—do—
Koyamala villu	158	—do—
Gangapahala villu	131	—do—
Velvette villu	179	—do—
Tirikonamadu villu	251	—do—
Mawila villu	18	—do—
Oddigar villu	62	Batticaloa
Tikkana villu	143	—do—
Periyakariyaveli villu/Kariyaveli villu	62	—do—
Kallakombu villu	9	—do—
Tamara villu	62	—do—
Vavana villu	225	Trincomalee
Palia villu	187	—do—
Tamarai villu	9	—do—
	5280	

TABLE II

Commercially important species of fish in the villus

Anabas testudineus
Clarias teysamanni
Heteropneustes fossilis
Labeo dussumieri
Ompok bimaculatus
Ophiocephalus striatus
Osphronemus goramy
Sarotherodon mossambicus
Sarotherodon niloticus
Tor khudree longispinis

TABLE III

Fish catches (lbs) from Karapola villu 1960 - 1966
(Fernando and Indrasena 1969)
Catches from October 1st to September 30th

Year	Total catch	S. mossambicus
1960 — 61	107,200	4560
1961 — 62	106,475	no data
1962 — 63	86,500	no data
1963 — 64	55,580	no data
1964 — 65	65,680	41,523
1965 — 66	64,650	41,900
1966 — 67	55,550	37,550

TABLE IV

Fish catches in tons from the major villus in Polonnaruwa district 1980-1982
(No. of craft in parenthesis)

	1980	1981	1982
Handapan villu/Bendiya villu ...	202 (22)	210 (30)	72 (13)
Gengala villu	51 (2)	14 (4)	13 (3)
Karapola villu/Hewanpitiya villu ...	157 (33)	20 (8)	91 (44)
Mutugalla villu/Katuwanwila villu	41 (10)	12 (6)	31 (15)
Velankadu villu	111 (17)	191 (40)	81 (34)

TABLE V

Fish production (kg/ha) in the major villus in Polonnaruwa district 1980-1982

	1980	1981	1982
Handapan villu/Bendiya villu ...	253	264	90
Gengala villu	193	53	49
Karapola villu/Hewanpitiya villu ...	284	36	165
Mutugalla villu/Katuwanwila villu	62	18	47
Velankadu villu	163	281	119

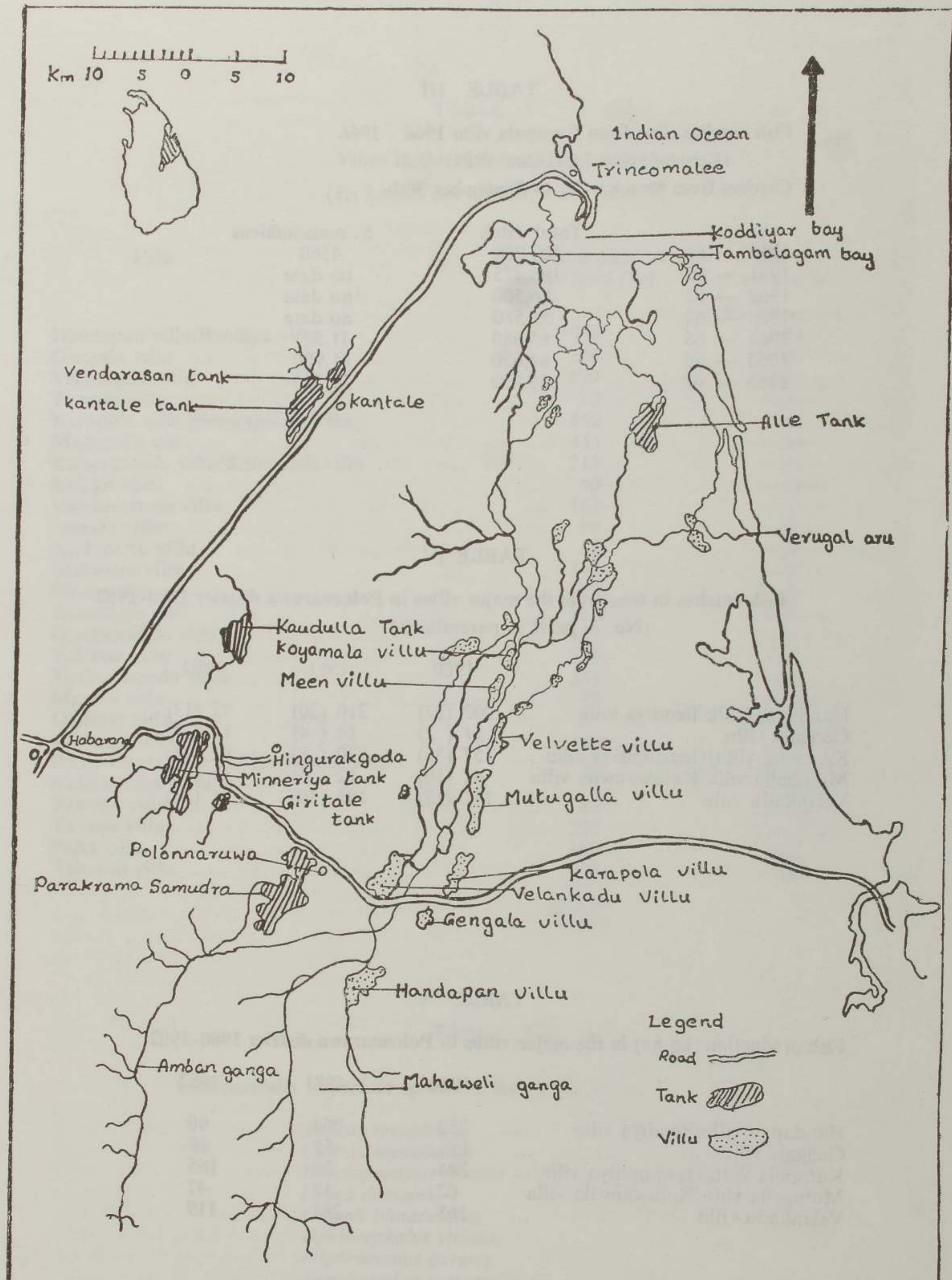

Fig. 1 – Lacation of major villus

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OBSERVATIONS ON FISH INTRODUCTIONS IN SOME RESERVIORS OF SRI LANKA

Jayantha Chandrasoma*

Introduction

The inland fishery of Sri Lanka is largely confined to the man-made reservoirs or tanks. Mendis (1977) classified the total resources available for the development of freshwater fisheries into major, medium and minor irrigation reservoirs, hill country reservoirs and flood lakes (villus). The Ministry of Fisheries has indicated these resources to be 125,600 ha. in which the latter category accounts for nearly 30% of the known existing reservoir acreage of the country (Fernando and De Silva, 1984). With the implementation of the accelerated Mahaweli programme, a further extent of 22,670 ha. is likely to be made available for fish production during the next few years (Thayaparan, 1982).

Fifty four (54) species of freshwater fish are now known to occur in Sri Lanka (Fernando and Indrasena, 1969) and the indigenous fish fauna lack truly lacustrine species (Fernando 1965, Fernando and Indrasena, 1969). The indirect consequences of this on the reservoir fisheries have been aptly documented (Fernando 1973, Fernando and Indrasena, 1969). Eighteen species of exotic fish have been introduced into Sri Lanka. since the first introduction of *Salmo trutta* in 1898.

The performance of fish introduced in some reservoirs of Sri Lanka is reviewed in the present communication. In addition, performances of indigenous fish are also discussed.

Fish Introductions

Fernando (1965, 1971) gave detailed lists of species and the years of their introduction into Sri Lanka. According to him in all fourteen (14) species of exotic fish had been introduced between 1898 and 1969 into Sri Lanka's freshwaters. During the period between 1969 to 1983, four species had been introduced. Table I gives details of the fish introductions. Five of these are African cichlids, three from mainland China, three from India, one from Indonesia, three from Europe, one from Thailand and one from Malaysia. Although records indicate that *Cetnopharyngodon idellus*, *Hypopthalmichthys molitrix* and *Catla catla* were introduced in 1948 (first two) and 1942, no attempt had been made to breed them. These were re-introduced in 1976, 1981 and 1982 respectively. Induced breeding of all these species of Chinese carps (*H. molitrix C. idellus* and *Aristichthys nobilis*) and two species of Indian carps (*L. rohita* and *C. mrigala*) is being carried out in Sri Lanka.

Performance of Introduced fish species in Perennial Tanks

Cichlids

Of the eighteen species of exotic fish introduced into Sri Lankan freshwaters, *S. mossambicus* has had a major impact on fish yields in perennial reservoirs. The establishment and the success of *S. mossambicus* is well documented (Fernando, 1965, 1971, 1973, Fernando and Indrasena, 1969, Mendis 1977). Fernando (1976) compared the fish yields of various reservoirs in some South-East Asian countries and found that Sri Lanka's reservoirs (tanks) showed the highest yield. Catch statistics of 16 major reservoirs indicate that the yield of *S. mossambicus* range from 71.0 to 579 kg/ha. and account for between 53% to 90% of the total yield in individual reservoirs (De Silva 1984a) Various reasons have been attributed to the success of *S. mossambicus* in Sri Lanka. Among them are breeding success, (Fernando and Indrasena, 1969) lack of lacustrine species in the indegenous fauna capable of colonizing the lake habitat (Fernando, 1965) and non-catholic nature of the diet of *S. mossambicus* (De Silva, in press).

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Of the other introduced cichlids *T.zilli* do not appear in fish catches of reservoirs. Although *T.zilli* was brought to Sri Lanka in 1969, there are no records as to whether the reservoirs were stocked with this species or not. Chandrasoma and De Silva (in preparation) report that the contribution of *Tilapia rendalli* (*T. melanopleura*), a macrophyte feeding cichlid to the fish catches of 4 southern reservoirs is around 10%. Chandrasoma (1980) reported that *T.rendalli* appeared regularly in catches of Parakrama Samudra, Sri Lanka and found that the contribution of *T.rendalli* to the total fish catch of that reservoir is less than 10%. According to Chandrasoma and De Silva (in preparation) the *T.rendalli* populations in reservoirs, where it has established is controlled by the limitation of macrophytes used as food. Also, they found that the contribution of another indigenous cichlid *Etroplus suratensis* which was transplanted into fresh waters from coastal lagoons (Willey, 1910) to the total fish catches of some reservoirs is similar to that of *T.rendalli.*

Chandrasoma and De Silva (in preparation) reported that in Soraborawewa (570ha. at FSL) another introduced cichlid *Sarotherodon niloticus*, had displaced *S.mossambicus* as the dominant species. They attributed this to the more efficient ability of *S. niloticus* to utilize blue-green algae (Moriarty, 1973, Moriarty and Moriarty, 1973), which was found in abundance in that reservoir.

Carps

Fernando (1976) commented that hardly any Common carp are caught despite the release of millions of fry into reservoirs. Here the questions that arise are whether it is that Common carp is not established in these reservoirs or that the method of fishing is not effective in making any significant catches of the species. Common carp is a bottom dweller and only few individuals appear in catches mostly during rainy seasons, when they come to the surface waters close to the margins of the reservoirs, where vegetation is present, for spawning. Most of the Common carp caught at Padaviya and Udawalawe tanks were in running condition and weighed 3-4 kg. as observed by the author. De Silva (personal communication) has observed a similar situation in Tissawewa in the Hambantota District. Common carp which had not appeared in the fish catches of Etumale tank in the Monoragala District were found in large numbers concentrated in few pools of water left behind, after the bund of the tank had breached during the 1984, floods. This probably indicated that common carp introduced earlier had established itself in this reservoir, as there had been no recent stocking of the species in the same. This could very well be true of most perennial reservoirs of the dry zone. One of the important features of Sri Lanka's reservoirs is the presence of extensive tree stumps. Generally these tree stumps are considered a hazard to fishing as they damage the nets and restrict fishing. Fishermen, therefore, show a reluctance to use bottom-set gill nets in such waters.

In the Udawalawe tank (3,374 ha. at FSL) where grass carp and bighead carp were stocked, reported early recaptures were low, due to reasons including restrictions imposed on fishing. Later large sized fishes were obtained such as bighead specimens weighing 20 kg. after three years from stocking of fingerlings. These large sized fish had low consumer preference because of high fat content. Also, gill nets used by fishermen were not effective in their capture.

Impact of the Indian carps, *Labeo rohita* and *Cirrhinus mrigala* (bred successfully in Sri Lanka in 1983) on reservoir fisheries is yet to be known. It is observed that in the Udawalawe tank, where 127,050 fingerlings of *L.rohita* were stocked, the species are appearing in the catches. They are found to have grown very well, reaching average weights of about 1 kg. in a period of 6-8 months. Sreenivasan (1982) strongly recommended the stocking of Indian carps in our reservoirs.

Performance of Indigenous Fish Species

The most important indigenous species in the fishery are the cyprinids, *Puntius, sarana* and *Labeo dussumieri* and the estuarine cichlid *Etroplus suratensis* (De Silva and Fernando 1980). Species composition of fish catches in 7 major perennial tanks in the Anuradhapura District for the year 1981 is given in Table II. Contribution of *L.dussumieri* to the catches of Kalawewa, Balaluwewa and Nachchaduwa are 41.47%, 32.7% and 16.7% respectively. In other tanks contribution of this species is in the region of 0% to 1.16%. De Silva and Fernando (1980) noted an increase in per cent contribution of *L.dussumieri* and *P.sarana* during the period 1973-1978. As a result of the Mahaweli river diversion scheme, high water levels are maintained in Nachchaduwa, Kalawewa and Balaluwewa for most of the time. In addition, flushing rate is very high in these reservoirs and riverine conditions seem to prevail as a result of the diversion. These three tanks can be considered as transient tanks, which distribute water to other major reservoirs. In addition, these supply water for cultivation to the paddies downstream.

Presence of higher percentage of *L.dussumieri* in fish catches of Kalawewa, Balaluwewa and Nachchaduwa may be attributed to the fact that conditions close to the riverine prevailed in these tanks, which may have favoured the population expansion of the species. De Silva (1983) discussed the effect of high water levels on the breeding of cichlids and pointed out that the catches of cichlids are on the decline, probably as a result of reduced breeding success. It is difficult to come to definite conclusions, as reliable catch statistics are not available for pre-diversion years.

Performance of Exotic Fish Species in Seasonal Tanks

In seasonal tanks the fish culture period is limited to 6-8 months. According to unpublished data available performance of different fish species can be summarized as follows : (a) of the cichlids, *S.niloticus* exhibits a superior growth and grow to larger sizes than *S.mossambicus*; (b) Bighead carp, *Aristichthys nobilis*, has performed well in almost all the seasonal tanks, where it had been stocked, reaching individual sizes of more than 1kg. in 6-8 months. Survival rates are very good; (c) performance of the Indian carps in these reservoirs is yet to be assessed and they are expected to do well in seasonal tanks, as these species are considered suitable for culture in ponds. Performance of grass carp *Ctenopharyngodon idella*, in these water bodies require further observation.

Conclusion and Recommendations

The cichlid *S.mossambicus* is well established in all the major perennial reservoirs and it is quite unnecessary to stock these reservoirs with *S.mossambicus*. Chandrasoma and De Silva (in preparation) had noted a dramatic increase in fish production in Soraborawewa, with the establishment of *S.niloticus*. It would be worthwhile to select few perennial reservoirs and stock them with large numbers of *S.niloticus*, instead of stocking more reservoirs with less numbers. *T. rendalli* do not appear in catches in most of the reservoirs (e.g. tanks in Anuradhapura district). It is recommended that the species be stocked in tanks, in which it is absent, in order to enhance production through utilization of macrophytes present in those reservoirs by the introduced species.

Thayaparan (1982) made a rough estimation of the extent of seasonal tanks in Sri Lanka and according to him 10,000 seasonal tanks with a command area of about 100,000 ha. could be utilized for fish culture. The Ministry of Fisheries has an ambitious plan to utilize the seasonal tanks for fish culture. It is proposed to make use of these seasonal tanks under a ADB funded project from 1984 to 1989, and these tanks will be stocked with fingerlings of carp varieties. Fingerling requirement for this would be around 20 million. In addition to this, the Ministry has to make arrangements to supply fingerlings for its pond culture programme. The present fingerling production in the country is around 8 million. To meet this challenge the Ministry is making necessary arrangements to put up more hatcheries, fry rearing ponds etc.

It is true that a number of compatible fish species would increase production in major reservoirs. But this leads to questions such as, can the introduced carp species breed naturally and build up stocks in these water bodies, is continuous stocking of carps profitable and what would be the recovery rate of introduced fingerlings.

The Chinese carps are not known to spawn naturally in reservoirs. The Indian carps, may spawn naturally in some reservoirs as reported by Sreenivasan (1982). It would be worthwhile to select two or three reservoirs, where short breeding runs are available and to stock these with sufficient numbers of Indian carps.

Fish introductions appear to have benefited inland fiisheries in Sri Lanka and have helped to increase fish production.

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TABLE I

FISH INTRODUCTIONS INTO SRI LANKA FRESHWATERS

SPECIES	ORIGIN	YEAR(S)
Salmo trutta	Europe	1982, 1983*
Salmo gairdneri	North America	1899, 1902*
Cyprinus carpio	Europe Singapore	1915 (Cold waters) 1948 (Warm waters)
Carassius carassius	Europe	1951
Osphronemus goramy	Indonesia	1927
Ctenopharyngodon idellus	China	1948, 1975*
Hypothalmichthys molitrix	China	1948, 1981*
Catla catla	India	1942, 1982*
Trichogaster pectoralis	Malaysia	1951
Sarotherodon mossambicus	East Africa	1951
Helestoma temmencki	Thailand	1951
Etroplus suratensis	Coastal lagoons and estuaries of Sri Lanka	1950
Tilapia hornorum	East Africa	1969
Tilapia rendalli (*T.melanopleura*)	East Africa	1969
Sarotherodon niloticus	East Africa	1975
Aristichthys nobilis	China	1975
Labeo rohita	India	1981
Cirrhinus mrigala	India	1981

*Re-introduction.

Table II — Species Composition of Fish Catches of some Perennial Reservoirs in the Anuradhapura District (1981)

Name of the tank	Area at F.S.L. (ha.)	*S.mossambicus* %	*L.dussumeiri* %	Other species %
1. Mahakandarawa	1440	91·56	1·16	7·53
2. Vilachchiya	960	96·44	0·335	3·22
3. Nuwarawewa	1182	92·9	—	7·08
4. Kalawewa }	2552	50·29	41·47	8·22
5. Balaluwewa }		60·24	32·7	9·64
6. Nachchaduwa	1763	83·32	16·67	—
7. Huruluwewa	2100	100·0	—	—

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INDUCED BREEDING OF INDIAN MAJOR CARPS IN SRI LANKA

L. K. S. W. Balasuriya*, C. R. Tilak*,
W. S. A. A. L. Kumarasiri* and H. K. G. Sirisena*

Eventhough Sri Lanka is blessed with vast inland water resources, contribution of the indigenous species towards fish production is little. We do not find the true lacustrine fish among the indigenous fauna and the riverine and the marsh species could only give low yields in reservoirs (Fernando, 1980). Accordingly, steps were taken to overcome this deficiency by introducing suitable exotic fish (Mendis, 1977). With the introduction of *Tilapia mossambica* in the 1950's fish production of the major reservoirs rose spectacularly and today tilapias contribute mostly to the reservoir fish production.

In recent times the situation has changed and fish culture programmes for raising food fish in seasonal village tanks, private ponds, etc., are underway.

Under these, there is increasing demand for the cultivable fish fingerlings throughout the country. Polyculture is being adopted in order to maximize fish yield. A mixture of compatible fish species is needed to make the best use of the various ecological niches of the waterbody. In the background of the vast experience gained in countries within the region, a typical species, mix would be the Chinese major carps; *Ctenopharyngodon idella* (Grass carp), *Aristichthys nobilis* (Bighead carp), *Hypophthalmythys molitrix* (Silver carp) and the Indian major carps, *Labeo rohita* (Rohu), *Cirrhinus mrigala* (Mrigal) and *Catla catla* (Catla). The Indian and the Chinese carps which were introduced in Sri Lanka during the 1940's did not establish due to the failure in maintenance of the brood stocks that could be used for breeding trials. The Chinese major carps were re-introduced in 1975 and the artificial propagation of these are being carried out since 1977 (Weerakoon, 1979). During 1981—1982 Indian major carps were imported again and introduced in ponds in Sri Lanka.

Management of brood stock of Indian major carps

In August 1981, small fingerlings of rohu and mrigal (525 nos. and 800 nos. respectively) of average size 4 cm. and 0.4 g. in weight were air-lifted from India and introduced into prepared nursery ponds of the Rambodagalla Fisheries Station, situated in the intermediate climatic zone in the Island. (Table 1) Three mud ponds, each of area 0.05 ha. were utilized. In two ponds the two species were cultured separately and in the other pond both species were cultured together. During the first two months a mixture of soyabean powder and rice bran in the ratio of 1:2 by weight was broadcast in the water. Later the feed was changed to a 1:1 mixture of rice bran and coconut meal. The quantity of feed applied was at the rate of 3-4% of the bodyweight of the fish. The feed mixture was made into a dough by soaking in water and placed in the feeding trays, below the water surface. Each pond was provided with a feeding tray (size, 0.5 m. × 1.0 m.) fixed near the enbankment in 0.5 m. water depth. Feeding was done twice daily, in the morning and in the evening. Cowdung was also applied at the rate of 100 kg/month/pond to fertilize the pond water for production of natural planktonic food. Replenishing and partial draining of the ponds and refilling of water was done at least once in three months.

During the process of building up the brood stock, higher stocking densities were used initially with small fingerlings and several thinning out operations were carried out during the culture period and some fish transferred to other Stations. The brood fish were checked once a month for growth, health and maturity and accordingly the application of feed and manure was adjusted. Some salient features are summarised in Table II.

*Freshwater Fish Breeding and Experimental Station, Dambulla.
**Freshwater Fish Breeding and Experimental Station, Udawalawe.

Induced breeding trials

The Indian major carps demonstrated remarkable growth attaining weight of 1.2 — 1.4 kg. in a period of 10 months. Secondary sexual characters of males were easily distinguishable within a short period of 8 months and in females in only 10 months. However, two females of rohu just 12 months old found in fully mature condition were selected for the first breeding trial. A small cement cistern (3 m × 7 m.) was used as the holding facility and arrangements made for maintenance of continuous water flow. Extracts of Common carp pituitary were administered to each of the females in two injections. The total dose was at 12 mg/kg. weight of female fish. The first injection was only one third of the total dose and the rest was given as the second injection. Males received a single dose of 4 mg/kg at the time of the second injection to the females. Fish spawned within an hour of the second injection application. The fertilization rate was estimated at 20%. As no proper hatching facility was available, the eggs were released into a cement cistern filled with water and a small number of fry was obtained.

After 20 months, more than 80% of the rohu female stock attained maturity and large scale fish breeding commenced in March 1983. Induced breeding of mrigal was carried out for the first time in June 1983 (Brood fish 22 months old). Breeding work was carried out in breeding hapas and two walled cloth hatching hapas, glass jar hatcheries and Chinese circulating type hatchery jars were used for the hatching of the fertilized major carp eggs. Some details of induced breeding trials with the Indian major carps carried out during its first breeding season are given in Table III.

Discussion

The experience in the raising of brood fish and the subsequent induced breeding of the Indian major carps transplanted in Sri Lanka indicate that these have not only acclimatised themselves to the new ecological conditions but also appear capable of getting established in the new habitat. Since there is no winter in Sri Lanka, the climatic conditions are favourable for year round growth. Consequently, the fish have demonstrated remarkable rate of growth. It is interesting to note that some specimens of rohu and mrigal had attained gonadal maturity within a year (Bhowmick, 1982). In India rohu and mrigal attain sexual maturity towards the end of the second year of their life in ponds (Alikuni, 1957). In Sri Lanka more than 90% of the fish population attained sexual maturity within 20 months of their life. In India the spawning season of rohu generally coincides with the south-west monsoon.

In Sri Lanka, we were able to carryout breeding of Indian major carps from March to October in 1983. On the basis of maturity by reared fish, the peak season for breeding of rohu would appear to be June and August for mrigal. It may be possible to breed one species for at least five consecutive months in a year.

In the case of catla, the brood fish are still in the process of gonadal maturation and no breeding as such has been attempted.

Despite the breeding trials not being extensive nor stretched over a period of years, it would appear safe to conclude that conditions as obtainable in Sri Lanka are favourable for the growth, maturity and response to hypophysation (induced breeding) by the Indian major carps, *L. rohita* and *C. mrigala*. The ease of raising the brood fish and breeding these in pond conditions together with their high fecundity is indicative of the high seed production potential of these carp species. Defining of the breeding season/seasons for the species, as also further information on minimum effective pituitary dose, etc., for breeding would be known after more work, spread over at least few seasons have been conducted.

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Bull. Fish Res. Stn., Sri Lanka, Vol. 29. pp. 55–62.

TABLE I : Climatic conditions during raising of Indian Major Carps at Rambodagalla Fisheries Station.

Year		Jan.	Feb.	Mar.	Apri l	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Remarks
	Average max. temp. °C	30·7	32·1	36·0	26·6	33·6	31·9	30·5	30·8	31·6	21·8	31·1	30·1	
1981	Av. min- temp. °C	18·6	18·5	21·3	24·3	24·3	24·1	23·5	24·4	23·5	23·2	22·1	20·6	
	Rainfall mm.	95·1	18·5	95·9	198·7	135·0	107·4	53·6	71·9	208·3	233·9	335·1	44·2	
	Av. max temp. °C	31·0	33·5	35·3	33·5	32·5	27·3	29·8	30·3	31·8	31·5	31·0	30·0	
1982	Av. mini.; temp. °C	17·0	18·4	22·6	24·5	24·3	25·0	24·6	24·0	24·6	23·2	22·9	22·5	
	Rainfall mm.	0·6	—	159·3	183·2	222·3	195·6	106·4	115·2	22·7	519·0	358·6	173·8	
	Av. max. temp. °C	30·0	33·5	36·2	36·1	33·3	31·8	31·1	30·8	30·6	31·8	31·0	30·9	→ (upto 20—12—83)
1983	Av. min. temp. °C	22·3	22·5	32·8	32·8	25·9	25·9	25·0	24·5	24·6	23·6	22·8	22·5	— (—do—);
	Rainfall mm.	2·0	—	2·0	2·0	196·4	103·5	50·9	80·5	115·8	230·0	368·4	107·2	— (—do—)

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TABLE II : GROWTH OF THE INDIAN MAJOR CARP SPECIMENS USED AS BROOD STOCK

Date	Average lenth		Average weight		Stocking density	Quality of the feed	Remarks
	Rohu	Mrigal	Rohu	Mrigal			
06.08.81	4.0 cm.	4.0 cm.	0.45g	0.40g	R. 150/0.05 ha M: 250/0.05 ha.	1 : 2 mixture of soya bean powder & rice bran	Broadcast on the water. 2 kg/pond/day
01.09.81	11.0 cm.	11.0 cm.	18.00g	15.00g	— do —	— do —	— do —
10.10.81	18.0 cm.	16.0 cm.	50.50g	48.00g	— do —	— do —	— do —
05.01.82	24.0 cm.	20. 0cm.	—	—	R. 75/0.05 ha.: M. 125/0.05ha	1 : 1 mixture of ricebran and coconut meal made into a dough by soaking in water	Feed mixture placed in a feeding tray. 5 kg./pond/day.
24.02.82	28.0 cm.	24.0 cm.	—	—	— do —	— do —	—
15.03.82	32.0 cm.	26.0 cm.	—	—	— do —	— do —	Roughness of the pectoral fin of some mrigal observed.
30.04.82	35.0 cm.	31.0 cm.	1.0kg.	0.7kg.	— do —	— do —	Roughness of the pectoral fins prominent in both rohu and mrigal. Some males exuded little milt.
10.06.82	44.0 cm.	42.5 cm.	1.25kg.	1.10kg.	— do —	— do —	Several rohu females displayed most of the features of maturity.
19.06.82	—	—	1.4kg.	1.1kg.	— do —	— do —	Several rohu females fullymature.
25.05.83	48.0 cm.	46.0 cm.	2.5kg.	2.0kg.	— do —	— do —	More than 80% of the females mature Maturity in males was more than 90%

TABLE III

DETAILS OF INDUCED BREEDING TRIALS WITH ROHU AND MRIGAL

Date & Place	Species	Age of brood stock	Sex ratio employed F. : M.	Temperature°C Air	Temperature°C water	Gonoadotropin material used	Solvent	1st dose strength	Time of injection	2n d dose	Time of injection	Spawning details	Fertilization rate	Hatching facility	Remarks
19.08.82 Rambodagalla	rohu	13 m.	1 : 2 2 pairs	29.5	28.0	CC pituitary	distilled water	3mg/ 1kg.	12.00 hrs.	9mg/ 1kg.	23.00 hrs.	A cement cistern used as the holding facility	20%	A cement cistern filled with water	Fish spawned within 1 hr. after the 2nd injection. Few fry obtained as no proper hatching facility was provided.
08.06.83 Rambodagalla	rohu	22 m.	1 : 2 2 pairs	— (1)	30.5	Ind. carp pit.	,,	2mg/ 1kg.	19.50 ,,	10mg/ 1kg.	02.00 ,,	Breeding hapa fixed in a cement cistern	70%	Hapas	Female weight 2.3 kg. and spawned 446250 no. of eggs.
				— (2)	31.0	,, ,, ,,	,,	2mg/ 1kg.	18.45 ,,	10mg/ 1kg.	00.30 ,,	Breeding hapa was fixed in reservoir (1ha.)	88%	Hapas	Female weight 2.1 kg. and spawned 637500 no. of eggs.
26.06.83 Rambodagalla	rohu	22 m.	1 : 2 1 pair	—	32.0	— do —	,,	3mg/ 1kg.	18.15 ,,	9mg/ 1kg.	00.25 ,,	Breeding hapa fixed in a reservoir	90%	Hapas	Brood fish were transported to the reservoir oxygen packed. (06 km. distance) But the fish performed well.
05.07.83 Rambodagalla	mrigal	23 m.	1 : 2 1 pair	—	31.0	— do —	,,	1mg/ 1kg.	18.45 ,,	10mg/ 1kg.	00.45 ,,	— do —	90%	Hapas	The first successful breeding of the species at the Station.
02.09.83 Rambodagalla	mrigal	25 m.	1 : 2 1 pair	—	31.5	— do —	,,	3mg/ 1kg.	18.00 ,,	9mg/ 1kg.	23.00 ,,	Breeding hapa fixed in a cement cistern	95%	Hapas	Female weight 1.6 kg. and spawned 55,000 no. of eggs.
10.06.83 Dambulla	mrigal	22 m.	1 : 2 1 pair	31.0	29.0	— do —	,,	3mg/ 1kg.	17.00 ,,	12mg/ 1kg.	23.30 ,,	Chinese circulating type hatchery jar was used	85%	Chinese hatching jar	The first breeding trial for mrigal
29.03.83 Dambulla	rohu	20 m.	1 : 2 1 pair	31.0	29.0	Labeo duss. pituitary	,,	3mg/ 1kg.	14.00 ,,	8mg/ 1kg.	20.00 ,,	Chinese circulating type hatchery jar was used	85%	— do —	The first successful breeding of rohu
20.06.83 Dambulla	mrigal	22 m.	1 : 2 1 pair	29.0	27.0	Ind. carp pituitary	,,	3mg/ 1kg.	16.30 ,,	—	—	Breeding hapas used	45%	— do —	Fish spawned with one injection
31.05.83 Udawalawe	rohu	18 m.	1 : 2 1 pair	28	29	Common carp pituitary	,,	3mg/ 1kg.	16.30 ,,	—	—	Circulating hatching jar used	75%	— do —	Only a single injection was given
15.06.83 Udawalawe	rohu	19 m.	1 : 2 1 pair	29.5	28	— do —	,,	4mg/ 1kg.	16.30 ,,	—	—	— do —	23%	No hatching was done	All females spawned before the time of the second injection. As the males were not injected the fertilization rate was low and the eggs were discarded.
	mrigal	19 m.	2 : 3 2 pairs	29.5	28	Common carp pituitary	,, ,,	4mg/ 1kg.	16.30 ,,	—	—				

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INITIAL SUCCESS AT BREEDING CATLA BY HYPOPHYSATION IN SRI LANKA

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Introduction

It has been recorded that (*Catla catla*) was first introduced to Sri Lanka from India in 1942. However, it did not get established in the natural waters. It was reintroduced to Sri Lanka on 15th September, 1982, with a view to propagate the species, specially as a component of the fish polyculture system in seasonal tanks in Sri Lanka. In the Indian sub-continent *Catla* breed in natural open waters during the monsoon. But they do not naturally breed in stagnant waters such as in ponds. This species has been successfully induced to spawn in captivity by administration of pituitary hormones, in India.

The fingerlings of *Catla* brought into the country from India in 1982, were raised to brood fish at Udawalawe, Dambulla and Muruthawela Fisheries Stations. By June 1984, a few specimens at Udawalawe showed signs of maturity and induced breeding of a set of spawners was successfull on 28th of June. This paper records this initial success achieved in the breeding of *Catla catla* in Sri Lanka by the hypophysation technique.

Materials and Methods

(a) Culture of brood stock :

The fingerlings of catla (Av. length 2-3 cm.) were stocked in an earthen pond (800 m^2) at the Udawalawe Fish Breeding and Experimental Station on 15th September 1982. At an average stocking density of 6 nos./m^2, 4875 fingerlings were stocked in this pond. By February 1983 the fish had reached a length of about 12-15 cms. and weights varying from 20-26 gms. each. The ponds were periodically fertilized using cowdung. Supplementary feed consisting of 1:1 by weight of a mixture of rice bran and poonac (coconut residue cake) powder was broadcast in the ponds daily (Table I).

A series of thinning out operations and transferences were carried out during the culture period.

In August 1983, 120 healthy fish (Av. weight 750 gms) were selected and stocked in a mud pond (800m^2). Fortnightly, pond water was replenished followed by fertilization with cowdung and urea. A supplementary feed consisting of soya bean, rice bran, coconut residue cake and fish meal in the ratio of 1:2:2:0.5 respectively was given. The fishes were netted out, monthly, to check their growth and maturity.

(b) Selection of breeders :

The criteria for selection of mature males and females were as follows:

Males — The pectoral fin in males is relatively rough to the touch specially the surface facing the body proper. When the abdomen is gently pressed towards the vent milky white milt oozes out.

Females — The pectoral fin is relatively smooth. The ventral, and ventrolateral portion of the abdomen is soft and bulging and abruptly tapering towards the vent.

Roughness of the pectoral fins in some male Catla was first detected in January 1984. On 28th of June 1984, two females appeared

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to be mature, on examination. Of these the better one was selected and subjected to hypophysation.

(c) Induced Breeding :

Common carp pituitary imported from China was used as the inducing agent.

Method of Injection

A mature female (2.0 kg.) and two males (av.wt. 1.75 kg. each) were selected for the induced breeding trial. The female was given two injections, the first dose being at 3 mg. PG/Kg body weight while the second was of 7 mg. PG/Kg body weight. The first injection was administered at 1700 hours while the second was given at 2245 hours. A dose of 3 mg. PG/Kg body weight was given to the males at the time of the second injection to the female. The mode of injection was intra-muscular and the region injected was the caudal peduncle a little above the lateral line. The pituitary extract was prepared in distilled water.

Holding facilities for breeders

The injected breeders were kept in a small breeding hapa (2 M×1 M×1.5 M) placed in the elliptical spawning pond (16.5 M× 9.5 M) at the station. Water was kept running through in the spawning pond and the flow rate was increased after the second injection to the spawner.

Incubation of eggs

Although the eggs had been laid very early in the morning (29.6.1984) these were collected only at 0645 hours and transferred to portable indoor hatchery jars (the Chinese model) using buckets. The eggs were measured before transferring to the incubation jars. The Chinese model incubation jar has an effective capacity of about one cubic metre designed to accommodate upto one million eggs at a time. Water is constantly kept in rotation and renewed by way of 6 inlet pipes ejecting water into the jar. A crown at the top fixed with a net retains the eggs while allowing free outflow of water.

Fry resulting from the eggs were collected manually from the jar using basins, on 5.7.84, and stocked in nursery ponds.

Results

Periodical checking of the breeding hapa showed that the spawning had taken place about 3 hours after the second injection.

The temperature fluctuation during the breeding activities was in the range 25°C to 27°C.

The total number of eggs collected were 300,000 in number. Fertilization rate observed after 6 hours of development of the embryo was about 55%.

The eggs hatched out in 18-20 hours after fertilization at a temperature regime of 25.°C to 27°C.

On the 5th day 50,000 fry were collected from the hatchery jar and stocked in an earthen pond.

Discussion

No conclusions could be drawn from this initial trial with respect to breeding cycle or attainment of maturity. However, it is clear that *Catla* could mature within 22 months. The brood stock at Dambulla had also shown signs of maturity by about 21 months (L.K.S.W. Balasuriya, personal communication). Out of the large population of maturing Catla in the different fish stations in Sri Lanka the attainment of desired maturity of the few fish used in the trial cannot give a clue to the actual breeding season or age at maturity. With better management and experience it may be possible in future to raise mature fish in good numbers within the same period, from stocked fish.

The fertilization rate of eggs and the resulting fry had been poor in this trial. The following may be the possible reasons :

(*a*) Fertilization rate has been poor due to the breeders not being in the ideal maturity condition.

(*b*) Inadequacy of space preventing or curtailing ease of spawning and fertilization.

TABLE 1

SUMMARISED DATA ON CULTURE OF BROOD STOCK OF CATLA

Date	Age	Av. Size	Stocking Density	Feeding Regime	Maturity
15.09.82	20 days	0.88 gms	6 fish/m^2	Rice bran + Poonac (1 : 1 ratio) 2 kg/5000 fish	—
29.09.82	34 days	1.88 gms 5.05 cms	6 fish/m^2	Rice bran + Poonac (1 : 1 ratio) 2 kg/5000 fish	—
15.10.82	50 days	5.2 gms 7.53 cms	6 fish/m^2	Rice bran + Poonac (1 : 1 ratio) 4 kg/5000 fish	—
22.11.82	87 days	11.1 gms 9.78 cms	6 fish/m^2	Rice bran + Poonac (1 : 1 ratio) 4 kg/5000 fish	—
06.12.82	100 days	15.8 gms	6 fish/m^2	Rice bran + Poonac (1 : 1 ratio) 6 kg/day	—
28.12.82	122 days	18.2 gms	1 fish/m^2	Rice bran + Poonac (1 : 1 ratio) 2 kg/500 fish	—
05.02.83	6 months	130 gms	1 fish/m^2	Rice bran + Poonac (1 : 1 ratio) 2.5 kg/500 fish	—
08.3.83	7 months	180 gms	1 fish/m^2	Rice Bran + Poonac (1 : 1 ratio) 3.0 kg/500 fish	—
02.04.83	8 months	230 gms	1 fish/m^2	Rice bran + Poonac (1 : 1 ratio) 4.9 kg/500 fish	—
18.05.83	9 months	250 gms	Stocked with other Indian carps due to lack of ponds	— do —	—
20.07.83	11 months	285 gms	— do —	— do —	—
15.08.83	12 months	320 gms	— do —	— do —	—
20.10.83	14 months	350 gms	120 fish seperated into a pond (800 m^2)	Rice bran + Poonac (1 : 1 ratio) 4 kg/day	—
15.11.83	15 months	420 gms	1 fish/6m^2	Soya bean powder + Poonac powder + fish meal + Rice bran (1 : 2 : ½ : 2) 5½ kg/day	—
20.12.83	16 months	600 gms	1 fish/6m^2	— do —	—
28.01.84	17 months	820 gms	— do —	— do —	Roughness of pectoral fin observed in few males.
12.02.84	18 months	960 gms	— do —	— do —	Roughness of pectoral fins still observed.
15.04.84	20 months	1350 gms	— do —	— do —	Five fish were in milting condition.
20.05.84	21 months	1445 gms	— do —	— do —	One spawner showed signs of maturity.
28.06.84	22 months	1550 gms	— do —	— do —	Two females showed signs of maturity. One was better than the other. Milting condition in five males.

TABLE 2 — DETAILS OF THE FIRST INDUCED BREEDING TRIAL OF CATLA CATLA IN SRI LANKA

Date	Sex	Weight	1st injection				2nd injection			Dosage	Number of eggs	Fertilization rate	Number of Fry
			Time	Temperature°C		Dosage	Time	Temperature°C					
			hrs.	Air	Water		hrs.	Air	Water				
28.6.84	Female	2.0kg	17.00	27.5	27.0	3 mg PG/kg. body weight	22.45	26.0	26.5	7 mg PG/kg body weight	300,000	55%	50,000
	Male	1.75kg	—	—	—	—	— do —	— do —	— do —	3 mg PG/kg body weight			
	Male	1.75kg	—	—	—	—	— do —	— do —	— do —	3 mg PG/kg body weight			

(c) Inadequate management at the hatchery.

