Bull. Fish. Res. Stn., Ceylon. Vol. 20,No.2, pp. 101–134 December, 1969

The Freshwater Fisheries of Ceylon

C. H. FERNANDO[1] AND H. H. A. INDRASENA[2]

INTRODUCTION

THERE is no comprehensive account of the freshwater fisheries of Ceylon. The present paper is an attempt at such a treatment. Our task has been somewhat simplified by the paucity of previous work but on the other hand data relevant to the subject is scattered and not easily available in the usual abstracting journals. This paper is based on a collection of data over the last fifteen years while associated with the Fisheries Department and information gathered from other agencies concerned with water resources in Ceylon. The authors have added their own work during this period both published and unpublished.

The introduction of *Tilapia mossambica* Peters into natural waters in Ceylon in 1951 and its subsequent rapid spread and dominance of the fish catches has had a profound impact on all aspects of freshwater fisheries. The tremendous increase in fish production has been accompanied by changes in fishing methods and improved utilization. On the basis of the experience with the introduction of this species other species have been considered for introduction. The expansion of the freshwater area by the construction of irrigation and hydro electric reservoirs has increased the fish production potential considerably during the last fifteen years. The evident paucity of lake species first pointed out by Fernando (1965*a*) has indicated the reasons for low fish production before the advent of *Tilapia mossambica*. In the present paper this idea is developed further to cover specific types of habitats. The present work is also intended as a review of fishery practices in Ceylon's freshwaters. Such a review, we hope, will, when taken together with the new data and conclusions of this study, enable more efficient planning and use of freshwater fishery resources in the future.

Most of the data available to the authors has been from the Polonnaruwa area, namely Parakrama Samudra and Minneriya tanks and Senanayake Samudra in the Gal-Oya Valley. Studies have also been made on *Tilapia mossambica* because of its great importance to the fisheries in general.

PREVIOUS WORK

The earliest mention of any type of freshwater fisheries in Ceylon is that of Knox (1681). His remarks although those of a layman indicate clearly that freshwater fisheries were not considered of any economic importance. He mentions that fishing was done by " boys ". Willey (1910) made a detailed study of a primitive form of fish culture practiced in the Hanwella area. In a series of reports by foreign experts on fisheries development in Ceylon, passing mention is made of freshwater fisheries by Hickling (1951) and Kestevan (1951). Popular accounts on the freshwater fisheries are those of Szechowycsz (1959, 1961) and Fernando (1961). Schuster (1951) and Anon (1962), the latter based on the work of Dr. S. W. Ling dealt at greater length with freshwater fisheries. Fernando (1965) discussed the remarks of Willey (1910), Amirthalingam (1949) and Schuster (1951) that the freshwater fish fauna of Ceylon was deficient in " desirable " herbivorous species. Fernando (1965*a*) offered an explanation for this apparent deficiency. Historical factors, according to him, made recruits of fish species for tanks from a fauna lacking typical lake species. Papers which deal directly with fisheries in the last ten years are those of Fernando and Fernando (1964), Indrasena and Ellepola (1964), Indrasena (1964, 1965*a* 1965*b*), Mendis (1964, 1965), Ellepola and Fernando (1966), Indrasena and De Silva (1964), Fernando (1967) and Fernando and Ellepola (1969). A number of papers on

[1] Department of Biology, Univ. of Waterloo, Canada (Formerly of Dept. of Fisheries, Ceylon).

[2] Department of Fisheries, P. O. Box 531, Colombo, Ceylon.

3—J 9445 (69/12)

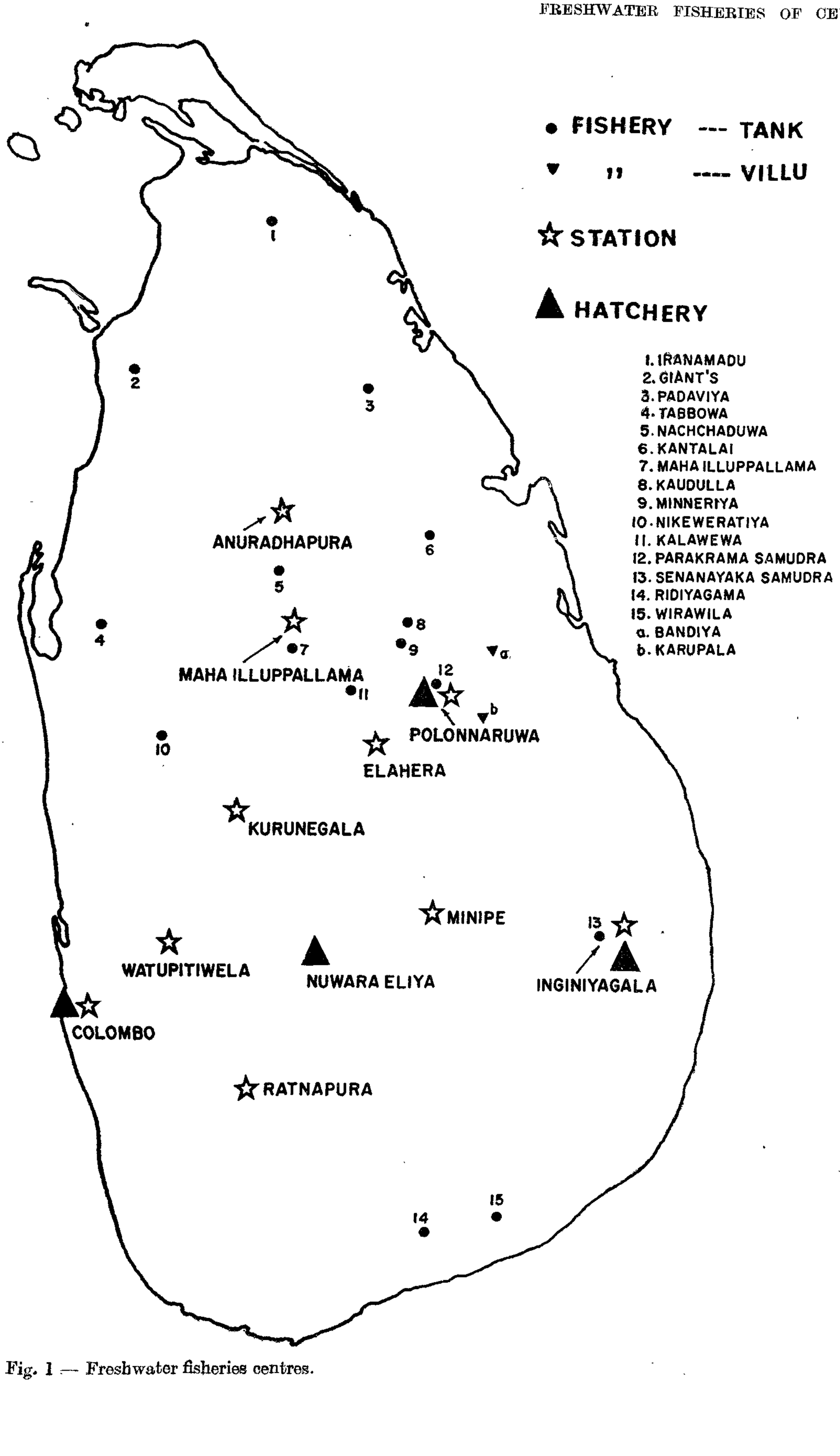


Fig. 1 — Freshwater fisheries centres.

systematics and ecology of the freshwater fauna have been published in recent years. These include works on taxonomy, limnology, distribution, food habits and parasites. All these have been listed in Mendis and Fernando (1962) and Fernando (1963, 1964 and 1969). The defensive spines of freshwater fishes were studied by Fernando and Fernando (1960).

Side by side with these scientific and semi-scientific publications there has been a gradual growth, by no means sustained at a high level however, of interest in freshwater fisheries. Comments and recommendations with some statistics of fish catches are found in the Annual Administration Reports of the Department of Fisheries from Malpas (1935) onwards. A separate section of this report was devoted to freshwater fisheries and more detailed statistics were provided in later years. Fisheries " stations " were established in a number of localities (Fig. 1). Fish hatcheries were established in Narahenpitiya (Colombo), Polonnaruwa and Inginiyagala. Besides, fisheries inspectors were posted at Kurunegala, Maha Illupuluma, Minipe, Watupitiwela, Elahara, Ratnapura and Anuradhapura. Only Polonnaruwa has survived as a viable station. Some extention work is also carried on in the Gal-Oya valley by personnel of the Gal-Oya Development Board (River Valleys Development Board). Perhaps we should mention if only in passing the fish hatchery at Nuwara Eliya where trout for stocking up-country streams are raised.

GENERAL REMARKS ON FRESHWATER HABITATS

Ceylon has an area of 25,332 square miles and is reputed to have over 10,000 ancient irrigation reservoirs popularly called tanks (Abewickrema 1956, Anon 1955). Sixteen major rivers drain 103 river basins. The major rivers originate in the Central Highlands located in the Southern portion and flow in a more or less radial fashion through the low country. Some of the rivers produce shallow flood plains in their lower reaches. These may be very short lived lasting only during the floods or they may be permanent as in the lower reaches of the Mahaweli ganga. These latter flood plains are referred to as villus and may have a permanent connection with the river (e.g., Karapala villu) or could be formed as a lake isolated from the river when the flood waters recede (e.g., Bandiya villu). Many ponds are left by the receding flood waters and rivers themselves may be reduced to a series of ponds during the dry season.

Tanks constitute by far the largest area of permanent standing water. They vary in size from a few acres to 25 square miles (Senanayake Samudra). They comprise ancient irrigation reservoirs often restored and expanded in recent years, new reservoirs built for irrigation and some especially in the up-country mainly designed for the generation of hydro-electric power. Many of the tanks are subject to considerable changes in water levels but these changes are gradual during the year as water for irrigation is drawn or drought prevents the replenishment of water used for hydro-electric plants. The surface areas of tanks is often given at F.S.L. (Fully Supply Level) but this level may be maintained for only a few months in any year.

The extent of development of new multipurpose water conservation schemes is shown for the whole island (Fig. 2) and two river basins namely Mahaweli ganga and the Gal-Oya valley (Figs. 3–4). The last named has been completed adding 43,000 acres of tank surface and many miles of channels. The Mahaweli scheme which involves a much larger area of land will add a considerable acreage of water in the form of tanks. Three other river basin development projects namely the Deduru Oya, Uda Walawe and Kelani Ganga schemes, will together with the Mahaweli and Gal-Oya projects encompass the whole island. When completed these projects will add a vast area of freshwater habitats in the form of tanks, irrigation channels, ponds and paddy fields. The impact of these developments on the fisheries potential will be to enhance it considerably. Planning and research are urgently needed if good use is to be made of this potential..

Because of their extent paddy fields constitute an important type of freshwater habitat. Their temporary nature for fish habitation however somewhat limits their potential. They serve as nurseries for many species of fish and might under suitable conditions be used for fish culture.

LIMNOLOGY

The major geological features of Ceylon are briefly as follows. The Island is composed almost entirely of crystalline rocks of the Pre-Cambrian age. This is overlain by Miocene limestone in the extreme North. There is a small area of Jurassic beds in the Puttalam area (Adams 1929). Water

Fig. 2.—Large reservoirs (tanks) constructed and planned.

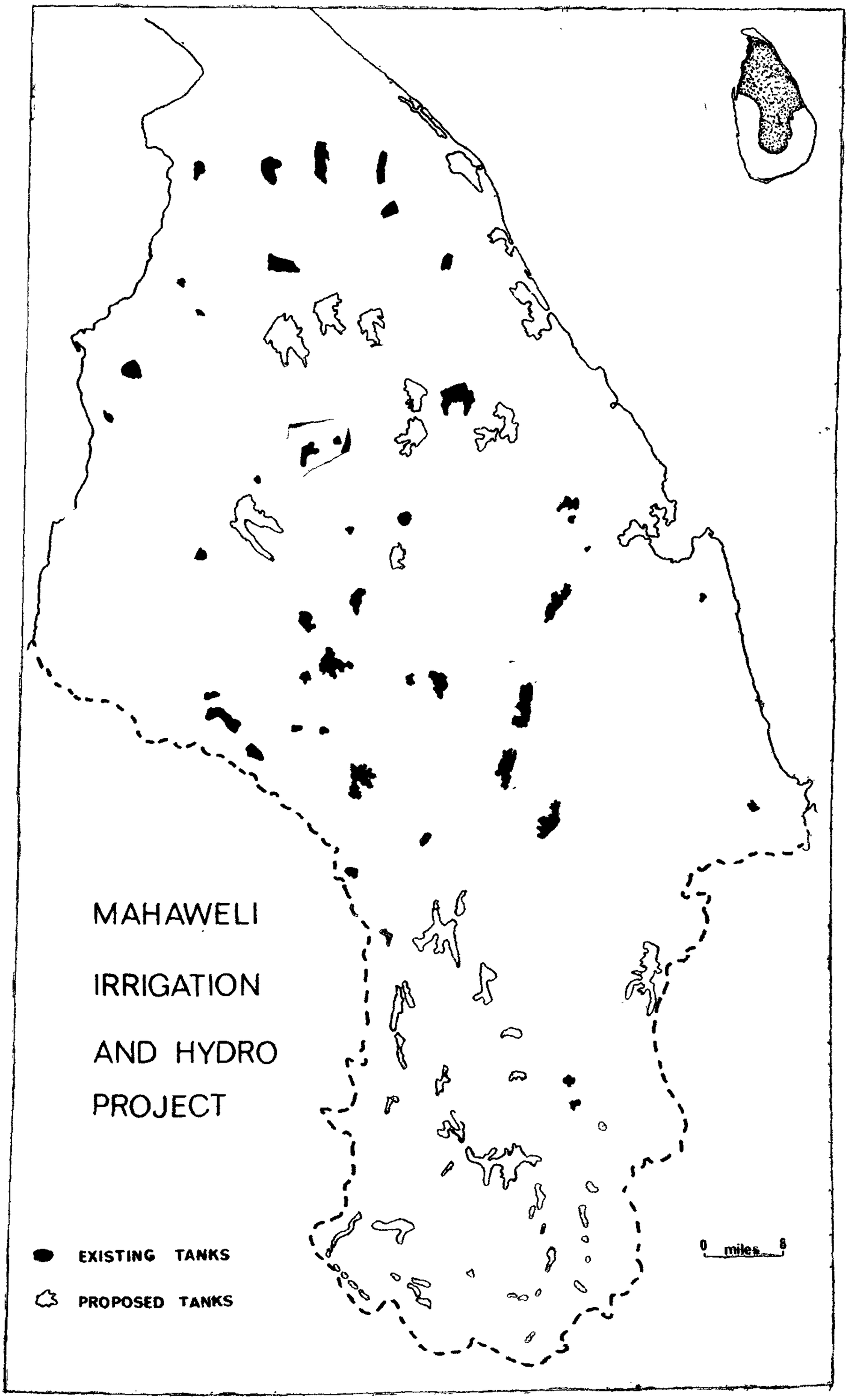


Fig. 3.—Map showing the existing and proposed reservoirs in the Mahaweli Irrigation and Hydro Project.

