REPORT TO THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH ON THE MADRAS RURAL PISCICULTURAL SCHEME WORKED FROM 1ST JULY 1942 TO 31ST MARCH 1952

COMPILED BY
M. D. MENON, R. SRINIVASAN AND B. KRISHNAMURTHI
OF
FRESH WATER BIOLOGICAL RESEARCH STATION
DEPARTMENT OF FISHERIES
MADRAS.

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MADRAS
1959

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BACKGROUND TO THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH SCHEME.

The Madras Fisheries Department was founded in 1907 on enquiries made by Sir F. A. Nicholson in India, Japan, Europe and America. The circumstances of its inception, the condition of fishermen engaged in the industry, the large fishery monopolies over chank and pearl fisheries and the vested rights of Government in Inland Fisheries necessitated in the early years concentration on administrative and revenue questions and not on research excepting technological and industrial research (in which Sir F. A. Nicholson was interested) and some cultural experiments with Trout, Hilsa and edible oyster. Marine Biological Research commenced only in 1920 when a Marine Biologist was appointed by the Government. This appointment and the opening of the Fisheries Research Station at West Hill (Calicut) in 1921 marks the first epoch in the History of Research as such in India.

In 1923, the Government observed that there had been no definite policy with regard to fisheries research and called for a detailed programme for the next ten years. Though there were many lines of investigations for a properly equipped scientific Department of Fisheries, a programme of research on urgent problems concerned with strictly practical and economic ends was drawn up and approved by the Government. In this programme the work done till 1926 and the work that remained to be done were indicated. Also in 1928, the Committee on Fisheries reported on the research work done by the department in great detail. The Committee recommended the appointment of a Fishery Biologist and eight Assistant Biologists and the opening of four Biological stations. To begin with, the Government sanctioned the employment

of one Assistant Biologist and staff including two Research Assistants for the two Biological stations one at West Hill and the other at Krusadai Island. They also recommended the establishment of a Fresh Water Biological Research Station at Madras and further staffing and equipping of the Tanur Experimental Station for technological research. This reports relates to the work done at the Fresh Water Biological Research Station at Madras for a period of ten years from its inception.

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RESEARCH ON RURAL PISCICULTURE.

With reference to the recommendations of the Royal Commission on Agriculture (in paragraph 415 of their report) the Government sanctioned in 1930 one Assistant Director and staff for propaganda in favour of Rural Pisciculture but owing to financial stringency the staff had to be disbanded in 1931. But the year's work had awakened considerable interest in pisciculture in private individuals and public bodies. Applications from different parts of the State were constantly received for advice and help in growing fish in village wells, ponds and tanks. But the department was not is a position to render adequate assistance not merely for want of staff but for want of the necessary information.

For assisting the ryots in the different districts in growing fish in their wells and ponds, the following information was then essential :—

(1) Which of the several kinds of fresh water food fish available in this State are suitable for stocking wells and small ponds?

(2) What is the breeding season of the selected kinds and where can the young fish for stocking wells and ponds be obtained cheaply by ryots?

(3) Are suitable fish for pisciculture available locally; if not, which is the nearest source where they can be had and what is the cheapest mode of transport?

(4) What is the favourite food of these fish and how is such food, natural or artificial, to be obtained by the villager cheaply?

(5) What weeds, snail and other vegetable and animal organisms are associated with the occurrence and abundance of these fish and how could they be cultivated in ponds and wells?

(6) What are the favourable physical and chemical characters of water in which the different fish thrive best and how can the unfavourable conditions present in certain wells and ponds be remedied?

(7) What are the enemies of the fish and how can they be eradicated in ponds and wells for successful culture?

(8) What are the diseases of fish in captivity and how are they to be controlled?

For gathering the above information (i) a properly equipped Fresh Water Biological Research Station (with Fish Farm) and (ii) qualified staff were necessary.

REPORT TO INDIAN COUNCIL OF AGRICULTURAL RESEARCH ON THE

As the research on pond and well culture to assist the ryots was the direct outcome of the recommendations made by the Royal Commission on Agriculture, proposals for establishing a Biological station for research on the problems peculiar to small scale pond culture were sent to the Imperial Council of Agricultural Research in 1932.

The scheme was approved but had to wait long for allotment of funds. In June 1940, the *Ad hoc* Fish Committee of the Imperial Council of Agricultural Research recommended it to be financed and the scheme was finally sanctioned by the Imperial Council of Agricultural Research for a period of five years. This period was by periodical sanction extended up to 10 years. The Government sanctioned the employment of the necessary staff and the construction of the necessary buildings.

The Research Station was opened in the Old Brickfields at Chetpet on 1st July 1942. A site measuring 13 acres in the Brickfields was selected for construction of ponds. Due to scarcity of materials during the war period much headway was not made in the construction of ponds and buildings. The office and laboratory were therefore housed from 16th November 1942 till the end of the scheme for ten years in 95, Poonamalle High Road, Madras, a private building adjacent and opposite to the Brickfields ponds.

The research station worked out the programme approved by the Imperial Council of Agricultural Research during the term of ten years. The problems contained in the programme can be broadly classified under the following four heads :—

(1) The detailed study of the bionomics of the important fresh water fishes of the Madras State.

(2) The Hydrobiology of the fresh waters of the Madras State to understand the ecological complex governing the lives of the fishes.

(3) Improvements in the methods of acclimatisation and transport of live fish.

(4) Studies on Pollution of waters and on fish diseases and mortality.

The progress of the work on the above lines has been periodically reported to the Imperial Council of Agricultural Research in the annual reports of the station. The present report is in the form of a final assessment of the results obtained or a compendium of the observations made in the respective problems tackled by the research station. Many of the investigations were carried on even beyond the period during which the Imperial Council of Agricultural Research had sponsored the scheme. But for cogency and completeness of the report some of the results of these investigations made during the post. Imperial Council of Agricultural Research Scheme period also have been included.

Again in this final report details of only investigations that have been fairly completed are included, so much so the bionomics of a few fishes that had been tackled during the period of the scheme are left out in this report for want of sufficient data.

In the original scheme sanctioned by the Imperial Council of Agricultural Research and the Government there were provision only for one Assistant Director and one Research Assistant. Subsequently the Government opened Hydrological and Algological wings. Though these two wings were completely financed by the Government and were outside the purview of the Imperial Council of Agricultural Research Scheme, the problems tackled by these two were of considerable bearing and interest on the programme suggested by the Imperial Council of Agricultural Research. So, the results of the observations of these two wings also are included in this report.

The details of the personnel who staffed the various technical posts under the Imperial Council of Agricultural Research Scheme are furnished below :—

ASSISTANT DIRECTOR.

Dr. T. J. Job	1st July 1942 to 17th July 1943.
K. Chidambaram	18th July 1943 to 19th September 1943.
Dr. T. J. Job	20th September 1943 to 14th January 1945.
N. V. Choodamani	15th January 1945 to 4th September 1945.
K. H. Alikunhi	5th September 1945 to 15th October 1948.
P. I. Chacko	16th October 1948 to 31st March 1952.

RESEARCH ASSISTANT.

K. Chidambaram	31st August 1942 to 17th July 1943.
I. Ram Mohan Rao	19th July 1943 to 8th November 1943.
G. Lakshminarayana Rao	9th November 1943 to 16th November 1944.
P. K. Jacob	17th November 1944 to 28th June 1946.
S. Nagaraja Rao	29th June 1946 to 3rd October 1948.
B. Krishnamurthi	4th October 1948 to 27th May 1951.
Mrs. J. G. Abraham	28th May 1951 to 15th September 1951.
B. Krishnamurthi	16th September 1951 to 31st March 1952.

SUB-ASSISTANT INSPECTOR.

K. Govinda Raj	1st July 1942 to 24th July 1945.
K. Rama Kurup	25th July 1945 to 5th September 1945.
P. Gunakkan	6th September 1945 to 6th March 1946.
K. Rama Kurup	7th March 1946 to 31st March 1952.

FIELDMAN.

A. P. Gopalan	18th July 1942 to 2nd May 1943.
K. Rama Kurup	3rd May 1943 to 23rd June 1943.
A. P. Gopalan	24th June 1943 to 21st April 1944.
T. Rameswami	8th May 1944 to 6th June 1944.
A. P. Gopalan	7th June 1944 to 15th August 1944.
K. Rama Kurup	23rd September 1944 to 6th March 1946.
K. Krishna Kurup	7th March 1946 to 27th April 1946.
J. P Michael	28th April 1948 to 31st March 1952.

I. BIONOMICS OF THE FRESH WATER FISHES OF ANDHRA AND MADRAS STATES.

These studies consisted of the examination of samples of fishes from various parts of the Andhra and Madras States collected from both lentic and loric types of waters. The food of these fishes has been studied by analysis of the gut contents of different size groups qualitatively and quantitatively. The growth of the fishes have been studied by the length frequency studies of samples from commercial catches. In the ponds the growth has been studied by introducing young ones and then noting their growth by direct observations. The fecundity has been worked out by actual count. The methods of capture and the mode of collection of the young sizes (fry and fingerlings) have been also furnished.

LABEO FIMBRIATUS.

Labeo fimbriatus is the commonest major carp in the river, reservoir, lakes and tanks of South India. Known as the Fringe-lipped carp (Tam. Selkendai) it contributes to a large proportion of the fishery of the Cauvery river and its reservoir systems. The colour of the fish is silvery along the back, becoming lighter on the sides and below. The fins are stained black. There is a dark blotch present on the caudal peduncle.

Food and feeding habits.—The food of the young stages of *Labeo fimbriatus* is entirely composed of planktonic organisms. Seventy per cent of the food is constituted by Diatoms and Desmids. The remainder is composed of Zooplankton (15 per cent Copepods and Cladocerans, 10 per cent Protozoans, 3 per cent Rotifera) and 2 per cent sand.

In the adolescent and adult stages it is a bottom feeder, browsing on filamentous algae and moss growing on rocks. A small amount of crustaceans and insect larvæ also are ingested. Often sand and very large amounts of mud are noted in the gut. In temple tanks and other waters subjected to organic pollution, this carp feeds voraciously on the filamentous blue green algæ *Oscillatoria* and *Microcystis*. The various organisms that comprise its diet are given below :—

Diatoms and Desmids : *Closterium*, *Cocconeis*, *Cyclotella*, *Cymbella*, *Desmidium*, *Eunotia*, *Fragillaria*, *Gomphonema*, *Pennularia*, *Stauroneis*, *Surirella*, *Synedra* and *Tabellaria*.

Green Algæ : *Ankistrodesmus*, *Spirogyra*, *Ulothrix* and *Oedogonium*.

Blue Green Algæ, *Aphanocapsa*, *Microcystis* and *Oscillatoria*

Protozoans : *Eudorina*, *Pandorina*, *Volvox*, *Vorticella*.

Rotifera : *Hydatina Rotifer*.
Copepods : *Eucyclops*, *Cyclops*, *Diaptomus*.
Cladocerans : *Daphnia*.
Ostracods : *Cypridopsis*.
Crustaceans : *Caridinia*, *Naupius larvæ*.
Insects : *Nepa*, *Notonecta*.
Mud and sand.

Fecundity and breeding.—The fringe lipped carp reaches sexual maturity when it is 260 to 300 mms. long.

In a gravid oozing female of a length of 516 mms. and weight of 2,270 gms., the ovaries weighed 200 gms. and contained 2,73,000 eggs of the following diameter frequency :—

Diameter. (1)	Percentage. (2)
0·6 mm.	9
0·8 ,,	8
1·0 ,,	11
1·2 ,,	28
1·4 ,,	30
1·8 ,,	2
2·0 ,,	1

The ovarian condition denotes an extended spawning. The fish spawns in the rivers during the monsoonic months of June to September. During this period the fish shows limited local migration in search of favourable breeding grounds. The spawning grounds are shallow marginal areas, two to four feet deep, with submerged and emergent vegetation such as *Colocasia antiquorum*, *Cyperus distans*, *C. exaltus*, *Herpestes monnieria*, *Lagarosiphon roxburghii*, *Nipa fruiticans*, *Panicum muticum*, *Polygonum tomentosum*, *Typha elephantina* and *Vallisneria spiralis*.

The size of the fertilized egg varies from 5.3 to 6 mm. diameter. The period of incubation is about 19 hours. The hatchling is 4·2 mm. in size, transparent, without pigment in the eye and without mouth and pectoral rudiments. The yolk is absorbed by the third day when the larva commences to feed. All the fins are differentiated by the 20th day when the fry is 16·5 mm. in size. The fry can be distinguished at this time by the ventrally situated mouth, a black shoulder spot and a grey circular patch on the caudal peduncle. The adult colour pattern is assumed when the fry is 28 days old and 22 mm. long. But the shoulder spot and the caudal spot disappear only when the fry attain a length of 50 mm. and 76 mm. respectively.

Growth.—The fish is reputed to grow to 75 to 85 cm. in the riverine condition. The commercial catches at Mettur are composed of specimens of a length range of 470 mm. to 580 mm. Occasionally specimens of 700 to 750 mms. also are caught. The comparative growth rates of the fringe-lipped crap in the river and the pond are furnished below :—

Year. (1)	River. (2)	Pond. (3)
	LENGTH.	LENGTH.
I	210 mm.	310 mm.
II	330 ,,	520 ,,
III	388 ,,	,,
IV	446 ,,	,,
V	504 ,,	,,
VI	562 ,,	,,
VII	620 ,,	,,
VIII	649 ,,	,,
IX	707 ,,	,,
X	736 ,,	,,

The growth of the fish in ponds is faster than in the rivers. In its natural environment *Labeo fimbriatus* is a slow growing, long living fish. The fish is found to grow very well in tanks having plenty of loose mud, organic debris and high organic pollution which brings in its wake a standing crop of the filamentous Blue green Algae.

Collection and transport of fry and fingerlings.—The fry of Labeo *fimbriatus* is available in large numbers from June to August in the river systems of Cauvery, Kistna and Godavari. The fingerlings can be collected in thousands in the channels and canals of the river system and the connected paddy fields from August to February.

Fry and fingerlings of Labeo fimbriatus are very hardy and stand transport very well. For short distances 500 fingerlings can be sent in one tin carrier. But for long distances overcrowding should be avoided and only 100 fingerlings should be transported in such tin carriers.

Labeo kontius.

Labeo kontius is known as Cauvery carp because it is peculiarly indigenous to the Cauvery system alone. It contributes to a very valuable fishery in the river and connected water systems of Cauvery. Next to *Cirrhina cirrhosa* it is the dominant major carp in Cauvery and its tributaries. The fish has a slaty colour and a red spot in the centre of each scale. The eyes are glossy and shining black in colour from which it derives its more common Tamil name " *Kaduvaichi kendai* " (the coal-eyed carp). Because of its conspicuous and thick snout, with the sub-terminal mouth and finely fringed lower lip, it is also called " *Pannicay kendai* " (the

pig mouthed carp) in certain places recapitulating to one's mind its similarity to the configuration of the pig's face. The fish is fairly abundant in the river throughout the year. In the very upper reaches of Cauvery the fish is rarely found.

Food and feeding habits.—In the young stages *Labeo kontius* is a surface feeder feeding mainly on zooplankton (45 per cent). Occasionally they have been found to gorge their stomachs with phytoplankton. Normally, however, phytoplankton forms only 30 per cent of food. Filamentous algae contribute to 20 per cent of the diet. The rest is made up of insect larvae, crustacean larvae and sand.

When it reaches adolescent and adult stages the fish becomes a browser feeding at the bottom. In its feeding habits it occupies almost the same feeding niche as *Labeo fimbriatus*. Aquatic macrovegetation (19 per cent) is avidly consumed by the fish. Filamentous algae (16 per cent), Diatoms (21 per cent), insects (9 per cent), worms (6 per cent), Copepods (4 per cent) and Crustaceans (3 per cent), form some of the other items of its food. A very high percentage of mud (22 per cent) is normally found ingested. While the presence of mud and worms and filamentous algae indicate its predominant bottom feeding and browsing habits, the occurrence of a fairly high percentage of planktonic organisms in the diet indicates that unlike many of its congeners it does not confine to the bottom alone for its food. The various organisms that contribute to its dietary menu are furnished below :—

Diatoms : *Fragillaria, Nitzschia, Cymbella, Cyclotella, Pinnularia, Navicula, Synedra, Tabellaria.*

Green Algae : *Cosmarium, Staurastrum, Scenedesmus, Ankistrodesmus, Selenastrum, Spirogyra.*

Blue green Algae : *Microcystis, Merismopedia, Spirulina, Oscillatoria.*

Protozoans : *Euglena, Trachylomonas.*

Copepods : *Cyclops, Diaptomus.*

Cladocerans : *Brachionus, Salpina, Pedalion.*

Insects : *Corixa, Ranatra, Plea, Micronecta.*

Crustaceans : *Caridina.*

Worms : *Nais.*

Vegetation : *Hydrilla, Bits of leaves.*

Mud.

It is interesting that the fish in lentic waters take more of the planktonic algae. Mud and organic debris formed only very minor items.

Fecundity and breeding.—The fish attains its maturity when it is about 280 to 300 mm. long.

A gravid and oozing female 37·7 cm. long had 76,582 ovarian ova of the following diameter frequency :—

Diameter.	Percentage.
(1)	(2)
0·6 mm.	2
0·7 ,,	1
0·8 ,,	2
0·9 ,,	6
1·2 ,,	20
1·7 ,,	69

The breeding season is from June to October and coincides with the monsoons. The fish spawns in the middle reaches of the river during the late hours of the night and early hours of dawn. Hogarnaikkal and Sundapatti are favourite breeding grounds of the fish. The fertilized egg is fairly large sized 3·7 to 4·4 mm. in diameter, demersal and transparent with a bluish tinge and a large perivitelline space. The period of incubation is about 27 to 30 hours. The hatchling is only 3 mm. long with a bluntly pointed head, rudimentary pectorals and 35 myotomes. The lens of the eye also is heavily pigmented.

When the larva is 10 days old and 12 mm. long, there are numerous and large chromatophores, on the dorsum of the head. There is a dark spot on the caudal peduncle and a row of chromatophores on the lateral line.

The fry of 32 to 36 mm. length and 1 month old had all the characters of the adult except the pigmentation and the proportion of the snout. There is a conspicuous lateral band extending from the operculum to the caudal peduncle where it is confluent with the caudal spot. Pigmentation is less below the lateral line except near the operculum.

Growth.—It grows to a size of over 2 feet in the fluviatile environment. Specimens of 350 to 500 mm. are common in the commercial catches of the Cauvery system and its tributaries.

The growth rate of the fish in ponds is given below :—

Year.	Length.
(1)	(2)
I	290 mm.
II	470 ,,
III	540 ,,

The growth is good in the first year and compares very favourably with that of *Labeo fimbriatus*. But after the first year the rate slows down. The fish grows well in ponds subjected to periodic and heavy organic pollution. Due to its ability in utilizing the organisms in the column layer of pond, the fish can safely be stocked with others of its own normal feeding niche without any deleterious effect.

Collection and transport of fry and fingerlings.—The fry of *Labeo kontius* can be collected in large numbers from the river system (Cauvery) and its branches from June to September. From October to February fingerlings are available in thousands in the channels and canals and paddy fields. *Labeo kontius* being an active fish do not stand transport when they are caught suddenly and transported in tin carriers. The fingerlings find it very difficult to quickly adjust themselves to the very limited space and consequently jump against the walls of the tin and injure themselves. Extreme care during collection and the least mechanical injury or shock are the factors that contribute to the success of transport. The fingerlings should be kept in a nursery for one week and then only transported in tin carriers.

CIRRHINA REBA.

Cirrhina reba is a minor carp of very great economic importance in South India. It is distributed throughout South India forming the major portion of the fishery of the various tanks connected with the river systems. It is silvery in colour with the dark edges of the scales forming bluish longitudinal bands above the lateral line. The young ones have sometimes a black tinge on the dorsal fin and a lead coloured band along the side. The fish is called Tattaranjan or Aranjan in Tamil.

Food and feeding habits.—The food of the young ones consist of the following :—

	PER CENT.
Diatoms	20
Algæ (mostly filamentous)	54
Rotifers, Daphnids and Copepods	14
Coleoptera larvæ	8
Sand	4

The food shows that the fish in the young stage itself is a browser feeding mostly on the filamentous algæ like *Spirogyra*, *Oscillatoria*, *Lyngbia* and *Rhizoclonium*. In the adolescent and adult stages also *Cirrhina reba* is a bottom feeder, browsing on the filamentous algæ at the bottom and covering the rocks and stones. Besides the items mentioned in the diet of the young ones, the adolescent and adults feed to a small extent on aquatic vegetation like the Duck weed. *Wolffia arrhiza*. The various organisms that compose its food are given below :—

Diatoms : *Nevicula*, *Tabellaria*, *Pinnularia*, *Campylodiscus*, *Amphora*.

Green Algæ : *Spirogyra*, *Rhizoclonium*, *Cladophora*.

Blue green algæ : *Oscillatoria*, *Lyngbia*, *Anabæna*, *Microcystis*.

Protozoans : *Euglena*, *Phacus*, *Paramaecium*.

Copepods : *Eucyclops*, *Mesocyclops*, *Pseudodiaptomus*.

Cladocerans : *Diaphanosoma, Ceriodaphina.*
Rotifers : *Pedalion, Hydatina.*
Polyzoans.
Insects : *Coleopteran larvæ.*
Vegetation : *Wolffia arrhiza.*

Fecundity and breeding.—Sexual maturity is attained very early in its first year itself. In rivers the fish is found to become mature when it is 100 mm. long. But in ponds they have been found to become mature only when they are 230 to 250 mm. long.

The fish breeds in rivers and streams during the south-west and north-east monsoons from June to October. The breeding conditions of this minor carp appear to be very varied. They have been found to breed in absolute summer conditions and also in conditions of high floods and turbidity. "Availability of suitable spawning grounds during the breeding season, either by flooding of the adjacent stretches by rain water or by lowering of the level of water and the consequent partial exposure of the shallower portions of the river bed thus appears to be one of the main factors responsible for spawning."

The fertilized eggs are spherical and almost transparent with a diameter of 2·8 to 3·2 mm. The yolk is granulated and there is no oil globule. Incubation is for about 14 hours. The newly hatched larva is 3·3 to 3·7 mm. long and is pigmented. The lens of the eye is clear. The yolk gets absorbed on the third day and independant feeding is resorted to. In the second week the larva measures 11 mm. and has bluish pigments along the lateral line. Three to five black spots also appear at the base of the caudal. In the third week it measures 16 mm. and a dark bluish band is formed along the lateral line. Adult characters are assumed within eight weeks after hatching.

Growth.—Though the fish reaches a length of 300 mm, specimens of 170 mm. to 240 mm. form the major size groups in the commercial catches of the river and tanks.

The growth in ponds is on furrows :—

	Year.	Length.
I. 230 mm.	I	230 mm.
II. 289 mm.	II	289 mm.

The growth of the fish is very rapid almost reaching its maximum size in the first year itself. Since it is not a species that will grow to a good size this fish is suggested for cultural purposes only in the absence of the major carps.

Collection and transport of fry and fingerlings.—The fry is available in large numbers in the Cauvery, Godavari, Krishna and Bhavani rivers from June to September. Very large numbers of fingerlings can be collected from the channels and canals and at the regulators of Cauvery system from September to March. The fry and fingerlings are very hardy and stand the transport very well.

CIRRHINA CIRRHOSA.

The white carp, *Cirrhina cirrhosa*, is the most abundant carp and forms the main bulk of the fisheries of Cauvery. Growing to over 1·5 feet in length it predominates in the large congregation of fish in Mettur reservoir and its channels. The fish is a very active one. This fish is silvery in colour and every scale has a red spot in the centre. Because of its silvery white colour the fish is called Venkendai in Tamil, meaning the white carp. The white carp is peculiar to Cauvery system alone. Even in the Bhavani river which is a tributary of Cauvery, *Cirrhina cirrhosa* is rare.

Food and feeding.—*Cirrhina cirrhosa* is a plankton feeder throughout its life history. In the young stages, only planktonic organisms are ingested. The diet consists of 78 per cent diatoms and unicellular algæ and 20 per cent zooplankton (*Copepods*, *Daphnids*, *Ostracod* and *Nauplius larvæ*). Two per cent of fine sand also is noticed. This must be mostly from the suspended material in water. In the adult and adolescent stages the fish includes in its diet fair amounts (19 per cent) of filamentous algæ also. But it is at this stage predominantly a plankton feeder also taking in 52 per cent Diatoms and unicellular algæ, and 29 per cent of zooplankton. The detailed list of organisms comprising its food is furnished below :—

Diatoms : *Amphora, Fragillaria, Navicula, Nitzschia, Pinnularia, Rhopalodia, Surirella.*
Green Algæ : *Ankistrodesmus, Cosmarium, Pediastrum, Scenedesmus, Spirogyra.*
Blue green algæ : *Anabæna, Microcystis, Oscillatoria.*
Protozoans : *Arcella, Difflugia, Euglena, Phacus.*
Rotifers : *Brachionus, Salpina.*
Cladocerans : *Ceriodaphnia, Diaphanosoma.*
Ostracods : *Cypridopsis.*
Copepods : *Microcyclops, Eucyclops, Diaptomus.*
Crustaceans : *Nauplius larvæ.*

Very rarely insect larvæ and aquatic weeds also have been noticed to have been ingested by a few individuals. But predominantly the fish is a surface feeder. Its top feeding habit is perhaps indicated by the fact that it constitutes the majority of the catch in the surface drift nets (Rangoon nets) in the Mettur Reservoir.

Fecundity and breeding.—It becomes sexually mature when it reaches a size of 220 to 240 mm. The males have their first dorsal fin ray elongated.

A fully gravid female 403 mm. long and weighing 970 gms. had ovaries weighing 167 gms. and containing 170,340 eggs of the following diameter frequency :—

Diameter. (1)		Percentage. (2)
0·8 mm.	...	22
0·9 ,,	...	47
1·2 ,,	...	31

Another fully gravid female 425 mm. long and weighing 1,10[illegible] gms. had its ovaries weighing 171 gms. and containing 178,978 eggs of the following diameter frequency :—

Diameter (1)	Percentage. (2)
0·9 mm.	8
1·1 ,,	18
1·2 ,,	31
1·3 ,,	43

The ovarian condition indicates a quicker spending of the ovary unlike several other major carps.

The spawning season coincides with the south-west monsoons and extends from June to September. During the breeding season, shoals of this fish have been noticed to undertake a spawning migration to the pools below the Hoggainaikkal falls.

Growth.—*Cirrhina cirrhosa* is reputed to grow to a length of over 150 mm. in the rivers.

Specimens of 500 to 550 mm. are occasionally caught in the Mettur Reservoir. But the commercial catch comprises mostly of 400 to 500 mm. No detailed data are available on the rate of growth of the fish in the fluviatile conditions. Its rate of growth in the ponds is given below :—

Year. (1)	Length. (2)
I	370 mm.
II	490 ,,

Because of its rapid growth, and surface feeding and non-carnivorous nature, it is an ideal fish for combined culture with Labeo fimbriatus or some other browsing and bottom feeding fishes and also in tanks that contain rich blooms of phytoplankton.

Collection and transport of fry and fingerlings.—Fry can be collected in large numbers in Cauvery from July to October. The fingerlings are available in thousands in the channels and canals of Cauvery river system from October to March. The fingerlings have a tendency to periodically jump and so they have to be kept in nurseries for at least a week to get acclimatised to confined conditions and then transported in tin carriers. Overcrowding has to be avoided. Hundred fingerlings in a tin carrier are quite safe and sufficient for long distances. The fry and fingerlings stand transport fairly well.

CIRRHINA MRIGALA.

Day has recorded *Cirrhina mrigala* (the Mrigal) only in the rivers north of Godavari. From 1944 the Madras Fisheries has been transporting large numbers of fry and fingerlings of this fish from Bengal and stocking them in the South Indian rivers and

reservoir systems with a view to establishing this in these water systems. In 1947 *Cirrhina mrigala* fingerlings were recorded in the Godavari river and by 1948 it was noticed that the Mrigal contributed to 30 per cent of the fish caught in Godavari and sold in the Rajahmundry markets. In general appearance it closely resembles the white carp, *Cirrhina cirrhosa* but differs from the latter in having only 2 barbels and the deeper kinkish tinge to the body from which the Telugu name of " Yerrameenu " is given to it meaning the " red fish ".

Food and feeding habits.—Mrigala is mainly a herbivorous fish at all stages. There is no difference in the food of the young and adults. The fish feeds mostly on blue green algæ, green algæ and diatoms. The organisms that constitute its diet are given below :—

Diatoms : Ampura, Cyclotella, Cymbella, Eunotia, Fragillaria, Frustulia, Nitzschia, Navicula, Pinnularia, Stauroneis, Synedra.

Green Algæ : Ankistrodesmus, Closterium, Cosmarium, Crucigenia, Mougeotia, Oedogonium, Pediastrum, Pleurococcus, Pleurotaenium, Scenedesmus, Staurastrum, Vaucheria.

Blue green algæ : Anabaena, Anabaenopsis, Gleotricha, Merismopedia, Microcystis, Spirulina.

Protozoans : Euglena, Glenodenium, Glaucoma, Pandorina, Phacus, Paramaecium, Stylonichia.

Rotifers : Conchilus, Diurella, Pedalion.

Crustaceans : Alonella, Bosmina, Ceriodaphnia, Cypridopsis, Diaptomus, Eucyclops.

The herbivorous habit of the fish is very well indicated by its long intestinal coil, which measured 1,524 cm. in a specimen of 75 cm. length.

Fecundity and breeding.—The Mrigal attains its sexual maturity in the first year itself at a size of 400 to 450 mm. A gravid female of 550 mm. contained in it 198,263 eggs. The ovarian condition shows that the spawning is of an extended nature.

The fish spawns in the Godavari, Krishna and Cauvery rivers from June to October. The fry and fingerlings are available in these rivers and their canal systems from July to January.

Growth.—Though the fish is reported to grow to a size of 85 cms. such monster specimens are not usually seen in the commercial catches of the rivers. Specimens of 500 to 600 mm. are common in these catches. The fish grows very rapidly in its early years. The rates of growth of the fish in the river and tanks are given below :—

Year. (1)	River. (2)	Tanks. (3)
I	500 mm.	580 mm.
II	640 ,,	720 ,,
III	,,	780 ,,

Some fry of mrigal brought from Bengal and stocked in Chetpet fish farm grew to a size of 330 mm. in four years. The growth appears to be very rapid in the first year and then it falls off very steeply in subsequent years.

Its rapid growth and non-cannibalistic habits make it a very ideal fish for culture in ponds and tanks having very good algal blooms and subjected to heavy organic pollution.

Collection and transport of fry and fingerlings.—The fry and fingerlings are available in fair numbers in the canals and channels of the irrigation systems of Godavari, Krishna and Cauvery from July to January. The fingerlings are collected by means of basket traps set against the flow of water in the channels and canals or by dip nets at the regulators.

The fry and fingerlings stand the transport very well. Hundred to 125 fingerlings of 25 mm. to 60 mm. size can be transported safely in one-tin carrier over a distance of 450 miles.

Barbus dubius.

One of the large-sized fluviatile carps of South India, this fish is peculiar to the Cauvery and Bhavani rivers in South India. Day has recorded it only in Bhavani at the foot of the Nilgiri hills. The fish has an elevated snout which is slightly drawn out in the form of a small beak, from which its name "*Kozhimeen*" (Cock fish) is derived. The fish is silvery in colour with a predominant pale red giving a tinge to the scales. The scales of the male display bluish reflections. The snout of the fish has many pores or tubercles. In the male these pores or tubercles are more in number than in the females.

Barbus dubius contributes to a very appreciable quantity of the fishery of the large reservoir systems of the Cauvery river and its tributaries. It contributes to about 10 per cent of the fishery at Mettur and 60 per cent of the fishery at Bhavanisagar. The fishery is fairly uniform throughout the year.

Food—Young ones.—The young stages of *Barbus dubius* scoop up insect larvae and filamentous algae from the marginal substratum. As much as 55 per cent of the food consists of insect larvae and 30 per cent of filamentous algae like *Spirogyra* and *Oscillatoria.*

Adolescents and adults.—*Barbus dubius* is mainly a Phytoplankton feeder occasionally browsing at the bottom on gastropodan shells. The organisms fed upon by the fish are given below :—

Diatoms : *Amphora, Cocconeis, Cymbella Diatoma, Eunotia, Fragillaria, Gomphonema, Melosira, Meriodon, Navicula, Nitzschia, Pinnularia, Pleurosigma, Stephanodiscus, Surirella, Synedra.*

Blue green algae : *Anabaena, Gleotricha, Merismopedia Oscillatoria, Spiralina.*

Green Algæ : *Ankistrodesmus, Closterium, Cosmarium, Eudorina, Mougeotia, Oedogonium, Scenedesmus, Spirogyra.*

Copepods : *Eucyclops, Diaptomus.*

Cladocerans : *Bosmina, Ceriodaphnia, Daphnia, Diaphanosoma.*

Rotifers : *Brachionus, Diurella, Hydatina, Pedalion.*

Ostracods : *Cypridopsis.*

Gastropods : *Limnæ.*

Insects : *Chironomid larvae, Laccotrephes, Mesovelia, Limnogonus, Plea* and *Corixid bugs.*

Fecundity and breeding.—The fish displays sexual dimorphism. The males have comparatively more pores in an elongated patch on either sides of the cheek than the female. The scales of male show bluish reflections while those of the female are silvery with a pale red tinge.

The fish reaches its maturity when it is 250 mm. long. The normal spawning season is from July to November. But the fish has been seen to breed during the scattered showers of off season also. Normally the spawners move upstream to spawn in the upper reaches of the river. But the fish has been occasionally found to breed throughout the river also. The fertilized egg is demersal and is 2 mm. in diameter. Incubation takes about 2·5 days and the hatched larva is very slender with an elongated yolk sac and a delicate median fin.

Growth.—The fish grows in the lacustrine condition of reservoir systems at the following rate :—

Year.		Size.
(1)		(2)
I	--	250 mm.
II	--	370 ,,
III	--	450 ,,

It has not been possible to culture the fish in tanks and ponds unconnected with rivers. The fish requires very typical fluviatile conditions and as such is not useful for pond culture. For large reservoir systems the fish is very ideally suited due to its quick growth.

Collection and transport of fingerlings.—Fingerlings of 25 mm. to 100 mm. can be collected in the Cauvery and Bhavani river systems after the monsoon months from October to February. A few from the spawning of scattered showers of off season can be collected in May also. The fingerlings are very frail and less hardy and do not stand transport to great distances. A few were transported with great care to Madras from Bhavani but they did not survive the conditions in the ponds. Repeated attempts ended only in failure denoting the necessity of typical fluviatile conditions for the survival and growth of the fish.

REPORT TO INDIAN COUNCIL OF AGRICULTURAL RESEARCH ON THE

BARBUS CARNATICUS.

Known as the Carnatic carp of Jerdon, this has a very restricted distribution, which according to Day confines to the rivers at the foot of the hills of Western Ghats. This major barbel is indigenous to South India. *Barbus carnaticus* is an excellent sporting fish and specimens of over 600 mms. are occasionally taken from the Cauvery and Bhavani. Like the chocolate mahseer, this fish also is more frequent in the Bhavani river. It would appear that the natural stocking of Cauvery river system is from the Bhavani river. The fish is called locally as "*Fouri*" in Tamil.

Food and feeding habits.—*Barbus carnaticus* in the young stages is predominantly a surface feeder. As much as 45 per cent of its food consists of insect larvae. Besides this the food consists of 13 per cent Diatoms and Desmids, 30 per cent of algae (Green and Blue green) and 10 per cent zooplankton. A very small quantity (2 per cent) of sand is seen occasionally due to the feeding on the filamentous algae from the margins.

Adolescent and adults.—Unlike the young stages, *Barbus carnaticus* in the adolescent and adult stages is primarily a browser feeding mainly on the spreading filamentous algae (39 per cent) and macro vegetation (32 per cent). Insects formed about 11 per cent of the food. Unicellular algae were also usually seen in the stomach. The occurrence of this in a proportion of 14 per cent is of interest. While normally this would indicate a fair amount of surface feeding, it is found that the majority of these planktonic unicellular algae are caught up in the filaments of or living as epiphytes on *Spirogyra*, *Oscillatoria* and other algae. It is therefore probable that the unicellular algae were taken in along with the clumps of filamentous algae. A very negligible (0·5 per cent) quantity of fish also is included in the diet.

The fish in its adolescent and adult stages is a decidedly herbivorous feeder, browsing on the algal growth, or aquatic weeds and vegetation and occasionally taking in organic debris from the bottom. The various organisms found in its food are given below :—

Diatoms and Desmids : ***Amphora***, ***Cyclotella***, *Cymbella*, *Diatoma*, *Eunotia*, *Fragillaria*, ***Gomphonema***, ***Melosira***, *Navicula*, *Nitzschia*, *Pinnularia*, *Surirella*, *Synedra*, *Cosmarium*.

Green Algae : *Ankistrodesmus*, ***Oedogonium***, ***Pediastrum***, *Rhizoclonium*, *Scenedesmus*, *Spirogyra*, ***Tribonema***.

Blue green algae : *Coelosphaerium*, *Gloeotrichia*, *Merismopedia*, *Lyngbya*, *Oscillatoria*.

Protozoa : *Euglena*, *Trachelomonas*.

Cladocerans : *Ceriodaphnia*, ***Diaphanosoma***.

Copepods : *Eucyclops*, ***Diaptomus***.

Ostracods : *Cypridopsis*.

Decapod crustaceans : ***Palaemon***, ***Caridina***.

Insects : *Plecopteran Larvae*, *Mesovelia*, *Limnogonus*, *Plea*, *Micronecta*.

Macrovegetation : *Ceratophyllum*, *Hydrilla*, *Potamogeton*, *Vallisneria*.

Fecundity and breeding.—Sexual maturity is attained in the first year itself when the fish is 120 to 130 mm. in size.

A gravid and oozing female of 450 cm. length and 1,254 gms. weight contained 7,430 eggs of the following egg diameter frequency :—

Diameter. (1)		Percentage. (2)
0·7 mm.	—	12
0·95 ,,	—	50
1·25 ,,	—	38

The ovarian condition is significant of extended spawning. The spawning season is from September to January. Spawning occurs throughout the length of the Bhavani river. Spawning of *B. carnaticus* has also been found to take place in the upper limits of Mettur Reservoir in extreme summer condition of low level of water, absence of monsoons and rain and perfectly clear water that are features not ordinarily associated with spawning of carps.

Growth.—The Carnatic carp is reputed to grow to over 600 mm. in length in the fluviatile environment. Specimens of 400 to 450 mm. are common in the commercial catches of the Bhavanisagar and Mettur Reservoir systems. The growth of the fish in the ponds is slower than in the fluviatile natural environment as can be seen from the comparative statement below :—

Year. (1)		Fluviatile. (2)	Ponds. (3)
I	—	175 mm.	170 mm.
II	—	300 ,,	296 ,,
III	—	360 ,,	350 ,,

The slow growth of the fish is not in its favour for active use in fish culture. But like *Barbus hexagonolepis* this can be used in ponds containing a very large quantity of decaying vegetable and organic debris at the bottom and in ponds having large quantities of the aquatic macro vegetation. Because of the high preference of the young ones of this fish for insects and insect larvae, introduction of the fingerlings of the fish for control of mosquito larvae can be effectively combined with its own culture for the table.

Collection and transport of the fry and fingerlings.—Early fry of the Carnatic carp are available in plenty in the Cauvery and Bhavani rivers at Bhavani from September to December. They are more available especially in the Bhavani river. Fingerlings of 25 mm. to 50 mm. are available at Bhavani from February to April. The fry and early fingerlings of the carp have a very dark and conspicuously rounded black caudal spot. The Dorsal fin is not

pigmented and their pectoral and ventral fins are ordinarily colourless and transparent. The fry of 10 mm. to 25 mm. are very hardy. Two hundred to 250 can be transported easily in one tin carrier over a distance of 200 miles. Advanced fingerlings of 100 mm. to 120 mm. stand transport fairly well. The tin carrier should not be overcrowded. One hundred fingerlings is a safe number for a tin carrier.

Barbus hexagonolepis.

Popularly called the Chocolate mahseer, *B. hexagonolepis* had been believed to be found only in the hill streams of Assam and Himalayan regions. The occurrence of this species in Cauvery and Bhavani is therefore interesting from the point of view of zoogeographical distribution. It is very common in the Bhavani and the fish contributes to a very significant proportion of the catches in Bhavanisagar Reservoir. Though they are not so common in the Mettur Reservoir, they are very frequently caught in the lower regions of Cauvery. Most probably the stocking of the Cauvery stretches with *B. hexagonolepis* takes place from Bhavani river. Because of its chocolate colour the fish is popularly called locally "Karambai" (Tamil) meaning the "Black one".