During this period a set of *Labeo dussumieri* was also subjected to induced breeding, separately, and the eggs were incubated in a hatchery jar of same type. The production had been very satisfactory and hence it appears unlikely that the poor survival in Catla was due to poor management at the hatchery.

Eggs spawned were about 150,000 eggs/kg. in the trial reported on *Catla* and this could be considered a satisfactory situation. Although not conclusive there is a possibility that the spawners had been at a satisfactory stage of maturity.

However, the space provided for 5kg. of brood fish is less than 2 cubic metres and this may be considered as not adequate for violent, chasing movements during spawning. This could have hampered fertilization in the breeding hapa.

Although very satisfactory results were not obtained, the present experience would no doubt pave way for better achievements in the field of induced breeding of *Catla catla* in the future.

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OBSERVATIONS ON THE INDUCED BREEDING OF CHINESE CARPS IN SRI LANKA

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Introduction

The first introduction of Chinese major carps (Big head carp, Grass carp, Silver carp) to Sri Lanka had been in 1948. However, success of breeding this stock or methodical attempts to breed them has not been recorded. A few specimens had been lying in the ponds at the Polonnaruwa Fisheries Station and subsequently this small population had withered away (official records DOF). Again in 1975 a small consignment of Grass carp and Big head carp (adults as well as fingerlings) was brought into the country as a test trial and what survived was stocked in the ponds at the Udawalawe Fish Breeding and Experimental Station in December, 1975. Subsequently two more consignments of these two species were brought to Udawalawe in mid 1976. Induced breeding of *Ctenopharyngodon idellus* (Grass carp) and *Aristichthys nobilis* (Big head carp) were successfully performed in March, 1977 and June 1978 respectively at Udawalawe by a team of Chinese experts and local Aquaculturists. Thereafter, it has been repeated annually. The preliminary attempts at induced breeding have been described (Weerakoon 1979). *Hypophthalmichthys molitrix* (Silver carp) was introduced to the ponds at Udawalawe in June 1981. Induced breeding was successfully carried out in December 1983. Details of this attempt has been described (Tennakoon-in prep). The techniques used in brood stock management and induced breeding of Chinese carps in Sri Lanka, have been described in detail (Tennakoon 1980, Tennakoon and Tilak, 1983). The present paper attempts to put into record some summarised data of the induced breeding trials of Chinese carps performed at the Udawlawe Fish Breeding and Experimental Station during the period 1975 to 1983. A discussion on some of the problems encountered in this field and certain comments and suggestions have been made which in the author's opinion would help to resolve certain problems in breeding to a considerable extent.

Material

(a) **Brood stock** : The brood stock of Chinese carps comprising Grass carp (*Ctenopharyngodon idellus*), Big head carp (*Aristichthys nobilis*) and Silver carp (*Hypophthalmichthys molitrix*) were reared from fry and fingerlings brought from the People's Republic of China. The brood stock was maintained at sizes ranging from 5kg to 13kg.

(b) **Brood stock ponds** : Initially, in 1976 two ponds were used as brood stock ponds for Grass carp and Big head carp but with the ensuing thining out operations gradually 10 ponds were utilised, five for each species, by the end of 1976. All these ponds were concrete lined on the dikes and having earthen bottom with an average water depth of 2 metres at full supply level. One pond is $1900m^2$ in area while the other 9 are equal in size each spreading to $1700m^2$ in area. Water is led by gravitational flow through the central inlet channel branching out to each of the ponds. The source of water is the Right Bank Canal of the Udawalawe reservoir (a perenial irrigation reservoir impounded in 1968 by damming the Walawe river, area at FSL being 3360 ha). Water evacuation from the ponds could be effected only by pumping out preferably using submerged water pumps.

A few more earthen ponds $900m^2$ in size had been used at different times as preparatory brood stock ponds

*Freshwater Fish Breeding and Experimental Station, Udawalawe.

but the former 10 ponds still could be considered the major brood stock ponds for Chinese carps. Out of these 2 ponds have been allocated for Silver carp and the rest for Grass carp and Big head carp. From 1981 onwards two earthen ponds (1500m^2) at the Udawalawe (Old) Fisheries Station had been used as supplementary brood stock ponds for Grass carp and Big head carp.

(c) **Fish feed** : Grasses such as *Isachne globosa* (Batadella — a grass that grows in paddy fields), land grasses (*Cymbopogon confertiflorus*) formed the main feed for grass carp. Poonac (coconut residue cake) crumbs and germinated paddy were also given at different times. Presently soyabean is also added to the supplementary feed.

Big head carp and Silver carp brood stock were fed with rice bran, poonac, molac, leybes and soyabean. Various combinations were used at different times. Fertilization of the Big head and Silver carp ponds was chiefly by using cowdung but occasionally chicken manure had been used.

(d) **Estrualising agents** : Various estrualising agents have been used in the past. Pituitary glands from Common carp and Crucian carp have been imported from China. They have been preserved in acetone. On a few occasions local sources of common carp donors have been utilised. LRH from China has been used twice. HCG and LHRH-A imported from China form the widely used hormones. Lately LHRH-A from Canada has also been used.

(e) **Spawning pond** : Elliptical spawning pond (16.5×9.5 m.) that opens into an egg collecting chamber accommodating an egg collecting apparatus, forms the major device facilitating spawning and egg collection. A tributory from the main feeder canal feed the spawning pond and is hence able to maintain a considerable water flow. The design of the various slopes and curvatures of the spawning pond is so as to facilitate the removal of any eggs laid in the spawning pond into the egg collecting apparatus consisting of a cone shaped net and a floating net cage made of 1/48 mm meshed net.

(f) **Water collecting pond** : Another branch canal feeds the water collecting pond (33m ×7.5 m×3 m) directly. Two barricade nets across this canal serve as sieves. From the water collecting pond 6″ centrifugal pumps, direct water to a 40 ton capacity overhead tank that feeds the hatchery.

(g) **Hatchery** : The hatchery building, house eight portable PVC hatchery jars each with an effective capacity of one cubic meter. The crowns that could be fixed to each of the jars consists of a frame fixed on with a 1/48 mm meshed net which prevents the escape of eggs and larvae while ensuring free outflow of water. In the hatchery jar eggs can be kept in suspension by a water ejection mechanism consisting of 5+1 inlets. One inlet is at the centre and placed on a dome shaped protuberance while the rest are directed clockwise at the bottom. Transfer of eggs to the hatchery from the spawning pond and fry from the hatchery jar to ponds has to be manually performed using basins and buckets. The hatchery jars have been imported from People's Republic of China.

Methods

Brood stock management :

(1) **Stocking density** : The general practice had been to maintain a stocking density of about 1,500 kg/ha. with a major species contributing 80-85% of the total. Male to female ratio was generally kept at 3 : 2. During early periods upto 1981, Grass carp brood stock ponds also had about 15-20% of Big head carp and *vice versa* in Big head carp ponds. Further every pond had 15-20kg. of common carp too. After 1982, the ponds were mostly used for each

of the major species (almost 90-95% of the total stocking density) with a minor addendum of other species.

(2) **Feeding** : From 1975 to 1979 *Isachne globosa* (Batadella) was given as the major feed for Grass carp supplemented with crumbs of poonac. In 1977 occasionally *Lemna major* were also fed. Again from 1981 to late 1983 *Isachne globosa* was sought. But in the interim period various types of land grasses chiefly *Cymbopogam. sp* were given. During this period no poonac crumbs were given due to a shortage in the market. The latest practice is again to give land grasses. After 1981, rice bran, poonac, soyabean, and germinated paddy seedlings had been given to Grass carp in various combinations in addition to grasses (Table 15)

(3) **Water management** : Renewal of water by allowing new water to pass through the pond was practiced as an important management measure. In the case of Big head carp it was carried out once a month for 6 hours while for Grass carp twice a week, 10 hrs. at a time.

(4) **Disease prevention and treatment** : The following steps were taken in the past with respect to disease prevention and treatment :

(*a*) Annual evacuation of ponds, subsequent drying and application of lime or bleaching powder before starting the next culture cycle. In this process *Tilapia* and wild fish were removed.

(*b*) Removing the bottom sludge once in about two years.

(*c*) During the culture cycle Dipterex is applied periodically in order to combat and prevent attack of *Synergasilus sp*. in Grass carp brood stock ponds.

(*d*) Occasionally garlic powder was mixed with feed (for Big head carp) or placed in bamboo cones and hung in the floating frame structure where grass is placed (for Grass carp) to prevent as well as a remedy for, certain intestinal ailments (a Chinese practice).

Induced breeding In the past 7 year induced breeding had been tried outs during various months of the year but mostly when the rains were abundant.

(1) **Selection of matured fish** : One day prior to selection of spawners supplementary feeding is curtailed and water level is reduced by about 30 cm for convenience in netting operations. Mature spawners and milters are selected based chiefly on the external features.

Milters : In the mature milters the pectoral fin is rough to touch and sometimes similar roughness is felt along the lateral line too. When the abdomen is gently pressed ventrally towards the vent milt oozes out. The following criteria are based on Chinese experience :

(*a*) milt very thick, slightly yellowish, forming a thick streak in water without diffusion — premature.

(*b*) whitish milt oozes out with ease and gradually diffuses into the water — ideal maturity.

(*c*) milt lightly coloured, too watery, diffuses into water immediately — overmature;

Spawners : In mature spawners, the abdomen is full and bulge laterally along the length of the body distinctly and abruptly tapers towards the vent. The vent is pinkish and prominently swollen without wrinkles.

Sometimes a catheter or an egg fetching spoon (30 cm long metal rod with a groove on one end) is carefully inserted through the vent to collect samples of ova.

Neat, round, uniform size radiant easily separable eggs are considered a sign of good maturity. Depending on the culture practice (with frequent running water condition) the ideally mature fish may have even eggs with the germinal vesicle eccentrically placed. To observe the germinal vesicle clearly, the eggs are placed in a petridish with 95% alcohol or a mixture of the following. (a Chinese practice)

85% Ethyl alcohol, 40% Formalin, and Glacial acetic acid in the ratio of 17 : 2 : 1.

(2) **Hormonal injection** : Intraperitoneal injection at the soft base of the pectoral fin has been the normal site of inoculation. In the case of Big head carp and Grass carp the common practice has been to give a stimulatory dose at about 16.00 to 18.00 hrs. and a resolving dose after a lapse of about 6 hours. The former is about 10% of the total dose. The milters have been subjected to a single injection given at the time of the second injection to the spawners. In the case of Silver carp single injection method has been adopted for both males and females and the time of injection had been about 16.00 to 18.00 hrs. When the milters have been found to be not very satisfactory double injection method has been adopted with them too.

Pituitary glands used have been preserved in acetone. All hormones used had been stored in refrigerators. General practice was to use hormones not older than one year but there had been several occasions when HCG and LHRH-A upto 4 years old and stored in refrigerators had been used. The medium for the preparation of injection had usually been distilled water but during 1981 dextrose solution has been also used. The dosages of estrualising agents used are indicated in Tables 1-14.

(3) **Induced spawning** : More frequent practice has been to perform stripping of eggs. Dry method of fertilization had been preferred. Sometimes saline water had been used as a temporary medium for milt when the performance of milters have been very poor with insufficient milt.

The fertilized eggs are washed at least thrice and measured before transferring to hatchery jars. There have been occasions when the injected fish had been allowed to undergo natural fertilization in the spawning pond. In such cases the recovery had been very poor.

The eggs are kept in suspension and rotation in the hatchery jars. On the 5th day after deposition of eggs the egg yolk had been observed to be fully absorbed and fry are transferred to nursery ponds at this 7 mm-8 mm stage. On the 5th day a boiled egg yolk feed is sometimes given at the hatchery jar itself.

Post spawners are given a bath of malachite green before transfering to the post spawner pond.

Observations: On scrutinising the results of induced breeding trials performed from 1977 onwards the following observations seem to have special significance.

1. The production from Artificial Propagation trials during the years 1979 and 1980 were very unsatisfactory when considering the quantum of brood stock that responded to successful induced breeding against the total weight of brood stock maintained during the aforesaid period. (Refer Table 17)
2. The status of Grass carp with respect to induced breeding trials has not been very satisfactory upto now. (Refer Table 17)
3. Considerable mortality of post spawners had occurred in 1979 and the average mortality of spawners per year is still significant. (Station records)
4. Although artificial propagation has been tried out in various months of the year, performance during the rainy seasons seems to be significantly better. (Refer Figs. 1 & 2)
5. Out of the two monsoonal rainy seasons, the latter monsoon period (North-East) seems to be a better breeding season. (Refer Figs. 1 & 2)
6. Heavy rains seem to bring in a stimulus for maturity and there appears to be some correlation between the time of maturity of the fish at the Fisheries Station and rains in the catchment area of the Udawalawe reservoir where the pattern of rain fall is often different from that of Udawalawe.
7. In the attainment of maturity during the North-East monsoon period Big head carp seems to be having a preponderence over grass carp.
8. Further, the males seem to attain maturity earlier than the females.

Subsequently there seems to be a short period of about 2 weeks when the milters and spawners are both in prime condition. Loss of maturity condition is earlier in the males than in the females.

9. The nutritional condition and health of the Grass carp brood stock is in question and correlation of the above condition to the response to artificial propagation cannot be ignored.

10. Use of PG* powder had given some detrimental results in 1979 and subsequent identification of the same as pig pituitary powder has shown the importance of guaranteeing the source of estrualising agents. (Table 3)

11. LHRH-A when used in combination with PG and HCG seem to be giving better results specially considering the ensuing low mortality of post spawners.

12. The elliptical spawning pond at Udawalawe does not serve the designed expectations of convenient collection of viable eggs. (Table 13)

13. High temperature seems to be one of the factors leading to mortality of eggs and hatchlings. Water temperatures above 32°C in hatcheries have caused severe mortality in some trials.

14. Low hatchery production of fry on certain occasions due to presence of macrozooplankton in hatchery jars seem to have a correlation with the stagnation of water in the water collecting ponds and low water levels in the Udawalawe reservoir. (Table 11)

15. There is an unfavourable coincidence of the peak of breeding season with low water issues in the RB channal, and also with frequent power failures. (Tables 1-14)

Discussion

1. **Breeding season** : The chronological distribution of successful breeding trials performed over the past 7 years indicates that the percentage of success is more during the later half of the year (Figs. 1 & 2). It could be assumed that the peak of maturation of stocks is synchronised with the North-East monsoon season when more rains are experienced in this area. So far this criteria has not been scientifically established through regular ovarian studies of a representative cross section of the brood stock elucidating actual state of maturity with respect to months and different environmental cues. The production oriented programme at the Fisheries Station and lack of large brood stocks for frequent dissections and investigations had curtailed any methodical gonadal maturation studies. However, other observations and occasional investigations of gonads at random seem to be supportive of the idea that the peak of maturity falls within the months September to December.

The degree of maturity of males determined by the quantity and quality of milt (the latter decided by the colour and observable viscosity) taken as a crude but useful standard together with assessment of maturity of spawners by external features suggest the presence of two different peaks of maturity for the milters and spawners. There is indication that the males mature earlier than the females and the loss of maturity in the males is earlier than females. The pattern of attainment of maturity shows a short period of overlap of the two peaks which could be taken as the ideal period for successful breeding. For clarity this observation has been hypothetically depicted in Fig. 4.

During the North-East monsoon it has been observed over the past that the Big head carp matures earlier than the Grass carp. The case of Silver carp is still premature to hypothise as this newly introduced stock reached its first maturity only in December 1983. The first few breeding cycles of an introduced species may be chiefly governed by an intrinsic genetically inherited chronological mechanism rather than dictated by the environmental cues of the newly introduced environment.

It should be also noted that the chronological schedule of breeding trials have been compulsorily influenced by the capacity of the hatchery. The present hatchery cannot be used for liberal mass scale production

*PG Pituitary gland of Pig

in keeping with the magnitude of brood stock and hence when the hatchery is full the next breeding trials have to be necessarily postponed for at least 5 days even if fish are in the prime of maturity due to the fact that one incubation cycle in the hatchery needs at least 5 days for completion. Thus the results of the breeding trials in Tables 1 to 15 do not necessarily indicate the actual chronological peaks of maturity with respect to species on individual or comparative basis. The facility of a bigger hatchery would have given the flexibility and liberty to use all the brood fish in the peak of maturity at any given moment without being limited by the hatchery space factor thus giving a more clear picture of the peak of breeding cycle.

However, there is a possibility of having one or two fish mature almost every month in a large population of brooders but in terms of ecomonics of productions frequent netting out of the ponds in search of these few will necessarily have to be discouraged.

A confusion over the breeding season proper and the ensuing operations to check the brood stock for maturity, frequently followed by desperate attempts to subject the brood stock to artificial propagation at random with a view to achieve some production, could have been a major reason for the failure in induced breeding trials during the period late 1979 to early 1981. Mortality during the same period has also been high (station records). The results of 1979, 1980 trials also seem to throw some light on the belief that frequent netting out operations in brood stock ponds could affect the process of attainment of maturity.

Years of breeding trials indicate a clear correlation between the rainy season of the area and the attainment of maturity of the brooders. There is also a glimpse of a possibility that rains in the catchment area of the Udawalawe reservoir causing thereby the high water inflow into the reservoir also have pronounced results in terms of induction of maturity. In this regard the ponds at the Fisheries Station, the reservoir (which is the water source) and the catchment area (far off from the reservoir) may be considered a single system thus enabling the transmission of pronounced fluctuations of environmental parameters of the catchment area to the ponds easily.

A confirmation of all the above observations have to be obtained through regular and methodical studies of gonads and physiology in relation to time, season and environmental factors.

2. **General performance of broodstock**: The general performance of grass carp during the 7 year period under consideration has been irregular and not satisfactory. Mortality of the post spawners has also been very high (station records). Experimental data are insufficient to provide any concrete reason for the poor performance. However among other factors nutrition and diseases may be playing a great role.

The major feed for grass carp had been land grasses the selection of which has been mostly as per availability and tenderness of the varieties on a comparative basis. No proper study of their suitability for Grass carp, has been done. However, there was a clear instance of deterioration of the quality of grass given in 1979 to early 1981 and this was reflected in the poor quality of the brooders during the same period. The unavoidable stoppage of supply of poonac crumbs that occurred during the same period would have aggravated the situation.

This condition may have had intensified effects specially because the Grass carp brood stock had been subjected to a severe attack of *Synergasillus* sp. parasite from 1976 onwards. Supply of better grasses and poonac crumbs and subjection to regular treatment of Dipterex to combat *Synergasillus* brought in better results of artificial propagation 1981 onwards. But still the problem seems to be far from settled. The *Synergasillus* attack on the brood stock of Grass carp that has become almost a permanent factor although causing no direct mortality, its effect on the quality of brooders thus affecting maturity, cannot be ignored.

In the case of Big head carp, the performance was poor during the period 1979 to 1981 whence the management of brood stock had deteriorated. After 1981 with more attention to management and with additional feeds such as soyabean powder the performance of the stocks have been restored.

It is also interesting to note that in 1983 trials, Big head carp from the brood stock ponds at the Old Fisheries Station with average sizes in the range of 3-6 kg. responded smoothly to artificial propagation in contrast to the bigger brooders cultured at the other station. As the age of fish and management measures were different, no conclusive data could be collected on the aspect of an economical, convenient size of brooders for induced breeding operations. However it is an area where further investigation is worthwhile.

It is also felt that the deep brood stock ponds without convenient mechanism for outflow of water from lower levels lead to collection of metabolites for long durations that might effect the maturity. A proper comparison with similar stocks in ponds with facilities to evacuate or renew water at lower levels should throw some light on this.

3. **Estrualising agents** : The types of estrualising agents used so far on Chinese carps at Udawalawe are given in Table 16. Although the extent of duplication of results is not sufficient to conclude concretely any comparative efficacy or advantages of one another, results of PG, HCG, LHRH-A mixture seems to be better in terms of production. Percentage mortality of post spawners had been low in the year 1981 to 1983 (station records) against the earlier years whence other mixtures or individual estrualising agents had been used.

The bad spell of results experienced continuously with the use of imported pituitary powder (PG*) was ultimately overcome when fresh pituitary glands from common carp cultured in a seasonal tank was used. The quality of pituitary powder was inspected but it was only in late 1981 that a confirmation was made that the supplier had wrongly supplied pig pituitary powder instead of fish pituitaries. The importance of a mechanism to guarantee the quality and source of pituitaries was well elucidated in this case.

4. **Spawning pond** : The engineering design and construction of the presently available elliptical spawning pond had proved ineffective in driving all eggs deposited in the spawning pond into the egg collecting chamber. Further, the direct tributory from the central supply canal although barricaded with net seives has not been successful in preventing wild fish eggs and fry entering the spawning pond and eventually the egg collecting apparatus due to various factors. These problems constitute a threat to natural fertilization in the spawning pond. Thus stripping of fish has become an obligatory procedure.

On the other hand violent activities of the large size brooders lead to physical damage of their bodies specially on account of the concrete lined sides both in brood stock ponds and in spawning pond. Further, the stripping operation itself aggravates the damage caused and culminates in frequent mortality.

A circular type of spawning pond with an effective water circulation and a mechanism to collect all the eggs could have solved the problem by providing an opportunity to resort to natural fertilization although stripping method has its own merits. The water supplied to the spawning pond would have to pass through a filter to avoid extraneous materials contaminating the eggs.

5. **Hatchery** : The ultimate success of the induced breeding may be finally dependent on the hatchery production. In the trials under consideration the following factors have played a significant role in the different trials affecting final output of fry.

(*a*) The continuous water supply to the hatchery is dependent on the water availability in the RB canal. As the breeding season coincides with the heavy rainy season very frequently it was found that during the breeding season the RB irrigation canal was completely closed or a small domestic supply was issued (refer Tables 1-14). This curtails the possibility of obtaining gravity fed water through the main sluice gates. Pumps have to be used continuously but the complete closure of the canal on various occasions aggravate the problem. During the low water levels in the RB canal the muddy run off water on account of heavy rains, makes the water still unsuitable for successful hatchery operations. Heavy dependence on pumps and frequent electricity failures during the rainy season had affected a considerable number of hatchery runs.

(*b*) Rainy seasons intermitently dotted with very warm days have been experienced during the last 7 years. There have been occasions when the temperature had risen above 32°C in the hatchery under operation. Premature hatching of eggs, deformities of the hatchlings and ultimate mortality has been observed on such occasions. The water collecting pond, and the overhead tank that supplies the hatchery are subjected to direct sunlight and as they are made of concrete structures such temperature fluctuations are easily transmitted in the present system of hatchery at Udawalawe.

(*c*) There have been two occasions when macrozooplankton level in the hatchery jars had gone up heavily on account of usage of water in the water collecting pond that had been stagnating for a few days. An observed coincidence was the very low water levels in the Udawalawe reservoir on such occasions. Thus the water source itself seems to have a higher plankton level and could transmit the same to the hatchery jars where the macrozooplankton gets collected continuously as the crown net with considerably blocked meshes would accumulate the bigger plankton within the jar. The macrozooplankton mostly identified as *Thermocyclops sp*. appeared to attack the eggs and early hatchlings. The absence of a biofilter seems to have aggravated this problem.

(*d*) The collection of fry had been done manually and this had lead to considerable mortality. A simple mechanical device at the bottom of the hatchery jar could relieve the fry automatically to a net cage fixed at the central draining canal of the hatchery thus reducing chances of damage to fry.

6. **Other factors** : There has been a very reasonable relationship between the success of fish breeding trials and the strength of human resources available at the station for management. A study done (reported in 1980) on the staff position during various years clearly indicate that a thorough management policy made possible by a strong experienced staff had been able to bring about success in breeding considerably.

Suggestions :

The following are some suggestions which in the author's view might help to resol ve some of the problems encountered :

1. Adherence to a strict breeding schedule should be compulsorily observed. The breeding of Big head carp and Grass carp may be initiated only after September with the onset of heavy North-East monsoonal rains, Until then brooders may not be disturbed.

2. Gonadal studies in correlation to environmental cues to be undertaken methodically to establish proper breeding season.

3. Hatchery to be extended to ensure completion of mass scale breeding of stocks of each species during the period of peak maturity of the population (period — P Fig. 4).

4. The nine year old introduction' saddled with a limited gene pool may be rejuvenated by a simple introduction of new blood. For this, wild fry from the rivers of China might be chosen for a new brood stock.

5. Through a more scientific study proper feeds to be recommended for the raising of broodstock.

6. More attention to be paid in disease control of the broodstock.

7. A cross canal regulator across the main supply canal (RB canal) to be constructed in order to head up water above the spill evel of the sluice gates thus ensuring gravity fed water even during lean seasons.

8. Spawning pond to be converted to a circular one with an effective mechanism to collect eggs from natural fertilization.

9. Water supply to the water collecting pond and spawning pond to pass through barricades, sediment tanks and a biofilter ensuring quality water to the spawning pond and hatchery.

10. The hatchery jars to be modified to have an evacuation pipe at the bottom enabling fry to be collected mechanically into a net cage system.

11. Ensuiing use of estrualising agents of guaranteed quality.

12. Fortifying the strength of Aquaculture personnel at the Fisheries Station to ensure proper management.

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Wu Hsien Wen and Chung Ling — Progress and Achievements in the Artificial propagation of four farmfishes — Contribution at the 1964 Peking Symposium — 13 p.

Table 1. — INDUCED BREEDING OF GRASS CARP 1977 (UDAWALAWE F.W.S.)

Date	Species	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Number of Spawners Responded	No. of eggs	No. of fry	Remarks
2.3.77	Grass carp	♀	2	12.0	1) 2μg LRH/kg 2) 0.5 mg PG/kg.	20μg LRH + 1000 IU HCG/kg 2 mg PG + 1000 IU HCG/kg	1	560,000	220,000	Spawner subjected to HCG+ LRH hormonal treatment did not respond.
		♂	3	15.0		11μg LRH + 500 IU HCG/kg				
3.6.77	Grass carp	♀	2	11.5	0.3 mg PG/kg	2.7 mg PG + 1000 IU HCG/kg	2	700,000	110,000	Fertilization poor.
		♂	3	14.0		1.5 mg PG + 500 IU HCG/kg				

Table 2. — INDUCED BREEDING OF GRASS CARP 1978 (UDAWALAWE F.W.S.)

Date	Species	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Number of Spawners Responded	No. of eggs	No. of fry	Remarks
9.2.78	Grass carp	♀ ♂	4 8	36.7 60.0	0.5 mg PG/kg	2 mg PG + 500 IU HCG/kg 500 IU HCG /kg	2	1,092,000	181,875	Water level in the R.B. channal low. Pumps had to be used.
10.2.78	Grass carp	♀ ♂	3 5	25.5 38.0	0.5 mg PG/kg	2.5 mg PG + 500 IU HCG/kg 500 IU HCG + 0.5 mg PG/kg	3	1,925,000	738,000	—

Table 3. — INDUCED BREEDING OF GRASS CARP 1979 (UDAWALAWE F.W.S.)

Date	Species	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Number of Spawners Responded	No. of eggs	No. of fry	Remarks
8.2.79	Grass carp	♀	4	40.0	0.5 mg PG*/kg	1) 2.5 mg PG* + 1000 IU HCG/kg 2) 2.5 mg PG* + 22 μg LRH/kg 3) 20 μg LRH + 100 IU HCG/kg	1	21,000	—	3 died 1 was cut open 9 died
		♂	12	100.0		500 IU HCG/kg				
9.2.79	Grass carp	♀	2	16.5	0.5 mg PG*/kg	1) 2.5 mg PG* + 3 mg HCG/kg	1	7,000	—	Stripping gave about 10ml of eggs.
		♂	7	48.0		2) 4.5 mg PG*/kg 1 mg PG*/1.5 mg HCG/kg				
19.3.79	Grass carp	♀	2	21.5	0.5 mg PG*/kg	1) 2 mg PG*/ kg 2) 4 mg PG*/kg	1	10,500	—	3rd Injection given no response
		♂	3	21.0		2 mg PG*/kg				
20.3.79	Grass carp	♀	4	32.0	0.5 mg PG*/kg	1 & 2) 2 mgPG* + 3 mg HCG/kg 3) 4.5 mg PG*/kg 4) 2.5 mg PG* + 1000 IU HCG/kg	—	—	—	3rd Injection given at the rate of 3 mg HCG/kg, 4th injection given to two fish @ 1.5 mg HCG/kg. No response.
		♂	4	28.0		3 mg HCG/kg				
16.5.79	Grass carp	♀	2	14.0	0.5 mg PG*/kg	5 mg PG*//kg	—	—	—	No response
		♂	4	24.0		4 mg HCG/kg				
15.10.79	Grass carp	♀	3	30.3	4 Pieces of PG/fish	4 Pieces of PG/kg	0	—	—	PG is 3 years old
		♂	6	52.0		3 mg HCG/kg				
17.10.79	Grass carp	♀	3	26.0	4 Pieces of PG/fish	4 Pieces of PG/kg	2	1,127,000		Performance of male very poor.
		♂	7	54.0		3 mg HCG/kg				
18.10.79	Grass carp	♀	2	18.0	4 Pieces of PG/fish	4 Pieces of PG + 2 mg HCG/kg	2	1,050,000	278,000	PG collected from common carp harvested from a seasonal tank. Condition of fish not so satisfactory.
		♂	5	41.0		3 mg HCG/kg				
7.11.79	Grass carp	♀	2	22.0	4 Pieces of PG/fish	4 Pieces of PG + 1.5 mg HCG/kg	0	—	—	Condition of females not so satisfactory.
		♂	5	50.0		2 mg HCG + 2 pieces of PG/kg				
11.11.79	Grass carp	♀	3	32.0	4 Pieces of PG/fish	1) 36 Pieces of PG/fish 2) 20 Pieces of PG + 36 mg HCG/fish 3) 16 Pieces of PG + 30 mg HCG/fish	2	1,400,000	300,000	—
		♂	5	51.0		5 Pieces of PG + 15 mg HCG/fish				
15.11.79	Grass carp	♀	3	25.0	4 Pieces of PG/fish	1) 30 mg HCG/fish 2) 18 Pieces of PG/fish 3) 24 mg HCG/fish	0	—	—	Spawners used were entering over maturity stage.
		♂	7	35.0		3 mg HCG/kg				
28.11.79	Grass carp	♀ ♂	2 [illegible]	20.0 25.0	4 Pieces of PG/fish	2 Pieces of PG + 3mg HCG/kg 3 mg HCG/kg	0	—	—	Over matured features exhibited by the spawners.

Table 4 — INDUCED BREEDING OF GRASS CARP 1980 (UDAWALAWE F.W.S.)

Date	Species	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Number of Spawners Responded	No. of eggs	No. of fry	Remarks
3.11.80	Grass carp	♀	1	11.0	0.5 mg PG/kg	3.5 mg PG/kg	0	—	—	A third injection given but no response
		♂	2	20.0		1.0 mg PG/kg				
4.11.80	Grass carp	♀	1	10.0	1 mg PG/kg	4 mg PG/kg	0	—	—	Condition of female not so satisfactory
		♂	2	21.0		1 mg PG/kg				
15.12.80	Grass carp	♀	4	41.0	0.5 mg PG/kg	3 mg PG/kg	0	—	—	Performance of male was poor. Saline water used as a medium of fertilization.
		♂	5	48.0		1 mg PG/kg				
21.12.80	Grass carp	♀	4	40.0	1 mg PG/kg	3 mg PG/kg	2	840,000	20,000	—
		♂	8	70.0		1.5 mg PG/kg				

Table 5 — INDUCED BREEDING OF GRASS CARP 1981 (UDAWALAWE F.W.S.)

Date	Species	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Number of Spawners Responded	No. of eggs	No. of fry	Remarks
7.9.81	Grass carp	♀	5	50.0	10μg L HRH-A/fish	65μg L HRH-A+2mg PG/kg	5	2,400,000	146,575	Low rate of fertilization
		♂	8	80.0		40μg L HRH-A+1.5 mg PG/kg				
4.10.81	Grass carp	♀	3	28.0	10μg L HRH-A/fish	40μg L HRH-A+2mg PG/kg	2	1,000,000	—	Poor fertilization
		♂	5	47.0	10μg L HRH-A/fish	30μg L HRH-A/kg				
21.10.81	Grass carp	♀	4	42.0	10μg L HRH-A/fish	50μg L HRH-A+1.5 mg PG/kg	3	600,000	10,000	Performance of male poor.
		♂	5	42.0	10μg L HRH-A/fish	50μg L HRH-A/kg				
02.11.81	Grass carp	♀	4	43.0	10μg L HRH-A/fish	40μg L HRH-A+1.5 mg PG/kg	3	2,200,000	196,000	—
		♂	4	38.0	10μg L HRH-A/fish	59μg L HRH-A/kg				

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Table 6 — INDUCED BREEDING OF GRASS CARP 1982 (UDAWALAWE F.W.S.)

Date	Species	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Number of Spawners Responded	No. of eggs	No. of fry	Remarks
22.6.82	Grass carp	♀	4	43.0	10μg L HRH-A/fish	50μg L HRH-A+2mg PG/kg	4	3,000,000	300,000	Poor fertilization
		♂	5	40.0		40μg L HRH-A/kg				
25.9.82	Grass carp	♀	3	30.0	10μg L HRH-A/fish	50μg L HRH-A+3mg PG/kg	3	800,000	10,000	Low water level in the R.B. Channal. Water had to be pumped.
		♂	5	40.0		40μg L HRH-A/kg				
15.11.82	Grass carp	♀	3	33.0	10μg L HRH-A/fish	50μg L HRH-A+2.5mg PG/kg	3	1,080,000	308,000	—
		♂	5	30.0		40μg L HRH-A/kg				
17.11.82	Grass carp	♀	4	36.0	10μg L HRH-A/fish	10μg L HRH-A+2mg PG/kg	3	2,700,000	—	Breeding practiced by trainees. 3 spawned. 4th given 3rd injection 60μg L HRH-A/kg. After 2 days all suffered mortality.
		♂	4	36.0		50μg L HRH-A/kg				
22.11.82	Grass carp	♀	3	38.0	10μg L HRH-A/fish	50μg L HRH-A+1 mg PG/kg	1	900,000	—	Only one spawned. The rest given 3rd injection @ 400 IU HCG + 4.5mg PG/kg.
		♂	5	35.0		50μg L HRH-A/kg				
24.11.82	Grass carp	♀	2	12.0	10μg L HRH-A/fish	40μg L HRH-A+2.25mg PG/kg	1	300,000	84,000	—
		♂	2	14.0		30μg L HRH-A/kg				
25.11.82	Grass carp	♀	1	10.0	10μg L HRH-A/fish	50μg L HRH-A+2.25mg PG/kg	1	1,260,000	364,000	—
		♂	2	15.0		40μg L HRH-A/kg				
29.11.82	Grass carp	♀	2	15.0	10μg L HRH-A/fish	1) 50μg L HRH-A+2mg PG/kg	2	3,200,000	140,000	Lower fertilization rate.
						2) 60μg L HRH-A+2mg PG/kg				
		♂	4	25.0		1 & 2) 30μg L HRH-A/kg				
						3) 40μg L HRH-A/kg				
9.12.82	Grass carp	♀	3	25.0	10μg L HRH-A/fish	50μg L HRH-A+2mg PG/kg	2	1,700,000	56,000	Lower fertilization rate.
					15μg L HRH-A/fish	60μg L HRH-A+1.5mg PG/kg				
		♂	5	30.0		30—40μg L HRH-A+1 mg PG/kg				
13.12.82	Grass carp	♀	3	26.0	5-15μg L HRH-A/fish	1) 15μg L HRH-A+400 IU HCG+1mg PG/kg	0	—	—	—
						2) 20μg L HRH-A+500 IU HCG+1.5 mg PG/kg				
						3) 30μg L HRH-A+600 IU HCG+2 mg PG/kg				

Table 7 — INDUCED BREEDING OF GRASS CARP 1983 (UDAWALAWE F.W.S.)

Date	Species	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Number of Spawners Responded	No. of eggs	No. of fry	Remarks
3.10.83	Grass carp	♀	2	14.3	30µg L HRH-A/big fish 25µg L HRH-A/small fish	60µg L HRH A+700 IU HCG+ 2 pieces of PG/kg	1	50,000	—	—
		♂	4	30.3	15µg L HRH-A/big fish 10µg L HRH-A/small fish	30µg L HRH-A+350 IU HCG+ 1 piece of PG/kg				
1.11.83	Grass carp	♀	2	21.0	20µg L HRH-A/fish	50µg L HRH-A+200 IU HCG+ ½ piece of PG/kg	1	720,000	—	Low water level in the R.B. channal.
		♂	2	18.0	10µg L HRH-A/fish	25µg L HRH-A+100 IU HCG+ ¼ piece of PG/kg				
6.12.83	Grass carp	♀	7	72.0	1 &2) 4 Pieces of PG/fish 3-7) 15µg LRH-A/fish	4 Pieces of PG/kg 50µg L HRH-A+1 piece of PG/kg	5	2,000,000	540,000	—
		♂	10	52.0	7.5µg L HRH-A/fish	25µg L HRH-A+½ piece of PG/kg				
12.12.83	Grass carp	♀	7	103.5	15µg L HRH-A/fish	50µg L HRH-A+1 piece of PG/kg	7	1,850,000	45,000	—
		♂	10	93.5	7.5µg L HRH-A/fish	25µg L HRH-A+½ piece of PG/kg				
15.12.83	Grass carp	♀	5	38.0	10µg L HRH-A/fish	40µg L HRH-A+1 mg PG/kg	4	1,430,000	100,000	—
		♂	6	40.0		20µg L HRH-A+0.5 mg PG/kg				
21.12.83	Grass carp	♀	5	52.5	10µg L HRH-A/fish	40µg L HRH-A+1.5 mg PG/kg	5	1,300,000	—	—
		♂	7	60.0		20µg L HRH-A+0.75 mg PG/kg				

Table 8 — INDUCED BREEDING OF BIG HEAD CARP 1978 (UDAWALAWE F.W.S.)

Date	Species	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Number of Spawners Responded	No. of eggs	No. of fry	Remarks
4.6.78	Big Head carp	♀	4	48.0	0.6 mg PG/kg	3 mg PG + 1000 IU HCG/kg	4	3,900,000	409,440 +358,960	Out of this, one female was subjected: to hybridisation using silver carp male — number of fry 358,960
		♂	6 BH 2 SC	96.0		1000 IU HCG/kg				
10.8.78	Big Head carp	♀	4	48.0	0.5 mg PG/kg	3 mg PG + 1000 IU HCG/kg	4	4,235,000	788,000	Successfully done in the peak of drought. Selection of spawners was done from 3 ponds.
		♂	6	72.0		500 IU HCG/kg				

Table 9 — INDUCED BREEDING OF BIG HEAD CARP 1979 (UDAWALAWE F.W.S.)

Date	Species	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Number of Spawners Responded	No. of eggs	No. of fry	Remarks
21.3.79	Big Head carp	♀	2	23.0	0.5 mg PG*/kg	0.5 mg PG + 4 mg HCG/kg	1	300,000	—	A third and a fourth injection was tried out but no response. All fishes died on 23rd. Temperature at the hatchery went over 31.5°C
		♂	6	70.0		2 mg HCG/kg				
21.6.79	Big Head carp	♀	2	26.0	4 Pieces of PG/fish	2 mg PG + 4 mg HCG/kg	1	1,200,000	20,000	Low fertilization rate
		♂	5	50.0		3 mg HCG/kg				
22.6.79	Big Head carp	♀	3	39.0	4 Pieces of PG/fish	2 mg PG + 4 mg HCG/kg	2 1	1,500,000	245,000	Low fertilization rate
		♂	5	50.0		3 mg HCG/kg				
12.7.79	Big Head carp	♀	2	26.0	4 Pieces of PG/fish	2 mg PG + 4 mg HCG/kg	1	300,000	70,000	—
		♂	6	78.0		3 mg HCG/kg				

Table 10 — INDUCED BREEDING OF BIG HEAD CARP 1980 (UDAWALAWE F.W.S.)

Date	Species	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Number of Spawners Responded	No. of eggs	No. of fry	Remarks
11.10.80	Big Head carp	♀	2	24.0	0.5 mg PG/kg	3.5 mg PG/kg	1	1,080,000	165,000	Performance of male poor. Water level in the reservoir and R.B. channal low.
		♂	4	38.0		1 mg PG/kg				
30.10.80	Big Head carp	♀	3	31.0	1 mg PG/kg	3 mg PG/kg	2	1,200,000	180,000	Water issues in the R.B. channal low.
		♂	7	60.0		1 mg PG/kg				

Table 11 — INDUCED BREEDING OF BIG HEAD CARP 1981 (UDAWALAWE F.W.S.)