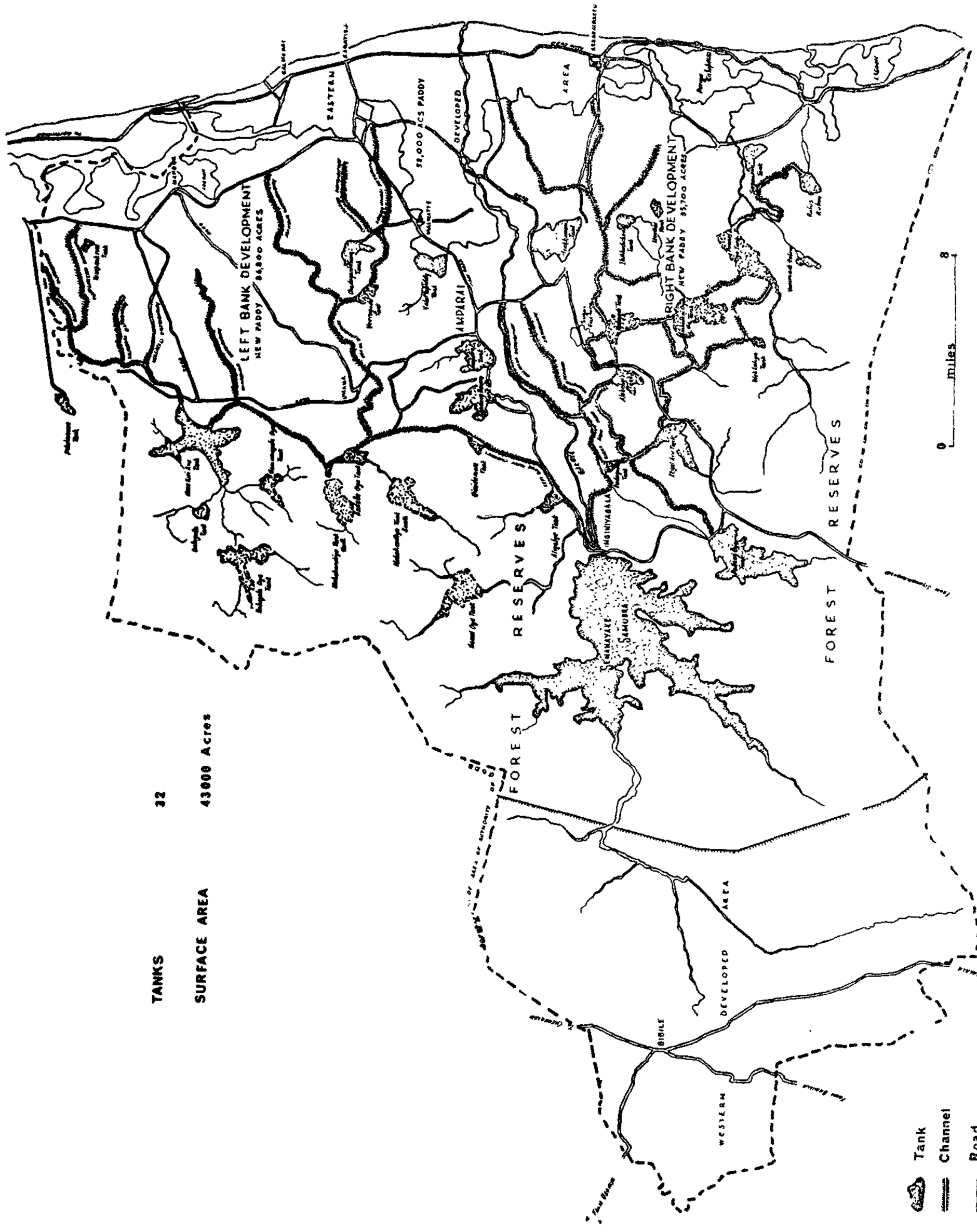


Fig. 4.—Reservoirs and irrigation channels in the Gal Oya development project.

chemistry is largely the product of the geological structure. Sirimanne (1953) provides extensive data on water analysis from all parts of the island. It is evident that in most areas the water is neutral or slightly alkaline with low to moderate amounts of dissolved solids. In the Western and Sabaragamuwa provinces the water is sometimes slightly to moderately acidic. In the coastal areas due to seepage from the sea considerable chloride concentrations are often encountered. Salt water may penetrate deeper inland in low-lying areas. Blackwater is not common but does occur in small pockets. The authors have noted it in the Nattandiya area (North Western Province) and the coastal parts of the Southern province. Mendis (1965) found darker water in some of the lakes of the Southern province. He found neutral to slightly alkaline waters in lakes in the Northern, North Central, North Western, Southern and Eastern provinces. Giesler (1967) found slightly acid waters in the localities he sampled in the Southern, Sabaragamuwa and Western provinces.

Some data on the morphometry of reservoirs (tanks) is available in the Administration Reports of the Director of Irrigation (e.g., Gunasekera 1960). The features given are water capacity, depth at sluice, surface area and capacity at full supply level (F.S.L.). Most tanks have a considerable "dead storage" which cannot be drained via the sluice. Depth contours have not been mapped for the vast majority although these could be arrived at in recently constructed reservoirs with a fair degree of accuracy from survey maps prior to impoundment. The depth contours are available for Parakrama Samudra and diagramatic cross sections of the lake can be made (Fig. 5). Fernando and Ellepola (1969) have given the contour (F.S.L.) and area capacity curve of a small reservoir (Dalukana wewa).

There is a great deal of variation in the morphometry of reservoirs. Many of the large ancient reservoirs were built close to the foothills and have undulating bottoms. Silting of varying degrees have occured however to alter the original condition. At the present time no classification of reservoirs based on their morphometry is available. A very tentative classification has been drawn up as follows :

1. Shallow ; silted heavily ; with even depth of water.
   (e.g. Giants tank, Fig. 6A)
2. Shallow ; with gently sloping bottom.
   (e.g. Tabbowa tank, Fig. 6B)
3. Shallow ; with undulating bottom countours.
   (e.g. Parakrama Samudra, Fig. 6C)
4. Deep ; encompassing one valley.
   (e.g. Nalanda reservoir, Fig. 6D)
5. Deep ; encompassing many valleys.
   (e.g. Senanayake Samudra, Fig. 6E)

Giants tank has a depth of only 10–12 ft. It has hardly any limnetic zone. Tabbowa tank has a gently sloping bottom with moderate silting and a maximum depth of about 25 ft. There is a gradation in the degree of silting and it is difficult to draw a line between category 1 and 2. However in general tanks belonging to category 1 are on relatively flat land as compared to those in category 2. Parakrama Samudra stands somewhat intermediate in category 3, but has a noticeably undulating bottom. It is not deep for the most part although a maximum depth of 37 ft. is shown on the contours. Many large tanks in the low country have bottom contours similar to that of Parakrama Samudra in general.

Nalanda reservoir consists essentially of one valley. The margins slope steeply and there is only a very small littoral zone. The slope is somewhat gentler in parts. Many reservoirs built recently fall into this category. Senanayake Samudra encompasses a number of small valleys. Therefore its bottom contours are more complicated. Categories 4 and 5 are invariably deep. Depending on the situation and height of the dam, the littoral zone may be very small or considerable. The latter is due to the intervening flat land close to the lake level at F.S.L.

The freshwater fauna is perhaps better known than in many Asian countries but the gaps in our knowledge are very considerable. Mendis and Fernando (1962) and Fernando (1963, 1964 and 1969) cover the systematics of the freshwater fauna. Freshwater algae have been dealt with by West and West (1902), Fritsch (1907), Lemmerman (1907), Crow (1923*a*, 1923*b*) and Holsinger (1955.)

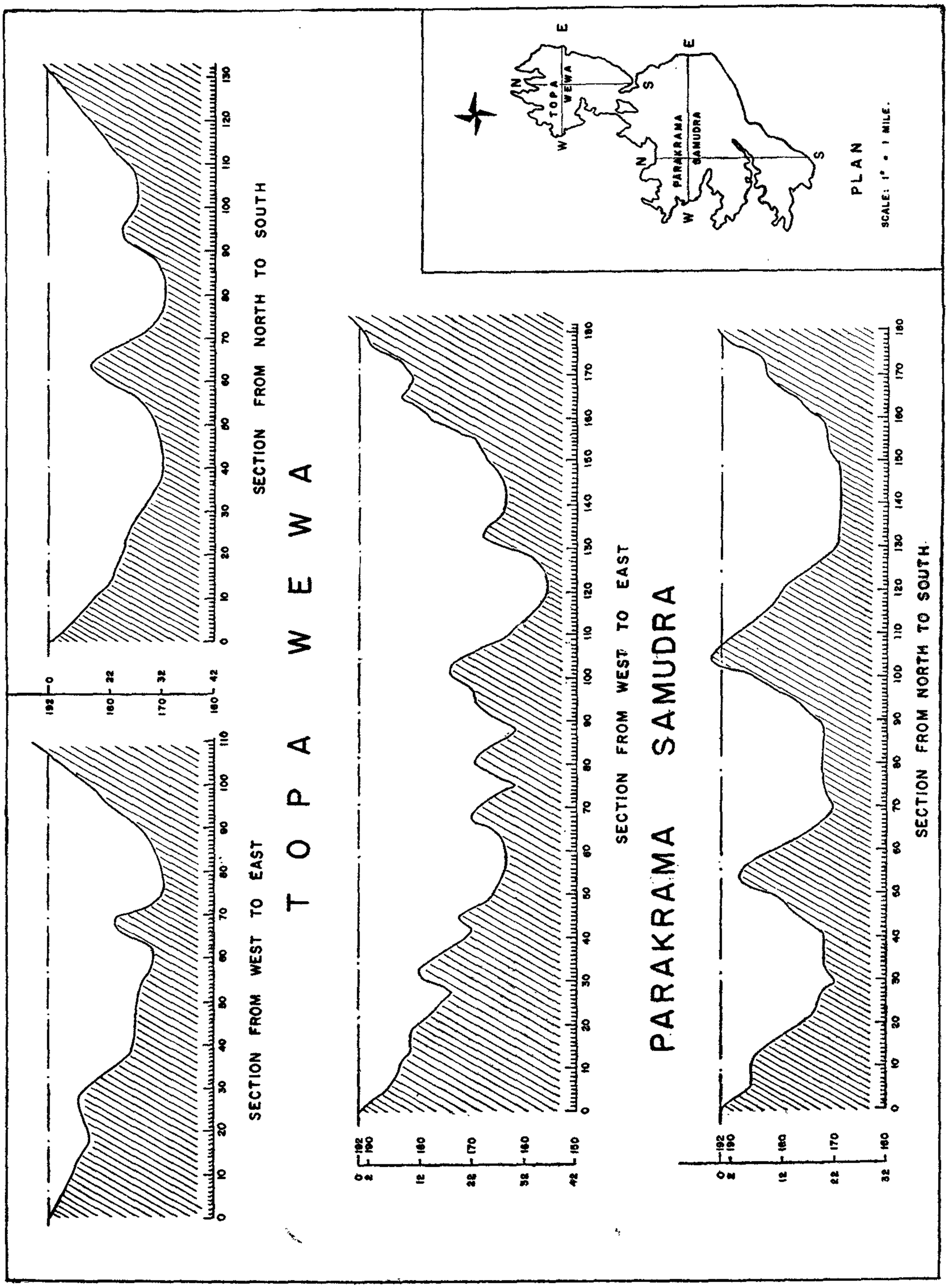
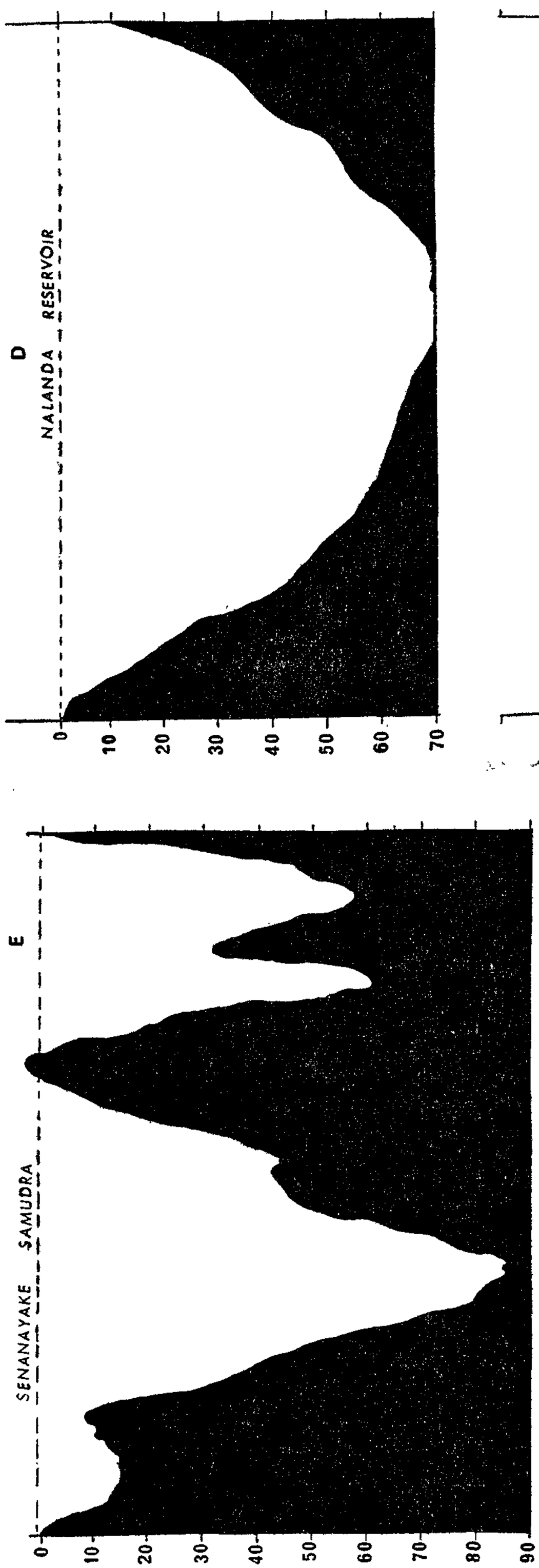


Fig. 5.—Cross sections of Parkrama Samudra a showing depth and shape of bottom (At right angles to the main dam)



(DIAGRAMMATIC SECTIONS PARALLEL TO MAIN DAM)

Fig. 6.— Diagramatic representation of different reservior types. (Parallel to the main dam Scale approximately as in Fig. 5).

Some quantitative data on plankton and bottom fauna is available in Holsinger (1955*b*) and Mendis (1964, 1965). Seasonal fluctuations in plankton organisms have been studied by Apstein (1907, 1910). The only quantitative data on the bottom fauna of lakes are those of Mendis (1964, 1965). Holsinger (1955*b*) on the basis of phytoplankton counts found that Gregory's lake at Nuwara Eliya was intermediate in productivity as compared to the higher Beira Lake and the lower Nuwara wewa. This is of some interest because plankton feeders are not numerous in the up-country lakes. For that matter the fish fauna in these lakes is poor. Fernando and Ellepola (1969) give some data on the plankton and littoral fauna of two small tanks in the Polonnaruwa area. Except for water chemistry where some broad generalizations can be made the data on plankton and bottom fauna of tanks in Ceylon is very meagre indeed. Limnological studies can be considered to be in their infancy in Ceylon.

FISH FAUNA

Fifty nine species of fish are found in freshwaters of Ceylon (Table 1). Five of these have been introduced into the country. At least seven other species have been introduced but have failed to establish themselves. Fernando (1965*a*) has discussed these introductions. Half the fish species are cyprinids. Most of these carps and carplets are herbivorous. The Cyprinidae include small very abundant species like *Puntius vittatus*, *Rasbora daniconius* and *Danio aequipinnatus*. These species serve no doubt as important forage for carnivorous fishes. Many of the carplets and medium sized carps are not very abundant as compared to the three species mentioned. Some of them however may be locally abundant. Of the larger carps *Labeo dussumeri* (Fig. 7), *Puntius dorsalis* and *Puntius sarana* are important food fishes but only *Labeo dussumieri* can be considered to be of major economic importance. This species is abundant and has an acceptable flavour. The common carp *Cyprinus carpio* has recently established itself in the Southern Province. However, together with the crucian carp it is a sport fish in up-country tanks. All the catfishes have an acceptable flavour but only *Wallago attu*, *Ompok bimaculatus*, *Heteropneustes fossilis* and *Macrones vittatus* are abundant. Of the snakeheads only *Ophiocephalus striatus* can be considered of economic value. The others are small or rare. The Cichlidae although few in species number constitute today the most important group of food fishes. *Etroplus suratensis*, a species indigenous to Ceylon, was introduced into tanks from its native haunts which were estuaries and coastal ponds. Today it is of considerable importance as a food fish, 20 years after this introduction. *Tilapia mossambica* (Fig. 8) constitutes from 50–90% of the catch by weight from large tanks. It is certainly the most important food fish. Of the anabantids *Osphronemus goramy* is of some importance as a food fish. *Anabas testudineus* although a coarse fish is eaten in some areas where other fish are not available or are expensive. *Glossogobius giuris* is a favoured fish but is by no means as abundant as the other large carnivores. *Macrognathus aculeatus* is abundant in some areas and is of some economic importance.

It has been the view of a number of fishery biologists that the Ceylonese freshwater fish fauna is poor in herbivorous species which are of economic importance. Fernando (1965*a*) discussed these views and showed that they were not entirely warranted. Fernando (1965*a*) showed that the paucity of "Lake" species was real and this was due to the absence of natural lakes. Fish recruits for irrigation reservoirs did not fill the niches in these efficiently.

Studies on the food habits of Ceylonese freshwater fishes by Fernando (1956, 1965*b*), Costa and Fernando (1967) and Giesler (1967) in Ceylon and by Indian workers has been used to compile the data for Table 1. Strict carnivores are few as is to be expected. Strict herbivores include small forage fishes and some large carps. Many species however have a varied diet including insects as a major component. *Heteropneustes fossilis* and *Mystus vittatus* have been shown to feed on molluscs (Fernando, 1965*b*). *Etroplus suratensis* was also found to feed extensively on one species of mollusc, *Bellamya ceylonica* (Dohrn) in Parakrama Samudra during the period when the fish comes into shallow water to lay its eggs. A number of siluroids and cichlids have been reported to feed on molluscs in Africa (De Bont and De Bont 1952, McMahon 1960). Perhaps the mollusc eating habit is more widespread among indigenous Ceylonese species of freshwater fish than has hitherto been suspected. Carnivorous species seem to be abundant in low-country tanks but there appears to be a paucity of species feeding on plankton and soft macrophytes. It is also likely that bottom feeders and insectivorous species could profitably be added to the present complement of freshwater fish species in the large tanks.