Food.—The young ones of *B. hexagonolepis* is a pure surface feeder feeding on diatoms (20 per cent), Algae (25 per cent), zooplankton (16 per cent) and insect larvae (35 per cent). A very small quantity of sand (2 per cent) is found in the stomach indicating occasional feeding from the marginal sides.

Adults.—*Barbus hexagonolepis* in the adult stages is a vegetable feeder feeding on plants like *Vallisneria* and *Hydrilla*. The fish is a very voracious feeder and usually the stomach and gut will be gorged with contents. Gastropod shells and worms also are ingested sometimes, indicating occasional feeding at the bottom in the marginal areas. The organisms that compose the food of the fish are furnished below :—

Diatoms : *Navicula, Fragillaria, Amphora, Synedra, Gomphonema, Cymbella, Cosmarium, Nitzschia.*

Blue green algae : *Oscillatoria, Merismopedia.*

Green algæ : *Spirogyra, Ulothrix, Oedogonium, Scenedesmus.*

Copepods : *Eucyclops, Diaptomus, Gastropod shells.*

Aquatic Vegetation : *Vallisneria, Grass, Hydrilla.*

Very small amounts of fish remains also are noticed, in the food occasionally.

Fecundity and breeding.—The fish reaches its maturity in the first year itself when it is about 180 mm. in length.

A gravid and oozing female of 519 mm. length and 2,280 gms. contained 30,200 eggs of the following diameters :—

Diameter. (1)	Percentage. (2)
0·99 mm.	25
1·2 ,,	24
1·35 ,,	13
1·5 ,,	28
2·1 ,,	10

The occurrence of eggs of varying diameters show that the spawning is one of extended nature. The fish does not spend itself completely and entirely at a time. This is seen in the extended spawning season of the fish from August to December. Fry and fingerlings are collected in the Bhavani and Cauvery river systems from September to February. The peak period of appearance of the fry and fingerlings is from October to December.

Growth.—The Chocolate mashеer is reputed to grow to more than 600 mm. in length. Specimens of 450 to 560 mm. (18 inches to 22 inches) are very common in the catches of the Bhavanisagar Reservoir. The growth of the fish in the fluviatile and pond conditions are furnished below :—

Year. (1)	Fluviatile. (2)	Ponds. (3)
I	235 mm.	269 mm.
II	345 ,,	380 ,,
III	400 ,,	...

The growth of the fish in ponds is greater than in the natural fluviatile condition unlike what was thought to be. The fish is a very hardy one and is ideal for ponds containing large quantities of submerged water plants and weeds and plenty of decaying vegetable debris.

Collection and transport of fry and fingerlings.—Large numbers of fry of *B. hexagonolepis* appear in the river Bhavani from September to December. Fair numbers of fingerlings can be collected from January to March. The fry have the anterior margin of the dorsal fin darker in colour and the caudal spot is not very conspicuous. The fry of 10 mm. to 50 mm. are the best to transport. They are very hardy and stand long distances very well. Overcrowding in the tins has to be avoided. Four hundred to 600 fry of 10 mms. per tin is a safe number in each tin for a distance of 200 miles.

Barbus curmuca.

Buchanan's carp, *Barbus curmuca*, is a large carp common in the upper reaches of the rivers of the Western Ghats. It descends to the plains also and are fairly common in rivers in the plains of Malabar, South Kanara and Madurai districts. They have been

frequently noticed to descend to the tidal limits for feeding purposes. But its normal range of distribution, otherwise, is the rivers in the hill regions above 2,500 feet. This species is a good sporting fish like the Carnatic carp. It can be caught with worms, insects, artificial flies and spools. Bits of boiled tapioca and sweet potatoes are also used as bait for this fish.

Food and feeding habits.—The fish in its young stages, is mainly a plankton feeder. Fifty per cent of its food consists of phytoplankton. The other compounents are 30 per cent zooplankton, 18 per cent insect larvae and 2 per cent filamentous algae and sand.

In the adolescent and adult stages Buchanan's carp is a vegetable feeder, occupying the same feeding niche as the Chocolate Mahseer. Thirty-eight per cent of its diet is macrovegetation like *Hydrilla*, *Ceratophyllum* and *Riccia*. Filamentous algae constitute 23 per cent. The various organisms that constitute its food are furnished below :—

Diatoms : *Achnanthes*, *Bacillaria* *Cocconeis*, *Diatoma*, *Eunotia*, *Fragillaria*, *Gomphonema*, *Melosira*, *Navicula*, *Nitzschia*, *Pleurosigma*, *Stephanodiscus*, *Synedra* and *Tabellaria*.

Green Algae : *Chaetophora*, *Closterium*, *Desmidium*, *Gonatozygon*, *Microspora*, *Mougeotia*, *Oedogonium*, *Selenastrum*, *Spirogyra*, *Tetraspora*, *Tribonema*, *Ulothrix*, *Zygnema*.

Blue green algae : *Anabaena*, *Aphanocapsa*, *Microcystis*, *Nostoc*, *Oscillatoria*.

Bryozoa : *Riccia*.

Macrovegetation : *Ceratophyllum*, *Hydrilla*.

Protozoans : *Euglena*, *Phacus*, *Lacrymaria*, *Zoothamnium*.

Rotifera : *Hydatina*, *Pedalion*.

Cladocerans : *Ceriodaphnia*, *Diaphanosoma*.

Ostracods : *Cypridopsis*.

Copepods : *Eucylops*, *Pseudodiaptomus*, *Nauplius*, *Larvae*.

Decapods : *Caridinia*.

Worms : *Nais*.

Insects : Larvae of *Chironomus* and *Ephemeroptera*, *Microvecta*, *Laccotrophes*, *Cylindrostethus*, *Metrocoris*, *Plea* and *Ptilometra*.

Breeding.—The fish attains maturity at a very early stage in the case of males when they are 100 mm. long. In the case of the females, maturity is reached at a size of 150 mms. Breeding occurs in the hill stretches of rivers and streams having sand bed with thick vegetation. Breeding takes place during the south-west monsoon from June to August. The eggs are demersal and measure 0·6 to 0·8 mm. in diameter. The hatchlings have an elongated transparent body with brown stellate chromatophores arranged in two long bands. They congregate in pools below small rocky falls.

Growth.—The fish is reported to grow to a size of 1,200 mm. in the upper reaches of the rivers in Malabar. Attempts have not been made to grow them in lentic condition and as such details of their growth have not been gathered.

Collection and transport of fingerlings and fry.—The fry and fingerlings can be collected in the upper reaches of rivers in Malabar and South Kanara and in the Periyar lake from June to September. No attempt has so far been made to transport the fry and fingerlings.

Barbus chrysopoma.

Barbus chrysopoma or the Olive carp constitutes a valuable fishery in the rivers and tanks of South Kanara and Tanjore districts. Though not so common, it occurs occasionally in the commercial catches of Bhavanisagar and Mettur Reservoirs. In the Deltaic canals and rivers of the Cauvery system, the young ones of *Barbus chrysopoma occur* in very large numbers especially at the regulators. The fish is called " Panjalai " in Tamil. The fish contributes 10 to 75 per cent of the catches of the tank and river systems in South Kanara district.

Food and feedings habits.—In the young stages, *B. chrysopoma* is mainly a surface feeder. As much as 40 per cent of its food is composed of zooplankton. The remainder consists of 35 per cent phytoplankton (*Diatoms* and *Desmids*), 10 per cent insect larvae, 12 per cent filamentous algae like *Spirogyra* and *Oscillatoria* and 3 per cent of sand and organic remains.

The olive carp in its adolescent and adult stages is predominantly a column feeder, feeding voraciously on the faster moving and larger crustaceans like *Caridinia*. In the diet it was found that as much as 55 per cent was composed of these Decapod crustaceans. A fair amount (10 per cent) of fish like *Perilampus*, *Nuria* and *Amblypharyngodon* also are ingested. At the various regulators of Cauvery system in the deltaic region large shoals of adolescent olive carp can be noticed snapping very voraciously at the shrimps and small fishes like *Nuria* and *Amblypharyngodon*. The following is a comprehensive list of the organisms forming the food of this species :—

Diatoms and Desmids : *Achnanthes*, *Bacillaria*, *Cocconeis*, *Diatoma*, *Eunotia*, *Fragillaria*, *Gomphonema*, *Melosira*, *Navicula*, *Nitzschia*, *Pleurosigma* and *Synedra*.

Green algae : *Chaetophora*, *Closterium*, *Desmidium*, *Gonatozygon*, *Microspora*, *Mougeotia*, *Oedogonium*, *Selenastrum*, *Spirogyra*, *Tetraspora*, *Tribonema*, *Ulothrix*, *Zygnema*

Copepods : *Cyclops, Eucyclops, Diaptomus.*

Decapods : *Caridinia.*

Polyzoa : *Pinnatella.*

Aquatic vegetation : *Ceratophyllum, Hydrilla, Lemna.*

Molluscs : *Limnaea, Melanoides.*

Other items : *Sand and small twigs.*

Fecundity and breeding.—Catla attains its maturity when it is about 550 mm. long.

The spawning season coincides with the south-west monsoons and is from June to September. Catla does not breed in small confined waters. It spawns in rivers and large water systems like reservoirs and bund type of tanks where fluviatile conditions occur during the floods.

The breeding grounds are usually parts of river containing large submerged rocks or emergent vegetation. Spawning migrations are mainly restricted to the plains and migrations to the upper reaches are seldom seen.

The fertilized egg is spherical, transparent demersal and without oil globules and measures 4·3 to 5·1 mm. in diameter. It has got a very large peri-vitelline space. Incubation is for 16 to 18 hours. The newly hatched larva is 4·3 to 5·2 mm. in size. It has a transparent body and conspicuous eyes. The fry of 8 to 10 mm. length has a large head, red-tinged operculum and a wide mouth. In five weeks the fry reaches a size of 30 mm. and has its mouth turned upwards. The body developes a greenish brown colour with a golden tinge over the head region. The adult characters are reached in six weeks.

Growth.—The Catla is the quickest growing fresh water fish in South India. In large reservoir systems the growth rate of Catla has been the following :—

Year. (1)		Length. (2)
I		
II	—	600 mm.
III	..	950 ,,
	..	1,120 ,,

In small tanks the growth rate has been the following on an average :—

Year. (1)		Length. (2)
I		
II	—	320 mm.
III	..	530 ,,
	—	700 ,,

The fish has been noted to grow very fastly in highly alkaline tanks containing large quantities of aquatic weeds.

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Because of its quick growth and non-predatory habits, the fish is a very ideal one for pond culture. It is the best suited fish for seasonal tanks also.

Collection and transport of fry and fingerlings.—The fry and fingerlings are available in the Godavari, Kistna and Cauvery river systems from July to November. They are collected from the channels and canals and the paddy fields by drag nets, dip-nets and basket traps. The fry and fingerlings are hardy and stand transport very well. One hundred to one hundred and fifty fingerlings of 25 to 40 mm. can be transported in one tin carrier, over a distance of 400 miles safely. The fingerlings have to be conditioned for 48 hours before transport.

Thynnichthys sandkhol.

Thynnichthys sandkhol is a medium sized carp and is an interesting example of discontinuous distribution. It occurs in Malaya, and in South India it appears in the Godavari, Kistna and Tungabhadra. This discontinuous distribution is regarded as an evidence for the Malayan affinities of the fresh water fauna of Peninsular India. The fish can be very easily recognized by its silvery sheen, minute scales and spindle-shaped body. Though not so common as *Labeo fimbriatus* and *Cirrhina reba*, it contributes to a fair fishery in the Godavari, Kistna and Tungabhadra.

Food and feeding habits.—Both the young ones and adults are predominantly phytoplankton feeders, ingesting mostly diatoms and unicellular algæ. Sand grains and mud also are occasionally met with in the stomachs. The various organisms that contribute to its diet are given below :—

Diatoms : *Achnanthes, Amphora, Anomoeneis, Cocconeis, Cyclotella, Cymbella, Eunotia, Fragillaria, Gomphonema, Gyrosigma, Melosira, Navicula, Nitzschia, Pinnularia, Rhopalodia, Surinella, Synedra, Tabellaria.*

Green algæ : *Ankistrodesmus, Chlorococcus, Closterium, Coelastrum, Cosmarium, Crucigenia, Eudorina, Gontobygon, Mougeotia, Oedogonium, Oocystis, Pediastrum, Pinnularia, Pleurococcus, Scenedesmus, Spaerocystis, Spirogyra, Tribonema.*

Blue green algæ : *Anabæna, Gleotrichia, Merismopedia, Microcystis, Oscillatoria, Spirulina.*

Protozoans : *Chlamydomonas, Euglena, Trachelomonas, Glenodenium, Phacus, Stylonichia.*

Rotifers : *Conchilus, Diurella, Pedalion, Rotifer, Noctiluca.*

Daphnids : *Alonella, Bosmina, Ceriodaphnia, Diaphanosoma, Simosa, Stenocypris.*

Copepods : *Diaptomus, Eucyclops, Microcyclops.*

Blue green algæ : *Anabaena*, *Aphanocapsa*, *Microcystis*, *Oscillatoria*.

Protozoans : *Euglena*, *Phacus*, *Lacrymaria*, *Zoothamnium*.

Rotifers : *Hydatina*.

Cladocerans : *Ceriodaphnia*, *Diaphanosoma*.

Copepods : *Eucyclops*, *Pseudodiaptmus*, *Nauplius larvae*.

Ostracods : *Cypridopsis*.

Decapods : *Caridinia*.

Insects : *Chironomus*, *Ephemeroptera larvae*, *Micronecta* and *Plea*.

Fish : *Nuria*, *Amblypharyngodon* and *Perilampus*.

Sand.

Macrovegetation : *Ceratophyllum*, *Hydrilla*.

Fecundity and breeding.—The fish attains sexual maturity in the first year itself when it is 120 to 130 mm. long.

A gravid and oozing female of 302 mm. in length and 460 gms. in weight contained 3,956 eggs of the following diameters :—

Diameter. (1)		Percentage. (2)
0·6 mm.	...	2
0·7 ,,	...	8
0·8 ,,	...	72
0·9 ,,	...	12
1·0 ,,	...	6

The fish breeds along river sections having submerged boulders and vegetation. The breeding takes place during the rainy season from July to October.

Growth.—The fish is a very slow growing one. In the fluviatile environment it is reported by Day to grow to about 900 mm. But such " monster " specimens have not been noticed in these investigations. Specimens of 300 to 350 mm. length are occasionally found in the commercial catches of Mettur and Bhavanisagar reservoirs. Its growth in ponds is the following :—

Year. (1)		Length. (2)
I	...	180 mm.
II	...	330 ,,

In the absence of the Decapod crustaceans this fish is likely to turn more of a piscivore and hence the introduction of this fish in a combined culture with other fishes has to be viewed with a certain amount of scepticism. In tanks which harbour a large number of *Caridinia* it will be worthwhile to introduce this fish.

Collection and transport of fry and fingerlings.—The fry of olive carp is available in large quantities in the rivers of South Kanara from July to September and in the Bhavani river from September to December. Large numbers of fingerlings of this fish are available in the channels and canals of the Cauvery Delta from November to February. The fry and fingerlings stand transport over long distances very well in tin carriers. They are very hardy. One hundred and fifty fry of 10 mm. to 25 mm. in one tin carrier can very easily transported over a distance of 300 to 400 miles safely.

CATLA CATLA.

Next to Mahseer, *Catla* is the largest carp in Indian waters. It is characterised, by a broad head, absence of barbels, prominent operculum and a lower lip with a continuous transverse fold. The distribution according to Day (1889) is " Sind, Punjab and throughout India to the Kistna " and eastwards though " Bengal and Burmah to Siam; not known to occur in India, south of Kistna nor in Tennasserim ". The fish has in recent years, after the construction of the Kurnool-Cuddapah canal, migrated to the Pennar and other water systems in Nellore district. From 1922 the Madras Fisheries Department has systematically transplanted several thousands of Catla fingerlings in the upper reaches of Cauvery, from the Godavari and Kistna and to-day the fish has stabilized very well in the Cauvery, breeding and growing very satisfactorily. The fish is called *Kistna botchu* (Krishna carp) in Telugu and *Topa meen* in Tamil.

Food and breeding.—Catla in all its stages is predominantly a plankton feeder. In the adult and adolescent stages it feeds periodically on the aquatic vegetation also. Occasionally it browses on the marginal bottom on the filamentous algae and molluscan forms. In its young stages it feeds entirely on plankton and filamentous algae (45 per cent Diatoms and unicellular algae, 35 per cent zooplankton and 20 per cent of filamentous algae). The various organisms that constitute its diet are listed below :—

Diatoms : *Amphora*, *Cocconeis*, *Coscinodiscus*, *Cyclotella*, *Cymbella*, *Eunotia*, *Fragillaria*, *Gomphonema*, *Melosira*, *Navicula*, *Nitzschia*, *Pinnularia*, *Podosira*, *Surirella*, *Synedra*, *Tabellaria*.

Green algae : *Ankistrodesmus*, *Chara*, *Closterium*, *Cosmarium*, *Eudorina*, *Mougeotia*, *Pandorina*, *Pediastrum*, *Rhizoclonium*, *scanedesmus*, *Spirogyra*, *Tribonema*, *Ulothrix*.

Blue green algae : *Aphanocapsa*, *Merismopedia*, *Oscillatoria*, *Spirulina*.

Protozoans : *Arcella*, *Difflugia*, *Chlamydomonas*, *Volvox*, *Carchesium*, *Epistylis*, *Vorticella*.

Rotifers : *Diurella*, *Hydatina*, *Pedalion*, *Ratifer*, *Synchaeta*.

Daphnids : *Bosmina*, *Ceriodaphnia*, *Daphnia*, *Diaphanosoma*.

Fecundity and breeding.—*Thynnichthys sandkhol* attains the maturity in its first year itself when it is 300 mm. long. The fish breeds during the south-west monsoon period of June-September in the three rivers. The hatchlings are washed down into the tanks, ponds and swamps connected with these river systems.

Growth.—Very little attempt has been made in collecting the young ones of this fish and culturing them in ponds and tanks. The fish grows to a maximum size of 450 mm. The hatchlings that enter the tanks, ponds and swamps connected with the irrigational systems have been noticed to grow to a size of 30 to 32 cm. in the first year.

Collections and transport of the young ones.—The young ones are available in fair numbers in the three rivers and their irrigational canals and channels from July to October. They are collected in basket traps. Handling and transport in tin carriers are not well stood by the young ones. The fish has more a fluviatile habitat and hence is not much used in pond culture.

Osteocheilus thomassi.

Osteocheilus thomassi occurs in the upper reaches of the Andhra State. The distribution of this carp in this area is considered an evidence of the strong Malayan affinities of the Fresh Water fish fauna of Peninsular India. This carp constitutes a very fair fishery in the Tungabhadra river. The adult fish prefers the deep pools in the course of the river.

Food and feeding habits.—*Osteocheilus thomassi* is mainly a plankton feeder in all its stages. The various organisms that constitute its food are given below :—

Desmids and Diatoms : *Closterium, Cosmarium, Fragillaria, Gomphonema, Melosira, Navicula, Nitzschia, Pinnularia, Staurones, Surirella, Synedra.*

Algae : *Oscillatoria, Schizomerias, Ulothrix.*

Protozoans : *Euglena, Stylonichia.*

Copepods : *Diaptomus, Eucyclops.*

Daphnids : *Daphnia, Ceriodaphnia.*

Molluscan shells.

Fecundity and breeding.—The fish attains its maturity when it is 200 to 250 mm. long. A gravid female, 250 mm. long, contained about 30,000 eggs of 1·14 to 1·17 mm. in diameter. The breeding season extends from June to September. The breeders move up the river in small shoals of about fifty, in search of shallow, shady and gravelly banks with a strong current of water. The eggs are carried down by the current to deep pools where the flow of water is reduced and they hatch there.

Growth.—This carp grows to a size of 690 mm. in Tungabhadra river. Specimens of 300 to 450 mm. are common in the river catches. In ponds they grow to a size of 30 cm. in the first year and 42 cm. in its second year.

Collection and transport of young ones.—The fry and fingerlings are available in fairly large numbers in Tungabhadra from July to end of December. They are collected by Velon Screen or Drag net or close meshed castnet. The fry and fingerlings stand the handling and transport very well. One hundred and twenty to one hundred and fifty young ones of 20 to 30 mm. size can be transported safely in one tin carrier over a distance of 450 miles.

Chela argentia.

The "Silver Fish" prefers quiet waters and deep pools of rivers. It is a very active fish keeping to the surface.

The fish feeds mainly on the following :—

Diatoms (10 per cent); *Green algæ* (10 per cent); *Blue green algæ* (5 per cent); *Protozoans* (5 per cent); *Copepods* (17 per cent); *Daphnids* (3 per cent); *Insects and insect larvæ* (55 per cent).

The fish breeds in running water during the monsoons. During this time the female has the ventral portion of its body slightly coloured orange or yellow. The ripe ovarian egg is yellowish, round and 1·25 mm. in diameter. The fertilized egg measures 2·0 to 2·5 mm. in diameter and hatches in about 20 hours. The hatched larva is 5 mm. in length. The fins get differentiated when the larva is 12 mm. and at 15 mm. length the fins and opercula are fully developed. The fry reaches a size of 20 mm. in about a month and is characterised by a thin laterally compressed body with prominent blue eyes and V-shaped bluish pigmentation on the head.

Chela are very delicate and do not stand transport well. The slightest bruise in transit is enough to kill it.

Being a feeder on insects and their larvæ it is a good larvicide. Its average consumption of mosquito larvæ in 24 hours has been found to be 100.

Chela untrahi.

Like *Chela argentia* this fish also prefers quiet waters and deep pools of the rivers. The fish occurs in all the rivers of the State. It is active and keeps to the surface during the day and twilight hours.

The food of the fish consists of the following :—

	Percentage.
Diatoms ..	4
Green Algae ..	1
Blue green algæ ..	2
Protozoans ..	3
Copepods ..	22
Daphnids ..	1
Ostracods ..	1
Insects ..	66

It breeds in the rivers during the monsoons. At the breeding time the ventral portion of the body in the female has an orange colouration. A gravid and oozing female of 140 mm. contained 7,630 eggs. The ovarian egg is round and is of 0·75 to 0·95 mm. diameter. The fertilized egg is 1·75 to 2·1 mm. in diameter. The period of incubation lasts about twenty hours. All the adult characters are developed in one month after hatching when the fry is 20 mm. long.

The flesh of the fish has a very fine and delicate flavour and the fish therefore is much esteemed as a food fish. As the fish consumes large amounts of insects and insect larvæ it can be used as a good larvicide.

The utilization of the fish as a larvicide can be very usefully adopted together with its culture as a food fish. The fry and young ones are very delicate and do not stand transport.

BASILUS BENDELESIS.

"The Baril" prefers clear water with rocky or sandy bottom and are abundant in hill streams. It occurs commonly in North Arcot, Chingleput, Coimbatore, Salem, Anantapur, Bellary, Chittoor and Kurnool districts.

It is both a surface and column feeder. The food consists of Filamentous algæ (10 per cent), Diatoms (8 per cent), Aquatic weeds (2 per cent), Protozoans (1 per cent), Larval worms (10 per cent), Insect larvæ (46 per cent), Copepods (10 per cent) and Daphnids (13 per cent).

The fish breeds in running water from July to December. A mature female contains eggs of 1 to 1·5 mm. in diameter. During breeding season the males attain bright colouration with tubercles on both jaws. The parents follow the schools of fry till they attain a size of 25 mm. A dark spot is developed on each scale when the fry is 12 to 15 mm. long. Eight greyish bars are developed when the fry is 25 mm. long. Five bars are predorsal. The full adult characters with 12 bars are attained when the fry is 70 mm. long. The bars gradually tend to become indistinct as the fish grows larger.

The barils are useful on a moderate scale as larvicides, their average consumption of mosquito larvæ in 24 hours being 50.

RASBORA DANICONIUS.

This minnow is found throughout the State both in the plains and in the hills. It grows to a size of 125 to 130 mm.

The food of the fish consists of the following :—

	Percentage.
Diatoms ..	20
Green algæ ..	5
Blue green algæ ..	7
Aquatic plants ..	12
Protozoans ..	3
Copepods ..	8
Insects and insect larvæ ..	40
Worms ..	5

In Chetpet Fish Farm the fish is observed to breed during November soon after heavy monsoon showers. Specimens have been found to be fully ripe and oozing during March and September in the Ootacamund Lake. The eggs are attached to submerged vegetation. The larvæ hatches out after 87 hours of fertilization. Hatching in the cold water of Ootacamund Lake is slower.

APLOCHEILUS LINEATUS.

The "Striped Panchax" occurs in South Kanara, Malabar, Tirunelveli and Chittoor districts. It occurs in almost all types of waters at all altitudes such as hill streams, reservoirs, rivers, tanks, wells, paddy fields, swamps and backwaters. It is a hardy fish thriving even in foul waters containing sulphuretted Hydrogen and Red Sulphur bacteria.

The maximum size recorded of this fish is 95 mm.

Its food consists of Corixid bugs, small beetles, Water mites, Insect larvæ (58 per cent), Phytoplankton (22 per cent), (*Merismopedia*, *Spirulina*, *Crucigenia*, *Mougeotia*, *Synedra*) and Zooplankton (20 per cent), (*Euglena*, *Phacus*, *Diaphanosoma*, *Ceriodaphnia*, *Diaptomus*, *Cyclops*, *Eucyclops* and *Nauplius*). In the aquarium the fish is found to consume young *Gambusia*, *Lebistes* and Carp fry. It takes artificial food like prawn shell meal, Earthworm, etc.

It attains maturity when it is 50 mm. long. The breeding season is throughout the year with the maximal period from August to September.

In view of its hardiness and adoptability to different environmental conditions, it can be transported easily over long distances. It is mainly an insectivore. It is therefore useful for larvicidal work. It is found to consume 270 mosquito larvæ in 24 hours.

Macropodus cupanus.

The "Indian Paradise Fish" occurs in streams, lakes, ponds, swamps and estuaries of the southern and western districts of the State and also in the River Tungabhadra. It has been introduced into the waters of Nilgiris, Kodaikanal and Yercaud and Chittoor and Cuddapah districts.

It is mostly a surface and midwater feeder. It browses on filamentous algæ also. Its food consists of the following :—

Desmids and *Diatoms* (35 per cent) : *Amphora*, *Closterium*, *Cyclotella*, *Desmidium*, *Eunotia*, *Fragillaria*, *Melosira*, *Navicula*, *Nitzschia*, *Staurastrum* and *Tabellaria*.

Algæ (20 per cent) : *Anabæna*, *Oedogonium*, *Oscillatoria*, *Spirogyra* and *Ulothrix*.

Microcrustacea (20 per cent) : *Cyclops*, *Cypridopsis* *Diaptomus*, *Daphnia* and *Nauplii*.

Insects (15 per cent) : *Ephemeroptera larvæ*, *Odonata larvæ* and *Dipteran larvæ*.

Protozoa (5 per cent) : *Chilomonas*, *Eudorina*, *Euglena*, *Phacus*, *Difflugia* and *Arcella*.

Sand particles and debris (5 per cent).

The fish attains maturity when it is 8 months old and 40 mm. in size. It is a bubble nest builder and breeds throughout the year with two maxima in April and September. During the breeding season the male is coloured with crimson vertical bands, black spots on the head region and bright blue colour on gill covers and fins.

The anal and dorsal fins of the males are longer and pointed. The female has 200 to 300 eggs in each ovary. The fertilized egg measures 1·0 to 1·2 mm. in diameter. The eggs float and are kept in position in the nest by the male. Heart, eyes and otocyst are developed by the 24th hour. At 36 hours the embryo exhibits wriggling movements and more pigments appear on the head region and along the base of the median fin fold. Hatching takes place between 45th and 50th hour and the hatchling measures 2·5 mm. The larvæ remains floating. On the third day the yolk sac is absorbed and the larvæ swims about. The young attains adult characters within six weeks, till which time the male guards the brood. The fish attains a maximum size of 90 mm.

Under laboratory conditions the fish has been observed to feed on 480 to 620 mosquito larvæ in 24 hours. It is found suitable for anti-malarial work in paddy fields, ditches, pits and other stagnant waters. It is hardy and stands transport over long distances. It is capable of surviving in waters with a pH of less than 6·6 and free CO_2 as high as 8·432 p.p.m.

Lepidocephalus thermalis.

This small loach occurs in all fresh waters of the State. It prefers to remain partly or fully burried in loose silt and fine vegetable sediment.

It grows to a maximum size of 70 mm. It is a browser and its food contains the following :—

Algæ (65 per cent) : *Chætophora*, *Cladophora*, *Microspora* *Merismopedia* *Nostoc*, *Oedogonium*, *Oscillatoria*, *Spirogyra*, *Spirulina*, *Ulothrix*.

Desmids and Diatom (25 pers cent) : *Achnanthes*, *Amphora*, *Closterium*, *Cosmarium*, *Cyclotella*, *Cymbella*, *Diatoma*. *Desmidium*, *Fragillaria*, *Gyrosigma*, *Naviculo*, *Nitzschia*, *Pinnularia*, *Stauroneis*, *Surirella*, *Synedra* and *Tabellaria*.

Crustacea (2 per cent) : *Alonella*, *Diaptomus* and *Cypridopsis*.

Protozoa (2 per cent) : *Vorticella*, *Euglena*, *Chlamydomonas*.

Rotifers (1 per cent) : *Hydatina* and *Pterodina*.

Sand-grains and debris (5 per cent).

The fish attains maturity when 50 mm. in size. Each ovary contains 100—150 ova of 0·8 mm. diameter. The inner pectoral ray of the male is developed as a flat spine. The breeding season extends from October to January. Spawning takes place over beds of Spirogyra. The fertilized eggs are attached to the algæ. The eggs are spherical, pinkish in colour and 0·9 to 1·1 mm. in diameter. The yolk mass is finely granulated and free of oil globules. The period of incubation is about 3 days. The hatching measure 3 mm. in length. The mouth and gill openings are formed on the third day after hatching. On the fourth day the larva starts swimming and browses on the algal filaments. It is golden yellow in colour. The dorsal, Caudal and ventral fins get differentiated on the fifteenth day. Adult features are attained on the fortieth day.

The fish is found useful for cyclopscidal work. It consumes 170 cyclops in 24 hours under laboratory conditions. Being hardy it stands transport well

Ophicephalus.

Commonly called "Murrel" it forms a major bulk of the indigenous fishery of the tanks and ponds of Madras State. Three species contribute to this fishery of Murrel normally. Two of these three species are carnivorous and even cannibalistic. For preparing the ponds and tanks for fish culture, the eradication of murrels is a very vital step for the success of the enterprise. Murrels are capable of living outside water for very long periods due to the possession of accessory air breathing organs. They can also lie buried in mud and pass over long periods of drought.

The three species of Murrels that are of cultural importance are *Ophicephalus marulius*, *Ophicephalus striatus and Ophicephalus punctatus.*

Food—Fry.—The fry of *O. striatus* and *marulius* are predominantly insectivorous in their feeding habits. They feed mainly on *Dipteran larvæ*. Copepods like *Diaptomus* and *Cyclops* also are ingested. Cannibalistic tendencies are sometimes noticed. The young ones of *O. punctatus* feed on protozoans (*Paramaecium, Vorticella, Stylonichia*), daphnids, copepods, dipteran larvæ and Ephemeropteran larvæ Chironomid larvæ and filamentous algæ.

Adolescents and adults.—Ophicephalus marulius is highly carnivorous in the adolescent and adult stages. They feed on fish (minnows) and frogs. Only in about 10 per cent of the cases examined had the fish ingested dead fish and kitchen refuse of animal nature. The rest stuck to live fish and frogs. They are very cannibalistic also, so much so in kitchen wells and other small pieces of water no more than a single individual survives. In one instance of a large specimen it was noticed to have snapped up fowls and crows which happened to fall into the well.

O. striatus also is predaceous although to a less degree than *O. marulius*. It feeds on small fishes, frogs, worms and insects.

In *O. punctatus*, the piscivorous tendencies are very negligible. They feed chiefly on aquatic insect stages such as larvæ of Ephemerids.

Chironomids and dragon flies, water beetles like Cybister and aquatic bugs like Notonecta and Belostoma. Crustaceans like Copepods (*Diaptomus* and *Cyclops*), Cladocerans and shrimps also are found eaten by this fish. Caterpillars, small crabs, molluscs (*Pila* and *Ariophanta*) and weeds like *Spirogyra* and *Hydrilla* were observed in the gut contents of some. Fish contributed to only a very low percentage in the natural diet, though under aquarium conditions, *O. punctatus* was noticed to swallow live small minnows.

Fecundity and breeding—O. marulius.—It attains maturity at a size of 300 to 350 mms. The breeding season is from March to June and from October to December when there are no floods. The fish builds a nest amongst weeds at the time of breeding. The average number of fry in a brood is about 500 and they are golden yellow in colour. Both the parents take equal share in guarding the nest and the young ones. When the fry are one inch in size, black pigments appear on the dorsal and ventral sides, leaving a yellow band along the lateral line. The parental care is discontinued when the young ones attain a size of 100 mm.

O. striatus.—It attains its maturity at a size of 250 to 300 mm. During the breeding time they move in pairs, the female being the larger. It builds a nest amongst the weeds. The fertilized egg measures 1·35 mm. in diameter and is light yellow or amber coloured. The egg becomes brownish or darker in colour when about to hatch. The parents are found to guide and move with the young ones until they attain a size of 100 mm. The breeding season coincides with the monsoonic months.

Ophicephalus punctatus.—It attains its maturity when it is about 120 to 150 mm. The fish breeds during the monsoonic months from June to November. The parents build a nest amidst water weeds and protect their brood. The eggs are pelagic and measure about 1 mm. in diameter. The yolk contains oil globules. The period of incubation is about one day. The number of fry in a brood vary from 400 to 1,300. Of the parents, the female is usually the larger one.

All the three species attain their maturity and breed prolifically in the first year itself.

Growth.—In the rivers *Ophicephalus marulius* is reputed to grow to a size of 1,200 mm. In irrigation wells with plenty of fauna like small minnows and frogs they grow to a size of 410 mm. in one year. *Ophicephalus striatus* is reported to grow in tanks to a maximum size of 900 mm. In tanks containing a very large population of insects, worms and frogs they grow to a size of 360 mm. in one year. *Ophicephalus punctatus* grows to a maximum of 260 mm. In ponds containing a large quantity of insects and molluscs it grows to a size of 210 mm. in the first year.

Because of the highly carnivorous and cannibalistic tendency, *Ophicephalus marulius* is useful for culture only in expansive lakes and tanks and in large irrigation wells with very dense weedage. *Ophicephalus striatus* is useful for culture in "Pumcha" irrigation ponds, deep domestic wells and weedy ponds. Its predaceous nature will however require it to be reared alone or in the company of very hardy or other carnivorous species. In irrigation wells they have been cultured together with the Pearl spot. The latter has very large spines in the fins which prevent them from being avidly predated by *O. striatus*. If food supply is deficient *O. striatus* has to be fed with artificial food like kitchen refuse, offal, etc. Otherwise the water has to be stocked with some forage fish like *Gambusia* or *Lebistes* that breed prolifically and thus will meet the food demand of *O. striatus*.

O. punctatus is very useful for foetid swamps and shallow muddy waters like those of paddy fields, small pools, tanks, ditches and wells. The diet being arthropodan and varied, the feeding problem is easily solved in its culture. Because of very low piscivorous habits this fish can be tolerated in systematic fish ponds also.

Collections and transport of the fry and fingerlings.—The fry and fingerlings of *Ophicephalus marulius* can be collected, from the deeper river sections having sandy bottom and submerged rocks from May to August and November to February. They are

collected in large numbers from the Bhavani river and the rivers of West Coast. The fry and fingerlings of *Ophicephalus striatus* and *O. punctatus* can be collected in large numbers from the paddy fields and uncleared tanks and swamps of the State during the monsoonic months. The fry are very delicate until the larval colouration is changed. Only when the postlarval colouration develop the young ones stand the transport. The adolescent and adult murrels can be transported for periods less than 48 hours packed in wet moss because of their air breathing character.

Wallagonia attu.

Owing to very highly predaceous habits this cat fish is popularly known as Fresh Water Shark. *Wallagonia attu* forms an important portion of the fishery in both lotic and lentic types of waters. In large irrigation reservoirs formed across big rivers, the fish grows to 180 cm. The fish contributes to a large portion of the commercial fishery of Mettur and Bhavanisagar reservoirs.

Food and feeding habits.—The food of *Wallago* in the young, adolescent and adult stages is mainly composed of fish (78 per cent). Almost all fishes that come in its way are "grist in the mill". A very large bag like stomach and a straight alimentary canal characterize this high piscivore. Large specimens of *Mystus seenghala*, *Cirrhina cirrhosa*, *Labeo fimbriatus* and *Catla catla* and small fishes like *Anthlypharyngodon mola*, *Esomus danrica*, *Rasbora daniconius*, *Barilius bendelesis*, *Danio aequipinnatus*, *Chela untrahi*, *Oryzias melastigma* and *Aplocheilus blochii* have been noted in its diet. Shrimps like *Caridina* and fresh water prawns form the next highest proportion of its food. Insects and insect larvae also are ingested. Cannibalism has been noticed in several instances even in young stages. The fish lurks amongst water weeds very quietly and on the approach of the forage fish makes a lightning dart on it with an open mouth. Sometimes the velocity of the darting movement shoots the fish itself out of water and it falls back nearby. The fish takes in dead and decaying material also. In Mettur and Hoggainakal the fish is found to take a hook, baited with dead fish.

Fecundity and breeding.—The fish breeds in the early months of the south-west monsoons in the river.

Growth.—Though the fish is reported to grow to 180 cm. in the large reservoir systems, specimens of 60 cm. to 90 cm. form the majority in the commercial catches of Mettur and Bhavanisagar. In tanks containing plenty of forage fish, *Wallago attu* grows to a size of 45 cm. in the first year. Owing to its highly predaceous nature often tending to cannibalism even this fish is not suitable for pond culture. The fish has to be eradicated completely before undertaking culture of any other fish in the pond. Observations have shown that even in the presence of abundant forage fish, *Wallago* turns to cannibalism so that often only a single individual survives in a small pond.

Collection and transport of young ones.—The fry and fingerlings are available in fairly good numbers in the river stretches of Bhavani and Cauvery from July to November. As the fish is not useful from cultural point of view no attempts were made on the collection and transport of the young ones.

Mystus seenghala.

The cat fish, *Mystus seenghala*, is one of the commonest and largest cat fishes in Madras State. It occurs in the rivers, tanks and ponds of the Peninsular India fairly in abundant numbers. It yields a valuable fishery in the reservoir and tank systems connected with Cauvery and Bhavani rivers. The fish is characterized by a black spot on the adipose fin, just at the junction of the adipose fin and the body.

Food and feeding habits.—In the very young stages this cat fish feeds mainly on insects and insect larvae and smaller crustaceans. The adults and adolescents are mainly piscivores feeding on small fishes like *Barbus filamentosus*, *Barbus tieto*, *B. stigma*, *Nuria danrica*, etc., and the young ones of other fishes. Fish forms 60 per cent of its diet. Crustaceans like *Palaemon*, *Caridina* and *Metapeneus* form 23 per cent of its diet. The other items in the diet are insects, insect larvae, worms, molluscs and a very small proportion of filamentous algae.

Fecundity and breeding.—*Mystus seenghala* attains its maturity when it is 45 cms. in length. The breeding season is from May to July, synchronising with the onset of the south-west monsoons. At the time of breeding it builds a nest in the form of a circular, clear depression of about 18 inches depth at the centre. The depression is made only in dark sand and silt in a rocky section of the river, behind a projecting rock, which protect it from strong currents. The eggs are guarded and incubated by the male. The number of fry in a brood is about 100.

Growth.—The fish grows to a size of 120 cm. in large reservoir systems. In tanks and ponds they grow to a size of 40 cms. in the first year and 65 cm. in the second year. Because of its highly predaceous nature the fish is not suitable for culture in ponds and so should be removed completely before culture of other fishes is undertaken in ponds.

Collection and transport of young ones.—The fry and fingerlings are available in large numbers in the river stretches of Bhavani and Cauvery from July to October. Since the fish is not of cultural value no attempt has been made for collecting and transporting the young ones.

Notopterus notopterus.

Commonly called the Feather back, *Notopterus notopterus*, has a wide distribution in Andhra and Madras States. It forms an important fishery in large lakes and reservoirs like the Veeranam

and Mettur. The body is laterally very much compressed, the ventral side being very thin as to present a broad knife like appearance from which the fish gets its vernacular name of "Ambattan-kathi valai" meaning the "Barber's knife cat fish". The fish presents all gradations of colour from a grey greenish shade to deep purple.