Date	Species	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Number of Spawners Responded	No. of eggs	No. of fry	Remarks
14.9.81	Big head carp	♀	1	15.0	10μg L HRH-A/fish	10μg L HRH-A + 600 IU HCG + 1 mg PG/kg	1	1,000,000	504,000	—
		♂	2	20.0		10μg L HRH-A + 600 IU HCG + 1 mg PG/kg				
17.9.81	Big head carp	♀	3	30.0	10μg L HRH-A/fish	10μg L HRH-A + 600 IU HCG/kg + 1 mg PG/kg	3	1,800,000	861,000	Low water issues in the R.B. channal. Water muddy due to rains. (16.9.83—25.4 mm)
		♂	5	50.0		10μg L HRH-A + 600 IU HCG/kg				
21.9.81	Big head carp	♀	3	33.0	10μg L HRH-A/fish	10μg L HRH-A + 600 IU HCG + 1 mg PG/kg	1	600,000	20,000	Heavy macrozooplankton load in the hatchery. RB channal low water level. Water stagnating in the water collecting pond had to be used.
		♂	5	52.0	10μg L HRH-A/fish	10μg L HRH-A + 600 IU HCG/kg				
22.9.81	Big head carp	♀	3	30.0	10μg L HRH-A/fish	24μg L HRH-A + 600 IU HCG + 1.2 mg PG/kg	3	3,000,000	1,471,000	Low water issues in the R.B. channal
		♂	5	50.0		28μg L HRH-A + 100 IU HCG + 1 mg PG/kg				
2.10.81	Big head carp	♀	5	50.0	10μg L HRH-A/fish	30μg L HRH-A + 600 IU HCG + 1 mg PG/kg	3	1,000,000	100,000	Insufficient milt.
		♂	14	98.0		20μg L HRH-A + 600 IU HCG/kg				
6.10.81	Big head carp	♀	3	31.0	10μg L HRH-A/fish	10μg L HRH-A + 600 IU HCG + 0.5 mg PG/kg	2	900,000	225,000	—
		♂	6	55.0	10μg L HRH-A/fish	10μg L HRH-A + 600 IU HCG/kg				

Table 12 — INDUCED BREEDING OF BIG HEAD CARP 1982 (UDAWALAWE F.W.S.)

Date	Species	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Number of Spawners Responded	No. of eggs	No. of fry	Remarks
14.10.82	Big head carp	♀	3	25.0	10μg L HRH-A/fish	10μg L HRH-A+850 IU HCG + 2 mg PG/kg	2	850,000	280,000	—
		♂	5	35.0		10μg L HRH-A+850 IU HCG/kg				
16.10.82	Big head carp	♀	1	12.0	10μg L HRH-A/fish	10μg L HRH-A+1000 IU HCG + 3 mg PG/kg	1	980,000	266,000	Power failure and malfunctioning of water pumps. Hence problem of renewal of water.
		♂	3	29.0		10μg L HRH-A+850 IU HCG/kg				
25.10.82	Big head carp	♀	2	13.0	10μg L HRH-A/fish	10μg L HRH-A+1000 IU HCG + 2.5 mg PG/kg	2	800,000	336,000	—
		♂	4	20.0		10μg L HRH-A+1000 IU HCG/kg				
26.10.82	Big head carp	♀	3	18.0	10μg L HRH-A/fish	10μg L HRH-A+850 IU HCG + 2 mg PG/kg	3	1,200,000	700,000	—
		♂	6	30.0		10μg L HRH-A+800 IU HCG/kg				
01.11.82	Big head carp	♀	3	18.0	10μg L HRH-A/fish	10μg L HRH-A+1200 IU HCG + 15 mg PG/kg	3	2,400,000	336,000	Quantity of milt insufficient.
		♂	7	45.0		10μg L HRH-A+900 IU HCG + 0.5 mg PG/kg				

Table 14 INDUCED BREEDING OF BIG HEAD CARP 1983 (UDAWALAWE F.W.S.)

Date	Spec:es	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Spawners Responded	No. of eggs	No. of fry	Remarks
19.12.83	Silver carp	♀	9	51.kg	1 00 IU HCG/kg	—	9	26,10,000	601,000	First induced breeding of Silver carp in Sri Lanka.
		♂	10	41.5kg	600 IU HCG/kg 800 IU HCG/kg					
24.12.83	Silver carp	♀	8	49.51kg	1200-1400 IU HCG/kg	—	8	1,900,000	530,000	mortality of males high due to physical damage.
		♂	9	45.00kg	600-800 IU HCG/k &					

P.G. — Pituitεry gland of common carp
P.G.* — Pituitary gland of pig
HCG — Human chorionic gonadotropin
LRH — Luteinizing hormone releasing hormone
LHRH-A— Luteneinizing hormone releasing hormone-analogue.

Table 13—INDUCED BREEDING OF BIG HEAD CARP 1983 (UDAWALAWE F.W.S.)

Date	Species	Sex	Number	Total Weight (Kg)	1st Injection (dosage)	2nd Injection (dosage)	Number of Spawners Responded	No. of eggs	No. of fry	Remarks
27.09.83	Big head carp	♀	5	27.0	20μg L HRH-A/fish	22μg L HRH-A+1200 IU HCG + 1 mg PG/kg	5	2,000,000	890,000	Water area in the reservoir was ¼ the FSL area. Water had to be pumped from the supply cana l.
		♂	7	58.0	10μg L HRH-A fish	11μg L HRH-A+600 IU HCG + 0.5 mg PG/kg				
03.10.83	Big head carp	♀	4	32.4	1) 25μg L HRH-A/fish 2) 3) 30μg LHRH-A/fish 4)	20μg L HRH-A+1000 IU HCG + 1 piece of PG/kg	4	2,110,000	450,000	Low water level in the reservoir and R.B. channal. Filamentous algae get collected in the hatchery jars.
		♂	6	35.4	10μg L HRH-A/small fish 15μg L HRH-A/big fish	10μg L HRH-A+500 IU HCG 1 ½ piece of PG/kg				
18.10.83	Big head carp	♀	3	16.0	15μg L HRH-A/fish	20μg LRH-A+1000 IU HCG + 1 piece of PG/kg	3	1,000,000	260,000	Low water levels in the reservoir and R.B. channel.
		♂	4	26.0	7.5μg L HRH-A/fish	10μg L HRH-A+500 IU HCG + ½ piece of PG/kg				
19.10.83	Big head carp	♀	4	25.8	15μg L HRH-A/fish	15μg L HRH-A+1200 IU HCG + 1 piece of PG/kg	4	2,300,000	625,000	Low water level in the reservoir and the R.B. channel.
		♂	5	26.6	7.5μg L HRH-A/fish					
26.10.83	Big head carp	♀	4	29.0	15μg L HRH-A/fish	20μg L HRH-A+1200 IU HCG + 1 piece of PG/kg	4	2,000,000	630,000	Low water level in the R.B. channel.
		♂	6	25.0	7.5μg L HRH-A/fish	10μg L HRH-A+600 IU HCG + ¾ piece of PG/kg				
01.11.83	Big head carp	♀	1	11.5	15μg L HRH-A/fish	15μg L HRH-A+1200 IU HCG + 1 piece of PG/kg	1	400,000	80,000	Low water level in the R.B. channel.
		♂	2	12.0	7.5μg L HRH-A/fish	7.5μg L HRH-A+600 IU HCG + ½ piece of PG/kg				
3.11.83	Big head carp	♀	10	28.5	15μg L HRH-A/fish	10μg L HRH-A+850 IU HCG + 0.5 mg PG/kg	10	2,000,000	490,000	Low water level in the R.B. channel. Brood stock from Old station.
		♂	12	32.5	10μg L HRH-A/fish	5μg L HRH-A+400 IU HCG + 0.25 mg PG/kg				
9.11.83	Big head carp	♀	5	17.5	10μg L HRH-A/fish	10μg L HRH-A+800 IU HCG + 0.5 mg PG/kg	5	1,200,000	427,500	Low water level in the R.B. channel. Brood stock from Old Station.
		♂	8	26.0	5μg L HRH-A/fish	5μg L HRH-A+400 IU HCG + 0.25 mg PG/kg				
10.11.83	Big head carp	♀	1	8.5	10μg L HRH A/fish	10μg L HRH-A+1200 IU HCG + 1 mg PG/kg	1	—	—	Spawned in the spawning pond itself. The eggs got spoilt.
		♂	1	7.5		10μg L HRH-A+1000 IU HCG/kg				
15.11.83	Big head carp	♀	3	19.0	15μg L HRH-A/fish	10μg L HRH-A+1000 IU HCG + 0.5 mg PG/kg	3	1,000,000	448,000	Low water level in the R.B. channel.
		♂	4	21.0	7.5μg L HRH-A/fish	5μg L HRH-A+500 IU HCG + 0.25 mg/kg				
29.11.83	Big head carp	♀	10	50.5	15μg L HRH-A/fish	15μg L HRH-A+800 HCG + 0.5 mg PG/kg	9	2,000,000	460,000	Low water level in the R.B. channel.
		♂	10	77.5	7.5μg L HRH-A/fish	7.5μg L HRH-A+400 IU HCG + 0.25 mg PG/kg				

TABLE 15 — Certain combinations of feed given to the brood stock of Chinese carps (Udawalawe Freshwater Fisheries Station) (Fish stocked at the rate of about 300 kg/1700 m^2 pond)

Type	Feed	Amounts of feed		
		Grass carp	Bighead carp	Silver carp
1.	Grass	40 kg.	—	—
	Poonac crumbs (Coconut residue cake)	5 kg.	—	—
	Poonac (powder)	—	3 kg.	—
2.	Grass	40 kg.	—	—
	Liquid cowdung	—	2 buckets/week (M)	2 buckets/week (M)
	Poonac powder	—	2 kg.	2 kg.
3.	Grass	40 kg.	—	—
	Soya bean powder	2 kg.	2 kg.	2 kg.
	Poonac powder	2 kg.	2 kg.	2 kg.
4.	Grass	45 kg.	—	—
	Paddy seedling	2 kg.	—	—
	Rice bran powder	1·5 kg.	2 kg.	2 kg.
	Soya bean milk	2 kg.	2 kg.	—
	Poonac powder	2 kg.	4 kg.	4 kg.
5.	Grass	40 kg.	—	—
	Paddy seedling	2 kg.	—	—
	Soya bean powder	1 kg.	2 kg.	2 kg.
	Rice bran powder	—	2 kg.	2 kg.
	poonac powder	4 kg.	3 kg.	3 kg.
	Vitamin E.	500 mg.	300 mg.	300 mg.

When fine feed is given to the Grass carp it is soaked in water. Sometimes made into a dough and fed.

Further to this Leybes, molac had been also used at different times.

TABLE 16 Types of Estualising agents used in mass scale induced breeding of carps in Sri Lanka

Type	C.C	B.H.C.	G.C.	S.C.	L.r	C.m.	L.d
P.G. Common carp	√	√	√	√	√	√	√
P.G. Indian major carp	√	—	—	—	√	√	√
P.G. Puntius sarana	—	—	—	—	—	—	√
P.G. Labeo dussumeiri	—	—	—	—	—	—	√
P.G. Crucian carp	—	√	√	—	√	—	√
P.G. Tilapia nilotica	—	—	—	—	—	—	×
P.G. (Pigs) Accidentally used	—	×	×	—	—	—	×
HCG	√	√	×	√	—	—	×
HCG + PG (CC)	√	√	√	√	—	—	√
LRH	—	—	×	—	—	—	—
LRH — A	√	—	—	—	—	—	—
LRH + PG (CC)	—	—	×	—	—	—	—
LRH—A + PG (CC)	√	√	√	√	—	—	—
LRH-A+HCG+PG(CC)	—	√	√	—	—	—	—

Method of injection :

Single injection	√	—	—	√	√	√	√
Double injection	√	√	√	√	√	√	√

Legend :

CC — Common carp
B.H.C — Bighead carp
G.C. — Grass carp
P.G. — Pituatary glands
HCG — Human chorionic gonadotropin
LRH — Luteinizing hormone releasing hormone
LRH-A — Luteinizing hormone releasing hormone analogue
P.G. (CC) — Common carp pituitary gland

SC —Silver carp
L.r —**Labeo rohita**
C.m —**Cirrhinus mrigala**
L.d.—**Labeo dussumeiri**

√ Successful X—Unsuccessful — Not tried out yet

TABLE 17 — Summerised data on the induced breeding trials of Chinese carps Udawalawe Fisheries Station

Year	Total population of spawners		Total number of spawners injected		% of spawners injected		Total number of spawners responded		% of spawners responded		Total number of fry	
	GC	BH	GC	BH	GC	BH	GC	BH	GC	BH	Grass carp	Bighead carp
1977	30	—	4	—	13.3	—	3	—	10	—	330,000	—
1978	45	45	7	8	15.5	17.8	5	8	11.1	17.8	919,875	1,556,000
1979	58	60	32	9	55.1	15.0	4	5	6.8	8.3	578,000	335,000
1980	47	64	10	5	21.2	7.8	2	3	4.00	4.6	20,000	345,000
1981	63	42	16	18	25.4	42.8	11	13	17.4	30.9	352,575	3,181,000
1982	37	33	28	12	75.6	36.4	16	11	43.2	33.4	1,262,000	1,918,000
1983	37	70	28	50	75.6	71.4	16	49	43.2	70.0	685,000	4,808,500
Total :	317	314	1 25	102	39.43	32.5	57	89	18.0	28.3	4,147,450	12,143,500

TABLE 18 — Data on monthly average rainfall and percentage of matured spawners of Chinese carp in each month (1977-1983)

Year	Month / % Monthly Rain fall	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
1977	MARF	—	126.41	105.41	255.02	92.96	9.65	2.54	49.02	17.27	301.24	445.77	194.05
	% of matured spawners—GC	—	—	3.3	—	—	—	—	—	—	—	—	—
	% of matured spawners—BHC	—	—	—	—	—	—	—	—	—	—	—	—
1978	MARF	61.98	104.01	204.02	223.76	324.98	10.16	5.08	94.23	—	209.79	373.35	102.37
	%—GC	—	11.1	—	—	—	—	—	—	—	—	—	—
	%—BHC	—	—	—	—	—	8.9	—	8.9	—	—	—	—
1979	MARF	—	179.83	—	152.66	146.30	23.88	14.35	7.11	164.58	186.96	331.82	209.31
	%—GC	—	—	—	—	—	—	—	—	—	3.4	3.4	—
	%—BHC	—	—	—	—	—	6.7	1.7	—	—	—	—	—
1980	MARF	—	11.68	56.89	193.04	75.95	10.92	—	—	17.01	161.53	214.62	164.08
	%—GC	—	—	—	—	—	—	—	—	—	—	—	4.3
	%—BHC	—	—	—	—	—	—	—	—	—	4.7	—	—
1981	MARF	23.88	46.74	75.44	247.38	98.04	34.03	11.44	44.97	109.47	94.50	311.12	96.51
	%—GC	—	—	—	—	—	—	—	—	7.9	4.8	4.8	—
	%—BHC	—	—	—	—	—	—	—	—	19.0	11.9	—	—
1982	MARF	1.52	68.07	217.41	201.16	315.21	128.01	25.39	74.68	6.35	309.12	369.07	88.25
	%—GC	—	—	—	—	—	10.8	—	—	8.1	—	19.0	5.4
	%—BHC	—	—	—	—	—	—	—	—	—	24.2	9.0	—
1983	MARF	16.51	14.48	48.26	35.81	165.86	—	16.94	10.67	56.13	240.53	214.89	308.37
	%—GC	—	—	—	—	—	—	—	—	—	—	—	43.2
	%—BHC	—	—	—	—	—	—	—	—	7.14	21.4	41.4	—

Note : Percentage maturity has been taken as the number of spanwers that sucessfully responded to induced breeding against the total population of spawners expressed as a percentage.

MARF — Monthly Average rainfall in mm.

TABLE 19 — Data on the monthly rain fall, monthly water level in the reservoir and the percentage of maturity of spawners (1977 — 1983)

Month	(A) Rain fall monthly av. m.m	(B) Water level in the reservoir, feet (Av)	(C) Matured spawner monthly; percntage	
			GC	BHC
January	14·84	285·36	—	—
February	78·79	282·20	1·5	—
March	106·20	279·43	0·3	—
April	186·98	282·42	—	—
May	174·10	285·67	—	—
June	30·95	285·50	1·8	2·54
July	10·82	280·52	—	0·3
August	26·64	273·95	—	1·27
September	66·43	269·58	2·5	4·1
October	214·81	272·01	1·5	9·8
November	323·06	280·54	3·8	10·5
December	166·13	287·08	6·3	—

(A) — Overall average of rainfall in m.m. in each month over a period of 7 years (1977—1983) (Based on data from MASL — WALAWE).

(B) — Overall average of water level in the Udawalawe reservoir (Feet above mean sea level) in each month over a period of 7 years (1977—1983) (Based on data from MASL — WALAWE).

(C) — The number of spawners that responded to induced breeding in each month over a period of 7 years (1977—1983) against the total number of spawners maintained over the same period expressed as a percentage.

TABLE 20 — **Some climatic data based on three years records showing the pattern of monthly variations at Udawalawe (based on records from MASL—Walawe)**

Month	*Max temp. av.*	*Mini. temp. av.*	*Mean av.*	*Pan evaporation*	*Sun shine*	*Wind velo city*	*Relative humidity (morning)*	*Relative humidity (evening)*	*Mean R.H.*	*Av. rain fall*
January	32·6	21·1	26·85	4·78	6·8	4·4	84·3	67·7	75·9	61·98
Feb.	33·5	21·6	27·55	5·72	8·15	5·51	82·0	69·0	75·5	98·5
March	33·4	22·5	27·95	6·02	8·2	3·9	82·7	61·3	71·9	86·97
April	33·3	23·5	28·35	4·5	5·7	3·2	83·3	76·0	79·65	189·82
May	33·3	24·0	28·68	4·68	6·6	5·6	82·3	76·3	79·3	182·21
June	33·1	23·3	28·2	5·94	6·5	12·8	74·7	66·0	70·35	14·9
July	33·0	24·6	28·8	6·4	6·7	15·52	71·7	65·7	68·7	6·47
August	33·5	24·3	28·9	6·7	8·0	14·68	69·7	62·0	65·85	2·37
September	32·9	24·0	28·48	5·16	6·05	11·5	74·5	77·0	75·8	91·94
Oct.	32·2	23·1	27·65	5·17	6·95	5·8	79·0	76·5	77·8	186·1
Nov.	31·0	22·3	26·7	3·4	3·7	3·53	85·5	82·5	84·0	306·6
Dec.	31·5	22·0	26·75	4·1	6·3	3·71	85·5	77·0	81·3	158·6

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OBSERVATIONS ON THE DEVELOPMENT OF EGGS AND MORTALITY OF LARVAE OF GRASS CARP AT HIGHER TEMPERATURE

D. E. M. Weerakoon*

1. INTRODUCTION

Ctenopharyngodon idella val. (grass carp) is a warm water fish, the brood fish exhibiting the best spawning behaviour between a temperature range of 26°C and 30°C (Ling and Hsienwen, 1963). The viable tolerance range for incubation and hatching according to them was between 22°C and 29°C Induced spawning of Grass carp was carried out in Sri Lanka, for the first time, during the months of February, March and June 1977. The air temperature during these months ranged between 32°C and 34°C.. The water temperature in a pond filled to maximum capacity during these months ranged between 30°C and 32°C. On the other hand, the water temperature, in the nursery pond, in which the water level is kept low (generally 2-3 ft.), goes considerably higher during these months, ranging between 32°C and 34°C. Further to this, between February and August, in the absence of rain, the water in the overhead tank which supplies water to the hatchery, warms up considerably, the temperature reaching 33°C to 34°C. In view of this, the present work was carried out in order to determine the viability of the eggs, and larvae of different females after spawning at varying temperatures, by studying the incubation and hatching of eggs and mortality of larvae.

2. MATERIALS AND METHODS

2.1 Incubation and Hatching :

Immediately after, mixing of eggs and milt in an enamel basin at the spawning site, 3 batches each containing 200 eggs were placed in three 12 l plastic containers with water, and in two of these the temperature, was gradually raised by means of thermostats to 32°C (Tank No. 2) and 33°C (Tank No. 3) within a time interval of 2 hours. In the remaining tank (Tank No. 1) the water temperature corresponded to the average water temperature of the laboratory, which was 28°C.

In tanks 2 and 3 the water was kept aerated and half volume of water was siphoned out every 3h, and replenished with freshwater pre-heated to the temperature desired for the experiment. In Tank No. 1, the water was kept aerated. The eggs were observed periodrically to detect progress in development and the embryonic axis formation was taken to be an indicator of incubation or fertilization. These experiments were carried out, in triplicate, for eggs of 3 females (nos. 1, 2 and 4) chosen at random. The hatchery in the field consisted of 8 cylindrical polypropylene jars, each having an inner diameter of 145 cm. and a height of 94 cm. (Figure 1). Each was provided with five peripheral openings directed at angles at the bottom, besides a central opening. These openings helped to keep water circulating in the jar during hatching of eggs. A crown or net frame made of polypropylene (See figure 1) fits snugly on to a circular wedge situated on the inside, about one foot from the top of the hatchery jar. The crown is covered with nylon netting (60-80 meshes per cm.). The crown prevents the eggs from getting out of the jar while allowing excess water to run through the net into the vertical outlet. The excess water is led out through an outlet on one side of the hatchery jar. This arrangement ensured a continuous supply of dissolved oxygen to the eggs and the hatching larvae.

2.2 Effect of temperature on the mortality of larvae :

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Two sets of larvae were collected from the hatchery jars from among the newly hatched healthy larvae of females (1) and these were placed in 12 l. containers with water. In one container (Tank no. 4) the larvae were subjected to a 5°C rise in temperature within two hours and the temperature was held constant thereafter at 33°C by means of thermostats. The other set of larvae were kept in tank no. 5 in which the water temperature was 28°C, the ambient temperature. The water was kept well aerated and the O_2 concentration maintained at 4 ppm. Mortality of larvae was observed in both containers every ½ hr. at the beginning of the experiment and later the time interval between observations of mortality was staggered depending on the frequency of mortality. This was carried out for a total period of 96 hrs. The same process was repeated for larvae of females (2 and 4). From the time of complete absorption of yolk to the end of the 2nd day, the larvae were fed with previously soaked and crushed soya bean, till the termination of the experiment. This experiment was carried out in triplicate, for larvae of all 3 females.

3. RESULTS

3.1 Development of eggs at different temperature :

From the experiments it was evident that there was no significant difference in time taken for the embryonic axis formation (fertilization) in the eggs of the 3 females at the three temperatures and those in the hatchery jars in the field. The embryonic axis formed 6-7 hours after mixing of eggs with milt in all four females. At 28°C, the percentage of development of the embryonic axis did not differ very much with that of the eggs in the hatchery jars in all 3 females, as is evident from Figure 2. Compared to the eggs in tanks maintained at 28°C and in the hatchery jars the percentage of the development of embryonic axis in eggs of all females in the tanks maintained at 32°C and 33°C was much lower, the lowest exhibited by eggs of female 2.

There was wide variation in the percentage of hatching of eggs of the females at the 3 temperatures and in the hatchery jars. The hatching percentage of the eggs of the 3 females at 28°C was not significantly different from the percentage hatching of the eggs of the 3 females in the hatchery jars (Figure 3). The lowest hatching percentage was exhibited by female 4 eggs, in these two cases. The eggs, of females hatched at 32°C and 33°C were all deformed. The deformities are shown in Figure 3.

3.2 Effect of temperature on larvae :

In the present study, a larvae is defined as that stage in the life-history which is between the immediate hatching of eggs to the time of complete absorption of the yolk. According to Figure 4, mortality of larvae at 28°C and 33°C, of all three females, increased with increase in time. The mortality of eggs of all three females at 33°C was much higher and significant than at 28°C. Of the three females, the eggs of female 4 exhibited the highest mortality at 28°C and 33°C. In all the females the mortality of larvae levelled off on the 4th day.

4. DISCUSSION

From the results it is seen that although higher temperature tends to bring about an accleration of the hatching process the development of the embryo becomes abnormal after the formation of the embryonic axis, resulting in deformation of larvae which hatch out. Apart from dissolved oxygen content, temperature is one of the most important factors which exercises a marked influence on the rate of development of eggs and hatching of larvae in fish, as it directly acts on the ontogenic events in the development process. Within certain limits, low temperatures seem to prolong development from fertilization to hatching, while higher temperatures seem to accelerate the process. (Apstein, 1909).

The upper limit beyond which normal development of grass carp eggs was affected was over 32°C, according to the present experiments. At the higher temperatures of 32°C and 33°C lethal effects were observed

10 hrs. after mixing of eggs and sperm i.e. with the begining of the development of the gastrula stage. As the gastrula developed, the anterior region, of the yolk sac, enlarged more like an inflated baloon as shown in Figure 5D. The dorsal side (notocord) was bent inwards showing that there was unequal growth towards the ventral side of the developing larvae (Figure 5D). The larvae in this stage of development were still alive and exhibited movements shown by normal larvae. In normal developing larvae, there was a gradual utilization of yolk in the yolk-sac which was clearly evident as the yolk-sac changed from an oval form (early gastrula stage) to a spindle shaped form in the larvae which came out of the egg-sac. The fact that this change did not occur in abnormally developed larvae at higher temperatures is evident from the enlarged anterior bulbous form of the larvae which hatched out at 33°C (Figure 5D) This shows that normal utilization of yolk had not taken place as a result of the effect of higher temperature.

Jones (1972) working with turbot larvae and Blaxter and Hemphel (1963), working with herring larvae have shown that, at different temperatures the percentage mortality equals 100 after the complete exhaustion of yolk-sac under continued starving conditions. In the present study with grass carp larvae the percent survival levelled at a certain time on the 3rd day, as the larvae were fed with finely crushed soya beans soaked in water overnight. The mortality of larvae at 28°C could have been due to some of the reasons described by Blaxter (1968). The larvae which died at the higher temperature had curved dorsal regions (Figure 4). Similar observations were reported by Shelbourne (1956) for plaice embryos. The abnormal skeletal deformities was described to be as a result of improper fusion of mesoderm and ectoderm to form the central part of the body wall, due to the improper utilization of yolk by the growing tissues (Shelbourne 1956). Schaperclaus (1954), has indicated that different forms of abnormal skeletal deformities may be due to hereditary factors.

In the case of mortality experiments with larvae, (Figure 5F), the higher temperature would have acted directly on the weak progeny as early as at the onset of the experiments thereby causing more deaths than that would have been effected at lower temperatures. Mortality of larvae were observed at lower temperatures also. The number of mortalities of larvae in different females could be hereditary related as suggested by Schaperclaus (1954).

More inferences, on the observations made here, could not be drawn as the experiment itself was of a limited nature, in that, only eggs and larvae of three females were studied. Further studies on the development of eggs and mortality of larvae at varying temperatures in a number of different females after spawning, should be made, if one is to use this method as a key to selection of effective and viable spawners, especially when they are being used continuously, over long periods.

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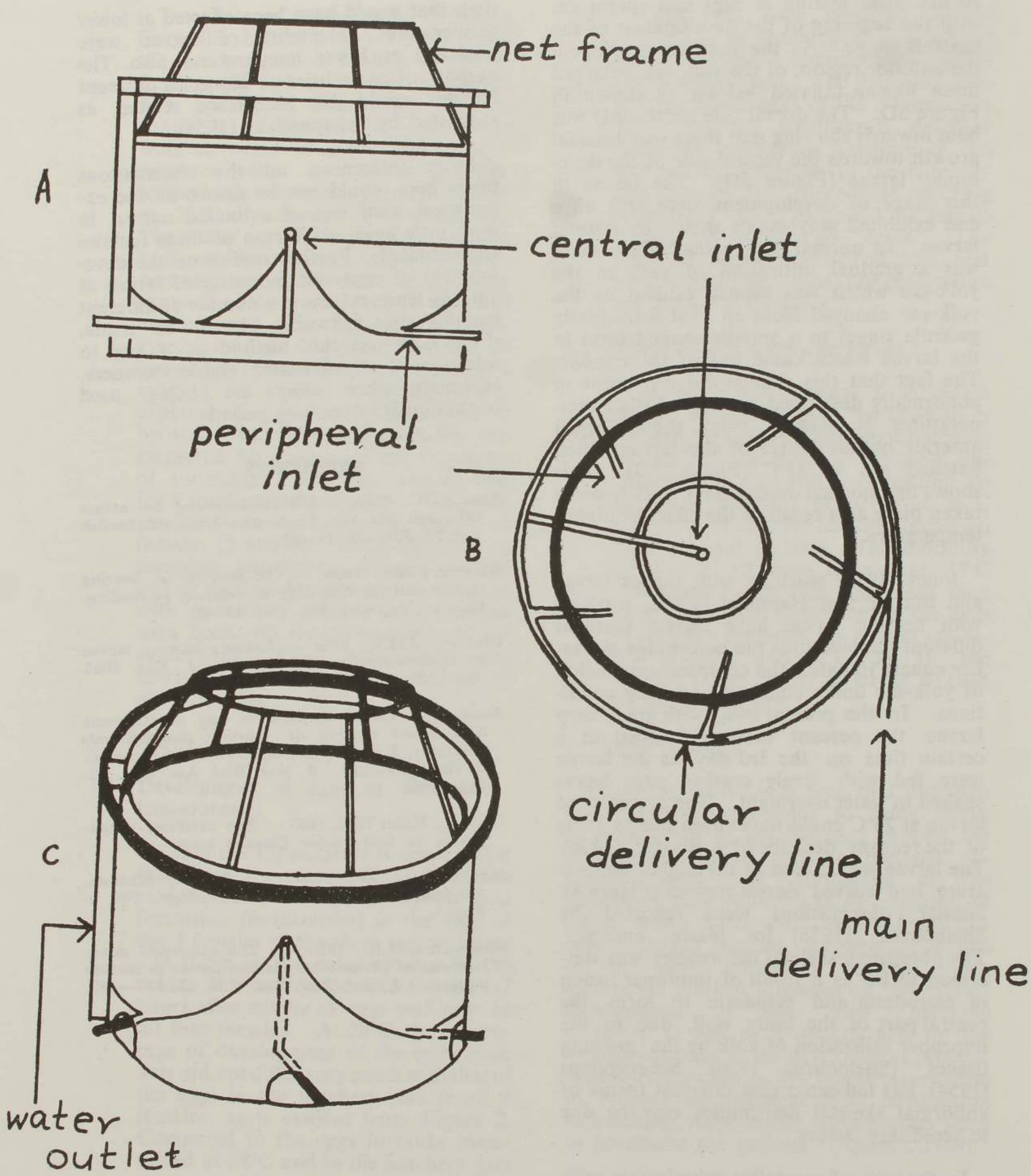
Figure 1

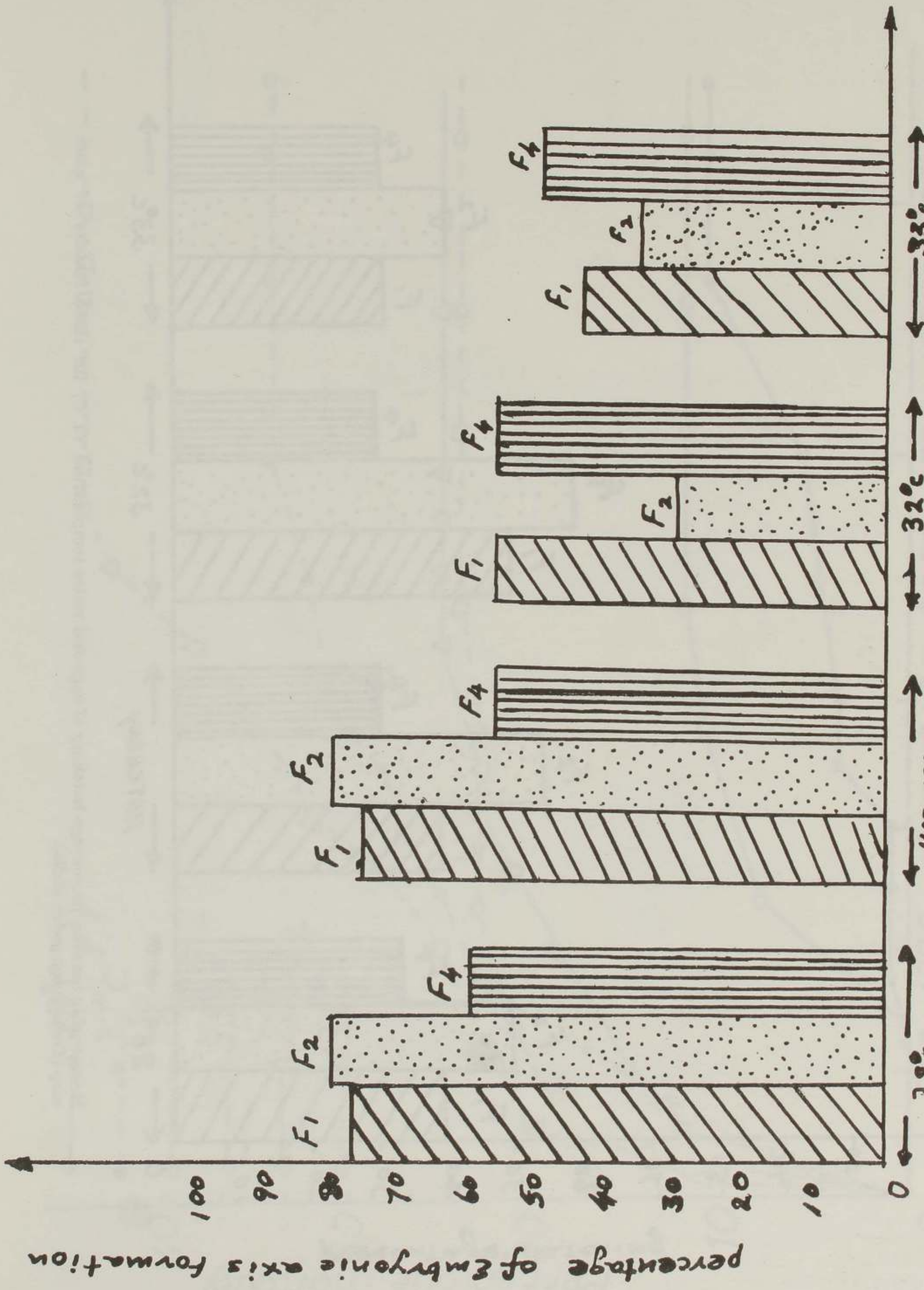


A. A longitudinal section of the hatching jar showing the central inlet and one of the peripheral inlets

B. A transverse section through the lower half of the hatching jar showing the arrangement ot the central inlet, 5 peripheral inlets and their connection to the circular delivery line.

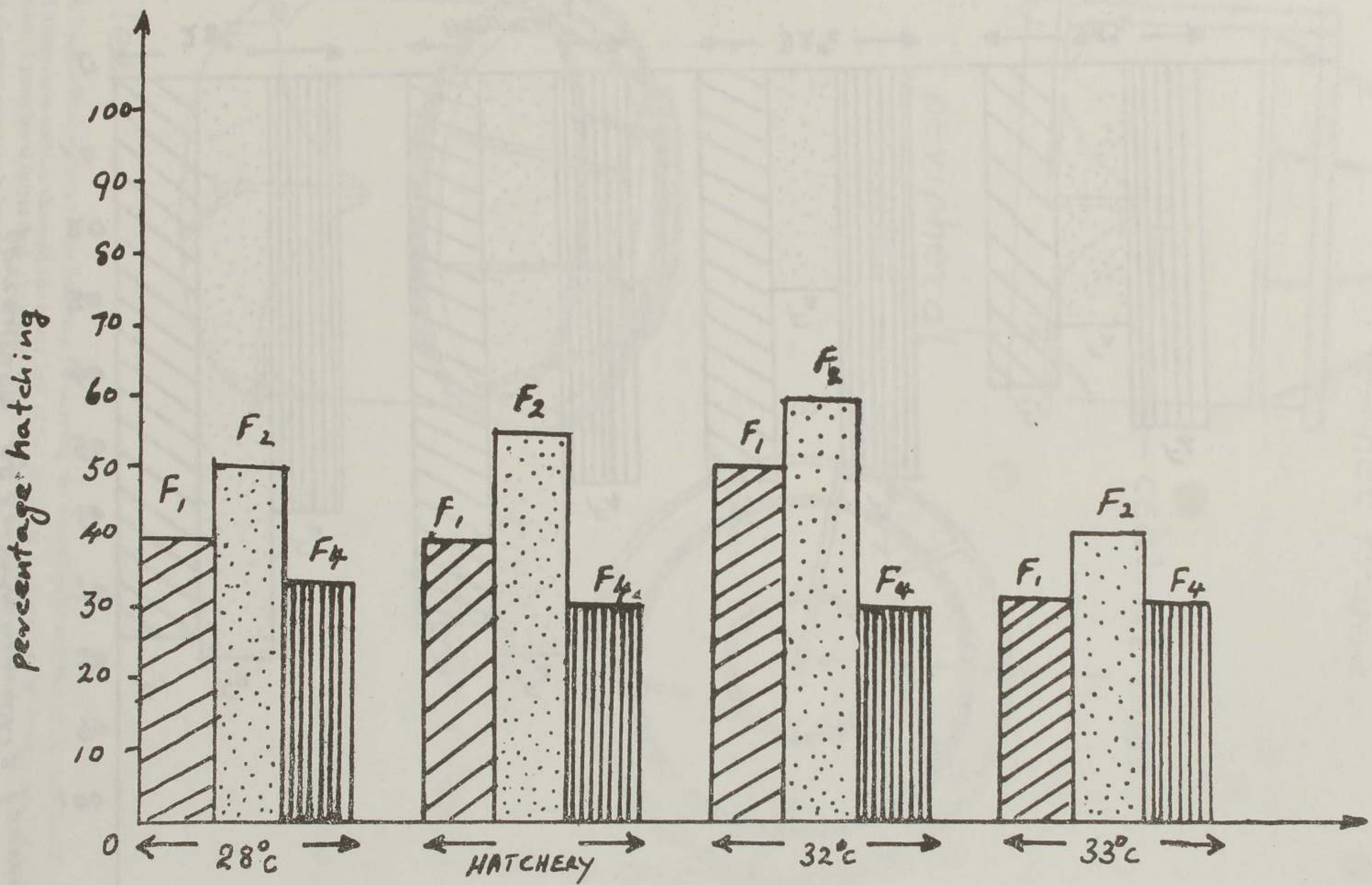
C. A diagram of a whole hatching jar with inlet arrangements shown

Figure 2

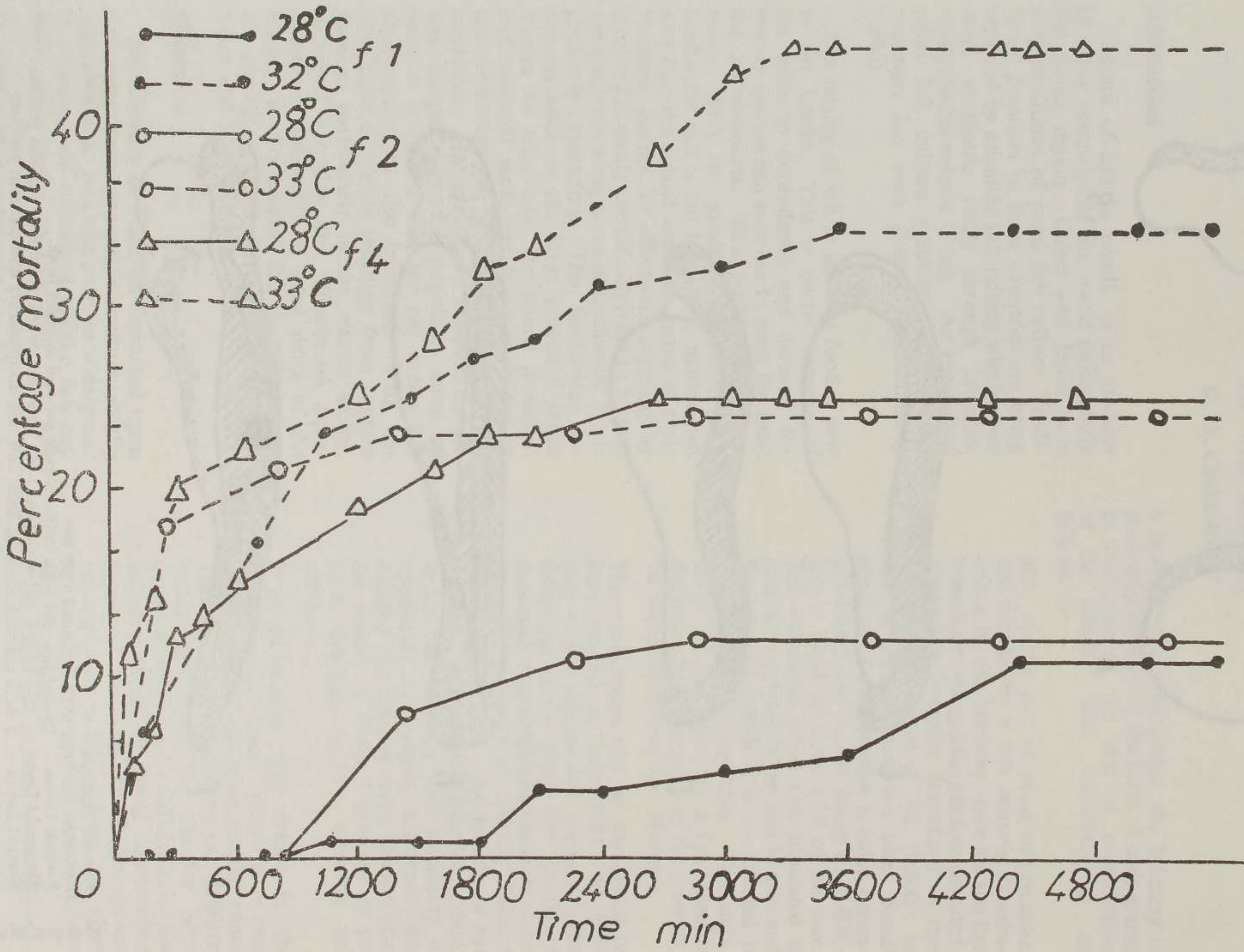


Relationship between the percentage of Embryonic axis formation of eggs and water temperature (T°C) for three females of grass carp (*Ctenopharyngodon idella*).