TABLE 1

Freshwater Fihes of Ceylon — Maximum Sizes and Food Habits

O = Omnivore C = Carnivore H = Herbivore

Species	Maximum Length cms.	Food Habits	Remarks
Chela laubuca	5·75	H	
Rasbora vaterifloris	3·75	O	Aquarium fish
Rasbora daniconius	10·0	O	Very abundant
Amblypharyngodon melittinus	7·5	H	
Horadandiya atukorali	2·5	H	
Esomus danrica	6·25	H	
Danio aequipinnatus	7·5	H	Aquarium fish; Abundant
Cyprinus carpio	60	O	Introduced
Carassius carassius	45	O	do.
Tor khudree	75	O	Game fish
Puntius melanampyx	2·25	H	
Puntius dorsalis	23·5	H	Food fish
Puntius filamentosus	11·75	H	
Puntius chola	8·75	H	
Puntius amphibius	7·5	H	
Puntius bimaculatus	5·75	H	
Puntius nigrofasciatus	5·75	H	Aquarium fish
Puntius pleurotaenia	15·0	H	do.
Puntius sarana	30	O	Food fish
Puntius vittatus	5·0	H	Very abundant
Puntius titteya	4·75	O	Aquarium fish
Puntius cumingi	5·0	H	do.
Puntius ticto	5·0	H	do.
Labeo dussumieri	35	H	Important food fish
Labeo porcellus	37	—	Food fish
Labeo fisheri	37	H	Rare
Garra ceylonensis	15	H	Torrent stream dweller
Lepidocephalus thermalis	5·0	H	Bottom feeder
Noemacheilus notostigma	6·25	H	do.
Noemacheilus botia	3·25	H	do.
Wallago attu	150	C	Food fish
Ompok bimaculatus	38	C	do.
Clarias teysmanni	30	O	do.
Heteropneustes fossilis	25	O	Food fish; Feeds on Molluscs
Macrones gulio	25	O	
Macrones keletius	12·5	O	
Macrones vittatus	10·0	O	Food fish
Anguilla bicolor	60	O	
Anguilla nebulosa	100	O	
Panchax melastigma	3·75	O	Surface feeders
Panchax lineatus	5·75	O	Feed on mosquito
Panchax panchax	3·75	O	Larvae
Channa orientalis	10·0	C	
Ophiocephalus marulius	80	C	Food fish
Ophiocephalus striatus	68	C	do.
Ophiocephalus punctatus	20	C	
Ophiocephalus gachua	15	C	
Tilapia mossambica	38	H	Introduced
Etroplus suratensis	30	O	Food fish; Feeds on Molluscs
Etroplus maculatus	7·5	O	Ornamental fish
Anabas testudineus	15	O	
Trichogaster pectoralis	25	H	Introduced
Belontia signata	11·5	O	
Osphronemus goramy	30	H	Introduced
Macropodus cupanus	4·75	O	Ornamental
Malpulutta kretseri	4·5	O	Rare; Aquarium fish
Glossogobius giuris	35	C	Food fish
Macrognathus aculeatus	25	C	do.
Mastacembelus armatus	62	C	

Naming and maximum size of fishes according to Munro (1955). Subspecific names have been omitted.

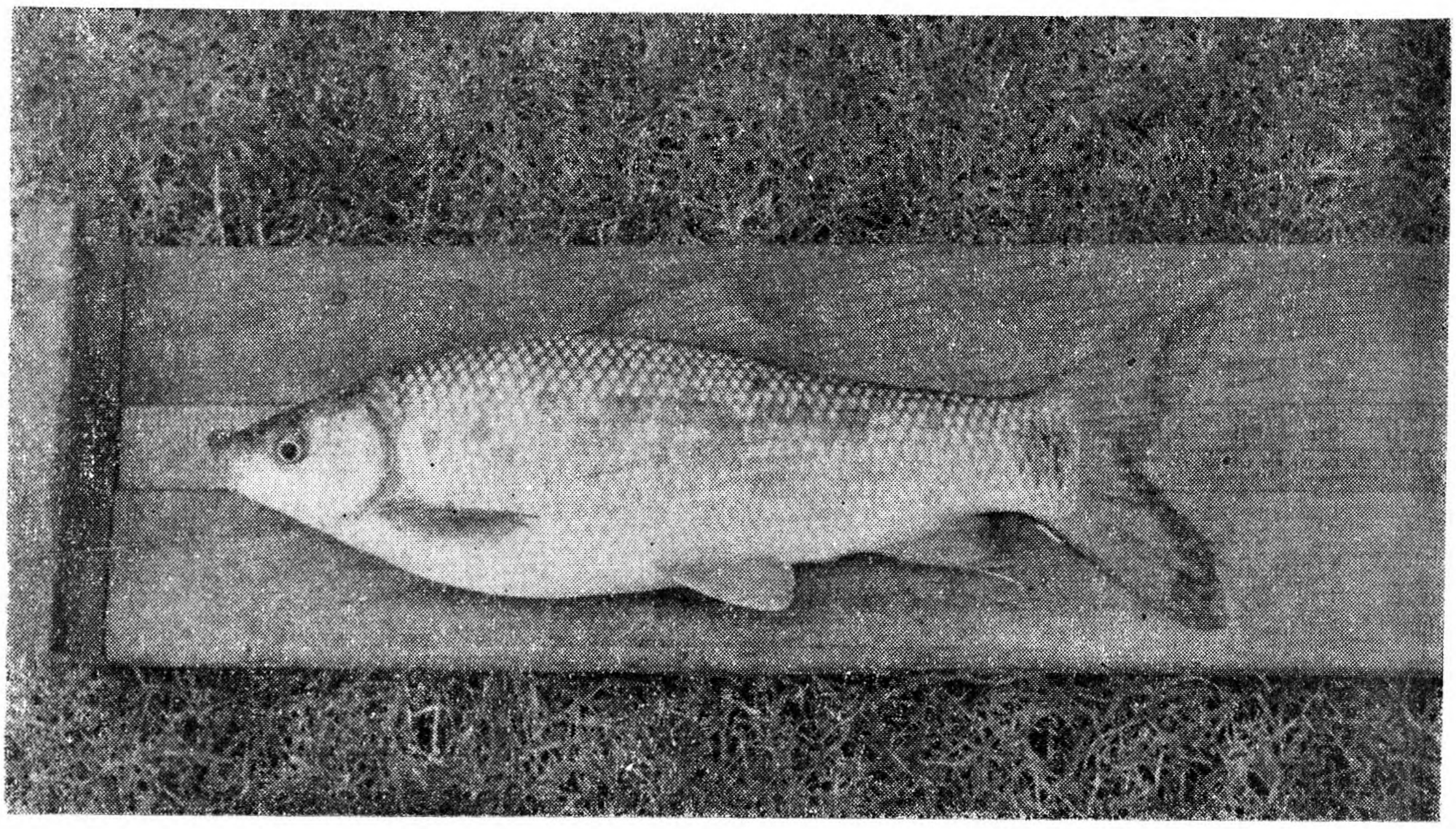


Fig.—7. Labeo dussumieri.

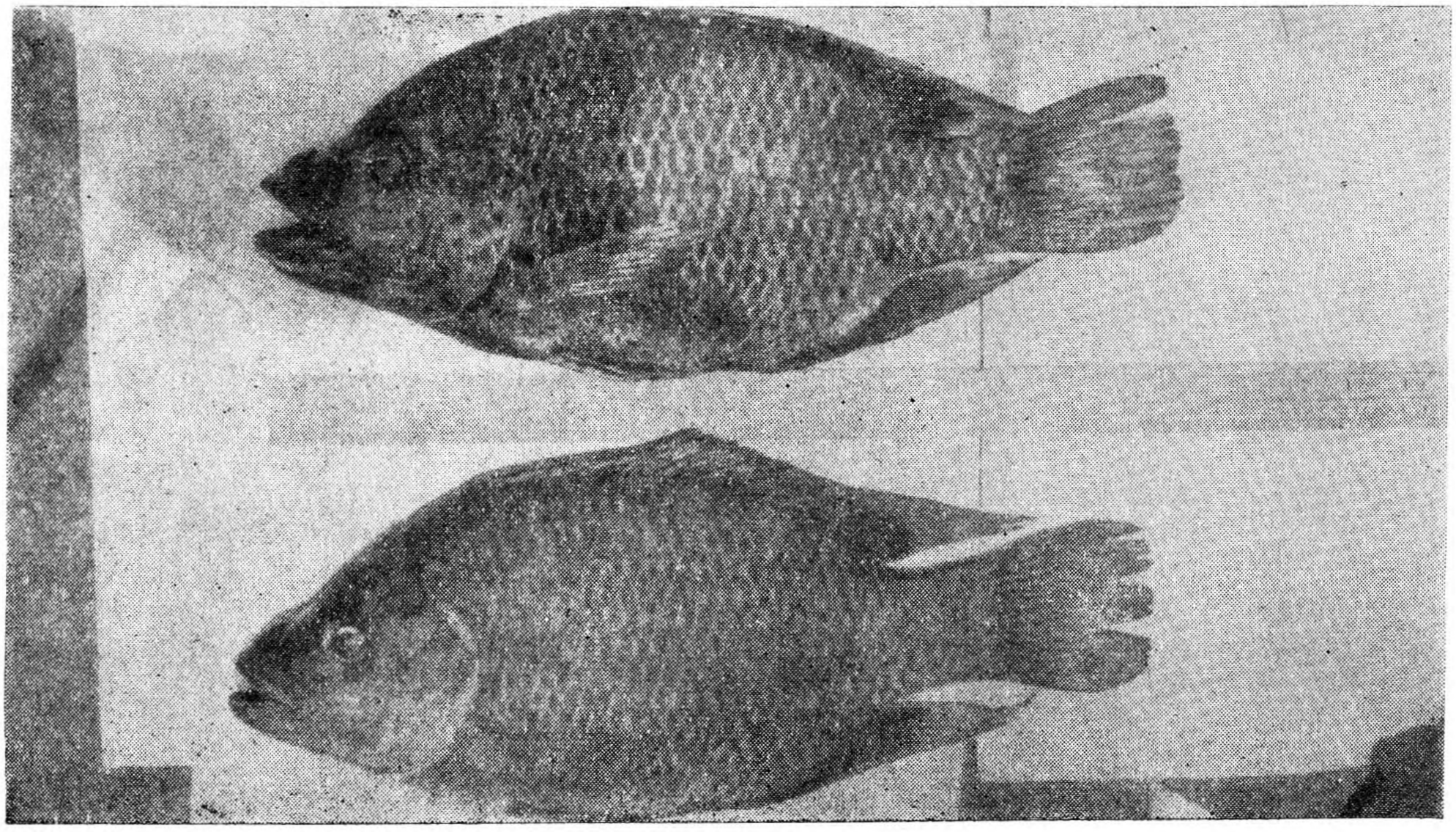


Fig. 8.—Tilapia mossambica. The male (upper) recognisable by its darker colour and more pointed anterior end.

THE ROLE OF INTRODUCED SPECIES

Fernando (1965*a*) gave a short account of fish introductions and discussed their importance in inland fisheries. It is clear that *Tilapia mossambica* is the most important commercial food fish forming as much as 90% of the catch by weight in some of the low country tanks. Its importance seems less in the Gal Oya valley but this may be due to inefficient fishing for this species.

A study of the status of *Tilapia mossambica* was undertaken to answer some questions that had arisen in regard to this species. The stunting of *T. mossambica* reported in many parts of S. E. Asia in small lakes and ponds seems to be less marked in some of the lakes with flourishing fisheries for this species. However stunting was common in other habitats, e.g., lagoons, some tanks and in ponds. It has been claimed from time to time that *Tilapia mossambica* was affecting "adversely" local species by predation or competition. However the fish is not carnivorous (Fernando 1965*a* and unpublished data).

The ubiquity of *Tilapia mossambica* enables it to be studied in a wide variety of habitats. 8 such habitats were chosen for a comparison of the coefficient of condition (K) and mean length and weight of fish caught in gill nets with 3″–5″ mesh. There is perhaps a slight bias towards larger fish where they are proportionately more numerous, since the smaller mesh sizes are not used. However the results of this study are indicative of a wide size range of the fish (Table 2). The coefficient of condition is also very variable. It is not necessarily correlated with the size attained by the fish in a particular habitat. The lowest value of K was found in Batticaloa lagoon which is by no means as productive of fish as shallow lakes. In fish ponds without artificial feeding and where overcrowding was most marked and K very low, the production per acre was very high. Beira Lake a highly polluted habitat where K is high, had a very high production of *Tilapia mossambica* (Mendis 1964).

TABLE 2

The Status of *Tilapia mossambica* in some Habitats in Ceylon

All Samples taken in 1964–65. Fish Production Values for 1963

HABITAT				FISH			
Name of Habitat	Max. Depth Ft.	Area (acres)	Description	Mean length cms.	Mean weight gms.	Coefficient of condition (K)	Fish catch lb./acre/annum
Beira lake Colombo	20	150	Brackish, highly fertilized	15·9	93	2·25	2,000
Batticaloa lagoon	15	29,500	Brackish	20·41	144	1·70	no data, low
Fish ponds	4	0.25	Freshwater	17·6	90	1·79	1,600
Karapala villu	30	1,500	Freshwater marsh connected to river	26·8	443	2·10	75
Tabbowa tank	30	1,140	Freshwater Lake (shallow)	24·8	338	1·95	no data, probably about 100
Parakrama Samudra	40	5,590	Freshwater Lake	28·4 (34·2 in 1957)	443	1·88	160
Minneriya tank	60	6,300	Freshwater Lake (deep)	29·4	598	2·00	105
Kandalama tank	70	2,430	Freshwater Lake (deep)	31·40	651	2·02	no data, probably about 100

$$K = \frac{W \times 10^5}{L^3} \qquad W = \text{wt. in gms.} \qquad L = \text{length in mm.}$$

A factor which could cause stunting and a low K would be overcrowding due to excessive breeding. Three lakes were chosen to check this namely Parakrama Samudra, Minneriya tank and Tabbowa tank. *Tilapia mossambica* makes prominent nests (Fig. 9) which can be located very easily. During the dry season the areas occupied by freshly made nests were plotted on maps of the lakes (Fig. 10). It is quite evident that in Minneriya the nests or breeding sites are restricted while in Tabbowa tank and Parakrama Samudra they are more extensive in proportion to the total area.

Fig. 9.—Nests of Tilapia mossambica in the shallow margin of Parakrama Samudra.