Food and feeding habits.—The fish in its young stages is mainly an insectivore feeding on the larvae and adults of *Plecoptera*, *Ephemeroptera*, *Ranatra* and *Plea*. A small amount of filamentous algae like *Oscillatoria* and *Spirogyra* and a small percentage of Molluses like *Limnea* also are eaten.

In the adolescent and adult stages it is primarily a carnivore. Fish like *Barbus stigma*, *B. ticto*, and *Nuria danrica* form 31 per cent of its diet. The Crustaceans form the next major component of its diet. The various organisms that constitute its diet are given below :—

Diatoms : *Navicula*, *Nitzschia*, *Amphora*, *Surirella*.
Green algae : *Ankistrodesmus*, *Oedogonium*, *Spirogyra*, *Ulothrix*.
Bluegreen algae : *Oscillatoria*, *Microcystis*.
Aquatic plants : *Hydrilla*, *Chara*.
Protozoans : *Euglena*, *Chlamydomonas*, *Phacus*.
Crustaceans : *Palaemon*, *Caridinia*.
Insects : *Plecoptera larvae*, *Ephemeroptera larvae*, *Laccotrophes*, *Mesovelia*, *Lymnogonus*.
Molluscs : *Melanoides*, *Indoplanorbis*, *Limnea*.
Fish : *Barbus stigma*, *Barbus ticto*, *Nuria danrica*, *Amblypharyngodon mola*.

Fecundity and breeding.—The fish attains its maturity when it is about 12 cm. long. In the male the urinogenital papilla is more conical and pointed than in the female. It breeds both in stagnant and running waters during the rainy season from June to October. The number of eggs in the ovaries varies from 200 to 1,000 according to size and age. The egg is 2 mm. in diameter and is yellowish in colour. The eggs are laid in small clusters on submerged vegetation and other substrata.

Growth.—The fish grows to a maximum size of 48 cm. in length and 454 gms. in weight. Specimens of 25 to 36 cm. are the common ones in the commercial catches at Veeranam. The fish grows in ponds and tanks to a size of 25 cms. in the first year and 36 cms. in the second year. Because of its highly predacious nature the fish is suitable for culture only in wild waters.

Collection and transport of young ones.—Fingerlings of 1 inch to 2 inches in sizes are available in large numbers in the upper reaches of Cauvery in July and August. As the fish is not used for systematic fish culture no attempt has been made to collect and transport the young ones.

Glassogobius giuris.

Glassogobius giuris is the largest of the true gobies and occurs both in salt water and fresh water habitats. It is one of the common fresh water fishes of Madras State occurring in ponds, ditches, lakes and rivers. Because of the fair flavour of its flesh and lack of fine bones, this fish is esteemed in some localities. It is called the "Ulavai" in vernacular. The fish is reported to reach its maximum size in fresh water lakes and large water-spreads. The fish has a very large and wide mouth provided with prominent sharp teeth. It is capable of adapting its colouration to suit its background. Its favourite haunts are amongst weeds and thick aquatic vegetation. In many of the tanks and ponds *glassogobius* contributes to as high as 80 per cent of the total fishery.

Food and feeding habits.—In the young stages, *Glassogobius* is predominantly an insectivore feeding on corixid bugs, Notonecta and larvae of Dipterids and Coleopterids. They form nearly 80 per cent of the diet. The vegetable portion of the diet is invariably very negligible. Worms and occasionally small minnows also are eaten.

In the adolescent and adult stages this goby is a very high piscivore predating upon smaller fishes like *Rasbora*, *Barbus spp*, *Amblypharyngodon* and *Nuria* and young ones of the major carps. Very often cannibalism also has been noticed. Fish forms 78 per cent of the diet. Insects from 11 per cent and molluscs 9 per cent of the diet. Aquatic vegetation forms 2 per cent of the food. The fish is thus a high predator and has to be generally removed from ponds and tanks before starting the culture of other fishes.

Fecundity and breeding.—The fish attains its maturity when it is about 85 mm long. The ripe ovary is bright yellow in colour in fresh condition. The breeding season of the fish is from September to December. The ripe ovarian egg is elongated and has at one end a number of long, extremely slender hair-like processes which in the laid egg fuse together into a rosy mass forming the anchoring organ. The fish attaches its spawn to under surfaces of hard objects such as stones, wooden planks, etc., and the spawn is guarded by both parents until they are hatched. The fertilized egg is almost round and it is well protected by the conspicuous tubular envelope formed by the expanded perivitelline space. The length of the tube varies from 3 mm. to 8 mm. The period of incubation is 60 to 72 hours. All the eggs in the same brood do not hatch at the same time, a difference of 4 to 8 hours being noticed in the

incubation period. The hatchling is a frail transparent one measuring 2·4 mm. in length. The yolk is absorbed in 72 to 80 hours after hatching.

The fish has a very high fecundity. One patch of laid eggs contained approximately 75,000 eggs.

Growth.—*Glassogobious giuris* attains a maximum size of 45 cm. But usually specimens of 30 to 36 cm. are the common ones in the catches from ponds and tanks. The fish grows to a size of 28 cms. in the first year and 40 cms. in the second year in weedy ponds of extensive nature and containing an abundance of minnows and acquatic insects. The fish is suitable for culture only in seggregated ponds, swamps and shallow waters that are not suitable for carp culture. They should be eradicated completely if culture of any other fishes is to be undertaken.

Collection and transport of young ones.—The fry and fingerlings of *Glassogobius giuris* are available in rivers, ponds and lakes of the State from October to February. The young ones are delicate and require very careful handling in transport. In overcrowded tin carriers the young ones snap at each other resulting in large scale mortality in transit. Not more than 50 fingerlings of 1 inch to 1½ inches should be transported in one tin carrier and periodical changing of water also is essential.

Hilsa ilisha.

Hilsa ilisha, known as Indian Shad, is mainly a neritic fish hugging to the foreshore and is quite at home in the estuaries and shallow flats close to the mouths of the major rivers of South India like the Godavari, Krishna and Cauvery. During the monsoons the fish ascends in shoals into these major rivers as well as some of the smaller rivers. The fish is a very fast swimmer and is considered a very great delicacy.

Food and feeding habits.—The food of the fish before its entry into the rivers and after its return to the sea appears to be planktonic. The following organisms constitute its food.

Diatoms : *Paralia, Thalassionira, Coscinodiscus, Detonula, Rhizosolenia, Bacteriastrum, Chaetoceros, Biddulphia, Fragillaria, Thalassiothrix, Asterionellia, Pleurosigima, Nitzschia.*

Protozoans : *Dinophysis, Peridinium. Ceratium, Glenodenium, Tintinnus.*

Crustaceans : *Evadne, Acrocalanus, Centropages, Pseudodiaptomus, Temora, Acartia, Oithona, Corycaeus, Harpacticus, Euterpina, Nauplius, Crab-zoea.*

Molluscs : *Spiratella, Cresis, Larval bivalves.*

Tunicates : *Oikopleura, Frittillaria, Doliun, Salpa.*

When the fish ascends or descends the river it is found to starve. It is able to sustain during this period due to the large quantity of fat in its body. This fact is gradually absorbed and assimilated during the spawning period.

Fecundity and breeding.—The males attain their maturity when they are 30 cm. long and the females when they are 35 cm. Both the lobes of ovary in the female are equally developed and are pale yellow in colour. One mature and oozing female 457 mm. in length and 912 gms. in weight contained 1,282,110 eggs of an average diameter of 0·72 mm. The ovarian condition indicated a complete discharge of the eggs at the first spawning itself.

Both the males and females move together in shoals into the river but the females usually are in greater numbers, the proportion of males to females being 1 : 9. The rivers are swollen by the rain floods of June and July and continue to be in full space till end of October. During this season, the levels of the rivers rise far above the various anicuts and other irrigational barriers for short periods varying from 1 to 15 days. It is during these days that the Hilsa congregating close to the anicuts migrate up the rivers. After breeding the fish is spent very much and is very lean and weak and they descend into the sea. The fresh water sojourn for breeding purposes lasts for about three months. The fertilized eggs drift down the river and hatch in the river stretch where the tidal influence is felt. In this tidal area the hatchings thrive and grow. Several of the eggs and hatchlings get carried through the irrigational canals into fresh water ponds where also they thrive and grow.

Growth.—Hilsa contributes to a good fishery in the rivers during the rainy season and to a fair summer fishery in the sea off the Godavari coast. Specimens of 45 to 60 cm. are fairly common in these fisheries.

The growth of Hilsa in its natural environment is the following :—

First year	30 cm.
Second year	52 cm.

The fry and fingerlings of Hisa are very delicate and do not stand any handling and as such attempts at growing them in impounded waters have not been successful. But in some cases when the fertilized eggs and hatchlings have got carried into the ponds connected with the irrigation systems the fish has been found to grow to a size of 33 cm. in the first year. The fish is typically fluviatile and marine in its habitat and hence is not suited for pond culture.

Collection and transport of young ones.—The young ones are available in very large numbers in the tidal areas of the rivers like

Godavari, Krishna and Cauvery from November to March. They are very delicate like all the clupeoides and do not stand the collection and transport.

Exotic Fishes.

The exotic fishes that are found in the fresh waters of South India can be divided into two types, viz., environmentally exotic and geographically exotic. Under the forms category card be included those marine and brackish water fishes that have been acclimatised and grown in the fresh water environment. The fishes that have been studied and reported in this report under these two types are the following :—

Environmentally Exotic. (1)	Geographically Exotic. (2)
Chanos chanos.	*Osphronemus gorami,*
Etroplus suratensis.	*Cyprinus carpio.*
Etroplus maculatus.	*Carassius carassius.*
Megalops Cyprinoide.	*Carassius auratus.*
	Tinca tinca.
	Lebistes reticulatus.
	Gambusia affinis.

Osphronemus gorami.

As the best freshwater table fish, Gourami has received attention ever since it was introduced into this State in 1916 from Mauritius and Java. Its large size, bonelessness and delicate flavour make it a favourite with many fish culturists. The fish was originally introduced only into small tanks and ponds. But later on it was introduced into large reservoir systems like Poondi and Mettur. They have stabilised fairly well in these reservoir systems also. It forms a fairly good fishery now in the Poondi reservoir. The fish is called in Tamil "Sangara".

Food.—In the very young stages the fish feeds mainly on zooplankton like Cladocerans and Copepods. But the adolescent and adults are found to be primarily vegetable feeders. The food consists mainly of aquatic weeds like *Vallisneria spiralis, Hydrilla verticellata, Water lilies, Ipomea aquatica* and grasses and filamentous algae like *Spirogyra, Oscillatoria* and *Microcystis*. Insect stages, shrimps and worms also are found sometimes in the gut contents. For artificial feeding, oil cakes, chopped shrimps and worms are found very suitable. The fish is very pugnaceous and very rarely has been found to consume fish and flesh. The aquatic vegetation forms as high as 60 per cent of its diet. The various organisms found in its food are the following :—

Diatoms : Cocconeis, Comphonema, Melosira, Navicula, Fragillaria.

Green Algae : Ankistrodesmus, Chara, Spirogyra, Ulothrix, Eudorina, Mougeotia.

Blue green algae : Microcystis, Oscillatoria, Merismopedia, Anabaena.

Crustaceans : Caridinia.

Insects : Chironomus larvae, Corixa, Plea.

Worms : Nais, Oligochaete, remains.

Fish : Fish Scales.

Aquatic vegetation : Hydrilla verticellata, Ipomoea aquatica, Nymphea, Vallisneria spiralis.

Grass.

Breeding.—The fish becomes mature when it is about 25 to 30 cms. long. When mature the fish shows sexual dimorphism. The mature male shows a distinct "hump" on the nose, a whitish colouring on the base of the pelvic fins and a yellowish fin. The female does not show such a hump and its fin bases are more black. Good female spawners are the white ones. The males show greater pugnacity, biting and fighting others. The fish breeds round the year but the peak period of breeding is during the monsoons. At the time of breeding the fish pair and build a nest of weeds of 9 inches diameter in the midst of marginal weeds in shallow regions. In the absence of weeds *Gourami* has been noted to breed rarely without nests. It takes almost seven days to build a nest. Two or three days after building the nest about 500 to 2,000 eggs are laid. The parents guard the nest by turns. The egg is round, about 1 mm. in diameter and lemon yellow in colour with a lot of clear oil inside. Incubation is for a period of ten days. The hatchling is 5 mm. long and has a fat belly. It clings itself to submerged rocks by its head and frequently darts about. The larva begins to feed on micro-organisms when about seven days old. In a fortnight's time the fins are differentiated. The vertical stripes and the characteristic juvenile character of a black ocellus near the tail appears in a month's time. The outer ventral fin also begins to elongate. The fish reaches a size of 7 to 8 cm. in three months.

It has been noticed that *Gourami* breeds very profusely in slightly acidic waters.

Growth.—Though the fish is reputed grow to a size of 600 mm. and weight of 24 lb. such monster specimens have not been observed in the fish cultural operations in Madras State. The normal rate of growth of the fish is given below :—

Year.	Length. MM.
I	150
II	289
III	370
IV	430

Because of its slow growth, Gourami is not essentially a fish of very high commercial possibilities. Its palatability, and boneslessness are the factors in favour of its culture in small garden ponds, weedy tanks, wells and shady cisterns. A minimum water depth of 2 feet is essential for the good maintenance of the fish. It can grow well up to an elevation of 2,000 feet.

Collection and transport of fingerlings.—The fry and fingerlings are collected from the *Gourami* breeding ponds in many of the State-owned fish farms. The fingerlings of 3 inches to 5 inches are the best for transport. Because of its air-breathing habits, it is a hardy fish and stands transport very well. Overcrowding and the water getting heated up cause mortality in transport; 40 fingerlings of 3 inches to 5 inches stand transport very well in one tin carrier over long distances.

The German carp (Cyprinus carpio).

The German carp is a fish exotic to India and was first introduced to the upland waters of the Nilgiri hills in 1939. In the upland waters they have established very well growing and breeding very profusely. In the early stages of its introduction the fish was utilised for systematic culture in the semi-temperate waters of the uplands. But later on they were successfully acclimatised to the higher temperature conditions of the plains and were transplanted extensively in the impounded waters of the plains of this State. Large numbers of this fish have been transplanted also to various other parts of India like Kashmir, Assam, U.P., Bombay, Hyderabad, Travancore-Cochin, Coorg, Mysore and Bengal. This carp grows very fast in the waters of plains but was found not to breed in such waters. Studies conducted, subsequent to the completion of the Scheme sponsored by the Imperial Council of Agricultural Research, have revealed that they can be made to breed in certain types of waters in the plains. The German carp *Cyprinus carpio* varies very greatly in many of its characters from the description given originally by Linnaeus. Several gradations of variations in shape of body, distribution of scales, nature of snout, etc., occur. This great range and frequency of variation in this carp is undoubtedly due to its domestication or semidomestication since early times. As is to be expected, this has resulted in the naming of a large number of varieties or races. Most of these can be grouped into the following three broad varieties as given by Hessel (1881) :—

1. *Cyprinus carpio var. communis.*—The scale carp with regular concentrically arranged scales, being, in fact, the orginal species involved.

2. *Cyprinus carpio var. specularis.*—The Mirror carp.

Thus named on account of its extraordinarily large and reflective scales, which run along the sides of the body in three or four rows, the rest of the body being bare.

3. *Cyprinus crapio var. Coriaceus or nudus.*—The Leather carp which has on the back either only a few scales or none at all, and possesses a thick, soft skin, which feels velvety to the touch.

All the three varieties grow to more or less the same size, having the same feeding and breeding habits and hence are treated together as one fish in this.

Cyprinus carpio contributes to 5 per cent of the total catches of Ooty lake now.

Food and feeding habits.—The German carp in its very young stages, is primarily a plankton feeder, feeding mostly on diatoms, green algae, and Blue green algae. They feed on the Blue green alga *Microcystis* very avidly. In the adolescent and adult stages they are essentially omnivorous feeding to a fairly large extent on the aquatic weeds. Insect larvae like (*May flies*, *Coleopteran bugs* and *Chironomus*), *Cardinia* and *molluscs* also are noted in its diet. Most of its food is obtained by rooting about in the mud. In several instances seeds and fruits of aquatic plants blown into the water have been ingested by the fish. The fish feeds largely on filamentous algae like *Oscillatoria*, *Spirogyra* and *Microcystis*, and aquatic vegetation like *Hydrilla*, *Chara*, *water lilies*, vallisneria, *grass* and *Potomageton*. Copepods, Ostracods and worms also are noted in its diet. On a few occasions fish eggs also have been found ingested. Often a large amount of fine and loose mud also is seen taken into its stomach. Because of its peculiar feeding habits of rooting about in the mud the water of the pond in which Mirror Carp is maintained appears turbid. When available mirror carp is noticed to gorge its stomach with fresh sewage.

Fecundity and breeding.—The German carp reaches its maturity in its third year when it attains a size of 38 to 42 cms. Sometimes in the case of quick growing conditions this size has been reached in two years and the fish has bred. At the time of spawning season the females can be easily distinguished by their distended bellies. The fish has a very high fecundity, the number of eggs increasing proportionately with size and age. One oozing female of 45 cm. and weighing 1,824 gms. had 493,200 fully developed eggs about to be shed. "Day (1880-1884) has quoted other estimates. Thus a female of 9 lb. had 600,000 (Bloch); one of 16-3/4 lb. had 101,200, one of 25-1/2 lb. 203,109 (Harmer); one of 21-1/2 lb. had 1,310,750 and one of 16-1/2 lb. had 2,050,750 (Buckland)".

The breeding season is from February to May and from September to October. At the time of breeding the fish move about in groups at the surface. The eggs are scattered about on the vegetation mostly on the roots of floating vegetation like *Eichornia*

in shallow waters. The spawning takes place mostly in the early hours of the morning. In the absence of floating vegetation, they scatter the eggs amongst the grass blades and other vegetation in the shallow regions. The eggs are not laid in bunches or clusters but are scattered about amongst the vegetation. The period of incubation at Ootacamund is about seven days. In the plains in a tank near Palghat which did not contain any vegetation, the eggs were attached to submerged rocks and boulders. The fertilized eggs are spherical and have an average diameter of 1·3 mm.

Growth.—In popular imagination this carp is thought to live to 100 or even 150 years and weigh 80 to 90 lb. But these are not based on sufficient scientific evidence. The fish rarely reaches to a weight of 25 to 30 lb. In Ootacamund lake the biggest specimen caught so far has weighed 35 lb. Specimens of 16 lb. to 18 lb. are fairly common in the catches of the lake. The growth rate of the fish in different environments are given below :—

Place.	First year.	Second year.	Third year.	Fourth year.	Fifth year.	Sixth year.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Gm.	Gm.	Gm.	Gm.	Gm.	Gm.	Ft. ALTITUDE.
Ootacamund ..	14	27	38	46	51	56	7,200
Yercaud ..	18	32	44	52	60	67	4,500
Madras ..	36	57					Tank fed periodically with cattle shed sewage.
Madurai ..	44	69				83	Tank with high organic pollution from sewage cowdung.
Bhavanisagar ..	27	46				64	Tank fed with Bhavani river water unpolluted with organic matter.

It is thus seen that the German carp grows very fast in the plains. Tanks containing a large quantity of filamentous algae and aquatic vegetation like *Hydrilla* and *Chara* and containing large amount of mud and subjected to organic pollution is found to be very ideal for the culture of this carp.

Collection and transport of young ones.—Fry and fingerlings are available at Ootacamund and Kattery almost throughout the year. The smaller fingerlings are available in large numbers from March to July and from October to December. These are collected by velon screen or small meshed cast nets. The fry and fingerlings have to be conditioned at least for 48 hours before transport. Eighty to hundred young ones of 1 to 1½ inches can be transported in one

tin carrier for a distance of 150 miles. Ice has to be periodically supplied to the water in the tin carrier to keep down the temperature. Sudden rising of temperature has very fatal results in the transport of the young ones.

Carassius carassius.

Carassius carassius, the golden carp also is an exotic fish introduced first into the upland waters of Nilgiris in 1871. They have established very well in these waters as well as in the waters in various other upland regions and plains of this State. They breed very profusely in these waters. In the plains they have bred only in certain types of waters as in the case of the German carp. Though not growing to the great sizes of the German carp, its prolific nature and greater hardihood are great assets for its systematic culture. In the Ootacamund lake this fish forms 30 per cent of the present fishery. It has got a golden sheen from which it takes its popular name of Golden carp.

Food and feeding habits.—Throughout its life the golden carp is mainly a plankton feeder. Its food consists of *diatoms, algae, protozoans, Rotifers, Copepods, Daphnids, Ostracods* and *insect larvae*. *Daphnias* form 60 per cent of its diet. The various organisms that constitute its diet are given below :—

Diatoms : *Nitzschia, Fragillaria, Cyclotella, Eunotia, Navicula, Melosira, Amphora.*

Green Algae : *Ankistrodesmus, Closterium, Spirogyra.*

Blue green Algae : *Anabaena, Oscillatoria, Microcystis.*

Daphnids : *Bosmina, Ceriodaphnia, Daphnia.*

Rotifers : *Rotifer, Pedalion.*

Ostracods : *Cypridopsis.*

Copepods : *Cyclops, Diaptomus.*

Insects : *Ephemerid larvae, Coleopteran larvae, Dipteran larvae.*

Fecundity and Breeding.—The fish attains its maturity in the first year itself when it is 10 to 13 cm. long. An oozing female of 12 cm. length had 3,980 eggs of 0·8 mm. diameter. The ovarian condition showed an outright shedding of the eggs. The breeding season is from February to April and September to October. The eggs are attached to aquatic plants like *water lilies, Vallisneria* and *Potomaeton*. The fertilized egg is 1·56 mm. in size. The fish has been successfully stripped and artificially fertilized.

Growth.—The fish grows to a maximum size of 45 cm. and weight of 540 gms. Specimens of 25 to 30 cm. are common in the catches of Ootacamund Lake. The growth rate of golden carp in various types of waters are given below :—

	First.	Second.	Third.	Fourth.	Altitude.
	cm.	cm.	cm.	cm.	
	(1)	(2)	(3)	(4)	
Ootacamund	17	29	28	44	7,200 feet.
Yercaud	21	36	..	..	4,500 ,,
Madras	26	44	..	Tank containing large quantities of plankton.	

The fish grows fairly rapidly in the plains. The growth can be quickened if the pond is manured with cotton seed meal, which brings in a high production of daphnids.

Collection and transport of young ones.—The young ones can be collected in large numbers from the Ootacamund lake from April to July and October to January. The collection and transport of the young ones of this fish are similar to those of the German carp.

Carassius auratus.

The "Gold Fish" is a very good aquarium fish. They are omnivorous but prefer a diet of earth worms, Daphnids and Copepods.

It spawns throughout the year with maxima from May to August and from November to January. It attains maturity in one year when 8 mm. long. The larvae commence feeding on the fourth day on the following :—

Desmidiaceae.—*Closterium, Cosmarium*

Diatoms.—*Cocconeis, Cymbella, Gomphonema, Melosira, Navicula, Nitzschia, Synedra.*

Algae.—*Ankistrodesmus, Aphanocapsa.*

Protozoa.—*Chilomonas, Euglena, Phacus, Eudorina.*

Adult characters are attained when the fish is 25 mms. long and one month old. The adult has been found to be predaceous feeding on the young of *Barbus lieto, B. stigma, Lebistes reticulatus* and on its own young ones.

The gold fish has been found to consume 200 mosquito larvae in 24 hours. It can be transported over long distances without mortality provided the temperature is kept below 30 degree C.

Tinca tinca.

The *Tench* is one of the first exotic fishes to be introduced into India. It was stocked in Ootacamund lake for the first time in 1874. It is a typical cold water fish and thrives only in the cold waters of the Nilgiris above 6,000 feet altitude. Ever since its introduction in the Ootacamund lake the *Tench* has been breeding freely indicating that it has stabilized well. It forms now a very significant portion in the commercial catches of Ootacamund lake.

Food and feeding.—The *Tench* at all stages is a pronounced plankton feeder, feeding mostly on zooplankton like copepods and Daphnids. The fish feeds very actively in the early morning hours. The percentage analysis of its diet consist of the following :—

	PER CENT.
Daphnids	35·7
Copepods	25·1
Protozoans	8·0
Diatoms	1·2
Green Algae	3·3
Blue Green Algae	3·0
Insects	10·3
Leafy bits	3·7
Mucilage	9·4

The various organisms that constitute its food are detailed below :—

Diatoms : Nitzschia, Fragillaria, Cyclotella, Navicula.

Green Algae : Ankistrodesmus, Closterium, Spirogyra.

Blue Green Algae : Anabaena, Oscillatoria, Microcystis.

Protozoans : Euglena, Ceratium.

Cladocerans : Bosmina, Ceriodaphnia, Daphnia.

Insects : Larvae of Ephemeroptera, Coleoptera, Diptera.

Breeding.—Sexual maturity is attained at a relatively small size. The males reach maturity at a size of 12 to 13 cm. and the females at a size of 17 to 19 cm.

Breeding takes place in the Ootacamund lake almost throughout the year but the months from February to April is the peak period of spawning. The eggs are highly sticky and they are attached to the weeds or roots of floating plants. The fertilized egg is round, 1·23 mm. in diameter and demersal. The yolk is colourless and finely granular. The incubation period is about 5½ days. The hatching is 4.2 mms. long and is a frail transparent one characterized by total absence of pigment over the body. The yolk is absorbed in 25 days after hatching when the fry begin to feed on zooplankton particularly small Daphnids.

Growth.—In its natural habitat in Europe, Asia Minor and Western Siberia the Tench is reported to grow to 55 to 60 cm. In the Ootacamund lake specimens of 45 cm. have been occasionally taken. But the commercial catches comprise of specimens of the size from 20 to 40 cm. The growth is slow in Ootacamund lake. The growth rate in the lake is given below :—

Year.	Size. cm.
I	
II	8 to 9
III	12 to 13
IV	16 to 18
V	21 to 25
	23 to 25

The fish is suitable only for extensive water spreads at an altitude higher than 4,000 feet.

Collection and transport of young ones.—Fry and fingerlings are available throughout the year in Ootacamund lake. But they occur in fairly large numbers from July to October. The fingerlings are collected by castnetting and Velon Screen. Hundred fingerlings can be transported in one tin carrier. Applying ice and keeping the temperature cool they can be successfully transported to plains. But they do not survive the higher temperatures of the waters of the plains.

Lebistes reticulatus.

The "*Barbados Millions*" or the *Guppy* were found in the tanks of Rameswaram temple in February 1946. The fish has been introduced to various parts of the State from this tank.

The fish feeds on insect larvae, Diatoms and filamentous algae. It is fairly good fish for larvicidal work. The diet consists of the following :—

	PER CENT.
Diatoms	15
Green Algae	15
Blue Green Algae	15
Protozoans	5
Copepods	10
Daphnids	7
Ostracods	8
Insects and Insect larvae	27
Worms	3

Sexual dimorphism is exhibited. The male is brightly coloured and the pelvics are modified as a sperm depositor. The males attain maturity when 18 mm. long and females when 25 mm. Each ovary contains 50 to 60 ova measuring 1·5 to 1·8 mm. in

diameter. Fertilization is internal and the fertilized egg measures 2·0 mm. The young ones are released in broods of 5 to 7 at a time.

The fish is found to consume 80 mosquito larvae in 24 hours under laboratory conditions.

Gambusia affinis.

The American mosquito fish was introduced into Madras in 1929 when 600 fish were imported from Ceylon by the Fisheries department. The fish has established itself excellently and is now found almost in all brackish and freshwater canals and creeks and other waters of the State, including the hill stations. It is a very hardy fish adapting to all types of waters.

Food.—It feeds on *Cladocerans* and *insect larvae*. The diet consists of the following :—

	PER CENT.
Diatoms	20
Green Algae	10
Blue Green Algae	10
Copepods	10
Daphnids	5
Insects and Insect Larvae	45

Breeding Habits.—The females attain a maximum size of 68 mm. whereas the males reach a maximum size of 52 mm. The fish attains maturity when 30 mm. long and three months old. They breed throughout the year. Each ovary has on an average 120 eggs. The fish is viviparous and the female releases 25 to 30 larvae in 30 minutes. In a population, generally, there are more females than males.

Being very hardy they easily adapt to all types of waters and are easily transported. The fish is found to live without any discomfort in highly polluted waters. It is a good larvicide and is extensively used in the control of mosquito larvae. Under laboratory conditions the fish consumes 260 mosquito larvae in 24 hours.

CHANOS CHANOS.

Chanos chanos, popularly called the milk fish because of the purely milky white colour of its flesh occurs along both the coasts. They enter the estuaries and backwaters very extensively. The fish is spindle shaped and is a fast swimmer, occasionally making long leaps over the water when disturbed. The fish show remarkable adaptability to get adjusted to fresh water milieu and grow in it quite well and rapidly. In the major backwater lakes like Pulicat and Muthupet *Chanos* forms a good fishery contributing to 10 per cent of the total catches. Though not so abundantly caught in the inshore waters of the seas around the State, they occasionally

form fair bulks of a day's catches in the catches of Visakhapatnam and Kerala coasts. This fish is extensively used in fish farming in the Philipines and Indonesia. In the Madras State also *Chanos* forms one of the most important fishes used for culture in inland water systems. Day (1889) has mentioned that Hyder Ali introduced this fish into the Coondapur tank. The fry and fingerlings of the milk fish occur in several places all along the Indian Coast.

Food and Feeding.—The milk fish in all its stages feeds on *microflora* occurring in the plankton or at the bottom. The larvae and fry in the sea consumer *Copepods, Fritillaria borealis, Hemidiscus hermanianus, Larval bivalves, Leucifer hanseni, Navicula, Pleurosigma, Spiratella, Tintinnus, Thalassiothrix, Trichodesmium, Lyngbya, Oscillatoria, Polysiphonia* and *Schizothrix.*

In the estuaries the fry feed on *Hemidiscus, Navicula, Pleurosigma, Thalassiothrix, Coscinodiscus, Fragillaria, Nitzschia, Rhizosolenia, Planktonella, Cymbella, Gomphonema, Pinnularia, Biddulphia, Ceratium, Peridinium, Tintinnus, Larval bivalves, Diaptomus, Acartia, Evadne, Acetes, Mysis, Leucifer, Nauplius* and *Megalopa larvae.*

When stocked in freshwater ponds and tanks, the fingerlings feed more on algae like *Microcystis, Oscillatoria* and *Spirogyra.* The other organisms usually found in its diet are diatoms and desmids like *Cosmarium, Coscinodiscus, Amphora, Surirella, Cymbella, Fragillaria* and *Navicula*, Copepods, like *Cyclops* and *Diaptomus*, Rotifers and Daphnids. Sand grains have also been found ingested occasionally.

The food of adults and adolescents in the sea and brackish water estuaries consisted of the following :—

Diatoms : *Coscinodiscus, Fragillaria, Nitzschia, Pleurosigma, Rhizosolenia, Thalassiothrix.*

Algae : Trichodesmium.

Copepods : *Acartia, Pseudodiaptomus, Paracalanus.*

Molluscs : *Larval bivalves, Larval gastropods, Spiratella.*

Crustaceans : *Leucifer, Mysids.*

Fish eggs and *Fish larvae.*

Tunicates : *Oikopleura, Fritillaria.*

In the freshwater ponds they feed on the Blue green algae *Microcystis* and *Oscillatoria* and on the green algae *Spirogyra* very avidly. *Diatoms, Copepods, Rotifers* and *Daphnids* also are eaten.

The emphasis in the diet of the milk fish in all milieu and at all stages is more on the vegetable matter like algae and diatoms. In Phillipines the milk fish is noted to selectively feed on the "Lab-lab" which is a biological complex compound of a variety of Blue green algae, flagellates, protozoans and some larval forms.

Growth.—*Chanos* grows to a size of 180 cm. in the sea. Occasionally specimens of 150 to 165 cm. feet length have been seen in the marine catches of both coasts. But the catches in the Pulicat lake comprise of specimens of 35 to 50 cm. The growth of Chanos varies in the different milieu. In the sea they grow to a size of 18 to 25 cm. in the first year. The fish grows to 21 to 25 cm. in the Marine Fish farm. It grows very fast from July to November and then slows off in the months of December to June. The rate of growth in marine fish farm is fairly the same as that in the neritic regions of the seas. The growth of the fish is faster in brackish water milieu. The rates of growth of the fish from the earliest brood of the year is greater than that of the subsequent broods. The former grows to a size of 41 cm. in the first year, 50 cm. in the second year and 59 cm. in the third year. The fish from the later broods grow to a size of 35 cm. in the first year and 41 cm. in the second year. The rate of growth is faster in a muddy brackish water pond than in a rocky one. The average growth of milk fish in the first year in different types of fresh waters are given below :—

1 Tank fed by a rivulet—60 cm. (about).

2 Tank frequently disturbed by bathers and cattle—52 cm. (about).

3 Spring-fed tank—32 cm. (about).

4 Well—17 cm. (about).

It can be seen from the above that the fish grows fastest in tanks fed by a river. The growth is good in tanks that are subjected to fair extent of organic pollution also. The milk fish is a very poor fish for culture in wells.

Fecundity and Breeding.—*Chanos* reaches its maturity when it reaches a size of 80 to 85 cm. in the sea. In the fresh water ponds and tanks the gonads are not developed. The milk fish is a fish of very high fecundity. One oozing female 157 cm. in length contained about 20 lakhs of eggs each of 0·75 mm. diameter. Another oozing female 140 cm. in length contained 1,935,500 eggs each of 0·7412 mm. in diameter. At the time of spawning, the spawners assemble in shoals of 50 to 60 in regions of sea close to backwaters or estuaries. The spawning takes place most probably during the nights of the newmoon periods in the months of March, April and May. There is a subsequent minor spawning period in October-November also. The fertilized egg is 1·1 to 1·2 mm. in diameter and has an yellowish frothy yolk. The larva has a transparent elongated body with 31–33 preanal myotomes and two rows of black pigments along the side of the body. The piements are scattered about on the caudal fin. No pigments are present on the other fins. The stomach and intestines are visible through the

transparent body. By the time the fry reaches a length of 20 mm. it loses its transparency. The dorsal side acquires a bluish tinge and the body becomes cylindrical with a silvery ventral side. The metamorphosis is almost completed by this time and the fry develop all the adult characteristics.

Collection and transport of the young ones.—The fry and fingerlings of the milk fish occur in several places along both the coasts. The fry usually swarm in tidal creeks and mud flats where the water is shallow in the months of March to June and November to December. The larvae after hatching hug the shore and swamps where there is a slow flow of fresh water. The fry are collected by dragging a scare line before a fine piece of cloth in shallow regions of mud flats. The fingerlings, afraid of the scare line jump out into the air and are collected in the cloth from where they are transferred to a container. The fry and fingerlings can be transferred straight to fresh water without resorting to gradual process of reducing salivity. They are very hardy and stand this sudden acclimatization very well without any mortality. The fry and fingerlings are conditioned at least for 24 hours and then they can be transported in tin carriers. Two hundred fry of 2·5 cm. can be transported safely in one tin carrier for a distance of 450 miles.

ETROPLUS SURATENSIS.

This is a common backwater perch found along both the coasts of this State but more abundantly on the West Coast. Though it naturally lives in the brackish or sea water it is easily acclimatized to freshwater, where it breeds in ponds and tanks. The fish has a light green colour with eight vertical black bands. The scales above the lateral line have a central white pearly spot because of which the fish is called commonly as the " Pearl Spot ". All the fins except the pectorals have a leaden colour. The pectorals are slightly yellowish with a black base. The fish has got very strong dorsal and anal spines. Because of its green colour background the fish is called " Karimeen " in Malayalam meaning the dark fish. The fish normally shoals in shallow creeks and in places where there is high sewage pollution or luxuriant growth of aquatic weeds. The fish has a peculiar habit of evading capture by lying flat on its side at the bottom. Sometimes it even feigns death by lying on its side and moving the opercula in very irregular spasms.

Food.—The young ones feed mainly on copepods, and filamentous algae like *Oedogonium*, *Spirogyra*, *Oscillatoria* and *Lyngbia*. Daphnids, *Cyprids*, *Euglenoids* and *Volvocales* formed some of the minor items.

In the adolescent and adult stages the pearl spot is a bottom feeder browsing mainly on algal filaments (44 per cent) and diatoms

(28 per cent). The various organisms that constitute its food are listed below :—

Diatoms : *Coscinodiscus*, *Fragillaria*, *Nitzschia*, *Navicula*, *Pleurosigma*, *Synedra*.

Green Algae : *Spirogyra*, *Oedogonium*.

Blue green Algae : *Oscillatoria*, *Lyngbia*.

Protozoans : *Ceratium*, *Peridinium*, *Tintinnus*.

Copepods : *Diatomus*, *Mesocyclops*, *Cyclops*, *Eucyclops*.

Cladocerans : *Ceriodaphnia*, *Diaphanosoma*.

Decapods : *Caridinia*, *Metapeneus*.

Insects : *Diptera larvae*, *Corixa*, *Chironomus*.

Worms : *Nais*, *Aelosoma*.

Aquatic Weeds : *Hydrilla*.

Fish : *Unidentified Fish Eggs*.

Whenever available, the pearl spot gorges its stomach with raw sewage. In garden ponds and wells, it readily feeds on cooked rice and oil cakes.

Fecundity and breeding.—The fish attains its maturity in the first year itself when it is about 15 to 18 cm. in length. It breeds throughout the year but the maximal period being the months immediately following the rainy season. At the time of actual breeding the fish swim in pairs, the female being smaller in size. On an average 2,000 eggs are laid by a female and these are attached to submerged objects like stones, tiles, bamboo poles, coconut husks, etc., in the form of oblong yellowish patches of 6 inches by 7 inches dimensions. The fertilized egg is oblong in shape, 2 mm. by 1 mm. in size. The period of incubation is about six days. The hatchling measures about 5·46 mm. in size. The parents guard the offspring for about four weeks after hatching. The parents make small saucer shaped depressions in which the off-springs are kept under guard, the female being more assiduous in the guard duty. It has been noticed that the brood are transferred from pit to new pit occasionally.

The fry of pearl spot though very similar to those of the Orange Chromide, *Etroplus maculatus*, can be easily distinguished by the more elongated body and absence of a dark spot at the tip of the caudal peduncle. When a little longer (about 20 mm. long), the pearl spot is characterized by a conspicuous ocellus at the hind portion of the dorsal fin, which is absent in *Etroplus maculatus*.

Growth.—*Etroplus suratensis* is reputed to grow to a size of 45 cm. In ponds and wells having a good amount of filamentous algae its rate of growth is the following :—

Year.				cm.
I	...	...	..	21
II	...	...	...	30
III	...	...	...	36
IV	...	...	...	41
V	...	...	..	44

The fish can be very easily grown in saline or brackish or fresh waters of all types. It grows and breeds in waters up to an altitude of 4,600 feet. But in the upland waters the growth has been very slow, a size of 20 cm. being reached only in about three years. In extensive reservoir systems like the Bhavanisagar they have been noticed to grow very fast. In Bhavanisagar a growth of 36 cm. has been reached in 20 months. Owing to palatability, absence of fine bones, vegetarian habits, hardihood, availability and ease of rearing and breeding in all types of waters, the pearl spot is much suited for fish culture in rural areas. Only some submerged objects like stones or tides have to be provided for breeding purposes. Because of the character of attaching the eggs, the fish is well suited for stone cut tanks and irrigation wells which may not be suitable for many other fishes. Again, being deep in body and armed with sharp spines at the back and at the vent, it escapes predators like murrels and can therefore be stocked in waters that, cannot be cleared of such species.

Collection and transport of young ones.—Young ones can be collected throughout the year from the backwaters. They are also available in ponds and wells stocked with the pearl spot previously. The young ones have to be collected very carefully as they are very delicate and do not stand rough handling. The bottom of the water spread wherefrom the collection are made should be disturbed to the least as in turbid conditions, the young ones die very easily. Fine meshed nets like a dip net or a cast net is the best for collecting. Another way is to float large bundles or twigs and leaves under which the young ones assemble when they can be easily scooped. If a cast net for drag net is used, only a few numbers like 10 or 12 should be taken in each haul as otherwise in the effort of taking more numbers in each haul the water is made turbid and delay in removing the young ones from the net also happens. The young ones should be conditioned for 48 hours before transport. As the demand for oxygen is great in the young ones water has to be changed once in 6 hours and not more than 40 young ones of 1 to 1½ inches should be transported in each tin carrier.

In the case of young ones collected from the brackish waters, they have to be acclimatised very slowly in 4 stages, each stage being separated by a time interval of 4 hours as follows :—

Stage number. (1)		Brackish water. (2) PER CENT.	Fresh water. (3) PER CENT.
I	.. .. ..	80	20
II	4 hours later	40	60
III	Do.	10	90
IV	Do.	0	100

The young ones should be retained in the fresh water for a minimum period of 36 hours. For a period of 84 hours after collection the metabolic activity of the fish is very much enhanced which results in greater oxygen demand. So during transport of a duration of 48 hours only 40 young ones of 1 to 1½ inches should be contained in a tin carrier, and the water has to be changed every six hours. At the same time 150 young ones of 1 to 1½ inches can be transported in the standard oxygen tin carrier without any mortality or without any further oxygenation or change of water after the initial one.