Figure 3

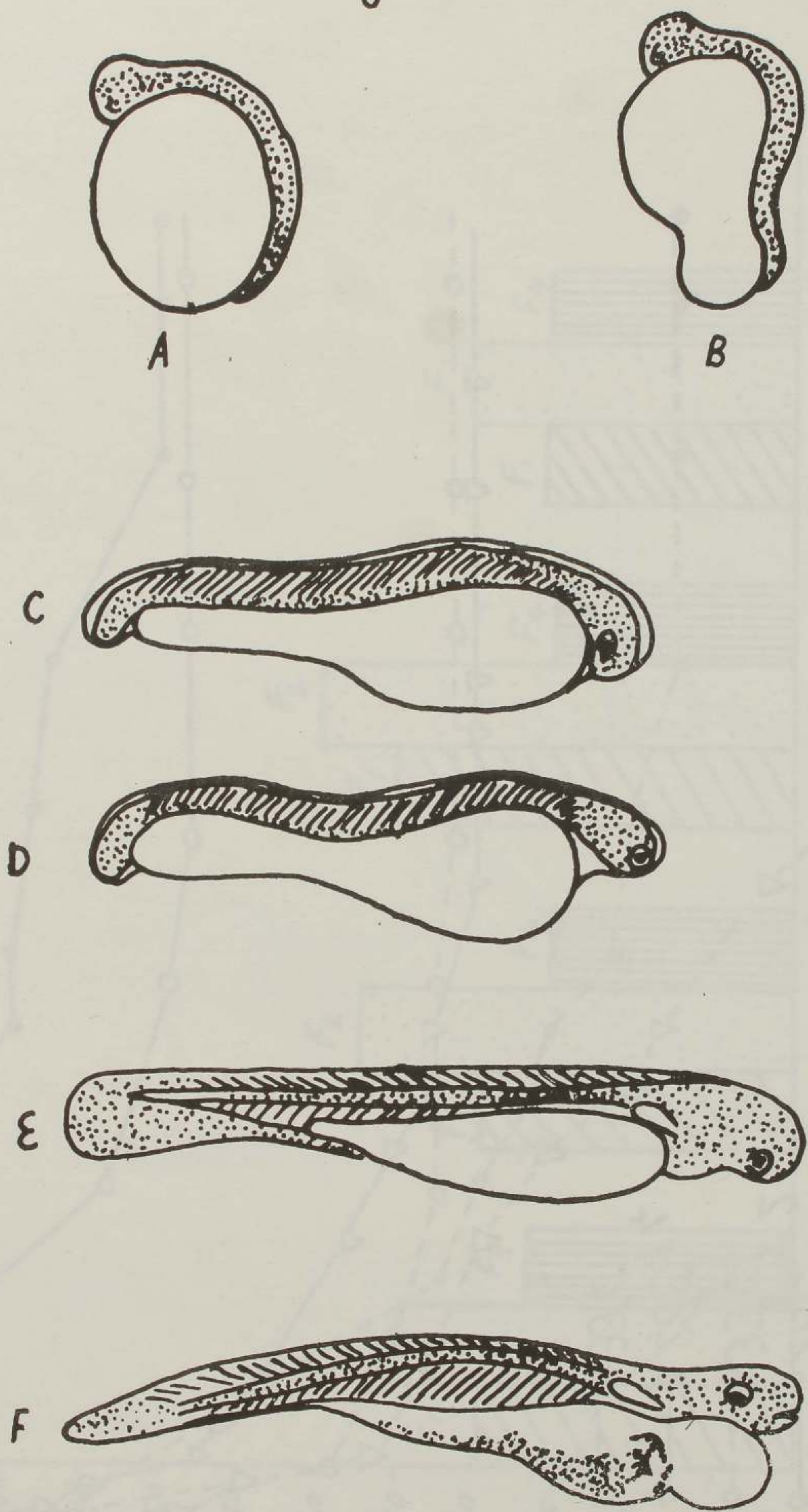


Relationship between percentage hatching of eggs and water temperature (T°C) for thsee females of grass carp (*Ctenopharyngodon idella*).



Relationship between percentage mortality of larvae and time (mins) of three females of grass carp (*Ctenopharyngodon idella*) at two temperatures.

Figure 5



A. Normal Embryo.
B. Abnormal Embryo with deformed yolk sac.
C. Normal Larva – 12– 14 hrs. old with uniform yolk sac and straight back.
D. Abnormal Larva – 12– 14 hrs. old with bent back (curved inwards) and non-uniform yolksac.
E. Normal Larva – 2 days old with straight back and fast disappearing and uniform yolksac.
F. Abnormal Larva – 2 days old bent back (curved outwards) with non-uniform yolksac.

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FISH PRODUCTION IN PONDS UNDER THE SUBSIDY PROGRAMME IN SRI LANKA

R. D. Chakrabarty*

Introduction

Culture of fish in ponds is in practice in many countries of the world particularly the Asian region. China and India have long traditions of pond fish culture. Traditional practices in these countries are being replaced by scientific fish raising which gives more profitable yields through intensive multi-species culture of fish. An account of pond fish culture practices in different countries has been given by Chakrabarty (1982).

The raising of fish to serve as food is new to Sri Lanka. This is partly because of the hitherto dependance and demand for mostly marine fish supplies to meet the food fish requirements. This position exists no more. With the gradual realisation that freshwater fish is not inferior to marine fish and that the inland areas by virtue of their location, cannot be effectively supplied by marine fish easily even if surpluses to be sent are available, acceptance of freshwater fish is gradually spreading. The freshwater resources such as the large perennial tanks known as reservoirs, the minor perennial and seasonal tanks are being exploited to the advantage of the fisherfolk and the consumer. However, such productions are not adequate for the populace, more so when it is desired that the per capita fish consumption be also increased. With uncertainties of yields resulting from capture fisheries particularly in the marine sector, increased adoption and reliance on aquaculture is noticeable in most parts of the world. In Sri Lanka, this is reflected in the growth of pond culture of both freshwater and brackishwater fish.

Objectives

The Ministry of Fisheries embarked upon a plan to popularize pond fish culture initially with an aim to make its practise widespread in attaining self-sufficiency of the fish culturist with regard to food fish. To give a boost to the programme, the Ministry is providing subsidy in the form of cash grants to meet part of the cost of construction of the ponds. The assistance is as follows :—

> 50% of the cost of pond construction undertaken by a fish culturist is subscribed by the Ministry, once the site has been approved and the pond constructed. There are financial limitations to this which is assistance of Rs. 10,000/- in case of pond of size two acre. Small sized pond construction is aided correspondingly, the lowest being Rs. 2,000/- for a pond of area 1/16 of an acre. The minimum pond size stipulated is that it be at least 10 perches in area and the plot on which it is constructed is of established ownership. The suitability of the site for a fish pond is decided after inspection of the same by an aquaculturist of the Ministry.

The programme can be considered to have started in July, 1981. In 1980 only a pilot scheme was operated. The following table gives the details of assistance requested and rendered under the Ministry's Pond Subsidy Scheme till the end of 1983. As the scheme was operated through the fisheries stations under the Ministry and suitability of applicants to receive assistance was decided by aquaculturists, the activities are shown in Table I grouped as per each fisheries station advising fish culturists.

It would be seen that except in the lowest rainfall areas, ponds have been constructed in all other rainfall zones. The assistance offered by the Ministry besides approving the site for pond construction and financial assistance also included advise on pond construction, supply of cultivable fish fingerlings and the imparting of fish culture knowhow at the time of stocking the ponds and also thereafter.

*Ministry of Fisheries, Colombo.

TABLE I

Assistance under pond subsidy programme

Station/Centre	No. applicants receiving subsidy	Pond area created (acres)	Annual average rainfall
Muruthawela	47	8	50″—75″
Udawalawe	60	10	50″—75″
Galle	250	82·75	75″—100″
Panapitiya	76	20·4	100″—125″
Pitipana	171	25·5	75″—100″
Beragala	14	5·4	75″—100″
Nuwara Eliya	42	20	100″—125″
Ginigathhena	451	58·53	150″—200″
Iginiyagala	136	75·3	75″—100″
Rambodagalla	37	24	50″—75″
Pambala	43	30	50″—75″
Dambulla	4	5	50″—75″
Polonnaruwa	146	67·1	50″—75″
Anuradhapura	16	15·4	50″—75″
Mankulam	22	25	50″—75″
	1515	472·38 or 472·4	

Response :

The response of people to the programme, was excellent as may be judged by the large number of applications received and enquries made for pond fish culture. The number of applicants assisted were limited by fund restrictions and only about half of the applications received culminated in pond subsidy being paid. A number of applicants had to be rejected because of unsuitability of the site chosen for fish culture. Among other reasons for non-approval of requests made was the pond site chosen being too small i.e. below the stipulated minimum of 10 perches. Other reasons were loss of interest of the applicant mid-way i.e. no construction actually being taken up after putting in the application and also suggested sites being disputed land raising doubts about the applicants ownership of the property. The response to the programme was heightened by the release of a colour film on pond fish culture, made by the Ministry of Fisheries, The film was shown over the National TV programmes more than once in the years 1982 and 1983.

The purpose of the subsidy programme being the creation of awareness among rural communities particularly, of the possibilities and prospects of culture of food fishes in man-made ponds, the pond size limit was kept somewhat low, i.e. 1/16 acre or ten perches in local terms, so that the benefit is available to more applicants.

The intensity of the fish culture operations undertaken varied with the pond area and resources at the comand of the fish culturist which were both a reflection of their economic well being and interest in the venture. This accounts for variations in management from no pond fertilization to adopting pond fertilization and supplementary feeding of fish and in a few instance integration of fish culture with poultry raising i.e. growing of ducks and chicken on the pond bank.

Results

Results obtained in fish culture from some ponds in each area have been shown in Table II. Generally five ponds from which more details were available than in others were chosen, and also these are the ones from which the better results were obtained.

As mentioned earlier, the management schedule followed by each farmer was not same. What was actually done was care and application of the pond fish culture methodology as per resources, time and also interest of the farmer in the venture. The water supply available to the ponds, as would be seen from Table II was adequate which would certainly have mattered in the attainment of productions as recorded and shown in the Table. Such conditions of water availability, may be considered as obtainable for all ponds, under the subsidy programme, as water supply has been kept as an important criterion for pond site selection. Obviously the resons for differing productions are other than water availability.

The species of fish cultured were the cichlids *Oreochromis mossambicus* and *O. niloticus*, the Chinese carps the bighead carp (*Aristichthys nobilis*), the grass carp (*Ctenopharyngodon idella*) and the common carp (*Cyprinus carpio*). The native carp species *Labeo dussumeiri* as also the milkfish (*Chanos chanos*) were also stocked. The Table also reveals that no uniform density of stocking fingerlings was followed, this varying from around 3000/ha to as high as over 20,000/ha. The tendency of the farmers appeared to be to stock as many fingerlings as they could get so that some would survive and some food fish would result from their efforts.

Fish productions obtained were from a low 200 kg/ha. to as high as over 5,000 kg/ha. Of the 47 ponds, in 10 the productions were less than 1,000 kg., in 18 it ranged from upwards of 1 ton to 2,000 kg., in 13 productions attained were over 2 tons but less than 4 tons and in 6 nos. of ponds the fish productions were high being from 4,000 kg. to 5,445 kg/ha. No clearly discernible reasons can be attributed for the varying productions obtained but it is clear that increased number of fingerlings did not result in higher yields.

Considered areawise better fish productions were obtained from ponds in the Polonnaruwa, Ginigathhena, Panapitiya, Udawalawe, Muruthawela, and Galle areas. The best out of these were the results obtained in Polonnaruwa where fish culture period was restricted to shorter durations (7-8 months) than in others where results were similar.

The results tend to suggest that the response to fertilization, the inherent soil fertility, etc. (supplementary feeding is reportedly restricted) are such that would make possible the raising of good fish crops from ponds in Sri Lanka and with adequate water even for durations somewhat short of a year, such results are obtainable. The results of polyculture trial in a farm pond (with cemented sides) in which the fish received duck house washings (including bird excreta and unused feed) mainly as nutrients, from which a fish production of about 4½ tonnes/ha. was obtained in 6½ months confirms this belief (Chakrabarty and Hettiarahchi, 1982). Hettiarachchi (1982) mentions of productions at over 4 to 6 tons./ha. in less than a year obtained by fish culture in the Polonnaruwa district. The higher productions are a reflection of the intensive nature of the cultures. There is, however, great scope for improvement and some suggestions are made herein

Suggestions for fish culture in ponds

Ponds that retain water are to be preferred as it may be easy to replenish evaporation losses than those resulting from seepage. Ponds constructed on such soil also are likely to be more stable and nutrient losses would be less.

Fertilization with cow-manure at around 3-5 tonnes/ha. after an initial liming at 500 kg/ha. may be carried out at least 2-3 weeks before stocking with fish fingerlings.

As may be seen from Table II, stocking densities employed were rather high. This generally result in the harvested fish being of small average size, not considered desirable either for consumption or marketing. As the fish rearing period may be restricted to 5-6 months a stocking density of around 3,000-4,000/ha. is adequate. This will save in the number of fingerlings required for the programme. The high production in fish polyculture reported by Chakrabarty and Hettiarchchi (1982) employed a stocking density of 5,000/ha. The size of fish stocked may be around 75-100 mm. A species mix would utilize pond resources better than one or two species. Fish combinations actually used could be dictated by availability, nevertheless efforts may be made to stock fish in desirable proportions. Some suggested species ratio may be :

(1) Bighead carp/catla — 25%
Rohu — 20%
Grass carp — 15%
Mrigal — 25%
and Common carp
(either one or in equal proportions)
Chanos & *Labeo dussumeiri* — 5%
O. niloticus — 10%

(2) Silver carp and catla — 30%
(used in the ratio of 2:1)
Rohu — 20%
Grass carp — 10%
O. niloticus — 15%
Common carp — 20%
Chanos or *L. dussumeiri* 1—15%

(3) *O. niloticus* — 30%

Bighead carp/Catla & Silver carp — 25%
(in the ratio of 1:2)
Rohu — 15%
Grass carp — 15%
Chanos — 10%
L. dussumeiri etc. — 5%

The Chinese silver carp, Bighead carp and Grass carp are presently being bred in the fish culture Stations of the Ministry. The Indian major carps more recently introduced have also been bred (Balasuriya *et. al.*, in press) except for Catla which is expected to be bred in the near future.

The seed of all these cultivable varieties of carps, the Common carp, the Nile tilapia, the local medium sized carp, *Labeo dussumeiri* and milkfish (*Chanos chanos*) used as stocking material together with judicious management by the fish farmer would result in good profitable crops of marketable fish under pond culture in Sri Lanka.

Acknowledgement

I am thankful to Mr. Anura Weeraratne Secretary, Ministry of Fisheries and Mr. K. Thayaparan, Director, Inland Fisheries Division for their interest in this programme. Thanks are also due to Mrs. Swarna de Silva, DFEO for information furnished for Table f of the paper. I am grateful to the OICs ol the fish culture stations for their response to my request for supply of pond culture information from their areas, made use of in this paper.

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TABLE II

FISH PRODUCTION IN SOME PONDS UNDER THE SUBSIDY PROGRAMME

Pond size and Location	Production obtained	Production ha.	Culture period	Species cultured, Total numbers stocked (stocking density per ha.)	Water supply and depth of pond, etc.
¾ acre, Wariyapola, Rambodagalla	764.93 kg. including 428kg.P.sp.	2549.78 kg.	One year	BHC,GC,LD,CC,TN & P.sp. (6800)/22667/ha.	(4ft.)
½ ,, Arunodagama, ,,	220.2 ,,	1101.0 kg.	Year long	BHC,CC,TM,TN: (2750)/13750ha.	(3¼ft.)
3 ,, J.E.D.B. Tank, ,,	302.9 ,,	252.42 kg.	One year	BHC,GC,LD,CC,TN,CC: (3800)/31,67ha.	(4.5ft.)
0.66 ,, Hiriyala, ,,	158.0 ,,	239.39 kg.	One year	GC,CC,CHC: (6975)/10568ha.	(4ft.)
⅛ ,, Nikadalupotha, ,,	34.0 ,,	680.00 kg.	8 months	BHC,GC,LD,CC: (650)/13000ha.	(3½ft.)— Rainfed.
10 perches, Singharaja Udyanaya, Yattapotha	116 ,,	4640.00 kg.	—	— —	—
60.6 perches, Katuneriya,Puttalam	788 kg.	5201 kg.	10 months	BHC,GC,CC,RC,Gourami TN, CHC(1074)/7089ha.	Rainwater and water, pumped from well (W.D. 6ft.)
25 ,, Ruwanwella, Ginigathena	250 kg.	4000 kg.	One year	T,CC: (650)/10400ha.	Spring fed (3½ft.)
10 ,, Gampola, ,,	43 kg.	1720 kg.	One year	T,CC : (300)/12000ha.	Spring fed (3½ft.-4½ft.)
05 ,, Watawala, ,,	25 kg.	2000 kg.	10 months	T,CC; (150)/12,000ha.	Spring fed (3½ft.)
10 ,, Nawalapitiya, ,,	89 kg.	3560 kg.	13 months	T,CC.GC: (300)/12,000ha.	Spring fed (3-4ft.); 4 ducks also raised
½ acre, Kalawewa, Anuradhapura	40 kg.	200 kg.	6 months	TM,CC: (1100)/5500ha.	Seepage water from Irrigation Channel + water pumped. Integrated with poultry.
½ ,, Galnaliduruwewa, ,,	335 kg.	1675 kg.	6 months	TN,CC: (2200)/11,000ha.	(5ft.) From adjoining tank and rain water
1.5 ,, Kekirawa, ,,	435 kg.	725 kg.	8 months	TN,CC,CHC: (2200)/3667ha.	(3-5ft.) — adjoining river and rain water
½ ,, Srawasthipura, ,,	530 kg.	2650k.	8 months	TN,CC: (1400)/7000ha.	(6ft.) at full supply.
¾ ,, · ,,	340 kg.	1133 kg.	6 months	TN,CC,CHC: (1400)/4667ha.	(4ft.) from adjoining village tank.
4000 Sq.ft.,Jayanthipura, Polonnaruwa	130 kg.	3539.25 kg.	7 months	TN,CC,CHC: (400)/10,890ha.	(5ft.) Irrigation Channel.
2800 ,, ,, ,, ,,	140 kg.	5445.00 kg.	7 months	TN,CC,CHC,GC: (400)/15557ha.	(4ft.) ,, ,,
40 perches, Higurakgoda, ,,	345 kg.	3450.00 kg.	10 months	TN,CHC,CC: (2000)/20000ha.	(4ft.) ,, ,,
52 ,, Trinco District ,,	431 kg.	3315.38 kg.	8 months	TN, CC CHC (700)/15385ha.	(5ft.) ,, .
38 ,, Channel Rd., ,,	160 kg.	1684.21 kg.	5 months	TN,CC. (625)/6579ha.	(4ft.) ,, ,,
10 perches,Julanpitiya,Muruthawela	44 kg.	1760 kg.	8 months	TN,CC.BHC,GC : (250)/10,000ha.	(3½ft.), Spring water,
10 ,, ,, ,,	52 kg.	2080 kg.	8 months	TN,CC.BHC,GC:(260)/10,400ha.	(4ft.), Canal and spring water
10 ,, Katuwana, ,,	28 kg.	1120 kg.	6 months	TN,BHC,CC,GC: (245)/9800ha.	(4ft.) Spring water.
10 ,, Kirama, ,,	36 kg.	1440 kg.	6 months	TN,BHC,CC: (200)/8000ha.	(3½ft.) Spring and hill side water.
20 ,, Julanpitiya, ,,	129 kg.	2580 kg.	8 months	TN,CC,BHC,GC: (425)/8500ha.	(4ft.). Spring and canal water.
310m^2, Ellawala, Udawalawe	125 kg.	4032 kg.	—	C,BHC,TN GC: (825)/26,612	(One meter). Supply source canal.
66 ,, Parakaduwa, ,,	13 kg.	1970 kg.	9 months	CC, (200)/30,303	Water supply from canal.
310 ,, Monaragala, ,,	100 kg.	3226 kg.	10 months	BHC-250,GC —150;(400)/12,903	(One meter). Supply source canal.
45m^2, Kuruwita, ,,	60 kg.	1333 kg.	8 months	CC,TM,: (96)/21333	(One meter). Supply source canal
350m^2, Ratnapura, ,,	50 kg.	1429 kg.	9 months	TM,TN,CC and Ld. (615)/17571	(3ft.). Supply source stream.
10 perches, Weragala Paduka, Negombo	27.5 kg.	1100 kg.	1 year	CC,Ld,CHC (500)/20,000	(5ft.), supply from spring and perennial stream.
120 ,, Pitipana North, Negombo	150 kg.	500 kg.	9 months	CHC: (1500)/5000	(Av. 40cm.), Water supply by tidal ingress.
20 ,, Ihalayagoda, Gampaha	35 kg.	700 kg.	10 months	TM, Ld. (500)/10,000	(4ft.) Spring water.
½ acre & 20 perches, Pitipana,	100 kg.	400 kg.	7 months	CHC (1500)/6000	(Av. 40cm.), Water supply by tidal ingress.
85 perches, Alupotha, Negombo Negambo	70 kg.	330 kg.	8 months	CHC and Ld. (800)/3765	(Av. 4ft.), Water supply by stream.
1/16 acre, Jalgaswalla, Galle	55 kg.	2200 kg.	10 months	TN, (300)/12,000	(3.2ft.) Supply from natural springs and adjoiningstream
10 perches, Dunawala, Galle	30 kg.	1200 kg.	10 months	TN, (300)/12,000	(3-5ft.). Natural springs.
1 acre, Agarapathana,Nuwara Eliya	500 kg.	1250 kg.	One year	CC,BHC, RC—/-	(10ft.) Natural supply and water supplied from small stream.
½ acre, Vavuniya	250 kg.	1,250 kg.	8 months	T,BHC and CC: (1500)/7500	(5ft.) Tank fed.
1/16 acre, Adampam	45 kg.	1800 kg.	6 months	CHC, (200)/8000	(3ft.). Tank fed. Waste from biogas plant.
2 acre, Parpankandal	700 kg.	875 kg.	6 months	Wild stock of Tilapia from the Giant's tank	(5ft.). Tank fed.
½ acre, Uyilankelan	220 kg.	1100 kg.	6 months	TM. (1500)/7500	(4ft.). Rain fed.
10 perches, Agalawatta,Panapitiya	70 kg.	2800 kg/ha.	11 months	CC,TN,CHC: (400)/16,000ha.	Spring water (4ft.). integrated with poultry.
10 ,, Yattapatta, ,,	116 kg.	4640 kg/ha.	8 months	TN,CC,CHC,BHC: (510)/20,400 ha.	Spring and canal water (4-5ft.)
10 perches, Navantuduwa	77 kg.	3080 kg.	8½ months	CHC and TN: (500)/20,000	(3¾ ft.—5 ft.) Spring water.
10 ,, Diwalkada, Panapitiya	87 kg.	3480 kg.	9 months	CC and TN: (525)/21,000	(4-5 ft.) Spring water.

Note :

Perch 272.25 sq.ft. }
Acre 43,560 sq. ft. } 160 perches = acre

Key :

BHC — Bighead carp
GC — Grass carp
T — Tilapia
LD — Labeo dussumieri
CHC — Chanos chanos
CC — Common carp
TN — Tilapia nilotica
P.sp. — Puntius sp.
TM — Tilapia mossambica

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CULTURE OF MILKFISH IN FISH FARM PONDS OF PITIPANA

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Introduction

At present bulk of the island's fish production comes from the marine capture fishery. This however might have reached its upper limits and also because of increasing costs of exploitation of marine fish catches future demands might not be met by this source. In order to ensure supplies for the growing demand for fish by the expanding population all avenues need to be exploited to boost fish production. Aquaculture both in freshwaters and brackishwater can contribute to much needed higher fish production in Sri Lanka.

Pond culture of milk fish (Chanos chanos) is an established industry in some of the South East Asian countries. Application of advanced culture techniques for milk fish has enabled Taiwan to attain a national average yield over ζ tons/ha /yr. (Lijuaceo and Baliao, unpublished) Milk fish possess most of the desirable qualities esteemed by the local consumers. Sri Lanka has the seed and water resources for the development of milk fish aquaculture as an industry (Villaluz *et al.*, 1982). But lack of know-how pertaining to milk fish farming is one of the principal reasons for the state of under development of milk fish culture in Sri Lanka (Thayaparan and Chakrabarty 1983).

Thayaparan and Chakrabarty (1983) mention of stray attempts made in the past to culture Chanos in ponds in Sri Lanka. In recent times trials have been conducted to culture the species by application of improved methods, developed in the Philippines as described by Baliao (1982).

The present communication reports recent experimental studies conducted to raise marketable milk fish in ponds of the brackishwater fisheries station at Pitipana near Negombo, Sri Lanka.

Culture Method

Two ponds (Figure 1), rearing pond nos. 11 and 12 at the Pitipana Brackishwater Experimental Station were utilised for the culture studies. The area of the ponds are 0.7 ha. and 0.4 ha. respectively. Each pond has a single sluice of 65 cms. breadth. The farm is sited bordering the Negombo lagoon at a distance of about two kilometres from the sea mouth. Twelve earthen ponds of varying dimensions are located on either side of a common channel five metres wide. The sluices of all ponds open into the common channel. The ponds nos. 11 and 12 are among the four ponds that lie closest to the lagoon.

After sealing the sluices with soil the ponds were emptied to the fullest possible extent by operating diesel water pumps. Due to heavy seepage of water from adjacent ponds and the lagoon, complete drying up was not possible. A nylon screen of 0.5 mm mesh size was installed at the sluices: bamboo poles were fixed inside the pond in an arch form close to the mouth of the sluice. The screen was tied to the bamboo poles. This screen has a height of 1.5 m and its lower part is firmly fixed to the pond bottom. Bamboo poles each of about 3m were fixed upright to the pond bottom along the bunds lengthwise at intervals of about 7 metres. In pond No. 11 another similar row of bamboo poles was fixed to run parallel to the peripheral rows along its mid line. To scare away predatory birds especially the cormorants (*Phalace crerax*) and also to prevent cast netting by poachers, coir ropes were drawn across the pond by tying ropes to the extremities of the upright bamboo poles.

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The ponds were prepared by broadcasting the following in the order and at rates indicated against each :

(i) Tobacco dust — 200 kg/ha. .

(ii) Quick lime (Cao) — 2 tons/ha.

(iii) Chicken manure — 2 tons/ha.

(iv) Urea (46% N) — 50 kg/ha.

Time intervals of two days were allowed before each of the successive treatment. Two weeks after the addition of urea triple super phosphate (P_2O_5) was broadcast at the rate of 25Kg/ha. Thereafter urea and T.S.P. were added alternately once a fortnight till the harvest.

The sluices were opened two days after addition of the first dose of urea and the ponds filled gradually. Chanos fingerlings were stocked on the 22nd day after the application of urea at 50 kg/ha. The fingerlings stocked were taken from a station pond in which fry collected from tidal flats at Kalpitiya during March/April were reared. In the early part of the culture period the sluices were opened for 3-4 days during full and new moon periods. At the end of the 3rd or 4th day of opening the sluices, these were soil sealed again and fertilisers applied fortnightly. When the water level of the pond no. 11 receded to 30 cm. on 48th day after stocking, pumping of water into the pond from the lagoon was done. From then onwards the water level of that pond was maintained at around 50 cms. by the operation of a 4″ diesel water pump. Filling the pond beyond 50 cm. was not attempted so as to avoid strain on the pump. Once a fortnight the water level was lowered by about 10 cm. by opening the sluices and then filled again upto the 50 cm mark. The pumping operation was timed to coincide with the spring tide. To minimise the decrease in salinity during the heavy rainy days the flash boards were kept at the level of the water surface of the pond. The pump brought down to maintain the water level in pond no. 12 failed to function.

Fig. 2. Harvesting a milkfish pond

From the 50th day after stocking, cowdung was added, twice a week, at the rate of 50 kg. (wet weight) per application. Before its application cowdung was placed in gunny sacks and these sacks were submerged in water for 1-2 days. The soaked stuff was taken and added to the pond in the form of slurry. As it was not possible to maintain the water level in pond No. 12 to a desirable depth cowdung was not added to pond no. 12. 65th day after stocking milk fish, supplementary feeding with a mixture of fish meal, Leybes (a poultry feed) and rice bran in the ratio of 2:3:5 was commenced. The fish were fed at 5% of their body weight, twice a day. The day's ration was divided into two equal parts one part was given in the morning and the other part fed in the evening. The feed ingredients were mixed with water and made into compact balls and such balls were thrown into the pond from eight fixed points marked along the bunds. 95th day from stocking the feed ration was increased by 40%. At the end of 5 months culture, water was baled out and fish harvested by dragging nets fixed to stakes and projecting far above the water level to prevent their escape by jumping out of the net (Fig. 2.)

Results and Discussion

The net and gross fish productions obtained from pond nos. 11 and 12 are presented in Tables II, III and V, VI, respectively.

In both ponds milk fish recovered were more than the numbers stocked. This may be explained as due to the Chanos fry that escaped from adjacent fry rearing ponds gaining entry into these ponds through the sluices. This also could account for the decline in the fingerlings (lower survival of stocked fry) observed in these adjacent rearing ponds. The study reported upon was conducted during the period in which Chanos fry appear in shore waters and it is probable such fry entered the ponds with tidal ingress. Numbers recovered show that the fish density in pond no. 12 had been very much higher than in pond no. 11. High fish density and low water depth, absence of fertilisation by cowdung and chemical fertilization could have all combined to contribute the lower yield of Chanos in pond no. 12.

It is of interest to note that a few Tilapia gained access to pond no. 12. as recorded at the time of harvesting. This is also true of prawns and fish species not stocked but recorded at harvest. The possible reason appears to be that water pumped in from the lagoon brought in more Tilapia than that which entered the pond with tidal ingress. Nevertheless it remains inexplicable as to how water that brought in Chanos seed (as revealed by higher numbers recorded than stocked, which was almost thrice as much in pond no. 12) did not carry Tilapia young with it. It is possible that Tilapia fry can swim away more effectively from tidal water entering the pond which was not possible when these were sucked in by the pump whatever be the reason the study revealed that by filtering water from the lagoon brought in by pumping, fish, prawn etc., may be prevented fairly effectively, from entering ponds in which fish culture is in progress. It may be worthwhile to examine, periodically the collection of fish fry, prawn seed etc., brought in by pumped water, from the deposits of these made on the filter cloth/ fine wire mesh, fixed to the pump outlet. The fish and prawn species abounding these waters and their periodic fluctuations with regard to quantity and quality may be known.

The production recorded is comparable to yields obtained in successful farming in the Philippines. Lijauco & Baliao, (unpublished) mention of productions 1.5—2mt/ ha/yr. which is less than two crops of Chanos 1,148.57Kgs. (Table II) which distinctly appear possible to be raised by application of methodology followed in this communication reported upon. Chanos production achieved in the Philippines as reported by Samaranayake (1982) of 2–3.5 ton/ha/yr. is also comparable to production obtained in our study. Stunting ponds that would ensure supply of fingerlings of requisite size for a second crop of Chanos to be raised within the same year should form and important part of the management technique if higher production of Chanos are to be obtained in ponds in Sri Lanka. The vast fry potential of the species (Thayaparan & Chakrabarty 1983) in Sri Lanka needs to be properly utilised through scientific farming of these important food fish.

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TABLE I

Rate of stocking, initial average weight and length of **Chanos** in pond No. 11

Pond Area	Date of Stocking	No. Stocked	Density (fish/ha)	Initial Av. Wt. in gm.	Initial Av. Length in cm.
0.7ha	83.05.03	2100	3000	5.30	7.30

TABLE II

Number recovered, total weight, final average weight and length of **Chanos** in pond No. 11

Dates of Harvest	No. Recovered	Final Av. wt. in gm.	Final Av. Length in cm.	Total Wt. in Kg.
11th-14th October 83	3856	208·50	34·9	804

Maximum Wt. = 416gms.

Minimum Wt. = 114gms.

Production/ha = 1148.57 Kg/ha/5 months

TABLE III

Species harvested, their numbers, weight and gross production in pond No. 11

DATE OF HARVEST	Chanos		Tilapia		Prawns	Miscellaneous
	No.	Wt. in Kg	marketable size (Kg)	under size (Kg)	(Kg)	(Kg)
83.10.11	3463	721	220	34	01	nil
83.10.12	346	70	50	10	04	02
83.10.13	10	03	11	05	01	01
83.10.14	37	10	05	16	02	03
Total	3856	804	285	71	12	06

Total production = 1,178 Kgs.

Total production/ha = 1,682.85 Kg/ha/5 months

TABLE IV

Rate of stocking, initial average weight and length of **Chanos** in pond No. 12

Pond Area	Date of Stocking	No. Stocked	Density (fish/ha)	Initial Av : Wt. In gms	Initial AV : Length in cm
0.4ha	83·05·11	1200	3000/ha	4·92	8·12

TABLE V

Number recovered, total weight, final average weight and length of **Chanos** in pond No. 12

Date of Harvest	No. Recovered	Final Av Wt. in gm	Final Av Length in cm	Total Wt. in kg
11th-13th October 83	3395	87·78	24·80	298

Maximum wt. = 325gms

Minimum wt. = 22gms

Production = 745 Kg/ha/5 months

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TABLE VI

Species harvested, their numbers, weights and production in pond No. 12

Date of Harvest	Chanos		Tilapia (Kg)	Prawns (Kg)	Miscellaneous (Kg)
	No.	Wt. in Kg			
82.10.11	2628	239	5	nil	nil
83.10.12	705	51	1	nil	nil
83.10.13	62	08	2	nil	03
Total	3395	298	8	nil	03

Total production = 309 Kgs
Total production/ha = 772.5 Kgs/ha/5 months

TABLE VII

Record of physico-chemical conditions in pond Nos. 11 & 12

Pond No.	W		A		T		E		R	
	Salinity (ppt)		pH		Temp °C		Dissolved O_2 in ppm		Depth in cm	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
11	31·11	22—37	8·3	8·0—8·6	29·4	27—34	5·62	1—7·8	43	33—53
12	30·6	21—37	8·3	8·0—8·7	29·75	28—33·0	5·82	2·1—8·5	35·5	30—41

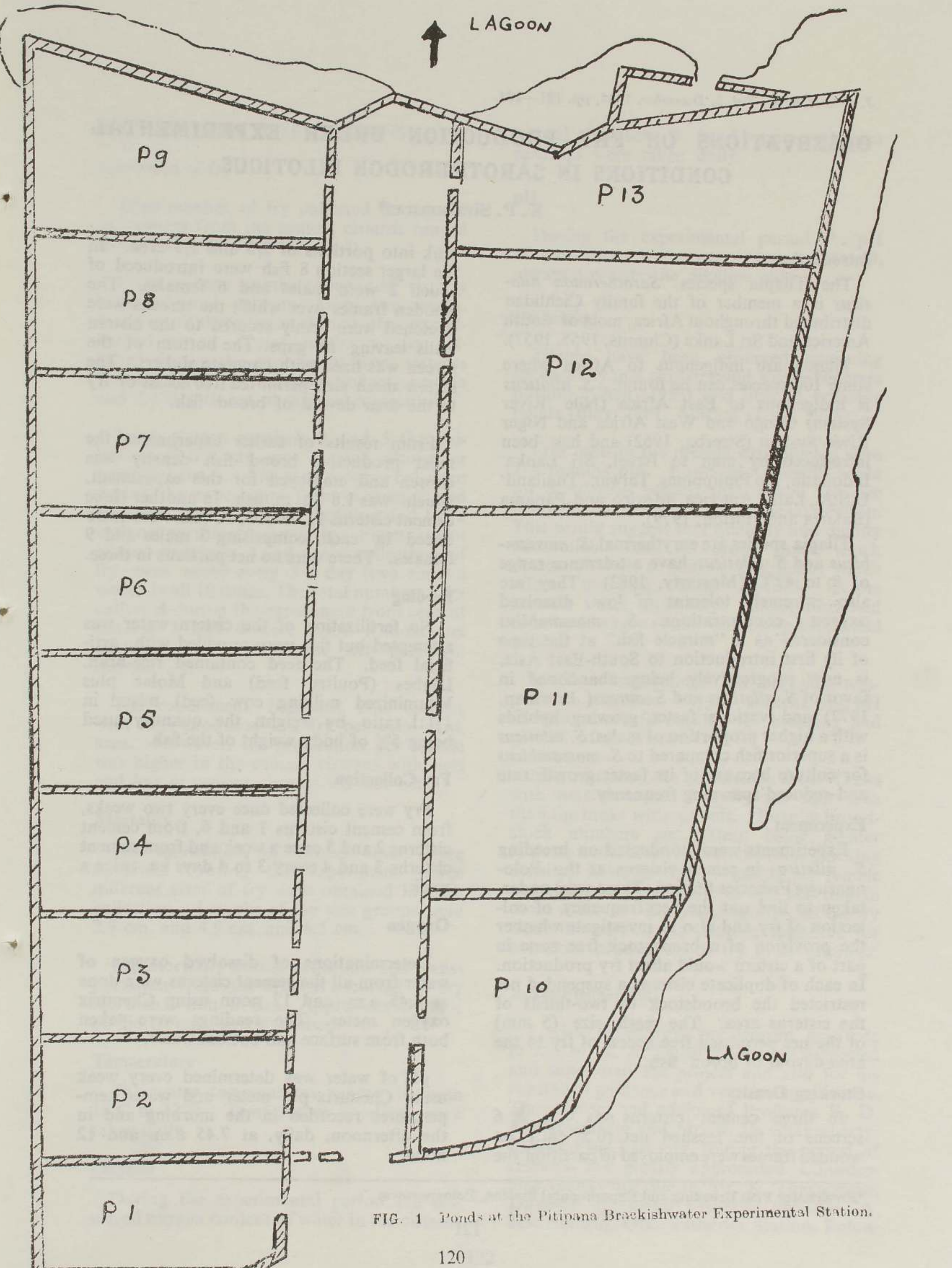

FIG. 1 Ponds at the Pitipana Brackishwater Experimental Station.

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OBSERVATIONS ON FRY PRODUCTION UNDER EXPERIMENTAL CONDITIONS IN SAROTHERODON NILOTICUS

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Introduction

The Tilapia species, *Sarotherodon niloticus* is a member of the family Cichlidae distributed throughout Africa, most of South America and Sri Lanka (Chimits, 1955, 1957).

Tilapia are indigenous to Africa where some 100 species can be found. *S. niloticus* is indigenous to East Africa (Nile River System) Congo and West Africa and Niger River System (Strerba, 1962) and has been introduced by man to Israel, Sri Lanka Indonesia, the Philippines, Taiwan, Thailand' U.S.A., Latin America, Mexico and Panama (Balarin and Hatton, 1979).

Tilapia species are eurythermal, *S. mossambicus* and *S. niloticus* have a tolerance range of 8 to 42°C (Moriarty, 1982). They are also extremely tolerant of low dissolved oxygen concentrations. *S. mossambicus* considered as a "miracle fish" at the time of its first introduction to South-East Asia, is now progressively being abandoned in favor of *S. niloticus* and *S. aureus*(Bowman, 1977) and various faster growing hybrids with a higher proportion of males. *S. niloticus* is a superior fish compared to *S. mossambicus* for culture because of its faster growth rate and reduced spawning frequency.

Experiment

Experiments were conducted on breeding *S. niloticus* in cement cisterns at the Polonnaruwa Fisheries Station. These were undertaken to find out the best frequency of collection of fry and also to investigate whether the provision of a broodstock free zone in part of a cistern would affect fry production. In each of duplicate cisterns a suspended net restricted the broodstock to two-thirds of the cisterns area. The mesh size (5 mm) of the net permitted free access of fry to the area devoid of brood fish.

Stocking Density

In three cement cisterns nos .4, 5, & 6 screens of fine meshed net (0.5 cm.) on wooden frames were employed to partition the tank into portions of 2/3 and 1/3 area. In the larger section 8 fish were introduced of which 2 were males and 6 females. The wooden frames over which the screens were stretched were firmly secured to the cistern walls leaving no gaps. The bottom of the screen was fixed with concrete sinkers. The screen mesh size permitted free access of fry to the area devoid of brood fish.