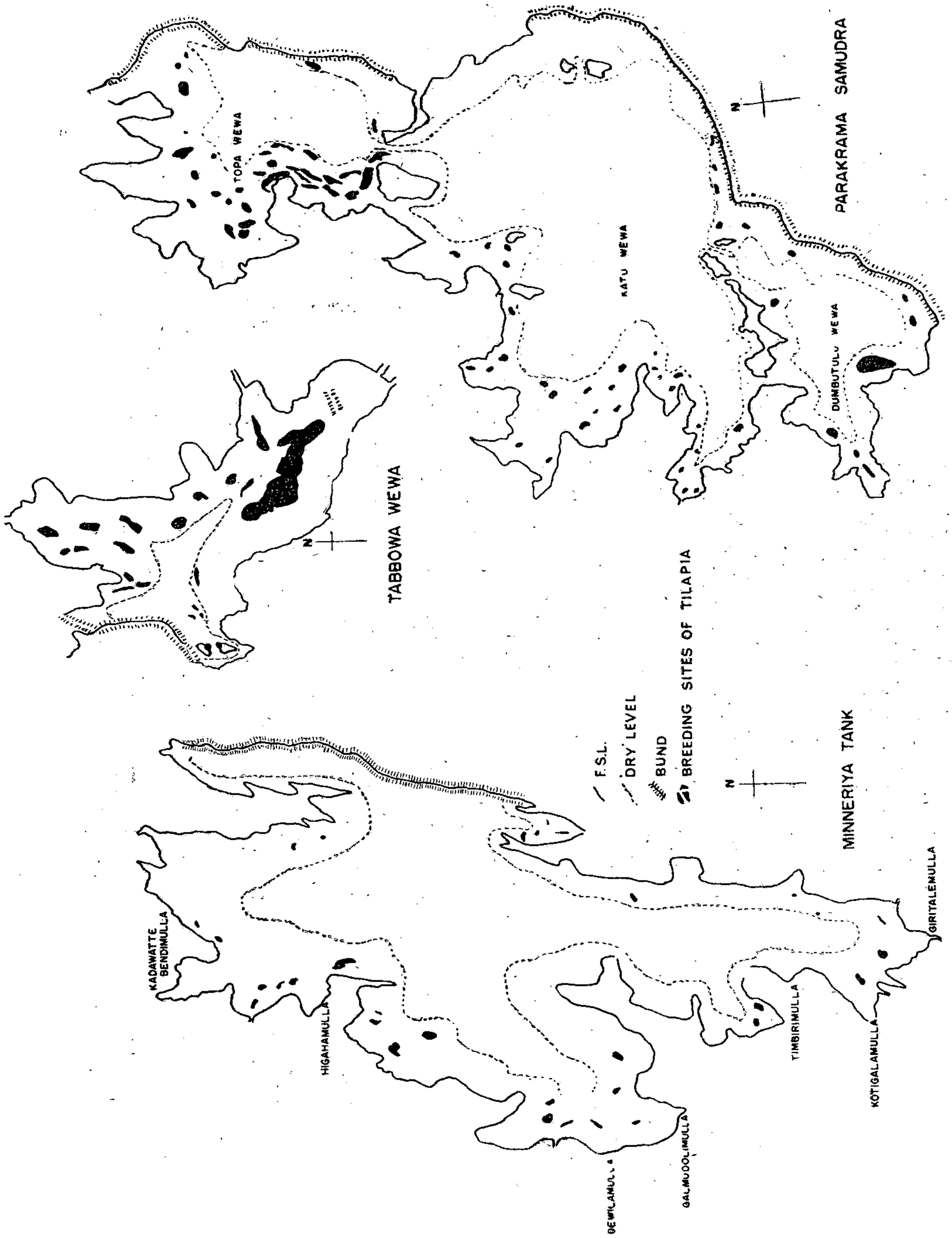


Fig. 10.— Breeding areas of *Tilapia mossambica* in three selected tanks

The slightly higher K value for Tabbowa tank fish is difficult to explain since the mean size and weight of fish from this tank is lower than in Parakrama Samudra. However exploitation of the fish stocks is very intense in Parakrama Samudra. But, on the other hand, it is a deeper tank than Tabbowa. It is likely that the deeper water with consequent spacing allows for better growth under normal conditions, but the K is lower due to some unknown factors. The small size of the fish from shallow water's like Batticaloa lagoon, Tabbowa tank and Beira Lake and the larger size of fish in deeper tanks like Minneriya, Kandalama and Parakrama Samudra is at least partly due to the restriction of breeding sites in the latter. Mendis (1964) found that the mean size of *T. mossambica* had increased from 18.3 cms in 1957 to 20·5 cms in 1963 in Beiralake. Calculation of K gives the values 2·10 and 1·99 respectively. This is interesting since the K value in 1964 from the present study is higher but the mean size is lower than the value for 1963. A steep gradient in the bottom does not allow *Tilapia mossambica* to build stable nests. An even or gently sloping mud-sand bottom is most suitable for nest building. Soft mud resulting from silting is not suitable either. Beauchamp (1958), Lowe-McConnell (1959) and Welcome (1966) found that the availability of suitable breeding sites may restrict the numbers of *Tilapia* spp.

It is evident from this study that *Tilapia mossambica* in Ceylon's " natural " waters shows a wide range of sizes and coefficient of condition (K). Further studies should elucidate the causes of these differences.

Canagaratnam (1968) found that *Tilapia mossambica* grows faster in salt water than in freshwater. However under natural conditions the fish is usually of smaller size in saline habitats because of the abundant breeding areas.

Of the other introduced species *Osphronemus goramy* is of some importance. The common carp *Cyprinus carpio* which has recently established itself in the tanks of the Southern Province has been considered undesirable as it damages breeding sites of *Tilapia* sp. (Pruginin 1967). But Maar (1960) considers it suitable for introduction into natural waters or for culture.

INTRODUCTION OF ADDITIONAL SPECIES

Two extreme views on the introduction of " foreign " species of fish can be taken namely total prohibition and indiscriminate introductions. Fernando (1956*a*) discussed views current before the introduction of *Tilapia mossambica*, a species which subsequently enhanced the fishery immensely. Fernando (1965*a*) pointed out the reasons for the success of *Tilapia mossambica* and the low productivity of our natural waters in indigenous species. In the same paper he pointed out that introductions had been somewhat haphazard. With the data we have on *Tilapia mossambica* which is discussed in the present paper and experience in other countries where fish introductions have been carried out it is, in our opinion, possible to obtain a relatively balanced species group capable of a high production of economic sized fishes. Fast growing species with a high fecundity are abundant in the genus *Tilapia* (Lowe 1955*a*, 1955*b*). This genus also offers a range of species as regards tolerance to the low temperatures prevailing in our up-country reservoirs (Chimits 1955, 1957). The two norms which should be aimed at are a balance of plankton, bottom feeding and higher plant feeding forms and a sufficient predator pressure to crop excess fish. Predator species are abundant in the low-country but may be needed in up-country reservoirs. Lowe-McConnell (1969) points out that high predator pressure may help more prey species to co-exist. Plankton and higher plant feeding indigenous species are not sufficient to crop efficiently these food items produced in artificial lakes. There are niches to be filled and the fish chosen should be selected for desirable qualities. The insect feeding fish fauna is prominent in our freshwaters (Fernando 1956, 1965*b*, Costa and Fernando 1967). Perhaps omnivorous species should also be introduced into both rivers and lakes. In 1969 *Tilapia zilli* Gervais *T. melanopleura* Dum. and *T. hornorum* Trewavas were imported for stocking local waters.

Some specific introductions are discussed in subsequent sections of the present paper but continuing research both on indigenous species and introduced species in regard to their biology should be a top priority for the freshwater division of the Fisheries Research Station.

PARASITES AND PREDATORS

The first paper dealing with freshwater fish parasites of Ceylon was that of Kulasiri and Fernando (1956). Subsequent papers are Crusz and Sathananthan (1960), Yeh (1960), Fernando and Furtado (1963*a*, 1963*b*), Ingle and Fernando (1963), Gussev (1963), Crusz, Ratnayake and Sathanathan (1964), Fernando (1965*b*) and Costa and Wijekoon (1966). A list of fish parasites recorded from Ceylon and the likely genera to be found are given in Fernando (1964).

Our present knowledge of the parasites of freshwater fishes of Ceylon is meagre although some ground has been covered by work published since 1956. No published data is available on the Myxosporidea and Microsporidia—important protozoan parasites. One record of a digenetic trematode is available from freshwater fishes. We have no data at all on the incidence and intensity of infestation. Seasonal cycles of infestation have not been studied. However a number of findings have some relevance to fisheries. Fernando and Furtado (1963*a*) reported the possible introduction of the cestode *Bothriocephalus gowkonensis* Yeh with Chinese carp imported for stocking. This parasite was found in an indigenous carp and was known previously from Canton. Professor O. N. Bauer (personal communication) says that this parasite was introduced with Chinese carp into the Ukraine. Fernando (1965*b*) attributed mortality of *Glossogobius giurus* to heavy infestation with larvae of the nematode *Hedruris* sp. Fernando (Loc. cit.) also noted heavy infestation of other carnivorous species with larval nematodes of *Hedruris* sp. and *Eustrongylides* sp. Increased mortality of carnivorous species could adversely affect the predator pressure so important in " controlling " the population of *Tilapia mossambica*. One of us (C. H. F.) in an examination of over 200 specimens of *Tilapia mossambica* found no metazoan parasites. Other workers have reported similar results with *Tilapia* spp. where few or no parasites were recorded in their " natural habitats " (Schuster 1952*a*, 1952*b* ; Worthington 1932). Chimits (1957) comments on this finding and a contrary view based on records by Du Plessis (1954). Chimits (Loc. cit.) states that in the latter case the Tilapias were living at the uttermost limits of their natural range. Parasites have however been reported from a number of *Tilapia* spp. including *T. mossambica*. Baker (1958) recorded protozoans including Myxosporidia. Fryer (1960) found *Lernaea* on *Tilapia* spp. Paperna (1963, 1964) reported many monogeneans from *Tilapia* spp. and found the interesting phenomenon of intestinal Monogenea in *Tilapia* spp. One of us (C. H. F.) has found an unidentified Monogenea in the stomach of *Etroplus suratensis*. Awachie (1965) and Ukoli (1965) recorded many species of helminth parasites from *Tilapia* spp. in West Africa. A factor that must be taken into account in the case of *Tilapia mossambica* in Ceylon is that since a small number of specimens were imported the chances of infested fish being among them was small. However it is surprising that the many non-specific parasites do not seem to occur in or on *Tilapia mossambica* in Ceylon. Ky (1969) found only a few protozoan parasites but no adult metazoan parasites in *Tilapia mossambica* in Vietnam.

Fernando (1965*b*) dealt with the predators of freshwater fishes in Ceylon. There is little to add to this account at the present time. The possible introduction of predatory fish species is discussed elsewhere in the present paper.

FISHERIES

Freshwater fisheries in Ceylon can be classified in various ways. For the present study we have drawn up the following categories :—

(*a*) Large tanks in the low and mid-country.
(*b*) Small tanks.
(*c*) Up-country reservoirs and lakes.
(*d*) Low and mid-country reservoirs.
(*e*) Rivers and streams.
(*f*) Villus.
(*g*) Paddy fields.
(*h*) Fish culture in ponds.
(*i*) Trout and other sport fishing.
(*j*) Miscellaneous fisheries.

4—J 9445 (12/69)

(A) Large Tanks In The Low And Mid-Country

This fishery is concentrated in the North Central, Northern, North Western, Eastern and Southern provinces. The tanks which fall into this category are mostly ancient irrigation reservoirs. A few recently constructed tanks e.g., Huruluwewa, Nachchaduwa and Mahakanadarawa fall into this category. The major fisheries of this type are shown in Fig. 1.

Intermittent fishing with gill net has been carried out in large tanks for about 20–25 years. The authors noted as early as 1952 a beach seine being used in Nuwara Wewa. Subsistence fishing using rod and line, traps, cast nets, small seines and with lights at night dates back to a period where no records exist. During severe droughts parts of large tanks became muddy pools choked with fish. The local inhabitants often took the opportunity of collecting fish at such times.

With the introduction of *Tilapia mossambica* in 1951, fisheries in large tanks became established on a firmer footing. Migrant fishermen from the sea coast started spending a few weeks to a few months each year fishing the rapidly expanding stocks of *Tilapia mossambica*. Some of the indigenous species like *Labeo dussumieri, Etroplus suratensis* and *Wallago attu* were also exploited to a greater and greater extent concomitantly. Some fishermen became permanent settlers near these tanks. These sites are shown in Fig. 1. All these localities have been visited by the authors. It is likely, however, that such fishing sites are more numerous.

Parakrama Samudra can be taken as a representative of large, relatively shallow, low country tank. It is the only tank where statistics of fish catches are available for any length of time (1949–1966). Catches for this period are shown in Fig. 14. From fragmentary data of fish catches in other large tanks it appears that Parakrama Samudra has the highest fish production/acre/annum. This figure is of the order of 160 lbs. The abundant aquatic bird population (Table 3) is also an indication of the high fish production.

TABLE 3

List of birds observed feeding in the water in Parakrama Samudra between 13–25th January, 1965

Podiceps ruficollis capensis Salvadori
Pelicanus roseus Gmelin
Phalacrocorax fuscicollis Stephens
Phalacrocorax carbo sinensis (Blum)
Phalacrocorax niger (Vieillot)
Anhinga melanogaster Pennant
Ardea cinerea rectirostris Gould
Ardeola grayii (Sykes)
Ardeola ibis coromanda (Boddaert)
Egretta alba modesta (Gray)
Egretta intermedia intermedia (Wagler)
Egretta garzetta garzetta (L.)
Nycticorax n. nycticorax (L.)
Ibis leucocephalus leucocephaluis (Pennant)
Dissouraepiscopus episcopus (Boddaert)
Dendrocygna javanica (Horsfall)
Haliestar indus indus (Boddaert)
Haliaetus leucogaster (Gmelin)
Ichthyophaga ichthyaetus plumbiceps Baker
Amaurornis phoenicurxs phoenicurus (Pennant)
Lobioanellus indicus lankae Koelz
Pluvialis dominica fulva (Gmelin)
Tringa stagnalis (Bechstein)
Tringa nebularia (Gunnerus)
Tringa glereola L.
Tringa ochropus L.
Actitis hypoleucos (L).
Himantopus himantopus ceylonensis Whistler
Burhinus oedicnemus indicus (Salvadori)
Sterna albifrons sinica (Gmelin)
Alcedo atthris taprobana Kleinschmidt
Pelargopsis capedsis gurial (Pearson)

Commercial fishing in Parakeama Samudra is carried on throughout the year with gill nets (Fig. 11). Beach seines are used for six months at most. Fernando (1967) has given a detailed account of the latter fishery. In addition there is a cast net fishery specifically for *Heteropneustes fossilis*. Thirty boats were used of which 18 were rafts (Fig. 12) and the rest outrigger canoes. In 1964, about 50 active fishermen were resident in Parakrama Samudra. The distribution of fishermen's huts is shown in Fig. 13. Gill netting was done mainly at night and the catch per fisherman per fishing day was about 75 lbs.

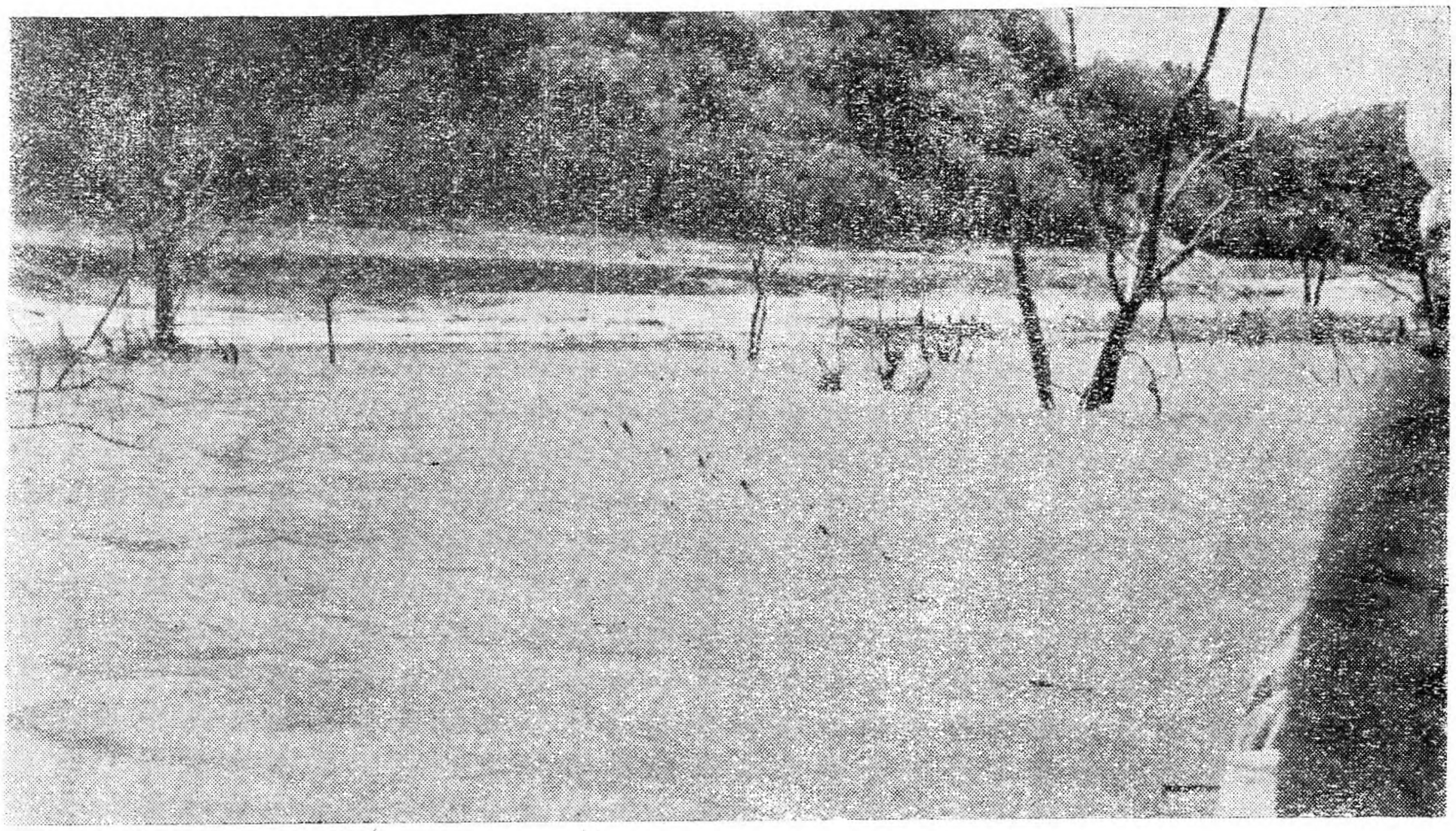


Fig. 11.—A gill net set in a tank.