ETROPLUS MACULATUS.

A congener of *E. suratensis* the "Orange Chromide" yields a fishery of some importance by virtue of its occurrence in large numbers in almost all the inland waters. It is equally at home in fresh as well as brackish waters. It breeds freely in both the types of waters.

Intense breeding takes place from November to April.

The fish feeds on worms (24 per cent), insects and their larvæ including mosquito larvæ (31 per cent), micro-crustacean like *Cyclops*, *Diaptomus*, and *Daphnids* (31 per cent) and diatoms, filamentous algæ and vegetable detritus (14 per cent). Few sand grains also are found in their gut contents sometimes. Under laboratory conditions they consume 100 cyclops in 24 hours. In view of this it is a very useful cyclopscidal fish.

MEGALOPS CYPRINOIDES.

Popularly called the ox-eyed herring. *Megalops cyprinoides* occurs along both the coasts and migrates into the lower reaches of the rivers and the coastal pools and tanks. In Godavari and Kistna rivers it migrates to a distance of 60 miles from the sea whereas in the Cauvery it has been recorded from the Mettur Dam, a distance of 250 miles from the sea. The fish is bright silvery in colour and has very large eyes displaced far apart on its sides from which it take its popular name of ox-eyed herring. The fish is considered a good food and game fish. It has a peculiar habit of leaping in water when disturbed.

Food and feeding habits.—In the young stages *Megalops* feeds mainly on copepods like *Cyclops*. Because of this the young stages of Megalops are considered as good cyclopoidals. The other items in the food of the young ones are Daphnids, diatoms (*Coscinodiscus*, *Fragillaria*, *Navicula*, *Pleurosigma*, *Nitzschia*, *Thalassiothrix*), Cyprids and rotifers. In the adolescent and adult stages *Megalops* feeds on shrimps (*Acetes*, *Caridinia*), mysids, insects, insect larvæ, and young ones of other fishes and minnows. It becomes a predator in its adolescent and adult stages.

Fecundity and breeding.—The fish attains its maturity in the first year itself when it reaches a size of 25 cm. The fish does not breed in fresh waters. The eggs of *Megalops* have not been recorded in nature during the course of studies. During the monsoonic months of July to August and October to December the larvæ of *megalops* are found in large numbers at the tidal flats and estuaries of the rivers. The larvæ development is characterised by a "Leptocephalus Stage". These larvæ are hardy and they successfully withstand and adjust to sudden and wide changes in salinity. The metamorphosis is characterised by a reduction in length and a forward migration of the dorsal fin.

Growth.—The fish grows to a maximum size of 60 cm. and 912 gm. in weight. In fresh water conditions it grows very fast growing to a size of 34 cm. in the first year and 57 cm. in the second year. Because of its piscivorous habits, this fish is suitable for culture only in wild uncleaned waters.

Collection and transport of young ones.—The larvæ of *megalops*, ribbon like in nature and transparent, can be collected in large numbers from the tidal flats and estuaries of the rivers on both coasts in the rainy months of July to August and October to December. The young ones are available at the estuaries from August to September and November to January. The larvæ stand sudden transfers to fresh water. But the young ones have to be acclimatised in two stages of 50 per cent fresh water and 50 per cent brackish water and 25 per cent brackish water and 75 per cent fresh water. They stand the acclimatisation and transport very well. The larvæ of *megalops* usually shoal with the "Leptocephalus" larvæ of *Elops*. The *Elops* larvæ are more transparent than *Megalops* larvæ. The latter has a pale yellowish tinge tending to an opacity. The dorsal fin in *Megalops* larvæ is opposite the level of anal whereas in the *Elops* larvæ it is very far backward near the caudal.

II. HYDROBIOLOGY OF THE FRESH WATERS OF MADRAS STATE (COMPOSITE).

A. Lakes and Reservoirs.

Malabar district.

1. *The Pookote lake, Vythiri, Wynaad taluk* was examined on 14th December 1950 to assess its suitability for fish culture. The lake is situated in a valley surrounded by hills at an elevation of about 2,600 feet above mean sea level. It is perennial with a water spread of about 12 acres and a maximum depth of about 15 feet. It has a small outlet that requires protection by a screen. As the lake was left unused for a long time, there was a rank growth of land flora (screw pines, grass, colocasia and ferns) along the margin and of aquatic vegetation (*Hydrilla*, *Ceratophyllum*, *Utricularia*, *Vallisneria*, *Cdyptocoryne* and *Limnophila*). At 5 p.m. the surface water had a temperature of 25·0° C. and a turbidity of 26 cm. and a dissolved oxygen content of 4·7 p.p.m. The water was slightly acidic with a pH of 6·8 and carbonic acid concentration of 1·68 p.p.m. and soft with bicarbonate content of 35·6 p.p.m. and cloried content of 9 p.p.m. The phytoplankton consisted of blue-gram algae (Aphanizomenon and Osillatoria), green algae *Cladophora Closterium*, *Coelastrum*, *Crucigenia*, *Cylindrocystis*, *Desmidium*, *Euastrum*, *Genicularia*, *Gonatozygon*, *Micrasterius*, *Penium*, *Scenedesmus*, *Spirogyra*, *Staurastrum*, *Tribonema*, *Ulothrix and Zygnema*) and diatoms (*Cyclotella*, *Cymbella*, *Eunotiam*, *Gyrosigma*, *Melosira*, *Navicula*, *Nitzschia*, *Surirella* and *Tabellaria*). The zooplankton consisted of infusorians (*Epistylis* and *Vorticella*), Cladocerans (*Bosmina* and *Daphnia*) and Copepods (*Eucyclops*). Worms (*Nais*), spiders and ants were found among the marginal vegetation. Water beetles (*Cyrinus*) and Water Bugs (*Gerris* and *Metrocoris*) were also common. Tadpoles of the jungle frog (*Rana curtipes*) were also found in swarms. Fish life was represented by minnows (*Barbus melanamphyx*, *B. melanostigma* and *B. arulius*). Large sized *murrels* and *Wallago* were also reported to be present.

The lake was on the whole found to be suitable for pisciculture operations. Suggestions were made to the Assistant Director of Fisheries, Malabar to remove the rank vegetation and the predaceous species of fishes and to stock the lake with both cold water species like *Mirror carp*, *Golden carp* and *Tench* and warm water species like *Gourami*, *Etroplus suratensis*, *Chanos chanos* and the major carps of the Cauvery system. An average production at the rate of 1,000 lb. per acre can be expected from the lake which would be a source of fish supply to the several estates in the Wynaad plateau where at present fish is dear.

2. *The Turiode lake, Wynaad taluk*—This lake is about 14 miles from Vythiri and about one mile east of the twelfth mile-stone on the Vythiri Turiode road. It is about 8 acres in extent and perennial with an average depth of 8 feet. It has two outlets which can be easily controlled and was covered with excessive vegetation as in the case of Pookote Lake. The lake was examined at 11-5 a.m. on 15th December 1950 for suitability for pisciculture. The surface water had a temperature of 25·6°C., turbidity 28 cms., and dissolved oxygen 9·2 p.p.m. and was alkaline with a pH of 8·8, phenolphthalin alkalinity of 3 p.p.m. and methyl orange alkalinity of 24·4 p.p.m. The phytoplankton consisted of blue-green algæ (*Aphanizomenon*, *Chroococcus*, *Merismopedia*, *Oscillatoria* and *Tetrapedia*), green algæ (*Ankistrodesmus*, *Closterium*, *Cosmarium*, *Crucigenia*, *Dictysphærium*, *Genicularia*, *Gonatozygon*, *Kirchneriella*, *Microsterius*, *Netrium*, *Oedogonium*, *Oocystis*, *Penium*, *Scenedesmus*, *Selenastrum*, *Spirogyra*, *Staurastrum*, *Tribonema*, *Ulothrix* and *Zygnema*) and diatoms (*Cymbella*, *Fragilaria*, *Melosira*, *Navicula*, *Nitzschia*, *Pinnularia* and *Surirella*). The zooplankton consisted of infusorians, cladocerans, cyprids and copepods. The riparian fauna was rich and larval stages of *Plecoptera*, *Ephemeroptera*, *Odonata*, *Trichoptera* and *Diptera* were observed in the shallow areas of the lake. Fish life consisted of minnows and murrels and cat fishes were also reported to occur in it. Suggestions were made for initiating pisciculture in this lake also on the same lines as indicated for the Pookote lake.

Nilgiris district.

3. *The Ootacamund lake.*—The Ootacamund lake is situated at Ootacamund in the Nilgiris range of mountains at an altitude of 7,210 feet and has a waterspread area of about 70 acres. Excepting for one or two small springs that lead into the lake, its main source of water-supply is the seepage water from the neighbouring catchment area which is generally utilized for raising vegetable crops. The municipal stream that empties into the north-east corner of the lake brings in a considerable quantity of drainage. The outlet from the lake leads finally into the Sandynullah stream. Cold water fishes like Mirror carp, Scale carp, Leather carp, English carp and Tench breed prolifically in this lakes.

To understand the physical, chemical and biological conditions of this upland lake where the above exotic species of fish have established themselves, a limnological study of the lake was made in March 1947 in collaboration with the hydrological and algological units attached to the station. Soundings were taken at 259 points in the lake and the maximum depth was found to be 9·3 meters (30·6 feet) near the outlet. For convenience of study the lake was divided into 3 sections. Section A adjoining the Railway line and opposite the Public Works Department bungalow; Section B a

narrow long strip near the Boat House; and Section C adjoining the outlet. Water and plankton samples were taken at different points in all the 3 sections and the collections were made both from surface and at different depths at each point. The diurnal fluctuations in the Hydrobiological conditions in the different layers of the lake were also assessed by making six-hourly observations in the deepest portion of the lake in Section C. Samples of bottom deposits were also collected from the three sections to study the bottom fauna.

The lake water was found to be oxygenated to a depth of 4·5 meters (14·76 feet) only from the surface. The deeper layers of water had the characteristic smell of sulphuretted hydrogen and the bottom deposits—soft muddy ooze—also smelled strongly of the same gas. In spite of the absence of dissolved oxygen anywhere near bottom, the bottom mud in section A contained large numbers of oligochæte worms. The pH varied from 6·5 to 8·7 Temperature of water at surface was cooler than the temperature 1·5 meters (4·92 feet) below surface, probably due to wind action and consequent cooling. With increasing depth the temperature steadily decreased. Phosphates and nitrates which are very essential for algal production were totally absent. Phytoplankton was very poor in variety but rich in numbers. Thick swarms of *Ceratium hirundinella* formed a scum all over and coloured the water deep dirty brown. It occurred almost to the exclusion of all other phytoplankton organisms. Cladocerans represented by the genera *Bosmina*, *Ceriodaphnia* and *Daphnia* predominated in the zooplankton. Copepods and copepod nauplii were also common.

The winter conditions of the lake do not seem to have been studied during the period of the scheme. However daily maximum and minimum temperatures and pH of the surface waters of the lake were recorded from June 1949 to March 1951 with the help of the Inspector of Fisheries, Ootacamund and the monthly averages of the data gathered are shown below in Table 1. The surface water temperatures of the lake varied from a minimum of 10·5°C. in December 1950 and January 1951 to a maximum of 25·0° C. in August 1949. The maximum temperatures were usually attained in the month of August or September and the minimum temperatures in December or January. The pH of the surface waters of the lake remained more or less uniform throughtout the period of observation and varied between 7·15 and 7·4 only.

TABLE 1.

	Maximum temperature. (Degree C.)	Minimum temperature. (Degree C.)	pH
June 1949	22·0	17·0	7·3
July 1949	23·5	13·3	7·1
August 1949	25·0	17·0	7·3
September 1949	23·8	15·0	7·3

TABLE 1—*cont.*

			Maximum temperature. (Degrees C.)	Minimum temperature. (Degrees C.)	pH.
October 1949	..	..	22·6	17·6	7·4
November 1949	..	..	22·5	15·0	7·4
December 1949	..	..	19·6	12·7	7·2
January 1950	..	..	20·2	13·0	7·3
February 1950	..	..	22·0	13·2	7·2
March 1950	..	..	20·2	13·0	7·2
April 1950 ..	..	..	20·4	14·2	7·2
May 1950 ..	..	..	19·2	11·7	7·2
June 1950 ..	..	..	21·6	12·0	7·2
July 1950 ..	..	..	19·2	11·1	7·15
August 1950 ..	..	..	23·0	12·1	7·2
September 1950	..	..	23·7	12·1	7·2
October 1950	..	..	22·9	12·1	7·3
November 1950	..	..	22·6	12·2	7·35
December 1950	..	..	21·5	10·5	7·3
January 1951	..	..	21·6	10·5	7·25
February 1951	..	..	20·8	11·5	7·3
March 1951	..	..	19·9	11·0	7·3

To confirm the above observations on summer conditions and to ascertain the winter conditions in the lake, the investigations were repeated in the hot weather period of 1952 and cold weather season of 1953. The hydrological conditions at 8 a.m. at different depths in the lake during both the seasons are shown below in **Table 2.**

TABLE 2.

Season.	Depth.	Temperature (Degree C.)	pH.	Dissolved Oxygen p.p.m.	Free CO_2 p.p.m.	Bicarbonates as HCO_3 p.p.m.	Chlorides as Cl. p.p.m.	Silicates as SiO_2 p.p.m.	Phosphates as PO_4 p.p.m.	Carbonates as CO_3 p.p.m.
(1)	(2)	(3)	(4)	(5)	(6)	(8)	(9)	(10)	(11)	(7)
Summer—May 1952	Surface.	22·9	7·0	3·0	35·2	148·5	8·0	1·0	2·60	Nil.
,,	2 m.	20·6	7·0	0·71	25·3	146·4	8·0	1·0	3·75	Nil.
,,	4 ,,	20·0	7·0	Nil.	18·7	152·5	8·0	1·0	3·75	Nil.
,,	6 ,,	18·2	7·1	Nil.	8·8	149·5	8·0	1·2	3·75	Nil.
,,	8 ,,	17·9	7·3	Nil.	13·2	149·5	8·0	1·4	Tr.	Nil.
Winter—February 1953	Surface.	18·0	7·2	5·2	1·43	115·9	36·0	6·0	Tr.	Nil.
,,	2 m.	17·2	6·0	2·3	2·42	125·0	36·0	6·0	Tr.	Nil.
,,	4 ,,	16·8	6·9	0·1	4·4	131·2	36·0	6·0	Tr.	Nil.
,,	6 ,,	16·4	6·9	0·1	3·51	131·2	36·0	6·4	Tr.	Nil.
,,	8 ,,	16·2	6·9	0·1	4·95	146·4	36·0	6·8	Tr.	Nil.

The surface water temparature varied from 22·9 C in the hot weather period to 18·0° C in the cold weather period. There was thermal stratification in the lake throughout the year; but stratification was mre pronounced in the summer months than in the winter months. The difference between surface and bottom water temperature was 5·0° C in the hot weather period but was only 1·8° C in the cold season. The seasonal fluctuation of pH was very little and the pH of the entire column of water in the lake varied between 6·9 and 7·3 only. During the winter, the pH decreased steadily with depth but during the summer the upper layers of water to a depth of about 4 meters had a lower pH than that of the bottom layers. This may be partly due to the decaying and floating water hyacinth that had grown dense in the lake and partly due to the overcrowding of the entire fish stock of the lake within the upper layers, consequent on the complete exhaustion of oxygen in layers 2 meters below surface and increased accumulation of carbondioxide by respiration of greater number of fishes. The oxygen stratification was also marked and there was practically no oxygen below 3 meters throughout the year. The relatively low oxygen values in the summer were due to the presence of decaying water hyacinth after the removal of which in January 1953, the oxygen figures increased in the winter. Carbonates were completely absent and carbondioxide, bicarbonates and silicates increased from surface to bottom. The bicarbonates were relatively high in the Ooty Lake (as compared with the Kodaikanal and Yercaud lakes—the other two upland lakes of Madras State and ranged from 115·9 p.p.m. in the winter to 152·5 p.p.m. in the summer. The silicates were higher in the winter than in the summer. The chlorides were uniform from surface to bottom and varied from 3 p.p.m. in the hot weather to 86 p.p.m. in the cold weather.

The diurnal variations of temperature, pH and dissolved oxygen were also studied in both the seasons and are shown in Table I of Appendix. It will be seen from the above that the surface as well as the deeper layers of water generally increased in their temperature from 2 a.m. to 2 p.m. after which their temperature gradually decreased till the early hours of next day morning when they once again increased. The diurnal variations of temperature were greater in the cold weather season than in the hot weather season and generally tended to decrease with increasing depth. As in the case of temperature, pH and dissolved oxygen of the surface waters also increased from 2 a.m. to 2 p.m. after when they decreased till the next day morning when they again began to increase. Their diurnal variations were, however, not very marked below 4 meters.

4. *Mukurti Reservoir.*—This has been formed by damming up the Mukdorti river and it has a waterspread area of about a square mile and a maximum depth of 84 feet. Rainbow trout is thriving

in this reservoir. The summer conditions f this reservoir were ascertained in March 1947 as in the case of the Ootacamund lake. Unlike the Ootacamund lake the water had no sewage contamination and was green in colour with very good visibility. The pH was low and ranged from 5·9 to 6·5. Dissolved oxygen was found at least in races up to a maximum depth of 18 meters from the surface. Phytoplankton was richer than the zooplankton and consisted mainly f desmids and diatoms. Though comparatively few in numbers there was great variety f species. Zooplankton was comparatively poor and mainly consisted of copepods.

Salem district.

5. *The Stanley Reservoir, Mettur Dam.*—The Stanley Reservoir is formed by the damming up of the Cauvery river at Mettur and has an area f about 61 square miles and impounds nearly 95,660 million cubic feet of water at its maximum level. The reservoir extends right up to Hogainakal and has a maximum depth of 112 feet at the sill level and 214 feet at the deepest portion of the river. Limnological conditions of the reservoir were studied in June 1947 when with the failure of the monsoon, more or less summer conditions prevailed, in November 1947 when monsoon conditions were prevalent and in February 1948 during the winter season.

In June 1947 the level of water in the reservoir was 94 feet. The Ellis surplus was not working and the high-level sluices were open and functioning, while the low-level sluices were closed though some leakage water was trickling. Samples of water, plankton, faunal and floral constituents and fish life were studied from the surface waters of the reservoir and at depths corresponding to the sill level of the high and low level sluices, the tail-race of the Mettur Pwer House and along the course of the river below the dam.

The surface water in the open reservoir was greenish in colour but transparent. *Synedra* and *Pediastrum* formed the dominant forms of phytoplankton. A few copepods and rotifers constituted the zooplankton which was poorer in quality and quantity than the phytoplankton. The water issuing out of the high and low-level sluices and the tail-race of the power house (at 44 feet, 94 feet and 124 feet respectively from the surface) was black in colour and smelt strongly of suphuretted hydrogen (contained 1,248 mg./l of HS_2 at 44 feet from surface). The stench was quite offensive and pervaded the vicinity. A difference of 2·7° C was noted between the surface and bottom temperatures of the water indicating the existence of a pronounced thermal stratification in the reservoir. Free carbondioxide was absent in the surface waters, while in the deeper layers it varied from 2·09 to 2·75 p.p.m. Corbonates were present only at the surface (19·5 p.p.m.) while the bicarbonates

ranged from 138·7 to 202·37 p.p.m. The pH varied from 8·5 at surface to 7·6 at a depth of 94 feet. The surface water was rich in dissolved oxygen (4·45 cc/litre and percentage saturation 79·4) while even at a depth of 44 feet from surface the sulphuretted hydrogen had neutralised all oxygen. The black malodorous water issuing from the tail-race of the power house contained 4·258 cc/l of dissolved oxygen. This is accounted for by the quick aeration of the bottom layers of water as they gush out through the turbines. This was also found to be the case with the water that was trickling down the closed low-level sluices. Though, in the reservoir, the water at the lower levels was completely devoid of oxygen, as it trickled down through the closed gates, it got aerated even in the presence of sulphuretted hydrogen. Chloride was low as in all stored up rain waters; phosphates were present only in deeper layers; free ammonia was present; nitrates were absent throughout; while silicates in the surface waters were being used up by the diatoms and hence were present only in lesser amounts than in deeper layers. Experimental fishing procured no fish below the 20 feet level from the surface.

Immediately below the dam, the water-supply was received from the high-level sluices and the tail-race of the Mettur Dam Power House. In the former, the black, malodorous water, while gushing forth from the narrow sluices and subsequently flowing at high velocity over the boulders, got fully aerated and regained normal colour before joining the river proper. From the tail-race, however, the water gushing out with tremendous force under a 94 feet head flowed more or less unmixed with the water from the high-level sluices for a distance of about half a mile below the dam. Because of the different colours of the water from the two sources, the appearance of two distinct streams flowing side by side was created. The physical, chemical and biological conditions of these two sections differed considerably. The coloured portion had lower temperature (26·6° C to 27·0° C), lower oxygen content (2·513 to 3·250 cc/l), percentage of saturation (42·9 to 55·6), pH (7·5), but higher phosphates (0·03 to ·05 p.p.m.) and silicates (38 to 39 p.p.m.) than the water from the high level sluices, which was flowing at torrential speed, coloured bluish-green because of oxidation of the black sulphides and had a slightly higher temperature (28·8 to 29·8°C.), increased dissolved oxygen (4·188 to 5·441 cc/l) and percentage of saturation (70·5 to 97·3). Phosphates and silicates were slightly lower.

A luxuriant, thick pavement like growth of sulphur bacteria *Thiothrix nivea* was characteristic of the entire course where the black malodorous water was flowing. The presence of free sulphuretted hydrogen as well as oxygen is essential for the sustenance of these bacteria and their presence in large quantities near the high

and lower level sluices and near the tail-race of the power house, was sample proof of the presence of sulphuretted hydrogen in the water that issued out of the lower levels of the reservoir. Together with sulphur bacteria there was a rich growth of filamentous algæ and diatoms like *Spirogyra*, *Rivularia*, *Oscillatoria*, *Ulothrix*, *Stegoclonium*, *Scenedesmus*, *Chroococcus*, *Amphora*, *Navicula*, *Fragillaria*, *Microcystis*, etc. Animal life in the environment was also rich. At the commencement of the low-level sluices where the black coloured water stagnated, gastropods and the fresh water prawn *Palaemon sp.* were actually teeming. Insect life was also in plenty on algal growth. Common species of fish like *Labeo kontius*, *Garra sp. Barileius bendelesis*, *Danio sp. Cirrhina reba*, *Barbus carnaticus* and *B. sarana* were quite frequent in the area. Examination of their gut contents showed that they have been feeding on the algal encrustations and that the sulphur bacteria also entered in their diet. In spite of the presence of sulphuretted hydrogen, the conditions of existence were not altogether inimical to biotal and fish life.

From the above observations it was clear that during the summer months, there was thermal stratification and consequent stagnation in the reservoir with the bottom layers of water completely devoid of their oxygen content. The extent of the oxygenless zone increased with the advancing summer rendering a major portion of the water space unsuitable for fish habitation. The churning and spraying of the water gushing forth from the narrow sluices from the tail-race of the Mettur Power House completely changed the conditions of existence, fully aerating the water and dissipating most of the H_2S into the air.

The monsoon conditions in the reservoir were studied in November 1947. A distinct change for the better was noticed over the previous examination. The reservoir was surplussing and there was no smell of H_2S. But while the colour of the surface water was bluish-green that of the bottom most water was deep brown The existence of a thermal stratification was evident from the results of the six hourly examinations of the water at different depths. The entire reservoir was fairly well saturated with oxygen.

The thermal stratification was found to exist in February 1948 also; the epilimnion extended to a depth of about 51 feet below the surface and in this region alone there appeared to be diurnal circulation. The region of hypolimnion extending from the sill level of the low level sluice to the sill level of the reservoir contained oxygen but remained unaffected by the thermal changes in the region alone.

6. *The Yercaud Lake* is situated in the Shevroy hills at an altitude of about 4,600 feet above mean sea level and has a waterspread area of 28·5 acres with a maximum depth of 12·5 feet. The lake

is the biggest sheet of perennial water in the locality and supplies fresh fish to the local people who normally depend on the supply of preserved fish from outside. The indigenous fishery of the lake consists of *Rasbora daniconius*, *Danio malabaricus*, *Ophiocephalus punctatus* and *Mystus cavasius*. Cold water fishes like the Tench (*Tinca tinca*), the German carp (*Cyprinus carpio*) and the Golden carp (*Carassius carassius*), and the warm water fishes like the *Labeo sp.* and the *Etroplus suratensis*, have been stocked in the lake.

The reported " non-breeding " of Mirror carp in the lake led to a series of hydrobiological investigations between January 1950 and March 1955. Plankton analysis on all occasions showed abundance of *Microcystis*, *Nitzschia* and *Ceratium* and *Copepoas*, *Daphnia* and *Rotifers* were represented in small numbers. The emergent and submerged vegetation consisted mostly of *Vallisneria*, *Hydrilla*, *Nitella*, *Utricularia*, *Scirpus*, *Cyperus*, *Colocasia*, *Polygonum and Hydrophyda*. The physico-chemical conditions of the lake on the various occasions are detailed in Table II of Appendix. The diurnal fluctuations in temperature, pH and dissolved oxygen of the different layers of water in the lake were also studied in May 1950, July 1952 and February 1953 and they are shown in Table III of Appendix.

It will be seen from the above that the surface temperature of the lake had varied from 16·5° C. in January 1950 to 28·8° C. in May 1950 and the pH from 7·1 in November 1947 to 8·9 in May 1950. There was a pronounced thermal and chemical stratification in the lake both in May 1950 (summer) and in February 1953 (winter) but the stratification was rather weak in July 1952 (south-west monsoon season). A comparative study of these data with those of Ootacamund lake would reveal that excepting for the water-spread, maximum depth, altitude above sea level and slightly higher temperatures especially in the summer, there are no marked differences between the two lakes in the hydrobiological conditions which appear to be favourable for the growth and breeding of Mirror carps. The emergent and submerged vegetation existing in the Yercaud Lake are also sufficient to provide ample facilities for shelter and spawning.

The question whether the Mirror carp has bred in the lake or whether it has not bred as repeatedly reported was also examined by the following two approaches to this intriguing problem :—

The first approach has been with the examination of the date of stocking and the length frequency data of the Mirror carp caught so far. These are furnished below :—

Date of stocking.

Date.	Size.	Number stocked.
	cms.	
1st February 1944	5—10	100
24th December 1946	5 —10	150

Date of stocking—cont.

Date.	Size.	Number stocked.
	cms.	
29th September 1947	7·5—15	320
19th September 1948	7·5—15	250
31st October 1948	7·5—15	250
26th June 1949	7·5 —15	250
8th February 1950	6	30
13th July 1950	3·5 7·5	725
Do.	11·5—16·5	200
27th June 1951	5—7·5	1,345
6th July 1095	2·5—7·5	2,106
10th November 1954	2·5—7·5	2,009
		7,513

Details of the mirror carp caught so far.—Data of catches from 1946 May to 19th March 1955 have been examined. Detailed data of 265 mirror carps caught during this period were assayed. These data revealed :—

(1) Mirror carp have grown quite very well in the Yercaud lake growing to 18 cm. in first year, 32 cm. in second year, 44 cm. in third year, 52 cm. in fourth year, 60 cm. in fifth year and 67 cm. in sixth year. There has been a record of a 70 cm. mirror carp in 1950 May. This seems to have belonged to the 1944 brood. The growth appears to be slightly faster than that in Ootacamund lake.

(2) Though the periodical stocking with fingerlings have obviously vitiated the conclusions that can be drawn from the length frequency data of the Mirror carp caught in the commercial catches, the appearance of specimens of 23 cm. length on 22nd July 1954 does give certain indications of proble breeding of mirror carp in the lake. After the stocking of 27th June 1951, a further stocking has taken place only on 6th July 1954 after a period of three years. Stocking of 6th July 1954 has been with fingerlings of 3·5 to 7·5 cm. These could never have grown to 23 cm. within a period of 16 days. The 1951 stock of fingerlings (5 cm.—7·5 cm.) should have grown definitely to a size very much higher than 23 cm. also, for the growth studies revealed that a Mirror carp of over 3 years age must have grown to a size of 44 cm. in Yercaud lake. Between the period of March and June 1954 specimen of 20 to 30 cm. have been caught on more than half a dozen times which denotes that these could never have belonged to 1951 brood but only to subsequent stock of 1952 or 1953 even and this recruitment of new brood could have happened only by breeding of the Mirror carps in the lake. In March 1955 a specimen of 21·3 cm. belonging to 1954 stock was caught. This has evidently only substantiated the growth studies and shown that a condition of stunted growth has not risen in the lake so far, to probably question the conclusions drawn above.

(3) Due to the periodical stocking that has taken place the length frequency data are vitiated to a great extent and as such, barring the possibility of the Mirror carp having bred in the lake no very conclusive evidence could be gathered.

The second line of approach has been with the examination of gonadial maturation and appearance of eggs and larvæ. The latter could not be verified and can be verified only by periodical examination of the submerged vegetation on which the Mirror carp would be laying their eggs. The examination of gonadial maturity has shown that the gonads mature to the full in both males and females. The investigations secured one female that has been fully spent also, further indicating the possibility of Mirror carp breeding in the lake.

The following procedures have also been suggested in April 1955 to fully and finally decide the issue :—

(1) No further stocking of the lake with Mirror carp fingerlings should be done to vitiate the conclusions regarding the younger brood that may be available in the next year's samplings if the Mirror carp does breed in the lake,

(2) the marginal submerged vegetation should be periodically examined for eggs of mirror carp, and

(3) from October to February "Kakkabans" may be placed at different parts of the lake as in Indonesia and these can be periodically examined for eggs.

Madurai district.

7. *Kodaikanal Lake.*—The Kodaikanal Lake is yet another upland water of the Madras State, situated in the Upper Palnis—a branch of the Western Ghats shooting into the Madurai district. The lake was formed in 1860 in the basin upon the sides of which Kodaikanal town is built. The lake has a water expanse of 65 acres with a thick grass fringe on the bunds and a road all around affording a pleasant promenade for visitors. The lake is fed by a few underground springs and mostly by rains during the two monsoons and has a maximum depth of 9 meters opposite the Municipal office. There is a surplus sluice through which excess water runs off down the hills.

Limnological studies of the lake were made in October 1949; June 1962 and February 1953 and the Physico-chemical conditions of the lake on the three occasions are shown below in Table 3 :—

TABLE 3.

Conditions p.p.m.	October 1949.	June 1952.				February 1953.				
	Surf. sa.	Surface.	2 m.	4 m.	6 m.	Surface.	2 m.	4 m.	6 m.	8 m.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Temperature in degree C.	31·3	21·6	21·2	20·6	20·6	20·2	16·6	18·2	18·0	17·5	...
Turbidity, in ems.	...	30	30	30	30	30	30	30	30	30	...
pH. " "	8·3	7·6	7·5	6·5	6·0	5·9	6·3	6·4	6·2	6·1	...
Dissolved Oxygen	5·10	6·7	6·5	5·9	5·9	0·1	4·7	3·7	2·4	0·4	...
Free CO_2 "	1·098	2·5	1·4	2·4	2·4	Nil.	2·2	2·2	2·75	3·5	...
Carbonates as CO_3	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	...
Bicarbonates as HCO_3	17·41	18·3	21·4	24·4	24·4	38·6	15·2	15·2	13·4	...	...
Chlorine in Chlorides	4·0	6·0	6·0	6·0	6·0	6·0	8·0	8·0	8·0	...	...
Silicates, as SiO_2	7·90	4·4	5·6	4·4	4·4	5·2	3·0	2·0	3·0	...	...
Phosphates as P.	1·23	...	...	...	...	...	...	...	...	...	...

The diurnal changes in temperature, pH and dissolved oxygen were also studied in June 1952 and February 1953 as in the case of Ootacamund and Yercaud lakes and are shown in Table IV of Appendix.

A study of the climatological conditions of Kodaikanal and Ootacamund in the year 1952-53 revealed that Kodaikanal had a more equable climate than Ootacamund: Ootacamund was hotter than Kodaikanal by 4·6°F. in the summer of 1952 and colder by 2·4°F. in the winter of 1953. This equable climate was also reflected in the surface waters of the Kodaikanal. There was thermal stratification in the lake throughout the year but this was very much less when compared with that of Ootacamund lake. The difference of temperature between the surface and bottom layers was only 1·4°C. in Kodaikanal lake as against a difference of 5·0°C in the Ootacamund lake. It is really interesting that the Ootacamund and Kodaikanal lakes situated at almost the same height above mean sea level, and having almost the same depth and waterspread should differ so much in the degree of thermal stratification. The winter at Kodaikanal being less severe, than at Ootacamund, the bottom layers of Kodaikanal lake are not probably cooled to the same extent as those of Ootacamund lake and this perhaps accounts for the weaker thermal stratification in the Kodaikanal lake. The diurnal fluctuations in temperature in the different layers were greater in the cold weather period than in the hot weather period as in the case of Ootacamund and Yercaud lakes. The annual changes in pH of the Kodaikanal and Yercaud lake waters were greater than those of Ootacamund lake.

The phytoplankton of the Kodaikanal lake water was composed of Cyanophyceae (*Microcystis*, *Oscillatoria* and *Anabaena*), Chlorophyceae (*Closterium*, *Staurastrum*, *Mougeotia*, *Zygnema*, *Ankistrodesmus*, *Scenedesmus Ulothrix*, *Oedogoniumu*, *Netrium*, *Cylindrocystis*, *Roya*, *Cosmarium*, *Spondylosium*, *Pleurotaenium*, *Penium*, *Sphaerozosma* and *Vaucheria*), Xanthophyceae (*Botryococcus*) and Bacillariophyceae (*Pinnularia*, *Cymbella*, *Tabellaria*, *Navicula*, *Caloneis*, *Eunotia*, *Nitzschia*, *Gomphonema*, *Acnanthes* and *Synedra*), *Botryococcus*, *Microcystis*, *Closterium* and *Staurastrum* were dominant. The zooplankoton was relatively poor and consisted of Protozoa (*Euglena Trachelomonas* and *Peridinium*), Rotifera (*Rotifer*, *Mastigocerca*, *Salpina*, *Callypna* and *Nuthollca*), Cladocera (*Daphnia* and *Ceriodaphnia*), Copepoda (*Microcyclops* and *Eucyclops*) and Insecta (*Plecoptera larvae*, *Ephemeroptera Odonata larvae* and *Trichoptera larvae*). Ferns (*Lastrea octhodis* and *Osmunda regalis*), sedge (*Scirpus squarrosus*), Water lillies (*Nymphaea stellata*) and *Potomogeton indicus* were the macro-vegetation found in the lake. Aquatic insects like *Laccotrephes ruber*, *Ranatra elongata*, *Micronecta quadristrigata* and *Metrocoris nepalensis* were common.

At the time of the first study of the lake on 19th October 1949, the lake fishery consisted of the English carp (*Carrassius carassius Linn*), Baril (*Barilius gatensis*) minnows (*Barbus melanamphyx* and *Rensbora dancenius*), few mashеer (*Barbus tor*) and murrels (*Ophicephalus gachua*). The English carp was introduced into the lake in November 1923 by the Palni Game Association and has grown well and bred prolifically in the lake attaining a weight of 3 lb. In this lake it was found to attain a maturity when 5 and 4 inches in the case of female and male respectively. The indigenous minnow, *Barbus melanamphyx* (Day) is abundant in the lake and breeds throughout the year. The males are pinkish in colour, possess few cheek tubercles and have a higher antero-dorsal profile. The females are yellowish, possess no tubercules and have lower and narrow profile. They do not exceed 70 mm. in length. The Baril, *Barilius gatensis* (Cuv and Val) was stocked in the lake in about 1860 and it has bred prolifically and attained a size of 8 to 9 inches whereas the size usually reached by this species in the plains is only 6 inches. The barils in the lake have also developed a pinkish tinge all over the body. Suggestions were made to stock the lake with Mirror carp (*Cyprinus carpio var specularis*), Scale carp (*C. carpio var communis*) and Tench (*Tinca Tinca*) to increase the bulk and variety of the lake fishery and to meet the fish demand of the Kodaikanal town. The initial stocking of Mirror carp was made on 6th December 1949 by Sri K. N. Anantharaman, I.C.S., Director of Fisheries, Madras.

8. *The Pambar Reservoir* in the Upper Palnis is used by the Kodaikanal Municipality for water supply to the town. A hydrobiological study of the reservoir was made in October 1949 to ascertain its indigenous fishery and suitability for pisciculture. Prior to the investigation, the reservoir seems to have been stocked with trout in the years 1916 to 1918 and 1926 and with 240 English carp in 1921: but trial nettings during the study could procure no fish specimens. The water was crystal clear with a temperature of 19·8°C. at 12 noon and slightly alkaline with a pH of 7·85. As the reservoir is periodically treated with copper sulphate, the vegetation was very poor excepting for a few marginal patches of *Scirpus*, *Chamaraphis*, *Alisma ranifornia*, *Acorus calamus* and water cress (*Nasturtium officinale*). Water Insects (*Laccotrephes*, *Ranatra*, *Metrocoris* and *Gerris nitida*), crabs (*Paratelphusia canicutares and Telphusia leschenaulti*) and small frogs (*Uvalis variabilis*, were found in the reservoir. The plankton was very poorly represented by *Maerismopedia*, *Cosmarium*, *Spondulosium*, *Staurastrum*, *Conatozygon*, *Tabellaria Navaicula*, *Synedra* and a few insect larvae of *Ephemeroptera*, *Odonata* and *Trichoptera*. The discontinuance of the copper sulphate treatment was considered necessary for any large scale fish cultural operations.

9. *The Berijam Reservoir* : the largest in the upper Palnis with a waterspread of about 100 acres and maximum depth of 30 feet and

situated about 14 miles from the Kodaikanal town was also examined in October 1949 for possibilities of fish production and supply especially to the forest labour colony in the vicinity. Though the records showed that about 400 rainbow trout have been stocked in the reservoir in 1926, no trace of them could be found during the study in 1949. However, the reservoir with its luxuriant microvegetation like *scirpus*, *Cyperus*, *Acorus*, *Polygonum* and *Nasturium*, fish fauna in the form of aquatic insects and snails and favourable hydrobiological conditions like temperature (21·4°C.), pH 7·7; and plankton (*Mougeotia*, *Cosmarium*, *Staurastrum*, *Tabellaria*, *Navicula*, *Peridinium*, *Dinobryon*, *Rotifer*, *Mastigocerca*, *Salpina Cathypna*, *Notholca*, *Daphnia*, *Ceriodphnia*, *Microcyclops*, *Eucyclops and insect larvæ*) was found highly suitable for the culture of cold water fishes like the Mirror carp and the English carp.

Tirunelveli district.

10. *Kadamba tank* is an extensive tank in Tirunelveli district with a waterspread of 1,649·24 acres and maximum depth of 17·7 feet. It is perennial and fed by the South Channel from the Srivaikuntam Anicut across the Tambraparni. Since 1948 the tank is being utilized by the Fisheries Department for large-scale fish production and exploitation through systematic stocking, conservancy and harvesting. The conditions of existence in the tank were studied at 3-40 p.m. on 17th March 1951 and were as follows :—Temperature 31·1°C.; Turbidity 11 cms.; Dissolved Oxygen 5·8 mg/l; free carbondioxide—1·8 p.p.m.; Bicarbonates—106·8 p.p.m.; pH—7·9—Chlorides—23 p.p.m.; Silicates as Sio 11·6 p.p.m.; Phosphates—traces and plankton—blue green algæ (*Microcylis*, *Oscillatoria Anabœna*, *Lyngbia*, *Aphanocapsa*, *Spirulna* and *Cylindrospermum*), Green algæ (*Pediastrum*, *Staurastrum*, *Cœlastrum*, and *Oedogonium*), diatoms (*Navicula*, *Melosira*, *Surirella*, *Synedra*, *Gyrosigma* and *Rhopalodis*), *Peridinium*, *Brachionus* and *Daphnia*. The tank had a natural fishery of *Barbus sarana*, *Mystus cavassius*, *Ophicephalus striatus*, *O. punctatus*, *Wallago attu*, *Anguilla bengalensis*, *Mastacembalus pancalus*, *Rynchobdella aculeata*, *Etroplus suratensis*, *E. maculatus*, *Saccobranchus fossilis*, *Glossogobius giuris*, *Amblypharyngodon mola*, and *Esomus danricus*. Fingerlings of *Cirrhina cirrhosa*, *Labeo fimbriatus* and *L. kontius* are being stocked in the tank to improve its fishery.