From results of earlier experiments the most productive brood fish density was chosen and employed for this experiment, which was 1.8 Sq. m./fish. In another three cement cisterns 1, 2 and 3, 12 fish were intro duced in each, comprising 3 males and 9 females. There were no net portions in these.

Feeding

No fertilization of the cistern water was attempted but fish were provided with artificial feed. The feed contained rice-bran, Laybes (Poultry feed) and Molac plus Vitaminized milking cow feed) mixed in 1:1:1 ratio by weight, the quantity used being 5% of body weight of the fish.

Fry Collection

Fry were collected once every two weeks, from cement cisterns 1 and 6, from cement cisterns 2 and 5 once a week and from cement cisterns 3 and 4 every 3 to 4 days i.e. twice a week.

Oxygen

Determinations of dissolved oxygen of water from all the cement cisterns were done at 7.45 a.m. and 12 noon using Chemtrix oxygen meter. The readings were taken both from surface and bottom water.

pH of water was determined every week using Chemtrix pH meter and water temperatures recorded in the morning and in the afternoon, daily, at 7.45 a.m. and 12 noon.

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RESULTS AND OBSERVATIONS

Collection of fry

Total number of fry collected during the experiment from the cement cisterns ranged from 1,793 to 3,374 (Table I).

From cistern numbers one and six, fry were collected once in every two weeks, being in all three times during the experimental period. Total number of fry collected during the experiment from cisterns 1 and 6 were 2,739 without use of net partition and 2,458 with net partitions, respectively

From cistern numbers 2 and 5 the collection of fry was once a week, altogether being five times. The total number collected during the experiment from cisterns 2 and 5 were 3,374 without net partition and 1,572 with net partition respectively. From cement cistern numbers 3 and 4, the collections of fry were made every 3-4 day (two times a week), in all 10 times. The total number of fry collected during the experiment from cement cisterns 3 and 4 were 2,938 without net partition and 1,793 with net partition, respectively.

The experiment indicated that cisterns with nets produced less fry per total tank area. However, fry production per female was higher in the cement cisterns with nets and less in cement cisterns without nets.

Mortality

No mortalities of brood stock were observed. During the experiment three different sizes of fry were obtained in each collection. Lengths of the size groups were 2.9 cm. and 4.9 cm. and 6.5 cm.

Fry mortality during collection and transportation from the cisterns occurred in fry less than10 mm. in size. Approximately 10% of the 10 mm. size class died.

Temperature

The water temperatures ranged between 26°C to 32°C. Temperature readings were taken daily.

Oxygen

During the experimental period the dissolved oxygen content of water in the cisterns ranged between 3 to 11 ppm. Oxygen readings were taken daily.

pH

During the experimental period the pH of the cistern water was between 7 to 10, always towards the alkaline side.

Discussion

Tilapia have been observed spawning successfully in a garden pond with a concrete bottom (Chen, 1953) and also in concrete ponds (Blay, 1981. Allision *et. al.*, 1976).

Fish used in the present experiments were 2-4 months old. Lowe McConnell's data for *S. niloticus* suggest that brood fish size is smaller if condition is low in the population. This would suggest that quantity and quality of available food for brood stock, which determine their condition, is a factor which affects breeding. Other possible factors include water chemistry, temperature and dissolved oxygen (Pullin and Lowe McConnel 1982).

In the experiment carried out temperature, dissolved oxygen content and pH of water were favourable for breeding and growth of *S. niloticus*

Nets restricted the broodstock area. Tanks with nets produced less fry per unit area than the tanks without nets. Despite broodstock numbers per cistern being greater in those without nets, given the same stocking density, however fry resulting per female was higher in cement cisterns with nets than in those without. Early segregation of the fry from the parents, as such, is suggested for enhanced production of fry in *S. niloticus*.

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TABLE I

Frequency of collection	Every two weeks		Once a week		3 — 4 days	
Cement Cistern No.	1	6*	2	5*	3	4*
Brood fish No.	12	8	12	8	12	8
Fry produced	2739	2458	3374	2571	2938	1793
No. of fry per female	304	409	374	428	326	387
No. of fry per sq. m. area	130	160	139	85	192	117

Note :

Sex ratio employed 3♀ : 1♂

*Cement cisterns 6,5,4 with net partition

Cement cisterns 1,2,3 without net partition.

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FISH CULTURE IN SEASONAL TANKS IN SRI LANKA

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Seasonal tanks as the name suggests are water bodies that retain water seasonally. In Sri Lanka these are primarily small irrigation tanks most being situated in rural areas of the dry zone. The water in these besides irrigating agricultural land are made use of by the populace around for domestic purposes as also by cattle. The seasonal village tanks, yield some fish, mostly small trash fish and some predatory species. This, however, is of a low order and realising the potential of such tanks, akin to fish ponds (at least the smaller ones), for production of food fish under proper management, the Ministry of Fisheries embarked upon studies in fish culture in selected seasonal village tanks which are continuing, 1982/83 being the fourth consecutive year.

Thayaparan (1982) has outlined the role of these water bodies towards contributing to freshwater fish production in Sri Lanka. Estimates vary as to the likely extent of such waters but it is agreed that these can contribute significantly to the annual fish production of Sri Lanka. The ADCP Mission of the FAO (1980) estimated the likely quantity of this as 25,000 tonnes/annum, from a programme of judicious stocking and management of these water bodies. The purpose of the present communication is to examine the results obtained in fish culture trials conducted in village tanks and suggest management methods that could give improved yields from these water bodies.

Water Supply

Fernando and Ellepola (1969), mention that the variability of village tanks with regard to their productivity, etc., is dependent among other things on the water supply. Rainfed or streamfed or receiving water from reservoirs the water in these tanks get connected during floods to other nearby sources of water which at times are permanent water bodies. Fernando and Ellepola (1969) mention that the rainfed Thimbrigaswewa (seasonal tank in Minneriya area) probably gets connected to streams and reservoirs in the area. In the absence of effective barriers to the entry of rain water from outside such conditions occur in most seasonal village tanks. This accounts for the presence of the group of fishes clubbed together under category "miscellaneous," (in the fish production figures) fish that had not been stocked in these tanks but figured in the harvests (Tables II, III and IV). Predatory fish species such as *Wallago attu*, the murrels (*Channa* spp.), *Glosogobius giuris* etc., and carp minnows together largely contribute to this category of fish. Also present may be fish such as Anabas, able to resist dessication prior to the 'Rains'.

Tanks that do not dry up completely may have some fish left over from the previous season particularly the mud-dwellers, tilapias etc. Fernando (1965) notes that there are over ten piscivorous species in the indigenous fish fauna of 55 species in Sri Lanka and also that these occur in considerable numbers. Predatory birds and reptiles and mammals also account for fish losses from such habitats.

Oglesby (1981), found fish-eating birds common including high concentrations in some of the 50 tanks visited in Sri Lanka. He also mentions of presence of the crocodile in some tanks and the capacity of the Ceylon otter to consume significant quantities of fish.

As such, the village tanks present the picture of land depressions large or small (0.3 to 40—50 ha.) located in or near rural habitations which dry up towards the third quarter of the year (depending on preceeding rainfall intensity), and thereafter start getting filled up with water resulting from the North-East Monsoon reaching maximum water level around December/January. Besides the few tanks that are perennial, the seasonal ones retain water for about

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6—8 months. The droppings left behind by grazing cattle together with the seasonal drying of the bottom by the hot sun enriches the tank resulting in production of plant and animal life. Hickling (1971), expresses that exposure to the sun and air is known to restore fertility to a pond. Same is the case with the seasonal village tanks.

It must be realised that the cultivable fish species are stocked in such water bodies. The results obtained in fish raising in these tanks as such need to be viewed against this background.

Tables II, III and IV include the extent of water spread of tanks and this, as would be seen, is found to vary depending on the seasonal rainfall.

Thayaparan (1982) mentioned that the effective water area in seasonal tanks is retained for 4-5 months. The data in Tables II to IV indicate that the fish culture period in the tanks extended to longer periods, the cultured fish being retained in the tanks beyond the optimum water level conditions for ease of harvesting in low water. It may be noted, however, that during the concluding part of the culture period when the fish have grown to bigger sizes, the stress on these due to low water level could be significant. In addition, such low water levels would ease poaching and make it easy for predators to catch fish.

Location, area

The seasonal village tanks are situated mostly in the dry zone and only a few in the wet zone or coastal areas. Consequently the latter retain water all through the year. Most of the tanks used for the trials are in the dry zone but some tanks in the wet zone were also utilized. The yearly break-up is as follows :—

1982-83:86 (dry zone) and 29 (wet zone); 1981-82:38 (dry zone) and 15 (wet zone); 1980-81:23 (dry zone) and wet zone nil and 1979-80-3 (dry zone) and 3 (wet zone). The dry zone areas receive rain mainly from the North-East Monsoon. Arumugan quoted by Thayaparan (1982) has indicated that the greater part of the rains in the dry zone is from October-January and during the South-West Monsoon period there are occasional cyclonic rains. Heavy rains lead to floods which in some cases cause spills. The chances of loss of stocked fish along with such water is a distinct possibility (e.g. Ihalawewa in Minneriya in 1982/83) as most tanks do not have protected spill-ways to prevent such fish escapes. The stocking of the tanks with fingerlings start when filling of these commences at the begining of the North-East Monsoon rains or more precisely the 'Autumnal cyclonic period' described by Thambipillay (1955) starting late in September.

However, it is the smaller tanks out of these that have been made use of for experimental studies from 1979/80 to 1982/83, based largely on manageability. The great majority of tanks covered by the study, however, have areas within 5-6 hectares at FSL.

Experimental details

Except for a few perennial and estate tanks (ET), the vast majority of the trials were made in seasonal village tanks.

TABLE — Ia Performance recorded (fish production) in Seasonal Tanks in different years

Year	Number of tanks		Tanks recording fish production of 500 kg/ha or more	Fish production between 250-500 kg/ha.	Tank nos. in which work was incomplete or abandoned
	Selected for stocking	Number stocked			
1979/80	5	5	3	—	1
1980/81	23	23	10	6	1
1981/82	53	53	6	8	28
1982/83	115	76	11	9	21

The experiments undertaken met with varying degrees of success such as total abandonment of work due to early drying up of the tanks, incomplete harvest because of inability to net effectively due to high water level or obstruction caused by weeds, loss of fish stock due to reported poaching, etc., to those in which tanks were dry and could not be stocked. Consequently, widely varying fish productions were reported. Table 1a indicates the results briefly.

It would be seen from the foregoing Table that a number of tanks have not been accounted for in it. This category is made up of tanks in which productions were less than 250 kg/ha.

The year 1982/83 experienced unprecedented drought. Many seasonal tanks stocked had to be harvested early as the water had receded fast and this adversely affected production in these tanks. The severity of the drought can be realised as even 10 tanks out of 29 in the wet zone which received almost twice as much rain as the dry zone, dried up. Low percentage of success was registered during the year when only 13% of seasonal tanks yielded fish production at 500 kg. or more per hectare. Drought conditions of less severe proportion though were also experienced in the year preceeding this i.e. in 1981/82, when too work in some tanks had to be abandoned after stocking. Such conditions however, have not been recorded for the earlier years of 1980/81 and 1979/80.

Results

Tables II, III and IV indicate the productions obtained from selected tanks. Only productions at 500 kg/ha (close figures also included) or more have been considered. This is so because even under no management village tanks naturally stocked, have been known to yield fish productions at around 150 kg/ha. (Mendis, 1976). Also, productions lower than 0.5 ton/ha. may not be worthy of attention and investment.

The seasonal tanks were stocked with fingerlings of cultivable fish varieties. The species stocked were the Chinese Carps, Bighead (*Aristichthys nobilis*), Grass carp (*Ctenopharyngodon idella*), and Common carp (*Cyprinus carpio*) and the indegenous *Labeo dussumeiri*, *Chanos chanos* (in a few instances) and *Tilapias*, *S. mossambicus* and *S. niloticus* (since renamed as *Oreochromis mossambicus* and *Oreochromis niloticus*). The size of the fingerlings stocked varied from 3–5 cm. and generally complete stocking of a tank was accomplished by release of fingerlings on a number of days, as per supply obtained.

The stocking density was not uniform and in the year 1979/80 it varied from 6,250 to 15,000/ha; in 1980/81 it varied from a low 535 to 11,388 per hectare; in 1981/82 the variation was less being 534 to 2,500/ha. and in 1982/83 the variation per hectare was from 750–4,500 (Tables II, III and IV). It would appear that the stocking density as also the species composition was largely dictated by availability of fingerlings. But as observed by Thayaparan (1982), the stocking density was reduced in later years. As unstocked fish (left overs of previous years or entrants with flood waters) also figured in the catches in many instances and that the tank water areas were approximations, correlations between numbers stocked and productions are not attempted. The management measures adopted was largely stocking of fingerlings and harvesting the same later on. Fertilization and feeding of fish was attempted in rare instances and that too only in the first year. Some liming of tanks also was tried then only.

Table I b shows the levels of production obtained in the seasonal tanks programme in different years. The gradual increase in the number of tanks taken up indicates expansion of the programme, but the success percentage has not correspondingly increased. Figures of this Table considered along with those of Tables II, III and IV indicate that productions were not found to be better in the same tank each year. Exception to this were few e.g. Tunkama tank as mentioned by Thayaparan (1982). Table VII shows that this tank too was affected by the drought conditions in 1982/83 and had to be harvested early after 4 months of fish growth, yielding only 858 kg. for the 4 ha. tank. Even of this quantity obtained at harvest, 35% was made up of fish not stocked, being the 'miscellaneous' category. Two more exceptions may be the Kadahatawewa and Maduwanwela tanks. In the former in two consecutive years, the fish harvest exceeded

500 kg/ha. being at 719 kg. in 1979/80 and 841 kg/ha. in 1980/81. Samaranayake and Nanayakkara (1980) have mentioned of the preparation of the tank Kadahatawewa prior to stocking, involving eradication of wild fish, removal of aquatic plants, repair of bunds, fixing of nylon net at the outlet through involvement of villagers and stocking of the tank after being water filled. They mention that despite the removal of unwanted fish even by resorting to application of bleaching power, catches made at the end of fish culture in these ponds revealed the presence of predatory fish species such as *Channa striatus*. In the tank, fish species not stocked but figuring in the catches, termed 'others' accounted for 16.6% of total production. In this tank the production was a low 70 kg/ha. in 1981/82 and in the year 1982/83 it was not found worthy of being stocked. In Maduwanwela, the production was good in two years and fair in one year (Table VII). The varying water level conditions, differing densities and species composition of fish stocked are differences that do not permit inter-specific or intra-specific corelations to be attempted. The overall fish culture performance in seasonal tanks has been summed up and presented in Table I b. It would be seen from this that though the water area stocked increased in later years, not gradually though, this could have been much more or faster if adverse weather conditions had not intervened. Whereas, drought conditions prevented stocking of seasonal tanks, untimely rains raising water levels also came in the way of harvesting of tanks. Taken altogether the average production obtained from the seasonal tanks work out at little over 200kg/ha. This however, masks the good results as also very poor production values obtained e.g. in 1981/82 whereas 16, 156 kg. of fish yield resulted from a number of tanks together adding upto 35.5 hectares (average 455 kg/ha.) only 221kg. came out of another 62 hectares (average 3.6 kg/ha). Similarly in 1982/83, water area of 3.5 hectares yielded 3,750 kg. (av. 1071.4 kg/ha), but another 53 ha. accounted for a meagre 3,403 kg. (av. 64 kg/ha). As such, the average production figures do not reflect the fish production potential of the seasonal tanks there being wide fluctuations in levels of fish productions obtained. The need for careful selection of tanks to be stocked is strongly emphasized by the results.

Fish productions varied from 1960.7 kg/ha. to 549.5 kg (the more successful tanks considered), in 1979/80. In the next year, 1980/81 productions, obtained varied from 563 kg/ha. to 1,415 kg/ha, in three out of ten the figures topping a ton/ha. In 1981/82 not one tank gave a ton/ha of fish yield, the best being 967 kg/ha in one tank and in others it being much less. In 1982/83 production at 2,594 kg/ha. was obtained from one tank and out of the ten tanks of which the productions were comparable to or better than in previous years, in eight these were more than 1 ton/ha. The obvious conclusion would appear to be that if a tank maintained sufficient water level for a reasonable period of time and the water did not harbour many predators and was stocked adequately and management measures that were possible ensured prevention of loss of fish through poaching or predatory animals and birds, yields could be expected to be reasonably good. The likely results under intensive fish culture and thorough management, in seasonal village tanks, granting there will be sufficient water for a desirable period of time could be expected to be better, but how much better needs to be worked out and seen through actual trials.

Fig. 1. Harvesting a seasonal tank.

Performance of the species stocked

Tables V and VI denote the performance of fish, species-wise, in the seasonal tanks.

From Table V denoting production from selected tanks in 1979/80, it would be seen that the Tilapias made up of the species *O. mossambicus* as also *O. niloticus* were the species stocked in largest numbers. Though the production figures of 437, 431, 547 kg/ha. obtained of Tilapia alone could be considered as satisfactory resulting from water bodies not fertilized and fish not fed, in the absence of data on average weight of harvested fish it is difficult to realise the proper worth of the harvest as it could have in it significant numbers of young ones (resulting from breeding of the species) not considered table sized.

With regard to Common carp, productions obtained varied from 7.5 kg/ha., to 64kg/ha, very poor productions resulting from stocking rates in the vicinity of 5,000/ha. (except in one tank). Obviously such performance is due to very low survival of stocked fingerlings.

Same appears to be the condition with regard to Grass carp, stocked fish being totally absent in catches in two tanks out of three. The Bighead carp gave satisfsctory performance accounting for a production of over 1 ton/ha. in a tank, but appears to have met the same fate as that of Common carp and Grass carp in the other tank. The performance of the species as observed in later years follow.

Table IV gives the survival rates of stocked fish in selected tanks. Widely differing survivals were observed in the case of Common carp in 1980/81 and to a lesser extent in 1982/83. In the latter this was possibly because of factors such as presence of fewer predatory fish in the tanks, reduced predation by birds and animals from outside, better water level during the culture period providing more space to fish for living and escaping from enemies. More than one of these factors are likely to have operated simultaneously. The common carp being a slow moving fish could be easier prey for predators particularly in the early stages, resulting in low survival and a few fish of high average weight (Table VI). The survival figures of the Tilapia species and the average weights attained are, similarly, inversely related. Except in a few instances, the performance of Bighead carp was the best of all the species and could be considered better than the Tilapia even when contribution by weight of the former species was somewhat less. The average weights attained by the Bighead carp were such as to make them marketable (Fish of 1lb. or roughly 0.5 kg. being taken as marketable). Rarely were harvested Bighead carp less than such sizes whereas average sizes of 2 kg. or more were attained in a number of instances (Table VI).

In appraising the performance of the Tilapia in seasonal tanks the likelihood of some of these being carried over from previous stock in tanks not completely dry before stocking as also the entry of such fish along with flood waters need be borne in mind. This together with precocious breeding of tilapias under adverse conditions (Balarin, 1979) such as low water levels, and the low oxygen demand of the species could lead to over population and stunting under conditions as obtainable in seasonal tanks. As photoperiod and light intensity influence early maturity (Balarin, 1979) and as reported by Mackintosh, (1983) *O. mossambicus* females may spawn when still as small as 5 cm. or weight 5 g., such problems could assume significant proportions with the species in tanks in Sri Lanka. Periodic thinning by netting and removal of the bigger marketable onces is, as such, advisable. As the tanks are harvested with water present in them the possibility of complete removal of fish from these, particularly the smaller size fish, (Tilapia young ones possibly dominating) appears remote. Also, when such fish are captured, these are likely to be neglected as not being worthy of being utilised or disposed and hence may not figure in the yield data. This perhaps account for lesser number of tilapia shown among harvested fish than actually happening. Chakrabarty and Hettiarchchi (1982), observed in a polyculture trial that three different size groups of fish resulted, in 6 months culture, of *Tilapia nilotica* fingerlings (Av. length 104mm.) stocked in a farm pond in Sri Lanka. The smallest size were around 5 cm. Such small sizes when harvested from seasonal tanks are likely not to be accounted for in the catches and hence production.

Discussion

Notwithstanding the differences in stocking densities and species ratio and variations in sizes of fingerlings (stocking being spread over a period of time) stocked, size and depth of stocked waters being dissimilar, certain broad observations regarding the fish culture attempts made in seasonal village tanks can be made: (a) Lower densities of stocking did not result in correspondingly lower productions despite losses due to predation, etc. In fact, stocking densities of lesser than 1,000/ha gave yields of over 0.5 ton/ha. whereas comparable productions were realised in many instances, by stocking 2½ times as much (Tables II and III) (b) Extension of the culture period, beyond a reasonable growing period (around six-eight months), did not give correspondingly higher yields. (Tables II and III). In fact, in 1982/83 when the culture period happened to be 5-8 months in contrast to year long culture in some tanks in 1980/81 and 1981/82 (not same tanks) higher yields materialized. Tanks retaining water all along, as such, are not preferable because of difficulty in preparing these to receive culturable fish stock by removal of unwanted predators (including fish) and also because of inability to harvest these effectively. (c) The smaller tanks gave better yield per unit compared to the larger waters, a reflection of better manageability including more thorough harvesting. In 1982/83 the better results were obtained from tanks varying in size from an acre (0.4 hectares) to 4 hectares.

As low survivals of Common carp and grass carp have repeatedly been encountered the obvious conclusion is that the fingerlings stocked could not tide over conditions prevelent in seasonal tanks. To meet this it may be desirable to stock fingerlings of larger sizes i.e. around 10 cm. as these may be able to escape predators better, meet unfavourable conditions of low water levels and additionally, in case of grass carp, macrophytes can be better utilized by bigger fingerlings leading to their rapid growth. In fact, it may be advisable to stock some advance sized fingerlings of 6″—8″ size of grass carp to take advantage of the aquatic weeds present in seasonal tanks and thereby fertilize the tanks by semi-digested excreta of vegetable matter of the fish. Other carp species benefit directly or indirectly from such conditions as reported in their studies in India by Chaudhuri *et. al.*, (1975), Sen *et. al.*, (1978) and Chakrabarty *et. al.*, (1980). Bailey (1972) expressed that by removal of weeds by grass carp nutrients are released increasing productiion of other fishes. The tendency of Common carp to browse at the margins make it susceptible to predators. As such, this species may be stocked in the deeper tanks, so that when the tank water goes down at the concluding part of the culture period the fish can be harvested employing nets with sinkers attached.

Future management policy

The results obtained from the trials in seasonal village tanks provide indication that can form the basis of a management policy that could result in more profitable utilisation of these water bodies in future towards augmentation of freshwater fish production in Sri Lanka.

Selection of Tank

The selection of such tanks that are suitable for fish culture is basic to implementation of any aquaculture programme involving these water bodies. Thayaparan (1982) has indicated the criteria for selection of tanks. The two most important requirements no doubt are retention of water of adequate depth (at least 1 metre) in most parts of a tank for such period of time e.g. six months, that would make possible raising of marketable size fish in the tank. Prevalence of required depth of water over greater part of a tank during the period of culture perhaps need to be emphazised as more than shallow water spread this would be helpful for fish growth. Chakrabarty (1981(observed better yields to result from ponds with more water (depth) in experimental carp polyculture studies in India.

Management

(a) **Village involvement** : The involvement of the village community nearby is essential for the success of fish culture in seasonal tanks. The well-being of the stocked fish can be ensured by participation of people living near the tank stocked. Apart from serving as deterrents to poaching (which at times could cause removal of fish not ready for the table) careful watch by villagers could reduce losses by predators of fish such as birds and animals. Periodical removal of weed infestations, assistance during fishing and keeping away hordes of cattle from wading into the water (muddying water in small tanks) and such helpful chores can also be performed by villagers.

(b) Stocking : Stocking of fingerlings of sizes that could circumvent predation better such as those 100-150 mm. in length may be adhered to as far as practicable. The stocking density and the species ratio are also important. Fingerlings should only be released when adequate water level in the tank has been reached.

(c) Tank preparation : Tanks that do not get dried up before being water refilled should be thoroughly netted to remove previous leftover fish which may have a good population of predators and minnows. Lime may be broadcast at 200-300 kg/ha before the tanks start getting refilled. Such management measures are likely to be possible in tanks that are not too large. The smaller tanks as such if otherwise found satisfactory, may be preferred. Providing guarded inlets and spills and also removal of major obstacles such as tree stumps, boulders, etc., may be also attended to. Deweeding also may be added as part of tank preparation work.

(d) Polyculture : The type of fish culture to be practiced is polyculture with an emphasis on carps (stocking material permitting) to attain good production. However apart from carps, the tilapias *O. mossambicus* and *O. niloticus*, may also be used for stocking along with some milk fish (*Chanos chanos*.)

The recent introduction of the major Indian carps have brought into Sri Lanka three carp species which grow fast and are likely to do very well under Sri Lanka conditions. The three species *Catla catla* (*catla*) a surface feeder, the *Labeo rohita* (*rohu*) a column feeder and *Cirrhinus mrigala* (*mrigal*) a bottom feeder may be expected to give good productions in seasonal tanks. The three species together with the Chinese silver carp and grass carp and the common carp have given high fish productions in ponds in India (Chakrabarty, *et al.*, 1980). In Sri Lanka apart from these species the Chinese bighead carp, are also available. Species combinations that can be suggested for stocking seasonal tanks are as follows :

(I)	(II)	(III)
Catla or Bighead carp	Catla or Bighead carp	Silver carp and Catla
Rohu	Rohu	Rohu
Mrigal	*O. niloticus/O. mossambicus*	*O. niloticus/O. mossambicus*
Common carp		
Grass carp	Common carp	Common carp
	Grass carp	Grass carp

(IV)

Silver carp

Rohu

Mrigal

Common carp

Grass carp

The species ratios in the various combinations have not been indicated as it may be dictated by fingerling availability. Equal numbers of each species may be tried, grass carp being stocked only in tanks that have soft aquatic weeds. The catla and bighead carp being similar in food preferences if stocked together would compete and as such only one may be used. Similarly, the growth of mrigal is likely to be adversely affected by tilapia and as such may be omitted from combinations that include these cichlids. Catla and silvercarp if used together may be in the ratio of 2 : 1. *O. niloticus* may be preferred to *O. mossambicus*.

As the growing period is short (approximately 6 months) the stocking density may be kept low such as, around 1,500/ha. and in no case exceeding 2,500/ha. Chakrabarty *et al.*, (1976) found a stocking density of 3,000/ha. preferable than higher rates of stocking for short term (6 months) polyculture in ponds of Indian and Chinese carps inclusive of Common carp, in India, involving the use of fertilizers, and supplementary feed and aquatic weeds for grass carp.

Harvesting

Effective cropping of the produce is of great importance in culture of fish in impoundments, more particularly in those that are seasonal, because if fish are left over after harvesting efforts these are likely to perish because of unfavourable conditions when the tanks are getting dried. Consequently, tanks that permit easy operation of gear i.e. those having even bottom and are devoid of major obstacles to fishing are to be preferred. Also important is the use of proper nets and their effective use. Seine nets, gill nets (and cast nets) are to be used, but these should be properly rigged e.g. for the capture of bottom dwellers it may be necessary to attach weights or sinkers to gill nets and seines (drag nets). In the larger tanks congregating fish by scaring and driving them towards sections that can be more easily netted should precede the actual netting operations.

As stocked fish will not grow uniformly, periodical netting and thereby removal of such specimens as have attained table sizes should be followed. This a sound practice in fish farming. Chakrabarty *et al.*, (1974) observed that periodic or intermediate harvesting makes for availability of marketable fish over a larger period of time (highly desirable for the village community around seasonal tanks), reduces intra and inter-specific competition, thereby enhancing growth of the left-over or later removed fish and minimises losses due to poaching. The periodicity of intermittent harvesting however is to be related to period of retention of water, stocking density, species ratio employed and fish food availability in the tank. Tank management groups formed of technical personnel and village representatives can decide on this after conducting sample nettings and work out cropping schedules that would make possible best use of the tank for fish production and proper utilization of fish catches.

Conclusion

The seasonal village tanks are excellent resources that can make significant contribution towards enhanced freshwater food fish production in Sri Lanka. Whereas all village tanks are not suitable for raising marketable (table) fish, there are many which can be put to such profitable use. The attractive feature of growing fish in these water bodies is that it involves low investment and that existing water resources are put to use to yield food of desired taste and nutrition. Nevertheless, judicious use of fingerlings of cultivable fish, raised at state expense and management cost involving participation of officials (fisheries and other departments) and villagers should guide the undertaking of any effort at realisation of the fish productive potential of these impoundments. Tanks that retain water of depth about a meter for 6–8 months but get completely dry during part of the year and are stocked with advance fingerlings of sizes around 100 mm, mostly of carp species at a combined density around 2,000/ha. in proportions indicated earlier in the paper, can be expected to result in fish productions around 0.75-1 metric tons per ha. Harvesting may be staggered but started along with attainment of marketable or table sizes by stocked fish. Thus a fish production of 1 million kg. may be expected yearly from stocking of 1,000 hectares of desirable seasonal village tanks. Properly selected, adequately stocked, managed systematically and timely harvested, seasonal village tanks in Sri Lanka are capable of raising food fishes at low cost in remote areas and would serve to improve nutritional and economic standards of rural communities.

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TABLE — I b

Extent of stocked waters and fish production, year-wise, of seasonal tanks

Year	Water area stocked (ha)	Fish produced (kg)	Production rate in kg. per ha.	Remarks
1979/80	26·7	16,418·5	614·9	Five tanks were stocked of which three were seasonal village tanks (SV), one perennial village (PV) and the other perennial estate tank (PE).
1980/81	138·6	31,323	225·99	The tanks were completely harvested. Twenty (20) were SV tanks, one PE and one PV tank; one tank poached did not provide data.
1981/82	177·38	27,565·55	155·43	Twenty six (26) SV tanks were harvested, many were partially poached, in some, harvesting was only partial because of rains. In some, part of fish stocked died due to drought; One PV and one PE tank were harvested. In the rest of the 25 tanks selected, fish culture was abandoned due to drought or fish stock poached or harvesting was not possible due to rains, etc.
1982/83	205·3	46,858·15	228·24	From thirty four (34) tanks stocked data not available because of early drying. 42 SV tanks were harvested many earlier than planned because of drought conditions (1 ET and 1 PV, rest SV). Selected 39 SV tanks no tstocked having dried up because of drought.

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TABLE — II

PRODUCTIONS RECORDED IN SEASONAL TANKS IN 1980/1981

(500 kg/ha and above considered)

Name of Tank (1)	*Location (Zone)* (2)	*Area (ha)* (3)	*Stocked Nos. species wise, figures in parentheses denote percentages of total fish stocked* (4)	*Stocking density (ha)* (5)	*Culture period* (6)	*Harvest details in kg. (percentage in production in parentheses)* (7)	*Production /ha* (8)	*Remarks* (9)
Tunkama	Embilipitiya (Dry zone interior)	0.4	T-11495:BC-4150: RC-6000 = 21645 (5.31) (19.2) (27.7)	5411.3	8 months	T-1851.0:BC-2747.0: RC-16.8 = 4614.8 (40.1) (59.5) (0.4)	1153.7	Completely dried before stocking and totally harvested.
Maduwanwela	Kolonne (Dry)	2.5	T-8100:BC-1000: CC-350 = 9450 (86.2) (10.6) (3.2)	3780	8 ..	T-1029:BC-724.0: CC-185 = 1938 (53.1) (37.4) (9.5)	775.2	Completely dried before stocking; complete harvest.
Kalawelgala	Tanamalvila (Dry)	2.5	T-13,000:BC-2200: CC-4000 = 19,200 (67.7) (11.5) (20.8)	7680	8 ..	T-1838.0:BC-1420: CC-254 = 3512 (52.3) (40.4) (7.3)	1404.8	Completely dried; completely harvested, partially poached,
Kudahatawewa	Minneriya (Dry)	6.5	T-30,000: (100)	4615.4	8 ..	T-5465 - (100)	840·8	Completely harvested.
Polonnaruwa	Tangalle (Dry)	6.0	T-10,000 (100)	1666.7	8 ,,	T-3163.6 - (100)	527.3	Completely harvested.
Alhenpitiya	Rambodagalla (Dry)	0.1	CC-1000:GC-539 = 1539 (65) (35)	1539	12 ,,	CC-150:GC-312 = 462	462*	Completely harvested. (*production close to 500 kg/ha.)
Akkaragama	Rambodagalla (Dry)	0.4	BC-1000-(100)	2500	12 ..	BC-200-(100)	500	
Dekanduwala	Ridigama	0.6	T.n-.500:CC-250: BC-2000 (16.7) (8.3) (66.7) L.d.-250 = 3000 (8.3)	5000	12 ..	T.n.-80:CC-50.0: BC-192.5 L.D.- 22.1 = 345.1 (6.4)	575.2	Completely harvested. Completely harvested
Arunodagama	Kurunegala (Dry)	0.3	T.n.-1500:T.m.-500: GC-500 (60) (20) (20) = 2500	8333.3	13 ..	T.n.-:T.m.-152:BC-474: CC-18.7 = 218.4 (—) (69.7) (21.7) (8.6)	728	Partially poached. Draining not possible before stocking.
Salpilawatte	Wariyapola (Dry)	0.6	T.n-250:BC-2000: RC-2000 (3.7) (29) (29) GC-50: L.d.-2500 = 6800 (1.5) (36.8)	11333.3	12 ..	T.n.-116:BC-125:RC-14.0: GC-43·75 (13·8) (14.8) (1·6) (5·2) L.d.-1170.0:Misc-431.2 = 848·8 (3·8) (50·8)	1414·6	Completely harvested.

Key :

T — Tilapia RC—Red carp CC—Common carp GC—Grass carp
BC — Bighead Carp T.n.—*Tilapia nilotica* Tm.—*Tilapia mossambica*
Ch — Chanos Misc—Miscellaneous L.d.—*Labeo dussumieri*

TABLE III

PRODUCTIONS RECORDED IN SEASONAL TANKS IN 1981/1982

(500 kg/ha and above considered)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Mahawewa	Embilipitiya (Dry)	06	BC–12000:L.d.–3000: = 15000 (80) (20)	2500	9 months	BC–5723:L.d.–78.5 = 5801.5 (98.6) (1.4)	966.9	Completely harvested.
Pelnehera	Dambulla (Dry)	02	BC–1200:GC–400: = 1600 (75) (25)	800	10 ,,	Total 1500 kg. (100)	750.0	Partially poached ; competely harvested.
Kidawaran-kulam	Medawach-chiya (Dry)	08	BC–1500:GC–275:Tn–2500: = 4275 (35.1) (6.4) (58.5)	534.4	3 ..	BC–2898:GC6113:Tn3011 = 6022 (48.1) (1.9) (50)	752.8	Completely harvested, partially poached.
Sitana-maluwa	Tangalle (Dry)	04	BC–3500:Ld. -2700 = 6200 (56.5) (43.5)	1550	8 ..	BC 1573.25:Ld. 36.25: (79.1) (4.9) Tn..–318.00 = 1,990.00 (16)	497.5	Completely harvested.
Bakmu-kotuwa	Dodagas-landa(Wet)	03 (pere-nnial)	BC–1225:Ld.–1000: Tm.–2800: (20.9) (17) (47.7) T.n.–300:RC–550 = 5875 (5.1) (9.3)	1958.3	12 ..	BH–1250: Ld.–75.0: CC–253: (65.7) (4) (13.3) T.–200:GC–124.0 = 1902.0 (10.5) (6.5)	634.0	Completely harvested.
Niyandagala	Tanamalwila (Interior dry)	12	BC–21000:Ld.–5000 = 26000 (80.8) (19.2)	2166.7	9 months	BC–4857.6:Ld.–619.0: Misc–439: (81.9) (10.4) (7.4) GC–11.5 = 5928.0 (0.3)	494.0	Completely harvested.

TABLE IV

PRODUCTIONS RECORDED IN SEASONAL TANKS IN 1982/83
(500 kg/ha and above considered)

Name of Tank	*Location (Zone)*	*Area (ha)*	*Stocked Numbers species-wise, figures in parentheses denote percentage in total fish stocked*	*Stocking density (ha)*	*Culture period*	*Harvest details in kg. (Figures in parentheses denote % of species in production*	*Production/ha*	*Remarks*
Kottaga-hakanatta	Uvapara-nagama (wet zone)	0.4	BC.800(53.3):GC.200 (13.3) : CC.200(13.3):Tn.300 (20.1) = 1500	3750	8 months	BC.610(99.7):GC.02 (0.3) = 612	1530	Completely harvested; partially poached.
Maduwan-wela	Kolonna (Dry)	3.5	BC.1000(13.4):GC.2000 (26.8) : CC.1450(19.5):Tn.3000 (40.3) = 7450	2128.6	8 ,,	BC.216.8(3.7):Tn.5393 (92) CC.253(4.3):GC.1.5 (0.03) = 5864.3	1675.5	Completely harvested
Morages-wewa	Dambulla (Dry)	2	BC.4300(39.8):GC.3000 (27.8) : CC.2000(18.5):Tn. 1500 (13.9) = 10,800	5400	6 ,,	BC.395(17.6):GC.1109 (49.4) CC.246(10.9):Tn:139(6.2) Misc.358(15.9) = 2247	1123.5	Completely harvested
Maduru-wattawan tank	Amparai (Dry)	4	BC.1000(21.3):CC.400 (8.5): Tn.3000(63.8):GC.300 (6.4) = 4700	1175	7 ,,	BC.1800(27.8):CC.150 (2.3) GC.25(0.4):Tn.3000(46.3) Misc.1500(23.2) = 6475	1766.5	Completely h arvested
Murugan-kovil tank	Amparai (Dry)	1.5	BC.700(35.9):GC.100(5.1): Tn.700(35.9):CC.50(23.1)/ = 1550	1625	8 ,,	BC.1000(65.4):Tn.500(32.7) CC.20(1.3):GC.10(0.6) = 1530	590.9	Completely harvested
Wavinna-wewa	Amparai (Dry)	1.0	BC.800(58.2):GC.75(5.5) : CC.110(7.3):Tn.400(29) = 1375	1687.5	6 ,,	BC.666.6(72.3):GC.6.6(0.7) CC.26.0(2.9):Tn.128.8 (24.1) = 828.6	828.6	Completely harvested.
Namal-talawa	Amparai (Dry)	1.5	BC.650(48.2):GC.50(3.7) : Tn.600(44.4):CC.50(3.7) = 1350	750	5 ,,	BC.1000(69.3):CC.35(2.4) Tn.400(27.7):GC.9(0.6) = 1444	552.7	Completely harvested
Gorakagaha	Wennappuwa (Wet Zone Coastal)	1.0	BC 200(9.5):GC.350(16.5) : CC.565(26.7):Tn.700(33.1) Ch.300(14.2) = 2115	2115	6.5 ,,	BC.157.3(15.6):GC.22.2 (2.2) CC.62.0(6.1):Tn.664(65.6) Ch.0.6(0.10):Misc.105.0 (10.4) = 1011.1	1011.1	Completely harvested
Majeed tank	Amparai (Dry)	2.5	BC.800(43.2):Tn.800 (43.2) : GC.50(2.7):CC.200(10.8) = 1850	925	5.0 ,,	BC.1000(32.4):Tn.1000 (32.4) : CC.15(0.4):CC.75(2.4) : Misc.1000(32.4) = 3090	662.0	Completely harvested.
Ihalagama	Yapatuna	3.0	BC.2200(50.0):Tn.400(9.1): Ld.1200(27.3):GC.100(2.2) CC.500(11.4) = 4400	1466.3	5 ,,	BC.465(27.4):CC.54(3.2) T.700(41.1):Misc.480(28.3) = 1699	566.3	Completely harvested.
Ethakada	Padaviya (Dry)	3.5	Tn.5000(47.8):Ch.4000 (34.8) CC.2000(17.4) = 11000	3285.7	5 ,,	Tn.2312.5(61.7):Ch.18.1 (0.3) : CC.1107(29.7):Misc.311.5 (8.3) = 3749.6	1071.3	Completely harvested.

TABLE V

PERFORMANCE OF FISH STOCKED, SPECIES-WISE, IN THE FIVE TANKS IN 1979/80

(data derived from Thayaparan, 1982)

Species	Number stocked. Density per ha in parentheses	Fish production in kg Production kg per ha. in parentheses	Period of culture	% of species in total stocking density/ production	Remarks about management (Tanks indicated by numbers)
Tilapia spp.	3,000(750)	1726(431.5)	8 months	12%/22%	1. Completely drained before stocking.
,, ,,	32,999(4923.1)	3556(547.1)	8 ,,	50%/77.4%	1. Complete harvest; partially poached.
,, ,,	10,000(2000)	2186.9(437.4)	12 ,,	13.3%/79.6%	2. Not drained completely; completely harvested.
,, ,,	28,000(4912.3)	548.8 (96.3)	8 ,,	50%/50.3%	3. Not drained; complete harvest not possible.
,, ,,	57,904(10528)	50.3 (9.1)	10 ,,	91.3%/35%	4. Completely drained; complete harvest.
					5. Partial draining; complete harvest not possible.
Bighead carp	9,000(2250)	1435.8(1109)	8 ,,	36%/56.6%	
,, ,,	15,000(3000)	92.9(18.6)	12 ,,	20%/9.4%	1.
					3.
Grass carp	11,000(2750)	749.7(187.4)	8 ,,	44%/9.6%	
,, ,,	4,000(800)	Nil	12 ,,	5.3/—	1.
,, ,,	1.275(231.8)	Nil	10 ,,	2.9%/—	3.
					5.
Common carp	32,000(4923.1)	272.1(41.9)	8 ,,	59%/5.9%	
,, ,,	28,000(5600)	320.2(64)	12 ,,	37.3%/11.7	2.
,, ,,	28,000(4912.3)	271.2(47.6)	8 ,,	50%/24.8%	3
,, ,,	4,245(771.8)	41.3(7.5)	10 ,,	6.7%/28.8%	4.
					5.