Fig. 12.—Sorting gill net catches. Note the type of boat used–Rafts (Teppam).

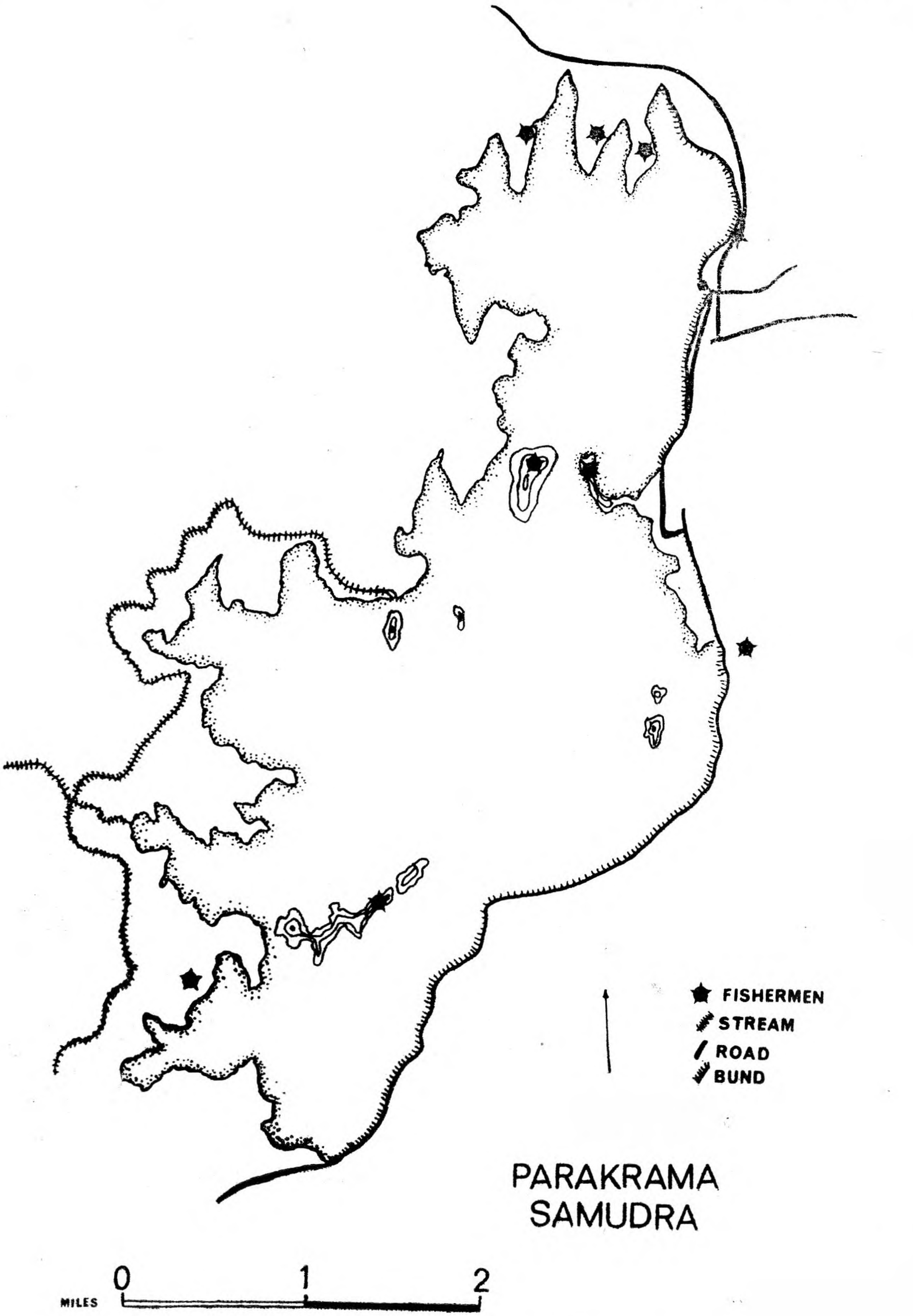


Fig. 13.—Parakrama Samudra showing fishing sites and fishermen's dwellings.

In addition to total fish catches from Parakrama Samudra for the period 1949–1966, data is available on the species composition of the catches. Some of this latter data is available in the Administration Reports of the Director of Fisheries and also in Fernando (1965*b*). The fish catches from Parakrama Samudra for the years 1949–1966 are shown in Fig. 14. Prior to the introduction of *Tilapia mossambica* in 1952 fish catches were very low. *Tilapia mossambica* started entering the fishery in 1954. Unfortunately no data is available for fish catches during this year. In 1955 considerable numbers of *Tilapia mossambica* were being caught according to reports by the Fisheries Officers stationed at Polonnaruwa but no separate statistics were kept of this species. In 1956 the percentage of *Tilapia mossambica* by weight was 21.9 of the total catch. The percentage increased rapidly reaching 90% in 1958. This figure has remained unchanged substantially although the percentage of *Tilapia mossambica* has shown decreases in 1960 and again beginning in 1964. The total fish catch has gone up tremendously since 1949. In 1963 it hit 1 million lbs. and has remained around that figure until 1966. Besides *Tilapia mossambica* a number of other species are caught in some numbers. They are *Labeo dussumieri, Etroplus suratensis, Wallago attu, Ompok bimaculatus, Puntius sarana* and *P. dorsalis*. Also small quantities of *Osphronemus goramy* and *Heteropneustes fossilis* are caught. It is evident that the fishery in Parakrama Samudra is maintained by *Tilapia mossambica*. The indigenous species are exploited only because of the high catches of *Tilapia mossambica*. It is also evident that the catches of indigenous species have not fallen. From data on species composition of catches it is clear that the large indigenous species are not being progressively reduced in quantity in the catches. Indrasena (1965*a*) and Fernando (1967) pointed out that the beach seine fishery in Parakrama Samudra diversifies the fish catch. Fernando (1967) also mentioned the possibility of using small meshed beach seines for catching small coarse fish. In all, 25 species of indigenous fishes were recorded by the authors in 1964. Their numbers did not seem to have diminished from pre-*Tilapia* days.

Mendis (1965) used the fish catches from Parakrama Samudra as a baseline to calculate fish production in other tanks. He used a figure of 100 lbs./acre/annum for this purpose. The figure in 1964 was closer to 150 lbs./acre/annum. It is likely that further increases in the fish production of Parakrama Samudra are possible. Perhaps the introduction of complementary species of *Tilapia* will accomplish this. Also if uses are found for small coarse fish a considerable quantity of this category is available for exploitation.

Some data is available of fish catches from other large tanks in the low country. The species composition of the fish catches from these is essentially the same as for Parakrama Samudra. Although no reliable statistics are available of total fish catches it appears that where exploitation is heavy fish catches of 100–200 lbs./acre/annum can be obtained from these large tanks.

(B) **Small Tanks Fig. (15)**

Fisheries in small tanks consist usually of subsistance fishing. However in recent years more intensive fisheries have been noted in a few small tanks. Fernando and Ellepola (1969) give two such instances. In a small tank near Wirawila one of us (C. H. F.) noted in 1968 a fishery using gill nets. The catch in this case consisted almost entirely of *Tilapia mossambica*. Perhaps similar fisheries exist in many other small tanks.

During the dry season many small tanks dry up. This provides the local population with the opportunity of collecting fish without any specialized fishing apparatus. This type of mud fishing (Hora 1932) is very prevalent.

It is possible to use small tanks as fish ponds with annual stocking of desirable species. *Tilapia mossambica, Etroplus suratensis, Labeo dussumieri*, and macrophytic plant feeding *Tilapia* spp. might well be used for this purpose. A preliminary study by Fernando and Ellepola (1969) showed the feasibility of such a fishery.

On a very conservative estimate there is at the present time about 50,000 acres of small tanks (each less than 100 acres in area). The figures of fish production given by Fernando and Ellepola (loc. cit.) for two tanks are 100 and 70 lbs./acre/annum. Using a very conservative estimate of 50 lbs./acre/annum this is a total production of 2.5 million lbs./annum. This figure is, we must stress, a very low estimate. Stocking with fast growing species could easily double this figure. Also the use of *Tilapia* hybrids giving monosex progeny (Hickling 1960, Pruginin 1967) may prove useful for small tanks as they have done in pond culture.

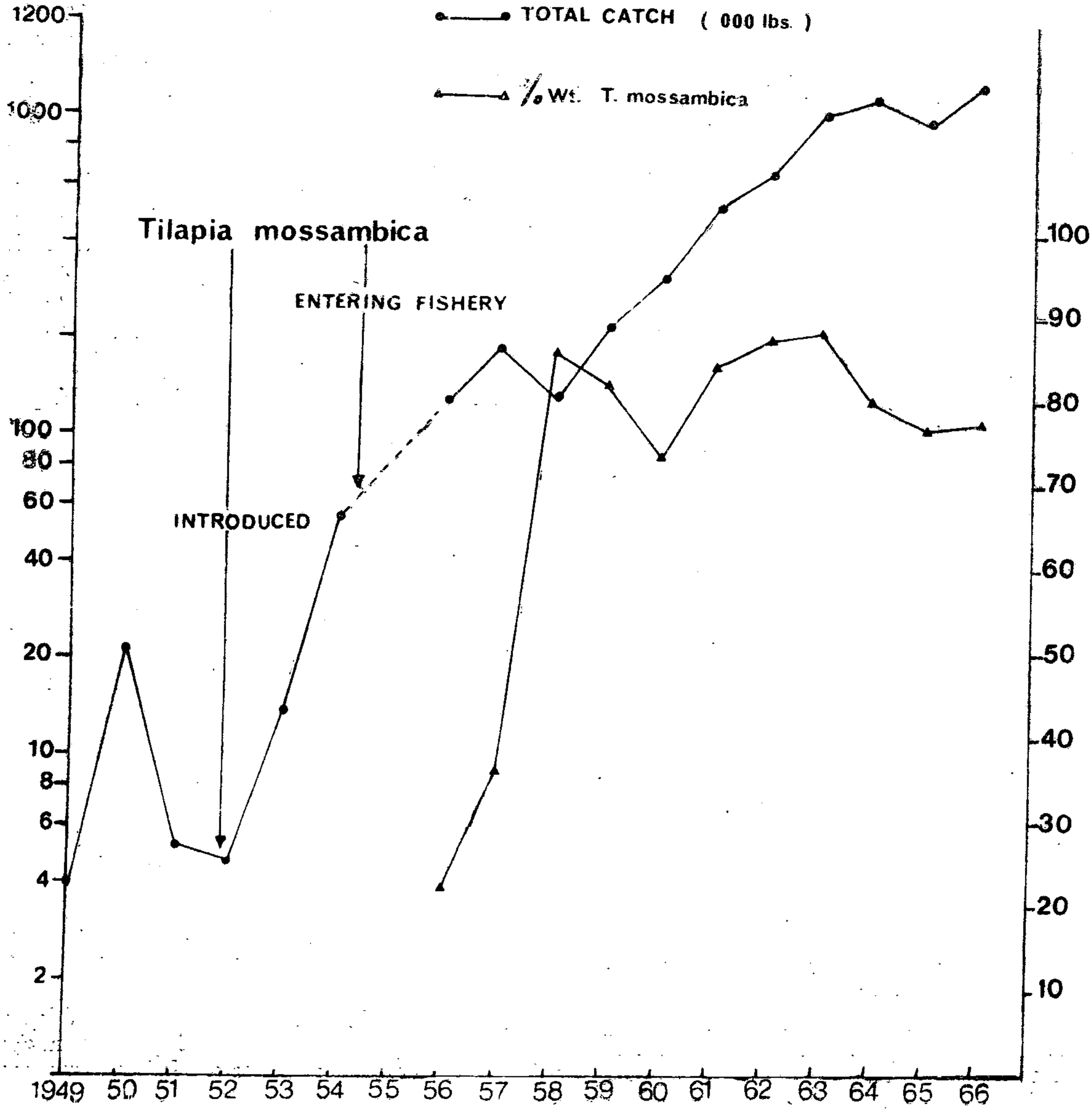


Fig. 14.—Fish catches from Parakrama Samudra, 1949–66.

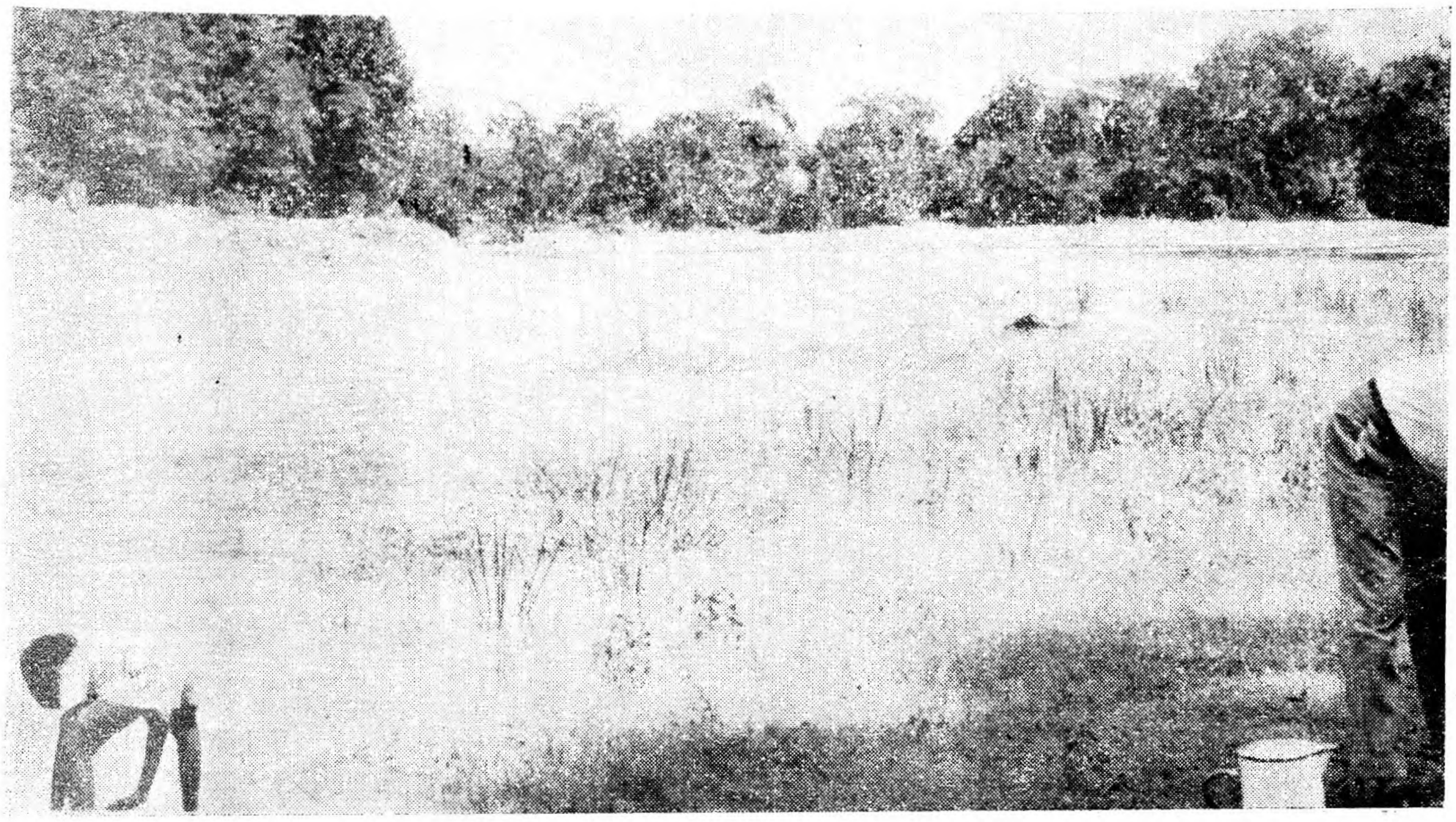


Fig. 15.—A small tank near Habarana.

Fig. 16.—Nalanda reservoir, showing the steep gradient of the margin.

(C) Up-Country Reservoirs And Lakes

These are the least productive of fish at the present time. They include the hydro-electric reservoirs, Norton Bridge and Castlereagh and the deep lakes, Kande-ela and Moonplains and the shallower Gregory's lake. Only in Gregory's lake is there any fishery at all and in this case it is a sport fishery. Common carp and crucian carp are taken by rod and line in Gregory's lake. No data is available on the total catch. Little if at all in the way of fish is taken from any of the other up country lakes.