11. *Sevalapuram Kulam* is an extensive irrigation tank situated about 14 miles south of Tuticorin. It is fed by the Tambraparni River and is about 2 square miles in extent. But it is shallow and seasonal. An examination of the tank in March 1951 showed that the tank had a good fishery of *Barbus pinnauratus*, *B. pulchellus*, *Etroplus suratensis*, *E. maculatus*, *Ophicephalus striatus*, *O. punctatus*, *Ichyncobdella aculeata* and *Rasbora daniconius* and that the

fishery can be further enriched by stocking the Tambraparni system. Macrophytic vegetation like *Hydrilla*, *Vallisneria* and *Najas* grow in the tank. The plankton consisted of *Anabæna*, *Lyngbia*, *Mougeotia*, *Oedogonium*, *Pediastrum*, *Spirogyra*,—*Cosmarium*, *Navicula*, *Synedra*, *Cymbella*, *Rhopalodia*, *Gomphonema*, *Euglena* *Brachionus*, *Glochidium larvæ* and *Dipteran larvæ*.

Nellore district.

12. The *Pulicat lake* was surveyed in 1951–52. The Pulicat lake is the largest stretch of backwater in the East Coast of the Madras State, lying mainly in the Nellore district with a small portion in the Chingleput district. It is about 178 square miles in area, its length and breadth being 37 and 3-11 miles, respectively. The depth in the western region ranges between 3 and 4½ fathoms; and the other portions are shallow. As the bar closes and opens often, the periodical fluctuation in the salinity of the lake water affects the nature of the fauna.

The temperature at the surface ranged from 27·4 to 33·3°C. and at the bottom from 27·3 to 33·3°C.; the atmospheric temperature varied from 26·2 to 34·5°C. The shore vegetation consisted of trees and shrubs. The littoral region was covered with *Enteromorpha*, *Chætomorpha*, *Hypnea*, *Polysiphonia* and *Gracilaria*. *Enhalus* is the one macrophanerogam occurring throughout the lake.

The plankton consisted of Cyanophyceæ (*Merismopedia*, *Anabæna*, *Oscillatoria*, *Lyngbia* and *Chroococcus*), *Chlorophyceæ* (*Enteromorpha*, *Chætomorpha* and *Oedogonium*), Bacillarieæ (*Thalassiothrix*, *Gyrosigma*, *Biddulphia*, *Rhizosolenia*, *Ditylum*, *Lycomophora*, *Skeletonema*, *Corethorn*, *Hemiaulus*, *Bacteriastrum*, *Streptotheca*, *Nitzschia*, *Navicula*, *Hemidiscus* and *Paralia*), Dinoflagellates (*Ceratium* and *Perisdinium*), Rhodophyceæ (*Polysiphonia*) *Crustacea* (*Microstella*, *Corucæus*, *Eucalanus*, *Diaptomus*, *Canthocamptus*, *Cypris* and *Nauplius larvæ*).

The lake was rich and varied in its invertebrate fauna, of which mollusca were well represented. The following fishes were common, *Lutjanus quinquelineatus*, *Equula raconius*, *E. fasciatus*, *Etroplus suratensis*, *Hemirhamphus xanthopterus*, *H. cantori*, *Chanos*, *chanos*, *Lates calcarifer*, *Polynemus tetradactylus*, *Triacanthus brevirostris*, *Tetradon leopardus*, *T. nigropunctatus*, *Ophichthys boro*, *Pseudorhombus platyphrys*, *P. arsius*, *Mugil Oer*, *M. cunnesius*, *Therapon jarbua*, *Therapon puta*, *Platycephalus insidiator*, *P. punctatus*, *Sillago sihama*, *Ambassis gymnocephalus*, *Macrones vittatus*, *M. aclatus*, *Engraulis indicus*, *Gobius gymnocephalus*, *Gerres setifer* and *Teuthis concatenatia*.

The dhoni (plank-built boats) are the crafts available in the lake. Dhonireyu is one of the important boat-building centres. Bodivalai,

Koudavalai, Kattuvalai, Siruvalai, Kalvalai, Koluvavalai, and cast nets are the tackles used in the lake. Fishes like *Mugil*, *Gobius*, *Siliago*, *Lates* and *Polynemus* are also caught by angling from the shore or from boats anchored in deeper waters.

Krishna district.

13. *The Collair lake* was surveyed in 1951–52. The Collair lake is only the large natural fresh water waterspread lying between the alluvial deposits of the Krishna and Godavari rivers. The definite shape and area of this lake cannot be said with certainty as the paddy fields and parts of villages around it are submerged during the flood season. During this period it exceeds 100 square miles in area, but in dry season (February to June) it shrinks considerably being represented only by jadas and gundams (channels and pools). The lake receives Gudivada channel, Motur drain, Polraz drain, Vattur drain, Jalipudi drain, Ramanakalva and the Pandikodu drain, which enters the lake at various points. The excess water from the lake drains into the sea through the Upputteru, which leaves the lake at Kottada and enters the sea near Gollapalam.

The plankton of the lake was fairly rich, and consisted of the following organisms in July 1951 :—

Myxophyceæ : *Oscillatoria*, *Anabœna*, *Lyngbia*, *Microcoleus*, *Spirulina*, *Chroococcus*, *Microcystis* and *Merismopedia*. Chlorophyceæ : *Spirogyra*, *Eudorina*, *Pediastrum*, *Closterium*, *Actinastrum*, *Oerogonium*, *Cosmarium*, *Mougeotia*, *Panrorina*, *Volvox* and *Scenedesmus*. Bacillariæ : *Navicula*, *Nitzschia*, *Gyrosigma*, *Fragillaria*, *Gomphonema*, *Surirella*, *Euaotia*, *Melosira*, *Synedra*, *Amphora*, *Diploneis* and *Cycloiella* : Euglenophyceæ : *Phacus* ; Copepoda : *Diaptomus doriai*, *Pseudodiaptomus dubius*, *Microcyclops karvei* and *Eucyclops agiloides*. Ostracoda : *Stenocypris malcæmsonii* ; Cladocera : *Daphnia lumholtzi*, *Diaphanosoma paucispinosum* and *Ceriodaphnia rigaudi* ; Rotifera : *Axplanchna sieboldi*, *Brachionus falcatus*, *Polyarthra platyptera*, *Anurea valga* and *Notholca scaphula*.

The lake abounded in large beds of shells of *Planispira vittatæ*, *Pachylabra virens*, *Neretina sequijorensis*, *Paludina dissimillis*, *Vivipara bengalensis*, *Melampus singaporensis* and *Cerithium obeliscus* ; prawns represented by *Metapenæus monoceros*, *Penæus carinatus*, *Palæmon malcolmsonii*, *P. scabriculus* and *P. carrinus* are found in the lake of these the first two species contribute to a large fishery from August to December.

The following species contribute to the fishery of the lake and the Upputeru : *Symbranchus bengalensis*, *Anguilla bicolor*, *Saccobranchus fossilis*, *Wallago attu*, *Callichrous bimaculatus*, *Pseudotropius*

taakree, *Macrones gulio*, *M. cavasius*, *Labeo fimbriatus*, *L. calbasu*, *Cirrhina mrigala*, *C. reba*, *Catla catla*, *Thynnichthys sandkhol*, *Barbus sarana*, *B. sophore*, *B. dobsoni*, *Rohtee rohta*, *Chela clupeoides*, *Chelaessus chacunda*, *Megalops cyprinoides*, *Channa channoides*, *Lates calcarifer*, *Ambassis ranga*, *Therapon jarbua*, *Scatophagus argus*, *Polynemus tetradactylus*, *Gobius bicellatus*, *G. striatus*, *Glossogobius giuris*, *Apocryptes bato*, *Boleophthalmus boddarti*, *Eleotris fusca*, *Rhynchobdella aculeata*, *Mastacembalus pancalus*, *M. armatus*, *Mugil dussumieri*, *M. cephalus*, *M. oligarcus*, *Ophicephalus striatus*, *O. punctatus* and *Anabas scandens*.

Palmyra dhonies and other boats form the crafts of the lake. The palmyra dhonies are about ten feet long, with the softer interior portion of the palmyra palm stem scooped out in such a way that the base is retained as a closed rounded end. The important tackles used here are cast nets, drag nets, stakenets, bamboo screens, basket traps and murrel noose.

B. Rivers and Streams.

1. *Trout Streams of the Nilgiris.*—The Makerti, the Kaurmund, the Mekod and Parson's Valley streams and Yenumakal in the northern portion, the Avalanche and Emerald Valley streams in the Central portion and the Billithadahalla, the Peermund and Thayershola streams in the southern portion constitute the trout streams of the Nilgiris plateau. The grassy downs and shrubs on the stream banks harbouring enough Trout food in the form of numerous insects, beetles, flies, etc., and the cold climate of the Nilgiris plateau with the annual temperature range of 45° F. to 80° F. gave hopes of the suitability of the streams for the culture of the excellent exotic sport fish. Though attempts were made as early as 1863 to introduce the game fish into the Nilgiris streams, the success of the establishment of the Trout in the Nilgiris must be attributed to the untiring efforts and inspiring work of Mr. H. C. Wilson, the Piscicultural Expert of the Madras Government who was responsible for the construction of the trout hatchery at Avalanche in 1906. The hatchery has been working from then onwards and almost every year trout eggs are hatched in it and stocked in the streams. The Avalanche, Emerald Valley, the Kaurmund, Mekod and Pykara Streams were thrown open to trout fishing for the first time in September 1911 ; but the anglers had been complaining since 1914 that the size of trout caught had been deteriorating.

To find out the causes for the alleged depreciation in the quality of the trout and to suggest possible remedial measures, surveys of the trout streams in the Nilgiris were conducted in the year 1945 for their physico-chemical and biotal features. All the streams were colourless and crystal clear and in this respect seemed to be ideal for trout growing. All the streams were sluggish and slow moving, but were well oxygenated with the dissolved oxygen content ranging

from 4.85 to 7.14 cc/litre. The temperature varied from 10.2°C. to 25.8°C. thus falling well within the viable range of temperature limits of 6°C. to 25°C. favoured by the trout. The chlorinity was very low and was between 2 and 6 p.p.m. only. Nutrients like nitrates and phosphates were absent. The trout streams were soft and were difficient in calcium. The pH varied from 7.0 to 7.8 and was higher than the value of 6.0 — 6.6 recorded for the steams in 1939. But it could not be inferred whether the increase in the pH was due to the several irregular treatments of the streams with coral calcite, lime stone, etc., between 1939 and 1948 as no systematic and regular study of the streams in different seasons of a year had been made. Further, the coral stones gave the appearance of not having dissolved much and the quantity of stone added in any one stream was not sufficiently large to warrant the increase in pH. As a result of the survey, many improvement works like the addition of powdered bone to improve the calcium content of the streams, construction of insect or food farms, planting water weeds, stocking of shrimps, prawns, snails and crabs, construction of boulder dams and afforestation of the Trout Stream banks were suggested and given effect to, but the complaint still continued that the Nilgiri Trout was undersized.

In a renewed attempt to seek a solution of the problem of decline in the quality of the Nilgiri trout, Menon and Krishnamurthi, (1955) found that the trout in the Nilgiris is the sea-run type, steel Head, which, prevented from its normal migration by the abnormal conditions prevalent in the Nilgiris Streams, has adjusted itself to these riverine conditions and has probably resulted in stunted growth, impoverished quality and poorer strain. The fish was also been found to be an omnivorous feeder, feeding more on surface food. The observations also showed that the Nilgiri trout were not underfed and that there was no scarcity of food in the streams. The growth rate of Nilgiris trout also compared favourably with those in other water. Population studies further revealed that there had been great depletion of catchable trout due to overfishing of the smaller size groups (8 inches to 15.5 inches) and that it would be possible to increase the number of bigger trout available to the rod and improve the conditions of the catchable fish by increasing the size limit of trout caught from 8 inches to 12 inches.

2 *Rivers of the Upper Palnis*—The possibilities of utilizing some of the rivers in the Upper Palnis in the Madurai district as Trout Streams were investigated in October 1949.

The Pambar river carrying the surplus waters of the Pambar Reservoir is perennial with excellent pools and cascades measuring one to ten feet along its course and appeared to be eminently suited for trout culture. The bottom was also sandy with scattered pebbles and boulders in a number of places. The river water was

clear with a pH of 7.0, low chloride content of 1 p.p.m. and oxygen content of 37.1 per cent saturation. The water temperature at 11-15 a.m. was only 17.3° C. The banks and margins of the river were covered with trees (*Rhododendron, Ilex, Ficus glomerata, Pinus communis, Eucalyptus, Cassia, Acacia elata, Artrocarpus integrifolia, Eugenia wightiana* and *Zizyphus rugosa*), bramles (*Rubus*) herbs (*Lysimachia, Pedicularis, Impatiens, Ranunculus* and *Commelina*), *Ferys* (*Athyrium, Diplasium, Grammits, Gleichenia, Lindsaea, Nephrodium* and *Poly-podium*), Sedge (*Cyperus distans*) aquatic herbs (*Potomogeton and Alisma*) and moss (*Piccia hinalayensis*), *Cyathophorum adiantum, Pyrhypus blandus, Acanthocladium tanyirichum, Hylocomnium, Entodon plicatus* and *Meteorium plicifolium*). The fauna of the river comprised of aquatic insects (*Metrocoris, Ptilomera, Hydrometra* and *Notomecta*) larval stages of stone-flies, may-flies, dragon-flies and Caddisflies; planarians (*Planaria sp*), crabs (*Paralelphusia cumculares* and *Telphusia leschnaulti*), toads (*Bufo melanosticus* and *Ixalis variabilis*) and snails (*Limnea succinea, Vipiparus dissimilis* and *Paludomus annandalei*). In the plankton, *Oedogonium* was common along with *Trichoptera larvæ*.

The Parappar river dropping into the plains through the "Silver Cascade falls" was found similar to the Pambar in its hydrobiological conditions and suitable for trout culture. The site on the right bank of the river immediately below the "Bear Shola falls" was also found to be ideal for the location of a trout hatchery.

The Kodiathanar river which is a tributory of the Amaravati river in Coimbatore district, is situated about 20 miles away from the Kodaikanal town. Though its banks are covered with grass, fern and moss there are no trees to provide shade over the water. The water was clear with a temperature of 19.9° C. and a pH of 7.35 and the plankton was poor. There was some macrophytic vegetation like *Nitella acuminata, Scirpus squarrosus* and *Spirogyra neglecta* and the hiparian fauna was fair with dragan flies, stone flies, may flies, caddis flies and water-bugs and their larval stages. But the distant location of the river from habitation and the open nature of the terrain make this river unsuitable for conversion into a trout stream.

The same was the case with the *Gundar river* which is about 5 miles from Kodaikanal town. It is seen from records that the Palni Hills Game Association established in 1915 stocked periodically the Pambar Reservoir. The Berijam Reservoir, the Konalar, the Thalavariar, the Gundar and the Pulavachiar between the years 1916 and 1945 with ova and fry of the Rainbow trout, but owing to heavy fishing depredations of otters, the trout population in these streams had gone down considerably. Suggestions were made to stock the Pambar and Parappar river alone with trout in

future and to establish a hatchery near the Bear Shola falls for annual stocking of these two rivers.

3. *The Suruli River.*—A hydrobiological survey of the Suruli river in the Highways, Madurai district, was made in April 1949 to determine its suitability for the introduction of the Rainbow trout and the details of the investigation have already been published by P. I. Chacko and S. V. Ganapati (1952). The Highways are an offshoot of the Western Ghats and from the southern border of the Periyakulam taluk of the Madurai district. The Highways ranges from 1,200 to 6,500 feet above mean sea level and are drained by the Suruli river and its tributary, the Manalar. After a course of 8·5 miles over the rocks, forming a series of cascades and pools at intervals, it flows down the lower range into a beautiful fall into the low country where it is joined by the Kali, an almost perennial stream which rises in the Bodinayakanur valley and by the vaigai. These streams finally form the Vaigai river of the Madurai district. The Suruli river passes through dense tropical jungle vegetation covering closely and providing shade over almost the entire water-course.

A study of the physico-chemical conditions of the river at 4 selected stations along its 9 miles stretch showed that the river was quite suitable for trout culture. The river water had temperature varying from 17·6° C. to 21·6° C. and pH from 6·3 and was poorly buffered with salts of calcium and magnesium. The atmospheric temperature of the locality varied from a minimum of 52° C. to a maximum of 80° C. Though the water appeared to be peaty due to the dead leaves and twigs accumulated at the bottom of the river the turbidity was still very low and not harmful to trout culture. It was fairly saturated with oxygen which could be further increased by the construction of boulder dams and weirs in suitable places in the river.

The Suruli river abounded in all the three types of food organisms of trout, namely, surface forms, midwater forms and bottom forms. The flora and fauna of the river were very rich and were composed of—

Phytoplankton: *Nostoc*, *Ankistrodesmus*, *Closterium*, *Cosmarium*, *Crucigenia*, *Dictyosphærium*, *Geniculuria*, *Gonatozygon*, *Mougeotia*, *Pleurococcus*, *Scenedesmus*, *Achnanthes*, *Amphiprora*, *Ampora*, *Anoœnsis*, *Cocconeis*, *Campyloidiscus*, *Cyclotella*, *Cymbella*, *Diatoma*, *Diploneis*, *Epithemia*, *Fragillaria*, *Gomphonema*, *Navicula*, *Nitzschia*, *Pinnularia*, *Rhopalodia*, *Spirotænia*, *Staurastrum*, *Stauroneis*, *Synedra* and *Tabellaria*.

Macroflora: *Cladophora*, *Microspora*, *Nitella*, *Spirogyra*, *Ulothrix*, *Batrachospermum* and *Piccia*.

Zooplankton: *Halophyra*, *Lacrymaria*, *Ulvella*, *Acroperus*, *Alonella*, *Amœba*, *Ceriodaphnia*, *Diaphonosoma*, *Simosa*, *Stenocypris*, *Rotifer*, *Rattulus* and *Pedalion*.

Macrofauna: Hydracarina, Polyzoa (Plumatella), Insecta (*Cybister confusus*, *Forcipura decoide*, *Lymnogonus nilidus*, *Metrocaris nepalensis*, *Microvecta*, *quadristrigata*, *Pulomera latilandata*, *Plectoptera larvæ* and nymphs, *Ephemeroptera* larvæ and nymphs, Odonata larvæ and nymphs and *Trichoptera* larvæ), Hirudinea (*Nyavoldella annandalei*), Gastropoda (*Ariophanta bistrialis*), Crustacea (*Paratelphusa auriculares*), Amphibia (*Rufo microtympanum*) and Pisces (*Barbus carnuca and Nemachilus minilus*).

The introduction of minnows, shrimps and snails along with suitable plants now absent in the stream, would also be advantageous as trout grows quickly and better on a cosmopolitan diet.

Though the altitude requirements of 6,000 feet and above cannot be assured in the Suruli river, it was felt that the trout might be able to negotiate during the monsoon periods the several cascades and go to the higher reaches for spawning purposes. Artificial spawning beds would also have to be provided at selected places by covering them with gravel to allow only a few inches of water on top. These should also be supplemented by the establishment of a suitable hatchery and spawning pond protected by adequate shade.

Introduction of rainbows into the Suruli river was recommended in the context of the above favourable conditions and subject to the suggestions made.

4. *Adyar River.*—A detailed survey of the Adyar river was made in February 1949. This river has a short course of about 25 miles along the southern border of the Madras City. It commences from the Guduvancheri hills in the Kancheepuram taluk, and flowing through the Saidapet taluk empties into the sea at Adyar, five miles south of the Fort St. George. It collects mainly the surplus water of the Chembarampakkam irrigation tank and other subsidiary natural drainages. It is full only during the north-east monsoon (October to December) when there is good flow of fresh water into the sea. The river-mouth is fairly deep and broad during this period. As the strength of the current gradually weakens after two months, tidal effects are markedly felt to a distance of about three to four miles up the river. The maximum tidal range is about three feet. The backwater closeby allows a good admixture of sea water and fresh water, and is therefore of much importance. With the advent of summer, the fringes of the backwater get dried up, leaving some of the mudflats exposed. The immediate effect is an increased flow of water from the sea into the river and the backwater; but this is soon retarded by the action of breakers, which raise up a sand bank at the mouth of the river on a line with the shore. The connection of the river and the backwater with the sea is thus intermittent during

February; but is completely cut off by the end of March. The sand bank, or the bar as it is called, widers out in latter months, reaching a maximum width of about three-quarters of a furlong. The bar is prominent until enough to force its way into the sea. The times of opening and closing of the bar may be considered as approximately occurring between October and November and between February and April respectively.

The bottom of the river as well as of the backwater is of a muddy consistency, but the sandy element in the soil becomes pronounced near the sea. The boulders of the Elphinstone Bridge and the small bridge near the Adyar cemetery and the stony embankment near the Theosophical Society's quarters on the southern bank of the river give shelter to rock-dwelling species. During the summer months, the upper reaches of the river are confined to some pools, averaging about three furlongs in length, 250 feet in width and 8 feet in depth. The bottom of these pools is muddy, sandy and rocky in different places.

The river can be roughly divided into three sections within the city, namely, (i) upper reaches, (ii) middle portion and (iii) estuary. The river presents one continuous sheet of good flowing water for a few days in the year especially just after a heavy rainfall in the upper reaches of river during the north-east monsoon season. On other days, it is meandering and forms a number of puddles all along its course. In the upper reaches of the river, the portion on either side of the Marmalong Bridge, for a distance of 200 yards, is rocky and is strewn with pebbles and boulders. This section of the river is used by washermen for washing clothes. Besides this kind of pollution, the river is also faecally polluted by the local residents. Wastes from a soap and glue factory are also allowed to drain into the river about hundred feet above the railway bridge. Thus the river in this area is badly contaminated, and the water is therefore discoloured and full of lie. The stretch of the river from the Teachers' College to the Adyar Boat Club may be considered as the middle portion. This section is fairly deep and continuous and cannot be easily crossed except by boat. Here the wastes from the Engineering College Hostels pollute the river. The water is almost always greenish and is rich with phyto and zooplankton. Being deep, this stretch is also used for boating purposes. Just below the Adyar Boat Club, the Buckingham Canal joins the river. This river section is not fishable to the same extent as the estuary. The latter forms the most important section of the river, as the fisherfolk inhabiting its shores live mainly upon the catches of fishes, crabs and prawns obtained from it. The colour of water and depth varied during the course of a day and also in different seasons.

The temperature of the water follows that of the atmosphere, being hottest during April and May and lowest during December and January. The highest temperature recorded is about 36° C. and lowest about 22° C. The chemical conditions of the river vary in the three sections. The river is alkaline in character throughout its stretch though showing slight variation. The middle portion of the river is more alkaline than the other two sections, the estuary showing the lowest. This is probably due to tidal influences. The oxygen content also is seen to be greater in the last two sections than in the first, where it is as low as 1·05 cc/1. At the Teachers' College Hostel, the water is supersaturated; and at other places the percentage of saturation varied between 45 and 100. As regards the nutrient substances of biological importance such as phosphates, silicates and nitrates phosphates are found to be highest in the middle portion and absent in the upper reaches, while they are present in fair amounts in the estuary. Silicates, on the other hand, are found to be more or less uniform, varying between 0·508 and 0·750 parts per 100,000. Nitrates are conspicuous by their absence. Regarding chlorides, the amount is lowest in the upper reaches, being about 40·0 parts, higher in the middle portion, being 580·0 to 1·480 parts, and highest being 1,640 to 2,800 parts, 100,000 is the estuary.

The vegetation is poor in the river; but the shallow stagnant backwater contains a luxuriant growth of algae, chief among the latter are *Enteromorpha* and *Chaetomorpha*. The shallow portion of the river are covered with Potamogetons. Marsh plants like *Avicennia* and *Sueda* are common in the mud-flats and the island-in the river. In the upper reaches, fresh-water forms like *Spirriogyra*, *Ceratophyllum*, *Hydrilla*, *Pithophora*, *Vallisneria* and *Ottelia* are found in large numbers.

The plankton, which forms the basic food of the fishes of the river is fairly rich and varied consisting of both marine and fresh water species. The following is a comprehensive list of phyto-planktonic organisms recorded from the river :—

Bacillariæ : *Melosira*, *Sceletonema*, *Thalassiothrix*, *Cyclotella*, *Coscinodiscus*, *Chaetoceros*, *Synedra*, *Asterionella*, *Eunotia*, *Achnanthes*, *Mastogloia*, *Gyrosigma*, *pleurosigma*, *Diploneis*, *Amphiprora*, *Amphora*, *Navicula*, *Pinnularia*, *Amphiprora*, *Amphora*, *Cymbella*, *Rhopalodia*, *Bacillaria*, *Nitzschia* and *Surirella*.

Chlorophyceæ : *Ankistrodesmus*, *Closterium*, *Cosmarium*, *Dictyosphœrium*, *Euastrum*, *Kirchneriella*, *Oocystis*, *Pediastrum*, *Scenedesmus* and *Staurastrum*.

Xanthophyceæ : *Botryococcus*.

Myxophyceæ : *Microcystis*, *Aphanocapsa*, *Aphanothece*, *Gleocapsa*, *Spirulina*, *Oscillatoria*, *Lyngbia* and *Schizothrix*.

The zooplankton of the river comprises of the following organisms :—

Protozoa : *Peridinium*, *Ceratium*, *Noctiluca*, *Tintinnus*, *Vorticella*, *Euglena*, *Pandorina*, *Gleocystis* and *Phacus*.

Crustacea : *Evadne*, *Podon*, *Alonella*, *Rhopalophthalmus*, *Mesopodopsis*, *Acarina*, *Pseudodiaptomus*, *Cirripedan nauplii*, *Ocypode megalopa*, *Leucifer* and *Leander*.

Chetognatha : *Sagitta*.

Mollusca : *Veliger larva*.

The fishery of the river is poor, except when the bar is open when several marine species enter the enstuary. The following are the 75 marine estuarine and fresh water species of fishes that occur in the river :—

(1) *Anguilla bengalensis*.
(2) *Ophichthys microcephalus*.
(3) *Elops indicus*.
(4) *Megalops cyprinoides*.
(5) *Chanos chanos*.
(6) *Engraulis purava*.
(7) *Stolephorus commersonii*.
(8) *Clupeoides lile*.
(9) *Wallagonia attu*.
(10) *Plotosus canius*.
(11) *Macrones vittatus*.
(12) *M. gulio*.
(13) *M. keletius*.
(14) *Labeo fimbriatus*.
(15) *Cirrhina reba*.
(16) *Barbus sophore*.
(17) *B. dorsalis*.
(18) *B. lieto*.
(19) *B. amphibius*.
(20) *B. filamentosus*.
(21) *Amblypharyngodon*.
(22) *Chela argentea*.
(23) *C. clupeoides*.
(24) *Nuna danrica*.
(25) *Barbus hendelisis*.
(26) *Aplocheilus blochii*.
(27) *Oryzias melastoma*.
(28) *Ilemiramphus limbatus*.
(29) *H. cantori*.
(30) *Belone cancila*.

(31) *Mugil cephalus*.
(32) *M. olivaceus*.
(33) *M. cunnesius*.
(34) *Lates calcarifer*.
(35) *Rhynchobdella aculeata*.
(36) *Mastacembelus pancalus*.
(37) *Serranus sexfasciatus*.
(38) *Ambassis commersons*.
(39) *A. nyops*.
(40) *A. ranga*.
(41) *A. nama*.
(42) *Apogon aureus*.
(43) *A. bifasciatus*.
(44) *Lutjanus johnii*.
(45) *L. lineolatus*.
(46) *Therapon jarbua*.
(47) *T. puta*.
(48) *Gerres oyena*.
(49) *Sillago sihama*.
(50) *Scatophagus argus*.
(51) *Polynemus tetradactylus*.
(52) *Equula insidiatrix*.
(53) *Upeneus sulphureus*.
(54) *Gobius polynema*.
(55) *Glossogobius giuris*.
(56) *G. criniger*.
(57) *Acentrogobius neilli*.
(58) *Oxyurichthys tentacularis*.
(59) *Apocryptichthys cantoris*.
(60) *Boleophthalmus boddoerti*.
(61) *Eleotris fusca*.
(62) *Periophthalmus koelreutri*.
(63) *P. pearsei*.
(64) *Pseudorhombus arsius*.
(65) *Caran ciliaris*.
(66) *Petroscirtes bhattacharyae*.
(67) *Platycephalus insidiator*.
(68) *Etroplus suratensis*.
(69) *E. maculatus*.

(70) *Triacanthus brevirostris*.
(71) *Tetradon patoca*.
(72) *T. inermis*.
(73) *Ophicephalus striatus*.
(74) *O. punctatus*.
(75) *Anabas scandens*.

The occurrence of young stages of salt-water species like ***Elops indicus***, *Megalops cyprinoides*, *Chanos chanos*, *Mugil spp.* *Lates calcarifer*, *Lutjanus spp.* and *Etroplus suratensis* in the estuary of the river offers facilities for the acclimatization of these species into fresh-water.

The larval stages of the Indian Tarpon, ***Megalops cyprinoides***, characterized by a leptocephalus form, are abundant in the estuary from October to December. They ascend the river from the coastal sea through the open bar. These larvae metamorphose into fingerlings and the later become available in large numbers from January to March.

To help proper conservation and exploitation of the fisheries of the Adyar estuary without causing either depletion of the fish fauna or hardship to the fisherfolk a detailed monthly study of the estuary was done from June 1952 to May 1953. Statistics regarding the fisherfolk depending on the fisheries of the estuary, their crafts and tackles and fishing methods and earnings and the fish landings of the different tackles were collected besides the data on the fluctuations of the hydrological and planktological conditions of the estuary. The details of the latter study have already been published by Chacko et al (1954) and the salient features are recounted below :—

The surface water temperature of the estuary was found to range from 25·0° C. in December 1952 to 32·0° C. in July and September 1952. The estuary water had a maximum turbidity of 12 cms. in October 1952 during the north-east monsoon floods. Excepting in January and February 1953 when the pH ranged from 7·4 to 7·8 the estuarine water was always alkaline with a pH varying from 8·1 to 8·8. The salinity of the estuary varied from 19·03 per cent in November 1952 to 31·5 per cent in April 1953. It is interesting to record that mullets (*Mugil spp.*) of sizes 4 inches to 8 inches were caught in large numbers in the Adyar estuary both in October 1952 at a low salinity of 19·23 per cent and in April 1953 and at a high salinity of 31·5 per cent indicating their remarkable toleration of a wide range of salinity under natural conditions.

Thirty planktonic organisms were recorded, but their occurrence was sporadic and not continuous. Copepods were

present throughout the year of observation with a peak from July to September. During this season their nauplii were also abundant indicating perhaps the favourable breeding period of these microcrustaceans. Of phytoplanktonic organisms, the green algae *Ankistrodesmus convolutus* was common from August 1952 to February 1953 and the diatom *Gyrosigma distolum* was present almost uniformly throughout the year. The marine diatoms *Fragillaria oceanica*, *Navicula gracilis* and *Sceletonema costatum* and other marine forms were present in good numbers between January and May when the bar was open. The amphipod, *Paracalliope fluviatilis* was present from July to November. One specimen of the Ctenophore *Pleurobrachia globosa* was also obtained in the plankton collected from the higher reaches of the estuary in September 1952.

A census conducted during the study revealed that 802 men, 677 women and 577 children constitute the fisherfolk of the 14 villages along the river course. They had 833 cast-nets (veechu valai and manivalai, 133 drag nets (konda valai, nethilivalai and Kalluvalai). 28 encircling nets (Penthuvalai, Peravalai and Seruvalai), 29 shore-seine nets (bodivalai or agnivalai), and 30 crab traps (katch valai). Two boats and 55 catamaran formed their crafts.

With cast-nets operated from shore 1½ to 3 pounds of fish were landed per day per net, the bulk being prawns (*Panalus carinatus*, *Penaeus indicus* and *Metapenaeus monoceros*), young stages of mullets (*Mugil cephalus*, *M. cunnesius* and *M. oliveaceus*), white sardine (*Kowala thoracata*), cat-fishes (*Macrones vittatus* and *M. guilo*), squeaking-perches (*Therapon jarbua* and *T. puta*), whiting (*Sollago sihama*), silver-perches (*Gerres setifer*), orange chromide (*Etroplus maculatus*) and unicorn fish (*Siganus vermiculatus*) being occasionally obtained. With cast-nets operated from catamaran better catches were obtained, the minimum being 2½ pounds per net per day in December 1952 and maximum being 8 pounds in July 1952. Prawns form a major portion of catches, together with small quantities of young stages of mullets, white sardine, cat fishes, gizard shad (*Anodontostoma chacunda*), Spinyeel (*Macrognathus aculeata*), glass fish (*Ambassis commersonii*) squeaking perches, horse mackerel (*Caranx ciliaris*), jew fishes (*Johnius coitor* and *J. belengeri*), silver perch, pearl spot (*Etroplus suratensis*) and unicorn fish.

Drag nets were operated in the estuary from June 1952 to January 1953, during the other three months only cast-nets being employed. The daily landings per drag net varied from 6 pounds (January 1953) to 15 pounds (June 1952). The composition of the catches was irregular, mullets being 35–40 per cent in the three months they were obtained, cat fishes 30–50 per cent when they were netted and prawns 10–50 per cent. *Etroplus suratensis* (1–5 inches) in size formed 40–50 per cent of the landings in the months

of January and February 1953, indicating that the cold weather period beginning from November, is its breeding season. The milk-fish *Chanos chanos* (4–5 inches in size) contributed to 5 per cent of the landings in July and December. This indicates not only the time for collection of its fingerlings but also that this species has got two breeding seasons. The other species that entered into the catches of this tackle in smaller proportions were the white sardine, white bait (*Anchovilla commersonii*), whiting, glass-fish, spreading perch and silver perch.

The *peravalai* (encircling net) is a fairly efficient tackle, the daily landings being 1½ to 15 pounds per day. The bulk of the catches (45–75 per cent) were mullets of larger size. The others captured by this net were the milk-fish, white sardine, gizzard shad, silver bellies (*Leiognathus insidiatrix* and *L. edentulus*), whiting, gobies (*Globius conniger* and *G. griseus*), rock-cod (*Serranus sexfasciatus*) and red perch (*Synagris japonicus*), silver perch, pearl spot and unicorn fish. It is interesting to note that with this net also *Chanos* (4–7 inches) were captured in July to the extent of 15 per cent of the total catch.

Seruvalai, another type of encircling net yielded 8 to 30 pounds per net per day. The composition of the catch was more or less similar to its congener, the *peravalai*.

The *bodivalai* (shore-seine net) was operated in February 1953 only. Its daily landing is 630 pounds; and no doubt it is an efficient tackle. Its catch consisted mostly of large mullets. Few bektis (*Lates calcarifer*) were also caught along with the other miscellaneous forms, of which the presence of few Chanos (12–15 inches) was noteworthy. These were most probably some of the young ones of July 1952 that had survived till February 1953. This shows a growth of 8 to 10 inches in six to eight months in this estuarine environment.

The *katchvalai* is a small crab-trap kept suspended in water by a float and with it the crabs (*Scylla serrata*, *Neptunus pelagicus* and *N. Sanguinolentus*) are lured to the bait in it.

A comparative study of the average daily earnings of individual fishermen using different tackles showed that those using cast-net from shore earned from 10 annas to Rs. 1-9-0 per day; whereas those operating the same from a craft obtained Re. 1-3-0 per day. With drag-nets they earned Re. 1 to Rs. 2-8-0 in a day, with peravalai Re. 1 to Rs. 1-11-0; with seruvalai Annas 12 to Rs. 2-1-0, with bodivalai Rs. 9-12-0 and with katchvalai Re. 1-2-0 per head per day.

The fishermen thus obtain a fair earning by thoroughly exploiting the available fishery wealth. The catches are mostly immature forms but a majority of the species that enter the estuary are those which do not either grow to a large size or attain maturity and breed

in this environment. The fuller exploitation of the estuary is however controlled and regulated from 22nd March 1953 by a licensing system introduced by the Madras Fisheries Department.

5. *The Machkund River.*—The conditions of existence in the Machkund river at the site of the new Hydro-electric project were examined on 20th April 1950. *Polygonum flaccidum*, *Hydrilla zeylanica*, *Hygrophila spinosa*, *Monochoria hastaefolia*, *Cryptocoryne retrospiralis*, *Alisma reniforme*, *Limnophyton obtusifolium*, *Cyperus distans* and *Argenione mexicana* formed the marginal and aquatic vegetation. *Oscillatoria*, *Spirulina*, *Closterium*, *Fragillaria*, *Synedra*, *Cymbella*, *Surirella*, *Nitzschia*, *Navicula*, *Gyrosigma*, *Melosira*, *Amphora*, *Pinnularia* and *Ceratium* were present in plankton collections. The water was brownish with a turbidity of 4·8 cm. and temperature of 29·1°C., pH 6·8, dissolved oxygen 5·25 c.c./l and percentage of saturation 88·5. Free carbondioxide, bicarbonates, chlorides, phosphates and silicates were 0·275, 7·050, 20·0, 3·25 and 1·67 parts per 100,000 respectively. Nitrates were absent. Trial nettings brought 15 specimens of *Barbus* (*Tor*), *khudree* (local name—Boriya), 8·1 to 14·2 inches in size. Of these four males (12, 13·1, 13·9 and 14·0 inches) were oozing their milt and one female (13·1 inches) showed its ovary in the spent condition. Presumably the fish was spawning at this time. But efforts to obtain eggs and larvæ were not successful. The guts of these mahseers contained roots, leaves, flowers and filamentous algæ (*Vaucheria zygnema* and *Rivularia*). *Notopterus notopterus* (local name—Polli; 10 inches in size, were found in too. *Labeo calbasu* (local name—Kannasu) and *Danio equipinnatus* (local name—dorakeli) were also obtained during the trial nettings.

6. *The Vamsadara River.*—Surveys of the Vamsadara estuary near Calingapatnam, Srikakulam district were made in April 1950 and June 1951 mainly for suggesting measures to prevent silt accumulation within the port limits of Calingapatnam as a result of 'indiscriminate' fishing methods adopted by the local fishermen. The opportunity was also availed of to ascertain some of the important hydrobiological conditions and their diurnal rhythm in the middle of the estuary. A detailed account of the investigation has already been published by Chacko and Srinivasan (1951) and so only a brief review is furnished below :—

The Vamsadara is one of the largest rivers in the Srikakulam district and empties into the Bay of Bengal near the Port of Calingapatnam. The estuary of the river is limited to about 1 miles from the mouth and is subjected to tidal influence throughout the year. The maximum depth is about 12 feet, but the major portion of the 0.75 mile broad estuary gets exposed in the low tide. As a result of continuous tidal mixing, there was no marked thermal or chemical stratification in the estuary. But the tidal oscillatory movements of water masses caused diurnal changes in the hydrological properties,

and the chlorinity ' conflict ' was very high. The esutary was well oxygenated throughout the day and was rich in silicates and phosphates.

There was a predominance of marine element in the plankton flora and fauna which were composed of 26 species of diatoms, 6 of protozoans and 7 of copepods. The shallow flats which get exposed during the low tide were covered with algæ like *Oscillatoria princeps*, *O. tenius*, *Lyngbia confervoides*, *L. aestaurii*, *Chaetomorpha linum*, *Enteromorpha intestinalis*, *E. compressa* and *Cladophora glomerata* and contained a few polychæte worms, amphipods and decapod crustaceans. The following 40 fishes were noted in the estuary : *Elops saurus*, *Megalops cyprinoides*, *Chanos chanos*, *Ilisha elongata*, *I. motius*, *Anodontostoma chacunda*, *Coilia ramacarati*, *Anchoviella indica*, *A. tri*, *Ophichthys boro*, *Mystus gulio*, *Hemiramphus cantori*, *Pseudorhombus arsius*, *Mugil cephalus*, *M. dussumieri*, *M. macrolepis*, *M. olivaceus*, *Polynemus indicus*, *Caranx kalla*, *Leiognathus equulus*, *Apogon bifasciatus*, *Ambassis dayi*, *A. Commersonii*, *A. miops*, *Lutjanus argentimaculatus*, *L. lineolatus*, *L. Johnii*, *Therapon jarbua*, *Chrysophrys datnia*, *Gerres punctatus*, *G. oyena*, *Sillago sihama*, *Platycephalus insidiator*, *Glypidodon bengalensis*, *Gobius cristatus*, *Awaous stamienous*, *Apocryptes lenoeolatus*, *Bolcophthalmus boddaerti*, *Trypauchen vagina* and *Triacanthus brevirostris*.

But most of them were young ones and juveniles. Of these, the mullets formed the bulk of the catches of the local fishermen. Perches (*Lates calcarifer*), sharks and rays and the Indian Shad (*Hilsa ilisha*) were reported to enter the river during the flood season.