Key : 1 = Tunkama
2 = Kadahatawewa
3 = Dummaladeniya
4 = Thimbirigaswewa
5 = Panmure

TABLE VI — Performance of Fish Stocked in Seasonal Tanks species-wise in the years 1980/81 to 1982/83

Tank (area in ha) (1)	Year (2)	Period of growth (months) (3)	species (4)	Survival per-centage (5)	Av. size attained at harvest (kg.) (6)	Remarks (7)
Tunkama (4)	1980/81	8	*T. mossambica*	90.9	0.18	—
	,,	,,	Bighead carp	69.4	0.95	—
	,,	,,	Common carp	0.37	0.76	—
Maduwanwela(2.5)	1980/81	,,	*T. mossambica*	93.8	0.13	—
	,,	,,	Bighead carp	79.7	0.91	—
	,,	,,	Common carp	53.1	0.99	—
Kalawelgala(2.5)	1980/81	,,	Tilapia	77.68	0.18	—
	,,	,,	Bighead carp	91.4	0.71	—
	,,	,,	Common carp	4.8	1.32	—
Alhenpitiya(1.0)	1980/81	12	Bigheadcarp	98.1	0.59	—
	,,	,,	Common carp	30.0	0.50	—
Dekanduwala(0.6)	1980/81	12	Tilapia	100%	0.10	—500 fish were stocked and the harvested number of fish were 805
	,,	,,	Bighead carp	71.5	0.13	—
	,,	,,	Common Carp	4.4	4.55	—
	,,	,,	*Labeo dussumieri*	49.4	0.18	—
Mahawewa(4)	1981/82	,,	Bighead carp	20.5	2.3	—
	,,	,,	*Labeo dussumieri*	23.3	0.1	—
Niyandagala(12)	1981/82	8,	Bighead carp	5.0	0.37	- perennial village tank
	,,	,	*Labeo dussumieri*	12.2	0.25	•—Only BH carp and *L. dussumieri* were stocked.
	,,	,,	Miscellaneous	—	0.12	
	,,	,,	Grass carp		0.63	
Bakmeekotuwa(3)	1981/82	12	Bighead carp	50.1	2.0	Perennial village tank. *T. mossambica* and nilotica were also stocked but in the absence of data on number of fish harvested survival percentage and av.size could not be computed.
	,,	,,	*L.dussumieri*	4.3	1.7	
	,,	,,	Common carp	22.5	2.0	
	,,	,,	Grass carp	30.7	5.4	
Sithanmaluwa(4)	1981/82	5	Bighead capr	20.4	1.45	Tn. and mossambica not stocked but featured in the harvest.
	,,	,,	*L. dussumic*	3.9	0.35	
Kidawarankulam(8) tank	1981/82	3	Bighead carp	75.1	2.2	
	,,	,,	Grass carp			
	,,	,,	*T. nilotica*	10.6	0.43	
Maduwanwela(3.5)	1982/83	8	Bighead carp	13.4	0.42	More tilapia were harvested than stocked.
	,,	,,	*T. nilotica*	—	0.45	
	,,	,,	Grass carp	0.15	0.50	
	,,	,,	Common carp	37.6	0.46	
Majeed tank(2)	1982/83	5	Bighead carp	56.3	2.5	
	,,	,,	Common carp	50.0	0.84	
	,,	,,	Grass carp	40.0	0.83	
	,,	,	*T. nilotica*	—	—	More tilapia obtained than stocked.
Murugankovil(1.2) tank	1982/83	8	Bighead carp	67.1	1.42	
	,,	,,	Grass carp	20.0	0.33	
	,,	,,	Common carp	40.0	0.66	
	,,	,,	*T.nilotica*	85.7	0.33	
Wavinna tank(1.0)	1982/83	4.5	Bighead carp	87.5	0.95	More tilapia were harvested than stocked.
	,,	,,	Grass carp	33.3	0.26	
	,,	,,	Common carp	—	0.27	More common carp obtained than stocked
	,,	,,	*T. nilotica*	—	0.25	
Namaltalawa(1.5)	1982/83	5	Bighead carp	76.9	1.03	
	,,	,,	Grass carp	40.0	0.30	
	,,	,,	Common carp	40.0	1.17	
	,,	,,	*T. nilotica*	66.7	0.33	
Moragaswewa(2)	1982/83	6	Bighead carp	29.3	0.31	358 kg. of miscel laneous fish, not stocked accounted for 15.9% of the production.
	,,	,,	Grass carp	33.8	1.09	
	,,	,,	Common carp	13.0	0.95	
	,,	,,	*T. nilotica*	20.0	0.45	

TABLE VII

COMPARATIVE PERFORMANCE OF SOME TANKS IN DIFFERENT YEARS

Name of Tank	Year	Area at FSL/ha	Stocking density ha	Harvest /ha	Period of culture	Remarks
Tunkama	1979/80	4.0	6250	1960.7	8 months	Completely dried before stocking. (partially poached)
,,	1980/81	4.0	5411	1153.7	,, ,,	Completely dried before stocking. Full harvest.
,,	1981/82	4.0	3475	326.8	,, ,,	Partially harvested. About 5000 kg. fish died due to pollution
,,	1982/83	4.0	1726.3	214.5	4 months	Harvested in April due to drought.
Thimbirigaswewa	1979/80	6.0	9824.6	194.6	8 months	Completely drained. Complete harvest.
,,	1980/81	6.0	5000	239.3	,, ,,	Complete harvest.
,,	1981/82	6.0	3500	18.0	7 months	Complete harvest. Partially poached.
,,	1982/83	Not	stocked			
Maduwanwela	1980/82	2.5	3780	775.2	8 months	Completely dried before stocking. Complete harvest.
,,	1982/83	3.5	2214.3	423.5	10 ,,	Completely harvested. Some fish died due to drought, after stocking.
,,	1982/83	3.5	2128.6	1675.6	8 ,,	Completely harvested.
Kadahatawewa	1979/80	7.0	9143	719.4	8 months	Completely harvested.
,,	1980/81	6.5	4615.4	840.8	,, ,,	Completely harvested.
,,	1981/82	7.0	3000	70.1	7 months	Completely harvested. Partially poached.
,,	1982/83	Not	stocked			

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BREEDING TRIALS ON THE GIANT FRESHWATER PRAWN IN SRI LANKA

R. P. Samarasinghe*

Introduction

The giant freshwater prawn (*Macrobrachium rosenbergii*) is one of the most economically important species of prawns in the world. The distribution of the natural stocks of this species in Sri Lanka is considerable and its exploitation from the wild is notably on the increase. Gradual depletion of wild stocks could occur with much vigorous exploitation. Mass scale culture of *Macrobrachium* would be a very worthwhile effort at this juncture. Presently only a very few farms have ventured into this field although many parts of Sri Lanka appear to be suitable for farming this variety. However, enthusiasm is steadily growing in the culture of this species. Therefore, establishing techniques of mass scale production of seed is also opportune for a growing programme. In the Fish Breeding Stations of Sri Lanka no work had been done in this direction until 1983 whence the author made some attempts to breed *Macrobrachium* at the Pambala Brackish Water Fisheries Station. With the limited facilities available, the author was able to raise a few numbers of post larvae in 1983. Subsequently better production of post-larvae was obtained in January 1984. This paper puts into record the initial experiments done from November 1983 to January 1984 in breeding and larval rearing of *Macrobrachium rosenbergii.*

Objectives

The experiments were undertaken to develop a suitable larval rearing technique for *Macrobrachium rosenbergii* utilising the available facilities at the Fisheries Station.

Materials

The following materials were used in the experiments :

(*a*) Aquarium tanks
(*b*) Small aerators
(*c*) Locally made sand filter(Fig. 1)
(*d*) Polythene tubes (diameter 3mm, 5mm, 1 cm, 2cm)
(*e*) Refractometer, pH meter, thermometer
(*f*) Clay pots (3 litre capacity)
(*g*) Scoop nets: 1. 1mm mesh mosquito netting;
2. Ordinary synthetic cloth.
(*h*) Enamel basins (4 litre capacity)
(*i*) Small plastic cups.

Methodology

Spawning and production of larvae : The brood stock consisted of four females and one male. The feed given was composed of a mixture of 20% poultry feed, 50% chopped Tilapia and 30% Ox blood. The brood stock was allowed to mate after the premating moult. When the females attained berried condition each was transferred to spawning tanks. Aquarium tanks of 85cm × 55cm × 55 cm dimensions and containing 100 litres of brackish water of 5 ppt salinity were used as spawning tanks. The females were placed in the tanks in the morning when the temperature and pH were observed to be around 27°C and 7.2 respectively. After a lapse of 15–18 days larvae were seen in the tanks. In all the four sets of experiments the larvae were produced in the night and the following morning the females were removed.

Larvae were siphoned out into enamel basins and the total number of larvae were determined by way of random sampling. These larvae were subsequently used in the larval rearing trials.

Feed for Larvae

1. **Brine shrimp** (*Artemia salina*) nauplii : Brine shrimp cysts collected from

*Brackish Water Fish Breeding and Experimental Station, Pambala.

Palavi and Bundala salterns, were used in these experiments. A special scoop net (known as kadippu) was used to collect *Artemia* "eggs". The cysts were found to be contaminated with algae, bird feathers etc. As such the collections were mixed with fresh water and filtered through a scoop net (mesh size 1mm) to remove the unwanted materials. The final filtrate was again filtered through an organdi cloth (300μ) and brine shrimp cysts were collected. The cysts were subjected to a series of washings in fresh water and finally dried in sun light. Well dried *Artemia* "eggs" were stored in a refrigerator.

The brine shrimp cysts were hatched in well aerated sea water contained in clay pots. This method gave around 70% hatching rate and optimal nauplii population was obtained after about 36 hours. *Artemia* nauplii were treated with 0.1% formalin solution, before being fed to the prawn larvae.

2. **Formulated feed** : Egg custard, boiled Tilapia meat, Soya meat powder, "Kurakkan" (*Elucine korakana*) powder, vitamins and antibiotics formed the ingradients of the formulated feed (Table I). Egg custard and Tilapia meat were ground well and filtered through a fine meshed scoop net before use in the feed composition. All the ingradients were mixed well and the wet mixture stored in a refrigerator ready for use.

Larval rearing

Aquarium tanks and cement cisterns were used as holding facilities for larval rearing. The water used in these trials was subjected to filtration by passing through a locally made strainer (Fig 1). The initial salinity of the water used in the rearing tanks was 10 ppt and the larvae from the 5 ppt water in the spawning tanks, were transferred to these larval rearing tanks. The larvae were subjected to different feeding regimes in the different experiments. Proper replication of trials could not be done due to severe limitation of facilities.

Experiment A : An aquarium tank (85cm × 55cm × 55cm) was filled with 200 litres filtered brackish water of salinity 10 ppt and pH 7.2. Twenty thousand numbers of one day old prawn larvae were stocked in it. Continuous aeration was provided. On the 1st day of stocking, no feed was given. From the 2nd evening *Artemia* nauplii were given as a feed until the end of the experiment. From the 8th day onwards the formulated feed was also provided in addition to *Artemia* nauplii. Quantity of feed given was decided in proportion to the density of larvae. To curtail pollution of water, unutilised feed particles, larval waste etc., that settled at the bottom were siphoned out once a day. Larval rearing was continued up to the 55th day. After the 35th day the salinity was gradually reduced The variations of salinity, quantity and frequency of feed are indicated in Table 2.

Experiment B : An aquarium tank of size 85cm × 55 cm × 55 cm containing 200 litres of brackish water of salinity 10 ppt and pH 7.2, was used for this experiment as in the earlier attempt. Ten thousand one-day old prawn larvae were stocked and provided with continuous aeration. Brine shrimp nauplii were provided on the 3rd day and from the 4th day onwards they were fed with both brine shrimp nauplii and the formulated feed. Experimental details are shown in Table 3. Salinity increased gradually and after the 10th day it was at 14 ppt and continued till the end of the experiment. The bottom sediment of the tank was siphoned out once a day.

Experiment C : A cement cubicle of 200cm × 110cm × 90cm dimensions was filled with 500 litres of unfiltered brackish water (salinity 10 ppt and pH 7.2) and 1000 numbers of one-day old prawn larvae were stocked. Aeration was provided. From evening day of the 2nd onwards formulated feed was provided to the larvae. The bottom of the container was cleaned only twice a week.

Results

At the end of the experiment (A), 3053 numbers of post larvae were obtained. The percentage of survival worked out to 15.2 on the 55th day.

In the experiment (B), on the 33rd day larvae refused to accept brine shrimp nauplii or formulated feed. A few larvae died on the same day. The water was renewed but all larvae died by the 34th day. Most of the larvae at the time of death were at X and XI stages and the total number was 1,170.

The experiment (C) failed and all the larvae died by the 16th day due to an infection. The exact causative agent could not be identified.

Discussion

In the experiment (B), when the mortality occurred, the salinity of the water was 14 ppt, pH 7.4 and the larvae were at stage X and XI.

In the experiment (C) too, mortality occurred when the salinity was at 14 ppt.

By the end of the 35th day in the experiment (A), the larvae became sluggish and responding poorly to feed. The salinity at this stage was at 14 ppt. Taking some guidance from the experiments (B) and (C) with respect to salinity, on the 36th day the salinity was brought down to 12 ppt. Surprisingly the larvae recovered and resumed normal life in a few hours. Thereafter, the salinity was gradually reduced to 6 ppt by about the 53rd day.

The following difficulties were encountered in conducting these experiments:

1. Insufficient holding facilities for rearing of larvae.
2. Fresh water supply at the station was very poor during the larval rearing period and it was cumbersome to maintain the desired salinity in the larval rearing tanks. On some days fresh water was collected from a place about 1km away from the station.
3. Electricity failure during the larval rearing period cut down aeration to about 2 hours per day. This affected primarily the hatching of *Artemia* eggs.
4. Supply of *Artemia* seed was inadequate to try out replication of the feeding schedule in different experiments.

The experiments were only preliminary attempts to achieve some degree of success in larval rearing of *Macrobrachium rosenbergii* under Sri Lankan conditions. With the very limited facilities, available, it was not possible to attempt more methodical approach in designing these field trials with sufficient replications.

However, although no concrete conclusions could be drawn from these preliminary experiments, the experience gathered indicated the importance of proper salinity, quality of water and feed at the crucial stages of the larval rearing period.

Percentage of survival upto the 55th day (15.2%) obtained under the above conditions; could be considered satisfactory.

Acknowledgement

The author wishes to express his gratitude to Mr. A. M. Jayasekera (DD/IF), Mr. K.S.B. Tennakoon (AD/IF) and Mr. R.A.D.B. Samaranayake (AD/BW) for providing necessary instructions, equipment and guidance. Mr. K.U. Dias (OIC), Mr. N.D. Wannigama (AC) and the staff of the BWFS Pambala are thankfully acknowledged for their participation and close co-operation in the work. I also thank Mr. R. D. Chakrabarty (Expert, Fish Farming) for his help in the preparation of this paper.

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TABLE — I

Composition of the formulated feed

	Ingredients	*Contents of the tablets or capsules*	*Quantity*
1.	Boiled Tilapia meat	... ...	20 g
2.	Egg custard	... ...	60 g
3.	Soya meat powder	... ...	10 g
4.	"Kurakkan" powder	... ...	10 g
5.	Vitamin A and D B.P	Vitamin A — 4500 IU Vitamin D — 450 IU	02 capsules
6.	Vitamin C B.P.	Ascorbic acid — 100 mg	01 tablet
7.	Vitamin B complex B.P	Thiamine — 1 mg Riboflavin — 1 mg Niacinamide— 10 mg	01 tablet
8.	Tetracycline B.P.	Tetracycline Hydrochloride — 250 mg	$\frac{1}{4}$ capsule

TABLE — II

Macrobrachium rosenbergii larval rearing

Experiment (A)

Date	Age of larvae (days)	Salinity (Medium) (ppt)	Feeding time and type of feed: 08hr.	11hr.	13hr.	14hr.	18hr.	24hr.	Amount of feed: BS*	ff*	Remarks
29-11-83	01	10	—	—	—	—	—	—	—	—	20,000 larvae stocked. T=26°C, SD=100/ litre
30-11-83	02	10	—	—	—	—	BS	—	03	—	
01-12-83	03	10	BS	—	BS	—	BS	—	10	—	
02-12-83	04	12	BS	—	BS	—	BS	—	10	—	Water renewed partially
03-12-83	05	12	BS	—	BS	—	BS	—	10	—	
04-12-83	06	12	BS	—	BS	—	BS	—	10	—	
05-12-83	07	12	BS	—	BS	—	BS	—	10	—	Sampled — 12,000 larvae
06-12-83	08	12	BS	—	—	ff	BS	BS	12	250	
07-12-83	09	12	BS	—	—	ff	BS	BS	12	300	
08-12-83	10	12	BS	—	—	ff	BS	BS	12	300	
09-12-83	11	12	BS	—	—	ff	BS	BS	12	300	
10-12-83	12	14	BS	ff	—	ff	BS	BS	12	300	Sampled — 8,000 larvae water renewed.
11-12-83	13	14	BS	ff	—	ff	BS	BS	12	500	
12-12-83	14	14	BS	ff	—	ff	BS	BS	15	500	
13-12-83	15	14	BS	ff	—	ff	BS	BS	15	500	
14-12-84	16	14	BS	ff	—	ff	BS	BS	15	500	
15-12-83	17	14	BS	ff	—	BS	ff	BS	15	700	
16-12-83	18	14	BS	ff	—	BS	ff	BS	15	700	
17-12-83	19	14	BS	ff	—	BS	ff	BS	15	700	
18-12-83	20	14	BS	ff	—	BS	ff	BS	15	700	
18-12-83	20	14	BS	ff	—	BS	ff	BS	15	1000	Half of larvae were transferred to another tank with the same conditions.
19-12-83	21	14	BS	ff	—	BS	ff	BS	15	1000	
20-12-83	22	14	BS	ff	—	BS	ff	BS	15	1000	
21-12-83	23	14	BS	ff	—	BS	ff	BS	15	1000	
22-12-83	24	14	BS	ff	—	BS	ff	BS	15	1000	
23-12-83	25	14	BS	ff	—	BS	ff	BS	15	1000	
24-12-83	26	14	BS	ff	—	BS	ff	BS	15	1000	
25-12-83	27	14	BS	ff	—	BS	ff	BS	15	1000	
26-12-83	28	14	BS	ff	—	BS	ff	BS	15	1000	Water renewed. Sampled 5,000 larvae.
27-12-83	29	14	BS	ff	—	BS	ff	BS	15	1000	
28-12-83	30	14	BS	ff	—	ff	ff	BS	10	1300	
29-12-83	31	14	BS	ff	—	ff	ff	BS	10	1300	
30-12-83	32	14	BS	ff	—	ff	ff	BS	10	1300	
31-12-83	33	14	BS	ff	—	ff	ff	BS	10	1300	Larvae transferred to another two tanks with the same conditions.
01-01-84	34	14	ff	BS	—	ff	ff	BS	10	1500	
02-01-84	35	14	ff	BS	—	ff	ff	BS	10	1500	
03-01-84	36	14	ff	BS	—	ff	ff	BS	10	1500	
04-01-84	37	12	ff	BS	—	ff	ff	BS	10	1500	Water renewed
05-01-84	38	12	ff	BS	—	ff	ff	BS	10	1500	
06-01-84	39	12	ff	ff	BS	ff	ff	BS	10	2500	
07-01-84	40	10	ff	ff	BS	ff	ff	BS	10	2500	
08-01-84	41	08	ff	ff	BS	ff	ff	BS	10	2500	
09-01-84	42	08	ff	ff	BS	ff	ff	BS	10	2500	Collected a few PL
10-01-84	43	08	ff	ff	BS	ff	ff	BS	10	2500	PL collected.
11-01-84	44	08	ff	ff	BS	ff	ff	BS	10	2500	
12-01-84	45	08	ff	ff	BS	ff	ff	BS	10	2500	PL collected
13-01-84	46	08	ff	ff	BS	ff	ff	BS	10	2500	
14-01-84	47	08	ff	ff	BS	ff	ff	BS	10	2500	
15-01-84	48	08	ff	ff	—	ff	ff	BS	10	2500	Water renewed
16-01-84	49	08	ff	ff	—	ff	ff	—	—	2000	PL collected
17-01-84	50	08	ff	ff	—	ff	ff	—	—	2000	PL collected
18-01-84	52	08	ff	ff	—	ff	ff	—	—	2000	
19-01-84	53	06	ff	ff	—	ff	ff	—	—	2000	
21-01-84	54	06	ff	ff	—	ff	ff	—	—	2000	
22-01-84	55	06	ff	—	—	—	—	—	—	500	Cycle completed

Total number of post larvae = 3053

Survival rate = 15.2%

Note:-

BS* = Number of brine shrimp nauplii/prawn larvae/day

ff** = mg of formulated feed/1000 prawn larvae/day

T = Water temperature

SD = Stocking density

Pl = Post larvae

BS = Brine shrimp nauplii

ff = Formulated feed

TABLE III

Macrobrachium rosenbergii larval rearing

Experiment (B)

Date	*Age of larvae days*	*Salinity (Medium) (ppt)*	*Feeding time and type of feed* 08*hr.*	13*hr.*	18*hr.*	24*hr.*	*Amount of feed* BS*	ff*	*Remarks*
30-11-83	01	10	—	—	—	—	—	—	10,000 larvae stocked T=26°C, SD=50/litre
01-12-83	02	10	—	—	—	—	—	—	
02-12-83	03	10	BS	—	BS	—	10	—	
03-12-83	04	10	ff	BS	ff	—	10	500	
04-12-83	05	12	ff	BS	ff	—	10	500	Water renewed
05-12-83	06	12	ff	BS	ff	—	12	500	
06-12-83	07	12	ff	BS	ff	—	12	500	
07-12-83	08	12	ff	BS	ff	—	12	500	
08-12-83	09	12	ff	ff	ff	BS	12	700	
09-12-83	10	14	ff	ff	ff	BS	12	700	Water renewed
10-12-83	11	14	ff	ff	ff	BS	12	700	
11-12-83	12	14	ff	ff	ff	BS	12	700	
12-12-83	13	14	ff	ff	ff	BS	12	700	
13-12-83	14	14	ff	ff	ff	BS	12	1000	
14-12-83	15	14	ff	ff	ff	BS	12	1000	
15-12-83	16	14	ff	ff	ff	BS	12	1000	
16-12-83	17	14	ff	ff	ff	BS	12	1000	
17-12-83	18	14	ff	ff	ff	BS	12	1000	
18-12-83	19	14	ff	ff	ff	BS	12	1500	Water renewed
19-12-83	20	14	ff	ff	ff	BS	12	1500	
20-12-83	21	14	ff	ff	ff	BS	12	1500	
21-12-83	22	14	ff	ff	ff	BS	12	1500	
22-12-83	23	14	ff	ff	ff	BS	12	1500	
23-12-83	24	14	ff	ff	ff	BS	12	1500	
24-12-83	25	14	ff	ff	ff	BS	12	1500	
25-12-83	26	14	ff	ff	ff	BS	12	1500	
26-12-83	27	14	ff	ff	ff	BS	12	1500	Water renewed
28-12-83	29	14	ff	ff	ff	BS	12	1500	
29-12-83	30	14	ff	ff	ff	BS	12	1500	
30-12-83	31	14	ff	ff	ff	BS	12	1500	
31-12-83	32	14	ff	ff	ff	BS	12	1500	
01-01-84	33	14	ff	ff	ff	BS	12	1500	A few larvae died. Water renewed.
02-01-84	34	14	—	—	—	—	—	—	Total mortality

Note:-

BS* = Number of brine shrimp nauplii/prawn larvae/day

ff** = mg of formulated feed/1,000 prawn larvae/day

T = Water temperature

SD = Stocking density

Pl = Post larvae

BS = Brine shrimp nauplii

ff = Formulated feed

TABLE — IV

Macrobrachium rosenbergii larval rearing

Experiment (C)

Date	*Age of larvae days*	*Salinity (Medium) (ppt)*	*Feeding time and type of feed* 08*hr.*	11*hr.*	13*hr.*	18*hr.*	*Amount of feed**	*Remarks*
30-11-83	01	10	—	—	—	—	—	10,000 larvae stocked. T=26°C, SD=20/litre
01-12-83	02	10	—	—	—	ff	500	
02-12-83	03	10	ff	—	ff	ff	700	
03-12-83	04	12	ff	ff	ff	ff	1000	Bottom of the tank cleaned.
04-12-83	05	12	ff	ff	ff	ff	1000	
05-12-83	06	12	ff	ff	ff	ff	1000	
06-12-83	07	12	ff	ff	ff	ff	1000	Bottom of tank cleaned.
07-12-83	08	12	ff	ff	ff	ff	1000	
08-12-83	09	14	ff	ff	ff	ff	1000	Water renewed partially. Bottom of the tank cleaned
09-12-83	10	14	ff	ff	ff	ff	1200	Larvae weak.
10-12-83	11	14	ff	ff	ff	ff	1200	Bottom of the tank cleaned.
11-12-83	12	14	ff	ff	ff	ff	1200	
12-12-83	13	14	ff	ff	ff	ff	1200	
13-12-83	14	14	ff	ff	ff	ff	1200	Larvae appeared to be affected and treated with malachite green.
14-12-83	15	14	—	—	—	—	—	Total mortality

* = Mg of feed/1,000 prawn larvae/day

ff = Formulated feed

T = Water temperature

SD = Stocking density

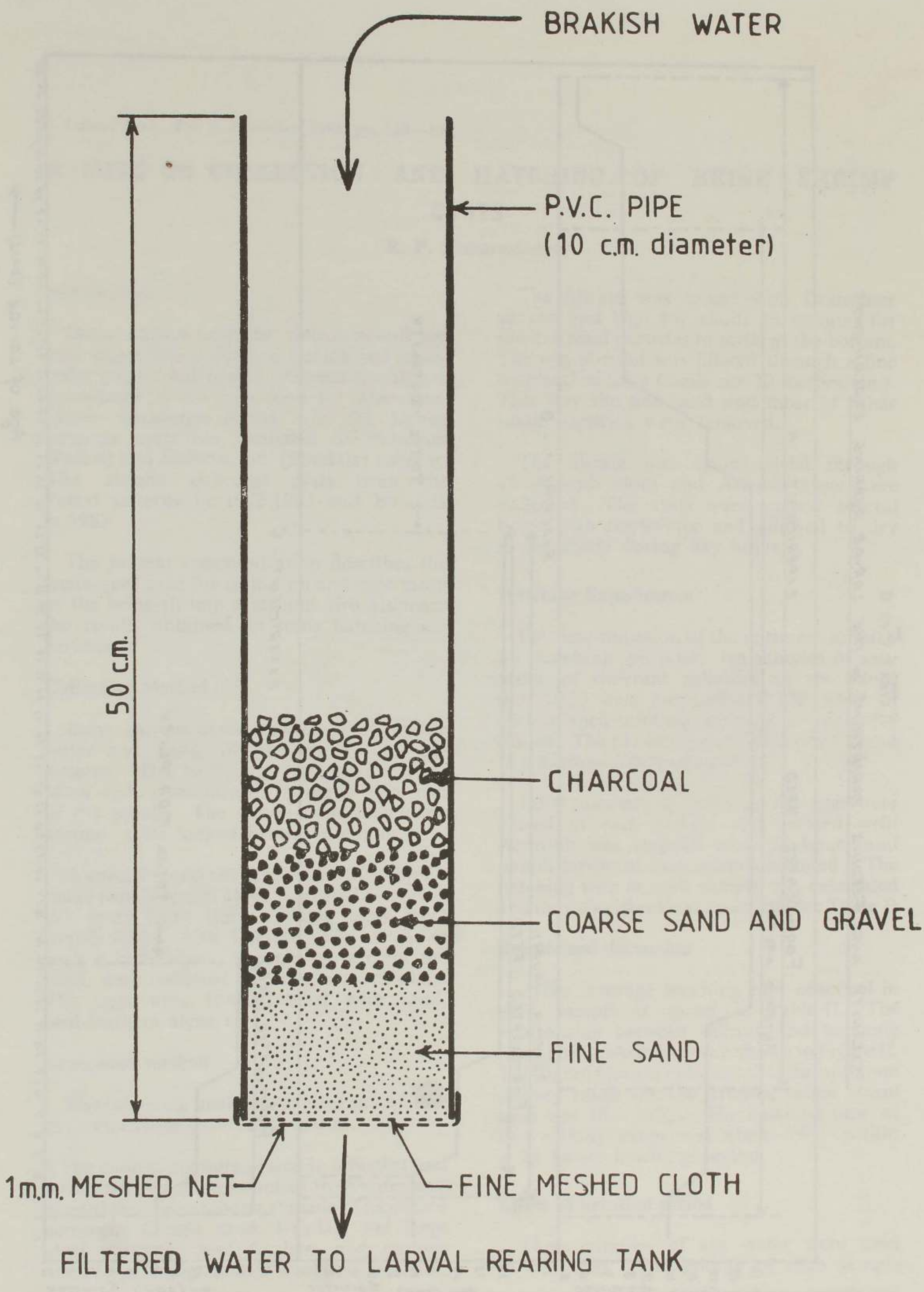
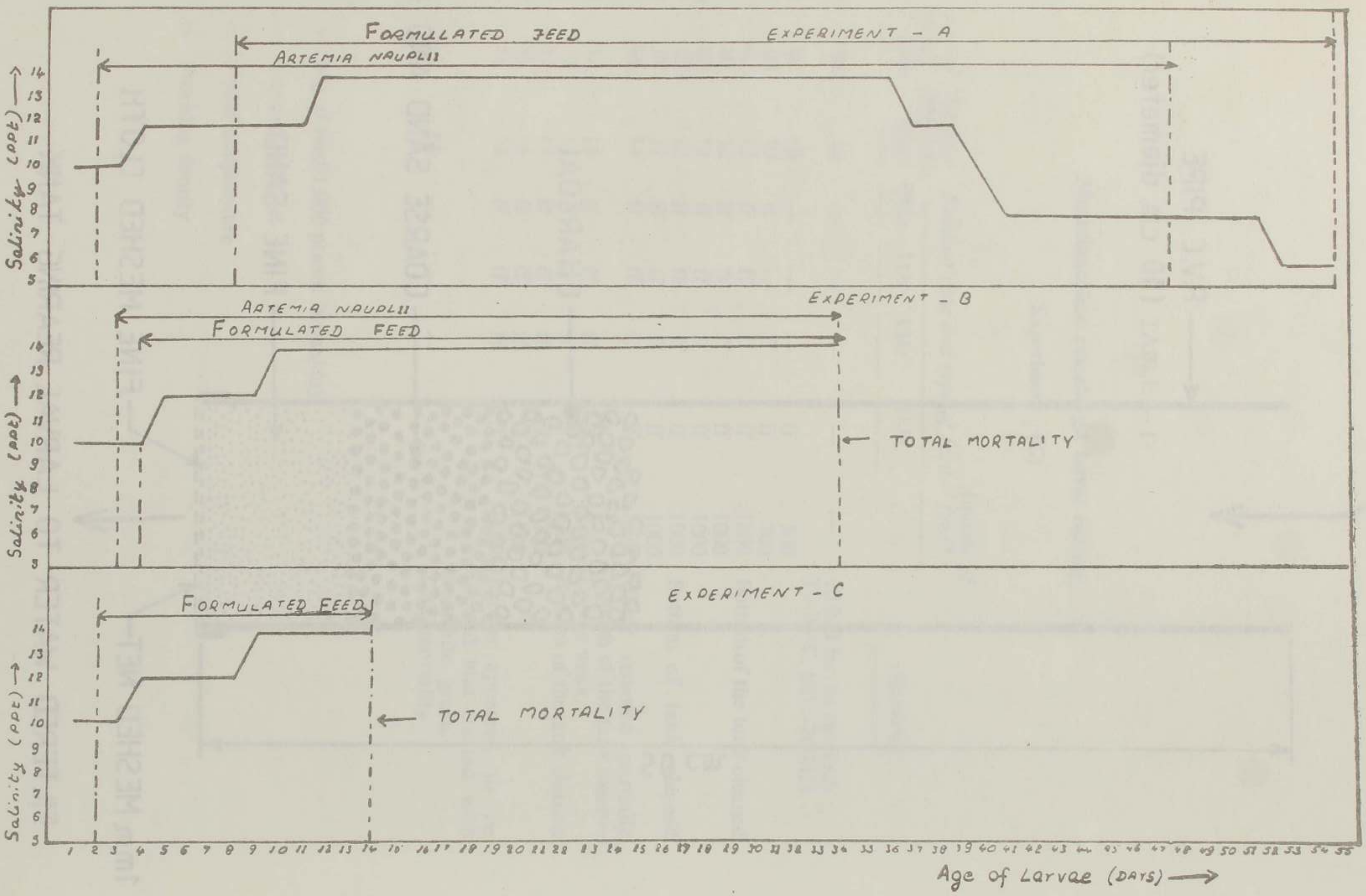


FIG - I LOCALLY MADE SAND FILTER

Text Fig II

SALINITY AND FEEDING VARIATIONS IN THE LARVAE REARING EXPERIMENTS



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A NOTE ON COLLECTION AND HATCHING OF BRINE SHRIMP CYSTS

R. P. Samarasinghe*

Introduction

Brine shrimp (*Artemia salina*) naupli are very important as food in marine and freshwater prawn hatcheries. *Artemia* naupli are considered as the best food for *Macrobrachium rosenbergii* larvae. In Sri Lanka Artemia cysts are available at Puttalam (Palavi) and Hambantota (Bundala) salterns. The author collected cysts from the Palavi salterns in 1982-1983 and Bundala in 1983.

The present communication describes the techniques used for collection and seperation of the brine shrimp cysts and also discusses the results obtained in some hatching experiments.

Collection Method

Brine shrimp cysts were observed in the water and sand of the ponds of the salterns. Due to the strong winds more often cysts concentrated towards one end of the ponds. The water containing brine shrimp cysts looked brown in colour.

A special scoop net (known as "Kadippu") made from organdi cloth, was used to collect the cysts from water. These cysts were found mixed with Lab-lab. Fig. 1 shows such a collection. *Artemia* cysts from the sand, were collected by using a metal plate. The eggs were found mixed with sand, bird-feathers, algae, etc.

Separation method

The following method was used to separate the cysts from associated matter.

The collections were placed in a bucket and mixed with excess amount of freshwater and filtered through a scoop net made of mosquito nettings. Coarse sand, Lab-lab and large algal particles, bird feathers and various other large foreign matter were thus removed.

The filtrate was mixed with freshwater shaken and kept for about 10 minutes for the fine sand particles to settle at the bottom. The top portion was filtered through a fine wiremeshed seive (mesh size 12 meshes/cm.). This way the fine sand and most of other small particles were removed.

The filtrate was again seived through an organdi cloth and Artemia cysts were collected. The cysts were washed several times with freshwater and allowed to dry in the shade during day hours.

Hatching Experiments

For determination of the optimum salinity for hatching purpose, ten samples of sea-water of different salinities in the range (0 - 70‰) were prepared and 200 ml. of each of such solution placed in a separatey beaker. The pH of each solution was 7.2 and in a average temperature 29°C.

1,000 numbers of brine shrimp eggs were placed in each sample and aerated well. Aeration was stopped after 24 hours and naupli larvae in each sample counted. The hatching rate in each sample was calculated and the experiment was repeated (See Table I)

Results and discussion

The average hatching rate observed in each sample is given in Table II. The relationship between salinity and hatching rate of brine shrimp cysts is shown in Figure II. This figure (graph) indicates that the optimum salinity range for the Artemia salina strain used was 30 - 35‰. The hatching rate at this salinity range was about 60% within a 24 hours hatching period.

Effect of aeration period

Three samples of sea water were used in this trial. The salinity of each sample

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was 30‰ and pH 7.2. Average temperature was maintained at 29°C.

5,000 numbers of *Artemia* cysts were placed in each water sample and aerated well. The naupli larvae in each sample were counted after 12 hours of aeration and the same repeated at 6 hour intervals (See Table I). The aeration was continued in all for 54 hours.

Results and discussion

Figure II indicates the effect of the duration of aeration on the hatching rate of brine shrimp cysts The hatching rate were observed to increase with increased aeration. It was 52.2% and 65.1% respectively at the end of 24 hours and 30 hours. Hatching rate was 68.5% after 54 hours of aeration.

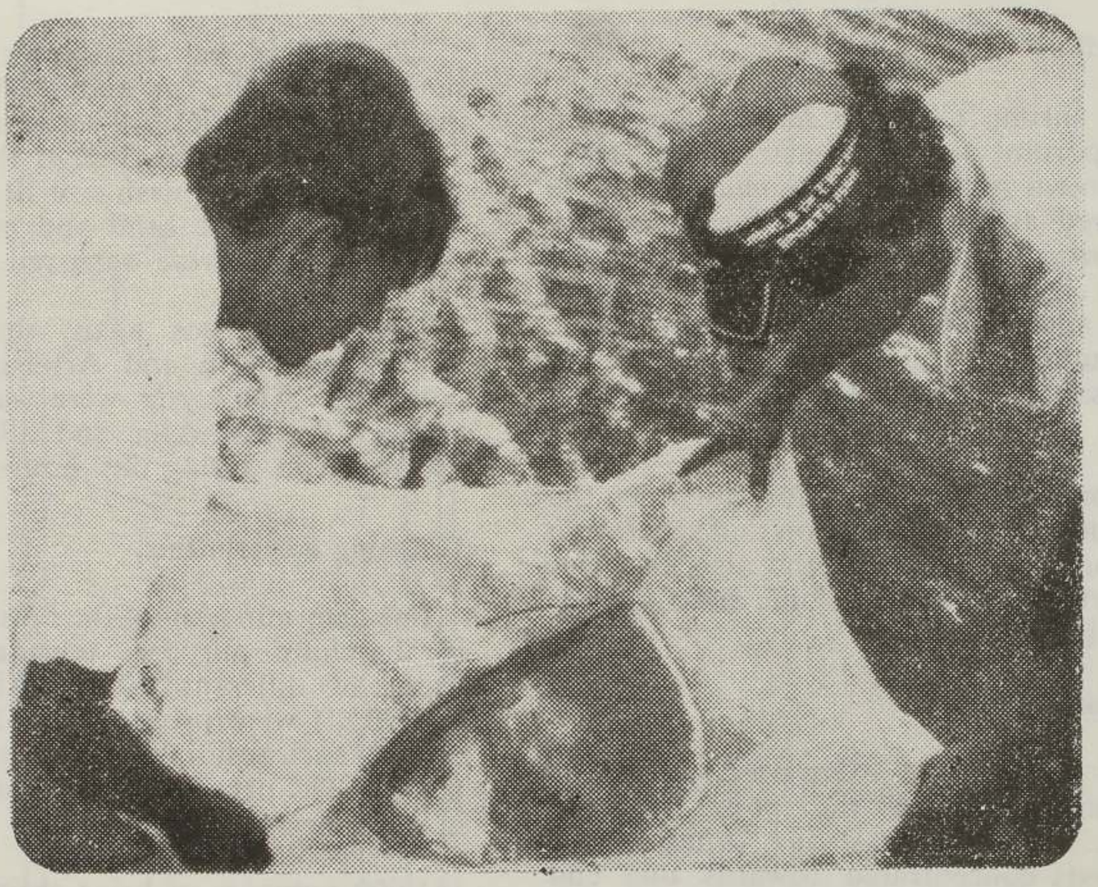

Fig. 1. Collection of Artemia eggs.

It was however, seen that the enhancement of the hatching rate was lower after 30 hours and it was only 3.4% for the next 24 hours (30 - 54 hours). Therefore, it may be assumed that the most suitable aeration period for hatching cysts of the strain used, was 30 hours.