Apstein (1910) and Holsinger (1955*b*) have studied the plankton of Gregory's lake. From the data of the latter's study it appears that Gregory's lake has a high phytoplankton productivity.

It seems likely that introduction of suitable species into up-country lakes will increase fish productivity. Species worth considering are *Tilapia sparmanni* (Castelnau) and *Tilapia galilaea* (Ardeti) both of which can withstand low temperatures. The former species has been used as a forage fish, (Hey 1953). *Tilapia sparmanni* is phytophagous and omnivorous and *T. galilaea* feeds on phytoplankton (Chimits 1955, 1957). Chimits (1955, 1957) states that *Tilapia sparmanni* can withstand temperatures as low as 7°C and *T. galilaea* 9°C. The absence of large predatory species might prove a disadvantage. *Notopterus chitala* (Ham.) a native of North India might prove a suitable introduction. Alikunhi (1957) states that it grows to over 4 ft. in length and is predatory and breeds in confined waters.

(D) Low And Mid Country Reservoirs

This category of lakes is somewhat varied in size but all of them are of recent construction. Many new reservoirs are planned (Fig. 2). They all have some features in common. They have a considerable portion of their area relatively deep and the margins have steep gradients (Fig. 16).

TABLE 4

Fish catches (lbs.) from Senanayaka Samudra 1961–64

	1961	%	*1962*	%	*1963*	%	*1964*	%
	Catch		*Catch*		*Catch*		*Catch*	
Tilapia mossambica	122,564 ..	36.75 ..	128,614 ..	32.74 ..	62,036 ..	41.27 ..	111,440 ..	50.84
Labeo dussumieri	197,198 ..	59.13 ..	165,290 ..	42.08 ..	65,359 ..	43.48 ..	75,479 ..	34.43
Total catch	333,510 ..	—	392,783 ..	—	150,329 ..	—	219,214 ..	—

Some data is available for fish catches from the largest reservoir in Ceylon, Senanayake, Samudra (Fig. 17 & 18). These fish catches are summarised in Table 4. The catch seems to be divided into a major portion consisting of 75–95% of the weight and consisting of *Tilapia mossambica* and *Labeo dussumieri* and a small portion 5–25% consisting of *Wallago attu*, *Etroplus suratensis*, *Puntius* spp., *Ophiocephalus striatus* and *Ompok bimaculatus*. Unlike in the large low-country tanks *Tilapia mossambica* constitutes only 50% by weight at most. *Labeo dussumieri* is equally important in the catch. The lower percentage of *Tilapia mossambica* as compared to the large low-country tanks is interesting. However it has become the most important fish in the catch displacing *Labeo dussumieri* from this role (Table 4). The steep gradients of the margins unsuitable for *Tilapia mossambica* breeding sites may be one of the causes of this differences. According to Mendis (1965) using 100 lbs. per acre per annum for Parakrama Samudra as a baseline, Senanayake Samudra should produce over one million lbs. of fish per annum. The actual production was of the order of a third of this figure. It is possible, in fact likely, that the fishing could be intensified considerably. One of the features of the fishery is that actual fishing is restricted to the shallower margin away from the bund (Fig. 17). The distances between the fishing sites and the fishermen's habitations are great thus reducing the efficiency of fishing.

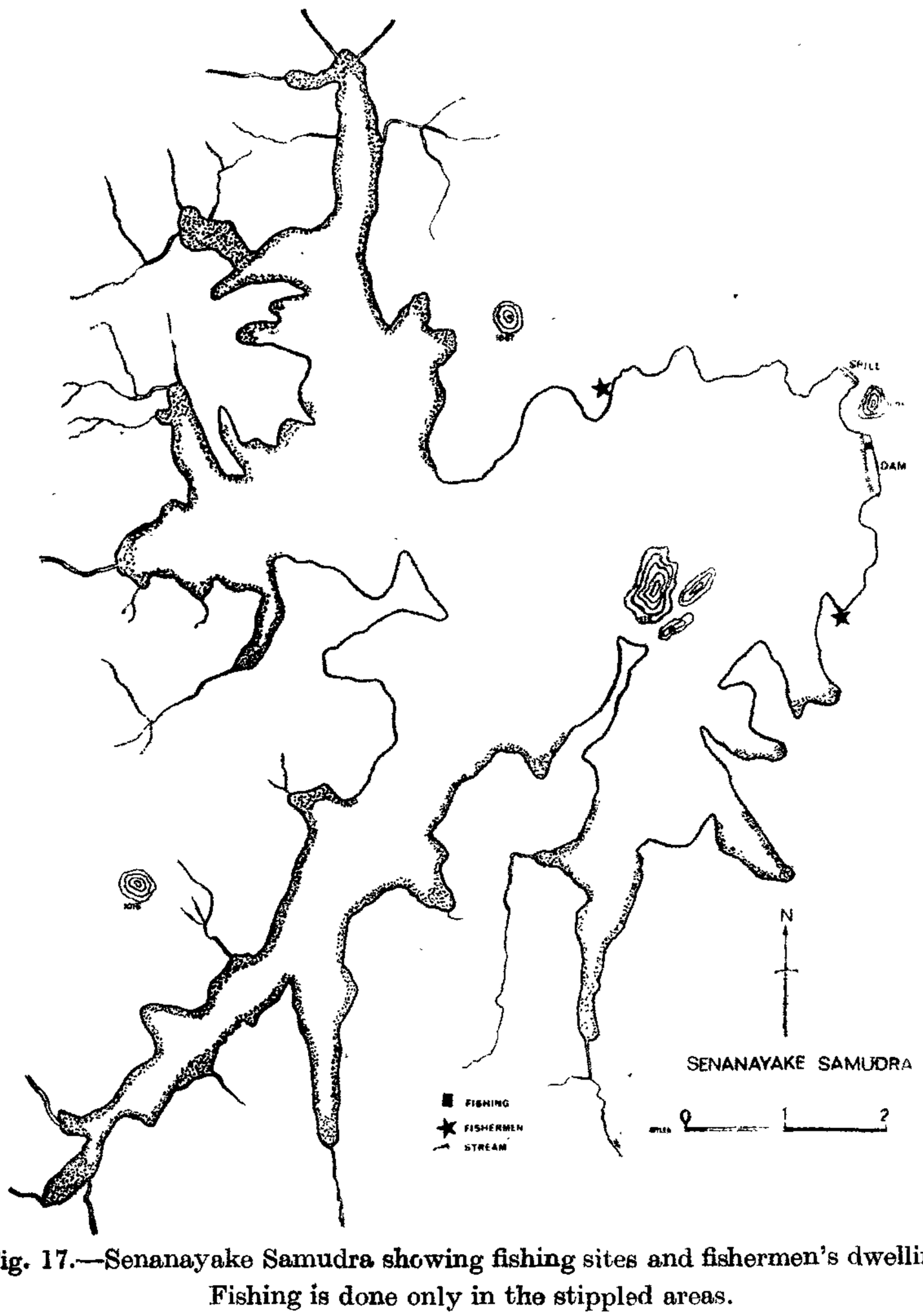


Fig. 17.—Senanayake Samudra showing fishing sites and fishermen's dwellings
Fishing is done only in the stippled areas.

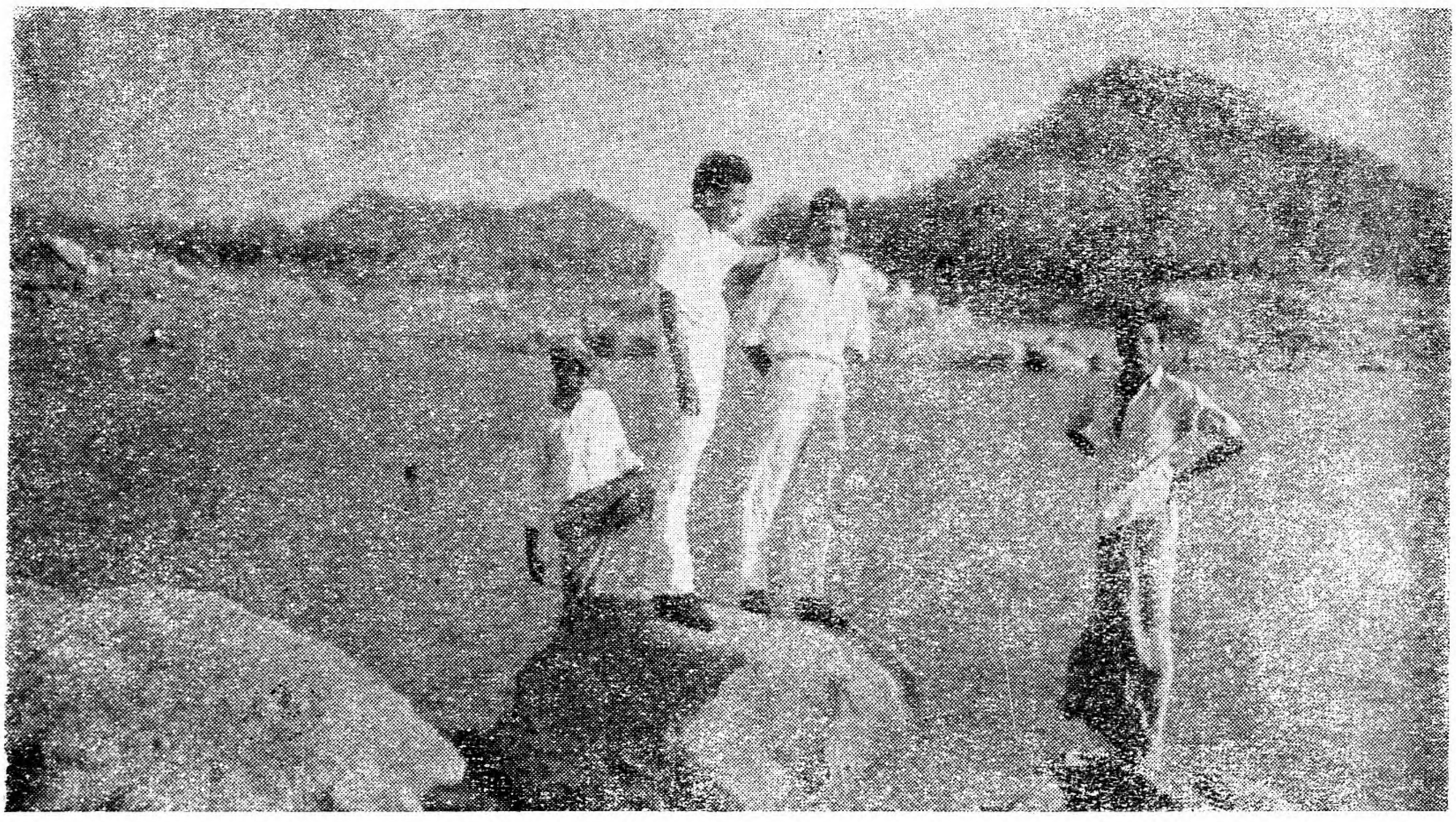


Fig. 18.—A view of Senanayake Samudra at low water level.

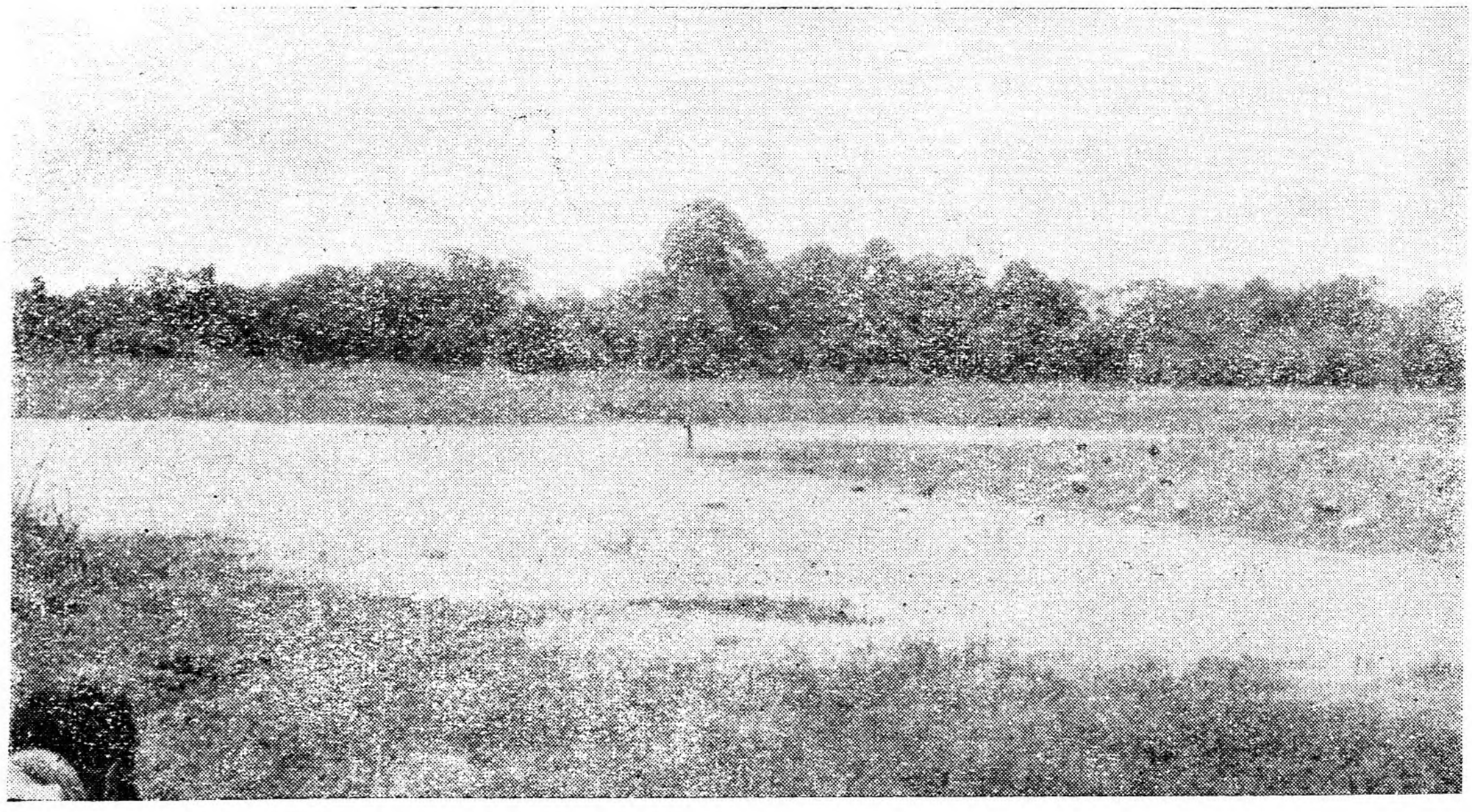


Fig. 19.—Bandiya villu.

The authors feel that the fish stocks could be enhanced by the introduction of complementary species of *Tilapia*. A plankton feeding species like *T. galilaea* or *T. macrochir* might prove suitable. If the fishable stocks are increased it might become economic to use motorised craft on large reservoirs

(E) Rivers And Streams

The sixteen major rivers have a vast number of streams criss crossing the river basins they drain. Some up-country streams provide suitable habitats for trout while many are torrential and flow by a rapid gradient into the low-country. Many low-country streams provide breeding sites for fish during the flood season. Important food species like *Labeo dussumieri* move upstream from tanks to breed. Rivers and streams are therefore an important part of the complex of freshwater habitats and though they do not yield the same amount of fish per acre as shallow tanks they nevertheless fulfill an essential role in the life-histories of some fish species. They also bring into lakes large quantities of nutrients and of course water.

A number of valuable indigenous species inhabit rivers for longer or shorter periods of time and fisheries have been developed to catch these using various legal and illegal (dynamiting, poisoning) methods. During floods spawners moving upstream are caught in traps and nets.

No records are available of the fish catches from rivers and streams. Nevertheless the extent of their area offers an important source of fish. Sport fishing is of some importance in rivers. Important river and stream species are *Labeo dussumieri*, *Wallago attu*, *Osphronemus goramy*, *Tor khudree* and large *Puntius* spp.

The mouths of rivers have a valuable fish and crustacean fauna. Many marine and freshwater species intermingle to varying degrees. Prawns (*Macrobrachium* spp.) are of some importance in certain areas like Madampe and Kalutara. Sited in many river mouths are fisheries for a variety of species both freshwater and marine. Again we have no data at present of the extent, the species composition or the size of the fish catches of these fisheries.

(F) Villus

The closest approach to natural lakes in Ceylon are the villus. They are of two kinds. Those connected permanently to a river (e.g., Karapala villu) and those formed as a result of the contraction of flooded areas (e.g., Bandiya villu, Fig. 19). Villus are common in the lower reaches of the Mahaweli ganga, the Wilpattu and in the Yala areas.