The chief method of exploitation was by the use of a series of basket traps in an ingenious device, locally known as Doddiyandra, which is set in the estuary during the low tide. As the water level increases during the high tide many young fishes and prawns are carried by the tidal current; and as the water recedes with the ebb, they get deflected into the stake and then enter the basket traps. At the next low tide, the contents of the traps are removed and the entire yandra is reset for the next flood tide. Detailed analysis of the catches of the doddiyandra showed that there was ruthless destruction of young stages of *Mugil sp. Chanos chanos* and *Therapon jarbua* and *prawns*. Further, the use of this device on an extensive scale all over the estuary caused heavy accumulation of silt and blocking of the river mouth. Recommendations were therefore made to the Assistant Director of Fisheries, Visakhapatnam to take steps to prohibit the use of fixed engines and the capture of immature fishes in the estuary.

7. *The Vellar river* also known as Vasistanadi takes its origin from the hills of Uttangarai taluk of Salem district. After traversing through Attur taluk of the same district it runs as the boundary

between Tanjavoor and South Arcot districts; and finally drains into the Bay of Bengal, at Porto Novo. The total course of the river is about 300 miles. The estuary is connected with the sea throughout the year and is subjected to tidal influence having a range of 1 to 3 feet extending to a distance of over 10 miles. A hydrobiological study of the Vellar estuary was made for a period of one year between May 1952 and April 1953 to gain knowledge of the seasonal fluctuations in the estuarine fishery, the relative efficiency of the different gears used by the fisherfolk and to suggest measures to conserve the estuarine fishery without adversely affecting the economic conditions of the fishermen. The details and the results of the study have already been published by Chack et al (1954) and the salient features of the observations are alone recorded here.

The catches of the different tackles comprised mostly of immature young stages of prawns, mullets and miscellaneous coastal fishes. Apart from few sharks and rays that entered the estuary occasionally during the summer months and few craps and fresh water siluroids that descended into it during the flood season, large sized fishes were almost absent. Even the supposed estuarine forms like *Mugil spp. Lates calcerifer*, *Polynemus indicus* and *Eleutheronema tetradactylum* which occurred in the estuary were either young ones or juveniles. As their adults or spawners were not found, it is obvious that these species breed only in the sea and the young ones enter the estuary with the tides and remain in it for some time for feeding and then return to the sea. This was supported by the presence of large adult individuals of these species in the catches of the sea fishermen. In the case of the prawns also, spawning appeared to be in the sea as only their young stages occurred in the estuary throughout the year. The tides brought in a fair number of young ones of shoaling sea fishes like *Sardinella albella*, *S. fimbriata*, *S. gibbosa*, *Pellona elongata*, *Ilisha brachysoma*, *Engraulis malabaricus*, *Carnax hoppos*, *C. sansun*, *Leiognathus edentula*, *L. insidiatrix* and *Johnius spp.* and also drained them back into the sea during the ebb tide. This indicates that the nearby sea is a favourable area for the spawning of these marine fishes and that many of the helpless young ones are carried away by the tides and currents. On the whole the belief that the estuary is an important breeding ground and nursery area of several marine fishes appeared to be exaggerated, though temporary shelter and facilitates for acclimatization and upward migration, were no doubt afforded to some species. In all probability, it is the coastal waters, especially those influenced by estuarine discharges, that are favourable breeding and nursery areas of the marine shoaling fishes. The fecundity of the fishes mentioned above is very great and only an insignificant fraction of their young ones entered or got drifted into the estuary. It was felt that the capture of these young ones within the estuarine area might not adversely affect the posterity of the species concerned. Suggestions were therefore made for the encouragement of all types of tackles by issing licences. The continuation of the

existing mesh regulation for all nets excepting ' Koonivalai ' with a minimum of 1 inch was also recommended, so that some of the young fishes might escape into the neighbouring Killai backwaters connected with the Vellar estuary.

The Major Rivers of Madras and Andhra States.—The principal rivers of South India are the Godavari, the Kistna (with its main tributory Tungabadra) and the Cauvery (with its main tributory Bhavani) and a major portion of these rivers are situated in Andhra and Madras States. These rivers together with their canal and irrigation channels are the chief source of fresh water fisheries in the two States and supply the fish seed required for transplanting into fish farms and public waters. An idea of the importance of these river systems as fish seed supply centres can be had from the number of fish-seeds collected by the Madras Fisheries Department from the various major rivers from 1943–44 to 1951–52 shown below in Table 4.

TABLE 4.

Year. (1)	Godavari. (2)	Krishna. (3)	Tungabhadra. (4)	Cauvery. (5)
1943–1944	25,000	8,500	5,500	..
1944–1945	32,000	13,750	13,050	1,200
1945–1946	300,000	61,500	32,000	46,000
1946–1947	517,500	380,000	120,000	102,900
1947–1948	446,000	286,000	139,800	190,200
1948–1949	163,000	41,850	32,150	105,000
1949–1950	173,370	73,175	108,100	596,100
1950–1951	864,350	1,136,750	793,300	7,900,500
1951–1952	1,649,920	2,395,000	1,230,900	3,200,400

The fish seeds have to be collected from the rivers year after year for replenishing the stock in tanks, as the Indian carps do not breed in confined waters. As a preliminary to the investigation of the factors influencing the spawning of carps in the rivers a number of hydrobiological studies of the major rivers at different points along their course were made to ascertain the natural conditions under which the carps spawn, and the results of these studies have already been reviewed by Chacko and Srinivasan (1955).

The Godavari river which finds its sources in the Western Ghats in the Bombay State, and flows through the Hyderabad territory before entering the Andhra State, is in floods usually between June and October when it assumes a brown colour all along its course. During the non-flood months the water becomes clear and colourless, especially in the lower reaches. The river water was alkaline with a pH ranging from 7·2 to 8·3 the higher values being usually recorded during the flood season when the water was almost saturated with oxygen. Even during the non-flood season, the oxygen saturation of the river was not low and was above 50 per cent on most occasions, except in places where there was local pollution. Near the

outfall of the effluents from the Andhra Paper Mills at Rajahmundry the oxygen concentration was as low as 0·84 cc/l. The oxygen content of the river water was generally low in the hot months of March, April and May when the flow of water was also very low. A maximum of 4·51 cc/l of dissolved oxygen was met with in June, immediately with the onset of floods. The chlorinity as well as its seasonal fluctuations generally increased towards the mouth of the river; the annual range of variations of chlorinity at Kotipalle was from 7·0 p.p.m. in flood season to 550 p.p.m. in the summer. Observations of the seasonal changes in the hydrobiological conditions of the river stretch immediately below the Dhowlaishwaram anicut during the year 1952 showed that the temperature ranged from a minimum of 27·5°C in February to a maximum of 36·4°C in May. Between June and October (south-west monsoon period) when the river is in floods and when the major carps are observed to spawn, the temperature ranged from 28·3°C to 31·2°C.

The plankton of the river was cosmopolitan and was subject to extreme fluctuations in quantity and constitution. There was a predominance of zooplankton (*Mesocyclops* and *Diaptomus*) during the flood season and of phytoplankton during the non-flood seasons. Filamentous algæ like *Oscillatoria*, *Mougeotia*, *Zygnema* and *Spirogyra* were the common phytoplankton. The important fishes of the river are the carps *Labeo fimbriatus*, *L. calbasu*, *L. boga*, *L. stiza*, *Cirrhina reba*, *C. mrigala*, *Catla catla*, *Thynnichthys sandkhol*, *Barbus* (Tor) *khudree* and *B. (puntius) kolus* and cat fishes *Ompok bimaculatus*, *Pangasius pangasius*, *Silonia silonia*, *Wallago attu*, *Mystus cor*, *M. seenghala* and *Bagarius bagarius*. In the lower reaches there are typical estuarine fisheries, particularly of mullets and prawns. Special mention may also be made of the shad, *Hilsa ilisha* which migrates into the river up to the Dhowlaishwaram anicut and even above for spawning purpose during the flood season.

The Tungabhadra river enters the Andhra State from the Mysore Plateau and runs a distance of about 300 miles before joining the Krishna river. The river is in floods from the end of June to the end of November and during the summer months from March to June the river practically dries up leaving certain pools connected by a sluggish stream. The seasonal changes in the rheological conditions of the river were studied for a continuous period of three years from January 1950 to December 1952 when the construction of the dam near Hospet was under progress and the Tungabhadra Reservoir was being formed. The river water temperature varied from 21·5°C to 29·3°C the minimum being recorded between December and February and the maximum in April or May. The pH was never above 8·0 and carbonates were conspicuous by their absence during the triennial period of study. The river was generally rich in oxygen throughout the year, sometimes reaching supersaturation, during the floods. The plankton was predominated by plant organisms especially the diatoms like *Cymbella*, *Cyclotella*,

Fragillaria, *Nitzschid* and *Navicula*, throughout the year. The fish fauna was almost similar to that of the Godavari excepting for the newly recorded *Callichrous pobo* which is of zoo geographical interest. (Chacko and Mathew, 1949.)

The Krishna finds its source in the Western Ghats and flows eastwards through Hyderabad State and joins with the Tungabhadra a few miles south of Sunkesula from where it has then a course of about 250 miles before emptying into the Bay of Bengal. As in the case of the Tungabhadra, floods occur from the end of June to the end of November and during the summer months the river practically dries up leaving certain pools connected by a sluggish stream. The hydrobiological conditions of the river were ascertained only once in July 1949 and these date are not adequate to draw general inferences. The river water was turbid and well-saturated with oxygen on the occasion and the pH ranged from 8·2 to 8·3. The plankton was comprised entirely of copepods, daphnids and rotifers and the fish fauna was similar to that of the Tungabhadra.

The *Cauvery river* which is the only major river of the Madras State also arises from the Western Ghats and follows a tortuous course and after the falls at Sivasamudram in the Mysore State, it enters the Madras State. A large masonry dam is formed across the river at Mettur forming a reservoir about 60 square miles in extent. About 27 miles below this dam, the Bhavani commencing from the Nilgiri range joins it. In the lower reaches it forms a delta, the main section of which is known as the Coleroon. The river is in floods between June and October when the water assumes a brown colour. The flow of water in the river was very slow between January and May when the pH varied from 8·3 to 8·5; but with the onset of flood, the pH dropped down to 7·9 in June and to 7·6 in July. Later the pH began to increase from November onwards. The chlorinity also followed a similar change and ranged from 21 p.p.m. in the south-west monsoon season to 280 p.p.m. in the hot weather period. The river was well oxygenated even during the months of slow flow. The temperature was found to vary from 26·0°C. in January to 30·0°C. in May. The plankton was well represented by filamentous algae, diatoms, copepods, rotifers and daphnids. The fish fauna comprise chiefly of carps and catfishes as in the case of the Godhavari and Thungabadra rivers, but carps like *Labeo kontius*, *Barbus dubius*, *Barbus (Puntius) carnaticus*, *Barbus hexagonolepis* and *Cirrhina cirrhosa* are peculiar to the Cauvery.

A comparative study of the above observations on the different rivers would first show their similarity in their source from Western Ghats, eastward flow and drainage into the Bay of Bengal. In all the cases, the river temperatures follow closely the air temperatures, low records being made between December and February and high records during the hot weather period. The greatest extremes

of turbidity occurred in all cases during the flood season. The Thungabadra was brown and turbid between June and December whereas the other rivers were turbid during the south-west monsoon only. Turbidity, in all instances was largely due to silt, detritus and other non-living materials. The dissolved oxygen supply was usually high in all the rivers, often being well toward saturation for the existing temperature and showed significant decline only in instances of pollution. The dissolved solids in the rivers varied greatly depending upon the regional characteristics of the drainage basin and upon the prevailing flood or non-flood conditions.

The plankton was cosmopolitan in all the rivers. The phytoplankton predominated during the non-flood season when the temperature is high and zooplankton during the flood season. This is probably due to the climatic conditions of South India. Unlike the rivers of temperate regions, the rivers of these parts depend on rains for their water-supply. During the summer months, the rivers almost dry up into scattered pools connected by sluggish streams and this condition seems to favour the growth and multiplication of phytoplanktons than zooplanktons. Among the phytoplankters, the diatoms are the most common. The high organic content and polluted nature of the flood waters may perhaps account for the predominance of zooplankton in the flood period.

The fish fauna of the three major rivers comprise mostly of carps and catfishes. Among carps, *Catla catla*, *Cirrhina mrigala*, *Thinnichthys Sandkhol* and *Barbus kolus* are peculiar to the rivers of the Andhra State, whereas *Labeo kontius*, *Barbus dubius*, *B. carnaticus*, *B. hexagonolepis*, and *Cirrhina cirrhosa* are indigenous to the Cauvery only. The giant cat fish *Bagarius bagarius* does not occur in the Cauvery. As the hydrobiological conditions of the above rivers do not show striking differences, an interchange of the above carps, which are non-predacious and quick growing will be advantageous. *Catla catla* which was first introduced into the Cauvery in 1922 has bred and established in it (Chacko and Kuriyan, 1950). About 1,740 fingerlings of *Cirrhina cirrhosa* from the Cauvery were introduced in the Thungabadra in 1951. The North Indian carp, *Labeo rohita* has been introduced in all the three rivers. The thriving and growth of these semi-exotic fishes in the new environments are being watched.

C. Ponds and Tanks.

During the ten-year period 1942–52, hydrobiological surveys of a number of ponds and tanks in the various districts of Madras and Andhra States were made with a view to understand the physical, chemical and biological conditions prevalent in them and their relationship to fish production. The hydrobiological conditions in the varions ponds and tanks are shown districtwar in Table V of Appendix. The observations made have helped to broadly classify

the fish ponds into the following five types depending upon the colour and pH of water, the nature of food organisms present and the type of pond bottom. The approximate yield of fish expected from each type is also indicated in the table shown below :—

TABLE 5.

Pond.	Nature of food organisms	Colour of water.	pH.	Nature of pond bottom.	Average yield of fish per acre (lb.)
(1)	(2)	(3)	(4)	(5)	(6)
I	Permanent bloom of a blue-green algae like *Microcystis, Anabaena or Oscillatoria.*	Greenish	8·0	Black rotting organic matter.	2,000
II	Abundant macrophytic vegetation like *Hydrilla, Vallisneria, Potamogeton,* water lilies, etc.	Colourless	7·5 to 8·5	Do.	1,000
III	Abundance of zooplankton and a few plant organisms.	Brownish	7·0	Do.	500
IV	Clear throughout with an occasional algal bloom	Clear	6·5 to 7·5	Brownish	300
V	Few phyto and zoo-plankton.	Do.	6·5 to 7·5	Sandy	200

Further it was found that the maximum yield of fish production was not realised usually from the various types of ponds, chiefly due to improper and unscientific stocking. The ponds were not generally stocked with the proper number of fishes and suitable combination of species. To help the fish farmer realise the maximum yield out of his ponds, the following table showing the number of fingerlings to be stocked per acre of water spread in the five type of ponds, was prepared :—

TABLE 6.

Kind of fish.	Number of fingerlings to be stocked.				
	Type I.	Type II.	Type III.	Type IV.	Type V.
(1)	(2)	(3)	(4)	(5)	(6)
Catla catla	1,100	550	280	170	110
Labeo fimbriatus	2,200	1,100	550	330	220
Labeo rohita	1,480	740	370	220	150
Labeo calbasu	2,200	1,100	550	330	220
Labeo kontius	3,470	1,740	870	520	350
Cirrhina mrigala	1,480	740	370	220	150
Cirrhina cirrhosa	3,470	1,740	870	520	350
Cirrhina reba	9,600	4,800	2,400	1,440	960
Thynnichthys sandkhol	3,470	1,740	870	520	350
Osteochilus thomassi	9,600	4,800	2,400	1,440	960
Barbus carnaticus	3,470	1,740	870	520	350
Barbus hexagonolepis	9,600	4,800	2,400	1,440	960
Chanos chanos	2,200	1,100	550	330	220
Etroplus suratensis	9,600	4,800	2,400	1,440	960
Cyprinus carpio	1,480	740	370	220	150
Osphronemus gorami	2,200	1,000	550	330	200

The numbers in the above table have been worked at using the following formula :—

$$\frac{\text{Number of fingerlings to be introduced.}}{\text{+ Per cent mortality.}} = \frac{\text{Total expected weight of fish crop according to type.}}{\text{Annual increase in weight of individual fish.}}$$

As maximum production can be obtained only be the utilization of all the available sources of food in a pond, a pond should be invariably stocked with a suitable combination of surface feeders like *Catla catla, Cirrhina mrigala, C. cirrhosa* and *Chanos chanos*, column feeders like *Catla catla, Labeo sp., Cirrhina sp., B. carnaticus, B. hexagonolepis, Thynnichthys sandkhol, Osteochilus thomassi, Etroplus suratensis, Cyprinus carpio* and *Osphronemus gorami* and bottom feeders like *Labeo sp., Cirrhina reba, Etroplus suratensis, Cyprinus carpio* and *Osphronemus gorami*. As a general rule, a pond may be stocked with 50 per cent surface, feeders, 25 per cent column feeders and 25 per cent bottom feeders.

The trend of seasonal and annual fluctuations in the hydrobiological conditions of the fish ponds was also studied by making weekly observations on the Chetput Fish Farm Ponds at Madras for a continuous period of ten years from 1942-52. The surface water temperature of the ponds varied from 24·8°C. in December 1945 to 37·1°C. in April 1949 and closely followed the air temperatures in their diurnal and seasonal fluctuations. The ponds being shallow, the bottom water temperatures followed the surface temperatures in their diurnal and seasonal changes and were always lower than the surface temperatures. A study of the diurnal thermal variations in the pond showed that both the surface and bottom water temperatures ordinarily increased from 6 a.m. to 4 p.m. when the maximum was reached; thereafter it fell gradually till about 6 a.m. on the next day when the minimum was reached. The range of diurnal fluctuations of the pond temperatures varied from a minimum of 1·8°C. in November 1949 to 9·9°C. in April 1949 and the diurnal variations were generally lower in the cold weather period and north-east monsoon season than in the hot weather period and south-west monsoon season. Though the ponds were shallow a distinct diminutive thermal stratification during daytime was observed in all of them throughout the year. There was tournover and mixing of the pond waters almost daily during the early morning hours. This circulation of the pond waters and higher bottom temperatures with the concomitant higher rate of bacterial decomposition of the bottom deposits make these ponds very productive.

The colour of the pond waters varied from brown to green and the pH from 7·0 to 9·1. The chlorides usually varied from 16·0 to 324 p.p.m. in the various ponds, but during the latter part of study increased considerably and ranged from 177 to 2,320 p.p.m. due to repeated failure of the north-east monsoon and consequent decrease of water in the ponds.

Seasonal fluctuations in the occurrence of the planktonic forms and their density indicated two maxima during the year, the first one during June-July and the second during November-December. Blooms of phytoplanktonic organisms like *Anabaenopsis*, *Microcystis*, *Oscillatoria*, *Pandorina*, *Eudorina*, etc., were very common during the peak period. In the zooplankton, copepods, Cladocerans, Rotifers, Euglenoids, etc., formed the major items and thick swarms of one or other of these were present in the ponds during the peak periods. The quantity of available plankton reached the maximum during October and November. Fish eggs and larvæ were present in the ponds either in June (few) or during the monsoon months, October to December indicating that the breeding of fish in the tanks takes place during the rainy months. Temperature and pH were comparatively low during the rainy months and the oxygen saturation increased. The chlorinity was low, but phosphates increased due to the inflow of sweepage and drainage. The presence of phosphates probably increased the phytoplankton in the succeeding months.

The diurnal variations at six hourly intervals of ten typical organisms in Pond IV of Chetput Fish Farm were studied in 1949. In the case of algal forms like *Pediastrum clahratum*, *Microcystis aeruginosa*, *Anabaena flosaquae*, *Scenedesmus*, *acuminatus* and *Oscillatoria splendida*, the number was generally greater at the surface layer of the pond at 6 in the morning. This difference was reduced by 12 noon and at 6 p.m. the number became almost equal in both the surface and bottom layers. At midnight the number was more at the bottom than at the surface and this condition was suddenly reversed at 6 a.m. the next day. In the case of diatoms like *Navicula cuspidata*, *Nitzschia pallea* and *Synedra ulna*, diurnal variations more or less similar to that of the algae was noticed. But the important zooplankters *Mesocyclops leuckarti* and *Brachionus falcatus* showed a different type of diurnal migration. They were more at the surface than at the bottom in the morning and with the sun rising they go to the lower level at such a rapid rate that at 12 noon most of them were at the bottom. This condition was slowly reversed from sunset onwards until at midnight when there was a preponderance at the surface.

The phytoplanktons were more in the surface layers during day time probably due to the preference of the chlorophyl bearing organisms for warmth, light and oxygen. The vertical distribution of phytoplankton was uniform in the evening when more or less homothermal conditions, prevailed in the ponds. The zooplankters which are capable of independent mobility avoided the bright light and relatively higher temperatures of the upper zone and were more at the bottom during day time and came to the surface in the night only.

The Madras and Andhra States abound in temple tanks which have usually a permanent bloom of blue-green algae and correspond

to first and most productive type of fish ponds mentioned above. As the elucidation of the hydrobiology of this type of ponds is of practical and economic importance, a detailed study of the physical, chemical and biological conditions of the Geangadhareswarar temple tank in Madras City was made at fortnightly intervals for a period of one year from April 1949 to March 1950. The surface temperature varied from 28·2° C. in October 1949 to 42·8° C. in May 1950; the bottom temperature ranged from 25·6° C. in December 1949 to 32·8° C. in February 1950. There was diurnal thermal stratification by day time and diurnal turnover in the night or early morning hours. The pH varied from 6·9 in August to 9·6 in May at the surface and from 6·8 in August to 8·6 in June at the bottom. The dissolved oxygen varied from zero in August to 9·14 cc/l in December at the surface and from zero in March, April and May to 5·37 cc/l in January at the bottom. Phosphates were present almost throughout the year with a maximum during hot weather and minimum during cold weather; they were always greater at the bottom layers and varied from "Traces" to 3·8 p.p.m.

A few zooplanktonic organisms like the Copepods, *Mesocyclops* and *Neodiaptomus* were met with in all the collections, but were very insignificant as compared with the phytoplankters which were represented by the following :—

(i) *Chlorophyceae* : *Ankistrodesmus* was abundant on one occasion only. *Pediastrum* was found in smaller numbers in July and September while *Scenedesmus* was noticed in slightly greater numbers on five different occasions.

(ii) *Bacillarieae* : Only one diatom, namely, *Nitzschia* was present.

(iii) *Myxophyceae* : *Microcystis aeruginosa* in large numbers was undoubtedly the most striking features of the tank, the distribution of this alga being maximum during the hot weather. But a few others also, namely, *Merismopedia*, *Oscillatoria* and *Anabaena* were present on a few.

(iv) *Euglenophyceae* : *Trachelomanas* was present in small numbers in December and March. Among the above, *Microcystis* and *Nitzschia* were the two most dominating organisms, the former constituting almost a permanent bloom. The cause for the permanent bloom could be traced to diurnal thermal stratification and diurnal turnover which was responsible for the large portions of the dissolved nutrients all through the year. Among the nutrients the nitrates were however absent probably because the ammoniacal nitrogen produced were very rapidly consumed by the algal flora of the tank as soon as they were formed, leaving nothing for conversion into nitrites and nitrates.

III. COLLECTION, ACCLIMATIZATION AND TRANSPORT OF YOUNG FISHES.

Several major carps and some brackish and marine fishes are regularly used in fish cultural operations in the State. Most of the major carps and all the marine fishes used in these operations do not breed in the confined cultural waters of the State. The young ones of these fishes are therefore, collected regularly from their natural habitat in the rivers, backwaters or the sea. In the case of the carps very often the collections of young ones are made from the actual spawning grounds. The young ones thus collected are conditioned and transported to the inland ponds, tanks, lakes and reservoirs. In the case of the young ones of the euryhaline species collected from the backwaters or the sea, they are acclimatized to fresh water conditions before conditioning and transport. The methods of collection, acclimatization and transport vary in the case of several species. These processes of collection, acclimatization and transport of young ones are done in such a way as to reduce the mortality of the young ones to the minimum and to assure the highest survival. With this in view detailed work was undertaken on the collection, acclimatization and transport of the young fishes and the results achieved are given in this section.

II. Places of collection and seasons.—The seed collection places of the former composite Madras State with the kinds of fish and their seasons of availability in large numbers are detailed in the following table :—

Table showing seed sources, kinds of seed and season of availability in the districts of Madras State.

District.	*Name of centre.*	*Kind of fish.*	*Season of availability.*
Srikakulam	Donku	Chanos	May-August.
		Lates	June-July.
		Mullets	December-February.
Do.	Pedakarivenipalem.	Chanos	May-August.
		Mealops	December-February.
Do.	Pundi	Chanos	April-August.
		Mullets.	December-February.
		Megalops	Do.
Do.	Naupada	Chanos	April-August.
		Mullets	December-February.
Do.	Calingapatnam	Chanos	May-August.
		Mullets	November-February.
Do.	Nagavali near Srikakulam.	Do.	January-March.
Do.	Pukkillipeta		
Do.	Kuppili	Do.	November-February.
Vizakhapatnam	Konda	Do.	Do.
		Chanos	May-July.
Do.	Bhimilipatnam	Mullets	November-February.
		Chanos	May-July.
		Mullets	November-February.

District.	*Name of centre.*	*Kind of fish.*	*Season of availability.*
Visakhapatnam	Visakhapatnam	Chanos	May-July.
		Mullets	November-February.
Do.	Gangavaram	Chanos	May-July.
		Mullets	November-February.
Do.	Pudimadaka	Chanos	May-July.
		Mullets	November-February.
East Godavari			
Do.	Pentakota	Do.	November-February.
Do.	Kakinada	Do.	October-February.
Do.	Jagannaikpur	Chanos	June-September.
		Mullets	Throughut the year.
Do.	Kotipalli	Mullets	November-March.
		Lates	November-April
Do.	Razole	Mullets	November-March.
		Lates	November-April.
Do.	Kumaragiripatnam.	Mullets	November-March.
Do.	Sivakodu	Do.	Do.
Do.	Samalkot	Catla	July-December.
		Mrigal	Do.
		Labeo	Do.
Do.	Undoru	Mrigal	Do.
		Catla	Do.
		Labeo	Do.
Do.	Husseinipuram	Catla	Do.
		Labeo	Do.
		Mrigal.	Do.
Do.	Vetlapalam	Catla	Do.
		Labeo	Do.
		Mrigal	Do.
Do.	Peddapudi	Catla	Do.
Do.	Medapadu	Do.	Do.
		Mrigal	Do.
		Labeo	Do.
Do.	Peddada	Catla	Do.
Do.	Venkatakrishnapuram	Do.	Do.
		Labeo	Do.
Do.	Sarpavaram	Catla	Do.
		Labeo	Do.
Do.	Karpa	Carla	Do.
		Labeo	Do.
		Mrigal	Do.
Do.	Ramachandrapuram	Catla	Do.
		Labeo	Do.
		Mrigal	Do.
Do.	Muggula	Catla	Do.
		Labeo	Do.
		Mrigal	Do.
Do.	Sitanagaram	Catla	Do.
		Labeo	Do.
		Mrigal	Do.
Do.	Katteru	Catla	Do.
		Labeo	Do.
		Mrigal	Do.
Do.	Jallakalva	Catla	Do.
		Labeo	Do.
		Mrigal	

District.	Name of centre.	Kind of fish.	Season of availability.
East Godavari	Dowlaicheruvam	Catla	July-December.
		Labeo	Do.
		Mrigal	Do.
Do.	Mandapeta	Catla	Do.
		Labeo	Do.
		Mrigal	Do.
Do.	Dwarapudi	Catla	Do.
		Labeo	Do.
		Mrigal	Do.
West Godavari	Nidadavolu	Catla	Do.
		Labeo spp	Do.
		Cirrhina spp.	Do.
Do.	Narasapuram	Mullets	Throughout the year.
		Latos	November-January.
		Megalops	November-February.
Krishna	Manginapadu	Chanos	May-June.
Do.	Masulipatanam	Catla	July-October.
		Labeo	Do.
		Mullets	Throughout the year.
Do.	Chinnapandraka	Chanos	May-June.
		Mullets	November-December.
Do.	Tallapalam	Chanos	May-June.
		Mullets	November-December.
Do.	Manginipadu	Chanos	May-June.
Do.	Puligodda	Mullets	December-February.
Do.	Vijayawada	Mullets	December-March.
		Catla	July-November.
		Labeo	Do.
Do.	Tarigopula	Cirrhina	Do.
Guntur	Tenali	Do.	Do.
		Catla	July-October.
		Labeo	Do.
Do.	Nizampatnam	Cirrhina	Do.
		Chanos	May-June.
Do.	Muttipalam	Mullets	October-February.
		Chanos	May-June.
Do.	Chinnaganjam	Mullets	October-February.
		Chanos	May-June.
Nellore	Ullapalam	Mullets	October-February.
Do.	Turninalapenta	Mullets	December-March.
		Chanos	May-June.
Do.	Nellore	Mullets	November-March.
		Labeo	October-December.
Do.	Sangam	Cirrhina	October-November.
		Labeo	November-December.
Do.	Mopad	Cirrhina	Do.
Do.	Iskapelli	Labeo	November-January.
		Chanos	May-June.
Do.	Krishnapatnam	Mullets	November-February.
		Chanos	May-June.
Kurnool	Kurnool	Mullets	October-February.
Do.	Do.	Catla	June-December.
Do.	Sunkesula	Labeo	Do.
		Catla	Do.
		Labeo	Do.

District.	Name of centre.	Kind of fish.	Season of availability.
Bellary	Hospet	Labeo	June-November.
Do.	Kampli	Do.	Do.
Do.	Siruguppa	Do.	Do.
Anantapur	Anantapur	Cirrhina reba	July-September.
		Barbus sarana.	Do.
Chingleput	Pulicat	Chanos	November-December.
		Mullets	Do.
Do.	Ennore	Chanos	April-June.
		Mullets	November-February.
Do.	Covelong	Chanos	May-June.
		Mullets	Throughout the year.
		Megalops	December-February.
Do.	Madras	Mullets	Throughout the year.
		Etroplus	November-February.
Do.	Chunampet	Chanos	April-June.
		Mullets	December-February.
Madras	Adyar	Etroplus	Throughout the year.
		Mullet	Do.
		Chanos	May-June and October-November.
		Megalops	August-January.
South Arcot	Lower Anicut	Labeo	Do.
		Cirrhina	Do.
		Catla	Do.
Do.	Vadavar head	Labeo	Do.
		Cirrhina	Do.
		Catla	Do.
Do.	Kondappan Cauvery near Lalpet.	Labeo	Do.
		Catla	Do.
		Cirrhina	Do.
Do.	Veeranam	Labeo	May-June.
		Catla	Throughout the year.
		Cirrhina	May-June.
Do.	Cuddalore	Chanos	Throughout the year.
		Mullets	August-January.
Do.	Porto Novo	Chanos	Do.
		Mullets	Do.
Tanjore	Kanchanmangalam Dam.	Labeo	Do.
		Cirrhina	Do.
		Catla	Do.
Do.	Cauvery-Koda-murutty.	Labeo	Do.
		Cirrhina	Do.
		Catla	Do.
Do.	Vettar-Vennar	Labeo	Do.
		Cirrhina	Do.
		Catla	Do.
Do.	Koravoikal	Labeo	Do.
		Cirrhina	Do.
		Catla	Do.
Do.	Needamangalam	Cirrhina	Do.
		Labeo	Do.
		Catla	Do.
Do.	Tiruvarur	Labeo	Do.
		Cirrhina	Do.
Do.	Mannargudi	Labeo	Do.
		Cirrhina	Do.

District.	*Name of centre.*	*Kind of fish.*	*Season of availability.*
Tanjore	Mulliayar head ..	Labeo ..	January-August
		Cirrhina ..	Do.
Do.	Harichandranadi ..	Labeo ..	Do.
		Cirrhina ..	Do.
Do.	Nanalur	Labeo ..	Do.
		Cirrhina ..	Do.
Do.	Poruvalandan ..	Labeo ..	Do.
		Cirrhina ..	Do.
Do.	Rajagiri	Labeo ..	Do.
		Cirrhina ..	Do.
Do.	Cauvery-Arasalar ..	Labeo ..	Do.
		Cirrhina ..	Do.
		Catla ..	Do.
Do.	Mudigondan regulator	Labeo ..	Do.
		Cirrhina ..	Do.
Do.	Arasalar-Nattar Regulator.	Labeo ..	Do.
		Cirrhina ..	Do.
		Catla ..	Do.
Do.	Manangiri	Labeo ..	Do.
		Cirrhina ..	Do.
		Catla ..	Do.
Do.	Tiruvelangam ..	Labeo ..	Do.
		Cirrhina ..	Do.
Do.	Nannilam	Labeo ..	Do.
		Cirrhina ..	Do.
Do.	Adirampatnam ..	Labeo ..	Do.
		Cirrhina ..	Do.
		Chanos ..	May-June.
Do.	Nagapattinam ..	Mullets ..	Throughout the year.
		Chanos ..	May-June.
		Mullets ..	Throughout the year.
Do.	Tranquebar ..	Labeo ..	August-January.
		Cirrhina ..	Do.
Do.	Muthupet swamp ..	Chanos ..	May-June.
		Mullets ..	Throughout the year.
Tiruchirappalli ..	Vathalai	Labeo ..	August-January.
		Cirrhina ..	Do.
Do.	Chinthamani ..	Catla ..	Do.
		Labeo ..	Do.
		Cirrhina ..	Do.
Do.	Patlavathalai ..	Catla ..	Do.
		Labeo ..	Do.
		Cirrhina ..	Do.
Madurai	Madurai ..	Catla ..	Do.
Ramanathapuram.	Pamban ..	Cirrhina reba.	September-October.
Do.	Manamadurai ..	Chanos ..	April-June.
		Mullets ..	Throughout the year.
Tirunelveli ..	Tuticorin	Cirrhina reba	September-November.
Do.	Pinnakayal ..	Chanos ..	April-June.
		Do. ..	Do.
Do.	Palaiyakkayal ..	Mullets ..	November-March.
Do.	Tiruchendur ..	Chanos ..	April-June.
		Do. ..	Do.

District	*Name of centre.*	*Kind of fish.*	*Season of availability.*
Tirunelveli ..	Kadamba tank ..	Etroplus ..	November-May.
Do. ..	Ambasamudram ..	Barbus sarana.	July-November.
Do. ..	Srivaikuntam ..	Do.	Do.
Coimbatore ..	Bhavani	Labeo spp. ..	Do.
		Cirrhina spp.	Do.
		Barbus spp.	Throughout the year.
Nilgiris	Ootacamund ..	Mirror carp.	Do.
		Golden carp.	May-June.
Malabar	Ponnani	Chanos ..	November-January.
		Mullets ..	Do.
		Etroplus ..	May-June.
Do.	Beypore	Chanos ..	October-January.
Do.	West Hill	Mullets ..	December-January.
		Megalops ..	Throughout the year.
		Etroplus ..	Do.
Do.	Elathur	Do. ..	Do.
Do.	Tellicherry	Mullets ..	May-June.
		Chanos ..	Throughout the year.
South Kanara ..	Mangalore	Mullets ..	Do.
		Etroplus ..	Do.
Do.	Nilleshwar	Do. ..	Do.
Do.	Malki	Mullets ..	May-June.
		Chanos ..	Throughout the year.
Du.	Malpe	Etroplus ..	May-June.
Do.	Coondapur	Chanos ..	Throughout the year.
		Mullets ..	December-January.
		Megalops ..	

III. *Methods of collection and transport of fresh water fish seed—A. Collection from natural sources*—(*a*) Carp *eggs and fry.*—Mixed fry and spawn are collected from the rivers Cauvery and Bhavani from August to February. Spawn collection nets are fixed at vantageous positions in shallow areas in the river. The eggs are sorted in the field and the eggs of cat fish are removed. The eggs are hatched in small nurseries and the fry of economical varieties are transported to stocking centres in open tin carriers.

The fry are collected with small rectangular pieces of mosquito cloth net or coarse cloth net (4 feet by 2 feet) and velon screen nets. The fry that get stranded in small isolated pools in the shallow areas of the river are scooped by these nets. As far as possible the fry of uneconomic species like *Chela*, *Rasbora*, *Nuria*, *Barbus ticto*, *Barbus mahecola*, *Amblypharyngodon* and loaches are removed and the others are transported to stocking centres in open tin carriers.

Experiments conducted in the transport of spawn and fry over 300 miles have revealed that larger fry stand transport better than early fry and spawn. But if water is changed once in three hours even spawn stand transport without high mortality. The spawn and fry of *Labeo fimbriatus*, *Labeo* (*parel*), *Cirrhina reba*

and *Carra sp.* were used for these experiments. It was also found that during transport over longer distances (more than 50 miles) involving a greater length of time, the fry require feeding with phytoplankton.

(*b*) *Collection of fingerlings.*—The collection of fingerlings of the riverine carps is done on a large scale from inundated paddy fields, irrigation channels, tanks, etc., connected with the main rivers. The young fish are caught by means of cast nets, drag nets and basket traps.

The basket traps are mainly used in inundated paddy fields. This practice is adopted in the Andhra districts of the former composite Madras State. The traps known as " Mavulu " are made of either palmyra leaves or split bamboos. They are rectangular in shape and measure about 4 feet 6 inches by 2 feet by 3 feet 6 inches. At either end of this basket, there are openings just above the bottom, with funnel shaped structures which permit the entry of fish but prevent their escape. These traps are fixed across the sub-channels and water allowed to flow through them. Young fishes that move up or down the water enter the traps and are caught in them. The traps are emptied of their contents once in 20 or 30 minutes. The economic varieties of fish are sorted out and used for cultural operations.

In the Cauvery delta, which is the main seed source for the Madras State, the fingerlings are captured by regulating the flow of water at the irrigation sluices. The flow of water is suddenly reduced for 30 to 40 minutes by closing the sluice gate shutters. The fingerlings that have congregated below the shutter gates get stranded in large numbers and are scooped up by drag nets or long rectangular pieces of cloth. As the fish are of identifiable sizes, the unwanted species are sorted out and rejected. The fingerlings of *Catla catla, Cirrhina cirrhosa, Barbus carnaticus, Barbus sarana, etc., are caught like this.* The fingerlings are usually " conditioned " before being transported to long distances. The conditioning is done by keeping the fish overcrowded in small nurseries or condition boxes, or big baskets made of split bamboo. In using the bamboo baskets or condition boxes for conditioning the fish, greater care is to be taken to see that the bottom of the pond or river where they are to be placed should not be muddy.

(*c*) *Transport.*—The fingerlings are transported in round tin carriers made of galvanized iron sheets and with a perforated lid to facilities aeration of the water contained in it. The transport of fish seeds to the stocking centres is done through motor cars, buses, trains and sometimes in carts to places not connected by buses or rail.

The results of experiments conducted on the transport of the various freshwater fish seed are given below :—

(i) *Barbus carnaticus.*—Fingerlings of 4—6 inches (100–150 mms.) stand transport fairly well only if there is no overcrowding in the tin carriers. Fifty to sixty is the ideal number of fingerlings of such sizes in each tin carrier. Fish seed of 12–50 mms. long are the best suited for long distance transport. Fry of less than 12 mms. are very hardy for transport but the difficulty in identifying the species in large collections makes this size not suitable.

When the fins are differentiated, the fry can be identified by the following characters :—

D : 4/8 LI : 32 Barbels four, both pairs shorter than eye. The last undivided dorsal ray nearly as large as head. Anal fin reaches caudal fin.

(ii) *Barbus* (*Lissochilus*) *hexagonolepis.*—The capacity of the fry of this species (12–50 mm.) to stand the strain of collection and transport is identical with similar fry of *B. carnaticus.* Experiments conducted showed that a size of 50 mm. appear to be the best for transport. Fingerlings of this species are delicate and do not stand well the transport over long distances.

Identification characters.—D. 3/9, LI : 28–31, four barbels, the rostral pair shorter. Anal fin does not reach the caudal.

(iii) *Barbus dubius.*—Early fingerlings of this fish are very frail and excessive mortality occur even during collection. Extreme care at all stages of transport and avoiding direct handling of the young fish are to be strictly followed to keep down mortality.

Fry and fingerlings of this species can be collected from river Bravani, at Sathyyamangalam, Kodiveri and Athani.

Identification characters.—D : 4/9, LI : 42–45, Snout somewhat elevated. Barbels four, the maxillary pair are a little longer—colour silvery.

(iv) *Labeo sp.* (*Parel*).—Fingerlings 3–6 inches (75–150 mms.) long, stand transport well even over long distances of more than 300 miles. One hundred fish of 3 inches (75 mm.) can be safely transported in a tin carrier.

(v) *Labeo kontius.*—The fingerlings do not appear to stand transport well if transported immediately after collection as it is a very active fish and pump against the walls of the tins and get injured. But if the fingerlings collected from the rivers are conditioned for a week or so in a small nursery, the mortality can be reduced to the minimum. In a tin carrier, 75 well conditioned fish of less than 3 inches can be transported.