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TABLE I

Effects of the salinity on hatching rate

Sample No.	*Salinity (ppt)*	*Hatching time (hrs.)*	*No. of cysts*	*Nos. of naupli*		*Average Nos. of naupli*	*Hatching rate (%)*
				1st trial	*2nd trial*		
1	00	24	1000	13	12	12·5	1·25
2	10	24	1000	374	360	367	36·7
3	20	24	1000	427	415	421	42·1
4	25	24	1000	481	486	483·5	48·35
5	30	24	1000	615	583	599	59·9
6	35	24	1000	609	597	603	60·3
7	40	24	1000	265	379	322	32·2
8	50	24	1000	225	238	231·5	23·15
9	60	24	1000	165	194	179·5	17·95
10	70	24	0100	42	46	44	4·4

TABLE II

Effects of aeration period on hatching rate

Hatching time(hrs.)	*Nos. of cysts*	*Nos. of naupli*			*Average Nos. of naupli*	*Hatching rate (%)*
		Sample A	*Sample* B	*Sample* C		
12	5,000	761	720	659	717	14·3
18	5,000	1380	1350	1260	1330	26·3
24	5,000	2630	2710	2495	2612	52·2
24	5,000	2630	2710	2495	2612	52·2
30	5,000	3442	3170	3160	3257	65·1
36	5,000	3590	3175	3190	3328	66·6
42	5,000	3612	3198	3195	3335	66·8
54	5,000	3630	3232	3420	3427	68·5

Fig: II- Relationship between the hatching rate and salinity of the medium

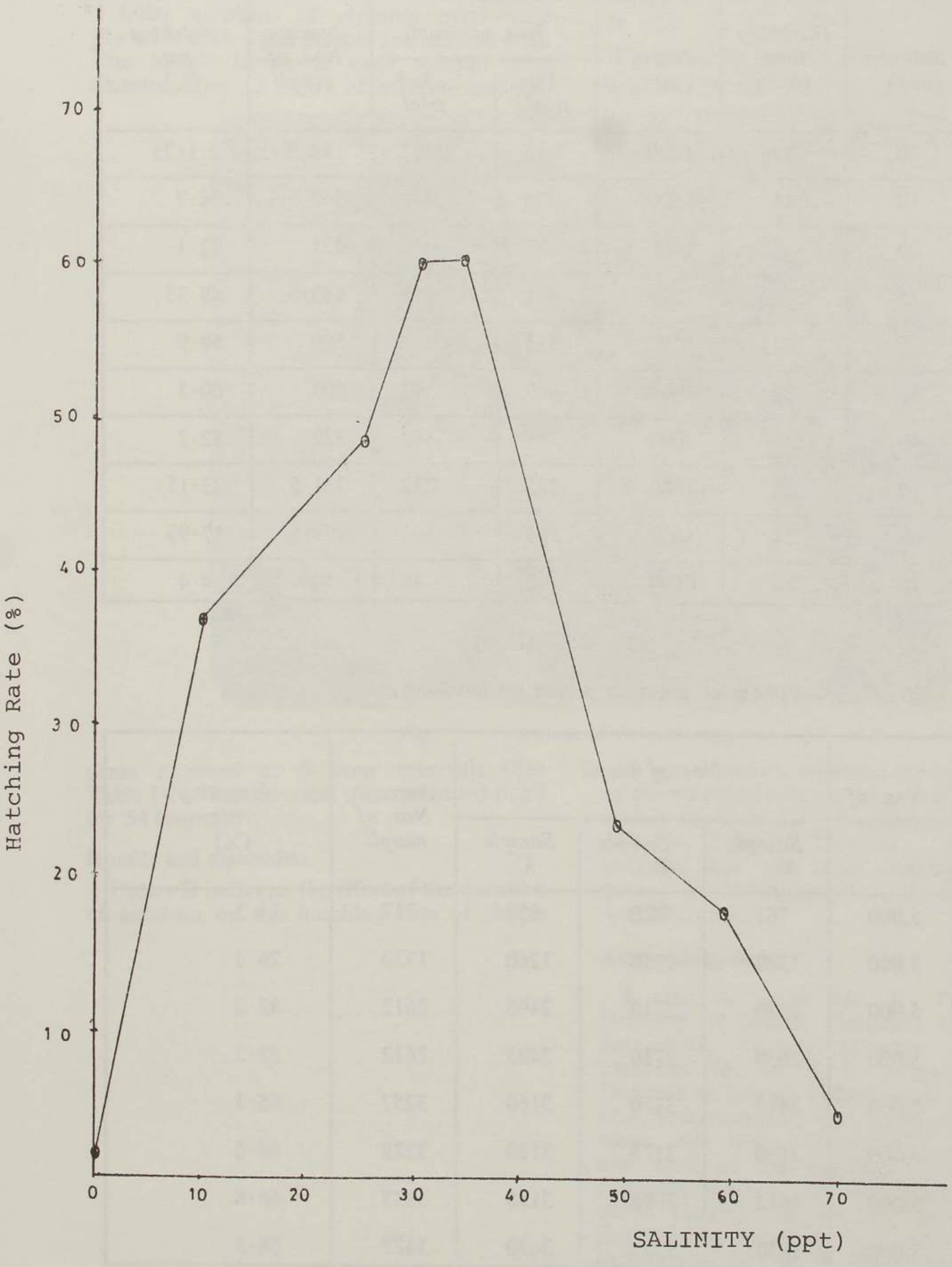
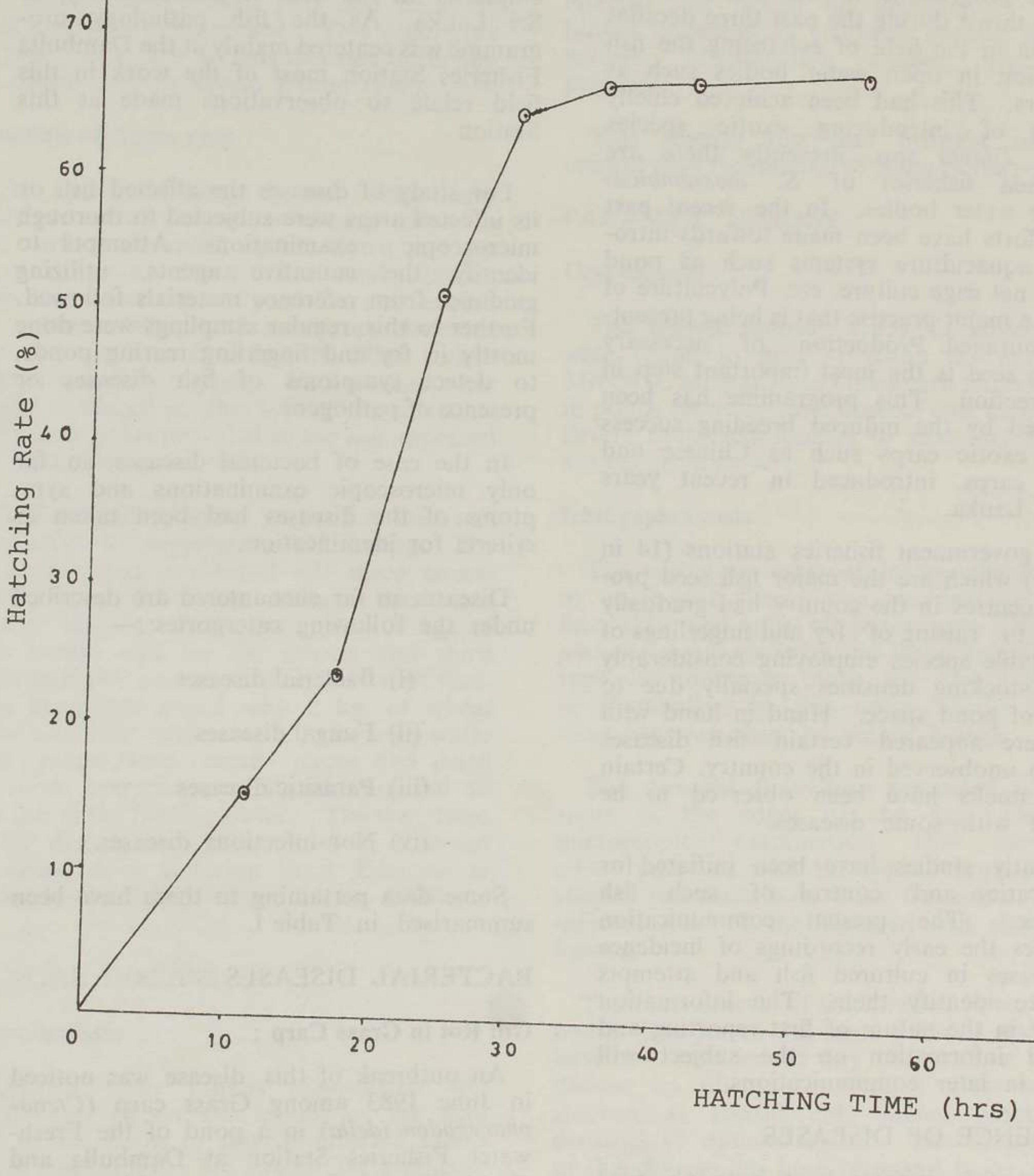


Fig: III- Relationship between the hatching rate & aeration period (Hatching time)



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PRELIMINARY OBSERVATIONS ON FISH DISEASES OF CARPS IN SRI LANKA

L. K. S. W. Balasuriya*

INTRODUCTION

The short history of inland fisheries development programme in Sri Lanka shows that the thrust during the past three decades had been in the field of enhancing the fish production in open water bodies such as reservoirs. This had been achieved chiefly by way of introducing exotic species such as *Tilapia* spp. Presently there are established fisheries of *S. mossambicus* in these water bodies. In the recent past some efforts have been made towards introducing aquaculture systems such as pond culture, net cage culture, etc. Polyculture of carps is a major practise that is being presently encouraged. Production of necessary s uitable seed is the most important step in this direction. This programme has been facilitated by the induced breeding success of the exotic carps such as Chinese and Indian carps, introduced in recent years into Sri Lanka.

The government fisheries stations (14 in number) which are the major fish seed producing centres in the country had gradually shifted to raising of fry and fingerlings of the suitable species employing considerably higher stocking densities specially due to dearth of pond space. Hand in hand with this there appeared certain fish diseases hitherto unobserved in the country. Certain brood stocks have been observed to be infected with some diseases.

Recently studies have been initiated for dentification and control of such fish idiseases. The present communication embodies the early recordings of incidence of diseases in cultured fish and attempts made to identify them. The information is more in the nature of first reporting and detailed information on the subject will follow in later communications.

INCIDENCE OF DISEASES

A few fish diseases have been observed and identified in different Fisheries Stations scattered all over the country. However, after 1982 there has been an additional emphasis in the field of fish pathology in Sri Lanka. As the fish pathology programme was centered mainly at the Dambulla Fisheries Station most of the work in this field relate to observations made at this Station.

For study of diseases the affected fish or its infected areas were subjected to thorough microscopic examinations. Attempts to identify the causative agents, utilizing guidance from reference materials followed. Further to this, regular samplings were done mostly in fry and fingerling rearing ponds, to detect symptoms of fish diseases or presence of pathogens.

In the case of bacterial diseases, so far only microscopic examinations and symptoms of the diseases had been taken as criteria for identification.

Diseases so far encountered are described under the following catergories :—

(i) Bacterial diseases

(ii) Fungal diseases

(iii) Parasitic diseases

(iv) Non-infectious diseases.

Some data pertaining to these have been summarised in Table I.

BACTERIAL DISEASES

Gill Rot in Grass Carp :

An outbreak of this disease was noticed in June 1983 among Grass carp (*Ctenopharygodon idella*) in a pond of the Freshwater Fisheries Station at Dambulla and about 30% of Grass carp weighing on an average 2kg. died in a week's time. Again

*Freshwater Fish Breeding & Experimental Station, Dambulla

in July 1983 the disease was observed among some Grass carp stocked in seasional tanks (rainfed small irrigation reservoirs drying up annually during the dry season) of the same area during the dry season.

Infected fish were found to be inactive and the dorsal part appeared more darkly coloured bordering on black. The body was covered with lot of mucus specially at the operculum region. The tips of gill filaments on examination looked pale and decaying and cartilage was exposed. This reportedly is one of the very serious diseases occurring in Grass carp in China (Anon 1980).

Enteritis of Grass carp :

At Dambulla some brood Grass carp were observed to be swimming close to the surface of water, upside down and the head dropping down. The anal opening appeared extraordinarily swollen and reddish in colour. When such a fish was dissected the intestine was found to be filled with a yellow liquid and gases. Red patches were found scattered on the wall of the intestine. Very little grass provided to the fish appeared to have been consumed.

Sulfaguanidine added to the fish feed was successful in suppressing the disease. The treatment was prolonged for three consecutive days. First day sulfaguanidine used was at the rate of 10 gms. per 100 kg. of fish weight and on the second and third days half the quantity was mixed with feed. The drug was mixed with 2 kg. of wheat flour and then made into a paste with water and made into small pieces and dried at room temperature. These were fed to the fish in the feeding frame. The symptoms of the disease are similar to those observed in Grass carp suffering from Enteritis in China (Pond fish culture in China, 1980).

FUNGAL DISEASE

Saproligniasis

Greyish white fungus (*Saprolignia* sp.) were observed on the lesions of the skin and at the bases of fins of infected *Labeo rohita* fingerlings. The caudal fin gradually got worn off and only the caudal pednucle remained covered with the fungal mycelia. At the initial stage the outbreak of the disease was brought under control by renewal of water (about 50%) in the pond. But the highly infected fingerlings died and could not be salvaged.

Unidentified Fungus Diseases :

An unidentified fungus disease was detected in Rohu fingerlings in ponds at Dambulla, where the fungus appeared at the inner side of the scales. This gave infected fish puffed up appearence. The fungus appeared as yellowish septate short mycelia. Identification studies are in progress.

This disease too was brought under control with the renewal of water in the pond.

PARASITIC DISEASE

Cryptobiasis :

The disease causing agent *Cryptobia* sp were found in gills of Rohu (*L. rohita*), Mrigal (*C.mrigala*) and Grass carp fingerlings in ponds receiving high dose of cow manure. Severe outbreaks leading to mortality have not occurred as yet.

Ichthyophthirasis :

The causative agent of Ichthyophthirasis or white-spot disease was observed on the fins, skin and gills of Sliver carp (*Hypophthalmichthys molitrix*) and Rohu fingerlings kept in aquarium tanks for experiments in Dambulla. In this setup about 25% mortality was observed within 4 days.

The diseased fingerlings possessed white spots at the edges of the fins. Under microscopic examination, slow moving ciliate parasites with the typical horse-shoe shaped macronucleous were detected. The infected gills of the diseased fish showed lesions.

The same species of fish stocked in rearing ponds (0.09 ha) in the same fisheries station have not experienced any outbreak of this disease up till now, although these were stocked at considerably higher stocking densities (3 million fry/ha). The incidence of this disease has been observed to be very high at temperatures ranging from 25°C—26°C (*Bauer et. al.*, 1973). This could be a possible reason for absence of the disease in the earthen ponds at Dambulla, in which the average water temperature is about 29°C as against 22°C-26°C in aquarium tanks.

Tricodinasis :

This is one of the most prevalent diseases in Station fish ponds in Sri Lanka. Several species of Tricodina were found in the skin and gills of fry and fingerling stages of Rohu, Mrigal, Catla Grass carp and Common carp. Very high mortalities were observed in fry ponds in some instances, specially during dry months in those under high stocking density. When some samples were examined a single fry of 1 cm. long was observed to harbour as many as 200 parasites.

Uniform broadcasting of $CuSO_4$ over the pond water at the rate of 5.5 ppm or a mixture of $CuSO_4$ and $FeSO_4$ in the ratio of 5: 2 at the rate of 0.5 ppm. has been successful in controlling the disease in many fisheries stations.

Glossatelliasis :

The causative agent of this disease *Glossatella* sp. were very common in fertile fish ponds during rainy season in Dambulla in 1980. It was observed that some samples had hundreds of them in each gill filament. When seriously attacked by this disease the fish begins to surface and are hence easily prone to predation. The affected fish suffered heavy mortality during transportation.

Myxosporidiasis :

The causative agent of this disease *Myxobolus sp.* were also very common in fish ponds. The cysts of this parasite were observed in the gills, skin and kidneys of Mrigal of all ages and in the gills and skin of Rohu and Common carp fingerlings. So far, three different species of *Myxobolus* have been observed in the above fish. Severe outbreak leading to mass mortality has not occurred as yet.

DISEASES CAUSED BY HELMINTHS

Dactylogyrosis :

Dactylogyrus sp. the causative agent of the disease is widely spread and epizootics often occurred in the fingerling ponds in which the stocking density was high. It was specially dangerous to fry 2-3 cm. long and high mortality caused by the disease to fry was observed during transportation. The pathogen has been found in the gills of fingerlings of Rohu, Mrigal, Catla, Grass carp and *Labeo dussumieri.*

Uniform spreading of Dipterex over the pond, at the rate of 0.5 ppm. has been in practise for the control of the disease in Dambulla in 1983.

Gyrodactylosis :

The causative agent of this disease *Gyrodactylus* sp. was found in the gills of Rohu and Mrigal fingerlings. The disease was not widely spread and mortality due to it not observed.

Other Helminths :

Several larval stages of Trematoda, the metacercaria stages, had been found among fingerlings of Rohu, Mrigal, Grass carp, Silver carp, Common carp and *Puntius* spp. These stages were observed commonly in the Fisheries Stations situated in the dry zone, where the snail population and that of predatory birds were high. Three varieties of metacercaria have been found so far. The sites of infection were skin, fins, gills, liver and muscles.

In the gills two varieties of the metacercaria stage were found. One of this is very commonly occurring and found in many varieties of fish including indigenous *Puntius* sp. They are found in an encysted condition and cause deformaties in the gill structure when occurring in abundance. Therefore, this variety is more harmful to the fish as it causes hindrance in respiration by hampering the capillary network. The highly infected fish exhibit surfacing and are prone to predation easily as observed in Udawalawe in 1983. Specimens of 2 cm. size were found to carry as much as 30-35 metacercaria per gill. It was observed that snail population was very high in these infected ponds. Cercaria stages of four varieties have been found in various parts of the body of snails. Further investigations are in progress. There is already some indication that the adult stages of the parasites may be in herons.

Ligulosis :

A mild epizootic of this disease had been observed in a Rohu fingerling pond in Dambulla in 1983 and about 5% of the fish were infected. Infected fingerlings showed a hard big belly and on dissection were seen to harbour plerocerciod of *Ligula* sp. in the body cavity. Usually one or two parasites were found in one fish and they were comparatively large in size. When some samples were examined a fingerling of 1.5 cm. long was found with a parasite of 2 cm. long. The infected fish had been stocked in reservoirs, too. In the same reservoirs the catches had some Rohu having such parasites. A Rohu of weight 400 g. caught from the Dambulla Oya reservoir in 1984 was found to have 2 parasites each 20 cm. long and 1.2 cm. broad.

DISEASES CAUSED BY CRUSTACEANS

Lernaeosis :

Severe outbreak of this disease occurred in 1979 among carp fingerlings and in brood fish ponds at the Rambodagalla Fisheries Station during a severe drought period. The fish in the Station had been kept in a few ponds and water was pumped into these from the nearby river. The disease outbreak was observed after about a month and some fish were found with large number of parasites, attached to the skin. To control the epizootic, diseased fish were given a bath in a solution of $KMnO_4$ of concentration 1:50,000, for two hours. Dipterex of concentration of 1 ppm. had been spread over the ponds thrice, at two week's intervals, to destroy the larval stages.

Later, this disease was found in other Fisheries Stations also and it could have spread along with the fingerlings transported from Rambodagalla. Mortality of fish was observed in fingerling ponds due to this disease. The following fish were found infected with Lernia: Common carp, Grass carp, Giant gouramy, Rohu, Mrigal, *Labeo dussumieri* and Silver carp.

Synergasilosis :

Synergasilus major the highly host specific parasite in grass carp (*Bauer et. al.*, 1973) had been found in gills of brood fish. The first detection was made at the Udawalawe Fisheries Station in 1976 just after one year of the introduction of Grass carp from China. Later this was also observed at the Dambulla Fisheries Station, in 1984.

In severe infections several hundreds of parasites were found in gills of a single fish and white necrotic areas were observed on gill filaments. The gills became pinkish and tissue were distroyed. Mass mortality has not been observed due to this epizootic.

The parasite is very common among brood fish and at least few parasites can be seen in the gills of almost all the brood fish. There could be a possible relation between the occurrence of this disease and the maturation problems in Grass carp experienced in certain fisheries stations, such as in Udawalawe.

Uniform spreading of Dipterex over the pond at the rate of 0.5 ppm. at two weeks intervals has been practiced for the control of the disease.

NON INFECTIOUS DISEASE

Gas Bubble disease :

This disease occurred among two day old hatchlings in the in-door hatchery at Dambulla Fisheries Station, where the water was supplied from a deep well. The hatchlings that came out from the glass incubation jars were kept in cement tanks inside the hatchery for further development. The disease was observed in cement tanks and affected hatchlings were found developing with a gas bubble inside the body, and these finally died. Mortality observed was about 25%.

Hatchlings resulting from the same breeding incubated at the out-door harchery, where the water was supplied from the reservoir were not found to have been affected with this disease.

DISCUSSION

It is clear that with the adoption of higher stocking densities requiring higher feed and fertilizer inputs, incidence of fish disease have reached new dimensions. At present although such intensive culture practices are restricted to the Government Fisheries Stations, with the extension programmes

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on aquaculture, similar occurrence could be encountered in private fish farms in the very near future. Prevention and control of diseases would be cumbersome at this level. Thus, timely measures should be taken to identify fish diseases and find control measures that would be effective at field level. Treatments tried out elsewhere in the world might not be suitable for direct duplication under our environmental conditions. Therefore, local measures or methods would be necessary. Methodical study and research in this field would help to find the answers to the problem.

There also could have been introduction of diseases with exotic fish. Due to the dearth of cultivable indigenous species, introductions of culturable food fish are obligatory in Sri Lanka. Hence, thorough quarantine measures becomes a compulsory pre-requisite, for introduced fish species. This policy also should be similarly adopted during the transportation of fish from one area to another within the country.

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TABLE I

FISH DISEASES ENCOUNTERED AT FRESHWATER FISHERIES STATIONS IN SRI LANKA

Name of the disease	Name of the Pathogen	Host fish and the stage	Site of inspection	Name of the Fisheries Station where located	Year and the season disease was detected	Remarks
Gillrot disease	Pseudomonas sp.	Grass carp adult fish	Gills	Dambulla	Aug., 1982	Severe mortality occured.
Enteritis of Grass carp	— do —	Grass carp adult fish	Intestine	Dambulla	April, 1984	Mortality occurred
Saproligniasis	Saprolignia sp.	Rohu, Mrigal & Grass carp fingerlings	Tail, fin base and skin	Dambulla	Feb., 1984	Few mortality occured.
Unidentified fungus	—	Rohu fingerlings & Puntius sp.	Base of the scales	Dambulla	March, 1984	Scale raised.
Cryptobiasis	Cryptobia sp.	Rohu, Mrigal & Grass carp fingerlings	Gills	Dambulla	June, 1983	Mild infection occured No mortality observed.
Trichodiniasis	Trichodina sp.	Rohu, Mrigal, Common carp. *Catla catla*, *Labeo dussumieri*, fry & fingerlings	Skin, gills and fins	Dambulla Udawalawe Nuwara Eliya Polonnaruwa	1983 onwards 1978 ,, 1980 ,,	Mortality occured in fry and fingerling.
Glossateiliosis	Glossatella sp.	Rohu, Mrigal & Common carp fingerlings	Skin & gills	Dambulla Udawalawe	1983 onwards	Mortality observed during transportation
Myxiosporidiosis	Myxobolus sp.	Rohu, Mrigal & Common carp fingerlings & adult fish	Skin, gills, kidney	Dambulla Udawalawe Polonnaruwa Rambodagalla	1983 onwards	No mortality observed
Dactylogyrosis	Dactylogyrus sp.	Rohu, Mrigal, *Catla catla*, Common carp Grass carp, *L.dussumieri* fingerlings & Bighead carp adult fish and fingerlings	Gills	Dambulla Udawalawe Polonnaruwa Rambodagalla Nuwara-Eliya	1983 onwards	Highly infected fish shows surfacing.
Gyrodactilosis	Gyrodactilus	Rohu, Mrigal fingerlings	Gills	Dambulla	1983 onwards	No mortality occured.
Metacercaria Stages	— do —	Rohu, Mrigal, Grass carp, Bighead carp, Silver carp, Common carp, Puntius sp./ fingerlings	Gills, skin, muscles, fins	Dambulla Udawalawe Polonnaruwa Rambodagalla	1983 onwards	Highly infected fish shows surfacing.
Ligulosis	Ligula sp.	Rohu, fingerlings and adult fish	Body cavity	Dambulla	1983 April	Always found only one or two parasites of large size.
Lerniosis	Lernia sp.	Common carp. Rohu, Mrigal, *L.dussumieri* Giant gouramy, Big head carp fingerlings and adult fish	Skin, specially base of the fins	Rambodagalla Udawalawe Dambulla Nuwara Eliya Ginigathhena	— 1983 onwards 83 onwards	Few mortality occured in fingerlings.
Synergasilosis	*Synerpasilus major*	Grass carp adult fish	Gills	Udawalawe Dambulla	1976 onwards 1984 onwards	Almost all the brood fish were infected with this disease.

Fig. 1

A. Metacercaria stages on the fins of *Puntius* sp. as observed under the microscope.

B. Gills of *Labeo rohita* fingerlings infected with metacercaria (low power).

C. Gills of *Labeo rohita* fingerlings infected with metacercaria (high power).

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TROUT CULTURE IN SRI LANKA: PRESENT STATUS AND FUTURE POSSIBILITIES

K. Tissera* and V. Tissera*

The rainbow trout, *Salmo gairdneri* is one of the principal species cultured in cold water fisheries. The body of the fish is latterally flattened and has a streamlined shape to withstand powerful flows. The dorsal side can be from light-green to dark purple in colour. Ventral side is usually silvery white. The body, dorsal fins and the caudal fin are speckled with black spots. Below the lateral line these spots are less prominent. The mature fish have a brightly coloured line which gives them the name' rainbow trout.

First attempts at introducing trout in Ceylon waters were done in 1882 when L. Hubbard then of St. John's Estate liberated about 20 brown trouts into a small stream in Nuwara-Eliya. Between 1886 and 1889 trout eggs were imported to Ceylon every year. However, these efforts were not successful and inspite of the fact that the stocked streams were closed to fishing, the fish had disappeared. More trout eggs were imported in 1892 and 1893. This proved to be successful and led to the formation of the Ceylon Fishing Club in 1896.

Eggs of rainbow trout were first imported to Ceylon in 1899 and again in 1902. The attempts at building a brood stock of trout were successful. The fish were found to be breeding at an altitude of 7,200ft. in the waters of the Horton Plains. Rainbow trout naturally bred at elevations down to 5800ft. (Fowke, 1936).

Natural spawning of the rainbow trout has been observed to occur during the coldest months when the breeders swim upstream and make spawning bed amongst gravel and stones, at depths which can be as shallow as six inches. The female makes a bowl like depression with the aid of the caudal fin. The male will chase away rivals during the time of spawning. In Ceylon a female trout is reported to spawn about 600-800 eggs only (Fowke, 1936)

Trout in Sri Lanka is reported to be ready for spawning in their second year (Fowke, 1936). Spawning continues for a period of 2-3 days during which time several spawnings could occur in one nest resulting in eggs to be deposited in several layers. Thereafter, another spot is chosen for another nest. After spawning is over the parent fish move downstream, abandoning the progeny.

In Sri Lanka, trout have been captured from the wild and successful artificial fertilization of the eggs has been carried out by stripping at Nuwara Eliya. The trout when ready for spawning were found to start moving upstream by mid-October. Fowke (1936) cautioned against capture of the brood fish till they reach the head waters where they can be netted out. No other method was recommended by him. Even though these fish can be taken on the fly or trapped, these were considered highly unsuitable resulting in the death of every egg.

A hatchery for trout eggs built by the Ceylon Fishing Club exists in Nuwara-Eliya. This was taken over by the Government in 1974 and is now run by the Ministry of Fisheries.

The hatchery is supplied with water from a stream. The intake to the hatchery is through a 2″ diameter galvanised pipe. Above this intake the stream runs through government protected forest areas thus ensuring the supply to be of unpolluted water. The intake pipe carries the water to a silt tank entering it from a depth of about 1.2 m. This is a concrete tank measuring about 1.2×1.2×1.2 m. This tank is filled with gravel and stones. Water rising from the bottom of this tank will rid itself of heavy particles. From the top of this tank a 2″ outlet pipe leads the water to the hatchery building.

Inside the hatchery building the water is collected in a head tank of dimensions 1.6×0.65 m. made of 4″ thick concrete.

*Freshwater Fish Breeding and Experimental Station, Nuwara-Eliya.

This is equipped with a drainage pipe for cleaning purposes. Water flows to the distribution trough through a 4″ earthern ware pipe. The distribution trough which measures 5.4×3.6 m. is also made of 4″ thick concrete. This has a 2″ overflow pipe and two drainage plugs for cleaning purposes. Water leaving the distribution trough can be controlled as it is equipped with a 2″ gate valve. At right angles to the distribution trough are the important filter troughs. These two filter troughs are each of dimensions 3.6×0.8×0.4 m. Made of 4″ thick concrete each of the troughs have four drainage plugs for cleaning purposes. Each filter trough has nine compartments divided by baffle plates. The 1, 3, 5 and 7th baffle plates come up to the top level of the trough but leave a three inch gap to the base. The other baffle plates start from the bottom and leave a 3″ gap at the top, thus causing the water to fall and rise to the compartments. This removes most of the silt contained in the water. Almost complete removal of the silt is obtained by filling a number of compartments with coarse gravel. The walls of these troughs are lined with glazed ceramic tiles. This filter is capable of an average output of about 22 l/min. Each filter trough supplies water to two hatching troughs also made of concrete. These have dimensions of 3.8×0.6 m. Each trough has a capacity for 25,000 trout eggs thus bringing the total capacity of the hatchery to 100,000 trout eggs. The troughs are lined with dark green glazed tiles. At the far end each trough has a drainage opening. During incubation these troughs can be covered with asbestos sheets to prevent harm by light. Six inches from the outlet of these troughs they can be blocked with a frame provided with a wire mesh. Below the outlets there is enough space to have trap boxes for extra control for possible escape of fry.

The eggs are placed on grills made with glass tubes fixed on a wooden frame. These frames are 0.6×0.2 m. in size and about 90 glass tubes are fitted, close to each other. The distance between these are such that the trout eggs would not escape through but there is enough space for good water circulation. One such tray of grills may carry about 6,000 eggs.

The average temperature of water flowing in the hatchery is about 12-13°C. Fowke (1936) reports that the eggs attain the eye-stage within about 14 days and complete incubation in 21-32 days. This shortening of the incubation period produces weak alevins, requiring extra care in fry rearing. In the hatchery, fungus and silt have been the main causes for loss of eggs. Silt is removed carefully with the help of a feather. Methodical use of malachite green in the hatchery troughs could effectively control fungal infections, in the Nuwara-Eliya hatchery resulting in attainment of hatching rates of more than 85% (J. Chandrasena, personal communication).

The rearing ponds are situated about 500 m. away from the hatchery. These consist of 5 ponds of dimensions ranging from 2.2×7.8 m. to 3.5×1.3 m. for rearing fry and 4 larger ponds for further rearing. Four ponds are each of 16.5 x 4.7 m. in size and another two of 6.2×2.9 m. in size. Water is supplied from the same source as for the hatchery. All these ponds are cemented and are fitted with overflow pipes. Each pond has its own freshwater inlet and drainage pipe.

Since its introduction to Ceylon trout have been used only to establish a sport fishery. Early introductions to the streams traversing Ohiya Valley had provided good results. Felling of trees and other activities leading to soil erosion and water pollution have now destroyed most of our trout streams. At present, research into these factors have to be carried out and necessary measures taken. If trout fishing has to continue and develop, measures should be taken to improve the suitability of streams as habitats for trout. These should be rich in natural food for trout. This could be attained by providing enough shade and by making the stream beds covered with weeds. The flora and fauna should be protected from coming to harm during the lesser water periods by building weirs at appropriate places.

Before the establishment of the Ceylon Fishing Club the Nuwara-Eliya stream had flown through barren land. Thanks to the efforts of the Fishing Club, this for some time had been converted into a model stream full of shade and beds covered with weeds encouraging growth of rich fauna which made it a very desirable habitat for trout (Fowke, 1936). Between 1918 and

1935 the Fishing Club had stocked 7,431, rainbow trout in this stream. As a result of this and other measures 26,975 trout had been fished out and 72,383 fish netted out for stocking purposes (Fowke, 1936). This makes for an annual average yield of 5407 fish from a stretch of 3½ miles of water, well maintained. Among the fish taken on the line were specimens weighing as much as 4 lbs. to 10 lbs.

The otter and the brown fish owl have been reported as the biggest predators of trout in Ceylon.

In 1978 an attempt to breed trout caught from the wild had been successful and 40% of fry survival had been obtained. Due to various reasons, attempts at maintaining a brood stock of trout at the hatchery had not been successful. Due to this reason trout ova were imported either from the Department of Wild Life, New Zealand or from Water Mill Trout Hatchery, U.K. They have been hatched at the Nuwara-Eliya trout hatchery and reared to fingerling stage using a mixture of poonac, rice bran and cattle blood as feed. The fingerlings had been stocked in the Horton Plains stream and some also distributed to private farmers. (A. M. Jayasekera, personal communication).

The potential of trout farming may be realised when it is known that the world's largest trout farm the Snake River Trout Farm, privately owned in the United States produces 600,000 kg. of trout per year with just 10 acres of land. (Bardach, 1972). As trout lives in flowing waters high stocking densities can be used by manipulating the water flow and through the aid of aeration. Rapidly advancing knowledge in feed technology and fish nutrition is bringing down the cost of rearing trout. At Nuwara-Eliya the stream waters have temperatures suitable for trout culture. When it is trapped from the head waters of the streams it can be obtained free from possible traces of agro-chemicals. Unlike in most countries where trout farming is practised, in Sri Lanka trout will grow throughout the year due to the lack of prominent seasonal changes that cause sub-freezing temperatures. Raw materials for the preparation of trout feed are readily available in Nuwara-Eliya. Ox-blood, cattle-offal, inactivated dry yeast, brewary waste and tubifex worms are all easily obtainable.

Cage culture of trout can also be productive as in race-ways and plastic pools. In the U.S.S.R., cages installed in water give high production of trout. In 1976, 28.5% of the total trout production in U.S.S.R. was from cages. Cages installed in the Dnieper reservoir gave a production of about 25 kg/m^3 (Titarev, 1980).

Information on status of trout culture in other countries and the facilities available in Sri Lanka suggest that it is time we advance from maintaining a sport fishery to commercial trout culture. Once necessities are provided and then properly managed, trout culture has the potential of becoming a big profit generating branch of inland fish culture in Sri Lanka.

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EXTERNAL ASSISTANCE FOR INLAND FISHERIES DEVELOPMENT IN SRI LANKA

K. Thayaparan*

INTRODUCTION

It is claimed that aquaculture is as old as civilization itself. In countries, like China and India, aquaculture has been practised from ancient times. Sri Lanka, unfortunately, does not have such a long tradition. Inland fisheries, infact, took root only after the introduction of Tilapia (*Oreochromis mossambicus*) from Singapore in 1952. Aquaculture is of still more recent origin. External assistance, in these spheres, is being used extensively for bringing about the necessary transformation.

THE FISHERY SECTOR

Sri Lanka is an island with a land area of 65,000 sq. km., a coastline of 1,200 km. and a shelf area (upto 120 m. depth) of 30,000 sq.km. The fishery sector is an important part of the Sri Lankan economy. In 1981, fisheries contributed to about 3% of total GDP, directly employing about 74,000 persons in fishing and another 14,000 persons in related occupations. Approximately, 84% of the total 1982 production of 213,516 tonnes (Appendix I) came from coastal fisheries, in which about 28,500 fishing craft are deployed, 45% of these being mechanized.

The inland fisheries resources are made up of about 120,000 ha. of brackishwater lagoons, estuaries and tidal flats and about 100,000 ha. of man-made perennial reservoirs and tanks. A further extent of about 22,670 ha. of freshwater bodies will be added with the development of the Mahaweli Basin. The extent under seasonal tanks is estimated to be another 100,000 ha. Inland fisheries accounted for about 15% of the 1982 production. In addition, about 4,000 tonnes were harvested from brackishwater fisheries. Nearly all the freshwater production came from capture fisheries in the large perennial irrigation impoundments and tanks. Tilapia accounts for about 90% of the current inland fish catch. The rest are made up of indigenous species, some only of minor commercial importance. Freshwater fishing is at present carried out by small-scale fishermen using gill nets and about 4,500 small non-motorised canoes with outriggers, dug-outs and log-craft.

Fish is the most important source of animal protein in the Sri Lankan diet, contributing to more than 60% of the animal protein consumed in the country. The per capita consumption of fish was 15 kg. in 1982.

The fishery sector is also a valuable source of foreign exchange earnings for Sri Lanka. In 1981 exports valued at Rs. 348 million contributed to nearly 2% of total earnings.

PRIORITY FOR INLAND FISHERIES DEVELOPMENT

Since fish is the major source of animal protein in Sri Lanka and considering that the country's inland water resources are substantial, the Ministry of Fisheries is now devoting greater attention to developing inland fisheries and aquaculture as a means of increasing domestic fish production.

The marine resources are reported to be limited and fishermen are also finding it extremely difficult to make ends meet due to the high capital and operating costs. Inland fishing, on the other hand, requires little investment and the operating cost involved are also low. The results are, however, very tangible. As freshwater fish is much cheaper than marine fish, it is consumed mostly by the poorer sections of the population, who live in the rural interior and the estate areas. Increasing the availability of freshwater fish would thus help to raise the nutritional standards of these rural people. It will also provide supplementary incomes and employment to these

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poor communities. In addition, Sri Lanka still imports fish to meet the local demand and also exports high valued species like prawns, lobsters etc. Hence increased production from aquaculture and inland fisheries will save/earn valuable foreign exchange for the country.

The Government has since the early 70's been devoting greater attention to the development of the inland fisheries sector. Under a Crash Programme which was initiated in 1973, seven Freshwater and one Brackishwater Fish Breeding and Experimental Centres were established. Some of these stations, unfortunately, are badly located and suffer from inadequate water supplies.

A concerted effort to develop inland fisheries and aquaculture on the basis of a well conceived and rationally drawn-up programme was started in 1978. The Master Plan for the period, 1979-1983 envisaged a three-fold increase in production from the inland fisheries sector. A seperate Division of Inland Fisheries was set up within the Ministry to implement development in this sector. The Division which is in charge of all aquaculture and inland fisheries activities, in both the freshwater and brackishwater areas, now operates 13 Freshwater and 2 Brackishwater Fish Breeding and Experimental Stations (Appendix 2). It also operates 4 Centres solely for carrying out extension activities. Two new fisheries complexes have been planned to be located at Kalawewa and Maduru Oya. A new organisation called the National Aquatic Resources Agency (NARA) was created in 1981 for the purpose of conducting research on aquatic resources.

The main programmes undertaken by the Ministry of Fisheries to spur the development of inland fisheries are :

(i) increased harvesting efforts in perennial tanks and reservoirs through a 90% subsidy scheme for the purchase of boats and fishing gear;

(ii) popularising pond fish culture through an incentive scheme amounting to 50% of total cost;

(iii) initiating new culture techniques such as cage and pen culture;

(iv) experimental stocking and harvesting of seasonal village tanks in order to demonstrate the fish production potential of these smaller water bodies;

(v) pilot studies directed towards the development and demonstration of coastal aquaculture techniques;

(vi) increasing hatchery production of fingerlings of desirable fish species, and

(vii) improvement in quality and quantity of extension services.

THE NEED FOR EXTERNAL ASSISTANCE

Aquaculture has been accepted as a major avenue for increasing food production, especially, of animal protein, in developing countries. Sri Lanka which does not have a tradition of aquaculture practices needs foreign assistance for capital investment, transfer of technologies developed in other countries of the region and training of manpower.

Developing countries like Sri Lanka requires substantial financial aid for the implementation of their development plans. As the country's resources are limited foreign capital assistance is needed to accelerate development. If Sri Lanka was to develop with her own resources it would take a very long time.

Today, highly advanced technologies on various types and aspects of aquaculture have been perfected in countries like China, India, Japan, Taiwan, Israel, Philippines, Thailand, etc. Hence, it is appropriate to transfer the technology and adopt it to suit local conditions rather than expend valuable time, money and effort to develop it on our own by trial and error.

Well trained and experienced practical aquaculturists are needed for rapid expansion of aquaculture. For this purpose, it is necessary to train local technical personnel viz. aquaculturists, technicians and extension workers, in modern concepts of aquacultural techniques and practices. As training facilities are not available locally it is necessary to send our core personnel to institutions abroad or to bring down foreign experts, to train them in the country.

External assistance is, therefore, crucial for achieving the long term objective of developing a viable aquaculture industry in Sri Lanka, along commercial lines.