The villus in the lower reaches of the Mahaweli ganga seem to be ideal nurseries for fishes. The giant gouramy, *Osphronemus goramy* which was accidentally introduced into the Mahaweli ganga around 1909 appeared in numbers first in the villus (De Zylva 1960). Malpas (1937) suggested using the villus for rearing gouramy.

It is unfortunate that no study has been undertaken on the biology of this interesting habitat, the villu in its various forms. Conservationists and freshwater biologists should join in preserving this unique habitat.

Data of fish catches from villus is meagre. Regular fishing has only been reported from villus in the Polonnaruwa area. Perhaps this is due to the fact that in other areas the villus are remote and there are no fisheries personnel to report such fisheries. We have some data from Karapala villu for the years 1961–1966 (Table 5). The annual catch seems to have varied between 50–100,000lbs.

TABLE 5

Fish Catches (lbs.) from Karapala Villu 1960–66

Catches are from October 1st to September 30th

Year	Total catch	T. mossambica
1960–61 ..	107,200 ..	4,560
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

The percentage of *Tilapia mossambica* by weight was only about 3% in 1961 and the records for 1964 have a value of about 75%, a figure repeated in 1965 and 1966. However, the total fish catch had fallen considerably from 1961–1966. Whether this is due to selective fishing for *Tilapia mossambica* it is difficult to state. It is true however that only one group of fishermen were involved in the fishing and the range of gear used was not as varied as in the large tanks. The authors visited Karapala villu on a number of occasions during the height of the fishing season. The species caught were more diverse than that of large tank fisheries on any one day. *Labeo dussumeiri, Wallago attu, Ompok bimaculatus, Etroplus suratensis, Ophiocephalus striatus, Osphronemus goramy* and *Puntius* spp. all figured regularily in the catches although in much smaller numbers than *Tilapia mossambica*

(G) **Paddy Fields**

During the floods paddy fields serve as vast areas of open water where many species of fish breed. They act as natural nurseries for most of the smaller species. However, the period during which sufficient water is available for fish is short and many of the species have high mortalities during the dry season. The survivors which are usually those which find their way into irrigation channels, streams and large ponds often suffer further decimation before the next monsoon rains set in.

Weerekoon (1957) gave a popular account of some invertebrate animals in paddy fields in Ceylon. Considerable quantities of small sized fish are caught in paddy fields and irrigation ditches. Fernando (1956*b*) found 24 species of fish in paddy fields in the Western lowlands. Notable absentees were the large species like *Labeo dussumieri, Wallago attu, Ompok bimaculatus* but 11 others including *Labeo dussumieri* and *Ompok bimaculatus* were found in irrigation ditches. The presence of 35 out of 54 indigenous species in paddy fields and irrigation ditches shows that this is perhaps the most favourable habitat for indigenous freshwater fishes. The abundant food and a refuge during the drought in irrigation ditches perhaps enables many species to reach considerable numbers in this habitat.

Attempts were made to use paddy fields for fish culture (De Zylva 1953). *Trichogaster pectoralis* and later *Tilapia mossambica* were used. This project was abandoned a few years later.

(H) **Fish Culture In Ponds**

De Zylva (1952) and Anon (1962) give detailed instructions regarding fish culture in ponds. A number of attempts to raise various species of fish in ponds have been made from time to time in the last fifteen years. At the fisheries stations some measure of success has been achieved in spawing common carp, gouramy and *Trichogaster pectoralis*. These have been used mainly for stocking "natural' waters. i.e., tanks. The breeding of carp and gouramy have been dealt with by Indrasena and Ellepola (1964) Indrasena and de Silva (1964) and Ellepola and Fernando (1968).

Fernando (1965*a*) attributed the failure of pond culture to the lack of a practical tradition among the indigenous people. The prospects for fish culture are not very promising, but with sustained efforts it could become an important source of fish.

The use of indigenous carp fry captured in natural waters could form an important source of fast growing species for culture in ponds. This type of culture is widely practiced in India (Alikunki 1957). Fry of *Labeo dussumieri* have been collected and successfully reared by the authors.

(I) **Trout And Other Sport Fishing**

The recreational aspect of fishing might be considered as inherent in some of the rod and line fishing done especially by young people. Most rod and line fishing is however more subsistance fishing rather than recreational. True sport fishing is not widespread in Ceylon for a variety of reasons. The religious sentiments of many people prevent them from engaging in such a pastime and the search for outdoor activities of this kind is still restricted to only a few enthusiasts.

Trout are introduced into up-country streams annually by the Fishing Club at Nuwara Eliya A trout hatchery is maintained for this purpose. Common carp, crucian carp and trout fishing is controlled by licence. An account of trout culture is given by Fowke (1938).

A number of indigenous species are caught in sport fishing in various parts of the island. *Torkhudree* is perhaps the most sought after sport fish. *Ophiocephalus striatus*, *Wallago attu*, and *Labeo dussumieri* are taken by sportsman besides the introduced *Osphronemus goramy*.

Sport fishing has considerable potential for development as a tourist attraction and for recreational purposes of the local population. Sport fisheries are useful means of getting non-professionals interested in biology and fisheries. Many articles on sport fishing can be found in Loris, the journal of Ceylon wild life.

(J) Miscellaneous Fisheries

Ceylon is fortunate in having a large number of aquarium fishes among its indigenous fauna (Table 1). A number of these species are however rare and are found only in very restricted localities. Studies on their population and breeding habits should be undertaken with a view to exploitation and conservation.

FISHING GEAR

Pearson (1923) described the various kinds of fishing gear in use at that time. Since then new materials have been used in the construction of some of the gear he describes but basically the gear has not changed where freshwater fisheries are concerned. Some marine gear has been introduced to fish the large stocks of *Tilapia mossambica*. The traditional gear used in freshwaters were traps, rod and line, cast nets and small seines.

Gill nets are the most widely used type of gear at the present time (Fig. 11). Stretched mesh sizes 3″–6″ are used. The nets are set from the bottom, in midwater or at the surface. Mendis (1965) on the basis of fishing trials suggested 3″–4″ mesh sizes during the day for *Labeo* and *Puntius* and 5″–6″ mesh at night for *Tilapia mossambica*. Most of the gill net fishing at present is done at night. Gill nets are subject to damage by crocodiles in many of the tanks. Also gill netted *Tilapia mossambica* have their gills eaten by *Heteropneustes fossilis* and *Anguilla* in some localities according to Fernando and Fernando (1965). Gill netting is done from rafts (teppams) or outriggers (orus). The quality of boats used is not high. Very often boats unfit for use in the sea are transferred to freshwater fishing.

Beach seines have been used in a number of large tanks on a regular basis. Fernando (1967) made a detailed study of this fishery in the Polonnaruwa area. Beach seines account for only a small portion of the catch but it diversifies the species composition.

The authors have used long lines for fishing in Parakrama Samudra, Nalanda reservoir and Senanayake Samudra. The species caught were *Wallago attu*,, *Ompok bimaculatus* and *Anguilla nebulosa*. As a commercial venture this method does not seem to have prospects. Trammel nets were also used on an experimental basis. The catches were similar in species composition and weight to that of gill nets. Fishermen are however unwilling to use them because of the novelty, cost and the difficulty of disentagling the fish caught.

UTILIZATION

Fernando (1965*a*) pointed out that though the fish production was low in the " pre *Tilapia* " period this small fish production provided much needed protein for the villager. In many areas subsistance fishing with cast nets, traps, rod and line etc. provided at least some fish for the villagers. There was also a prejudice against freshwater fish as compared to marine fish. One reason for this was perhaps the paucity of desirable species. Religious sentiments too played an important part in the aversion to eating freshwater fish, many of which remained alive at the time of selling to the householder.

At the present time freshwater fish reaches a wider area and are eaten by a greater percentage of the people especially in towns far away from the site of the fishery. *Tilapia mossambica* is by far the largest contributor to the fish catch. This species has an agreeable flavour. It is sold fresh, iced, dried with salt or smoked. The price is low compared to marine fish of " equivalent " standards in size and taste. Since it is likely that the production of *Tilapia* spp. will be increased considerably in the near future, other methods of utilization should be considered. De Silva (1963) worked out a

process for canning *Tilapia mossambica* in curry sauce. This and other methods of utilization, e.g., fish meal, sauces, etc., should be explored in Ceylon. Hess (1968, 1969) investigated in Uganda the canning of *Haplochromis* spp. which are smaller than *Tilapia mossambica*. He found a tomato sauce base most acceptable. However canning of freshwater fish on a commercial scale has not been done so far.

SOCIO-ECONOMIC PROBLEMS

Fernando (1965*a*) and Indrasena (1965) have commented on some socio-economic problems. Commercial fishing in freshwaters is a recent phenomemon. Legislation may be necessary to prevent abuses but we feel that no laws are better than ill-conceived ones. On no account should legislation be introduced without consulting fishermen and Fisheries Officers. An effort should be made to help economically fishermen on similar terms as those employed in marine fisheries. These fishermen are contributing a vast quantity of protein to the country at very little cost in foreign exchange. A tank like Parakrama Samudra produces a catch by weight equivalant to half that of a large trawler's catch (Weerekoon 1965). We need hardly stress the difference in cost of the two operationes

SUMMARY

Based on our present knowledge a comprehensive account of the freshwater fisheries of Ceylon is given. The material for the present paper comes from data gathered by the authors over a period of fifteen years on the general setup of the fisheries and specific research carried out on a few major aspects of the fisheries. All the previous published work is gathered together.

The fish production from freshwaters has increased immensely since the introduction of *Tilapia mossambica* in 1951. The introduction of complementary species of *Tilapia* is suggested to enhance further the fish production. For up-country reservoirs a predator is suggested in addition because of the lack in the Ceylon fish fauna of a large lake dwelling predator tolerant to low temperatures.

A study of the "status" of *Tilapia mossambica* has shown that it has a wide size range and coefficient of condition in different habitats. Restriction of breeding sites and living space may account partly for these differences.

Fish catches from different types of habitats show differences in fish production, species composition of catches and the relative proportions of the fish caught. In Parakrama Samudra the fishery is dominated by *Tilapia mossambica* which forms about 90% of the catch by weight. A similar situation exists in most if not all the large low-country tanks. In Senanayake Samudra the fishery is maintained by *Tilapia mossambica* and *Labeo dissumieri* and in Karapala villu *Tilapia mossambica* dominated the fish catch comprising about 75% by weight in 1966. The species caught are most diverse in Karapala villu and least so in Senanayake Samudra. Figures available on fish production show a catch of about 150 lbs./acre/annum for Parakrama Samudra. In comparison the catches for Senanayake Samudra and Karapala villu are low.

The extension of freshwater areas by construction of tanks for irrigation and reservoirs for hydro-electric power will increase considerably the fish production potential. Planned introductions of selected species could well increase the fish stocks considerably. A relatively unexploited source is the small tank of which there are many thousands in the country. A fry fish industry and annual introduction of fingerlings for harvesting in a few months could utilize these habitats for fish production.

A review of the literature on the freshwater fauna and limnology shows clearly that our knowledge in these areas is meagre. We also know little regarding fish parasites and their dynamics. No fisheries development programme could be successful in the long run if research on these vital subjects is neglected.

The prospects for increasing the fish production from freshwaters are good. The spectacular success of *Tilapia mossambica* may not be repeated but the fish production can most certainly be enhanced, the catch better utilized and the fishermen's lot improved.

ACKNOWLEDGEMENTS

We wish to thank the many fishermen who supplied us with valuable information on fish catches, fishing methods, etc., The two Sub-Inspectors of Fisheries Messrs. M. T. T. Fernando and W. B. Ellepola were responsible for gathering some of the data. They also took an active part in the field research. Mr. David Perera, the lorry driver, Mr. W. P. Silva, boatman, Mr. W. John Fernando net mender and at times cook, and Mr. W. K. T. Perera, laboratory assistant trained in gear technology went beyond the call of duty to help in this work. Data of fish catches from Senanayake Samudra was provided by Messrs. D. K. de Alwis and T. Poopalapillai of the Gal-Oya Development Board. Mr. P. B. Karunaratne, Entomology section, Ceylon National Museum provided the data on water birds in Parakrama Samudra. Professor O. N. Bauer, Institute of Fish Diseases, Academy of Science, Leningrad provided information re parasite infestation of carp. Dr. Ernest Hess, formerly F. A. O., Rome discussed canning of freshwater fish and Mr. R. C. K. Pieries, formerly of the Irrigation Department, Ceylon, supplied some of the data on reservoirs.

REFERENCES

ABEYWICKREMA, B. A. 1956—The origin and affinities of the flora of Ceylon. *Proc. Ceylon. Assn. Adv. Sci.* (1955) 99–121 pp.

ADAMS, F. D. 1929—The geology of Ceylon. *Canad. J. Res.* I, 425–511.

ALIKUNHI, K. H. 1957—Fish culture in India. *Indian Counc. Agric. Res. Farm Bull.* 20, 144 pp.

AMIRTHALINGAM, C. 1949—The wealth of Ceylon waters. *Proc. Ceylon Assn. Adv. Sci.* (1948), 77–86.

ANON 1955—Six years programme of investment 1954–55 to 1959–60. *Planning Secretariat, Govt. of Ceylon* 510 pp.

ANON 1962—Report to the Government of Ceylon on a project of inland fisheries development based on the work of S.W. Ling. *FAO/EPTA Rep.* (*1527*) 43 pp.

APSTEIN, C. 1907—Das plankton in Colombo—see auf Ceylon *Zool Jb.* (*Abt. Syst.*) 25,201—244.

APSTEIN, C. 1910—Das plankton des Gregory see auf Ceylon. *Zool. Jb.* (*Abt. Syst.*) 29, 661–680.

AWACHIE, J. B. E. 1965—Preliminary notes on the parasites of fish in the Kainjii reservoir. *First Scientific Report Kainjii Biol. Res. Team* 65–69 pp.

BAKER, J. R. 1958—Protozoan parasites, *Ann. Rep. E. Afr. Fish Res. Org.* 1956–57, Kampala 41–43 pp.

BAUER, O. N. Personal communications.

BEAUCHAMP, R. S. A. 1958—Utilizing the natural resources of L. Victoria for the benefit of fisheries and Agriculture *Nature, Lond.* 181, 1634–1636.

CANAGARATNAM, P. 1966—Growth of *Tilapia mossambica* Peters in different salinities. *Bull. Fish. Res. Stn. Ceylon* 19, 1–4.

CHIMITS, P. 1955—*Tilapia* and its culture. *F.A.O. Fish Bull.* 8, 1–33.

CHIMITS, P. 1957—The Tilapias and their culture *F.A.O. Fish. Bull.* 10, 1–24.

CHOPRA, B. N. (Edit.) 1951—Indian fisheries. Handbook on Indian fisheries prepared for the third meeting of the Indo-Pacific fisheries Council Madras Feb. 1951. *Govt. of India Min. Agric.* 128 pp.

COSTA, H. H. and FERNANDO, E. C. M. 1967—The food and feeding relationships of the common meso and macro-fauna of the Maha Oya, a small mountaineous stream at Peradeniya, Ceylon. *Ceylon J. Scr.* (*Bio-Sci.* 7, 74–90.

COSTA, H. H. and WIJEKOON, S. 1966—*Spinitectus corti*, a fish nematode new to Ceylon. *Bull. Fish. Res. Stn. Ceylon* 19, 3–4.

CROW, W. B. 1923*a*—Freshwater plankton algae from Ceylon .*J. Bot. Lond.* 61, 111–114 ; 138–145 ; 164–171.

CROW, W. B. 1923*b*—The taxonomy and variation of the genus *Microcystis* in Ceylon. *New Phytol.* 22, 59–68.

CRUSZ, H. and SATHANANTHAN, A. H. 1960—Metacercaria of *Transversotrema patialense* from a freshwater fish *Macropodus cupanus*. *J. Parasit.* 46, 613.

CRUSZ, H., RATNAYAKE, W. E. and SATHANANTHAN, A. H. 1964—Observations on the structure and life-cycle of the digenetic fish trematode. *Transversotrema patialense* (Soparkar) *Ceylon J. Sci.* (*Bio. Sci.*) 5, 8–17.

DE BONT, A. F. and DE BONT-HERS, M. J. 1952—Mollusc control and fish farming in Central Africa. *Nature, Lond.* 170, 323–324.

DE SILVA, N. N. 1963—A report on the prospects of fish canning with special reference to inland fish. *M. S. Report Fish. Res. Stn. Colombo, No. 23*, 1–39. (Unpublished)

DE ZYLVA, E. R. A. 1952—Fish farming in Malaya (as a guide to fish farming in Ceylon). *Bull. Fish. Res. Stn. Ceylon.* 1, 10 pp.

DE ZYLVA, E. R. A. 1960—The gouramy in Ceylon. *Loris* 8, 291–292.