Identifying characters of fry.—D: 15–16, L1: 38–41. Barbels, 4 short. The eyes in the young are usually in the middle of the length of head. Profile above eye is rather concave. Mouth inferior and lower lip alone fringed. Ventrals do not reach the anal. Fry of L. *kontius* are darker than those of *L. fimbriatus.*

(vi) *Labeo fimbriatus.*—This fry stand transport very well and are very hardy. Fingerlings 4–5 inches (100–125 mms.) long can be transported even at 100 in each tin carrier without mortality over long distances, if they are previously well conditioned.

Identification characters.—D. 19–22, L1: 44–47. Four short Barbels. Both lips are fringed. Profile above the eyes, convex. Ventrals nearly extend to the anal. At the base of caudal fin there is a diffused dark blotch. Colour silvery along back and lighter beneath.

(vii) *Osteocheilus thomassi.*—The fish occurs in the river Tungabhadra. Transplantation of this fish to Madras showed that fingerlings of 115–125 mm. length stand transport well.

Other fishes that stand transport well in the fingerling stages are *Catla catla*, *Cirhina cirrhosa*, *C. reba* and *Labeo ariza.*

In the transport of carp fingerlings, rough handling at collection centres and overcrowding in tin carriers are the main reasons for heavy mortalities in transit. For short distance transport over 40 to 50 miles even 500 fingerlings can be taken in a tin carrier with a negligible mortality of less than 8 per cent if transported in a motor vehicle.

(*B*) *Collection of pond breeding fishes.*—The major carps of Madras breed only in fluviatile surroundings but fishes like the German carp, Golden carp, Tench and Gourami breed in confined waters and their seed are collected from ponds, or tanks or lakes or Departmental farms for stocking in other lentic and lotic waters. Of the above fishes excepting Gourami, the others have been noted to breed in waters of higher altitudes only except in one instance and are so termed here as "Cold water fishes". Though the seed of the Pearl spot, the *Etroplus suratensis*, are at times collected from freshwater ponds and tanks, they are mostly collected from backwater and estuaries. Hence the collection and transport of the Pearl Spot is dealt with separately.

(*a*) *Collection of "Cold Water Fishes".*—The German carp *Cyprinus carpio* (*var*) *specularies*, the scale carp *C. carpio* (*var*) *communis*, the Golden carp or English carp *Carassius carassius*, and the Tench, *Tinca tinca* are the common varieties that are maintained in the Departmental waters in Ootacamund on the Nilgiris. The fish breed prolifically in the Ootacamund lake and

the Katteri reservoir and the seed are annually collected and transported to various departmental waters in the plains in Madras. They are also sent to other States on demand.

The induced breeding of the German carps practised in Indonesia and China is not done in this State. The fish breed in wild attaching their eggs to floating *Eichornia* roots, *Potomageton* and *Hydrilla*. The eggs hatch in the lake or reservoir itself and only the fry and fingerlings are collected. The collections of the fry is made by dragging a rectangular piece of velon screen or coarse cloth net in the shallow areas of the lakes and other waters where the fish breed. Fingerlings are collected by drag net and cast nets. The fry are kept in nurseries in the Wilson Fish Farm at Ootacamund if they are too tender to be transported. The fingerlings are conditioned in nurseries before transport.

(*b*) *Transport.*—Young fry of this species were found to be quite hardy and capable of withstanding the strain of direct transfer from the upland waters (Temp. 15–17°C.) to the waters of the plains (Temp. 30–32° C.). Three sets of experiments were conducted on the transplantation of the fish from the cool upland waters to the warmer waters of the plains.

(1) The temperature of water in the container in which the fingerlings were transported was kept cool by putting in ice blocks all the way to the plains. The fingerlings were thus gradually acclimatised to the pond water before being released. It was found that, if water temperature was kept at 20°C., they stand transport well even over long distances.

(2) The next experiment consisted of keeping the water in the container cool by placing ice blocks outside the tin carrier. The fish were released in the ponds after slowly equalising the temperatures of the water in the tin carrier and the pond. There was no mortality at all in both the above cases.

(3) In the third experiment, Mirror carp fingerlings of 55-100 mms. were transported from the upland waters to the tropical plains without application of ice at all. They were conditioned for at least 36 hours prior to transport and the water in the container was changed once in every three hours. There was only very negligible mortality. These experiments show that for short distances there is no necessity of application of ice. Even in long distances, the mortality was negligible in such cases. But application of ice is desirable to prevent any mortality during transport.

(i) *Scalp carp* [*C. carpio* (*var.*) *communis*].—The Scale carp are also like the Mirror carp in their capacity to stand the strain of transport, etc. Fish of 40–100 mms. can be transported at 100 in a tin carrier.

(ii) *Carassius carassius* (Golden carp).—The Golden carp fingerlings also stand the strains of collection and transport very well. Experiments conducted without application of ice reveal that the mortality in transit does not exceed 6 per cent even when water is not changed en route. The fish can, however, be transported without mortality if they are conditioned for at least 24 hours prior to transport and water is changed en route every three hours. Forty to 50 fingerlings of a size of 80 to 110 mms. can be transported in each tin carrier.

(c) *Collection and transport of Osphronemus gourami.*—The Gourami breeds easily in confined waters. The main requirement of the Gourami for breeding is the availability of suitable water plants or other material for the construction and attachment of the nest. In Madras, the fish are reared in Departmental farms, where Typha grass are planted at the margin of the pond for the fish to build nests. The young ones are collected from the farm by drag nets and small meshed cast nets. The fish have been stocked in fluviatile waters, but the young ones for stocking have not yet been collected from the natural waters.

This hardy air-breathing fish stands transport well. Investigations during transport have revealed that mechanical injury owing to violent beating about especially when overcrowded is the prime cause for the mortality of the young ones. The water getting heated is another factor to be avoided. Fish of 3 to 5 inches (75–125 mm.) are the best suited for long distance transport. It is advisable to transport fingerlings of approximately one size as otherwise bigger fish attack the smaller one and mortality may occur due to injury. Twenty-five to thirty fingerlings can be safely transported in a tin carrier.

IV. *Euryhaline fishes, their collection, acclimatisation and transport.*—Acclimatisation of salt water fish to brackish and freshwater is of primary importance in increasing the variety as well as the quantity of fish that could be produced under controlled conditions in brackish water lagoons and fresh water ponds. The estuaries and backwaters all along the east and west coasts of the State offer excellent collection grounds for the fry and fingerlings of the salt water fishes like Mullets (*Mugil*), Milk fish (*Chanos*), Pearl Spot (*Etroplus suratensis*), Ox-eyed herring (*Megalops cyprinoides*), *Elopes indicus*, the Cock up (*Lates calcarifer*), Thread fin (*Polynemus*), "Indian whiting" (*Sillago sihama*) etc., which are capable of being acclimatised to fresh water for culture in ponds. But of all the above salt water fishes, *Chanos chanos*, *Mullets*, *E. suratensis* and *M. cyprinoides* are the most important fishes and the young ones of these are annually collected in large numbers by the Madras Fisheries department for culture in Inland waters.

(i) *Grey Mullets.*—The following species of Mullets have been observed to be available in the State :—

Mugil cephalus, *M. dussumieri*, *M. crenilabris*, *M. oligolepis*, *M. corsula*, *M. cunnesius*, *M. macrolepis*, *M. planiceps*, *M. parsia*, *M. subviridis*, *M. waigiensis*, *M. tade*, *M. troschelii*, *M. jerdoni*, *M. klunzingeri*, *M. speigleri*, *M. tade*, *M. troschelii*, *M. waigiensis* and *M. cascasia*.

Young mullets of 1 to 3 cm. occur in swarms in shallow brackish water expanses. Salinity in this region varies from 840 p.p.m. at low tide to 1,540 p.p.m. at high tide. As such in nature itself, the fry that freely frequent the brakish water tolerate a wide range of salinity.

Fry and fingerlings of Mullets are collected from the estuarine and backwater lagoons and creeks, pits and puddles in the backwater area that get flooded during high tide. The young fish are caught with drag nets and cast nets. In some places small embankments are raised during low tide, and when high tide sets in, these shallow portion on the shore receive water and along with it the young Mullets also enter. When the low tide sets in the young fish are trapped in these flats. They are then lifted by using a dragnet of fine mesh or velon screen net.

Acclimatisation mainly consists of reducing the salinity of the medium in which the fish are kept in gradual stages to get the fish accustomed to lower salinity and finally to freshwater conditions.

Experiments conducted on various occasions have revealed that the acclimatisation should be carried out in the quickest possible time as otherwise, heavy mortality sets in. It was found that stepping down the chlorinity from 1,200 p.p.m. to fresh water conditions in three steps of 6 hourly intervals in the course of 12 hours yielded the lowest mortality of 10·4 per cent. It is also found that Mullet fry of 2 to 5 cm. are very delicate and do not stand the strains of collection, acclimatisation and transport. Even after acclimatisation and stocking the percentage of survival is very low being only about 4 per cent. Feeding of the fry with moss and algæ during acclimatisation helps to reduce the mortality.

(ii) *Chanos chanos.*—The collection of *Chanos* seed for culture in freshwater is an established practice in Madras.

Fry are collected from coastal areas like sheltered lagoons, sandy or muddy areas near salt swamps, etc., where they are found in shoals. Two persons wade ankle deep of water carrying the two ends of a saree or cloth measuring 10 feet by 4 feet, holding it loosely above the water surface. Another pair drag a coir rope (Scareline) about 10 feet in length with palmyra leaves attached along its length just in front of the saree, almost touching the bottom of the area. The fry that are in the area get

frightened by the trailing scareline and leap in an attempt to escape only to fall on the cloth behind. The fry are removed by a hand net and kept in a tin carrier or mud pot. Sometimes a drag net of fine mesh is also used to lift the fry. The fry are kept in small nurseries (100 by 25 by 3 feet) before being transported. Conditioning takes place for a period of about 24 hours. The fry intended for transport are loaded in the tin carriers in a medium of water collected from the nursery itself. Two hundred fry of 15 to 50 mms. are put in each tin carrier. If the fry are bigger, only 100 in each tin can be put.

Experiments conducted on the acclimatisation of this fish have revealed that the fish can be transferred from saline conditions to fresh water conditions directly without any mortality. Further experiments were conducted to see the advisability of adopting the " direct transfer " method over " acclimatisation in transit " and it was found that " acclimatisation in transit " gave lower mortality rates. " Acclimatisation in transit " consists of keeping the fish in saline water in the tin carried and changing the medium to fresh water conditions in stages at important railway stations en route. At the collection centres, acclimatisation is carried out as above in stages as follows :—

The fry are placed in a tin carrier filled to its third with sea water. The tin carrier is taken to the nearest freshwater source. A bucketful of water is removed from it and one bucket of freshwater is poured into it. This process of dilution is repeated three or four times and before actually loading the tin in the train, the tin carrier is practically drained and 5 buckets of freshwater are poured in, thus making the water in the tin almost completely free. The whole process of acclimatisation is done within a period of 6 hours.

(iii) *Etroplus suratensis*.—This common backwater perch is found along both east and west coasts of India. They breed in estuaries, creeks and backwater lagoons from where their young are collected. This is the only backwater fish that can be successfully bred in confined freshwaters like ponds, tanks and wells. Its young are, however, not available in such large numbers in the freshwater sources and so they are annually collected from the backwaters.

This fish has the habit of lying on its side to escape the fishermen's net. The fish are, therefore captured by adopting the " bush method " of fishing. A few branches or twigs of plants are tied together and dropped at various places in the water in the collection ground. Fry and fingerlings take shelter among the bushes. At intervals of 4 to 5 hours fishermen wade through the water and carefully drag the bushes towards the shore. The fish that are inside are shaken out, picked up and transferred to

the containers. Though this is a common method of fishing for the young of this fish, drag netting is also done to capture shoals of the young ones.

Graduai acclimatisation from brackish water to freshwater as carried out for Chanos, in the tin carrier itself, is adopted for this fish. The following acclimatisation procedure is found to be the best :—

Stage number. (1)			Brackish water. (2) PER CENT.	Fresh water. (3). PER CENT.
I			80	20
II	4 hours later	...	40	60
III	Do.	..	10	90
IV	Do.	..	0	100

The acclimatised fish should be kept in freshwater nurseries for about 36 hours before being transported. Overcrowding in the condition box and in the tin carriers during acclimatisation and transport cause heavy mortalities. Forty fingerlings of 25 mms. can be put in a tin carrier.

(iv) *Megalops cyprinoides*.—The Indian Tarpon or Ox-eyed herring breed in the estuarine conditions and their leptocephali appear in large numbers from October to December. The leptocephali seem to acclimatise itself in freshwater ponds near the coast as specimens over a foot in length have been found in these ponds.

Experiments have shown that, during the post-larval leptocephalus stage the fish is very hardy and can withstand even direct transfer from brackish water of salinity 18·54 to fresh water. While working on the larval history of the fish, it was found that the change in medium even during its development had no adverse effect on the fish. The post larvæ from brackish water were transferred to freshwater and the metamorphosis of the " leptocephalus " larvæ was completed in freshwater conditions without any mortality. The capacity of the species for acclimatisation appears to be less in the older fingerling stages than in the post-larval stage.

(v) *Elops indicus*.—This fish usually occurs along with *M. cyprinoides* and *Chanos chanos*. This fish is not very hardy and is more susceptible to the strain of transplantation to freshwater than Megalops. Under natural conditions, however, it gets acclimatised to less saline habitats and finally to freshwater. The leptocephali of this occur in fairly large numbers in the backwaters and estuaries.

Early fingerlings of this species collected from freshwater section of the R. Cooum in Madras and also from the backwaters

at Adyar have shown heavy mortality in acclimatisation and transport. But the leptocephalus—like post-larvæ were found to be very hardy and adjusted easily to direct transfer from brackish to freshwater. The post-larval development was noted to be not affected by the transplantation to freshwater medium. Owing to its predaceous habits, the species is not usually used for freshwater farming.

(vii) *Sillago sihama*.—Specimens of 2 to 5 cm. size of the so-called Indian whiting are collected from the Adyar estuary. The fingerlings do not stand direct transfer to freshwater from brackish water conditions. The fish stands only a very gradual acclimatisation in stages as follows :—

Stage number. (1)	Brackish water. (2)	Fresh water. (3)
I	3	1
II	2	1
III	1	1
IV	1	2
V	1	3
VI	0	1

Each stage should be separated by an interval of 30 minutes. The fish can be acclimatised very successfully by the above process. But it does not survive in confined fresh water conditions.

V. *Improved methods in transport*.—In Madras State transport of the fish seed is done in carriers made of galvanised iron sheet. This involves change of water at intervals of about 6 hours. Experiments were, therefore, conducted to effect improvements in the method of fish seed transport which would reduce mortality and the handling of fish to the minimum. As reduction in oxygen content of the medium and increase in CO_2 content are two major causes for mortality in transit, transport of fish in closed cans with a layer of oxygen above the water was tried.

(*a*) *Transport in oxygen tin carriers*.—Experiments were conducted in specially made oxygen tin carriers of the model of those used by Dr. Hamid Khan in the Punjab. The experiments showed conclusively that oxygen tin carriers are to be preferred to the ordinary tin carriers especially when fish seed have to be transported over long distances. Mortality is low and the method is less cumbersome. Transport of *Chanos* (50–75 mms.) in oxygen tin carriers showed a mortality of only 8 per cent whereas it was 22 per cent in ordinary tin carriers in 24 hours. Similar sets of experiments conducted with the Grey Mullets (25 to 75 mms.) showed that the mortality were same in both the oxygen tin carriers and ordinary tin carriers for a duration of 7 hours. Transport

of *E. suratensis* (50–75 mms.) in oxygen tin carriers showed a very negligible mortality whereas it was very high in the ordinary tin carriers. Consignments of aquarium fishes like *Trichogaster fasciatus*, *Barbus aurelius*, *Oryzias melastigma*, *B. mahecola*, etc., were transported from Madras to Bombay in oxygen tin carriers without any mortality.

(*b*) *Use of ant hill earth*.—A series of experiments were carried out to test the effect of the addition of varying amounts of ant hill earth in preventing mortality of fish during transport. The earth was well powdered and sieved, through a screen of 225 mesh per square cm. Solutions of this earth in water were made in different concentrations. The ant hill earth increased the pH of water and decreased the amount of free CO_2. Experiments revealed that the earth did help in increasing the survival of the fishlings in transport.

IV. POLLUTION STUDIES.

The problem of water pollution by industrial wastes is assuming great importance in the various Indo-Pacific Countries because of the extensive industrialization programme in these regions, and in India, attention was first drawn to the problem by Dr. S. L. Hora in his note to the Imperial Council of Agriculture Research on the pollution of streams in India and its likely effects on fishes. Following this a few investigations were made in the country to assess the actual extent of damage caused by industrial wastes to fish populations in the various water resources. In the Madras and Andhra States six instances of fouling of natural waters have so far been investigated in this connection and the results of these investigations are briefly reviewed below :—

Pollution of the Cauvery River.

1. *By Factory effluents from the Mettur Chemicals and Industrial Corporation, Limited, Mettur Dam*.—The Cauvery is one of the major rivers of Madras, fetching nearly two-thirds of the total revenue from inland fisheries. Chacko and Kuriyan (1948) have listed 77 species of fish from this river, the important ones being *Catla catla*, *Labeo kontius*, *L. fimbriatus*, *L. ariza*, *L. boga*, *Cirrhina cirrhosa*, *C. reba*, *Barbus carnaticus*, *B. dubius*, *Mystus seenghala*, *M. aor Wallago attu*, *Pangasius pangasius*, *Silonia silonia and Gallichrous bimaculatus*. Almost all these species breed in the river which, therefore, is the chief seed source for the Madras Fisheries Department.

Located close to the Mettur reservoir on this river is the Mettur Chemical and Industrial Corporation, Limited. This factory produces caustic soda, bleaching powder, bleach liquor, Vanaspati (Hydrogenated vegetable oil) and refined oil; and discharges its effluents into the Ellis Surplus Course at the rate of about 10,000

gallons per day. These effluents were found to kill thousands of carps and catfishes which were entrapped in the series of rock pools in the surplus course during the summer months when the water in the reservoir ceased surplussing. The fishes in the pools could not be salvaged and released into the reservoir, since they had steep sides and were not easily accessible. Analysis of the effluents revealed that carbonates and chlorides of calcium and sodium were the dominant salts present in them. The large amounts of caustic alkalis and the excess of suspended matter were responsible for the large-scale fish mortality. The hydroxide content of the effluents varied from 1·36 to 75·3 parts; carbonates (expressed as Co3 from 0·8 to 27·53 parts; free chlorine from nil to 19·6 parts and total chloride chlorine from 31·5 to 424·8 parts per 100,000. During the period of stagnation dark floating masses of the blue-green algae, *Oscillatoria*, and thousands of aquatic oligochaetes (Tubificids) were seen in the pools, phytoplankton was not very rich and was represented by *Anabaena*, *Pediastrum* and *Pleurococcus*, while zooplankton was fairly rich, consisting mainly of copepods (*Mesocyclops*) and rotifers (*polyarthra*). When the Ellis Surplus functioned in the flood period (June to August and October to December) the pools overflowed and the pollutional waters were considerably diluted and became harmless to the fishes that congregated and migrated upstream for spawning purposes. More details of the nature of the effluents and the fisheries have already been reported by Ganapati and Alikunhi (1950).

To protect the valuable fisheries of the river, various alternate methods of disposal of the effluents were tried. Neutralization of the waste waters with hydrochloric acid was found ineffective and uneconomical. Lime and free chlorine which formed the bulk of the effluents could be recovered for utilization for water-purification purposes, but the easy availability of pure calcite in sufficient quantities in the neighbourhood rendered attempts at setting up recovery plants expensive. Dilution of the wastes by pumping water from the reservoir into the effluent pit in the factory involved recurring expenditure and did not guarantee immunity for the trapped fish which might even be affected by the diluted effluents that might accumulate in the pools during the stagnation period. Viewing the whole problem from financial and practical aspects it was suggested that the effluents be taken by hume pipes to a place in the main river, below the intake for the Mettur water-works, where the constant flow of water from the tail-race of the electricity generating station would ensure thorough mixing and dilution of the wastes. It was estimated that even the maximum daily discharge of about 25,000 gallons of the effluents would be effectively diluted over 5,000 times when the rate of flow from the tail-race was about 10,000 cusecs.

The authorities of the Mettur Chemical and Industrial Corporation, Limited, however expressed certain practical difficulties

in laying the effluent pipes for long distances along the rocks and boulders in the region and as an alternative have agreed not to let in the effluents into the river but to soak them in their own vacant lands adjacent to the factory premises.

2. *By waste waters from the Erode Cauvery Textiles, Limited, Bhavani.*—Bhavani is an important fishing centre on the Cauvery river and the 27 miles stretch of the river between Mettur Dam and Bhavani is noted for its following rich fishery :—

Anguilla bengalensis, *Barbus dubius*, *B. Sarana*, *B. carnaticus*, *B. hexagonolepis*, *B. tor*, *B. stigma*, *B. ticto*, *Belone cancila*, *Catla catla*, *Callichrous bimaculatus*, *Chela argentia*, *Chela clupeoides*, *Cirrhina cirrhosa*, *Cirrhina reba*, *Labeo fimbriatus*, *L. kontius*, *L. calbasu*, *L. boga*, *Macrones aor*, *M. vittatus*, *M. seenghala*, *M. punctatus*, *Mastacembalus armatus*, *Notopterus notopterus*, *Ophicephalus marulius*, *O. striatus*, *O. punctatus*, *O. gachua*, *Pangasius pangasius*, *Rhynchobdella aculeata*, *Silundia silundia*, *Wallago attu*, etc. The portions of the river between the Mettur Dam and the confluence of the Ellis Surplus with the river is a conservancy area. The remaining stretch of the river is either leased out or enjoyed as private patta fisheries. This river stretch also contains various fry collection centres like Neriujipet, Ammapet, Sanyasipatti, Vanankombu, Pulianipatti and Pallipayalam kombu from where the State Fisheries Department collects carp fries in large numbers every year for stocking the various tanks and ponds in the State. The number of carp fries collected and distributed from these centres from 1949 to 1954 is as follows :—

Year.	Total carp seeds collected.
1949–1950	1,035,470
1950–1951	1,858,558
1951–1952	844,960
1952–1953	737,030
1953–1954	800,625

Further, this stretch of the Cauvery river between Mettur Dam and Bhavani has been found to be the spawning grounds of fishes like *Labeo fimbriatus*, *Cirrhina reba* and *Garra mullya* (Ganapati et al 1951). It is therefore very necessary that steps have to be taken to see that this river stretch is not polluted by any industrial wastes which may harm the above fishery interests. The effluents from the Erode Cauvery Textiles, Limited, Bhavani, which were polluting this river stretch of fishery importance were therefore examined as detailed in the succeeding paragraphs for their adverse effects on fish life and suitable remedial measures suggested to compensate the harmful effects.

The Erode Cauvery Textiles, Limited, process unbleached handloom cloth in their factory at Bhavani in Coimbatore district. The factory is located on the Bhavani-Mettur Road and receives supply of raw water from the Cauvery river making its course about 150 yards behind the factory limits. A pumping plant is installed on the bank of the river and water is pumped into a masonry tank of about 37,000 gallons capacity within the factory premises. The processing of cloth in the factory involves a number of steps like desizing, kier boiling, bleaching, souring and finishing and for one cycle of the above operations for the processing of about 15,000 yards of unbleached handloom cloth, a total quantity of about 21,000 gallons of waste waters are collected. It takes nearly three days to complete only cycle of operations. Occasionally the factory also prints chintz by using soluble derivatives of leuco-bases of vat dyes and by developing the colour in the acid bath. The quantity of waste waters derived from the printing section will be about 500 gallons for 1,000 yards of chintz printed.

The public health aspects of letting these waste waters into the adjacent Cauvery river were investigated in May 1953 by the King Institute, Guindy, who found that the effluents were bacteriologically sterile and did not adversely affect the chemical quality of the river. However, since the flow of water in the river is very low in the summer months they recommended that a sedimentation-*cum*-coagulation basin with an overall capacity of 35,000 to 40,000 gallons should be constructed and the effluents treated in it with 20 grains of lime and 10 grains of alum per gallon of effluent. The treated wastes must be allowed to settle for about eight hours before finally drawing into the discharge pipe for disposal. The discharge was also to be extended further into the river bed to ensure adequate mixing of the waste with the flowing water.

When the present investigation to assess the effect of the factory wastes on the fisheries of the Cauvery river was started in December 1953, the factory authorities had constructed the sedimentation tanks, but were allowing the effluents collected in the mixing tanks to discharge direct into the river. The discharge pipe ending on the bank of the river had also not been extended into the middle of the river bed as recommended by the King Institute, Guindy.

The untreated effluents were examined on the 16th December 1953 and 18th February 1954 during the course of the investigation. The effluents were turbid and brownish in colour with a sour smell. On the second occasion they had a slight smell of bleach liquor also but there was no free chlorine in the effluent on both the occasions. The waste waters were acidic with a pH ranging from 5·2 to 5·4 and an acidity varying from 128 to 143 p.p.m. CaCo3. Boiling of the effluent did not remove the acidity completely which may therefore be due to the presence of mineral acids. The biochemical oxygen demand (three days) varied from

1,000 to 1,600 p.p.m. and the suspended solids from 60 to 180 p.p.m. as against 20 p.p.m. of B.O.D. and 30 p.p.m. of suspended matter prescribed for the general standard effluent by the Royal Commission on Sewage Disposal.

In order to find out the effect of the untreated effluents on the chemical quality and plankton of the river water, water and plankton samples were collected on 16th December 1953 from three places in the river as follows:—

(1) About 100 yards above the effluent outfall on the upstream side, (2) at a point opposite the effluent outfall, and (3) at a point 100 yards below the point of discharge on the downstream side. The effluent decreased the pH and increased the acidity, methyl orange alkalinity and B.O.D. of the river water to a slight extent though other physical-chemical variables like colour, temperature, dissolved oxygen, chlorides, total solids and suspended solids of the river water remained almost unaffected. This observation along with the results of analysis of the untreated effluents would indicate that the waste waters were acidic with a high B.O.D. and might be harmful if not sufficiently diluted. At the time of the investigation there was good flow of water in the river at the point of discharge and as such the chemical quality of the river waters was not adversely affected as evidenced by the B.O.D. being only about 2·0 p.p.m. as against 4·0 p.p.m. permitted by the Royal Commission.

Though the chemical quality of the river water was not adversely affected, there was a significant change in the character of the river plankton by the discharge of the effluents. The phytoplankton of the river water was fairly rich and before pollution by the factory wastes was composed of Chlorophyceae (*Spirogyra*), *Bacillariae* (*Fragillaria* and *Gomphonema*) and Dynophyceae (*Ceratium*). After admixture of the effluents the rheo-plankton became very rich in Chlorophyceae (*Ankistrodesmus*, *Mougeotia*, *Pediastrum simplex and Spirogyra*). The plankton collection in the river opposite the effluent outfall was mainly composed of green algae only. Chlorophyceae are usually associated with polluted conditions of a river and the increase in the green algae in the Cauvery river water after admixture of the effluents certainly reflected on the high polluting capacity of the waste waters. The zooplankton was poor in the river and consisted of stray specimens of copepods (*Cyclops* and *Diaptomus*) only.

Laboratory experiments were done in February 1954 to find out the effect of the untreated effluents on fish life. About 100 fry of *Labeo sp.*, *Cirrhina reba*, *Barbus chrysopoma*, *B. carnaticus*, *B. ticto* and *Amblypharyngodon sp.*, and six fingerlings of *Barbus hexagonolepis* and *B. carnaticus* were used as test fishes. The following dilutions of the untreated effluents were used in the experiments and the results are shown below in Table 7.

TABLE 7.

Serial number and proportion of effluents to Cauvery river water.	Percentage mortality after				
	4 hrs.	24 hrs.	28 hrs.	32 hrs.	36 hrs.
(1)	(2)	(3)	(4)	(5)	(6)
(1) Effluent proper	100	..	..	..	..
(2) 1:5	Nil.	89	4	7	..
(3) 1:10	Nil.	84	2	14	..
(4) 1: 20	Nil.	79	9	12	..
5) 1:80	Nil.	6	Nil.	3	6
6) 1:200	Nil.	1	Nil.	Nil.	Nil.
(7) Cauvery water only	Nil.	Nil.	Nil.	Nil.	Nil.

The above showed that a minimum of 200 times dilution was necessary to render the untreated effluents harmless to fish life.

The same sample of effluent was treated with 20 grains of lime and 10 grains of alum per gallon of effluent and allowed to settle for about 8 hours as suggested by the King Institute, Guindy. The effluent was neutralized and the suspended matter was coagulated and precipitated. The clear supernatent liquid which had a pH of 7·9 was tested for its effect on fish life. About 100 fry consisting of *Labeo sp.*, *Cirrhina reba* and *Barbus sp.*, and six fingerlings of *Barbus hexagonolepis* and *B. carnaticus* were put directly into the clear treated effluent. No mortality was observed for about 48 hours at the end of which the experiment was discontinued. The laboratory experiments thus showed that the factory wastes had to be treated with lime and alum on the lines described above or diluted about 200 times with the river water to make them harmless to fish life.

But the flow of water in both the Cauvery and Bhavani rivers is controlled by dams constructed above Bhavani and so, on occasions especially during the summer months, may be very low and may not be sufficient to dilute the wastes to safe limits or to guarantee a good degree of self-purification of the river. The factory authorities were therefore asked to permanently close the direct passage connecting the mixing tanks and the discharge pipe and treat the effluents on the lines described above so that the effluents will not do any harm to the fishery interests in the river. Further, at the time of investigation, the wastes were discharged close to the bank of the river at a spot containing rocks and boulders in the river bed leading to stagnation of the effluents during the periods of lean flow in the river. To avoid this, the factory authorities were insisted upon to extend the discharge pipe to the middle of the river where there is adequate flow of water. It is gratifying to note that the authorities had extended the discharge pipe into the middle of the river as suggested above by July 1954.

POLLUTION OF THE GODAVARI RIVER.

By the effluents from the Andhra Paper Mills, Rajahmundry.—The Andhra Paper Mills, situated on the bank of the Godavari river at Rajahmundry, discharged its effluents into the mid-section of the Godavari and caused mortality of fish during the non-flood season from January to June, when there was not much flow in the river. The effluents were derived from three sections of the mill, namely, (1) pulp preparation section, (2) pulp purification section and (3) craft paper manufacturing section. The pulp was prepared from waste paper, bamboos and rags. The waste papers were sorted out and kneaded into a pulp with water and steam; the bamboos were treated under pressure with a solution containing 80 per cent caustic soda and 20 per cent sodium sulphide for removing the non-cellulose portion like lignin; and the old gunny bags, rags, etc., were boiled with lime or soda and then washed with water in preparing the pulp. These palpy materials were made ink-proof by the addition of rosin and alum. The waste waters from the first two sections thus consisted mainly of a dark coloured liquid containing sulphides, sulphates, lime, soda and suspended matter resulting from the treatment of bamboos and excess water used for washing and screening the pulp. The effluent from the paper manufacturing section consisted of a suspension of minute particles of pulp in water containing about 0·01 per cent rosin and alum. The effluents from the three sections first collected in separate tanks and then mixed. Physico-chemical conditions of these effluents (as on 23rd October 1946) were: Turbidity—10·0 cm.; temperature—31·1° C.; carbonates (Co_3)—2·25 p.p.m.; bicarbonates (HCO_3)—11·742 p.p.m.; chloride—2·5 p.p.m.; pH—8·5; and dissolved oxygen—2·442 cc/l. The total quantity of effluents discharged into the river was about 60,000 gallons per day.

The details of the effect of these effluents on the river have already been reported by Ganapati and Chacko (1952). The effluents reduced the oxygen content of the river water during the summer months and produced flocculent precipitates of aluminium hydroxide and large quantities of hydrogen sulphide. The river water was black in colour for a distance of one mile below the outfall and about one furlong above it and about half a mile across the river; but was bottle-green beyond this region. Thick patches of macro-vegetation consisting of *Hydrilla verticillata*, *Vallisneria spiralis* and *Potamogeton pectinatus* occurred in the sheltered portions above the outfall. There was marked difference in the physical, chemical and biological conditions between the polluted and non-polluted sections of the river as indicated. The non-polluted portion of the river was highly oxygenated and was rich in variety and bulk of plant and animal life. The polluted region, on the other hand, was poor in both macro and micro organisms indicating thereby the harmful nature of the effluents.

Laboratory experiments on the physiological responses of *Barbus stigma* to different concentrations of the effluents showed that a minimum dilution of 1 : 500 was necessary for making the effluents of this mill harmless to fish life. It was therefore suggested to the authorities of the mill that the effluents should be pumped into the river only when the latter was in high floods or purified by a sort of rough and rapid filteration through sand before being discharged into the river.

Pollution of the Adyar Estuary.

By septic sewage from the Gandhinagar colony.—The Adyar river began to emit a foul odour from 21st June 1950 onwards and caused considerable nuisance to the people residing nearby. Use of bleaching powder by the Corporation authorities to minimise the nuisance did not meet with any success. A detailed hydrobiological survey of the river made on 27th June 1950 revealed that the river was polluted by septic sewage from the sump-pit near the sewage pumping station of the newly formed Gandhinagar colony. It was also ascertained that the sewage which was regularly pumped into a cast iron pipe leading to the Adyar Pumping Station was not pumped on all days particularly on Sundays and that the entire sewage was allowed to overflow into the river on all rainy days.

The river course could be roughly divided into three natural sections on the basis of the colour of water as it appeared to the naked eye on the day of investigation. The first section extending from the boat house to the middle of the Gandhinagar colony was greyish in colour; the section running almost parallel to the Gandhinagar colony was deep brown in colour and the third section beginning from just above the Adyar bridge to the sand bar was yellowish green. The water above the bridge was deep brown or greyish and was fairly well saturated with oxygen. It had also a bloom of *Peridinium*. But lower down the bridge, the water was yellowish and highly turbid. The water was devoid of oxygen in this portion and several species of fishes including air-breathing forms like *Anguilla bengalensis* and *Ophichthys boro* were washed ashore either dead or in a dazed condition. *Peridinium*, which was the dominant planktonic organism, was also in a dead condition and caused the foul odour. The fish mortality was in all probability due to the creation of anærobic conditions from the bottom to surface by sewage pollution. The creation of anærobic conditions would have been helped by the depletion of oxygen by sulphuretted hydrogen produced from the bottom sediments and by the decrease in photosynthetic activity from 20th June 1950 to 22nd June 1950, when cloudy weather with slight drizzle prevailed. Further, on 23rd, 24th and 25th June 1950 there was heavy overflow of sewage from the Gandhinagar colony into the river. Thus both meteorological and hydrobiological evidences showed that sewage pollution was mainly responsible for the causation of the foul odour.

Suggestions were made to the authorities to prevent the pollution of the river by the sewage from the Gandhinagar colony and to flush the river by opening the closed sand bar and connecting it with the sea.

Pollution of Chandriya Kalwa.

By foul waters from the Cane Sugar Factory at Vuyyur.—The Chandriya Kalwa is an open drainage in Krishna district, making a course of about 25 miles before joining the Collair lake beyond Gudivada. Major carps like *Catla catla*, *Cirrhina mrigala* and *Labeo fimbriatus* and other species like *Wallago attu* and *Ophicephalus striatus* used to occur in the kalwa and the fisheries of the kalwa was used to be taken on lease by the local fishermen. it was alleged by the local fishermen that the fishery had dwindled considerably, probably due to pollution of the kalwa by the effluents from a cane sugar factory located at Vuyyur.

On an investigation of the case, it was found that the factory operated from November to May, with a maximum production in the months of February and March. The total quantity of effluent falling daily into the kalwa was about 15,000 gallons on the average. The factory besides producing sugar, manufactured such bye-products as confectionary, denatured spirits and carbondioxide gas. The effluents were first taken across the Pullern canal through an open drainage channel about 300 yards east of the factory. The drainage then made a course of about two miles through paddy fields before joining the kalwa, which crossed the Revos canal through an underground tunnel.

The effluent was highly acidic with a pH of 5·1 and contained large amounts of free carbondioxide. It contained also large amounts of putrescible organic matter which had a deleterious effect upon the oxygen saturation of the water of the kalwa and consequently had harmful effect upon its capacity to support fish life. Excepting for one or two patches of *Ipomea aquatica* in the lower reaches of the kalwa, there was no macrophytic vegetation. The absence of vegetation would make the kalwa dependant on diffusion from air for its oxygen supply and would thus render its recovery from the pollution more difficult. The effluent got diluted beyond Reves canal as indicated by the increase in pH, decrease in Tidy's oxygen figures and increase in oxygen content. The phytoplankton was poorly represented by few individuals of *Navicula*, *Pleurosigma*, *Cocconeis*, *Synedra*, *Nitzschia*, *Microcystis*, *Nostoc*, *Oscillatoria*, *Oocystis*, *Spirulina* and *Ulothrix*. The zooplankton was constituted by *Rotifer*, *Polyarthra*, *Anuria*, *Euchlanis*, *Schizocera*, *Diaptomus*, *Daphnia*, *Macrothrix*, *Diaphanosoma*, *Cypris*, *Nauplius larvæ* and *Dipteran larvæ*. Trial nettings conducted and examination of the catches of the local fishermen revealed that excepting few minnows, murrels, spinyeels and climbing

opposite the point of discharge of the waste waters and diminished in number towards the mouth of the estuary as the waste waters got diluted.

No deleterious effects to fish life of the estuary have been reported to be caused by the effluents till now. However, laboratory experiments conducted in April and May 1955 revealed that the factory wastes were harmful to fish life, if not sufficiently diluted. Fishes like *Cirrhina sp*, *Danio sp* and *Etroplus maculatus* were found to die in about 1·5 hours in 50 times dilution, in about three hours in 200 times dilution and in about 16 hours in 2,000 times dilution of the effluents. A minimum of 8,000 times dilution was necessary for rendering the wastes innocuous to fish life.

The above investigation has shown that the undiluted effluents from the South India Starch Product Company, Limited, at Porto Novo were harmful to fish life by their acidity, high B.O.D. and high suspended matter. The pH of 4·0 of the wastes was below the limits of toleration of carp. The high B.O.D. of the waste waters might cause oxygen deficiency in the river water leading to fish mortality. The large amounts of suspended matter might cause fish mortality by directly choking the gills and gullets or might form a sludge blanket on the river bed to the detriment of the bottom fauna and productivity of the estuary. But such adverse effects were not discernible at the time of the present investigation as the effluents were considerably diluted in the estuary. The absence of the sludge blanket might partly be due to the suspended matter forming direct food for the animalcules and the innumerable young fishes in the estuary. The diurnal tidal action might also help to flush the estuarine bed and keep it free from sludge.

The Vellar river was nearly 300 feet wide and 6 feet deep opposite the factory limits and had an average rate of flow of 1,332 cusecs or 8,325 gallons per second at low tide at the time of study. The factory effluents were ordinarily discharged into the river during low tide only for about five hours between 12 noon and 5 p.m. every day. Assuming that the waste waters were let out at a uniform rate during these five hours, the rate of discharge of effluents worked out to about 0·25 gallons per second. The effluents were therefore diluted nearly 33,300 times in the estuary. This was more than four times the dilution necessary for rendering the effluents harmless to fish life. For the remaining 19 hours in a day the estuary was free from pollution by the factory wastes and this might cosiderably aid in the further dilution of the effluents and in the mitigation of their polluting effects. Further, as the effluents were discharged right into the tidal zone where the full manifestations of the tidal rise and fall of water level were encountered, considerable dilution of the waste waters could be expected due to the persistent mixing of the estuarine system with the adjoining neritic waters.

The present investigation was made in the summer in the last week of April 1955 during a period of minimal flow of water in the river. The salinity figures on the different parts of the estuary and the dominance of the marine forms of plankton flora in the entire estuarine system clearly pointed to remarkable penetration of the neritic waters into the estuary at the time of the study. This would guarantee sufficient dilution of the factory waste waters to render them harmless to fish life. During flood discharge in the river, the flow of water towards the river mouth would increase considerably regardless of the tidal movement and would effect a greater proportoin of the mixing and dilution of the effluents than in the summer. Thus it would be seen that the factory wastes would be considerably diluted in the Vellar estuary both during flood discharge and during minimal period of flow in the river. No mechanical or chemical treatment of the waste waters was therefore considered necessary in this case.

perches there was no important fishery. As the fishery was reported to be rich with major carps in years prior to the discharge of the effluents into the kalwa it was considered likely that the present adverse changes brought about by the effluents might have prevented the carps from ascending the kalwa from the Colair lake and thus reduced the fishery. Suggestions were made to the Assistant Director of Fisheries, Vijayawada, to take suitable steps for stopping the above pollution, if the loss of fisheries was considerable as reported.

Pollution of the Vellar Estuary.