GENERAL REVIEW OF AID PROGRAMMES FOR THE INLAND FISHERIES SECTOR

External assistance received have been from multilateral sources like the UNDP, FAO, ADB, SEAFDEC, etc., or from bilateral sources like China, Japan, USA, India, IDRC, CIDA, etc. These can again be divided into technical assistance projects and capital aid projects. Total external aid for the inland fisheries sector (whether received or in pipe line) amounts to approximately US $ 22.97 million (Appendix III) The total aid received for the entire fisheries sector is reportedly close to $ 60 million. The budgetary allocations for the fisheries sector show a gradual increase since 1978. The allocation for inland fisheries development has been greatly increased after 1981 (Appendix IV).

In 1983, foreign aid provisions for inland fisheries development amounted to Rs. 12 million i.e. over 22 per cent of total aid received for the fishery sector for that particular year.

Almost all assistance received upto 1983 were for technical assistance projects. The picture changes with the ADB funded Sri Lanka Aquaculture Development Project which is mainly though not exclusively, a capital development project.

SUMMARY OF PAST, CURRENT AND PROPOSED AID PROGRAMMES FOR THE INLAND FISHERIES SECTOR

All externally aided programmes for the inland fisheries sector, completed, on-going or in pipeline are listed below according to source of funding :

United Nations Development Programme (UNDP) and Food and Agriculture Organization of the United Nations (FAO) :

The UNDP and FAO have been providing technical assistance for inland fisheries and aquaculture development in Sri Lanka since the early 50s. Initially, the involvement mainly consisted of the assignment of one or two experts to carry-out surveys or feasibility studies. In course of time, the scope and size of projects have increased to full-scale technical assistance programmes.

W. H. Schuster who was functioning at that time as Chairman of the Committee on Fish Culture of the Indo-Pacific Fisheries Council, appears to be the first inland fisheries expert of repute to visit the country. He was here from 15 October to 18 November 1950 to advise on measures to be taken to develop brackishwater and freshwater fisheries in Sri Lanka. The services of Dr. S.W. Ling was obtained from February, 1955 to June 1959 (with short breaks in between) to assist and advise the Government on the development of inland fisheries in Sri Lanka, with emphasis on the introduction and development of fish stocking and fish culture. This assistance was provided under the "Expanded Programme of Technical Assistance (FAO/ETAP-1527)." Dr. V.G. Jingran worked in Sri Lanka during 1975 on the formulation of an Aquaculture Development and Training Project for funding by UNDP. He is reported also to have assisted the Ministry in preparing a Crash-Programme for the development of inland fisheries in the country.

The UNDP also assisted the Ministry in training 24 Aquaculturists in the People's Republic of China during the period 1975-1977. The training imparted for a period of 6 months was meant to train competent personnel to be in charge of Freshwater Fisheries Centres established for the purpose of producing fingerlings for culture and to demonstrate relevant techniques to those interested in fish farming.

Under the FAO Technical Co-operation Programme, assistance was offered through Project No. TCP/SRL/8804 — Development of Fisheries in the man-made lakes and reservoirs. The Project objectives were (i) to assist the Ministry in developing programmes to increase the yields of fish from the freshwater tanks and (ii) to provide advice on the introductions of new species of freshwater fish and on stocking practices suitable for the various types of tanks. The Consultants, Professor R.T. Oglesby and Dr. H. Rosenthal conducted their studies between April 1979 to July 1980.

Under the Project "Social Development of the Mahaweli Development Area" the UNICEF supplied equipment required for the Fish Breeding cum Extension Centre which has been established at Dambulu Oya. During the period 1979-83 UNICEF provided equipment to the value of over $ 25,000. One of the objectives of the project is the upliftment of the nutrition status of the residents in the Project Area. The infrastructure facilities for the fisheries station were provided by the Mahaweli Authority and the Ministry of Fisheries is responsible for the operation and management of the station. *Labeo rohita* and *Cirrhinus mrigala* were introduced by the Ministry for the first time in 1981 and the station now functions as the premier Indian major carp breeding station in Sri Lanka.

A Planning Mission from the Aquaculture Development and Co-ordination Programme (ADCP) consisting of U.N. Wijkstrom (Economist and Team Leader), K. H. Alikunhi (Freshwater Aquaculturist), H. L. Cook (Brackishwater Aquaculturist) and J. Kovari (Aquaculture Engineer) was in the island during September/October 1980 to undertake a review of aquaculture development possibilities in Sri Lanka. The Mission identified several culture systems and ranked them on the basis of Government's development objectives, economic viability and social relevance and also finalised the scope and content of a technical assistance project to promote culture of fish in seasonal tanks.

The Aquaculture Development and Training Project (SRL/023/79) really took off the ground in November 1981. UNDP contribution for this 3 year technical assistance project is $ 750,301. The immediate objectives of the project are (i) increased supply of fingerlings of suitable freshwater fish species for stocking in seasonal and perennial tanks; (ii) providing on-the-job training for technical, research and extension personnel in order to effectively implement the inland fisheries development programme and (iii) training of fish farmers in the technology of commercial polyculture and fishery management of seasonal tanks. A special feature of the project is the furtherance of technical co-operation among developing countries (TCDC) through reliance on expertise from China to transfer a part of the know-how required for the project's success. The Senior Adviser to the Project is R.M. Bhowmick. The project introduced *Catla catla* to complement earlier introduced species of carps, set up a glass jar type hatchery, organised experimental stocking/harvesting of seasonal tanks and provided training to extension officers and fish farmers. There is also provision for short term consultancies for a Hydrobiologist (6 m/m) to carry out survey of hydrobiological parameters etc., in seasonal tanks and a Carp Rearing Expert (3 m/m) for rearing of fry/fingerlings in pens and cages in reservoirs. The Project which is due to end in February 1984, is likely to be extended till December 1984.

Under the co-operative agreement between FAO and ADB, a FAO/Investment Centre Mission consisting of Dr. I. Sobhan (Mission Leader), K. H. Alikunhi (Aquaculturist), K. Husain (Marketing) and J. McCall (Aquaculture Engineer) visited Sri Lanka during March/April 1982 for the preparation of an investment project for aquaculture development for possible financing by the ADB. The project proposals originated from the earlier ADCP Mission. This was followed later by a joint FAO/ADB Fact Finding Mission (March/April 1981) which outlined the likely project scope and specified the terms of reference for full preparation.

The FAO/UNDP project for Small-Scale Fisheries Promotion in South Asia (RAS/77/044) sponsored a Thai Aquaculture Mission in 1978, for three weeks. The members of the Mission were Umpol Pongsuwana, Kasemsant Chalayondeja and Niwes Ruangpanit. The Thai experts concluded that there are good opportunities for coastal aquaculture development in Sri Lanka.

In 1981, a two member Aquaculture Mission from India consisting of T. Franklin and R. Soundararaj was sponsored by FAO/BOBP (Bay of Bengal Programme for Fisheries Development). The main items of work performed by this TCDC Mission were (i) a survey of hydrobiological parameters for the purpose of identifying areas suitable for brackishwater shrimp culture and (ii) conducting of shrimp culture trials in two ponds at the Pitipana Brackishwater Station.

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In late 1983, the Pilot Project-Development and Demonstration of Coastal Aquaculture Techniques in Sri Lanka was finalished. The main purpose of this project is to evolve and demonstrate some locally suitable basic techniques of brackish-water shrimp culture by (i) pen culture of shrimp either exclusively or in combination with fin-fish and (ii) demonstration of the basic hatchery techniques through the establishment of interim make-shift hatchery facilities. BOBP is making a contribution of $ 43,500 towards this project, which is of two years duration.

NACA (Network of Aquaculture Centres in Asia) instituted under the Regional Project, RAS/76/003, between UNDP/FAO and the participating Governments operates within the framework of TCDC. The main objectives of this project, which commenced in 1979 are the development of appropriate aquaculture technologies, trained personnel and information required for structuring fish production programmes in the Asia-Pacific Region. Under this programme the Ministry has been fortunate enough to train 6 Senior Aquaculturists in the one year post-graduate course and another 6 Junior Aquaculturists in the 4 months integrated fish farming course. Fellowships for this purpose have been awarded by China, UNDP, IDRC, and the ADB.

Assistance from the People's Republic of China (PRC)

Under a bilateral agreement signed in 1974 the PRC agreed to provide assistance for the establishment of a Fish Breeding and Experimental Station at Udawalawe, mainly to commence the breeding of the Chinese major carps in Sri Lanka. The Chinese undertook the construction of ten 1/3 acre ponds for culture purposes and a fully equipped hatchery. They also provided hatching equipment and machinery to service this station. The total Chinese contribution was estimated to be about Rs. 8.5 million. The Fisheries Station at Udawalawe was completed in 1977 and fish fry of Grass Carp and Bighead Carp were flown from China and their spawning was successfully supervised by Chinese Experts during 1977/78. In addition to this, the Chinese Government also undertook the training of local staff in various aspects of fish culture. As mentioned earlier these programmes were sponsored by FAO/UNDP.

Since then close co-operation has continued and pituitary glands, hormones etc., have been imported at regular intervals. Due to difficulties experienced in the breeding of Chinese carps the services of 2 Chinese Experts was obtained in 1980 under bilateral arrangements. The Ministry also took steps to introduce Silver Carp in 1982. A new batch of 5 Chinese Experts, specialised in breeding, fish diseases, integrated farming etc., obtained by the Ministry in May 1983, are now attached to the Polonnaruwa Fisheries Station.

Recently, a joint venture in the form of the Lanhua Fisheries Joint Venture Co., has been established between the Ceylon Fisheries Corporation and the Chinese International Engineering Corporation. This is largely a capture fishery oriented project with a relatively small aquaculture component. There is provision in the project for a 32 acre penaeid shrimp farm and another 25 acre fish farm. Technical expertise is to be provided by Chinese Aquaculture Experts.

International Development Research Centre (IDRC)

In 1979, agreement was reached with the IDRC for the implementation of a Cage Culture Project. The objectives of this research oriented project were (i) to study the applicability of cage culture systems in lakes and tanks and other inland waters using various freshwater fish species; (ii) to determine the potential economic value of technologically sound cage culture systems, together with the constraints to their adoption; (iii) to train Sri Lankan research and extension workers in research techniques and the demonstration and implementation of acceptable technologies and (iv) to co-operate with rural farmers and fishermen in the development and implementation of cage culture techniques.

IDRC has given a grant of Canadian $ 99,700 towards this 2 year project. The project actually commenced in January 1980 and went on till August 1982. During this phase Dr. Chua Thia Eng undertook a short visit to design the cages for the trials.

Phase II of the Cage Culture Project which commenced in September 1982 will continue till August 1985. The activities under Phase I will be continued into Phase II as well. In addition, it is proposed to conduct preliminary surveys on productivity of lagoons and inland tanks and test the feasibility of pen culture in selected areas. IDRC grant towards Phase II totals Canadian $ 216,600. A short term visit by Sergio SM Felix was arranged by IDRC in order to survey suitable sites and for construction designs for pen culture.

IDRC has also funded a Mollusc Culture Project which is being implemented by the National Aquatic Resources Agency. This 3 year research study which commences in 1984 proposes to (i) study the applicability of rack, raft and stake culture in selected areas for mussels and oysters, (ii) examine the profitability of marketing of cultured molluscs, (iii) train Sri Lankan research workers in the relevant technology and, (iv) co-operate with rural fishermen in the development and implementation of the different culture systems. IDRC grant for this project amounts to Canadian $ 159,950.

IDRC has also shown interest in funding a research project to carry out investigations on suitable indigenous feed materials and other relevant aspects of fin fish nutrition with reference to intensive culture systems in Sri Lanka. This study is to be jointly implemented by the University of Ruhuna and the Ministry of Fisheries. IDRC contribution is expected to be around Canadian $ 116,450.

The IDRC has also been sounded on the possibility of undertaking a pilot study on integrated fish farming in the country. The outlines of the project are being worked out.

IDRC has also provided awards for about 10 Aquaculturists for pursuance of overseas training in various fields of aquaculture.

Asian Development Bank (ADB)

The Government requested the Bank in June 1980 for technical assistance to formulate an aquaculture development project. In response to this a Mission from the ADB visited Sri Lanka from 24th March—2nd April 1981 to finalise the scope of the technical assistance. A project preparatory technical assistance grant of $ 105,000 was approved by the Bank in September 1981 on a cost sharing basis with FAO (TA 412-SRI). The FAO Investment Centre conducted field work in Sri Lanka during March/April 1982, and submitted a detailed feasibility study to the Bank and the Government and in November 1982 a Fact Finding Mission from the Bank came to Sri Lanka. This was followed by an Appraisal Mission from 15th February—2nd March 1983. The final agreement with the Bank was signed on 23rd November 1983. The loan effectiveness target date is 23rd February 1984.

The proposed loan is reported to be the Bank's thirty fourth loan to Sri Lanka, the third loan to the fisheries sector and the first loan exclusively for an aquaculture project. It also becomes the largest ever foreign funded fisheries project in Sri Lanka and the first large scale capital aid project for the inland fisheries sector.

The main objectives of the Sri Lanka Aquaculture Development Project are (i) to increase fish production for domestic consumption, (ii) to establish the basis for shrimp culture as an additional means of earning foreign exchange, and (iii) to strengthen the institutional infrastructure for the future development of aquaculture in Sri Lanka.

The major project components are, (i) provision of 6 major seed production centres (freshwater fish hatcheries) to provide fingerlings for the Seasonal Tanks Programme, (ii) provision of pools and pen enclosures at 8 other sites to function as rearing stations, (iii) assistance in the preparation of seasonal tanks to improve conditions for fish growth, (iv) construction of a fully equipped National Inland Fisheries Development Centre; (v) construction of a shrimp hatchery to produce 20 million marine shrimp post-larvae annually, plus brackishwater demonstration ponds and pens, (vi) construction of a small number of commercial brackishwater ponds to be stocked with hatchery produced shrimp post-larvae and milkfish, to be financed through the 2 State Banks. The total area occupied will be 200 ha. with individual ponds averaging 5 ha, (vii) establishment of a fully developed, staffed and equipped extension services system, (viii) consulting services to assist in the implementation and initial operation of the shrimp hatchery development and seasonal tanks programme, (ix) local and foreign training for key technical personnel, and (x) funding for monitoring and evaluation of Project's benefits and socio-economic impact.

The total cost of this 6 year Project is $ 21.62 million, including a foreign exchange component of $ 9.2 million (43%). The proposed Bank loan of $ 17.27 million will cover 79.9% of the total project cost including the entire foreign exchange cost and $ 8.07m. of the local currency cost. Approximately, 5,000 inland farmers and 200 Shrimp farmers will be employed under the project, and the number of direct beneficiaries from the seasonal tanks component will be about 250,000. The Project will result in an incremental production of 7,500 mt. of carps and 25 mt. of milkfish per year for domestic consumption. In addition, about 200 mt. of shrimp will be produced for export.

Canadian International Development Agency (CIDA)

CIDA's interest in inland fisheries dates as far back as February 1977, when a Planning Mission visited the country to draw up a fisheries programme for the entire sector The Mission which consisted of L. D. Johnston, N. Tibbo. R. O'Keefe, H. Rabanal and L. Hinds identified 5 project components, only one of which related to aquaculture development. Canadian grant for this action oriented project in aquaculture was expected to be $ 2.8 million. The proposal, however, never proceeded beyond the planning stage.

In April 1983, CIDA fielded a Mission to Sri Lanka with the objective of identifying a project within the inland fisheries sector. The Team composed of K. Rayes, L. Hinds and B. Bacon, identified an inland fisheries project centred round the Maduru Oya Reservoir (in System B of the Accelerated Mahaweli Development Area) which was recently completed with Canadian assistance.

The proposed project would provide for (i) a hatchery and rearing facility capable of an annual production of 2 million fingerlings for stocking in ponds, seasonal tanks and reservoirs, (ii) a demonstration fish farm unit for demonstrating fish and integrated farming techniques to people of the area, (iii) development of improved breeding and rearing method through the inclusion of a pituitary bank and diet formulation facility, (iv) improved harvesting techniques for seasonal and perennial tanks, (v) management and cash control programmes which would emphasise efficient operation of the facility.

The principal aim of the project is to assist the Ministry of Fisheries to raise the per capita consumption of fish through greater exploitation of the freshwater fisheries resources. The proposed Project is to be implemeated over a 5 year period at an approximate cost of Canadian $ 2.6 million, out of which CIDA would contribute $ 2.23 as grant. A Planning Mission from CIDA is expected in early 1984 to finalise proposals and the project is to be implemented from January 1985.

Indian Technical and Economic Co-operation Programme (ITEC)

The services of R.D. Chakrabarty, Expert Fish Farming and Fish Farm Management was obtained by the Ministry in August 1981, for a period of 3 years. Two other experts, namely Dr. J. P. Rayan (Artemia Culture) and Dr. Sumitra Vijayaraghavan (Aquaculture) arrived in April 1983 to assist NARA in their research programmes. Two training programmes in India for extension staff were also arranged under this programme.

A. Sreenivasan, formerly Joint Director of Fisheries and General Manager of the Tamil Nadu State Fisheries Corporation in India was directly employed by the Ministry as Inland Fisheries Advisor in May 1982, for a period of 3 years.

Technical Assistance from Japan :

In March, 1974, Professor Yutaka Uno of the Tokyo University of Fisheries and Dr. Ryago Yuki, Director of Hokkaido Mariculture Center came out to Sri Lanka to conduct a survey into the possibilities of mariculture in the lagoons.

During January/February 1977 a four-member Investigation Team headed by Dr. Masaru Fujiya was sent by JICA to examine the possibilities of developing the aquaculture industry in the coastal zone. The Mission recommended that there were good prospects for the development of coastal aquaculture in Sri Lanka and that this should be carried out on the basis of a long-term programme, including the framing of a Master Plan and the setting up at an appropriate stage of an Aquaculture Training Course at the Sri Lanka Fisheries Training Institute.

In order to prepare this Master Plan two Senior Officers from the Ministry went on a study tour to Japan in June 1978 to identify appropriate aspects and fields of coastal aquaculture that could be adopted for development in this country. The Master Plan drawn up by these officers envisaged the establishment of a Marine Aquaculture Research Laboratory to undertake research and survey in relevant fields, training of field officers in aquaculture techniques and pilot projects to establish economic viability of aquaculture. The total cost of the project was estimated at $ 2.5 million. The project, however, was given a low priority and, therefore, could not find a place in the Public Sector Investment Programme.

New efforts were made in 1983 to review the project and a proposal to establish a Coastal Aquaculture Research and Development Center to conduct activities, directed towards coastal aquaculture research of applied nature (fin-fish, prawn, seaweed, etc.) in order to develop viable coastal aquaculture technologies and demonstrate the same for the spread of these for raising of food fish, crustacean, etc., has been submitted to the Government. The total estimated cost is about $ 2 million. The Japanese authorities have again expressed interest in this project.

Apart from these, a group training course in general aquaculture of 6 months duration is being conducted by the Japanese Government under the Colombo Plan and 6 Aquaculturists have benefited from this training, so far.

United States Agency for International Development (USAID) :

Technical assistance in aquaculture, more specifically for hatchery and farms for both fresh and brackishwater shrimps was requested in 1982. In response to this request Kenneth Osborn, Fisheries Advisor, made a short visit to Sri Lanka to review and discuss scope of work for technical assistance. As a follow-up of the discussions, two Consultants, namely, Clarence P. Idyll and Harry Cook carried out a survey in Sri Lanka recently. Their main task was to provide advice on activities and actions which might accelerate the development of commercial shrimp farming in Sri Lanka. The Consultants noted some gaps in the programmes now underway for shrimp culture and identified six projects for strengthening the activities.

Two Aquaculturists also received training at the Auburn University, U.S.A. during 1983.

South-East Asian Fisheries Development Centre (SEAFDC) :

The SEAFDC Aquaculture Department located in Iloilo, Philippines has provided training for several of our Aquaculturists in brackishwater pond culture, cage culture, artificial propagation and pond/pen culture of milkfish etc.

SEAFDC also sent out two of its Senior Researchers namely Antonio Villaluz and Dan Baliao during April/May, 1982 for transfer of technology in milkfish fry collection, storage, transport and nursery techniques.

All these activities have been funded from IDRC grants.

World Bank :

Dr. Y. A. Tang, a World Bank Fisheries Expert was in the Island recently and he has evinced interest in two projects to promote the development of shrimp farming by small-holders, and intensification of fish production from reservoirs.

CONCLUSION :

In view of the potential contribution of inland fisheries and aquaculture to the protein food supply the Government has rightly attached priority to this important sub-sector. In order to plan and fulfil effectively long term aquaculture development goals external assistance is needed in large measure. In this respect, Sri Lanka has been fortunate in that substantial amount of technical and financial support has been forthcoming from donor agencies.

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Appendix I

FISH PRODUCTION (Tonnes)

Year	Offshore & Deep sea	Coastal Fisheries	Inland Fisheries	Total Production	Inland Fisheries as % of total production	Per Capita Consumption (kg)
1950	NA	30,000	500	30,500	1.64	NA
1955	NA	NA	NA	38,810	NA	NA
1960	858	47,973	3,350	52,181	6.42	NA
1965/66 (a)	2,535	89,050	9,187	100,772	9.12	22.05
1966/67 (a)	3,428	105,448	9,901	118,777	8.34	17.78
1967/68 (a)	3,279	125,054	8,563	136,896	6.26	18.50
1968/69 (a)	4,328	121,105	(d) 8,412	133,845	6.28	16.10
1969/70 (a)	3,030	88,097	8,340	99,467	8.38	15.28
1970/71 (a)	2,712	74,171	9,690	86,573	11.19	14.06
1971/72 (b)	2,985	108,143	10,885	122,013	8.92	15.69
1973	2,347	90,874	6,889	100,110	6.88	11.18
1974	2,000	99,413	7,539	108,952	6.92	11.00
1975	955	113,054	13,097	127,106	10.30	11.86
1976	539	121,388	12,343	134,270	9.19	10.88
1977	307	123,411	12,863	136,581	9.42	10.41
1978	2,903	134,744	16,474	154,121	10.69	11.80
1979	2,066	146,507	17,150	165,723	10.35	13.00
1980	2,316	162,459	19,947	184,722	10.80	14.88
1981	2,144	172,318	29,124	203,586	14.31	14.12
1982	1,061	179,657	32,798	213,516	15.36	15.36
1983	1,700	181,270	35,530	218,500	16.26	15.99
1984 (c)	2,800	200,000	45,000	247,800	18.16	—
1988 (c)	12,850	238,450	64,000	315,300	20.30	—

(a) = For financial year from October—September.

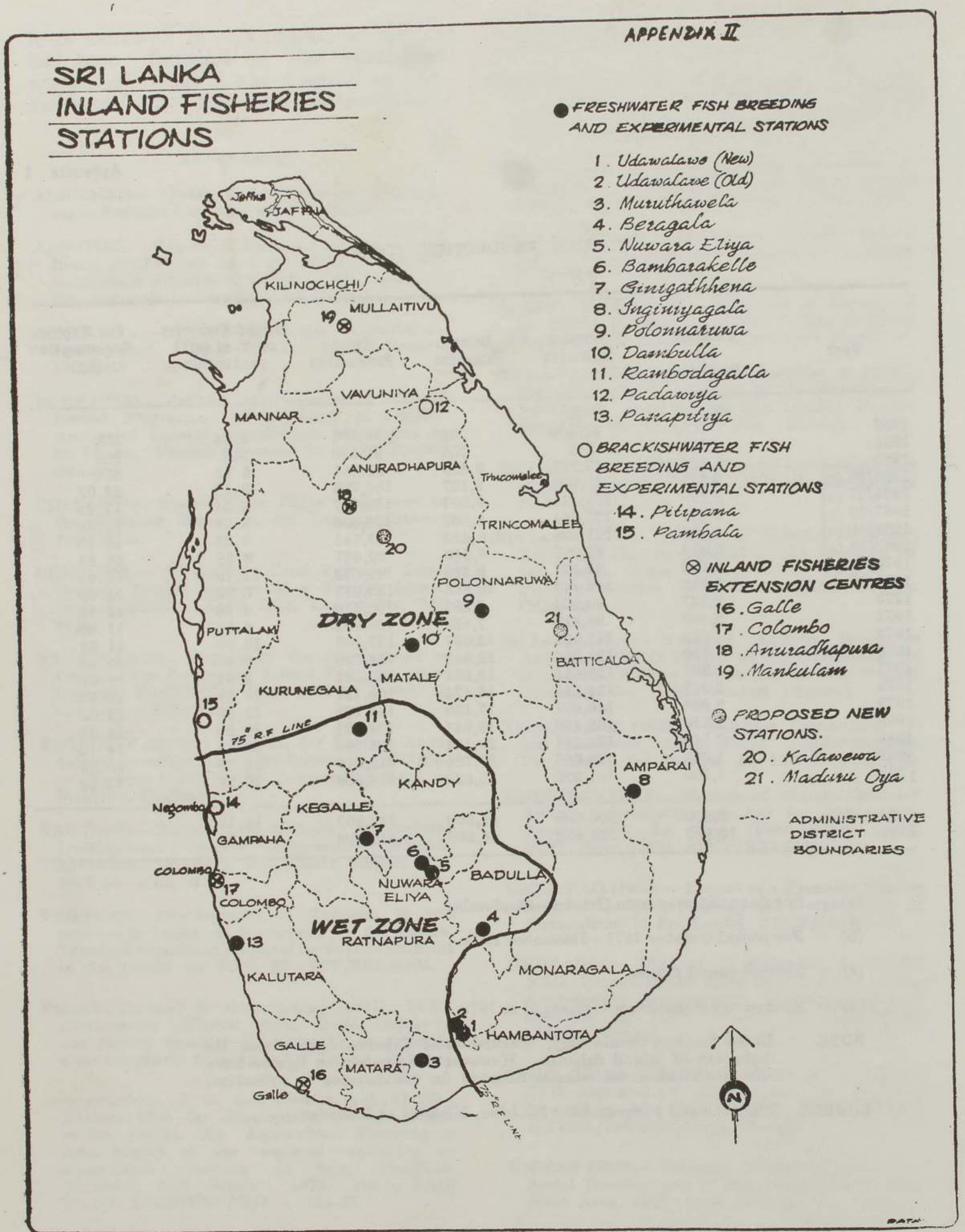
(b) = For period October 1971—December 1972.

(c) = Revised target figures.

(d) = Method of estimation was changed in 1970.

NOTE : In Sri Lankan terminology, brackishwater fisheries falls within the definition of inland fisheries. However the production figures have been included under coastal fisheries for convenience of collection.

SOURCE : Planning and Programming Division, Ministry of Fisheries.


APPENDIX II
SRI LANKA
INLAND FISHERIES
STATIONS
FRESHWATER FISH BREEDING AND EXPERIMENTAL STATIONS
1. Udawalawe (New)
2. Udawalawe (Old)
3. Muruthawela
4. Beragala
5. Nuwara Eliya
6. Bambarakelle
7. Ginigathhena
8. Inginiyagala
9. Polonnaruwa
10. Dambulla
11. Rambodagalla
12. Padawiya
13. Panapitiya
BRACKISHWATER FISH BREEDING AND EXPERIMENTAL STATIONS
14. Pitipana
15. Pambala
INLAND FISHERIES EXTENSION CENTRES
16. Galle
17. Colombo
18. Anuradhapura
19. Mankulam
PROPOSED NEW STATIONS.
20. Kalawewa
21. Maduru Oya
ADMINISTRATIVE DISTRICT BOUNDARIES
Jaffna
JAFFNA
KILINOCHCHI
MULLAITIVU
VAVUNIYA
MANNAR
ANURADHAPURA
Trincomalee
TRINCOMALEE
POLONNARUWA
DRY ZONE
PUTTALAM
BATTICALOA
MATALE
KURUNEGALA
75" R.F. LINE
KANDY
AMPARAI
Negombo
KEGALLE
GAMPAHA
NUWARA ELIYA
BADULLA
COLOMBO
WET ZONE
RATNAPURA
KALUTARA
MONARAGALA
HAMBANTOTA
GALLE
MATARA
Galle
75" R.F. LINE
N

Appendix III

EXTERNAL ASSISTANCE FOR INLAND FISHERIES

Serial No.	Name of Project/Activity	Project No.	Source	Terms	Year	Amount US $ million	Status
1	Inland Fisheries Development	8/SRL/04/m	FAO/ TCP	Grant	1962	0.0415	Completed
2	Training of Fish Culturists	SRL/74/052	FAO/ UNDP	Grant	1975	0.0756	Completed
3	Estd. of FW Fish Breeding Station at Udawalawe	—	China	Grant	1975/76	1.20	Completed
4	Inland Fisheries Fellowships	SRL/76/020	FAO/ UNDP	Grant	1977	0.0078	Completed
5	Development of Fisheries in Man-made Lakes and Reservoirs	TCP/SRL/8804	FAO/ TCP	Grant	1979/80	0.04	Completed
6	Equipment for Dambulu Oya Fisheries Station	—	UNICEF	Grant	1981/82	0.025	Completed
7	Cage Culture — Phase I	3—P—79—0018	IDRC	Grant	1980/82	0.09	Completed
8	Aquaculture Development & Training	SRL/079/023	FAO/ UNDP	Grant	1981/84	0.75	On-going
9	Aquaculture Development — Project Preparation	TA 412	ADB	Grant	1981	0.105	Completed
10	Aquaculture Development — ISP Preparation Mission	2/82 AS-SRL 24	FAO/ ADB	Grant	1982	0.92	Completed
11	Cage Culture — Phase II	3-P-81-0170	IDRC	Grant	1982/85	0.20	On-going
12	Aquaculture Development Project	648-SR1 (SF)	ADB	Loan	1984/8	17.27	On-going
13	Mollusc Culture	—	IDRC	Grant	1984/86	0.14	On-going
14	Inland Fisheries Development	221/27077	CIDA	Grant	1985/89	2.00	Pipeline
15	Fin Fish Nutrition	—	IDRC	Grant	1985/87	0.11	Pipeline
						22.97	

* Several technical assistance programmes and fellowships mentioned in the article could not be listed for want of information regarding costs.

MINISTRY OF FISHERIES

Budgetary Allocations 1978–1984 (Rupees)

	Total allocation for Ministry			Allocation for Inland Fisheries Development			Allocation for IFD as % of total allocation	Total foreign aid for Ministry	Total foreign aid for Inland fisheries development	Foreign aid for IFD as % of total foreign aid
	Capital	Recurrent	Total	Capital	Recurrent	Total				
1978 (Actual)	74,995,449	31,481,690	106,477,139	3,770,628	1,957,635	5,728,263	5.38	10,096,921	—	—
1979 (Actual)	115,742,836	13,638,858	129,381,694	4,973,232	1,711,286	6,684,518	5.17	11,890,547	—	—
1980 (Actual)	266,210,737	19,718,981	285,929,718	7,001,789	1,906,444	8,908,233	3.12	571,983	—	—
1981 (Actual)	151,965,715	19,305,262	171,270,977	21,080,258	2,573,961	23,654,219	13.81	19,040,457	330,195	1.73
1982 (Actual)	140,215,769	46,583,053	186,798,822	27,648,930	3,914,699	31,563,629	16.90	24,665,907	540,366	2.19
1983 (Estimate)	132,067,000	31,448,000	163,515,000	21,000,000	5,232,000	26,232,000	16.04	54,200,000	12,000,000	22.14
1984 (Estimate)	199,300,000	36,117,000	235,417,000	44,500,000	7,159,000	51,655,000	21.94	105,580,000	22,820,000	21.61

* The Inland Fisheries Division was formed in July 1979. Prior to this it was under the Research Division and before 1978 under the Department of Fisheries. Allocations for inland fisheries research to NARA, after its formation in 1981 have not been included in the table.

J. Inland Fish., *Vol.* 2, *December*, 1983, *pp.* 178—179.

A NOTE ON THERMAL STRATIFICATION AND OXYGEN DEPLETION IN UDAWALAWE RESERVOIR, SRI LANKA

A. Sreenivasan*

Limnological studies of Reservoirs are essential for planning and developing the fisheries in these waters. Information available on Sri Lanka waters, except for the monographic accounts on Parakrama Samudra, by the Austrian team is fragmentary. The physico-chemical parameters have not been studied depthwise. The Ministry of Fisheries has initiated, in a limited way, a limnological study of select reservoirs to gain an insight into the ecology of these.

A preliminary study of Udawalawe Reservoir has furnished interesting results. Thermal stratification, so rare even in deeper reservoirs of South India (Sreenivasan 1970) was sharp on the date of sampling (13.3.1983). Since thermal stratification has an important bearing on the recycling of nutrients, on movement of fishes, productivity etc., (Ganapati and Srinivasan 1951), it would be very useful to obtain data on this, for the entire year.

Thienemann (1926) postualed that oxygen deficit in lakes is an indication of their relative productivity. "Metabolism concept" in freshwater ecosystems would support the postulation of Thieneman. (Sreenivasan 1971). In oligotraphic waters because of low metabolic rates, the oxygen consumption is low and hence deficits are low and depletion unknown. The oxygen curve is orthograde. On the day of sampling Udawalawe Reservoir there was complete depletion of oxygen in the bottom (12 m. depth). Upto 8 m. depth, the reservoir water was fairly well-oxygenated (Fig. 1).

In comparison, a neighbouring reservoir, Muruthawela was only slightly thermally stratified, in the upper layers between 1 and 2 m. depths. No oxygen depletion occurred though at 12 m. (bottom) there was oxygen deficit. In this reservoir, the conductivity did not increase with depth and there was only a marginal variation between surface and bottom (128–120 μmho/cm.). It was surmised that the shallow low country reservoirs in Sri Lanka are unlikely to develop and retain strong thermoclines or chemical stratification for long (Bauer 1983).

Detailed investigations covering at least a full year are needed to have a clearcut picture of the dynamics in the reservoir ecosystem. Biochemical and thermal stratification should be looked into. If the present trend is any indication, Udawalawe would be more productive than Muruthawela Reservoir. Investigations now under way would confirm this.

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Bauer K., 1983 — Limnology of Parakrama Samudra Ed. F. Scheiner W. Junk. The Hague.

Ganapati, S.V. and Srinivasan R. 1951 — Thermal Stratification in lakes and ponds Ind. Com. Jour **6** : 568-571

Sreenivasan, 1970 — Limnology of tropical impoundments : A comparative study of the major reservoirs in Madras State (India). Hydrobiologia **36** : 443-459.

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Thienemann A. 1926— Die Sauerstoff in Eutrophen and Oligotrophen Seen. Binnengewasser IV : 1-175.

*Ministry of Fisheries, Colombo.

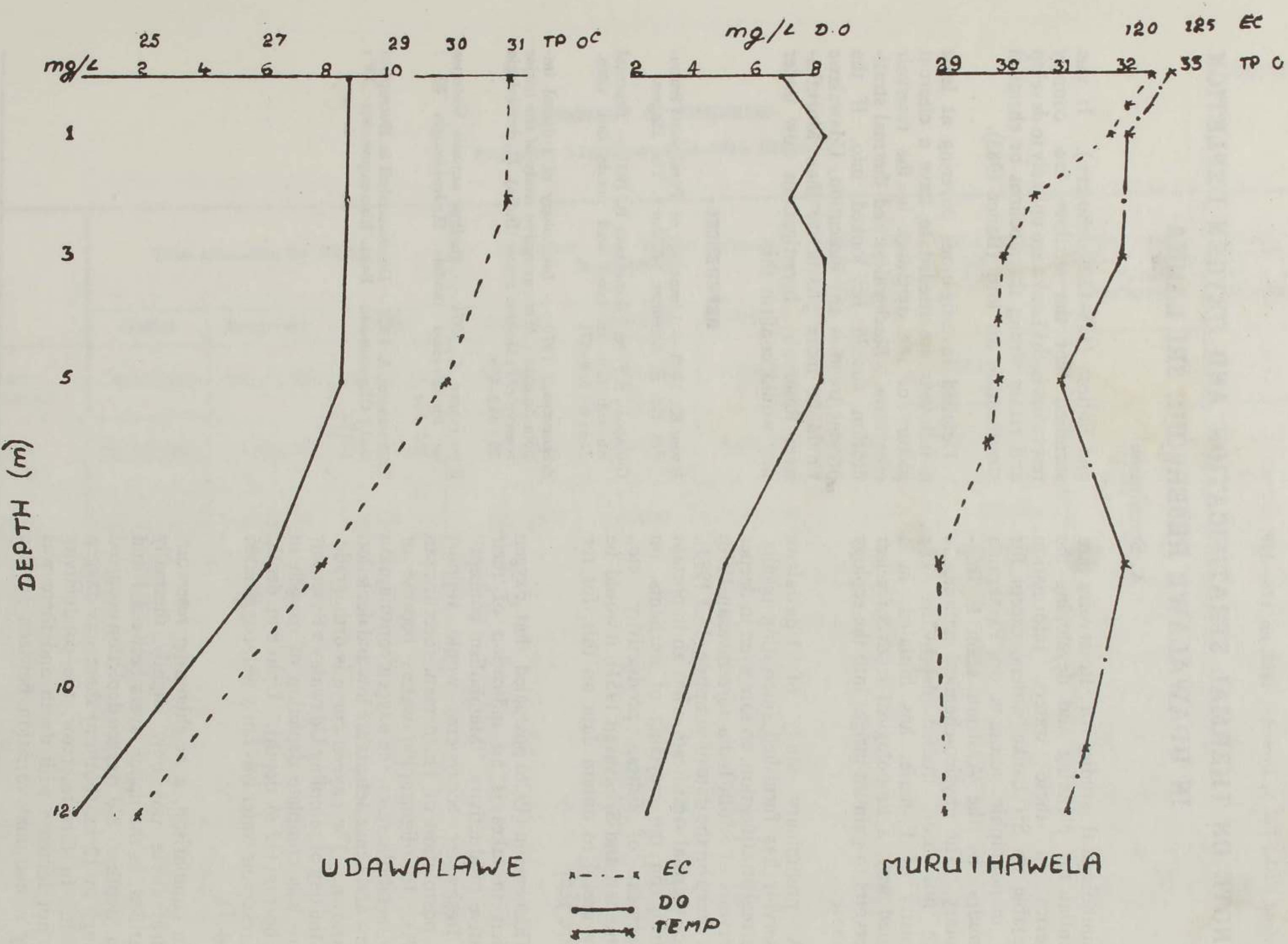

FIG 1: THERMAL AND OXYGEN REGIME RESERVOIRS

ERRATA

Journal of Inland Fisheries, Vol. I. December, 1982

p. 19. (left) Col. 2, line 2; instead of 'from 1.5 to 2.7 cm.(av. = 1.93 cm.) and 0.03 to 0.13g.'

read 'from 1.4 to 2.9 cm. (av. = 1.97 cm.) and 0.03 to 0.15g.'

p. 20. (left) Col. 2, line 7; instead of 'and 6.9 to 9.1 respectively'
read 'and 6.0 and 9.1 respectively'

p. 20. (left) Col. 2 line 11; instead of from 24.5 to 33°C' read 24.5 to**34**°C'.

p. 20 5(a) line 3 onwards : instead of 'from 0.03 to 0.13 g. (av. 0.067g.) and 1.50 to 2.71 cm. (av. = 1.93cm.
read 'from 0.03 to 0.15g. (av. 0.067g.) and 1.40 to 2.91 cm. (av. = 1.97cm.)'

p. 20, line 8 : instead of '2.20 to 9.0 cm. (av. = 2.35)' read '2.20 to 9.0 cm. (av. 4.9cm.')

p. 22 (a.5) : instead of 'Increase water depth gradually, 3.5 cm. at a time until stocking depth will cause lab-lab to detach and float' read 'Increase water depth gradually, 3 to 5 cm. at a time until stocking depth of 40-50 cm. Abrupt increase will cause lab-lab to detach and float'.

p. 25. Table 2; instead of

Pond No.	Length(cm)				Weight(g)		Percentage	Relative growth
	Initial		Final		Initial		Survival	Increment (g/day/ fish)
	Range	Mean	Range	Mean	Range	Mean		
CNP[1]	1.5—2.7	1.93	2.2—6.8	5.64	0.03.0.13	0.050	96%	0.073
CNP[2]	1.4—2.9	2.01	4.0—9.0	5.18	0.04—0.15	0.076	100%	0.079
Mean	1.4—2.9	1.97	2.2—9.0	5.41	0.03—0.15	0.067	98%	0.076

Read

Pond No.	Length(cm)				Weight(g)				Percentage Survival	Relative Growth Increment (g/day/ fish)
	Initial		Final		Initial		Final			
	Range	Mean	Range	Maan	Range	Mean	Range	Mean		
CNP[1]	1.5—2.7	1.93	2.2—6.8	4.64	0.03—0.13	0.050	1.10—4.50	2.25	98%	0.073
CNP[2]	1.4—2.9	2.01	4.0—9.0	5.18	0.04—0.15	0.076	2.21—5.20	2.45	100%	0.079
Mean	1.4—2.9	1.97	2.2—9.0	4.91	0.03—0.15	0.067	1.10—5.20	2.35	99%	0.076

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References at the end of the article should be arranged in alphabetical order according to the names of the author or first author. The full title of the paper must be given. Title of journals should be abbreviated as in the World List of Scientific Publications (3rd ed. 1952). Volume (*Vol.*), Band (*Bd.*) or Tome (T) Numbers should be in Arabic numerals. References to text books should include the publisher.

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