DU PLESSIS, S. S. 1954—Fish diseases in the Transvaal. *Rec. Symp. Afr. Hydrobiol. Inland Fish. Entebbe, Uganda* 128–129.

ELLEPOLA, W. B. and FERNANDO, C. H. 1966—Hatching and rearing of gouramy (*Osphronemus goramy* Lacepede) in the Polonnaruwa nursery. *Bull. Fish. Res. Stn. Ceylon* 19, 5–7.

FERNANDO, C. H. 1956*a*—The food of four common freshwater fishes of Ceylon. *Ceylon J. Sci.* (*c*) 7, 201–217.

FERNANDO, C. H. 1956*b*.—The fish fauna of paddy-fields and small irrigation ditches in the Western lowlands of Ceylon ; and a bibliography of references to fish in paddy-fields. *Ceylon J. Sci.* (*c*) 7, 223–227.

FERNANDO, C. H. 1961—Inland fishes of Ceylon. *Loris* 9, 9–11.

FERNANDO, C. H. 1963—A guide to the freshwater fauna of Ceylon. Supplement 1. *Bull. Fish. Res. Stn. Ceylon* 16, 29–38.

FERNANDO, C. H. 1964—A guide to the freshwater fauna of Ceylon. Supplement 2. *Bull. Fish. Res. Stn. Ceylon* 17, 177–211.

FERNANDO, C. H. 1965*a*—The development of Ceylon's fisheries XI. The role of inland waters in relation to the development of Ceylon's fisheries, and a note on the pearl oyster fishery. *Bull. Fish. Res. Stn. Ceylon* 17, 291–297.

FERNANDO, C. H. 1965*b*—A preliminary survey of 21 Ceylon lakes. 3. Parasites and predators, food of fish and marginal fauna. *Bull. Fish. Res. Stn. Ceylon* 18, 17–28.

FERNANDO, C. H. 1967—The beach seine fishery in Ceylon's freshwaters. *Indo-Pacif. Fish. Counc. Curr. Affr. Bull.* No. 50, 1–21.

FERNANDO, C. H. 1969—A guide to the freshwater fauna of Ceylon, Supplement 3. *Bull. Fish. Res. Stn. Ceylon* 20.

FERNANDO, C. H. and ELLEPOLA, W. B. 1969—A preliminary study of two village tanks (reservoirs) in the Polonnaruwa area with biological notes on these reservoirs in Ceylon. *Bull. Fish. Res. Stn. Ceylon,* 20.

FERNANDO, C. H. and FERNANDO, A. 1960—The defensive spines of the freshwater fishes of Ceylon. *Ceylon J. Sci.* (*Bio. Sci.*) 3, 131–141.

FERNANDO, C. H. and FERNANDO, M. T. T. 1965—Gill damage in netted *Tilapia mossambica* Peters. *Bull. Fish. Res. Stn. Ceylon* 17, 242–243.

FERNANDO, C. H. and FURTADO, J. I. 1963*a*—Some studies on helminth parasites of freshwater fishes. *Proc. First-UNESCO Symp. Trop. Parasit. Singapore* (1962) 292–302.

FERNANDO, C. H. and FURTADO, J. I. 1963*b*—A study of some helminth parasites of freshwater fishes in Ceylon. *Z. Parasitenk.* 23, 141–163.

FOWKE, P. 1938—Trout culture in Ceylon. *Ceylon J. Sci.* (*C*) 6, 1–78.

FRITSCH, F. E. 1907—A general consideration of the subaerial and freshwater algae of Ceylon. A contribution to the study of tropical algae ecology. *Proc. Roy. Soc. Lond.* (*B*) 89, 197–254.

FRYER, G. 1966—Crustacean parasites of fishes *Ann. Rep. E. Afr. Fish. Res. Org.* 1959. Kampala p. 28.

GIESLER, R. 1967—Limnologisch-ichthyologische beobactungen im Sudwest-Ceylon. *Int. Rev. Hydrobiol.* 52. 559–572.

GUNASEKERA 1960—Administration report of the Director of Irrigation for 1959. *Ceylon Govt. Press* (1960) 73–123.

GUSSEV, A. V. 1963—New species of Monogenoidea from fishes in Ceylon. *Bull. Fish. Res. Stn. Ceylon* 16, 53–93.

HESS, E. 1968—Interim technical report on the canning of *Haplochromis*. Mimeo report Entebbe 12 pp.

HESS, E. 1969—Final report on the canning of *Haplochromis*. Mimeo report Entebbe 7 pp.

HEY, D. 1953—Programme of fish for food. *Provincial Admin. Cape of Good Hope, Dept. Nat. Conserv. S. Afri.* Rep. No. 10, 51–60.

HICKLING, C. F. 1960—The Malacca *Tilapia* hybrids. *J. Genetics,* 57, 1–10.

HOLSINGER, E. C. T. 1955*a*—The plankton algae of three Ceylon lakes. *Hydrobiologia* 7, 8–24.

HOLSINGER, E. C. T. 1955*b*—The distribution and periodicity of the phytoplankton of three Ceylon lakes. *Hydrobiologia* 7, 25–35.

HORA, S. L. 1932—Mud fishing in lower Bengal. *J. Asiat. Soc. Beng.* 28, 197.

INDRASENA, H. H. A. 1964—The development of Ceylons fisheries. IX. The development of freshwater fisheries in Ceylon. *Bull. Fish. Res. Stn. Ceylon* 17, 287–289.

INDRASENA, H. H. A. 1965*a*—A preliminary survey of 21 Ceylon lakes. I. Fisheries of two lakes, Parakrama Samudra and Minneriya wewa. *Bull. Fish. Res. Stn. Ceylon* 18, 1–5.

INDRASENA, H. H. A. 1965*b*—Freshwater fishery resources. *Bull. Fish. Res. Stn. Ceylon* 18, 87–90.

INDRASENA, H. H. A. and ELLEPOLA, W. B. 1964*a*—Hatching and rearing of carp in the Polonnaruwa nursery. *Bull. Fish. Res. Stn. Ceylon* 17, 245–246.

INDRASENA, H. H. A. and DE SILVA, J. C. 1964—The breeding of giant gouramy (*Osphronemus goramy* Lacepede) and the rearing of its fry in the Departmental fish hatcheries *Indo-Pacif. Fish. Counc. Occ. Pap.* C64/TECH 1, 1–11.

INGLE, R. Wand FERNANDO, C. H. 1963—On Some fresh and brackish water Crustaceans from Ceylon. *Crustaceana* 6, 101–109

KESTEVAN, G. L. 1951—Ceylon Fisheries. Recommendations of experts on fisheries development, research, Socio-economic and industrial problems. V. Report on the Ceylon fishing industry. *Sessional Pap. VI Govt. Ceylon pp.* 152–170.

KNOX, R. 1681—An historical relation of Ceylon. *Publ. Ceylon Hist. J.* 6, (1957) 304 pp.

KULASIRI, C. and FERNANDO, C. H. 1956—Camallanidae parasitic in some Ceylon fishes. *Parasitology* 46, 420-424.

KY'HA 1969—(The parasite fauna of some freshwater fishes of North Vietnam and measures for control of diseases). in Russian. *Spec. Publ. Acad. Sci. USSR Leningrad* 1969. 1–18.

LEMMERMANN, E. 1907—Protophyton-plancton von Ceylon. *Zool. Jb.* (*Abt. Syst.*) 25, 263–268.

LOWE, R. H. 1955—Species of *Tilapia* in East African dams, with a key to their identification. *E. Afr. Agric. J* 20, 256–262.

LOWE-MCCONNELL, R. H. 1959—Breeding behaviour patterns and ecological differences between *Tilapia* species and their significance for evolution within the genus *Tilapia* (Pisces : Cichlidae). *Proc. Zool. Soc. Lond.* 132, 1–30.

LOWE-MCCONNELL, R. H. 1969—Speciation in tropical freshwater fishes, *Biol. J. Limn. Soc.* 1, 51–75.

MALPAS, A. H. 1937—Administration report of the marine biologist for the year 1936. *Ceylon Govt. Press.* 11 pp.

MAAR, A. 1960—The introduction of carp in Africa South of the Sahara. *Third Symp. Hydrobiol. Inland Fish. Lusaka.*

MCMAHON, J. P. 1960—Preliminary observations on the control of snails and mosquitoes in dams. *Ann. Rep. E. Afr. Fish. Org. 1959.* Kampala 41–46.

MENDIS, A. S. 1964—A contribution to the limnology of Colombo Lake. *Bull. Fish. Res. Stn. Ceylon* 17, 213–220.

MENDIS, A. S. 1965—A preliminary survey of 21 Ceylon lakes. 2. Limnology and fish production potential. *Bull. Fish. Res. Stn. Ceylon* 18, 7–16.

MENDIS, A. S. and FERNANDO, C. H. 1962—A guide to the freshwater fauna of Ceylon. *Bull. Fish. Res. Stn. Ceylon* 12, 160 pp.

MUNRO, I. S. R. 1955—*The marine and freshwater fishes of Ceylon.* Canberra, Australia 351 pp.

PAPERNA, I. 1963—*Enterogyrus cichlidarum* n. gen. sp., a monogenetic trematode parasite in the intestine of a fish. *Bull. Res. Counc. Israel* 11, 183.

PAPERNA, I. 1964—Parasitic helminths on inland-water fishes in Israel. *Israel J. Zool.* 13, 1–20.

PEARSON, J. 1923—Fishing appliances of Ceylon. *Bull. Ceylon Fish.* 1, 65–134.

SCHUSTER, W. H. 1951—Report on a survey of the inland fisheries of Ceylon. *Sessional Pap. 24, Govt. Ceylon* 15 pp.

SIRIMANNE, C. H. L. 1953—A survey of the potable and industrial waters in Ceylon. *Proc. Ceylon Assn. Adv. Sci.* (1952) 5–36.

SZECHOWYCZ, R. W. 1959—Freshwater fishing. *Loris* 8, 220–227.

SZECHOWYCZ, R. W. 1960—Freshwater fishes of Ceylon. *Loris* 8, 285–290.

UKOLI, F. M. A. 1965—Preliminary report on the helminthic infections of fish in the R. Niger at Sagunu. *First Scientific Rep. Kainji Biol. Res. Team* pp. 70–73.

WELCOME, R. L. 1966—Recent changes in the stocks of *Tilapia* in Lake Victoria. *Nature, Lond.* 212, 52–54.

WEERAKOON, A. C. J. 1957—Some animals of the paddy field. *Loris*, 7, 1–8.

WEERAKOON, A. C. J. 1965—The development of Ceylon's fisheries I Ceylon's fisheries ; Past and future. *Bull. Fish. Res. Stn. Ceylon* 17, 247–256.

WEST, W. and WEST, G. S. 1902—A contribution to the freshwater algae of Ceylon. *Trans. Linn. Soc. Lond.* (*B*) *Bot.*, 6, 123–215.

WILLEY, A. 1910—Note on the freshwater fisheries of Ceylon. *Spolia Zeylan.* 7, 88–106.

WORTHINGTON, E. B. 1932—A report on the fisheries of Uganda. *Crown Agent for Colonies Publ. London.*

YEH, L. S. 1960—On a collection of camallanid nematodes from freshwater fishes in Ceylon. *J. Helminth* 34, 107–116.

ADDENDUM

Since this paper was written we received from Professor O. N. Bauer a list of references to the occurrence of the very pathogenic cestode *Bothriocephalus gowkonensis* which was recorded in Ceylon by Fernando and Fernando (1963). Since this species will certainly be of considerable importance to the freshwater fisheries of Ceylon and the references are not cited in English journals we have included the references mentioned below. *Bothriocephalus gowkonensis* has spread into the U.S.S.R. and Rumania. Although unrecorded in many parts of Asia and Europe it has probably invaded both cultured and wild cyprinid fishes. The senior author certainly saw this species in Malaysia and it is likely to spread into Africa and North America with imported fish. It is relatively non-specific nd seems to be restricted to the Cyprinidae.

REFERENCES

ANTZISHKINA, L. M. and Chaplina, A.M. 1962—*Bothriocephalus gowkonensis* Yeh, v usloviyach Dneprovskogo vodokhranilishtcha. (Bothriocephalus gowkonensis Yeh, in conditions of Dneprovskoe Reservoir.) *Voprosyekologii, Publ. House University Kiev. Vol.* 8 6–7.

BABAEV, B. and SHTCHERBAKOVA, A. I. 1963. Iz opyta bor'by s botriocefaljusom belogo amura. (Experience with the control of Bothriocephalus of Chinese grass carp.) *Izvestija AN Turknenskoj SSR, Seria biologit-cheskish nauk* No. 4. 86–87.

BABAEV, B. 1965—Resprostranenie *Bothriocephalus gowkonensis* Yeh, 1955 (Cestoda, Pseudophyllidea) v vodoemach karakumskogo kanala. Distributions of *Bothriocephalus gowkonensis* Yeh, 1955 (Cestoda, Pseudophyllidea) in the reservoirs of Kara-Kum Canal.) *Zool. Zhur.* Vol. 14, No. 9.

BATCHINSKI, V. P. 1965—*Bothriocephalus gowkonensis* Yeh, 1955 u ryb Krementchugskogo vodokhranilishtcha. (*Bothriocephalus gowkonensis* Yeh, 1955 u ryb Krementchugskogo vodokhranilishtcha. ((*Bothriocephalus gowkonensisi* Yeh, in fish. n Krementchugskoe Reservoir.) *Tezisi dokladov simpozijuma po parasitam i boleznyam rybv vodokhranilishtchach.* Publ. House " Nauka " Leningrad. 6–7.

BAUER, O. N., MUSSELIUS, V. A. and STRELKOV, J: A. 1969—Die parasiten und krankheiten von *Ctenopharynogodon idella, Hypopthalamichthys molitrix* und *Aristichthys nolibis* bei der aufzucht in tiechwirtschaften der Ud SSR, Z. *Fischerei* 17, 205–213.

MALEVITZKAYA, M. A. 1958—O zavoze parazita so slozhnym ciklom razvitia *Bothriocephalus gowkonensis* Yeh pri akklimatizacii amurskich ryb. (On the introduction of the parasite *Bothriocephalus gowkonensis* Yeh with complicated cycle of development during the acclimatization of fish from the Amur River.) *Dokl. Akad. Nauk SSR* Voll 123 No. 3. 572–575.

MARITZ, N. M. 1965—Botriocephalex karpov. (Bothriocephalosis of Carp.) Sbornik " Raboty po parasitofaune jugozapada SSR, Kishinev. 88–89.

MUSSELIUS, V. A. 1960—Profilaktika i letchenie botriocefaleza. (Prophylaxis and treatment of bothriocephalosis). *Rybnoe chozyaystvo* No. 10, 28–29.

MUSSELIUS, V. A. 1962*a*—Zabolevanie prudobykh ryb botriocefalezom. (Bothriocephalosis of pond fish.) *Trudy sovieshtchchaniya ichtiologitcheskoy komissii AN SSR.* No. 14. 220–224.

MUSSELIUS, V. A. 1962*b*—Botriocefalex segoletkov karpa i mery bor'by s nim. (*Bothriocephalosis* of carp fingerlings and methods of control.) *Trudy VNIIPRCh* Vol. II. 78–88.

MUSSELIUS, V. A. 1963—O rasprostranenii *Bothriocephalus gowkonensis* Yeh v vodoemakh srednei polosy RSFSR. (Distribution of *Bothriocephalus gowkonensis* in water bodies of the " central belt " of Russian SSR.) *Trudy VNIIPRCh* Vol. 12, 179–182.

MUSSELIUS, V. A. 1967—*Parazity i Bolezni Rastitel'noyadynkh ryb i mery bor'by s nimi.* (Parasites and diseases of herbivorous fish and methods of Control. Publishing House Kolos, Moscow, 83 pp.)

MUSSELIUS, V. A. and STRELKOV, J. A. 1966—Parasites and disease of the grass and silver carps in fish farms of the USSR. *FAO World Symposium n Warm Water fish culture. Rome* 1966. 1–8.

SHTCHERBAN', N. P. and TCHEKHUN, F. N. 1959—O novom parazitarnom zabolevanii karpov v nekotorykh prudakh USSR. (On new parasitic diseases of carp in some ponds of the Ukraine SSR.) *Rybnce khozyaystvo* No. 4. 36–38.

SHTCHERBAN', N. P. 1963—K izutcheniyu zhiznennogo cikla *Bothriocephalus gowkonensis* Yeh. (On the life cycle of *Bothriocephalus gowkonensis* Yeh.) *Sbornik " Problemy parazitologii, Trudy 4-j nautchnoy konferenii parazitologov USSR. Kiev.* 1963.

SHTCEHRBAN', N. P. 1965—Noi cercetari asupa infestarii pesticolor cu *Bothriocephalus gowkonensis* Yeh. *Bull. Inst. de Cetcetare Proiectari piscicola* Viol. 1.