By waste waters from the South India Starch Products Company, Limited, Porto Novo.—The South India Starch Products Company is situated on the banks of the Vellar estuary at Porto Novo within a distance of 1,000 yards from the mouth of the river and is engaged in the production of starch from tapioca obtained from the neighbouring villages where they are grown. The factory works for about nine months every year from September to May depending on the availability of roots. Daily about 3,000 thookus (12,000 lb.) of tapioca are processed in the factory and about 15 bags or 3,000 lb. of starch are manufactured. The starch produced by the factory is said to be used by the country's textile industry. The factory is reported to provide employment to about 200 people in Porto Novo.

The tapioca roots are first washed with water to free them from mud and dirt and when the roots are still wet the outer skin of the roots is pealed of by hand. The white roots are then put into a crushing machine which is fed with copious supply of water. The milky liquor from the crushers is macerated with water in a series of fine sieves to eliminate coarse materials and the milky filtrate containing fine starch in a suspended state is allowed to flow very slowly along parallel rows of narrow channels. The starch settles as a paste on the floor all along the channels, allowing opalescent supernatant liquid to fall into a common drain and form the waste waters. The waste waters flow along the drain by gravity to a distance of about 50 feet within the premises and then fall directly into the Vellar estuary behind the factory premises. The Vellar river makes its course within 20 feet from the factory limits and the river water touches the factory wall on some occasions during high tides. The total quantity of effluents discharging into the river daily amounts to about 5,000 gallons.

The effluents.—The effluents were examined on 27th April 1955 to ascertain its chemical quality and polluting capacity. The effluents were turbid and whitish in colour with a starchy odour and were acidic with a pH of 4·0. The acidity may be due to carbonic and other organic acids resulting from the putrefaction and fermentation of starch. The waste waters had total solids of

18,000 p.p.m. of which 10,050 p.p.m. were organic matter. Most of the organic matter was derived from the processing of tapioca into starch. The organic matter was also highly putrescible as indicated by the high figures of 1,764 p.p.m. ovygen absorbed in four hours. The B.O.D. (three days) of the effluents was as high as 5,000 p.p.m. and could have been due to the presence of complex, unstable, hydrolysed forms of starch products and due to the high ammoniacal nitrogen that increases bacteria. The free ammonia was nearly three times that of the albuminoid ammonia as is normally met with in crude sewage. The large amounts of free ammonia in the process waters was probably formed by microbiological action and enzymatic digestion of the nitrogenous gluten and proteins present in the tuber. The electrical conductivity of the effluents was greater than 3,000 reciprocal megohms as the water-supply for the factory is from a brakish water well within the factory premises.

Effect of effluents on river water and Biota.—The effect of discharging the untreated factory effluents into the Vellar river was investigated on 27th April 1955 by examination of the river water and plankton samples collected from opposite the effluent outfall, from a spot 100 yards above the point of discharge on the upstream side and from a place 100 yards below the effluent outfall on the downstream side. The effluents had the capacity to decrease the dissolved pH of the river water from 8·5 to 7·2 and reduce the dissolved oxygen content of the river water by 2·0 mg./1. They also increased the carbondioxide content, bicarbonates, organic matter and B.O.D. of the river water considerably. But this polluting effect was felt in the estuary only over a small zone near the effluent outfall as was evidenced by the river attaining the original values of pH, dissolved oxygen, and B.O.D. at a distance of 100 yards after admixture with the effluents. This may be due to the high degree of dilution of the effluents ensured in the estuary, by its proximity to the sea with which it is connected throughout the year. The dilution of the effluents in the estuary was also reflected in its plankton characteristics. In the first spot 100 yards above the point of discharge of effluents the phytoplankton was represented by Chlorophyceæ (*Pediastrum*), Bacillarieæ (*Cyclotella*, *Navicula sp* and *Coscinodiscus*), Myxophyceæ (*Microcystis sp.* *Oscillatoria* and *Cylindrospermum*) and Dinophyceæ (*Ceratium*). Opposite the effluent outfall there was more than 200 per cent increase in the Chlorophyceæ which is really dominant in heavily polluted streams. Chlorophyceæ was totally absent from the sample collected from 100 yards below the effluent outfall, and the diatoms increased both in species and in number indicating considerable dilution of the waste waters. The Zoo-plankton was very poor in the Vellar river and consisted of stray specimens of polychaete trocophore before admixture of the factory wastes. Nauplius, Copepods and trocophores were present in good numbers

V. STUDIES ON FISH DISEASES AND MORTALITIES.

A number of instances of fish diseases and large scale fish mortalities were investigated during the period of the scheme with a view to find out measures for curing the diseases and for preventing the recurrence of large scale mortalities.

1. *Fin Rot.*—Two cases of fin rot due to bacterial attack were examined. In the first case observed in 1946-47 carp fries kept in a glass aquarium were found to have their fins affected and gradually eaten off. The affected fins turned black and the fry had difficulty in the proper use of the fins for movement. All the affected fish were removed from the aquaria and a fresh batch of healthy fry was put in. From 8th or 9th day signs of infection were evident. Examination of the portions of the affected fins showed that numerous minute bacteria executing a spiral movement were crowded between the fin-rays, particularly in the areas that had become reddish in appearance. In 4 or 5 days, the outer portion of the fins began to be eaten off, leaving the chromatophores to accumulate, giving rise to the black appearance of the fins. The caudal fin was almost invariably affected first and then the dorsal, followed by the ventrals and anal respectively. The fin rot was found to be due to bacterial infection and was characterized by the early reddish and later black colour of the infected fin. The exact identification of the bacterium could not be made. A dilute permanganate bath for a couple of minutes was an effective remedy and the treated fish soon regenerated the fins.

In the second instance examined in March 1949 a large size gourami was the victim and it had its fins badly disintegrated. The fins were cleaned with a cotton swab soaked in 2 per cent $KMnO_4$ solution and the fish was given a bath for one minute in 1 per cent $KMnO_4$ solution. The treatment was repeated daily for a week when the fins were regenerated.

2. *Ulcers.*—Four adult Gourami in February 1949 and two Gourami in April 1949 were found to have developed a large number of ulcers on their body. Each ulcer was roughly circular, 1cm. in diameter and reddish in colour. The scales were falling off when touched. The disease was apparently due to a bacterial infection of the surface of the body. Each ulcer was swabbed with 2 per cent solution of KMno 4 for 1 or 2 minutes and the treatment was repeated for 12 days till the ulcers healed up.

3. *Fungus attack.*—A pair of young Gourami kept in an aquarium were found infested with fungus (*Saprolegnia sp*) in February 1949. The fungus appeared as tufts of white threads on the sides of the fishes. The fungal filaments were carefully scrapped

from the body of the fishes by a sharp scalpel and the fishes dipped for a minute in 2 per cent salt solution. The treatment was repeated for three days after which the fishes became healthy.

4. "*Cholera*" *in gold fish.*—A gold fish kept in an aquarium of the station for more than two years died suddenly on 23rd March 1950. The fish was observed to be not behaving well prior to its death, showing signs of distress. It used to remain motionless on the bottom of the aquarium and to make sudden darts now and then only to come to rest again with extreme suddenness. Externally the dead fish looked very healthy and showed no signs of fungus or parasitic growth. But there was a deep greenish blue tinge on the lateral side near the right pectoral fin. The body wall at the site of this staining showed necrosis, the skin being very thin. On opening the body of the fish, the respiratory system was found to be normal. But the abdominal contents (the whole of the intestine) was found to be in a putrefying stage. The liver and bile ducts were found to be affected also, leading to rupture and consequent staining of the abdominal wall. The body cavity was filled with the greenish bile fluid. The necrosis had spread to the body wall lining the body cavity. The cause of death must be due to some organism that must have been present in the medium and that must have entered the digestive tract of the fish while feeding. The pathology of the disease appeared to be similar to that of cholera in human beings.

5. *Parasites*—(*a*) *Lernaeid parasites.*—Widespread infection by learnaeid parasites were observed on two occasions once in August-September 1946 in the Chetput Fish Farm ponds and the second time in July-August 1949 in the Poondi Fish Farm. On the first occasion the water level was going down in all the ponds and the parasites were prevalent in several species of fish. Mechanical removal of the parasites and a two-minute permanganate bath were very effective.

In the second case, only the Gourami population was affected even though other fishes such as *Cirrhina cirrhosa, Labeo rohita, L. fimbriatus, Barbus carnaticus* and *Catla catla* were present in the same pond. An examination of the conditions that favoured the incidence showed that the water in the pond was stagnating since January 1949 and was favouring the multiplication of the parasites whose copepodid stages had good chances to find hosts among the large number of fishes crowded in the pond. Among the various fishes in the pond, Gourami was in a very weak condition and this probably accounted for this species becoming the permanent host of the female lernaeid. Besides mechanical removal of the parasite with forceps and the treatment of each fish with one per cent Condi's fluid and two per cent salt solution, the following remedial measures adopted resulted in the complete

The bottom sediment from the pond was dark brown in colour and oozy in consistency. On treatment with dilute acid it gave quantities of sulphuretted hydrogen. Observations on the physico-chemical conditions of the water and the condition of the fish were made at 4-hourly intervals for the next 24 hours. During the early morning hours there was a sudden depletion of dissolved oxygen on the days of the distress. This has been brought about by some agency other than the respiratory activity of the planktonic bloom. The meteorological conditions prior to the day of fish distress were helpful to cause thermal stratification and prevented the daily turnover. Under these conditions the oxygen in the deeper layers of water would soon be depleted and anaerobic conditions would prevail. As the bottom ooze consists of plenty of dark ferrous sulphide, the prevailing conditions would facilitate sulphate reduction and as a result sulphuretted hydrogen would be formed. At the bottom layers therefore not only was the dissolved oxygen completely denuded but poisonous gases were also being evolved and accumulated. As long as the thermal stratification continued, the fish could resort to the surface layers which were daily being surcharged with oxygen. On the day prior to the occurrence of mortality, there were some sudden showers of rain resulting in a sudden cooling and consequent turnover. As the bottom layers were practically anaerobic, with this sudden turnover, the available oxygen was distributed throughout the different layers with the result that there was a general depletion of the life-giving gas. This happened during the early morning hours when the signs of distress manifested in the fish. When the photosynthetic activity commenced again with the rising sun, the oxygen content of the water increased and the fish had revived and gone down, and there were no untoward signs in the pond except that by noon several of the fish that succumbed to the distress began to float on the surface upside down.

Summer stagnation, sultry weather and the attendant meteorological conditions, sudden showers and the nature of the bottom ooze combined to create inimical conditions which resulted in the lethal depletion of oxygen that was directly responsible for the distress and mortality.

(b) *Public Health Fish Nurseries, Ennore.*—A case of persistent mortality of Gambusia at Ennore was investigated. The fish were thriving normally in a large breeding tank while in an adjacent chain of small nurseries, they died soon after introduction. Water in the nurseries was crystal clear and biotal life was very poor. Analyses of samples of water from the nurseries and the breeding tank showed entirely different sets of conditions. While the water in the main pond was definitely alkaline with a pH of 9·0, those in the nurseries were highly acidic with a low pH of 2·1—2·8 probably due to the presence of a free mineral acid

derived from some natural springs in the nurseries. The free acid probably reacted on the gill membranes and interfered with breathing and resulted in mortality.

Another instance of alleged mortality of Gambusia in the Public Health Tank at Ennore was investigated in October 1948 and it was found that there was no mortality as such but only a reduction in the fish population. The fishes were healthy and the hydrobiological conditions of the tank normal. The reduction of the Gambusia population was traced to the predatory habits of the frogs *Rana hexadactyla* which were present in large numbers. The Public Health Inspector was advised to eradicate the frogs.

(c) *Poondi Reservoir.*—A large scale mortality of fish was observed on 10th February 1949 in the Poondi Reservoir, which impounds the flood waters of the Kortalayar river for augmenting the water supply of the Madras City. The reservoir has a total storage capacity of 2,600 million cubic feet and a waterspread of 12·6 square miles at full tank level. Since 1945, it is being utilized by the Fisheries Department for fish production. In addition to local fishes, non-indigenous species such as *Catla catla*, *Labeo rohita*, *Cirrhina mrigala*, *Labeo calbasu*, *Chanos chanos*, *Mugil cephalus*, *Etroplus suratensis* and *Osphronemus gouramy* are stocked and conserved, and their fisheries exploited by a judicious system of licensing and departmental fishing. During the hot weather period of March to June 1948, a fishery weighing 136 tons and worth about Rs. 40,000 was harvested. The growth attained by some of the introduced species in 1948 was considerable ranging from 8·9 inches in the case of *C. mrigala*. But, unfortunately due to failure of the north-east monsoon rains during the years 1947 and, 1948 the level of waters in the Red Hills lake became so low that the Public Works Department had to deplete the waters of the Poondi Reservoir in order to replenish it so as to meet the city water supply. But the way this depletion was accomplished appeared to be mainly responsible for the large scale mortality. At 6 p.m. on 5th February 1949, when the depletion started, the level in the reservoir was 119·7 feet. On the 7th at 12 noon, it was 115·0 feet; and on the 8th at 6 a.m. 110·0 feet. Then the weep holes in the baffle wall at the rear of the regulator were opened and water allowed to flow out suddenly so that on the 11th morning there were only two small muddy puddles close to the regulators. From 9th onwards fishes showed acute signs of distress and they gasped at the surface and a few dead ones were seen floating about. One thousand and eight hundred pounds of them were caught inside and outside the baffle wall until 1-30 p.m. with cast nets and small bag nets. Catches consisted mostly of big dead fish that had settled at the bottom. About one ton were thus obtained and sent immediately to Madras in a specially chartered motor van. Collection of the dead fish continued until

control of the incidence: (1) Letting in of fresh water from the reservoir into the pond, (2) plenty of macrovegetation in the pond to serve as food for Gourami and (3) removal of other species of fishes from the pond.

(*b*) Several fry of *Rasbora* kept in an aquarium were found to have developed certain smooth light yellow prominences, particularly near the caudal portion of the body. There was obvious difficulty in the proper use of the caudal fin. There were no lesions. The contents of the tumorlike growth were examined. There was a pale liquid which contained numerous minute, pear shaped, apparently non-motile bodies, each with two oval structures, like the pyrenoids of plant cells. In a pond at Eriyad about 10 per cent of the *Rasbora* fry were found to be similarly infected. The infection was not confined to the tail portion. The infected fry were easily caught because of their less vigorous movements. The exact identification of the parasite was not possible.

(*c*) *Occurrence of metacercaria of Euclinostomum indicum*, Bhalerao, in *Notopterus notopterus* (*Pallas*).—Two specimens of *Notopterus* captured on 23rd August and on 13th September 1949 from the Tungabhadra river near the new hydro-electric project had several swellings on the body. On the first specimen, measuring 19·5 c.m. in length, there were 12 swellings particularly under the chin, and at the base of the pectoral and dorsal fins. The swellings averaged 1 c.m. in diameter. The scales over these swellings were carefully removed, and latter were punctured. From each swelling an encysted fluke was scooped out. On peeling off the coverings of the cysts, immature *Euclinostomum indicum* (kindly identified by Dr. G. S. Thapar) wriggled out. The fish was kept under observation in an aquarium; but after six weeks it died, though it gained about 1.5 cm. in length. The other specimen 25 cm. in length had four swellings on the caudal peduncle and at the base of the anal fin. On dissection these swellings also revealed the presence of metacercaria of *Euclinostomum indicum*.

Each worm was thick and fleshy and oval in shape. They measured about 10 mm. in length. The oral sucker was terminal and about 0·4 mm. in diameter. The prepharynx was small; and the œsophagus was very short. The intestinal caeca passed up to the posterior end of the body. Each caecum had eight branches externally, of which the fifth divides into two small sub-branches distally. The ventral sucker was situated in the second—fifth at the posterior end of the body. The excretory bladder was small and gave out two lateral branches which ramified profusely in the body.

Adults of *Euclinostomum* usually occur in the buccal cavity, pharynx and œsophagus of aquatic birds like the heron, bittern, cormorant and herring gull. The first intermediary host is the snail.

6. *Fish mortalities*—(*a*) *Chetput ponds*.—During the first week of May, an interesting case of fish disease and mortality was observed in Farm Pond I. During April, the pond water was bottle green in colour due to a thick bloom of *Anabaenopsis*. On the day previous to the mortality, there were a few showers. Signs of distress were manifest during the early morning hours and with the rising sun the fish gradually revived. Several species of fish like *Glossogobius giuris*, *Etroplus suratensis*, *E. maculatus*, *Barbus* sp., *Cyprinus carpio*, *Catla*, *Ambassis*, *Rasbora*, *Danio*, etc., were affected. The affected fish came to the margin or surface and were gasping for breath, but they revived when put in water from another pond. Air breathers like Gourami and murrels were not affected. The prevailing hydrological conditions were analysed and the condition of fish during night closely observed. It was found that during day time the surface water got surcharged with oxygen due to the photosynthetic activity of the algae. Though this had been the case ever since the algal bloom appeared in the pond, during the night prior to the fish distress there was a sudden depletion of the dissolved oxygen. Fish began to show distress by 2 a.m. in the morning. Dissolved oxygen was at its lowest at this time. Quantity of dissolved oxygen increased in the morning and the fish gradually revived.

It is obvious from the foregoing data that the immediate cause for the distress was lack of sufficient dissolved oxygen in the water. As will be shown in the subsequent section, the sudden depletion of oxygen is accountable to the prevailing meteorological conditions which aided thermal stratification and led to the creation of anaerobic conditions near the pond bottom and the subsequent formation of poisonous gases like sulphuretted hydrogen.

A similar but more serious case of distress and mortality was studied in Pond IV on 19th August 1946. Conditions of existence prior to and during the mortality were similar to the case in Pond I. The algal bloom in the present case was formed of *Microcystis* and *Oscillatoria*. The bloom had been in existence in the pond for the past six or eight weeks. Several specimens of *Etroplus suratensis* and *Cirrhina sp*. were already dead by 6-30 a.m., while specimens of *Cirrhina mrigala*, *Catla catla*, *Labeo rohita*, *L. fimbriatus*, *L. calbasu*, *mullets*, *Barbus dorsalis*, *Glossogobius giuris*, etc., were experiencing acute distress. Analysis of a sample of water taken at 6-30 a.m. revealed that dissolved oxygen was practically nil. Air breathers in the pond like murrels and tarpon were not affected.

3 p.m. by sweeping the water surface with a net from a coracle. On the whole a poor harvest of only 8,800 pounds could be made as most of the fish died suddenly and putrified. Post-mortem examination revealed that the gills and gullets of the dead fish were choked with mud, filaments of *Oscillatoria*, and diatom frustules which were present in the hyptoplankton of the reservoir. The number of species that suffered this extensive mortality was over forty. The hydrobiological conditions were as follows :—

TABLE 8.

(Results expressed in parts per 100,000.)

Particulars. (1)	Before depletion. (2)	After depletion. (3)
Date	30th January 1949.	10th February 1949.
Turbidity (cm.)	24·0	15·0
Colour	Yellowish green.	Dirty green.
Temperature (degree C).	26·6	28·6
Free CO_2	Nil.	0·2112
CO_3	4·379	Nil.
HCO_3	17·526	37·198
pH	8·6	7·9
Dissolved O (cc 1) ..	2·583	Nil.
Per cent saturation ..	42·9	..
Chloride	6·00	10·00
Phosphate (P)	Nil.	0·1363
Nitrates (NO_3N) ..	Nil.	Nil.
Silicates (Sio_2)	1·316	1·744

The phytoplankton mainly consisted of three species *Oscillatoria* one of *Microcystis*, one of *Euglena* and one of the diatom Nitzschia. After the sudden depletion, it became muddy and contained a large amount of carbon-dioxide, but little or no oxygen. The sediments at the bottom were almost knee deep; their disturbance by the fishermen had rendered the water very turbid, thus choking the gills and gullets of the fishes and reducing the oxygen content to the lethal limit. This heavy mortality could have been prevented if the Public Works Department had given sufficient notice to the fisheries staff and if the water had been let out gradually.

(d) *Nagasuni tank, Sankaranainarkoil, Tirunelveli district.*—The Nagasuni tank of the Sankaranainar temple in Tirunelveli district has a waterspread of 2,450 square yards and an average depth of 10 feet. Its water was once baled out in 1945, and was found on examination in March 1946 to be favourable for fish culture (Table 9). The tank was taken over by the Madras Fisheries Department in April 1948 and stocked with 500 fingerlings of *Labeo fimbriatus* and *Cirrhina reba* in November 1948 and with 840 *Etroplus suratensis* in the beginning of February 1949. The plankton

of the water and the filamentous algal growth on the sides of the tank were rich and varied and consisted of the following :—

Myxophyceae : *Anabaena*, *Aphanocapsa*, *Microcystis*, *Oscillatoria* and *Spirulina*.

Chlorophyceae : *Ankistrodesmus*, *Chaetophora*, *Closterium*, *Crucigenia*, *Euastrum*, *Gonatozygon*, *Oedogonium*, *Pandorina*, *Pediastrum*, *Selenastrum*.

Bacillariceae : *Mastogloia*, *Melosira*, *Nitzschia* and *Synedra*.

Protozoa : *Chilomonas*, *Chlamydomonas*, *Euglena*, *Phacus* and *Epistylis*.

Rotifera : *Brachionus*, *Diurella*, *Philodina* and *Salpina*.

Copepoda : *Diaptomus* and *Mesocyclops*.

On 12th February 1949, about 100 fish were found floating dead in the tank; and thereafter 10 to 15 fish were found to die and float daily. Towards the end of February 1949, the water in the tank became black in colour and began to stink badly. By April, the colour of the surface water became dark green due to a thick bloom of *Microcystis aeruginosa*, but the botton layer was almost colourless containing few specimens of the alga. The hydrological conditions of the tank both at the surface and bottom at 11-45 a.m. on 28th April 1949 are given in Table 9.

TABLE 9.—*Showing hydrological conditions in the Nagasuni tank on 21st March 1946 and 28th April 1949.*

21st March 1946.			28th April 1949.	
			Surface.	Bottom.
7-25 a.m.	3-40 p.m.	Conditions.		
Green. (1)	Green. (2)	Colour. (3)	Dark green. (4)	Colourless. (5)
17·5	9·3	Transparency cm. ..	5·0	30·
27·2	32·0	Temperature Degree C.	3·38	27·9
7·1	8·9	pH.	7·9	7·1
0·88	7·64	Dissolved oxygen. cc/ litre.	0·98	Nil.
0·36	Nil.	Free CO_2 p.p. 100,000 ..	0·234	0·796
Nil.	1·5	Carbonates p.p. 100,000.	Nil.	Nil.
13·12	16·7	Bicarbonates, p.p. 100,000.	13·25	16·54
6·8	8·8	Cholorides as cl. p.p. 100,000.	18·0	18·0
...	..	Silicates as Sio_2. p.p. 100,000.	0·77	0·33
0·006	..	Phosphates as P_2O_5. p.p. 100,000.	0·16	0·18
..	..	O_2 absorbed in 30 minitues at 100 Degree C. p.p. 100,000.	5·03	4·73
Nil.	Nil.	Nitrates as N. p.p. 100,000.	Nil.	Nil.

Abnormal or pathological conditions could not be noted in the dead fish. But from the above table it could be seen that the oxygen content of the surface sample was low and that the bottom sample was practically free of oxygen. The low oxygen content was due to the excessive rotting of the alga, which formed a coalesced slimy mass covering almost the entire water surface. There was a pronounced thermal stratification, as indicated by the high difference of 5·9° C. in temperature between the surface and bottom layers. Sulphuretted hydrogen was present in the bottom layer alone. But the water was frequently stirred from top to bottom by thousands of worshippers bathing in the tank; and this mixing of the hydrogen-sulphide-containing-bottom-layer with the surface water would deplete the small amount of oxygen contained in the surface layer and thus bring about fish mortality. The formation of hydrogen-sulphide was due to the decomposition of excessive amount of organic matter under anaerobic conditions at the bottom. The excessive amount of organic matter was to be traced to heavy organic pollution and to throwing into the tank by the worshippers of large quantities of jaggery which is easily decomposed by the common saprophytic bacteria. Every last Friday in a month several devotees assemble to worship the deity and each of them throws into the tank approximately 0·3 lb. of salt and 1 lb. of jaggery. Further, during the Tamil months of Thai (January-February) and Adi (July-August) more than 50,000 people are reported to assemble in the temple and dissolve large amounts of jaggery in the tank.

Laboratory experiments have also shown that one per cent concentration of jaggery was sufficient to kill young fishes in about 8 days, the addition of jaggery decreasing the dissolved oxygen and pH and increasing free CO_2 and bicarbonates of the water. Similar chemical effects produced by the cane sugar factory effluents from the Vuyyur Factory and their harmfulness to the fish fauna of the Chandriya kalwa in Krishna district have already been noted elsewhere in this report.

(*e*) *Fort Moat, Vellore.*—On 27th September 1949, the Inspector of Fisheries, Vellore, reported that several large-sized *Catla* (12 to 24 inches in length) were seen floating in one out of four sections of the Fort Moat Farm at Vellore since the 23rd of the month, and wanted the case to be investigated. All the dead fish were seen in a highly decayed condition, and examination of the external appearance and internal organs failed to give any satisfactory clue. So, in order to find out whether any hydrological factor was responsible for the mortality, samples of water were collected from the surface, middle and bottom layers of water at six-hourly intervals for 24 hours on 28th and 29th September, from (Section A) of the farm where the mortality happened and also from the adjoining section (Section B) where there was no fish mortality, for purposes of comparison.

Section A of the farm was about 2,500 feet in length, 3 feet in width and 15 feet in depth. Its water was dark green colour, highly turbid, and contained an abundance of the blue-gre alga, *Microcystis sp.* (80,000 per cc.). The rotifer *Brachionus* was the dominant zooplanktonic organism. Section B where mortality occurred was about 1,600 feet in length, 200 feet in wid and 10 feet in depth. Its water was light green with the presen of the same species of alga, but was more transparent as the al was fewer in number (about 5,000 per cc.).

The clue to the mortality in Section A was given by th oxygen content at 6 a.m. Comparing the oxygen relations in th two sections, it would be seen that the difference in amount was n the same from the surface to the bottom. Also the amount wa found to vary in the two cases. The difference in the quantity oxygen in each of the two sections at 6 a.m. was very significan The quantity in Section A was only 0·4 mg/l or nearly a third the amount found in Section B. It would therefore appear tha on a particular day preceding the mortality, the photosynthet activities of the algae were very low probably on account of cloud weather, with the result that only a small amount of oxygen wa manufactured during day time on that date, which, was perhaps almost entirely consumed by the plants, animals and bottom depo sits during the night in Section A, leaving very little for the fishe to breathe in the early morning hours. So, all the fishes should have died at that time and sunk to the bottom.

But all the fishes stocked in Section A did not die. Large-sized *Catla* alone died, which was rather significant. Other fishes such as *Mirror carp*, *Labeos*, *White carp*, *Mullet* and *Milk Fish* which were considerably smaller in size (about 6 inches) did not die. The explanation for this strange phenomenon had to be sought for in the fact that the minimum oxygen requirements seem to vary with individual species and size of fishes. Therefore, the death of large-sized Catla (12—24 inches) alone in Section A appeared to have been due to insufficient oxygen content for its sustenance in the early morning hours a few days prior to 23rd September 1949. Other fishes in the pond found the amount tolerably sufficient for their existence and so did not die

(*f*) *Virudhunagar quarry pools.*—On the outskirts of Virudhunagar Town, Madras State, are three quarry pools used by the Fisheries department for rearing fish. These pits are big and deep enough to be perennial. Pool No. 1 locally known as Pallivasal Quarry pool has a waterspread of about 1·3 acres. The Government-owned (known as Porambokes) pools Nos. 2 and 3 are 0·3 and 0·4 acres in area respectively, with depths ranging from 6 to 18 feet.

TABLE 10.—*Showing particulars of fish stocked in the Quarry Fish Farm.*

Month of stocking.	Kind of fish.	Size in inches.	Number stocked.		
			Pool 1.	Pool 2.	Pool 3.
(1)	(2)	(3)	(4)	(5)	(6)
May 1950	*Chanos chanos*	1-2	5,240	..	..
May 1950	*Etroplus suratensis*	1-3	..	25	..
June 1950	*Chanos chanos*	1-2	..	7,200	..
July 1950	*Etroplus suratensis*	1-3	..	540	..
August 1950	*Etroplus suratensis*	1-2	14	..	200
	Gouramí	12-13½	2	..	..
September 1950	*Cyprinus carpio*	2-3	450	..	..
November 1950	*Labeo fimbriatus*	1½-3½	1,824	245	168
	Cirrhina cirrhosa	3-3½	848	210	..
December 1950	*Cirrhina cirrhosa*	3-3½	152	..	..
	Labeo fimbriatus	1½-3½	1,181	..	..
January 1951	*Labeo fimbriatus*	1½-3½	6,287	6,226	3,152
June 1951	*Chanos chanos*	1-2	..	..	13,628
July 1951	*Chanos chanos*	1-2	..	..	59
December 1951	*Labeo fimbriatus*	1½-3½	..	..	850
May 1952	*Chanos chanos*	1-2	..	2,500	..
June 1952	*Chanos chanos*	1-2	..	7,200	..
October 1952	*Labeo fimbriatus*	1½-3½	..	13	..
	Cirrhina cirrhosa	3-3½	..	85	..
November 1952	*Labeo fimbriatus*	1-2	..	410	..
December 1952	*Cirrhina cirrhosa*	3-4	..	3,986	28,881
January 1953	*Cirrhina cirrhosa*	3-4	..	920	822

The steep sides of the pools do not support vegetation. But macrophytes like *Chara zeylanica* were present in Pool No. 1 and *Typha elephantina* occurred in the other two. The fishes present in the pools were *Barbus chrysoporna*, *B. melanostigma* and *Gambusia affinis*; but since 1950 *Chanos chanos*, *Etroplus suratensis*, *Labeo fimbriatus* and *Cirrhina cirrhosa* have been stocked as shown in Table 10. Trial nettings on 1st August 1951 showed that introduced species thrive and grow satisfactorily. But the total production of fish in 1950-1951 in all the three pools was only 365 lb. due to loss of fish by periodical natural mortality.

TABLE II—*Showing hydro-biological conditions of the Virudhunagar quarry fish on 19th July 1950.*

Condition.	Pool number 2.		Pool number 3.	
	Surface.	Bottom.	Surface.	Bottom.
(1)	(4)	(6)	(8)	(9)
Time	10-30 a.m.	10-47 a.m.	11-6 a.m.	11-15 a.m.
Colour of water	Light green.	Light green.	Dark green.	green.
Temperature Degree C.	29·4	26·6	27·3	26·0
Turbidity, cm.	9·5	8·5	100	100
Dissolved Oxygen mg/litre	0·49	Nil.	0·14	1·12
Dissolved Oxygen % Saturation	8·2	Nil.	2·4	18·8
Free CO_2 p.p.m.	Nil.	Nil.	Nil.	Nil.
Carbonates	4·26	4·26	6·08	6·48
Bicarbonates	63·08	66·79	17·32	17·32
Chlorides as Cl	22·0	19·0	47·0	47·0
pH.	9·2	9·2	9·3	9·2
Silicates as SiO_2	1·4	1·64	1·76	1·82
Nitrates as N	Nil.	Nil.	Nil.	Nil.
Phosphates as P_2O_5	0·05	0·052	Trace.	Trace.
Macrophytic Vegetation	*Typha elephantina*	.. ..	*Typha elephantina*.	
Invertebrate macrofauna	Water bugs.		Water bugs.	
Fish food	*Microcystis* in bloom. Rotifers; (*Brachionus* and *Notholca*)—rare.		*Microcystis* in bloom. Daphnids—rare; Copepods—rare; Nauplius —rare; —*Cypris*—rare.	

Fish mortality in Pool No. 1.—On the morning of 5th July 1950 about 150 *Chanos chanos* (8 inches long) and a number of *Gambusia affinis* and *Barbus spp.* were found floating dead and the mortality continued thereafter of a few fish daily for about a week. The hydrological conditions of the three pools on 19th July 1950 are shown in Table II. Pool No. 1 differed from the others in (*a*) having higher content of dissolved oxygen, (*b*) lower pH and (*c*) dominance of zoo-plankton. The higher oxygen content might have been due to the photosynthetic activity of the thick growth the macrophytic vegetation. The low pH and the abundance zoo-plankton were probably due to the death and decay of the excessive plant organisms. From 1st to 4th July it had been cloudy with slight drizzling on 4th evening restricting photosynthetic activity on those days. The metabolic activities of the animal and plant communities in the pool must have also contributed to the exhaustion of almost all the dissolved oxygen in the water on the night of 4th July 1950, and to the suffocation and death of *Chanos chanos* during the early morning hours of 5th July 1950. The decay of plants might have also contributed to the early depletion of oxygen.

Fish mortality in Pool No. 3.—In this pool 220 *Chanos chanos* and 25 *Etroplus suratensis* were floating dead on 12th August 1950 followed by 22 more Chanos on the following day. The fishes were already in an advance stage of decay, indicating that mortality had taken place a few days earlier. Surface and bottom samples of water from the pool (Pool No. 3) and in Pool No. 1 where there was no fish mortality collected at different hours on the 14th and 15th August 1950 were examined for their hydrological conditions. The difference between the two pools are tabulated below :—

Pool No. 3.	Pool No. 1.
(*a*) There was a strong thermal stratification by day and an absence of "turnover" by night as indicated by (i) a difference in temperature as high as 4·6°C. at 4 p.m. on 14th and 4·3°C. at 12 noon on the 15th between the surface and bottom layers throughout the day time; (ii) persistence of this difference even at 6 a.m. when homothermal conditions are usually observed; (iii) prevalence of almost uniform bottom temperature during day and night; and (iv) supersaturation of surface	There was thermal stratification by day time, the maximum differences by day between the surface and bottom being 2·1° on 14th August; these differences being much lower than those recorded for pool No. 3, in spite of the fact the Pool No. 1 is deeper. There was a "turnover" by night as indicated by the almost homothermal conditions prevailing from 10 p.m. of August 15th and by the uniform oxygen distribution during the early

(g) *Tirur Rice Research Station, pond, Tirur, Chingleput district.*—Twelve gouramies were being reared in a small pond 20 by 20 by 3 feet, in the premises of the Rice Research Station Tirur. The fish were observed to be in distress and to gasp for breath in the early hours of 3rd November 1950; and seven of them died within a short interval. The remaining fish were rescued and placed in an irrigation well, in which they were thriving well. On an investigation it was found that the pond was choked with an overgrowth of vegetation like *Hydrilla, Chara, Typha* and *Nymphaea*, giving little or no moving space for the fish. The vegetation was also in a decaying condition over part of the pond. The bottom was black in colour due to putrifying organic matter. During the two days prior to the mortality, the sky was overcast with intermittent rain without any sunshine. It was evident that the environmental and meteorological conditions, causing the reduction of the oxygen content of the water due to suspension of photosynthetic activities of the plants was directly responsible for this mortality.

(h) *Large scale mortality of Etroplus suratensis in Nileshwar and Coondapur.*—Large numbers of fries and fingerlings of *Etroplus suratensis* are collected every year from the Nileshwar estuary and Coondapoor backwaters in South Kanara district for stocking the inland waters in that district. In November 1951, mortality up to 70 per cent was noticed in the catches kept in the condition boxes prior to distribution. From a study of the collection and distribution operations and from an analysis of the hydrological conditions, it was found that the mortality was due to careless handling during collection and over crowding in the condition boxes. Necessary instructions were given to the staff concerned to avoid such large scale mortalities.

(j) A curious case of a specimen of Rohu in the farm pond was investigated. By 9 a.m. on 7th October 1946 the fish, 24 inches long and weighing 6·75 pounds was found lying dead in the pond. Closer examination showed that a specimen of catfish *Mystus vittatus* was stuck up in the mouth of the Rohu, the head and pectoral region of the catfish being inside the mouth.

The condition of the gills showed that both the fish had not been dead for long. With the catfish stuck up in its mouth the Rohu was apparently not able to close and open its mouth for respiratory movements and would have died of asphyxiation. Catfish spines have been reported to be poisonous also.

APPENDIX.

TABLE No. I.

Season and depth	pH. 8 p.m.	pH. 2 a.m.	pH. 8 a.m.	pH. 2 p.m.	Dissolved oxygen p.p.m. 8 p.m.	Dissolved oxygen p.p.m. 2 p.m.	Dissolved oxygen p.p.m. 8 p.m.	Dissolved oxygen p.p.m. 2 a.m.	Dissolved oxygen p.p.m. 8 a.m.	Dissolved oxygen p.p.m. 2 p.m.	Dissolved oxygen p.p.m. 8 p.m.
Summer—											
Surface		7·2	7·0		7·3		5·4	3·0		4·0	2·9
2m.		7·0	7·0		7·1		0·57	0·71		8·0	1·0
4m.		6·7	7·0		7·1		Nil.	Nil.		Nil.	Nil.
6m.		6·8	7·1		7·0		Nil.	Nil.		Nil.	Nil.
8m.		6·8	7·3		7·3		Nil.	Nil.		Nil.	Nil.
Winter—											
Surface		7·1	7·2	7·2	7·2		8·8	5·4	5·2	5·5	
2m.		7·2	7·0	7·0	7·0		4·7	4·6	2·8	5·7	
4m.		7·3	6·9	6·9	6·9		0·5	0·1	0·1	0·1	
6m.		6·8	6·8	6·9	8·6		Nil.	0·1	0·1	0·5	
8m.		6·8	6·8	6·9	6·8		Nil.	0·1	0·1	0·1	

Season and depth	Temperature in °C. 8 p.m.	2 a.m.	8 a.m.	2 p.m.	8 p.m.	2 p.m.	8 p.m.	2 a.m.	8 a.m.	2 p.m.	8 p.m.
Summer—											
Surface		22·2	22·9		29·4	22·8					
2m.		19·5	20·5		21·6	21·6					
4m.		19·5	20·0		20·0	19·8					
6m.		19·1	19·2		19·4	18·1					
8m.		18·5	17·9		18·2	19·2					
Winter—											
Surface		18·4	17·6	18·0	20·4					7·1	
2m.		18·3	17·9	17·0	19·3					7·1	
4m.		18·0	16·5	16·8	17·8					6·8	
6m.		17·8	16·2	16·4	17·4					6·8	
8m.		17·	16·2	16·2	17·0					6·8	

Pool No. 3.	Pool No. 1.
layer continued to have a very low content or oxygen throughout the day and night.	morning hours of 15th August. The oxygen content of the bottom layer was high and was four to eight times the amount of oxygen contained in Pool No. 3.
(*b*) The oxygen content of the bottom layer was low and varied from 0·6 to 1·2 p.m.	
(*c*) There was an abundance of Microcystis and rotifers in the plankton. The photosynthetic activity of the blue-green alga Microcystis was responsible for the high oxygen content in the surface layers during day time. The respiratory activities of this alga and the rotifers which were next in the order of abundance were also responsible for the low content of oxygen in the surface layers during the night.	The phytoplankton was poor, and rotifers were not so abundant as in Pool No. 3. So, the amount of oxygen produced by day and consumed by night were also comparatively lower.

Thus the conditions were entirely different in the two pools. Where there was no turnover by night, fish mortality had taken place. It would appear that there had been no turnover for several nights prior to the mortality on 12th August 1950 resulting in the formation of a gradually increasing oxygen deficient zone at the bottom especially during the night and of a very narrow upper zone with a moderate oxygen content, which was not sufficient to accommodate all the 8,000 and odd *Chanos chanos* and *Etroplus suratensis* stocked in the pool. Hence the mortality of a few hundred of fish.

The third instance of fish mortality was also observed in Pool No. 3. All the fish stocked were in distress, gasping for breath near the surface during the early hours of each day from 12th July 1952 onwards, and some of them even died. As the death of fish continued throughout the period, July to January, mortality could not be attributed to high temperatures alone. In the course of the investigations of the cause of this mortality between 4th and 8th February 1953 a few *Cirrhina cirrhosa* also died, a post-mortem examination of which failed to give any satisfactory clue for their death. The thermal and oxygen conditions at different times of the day on the 5th and 6th February 1953 clearly showed that while there was a turnover by night in Pool No. 2 there was none in Pool

No. 3. Further, the blue-green alga, *Microcystis* was very abundant (as much as 13,550 individuals per ml. at 12 noon on 5th February 1953) in Pool No. 3, whereas Pool No. 2 supported only a moderate amount of this algae (about 3,125 per ml. at 12 noon on 5th February 1953). As already indicated, the presence of large number of organisms in Pool No. 3 might have disturbed the biological balance in the pond, depleting on occasions almost all the contained oxygen, thereby causing the fish mortality. The rotting of the excessive algae might have also hastened the depletion of oxygen.

The three instances of fish mortality in the Virudhunagar Quarry Fish Farm show how a disturbance in the biological balance of a pool maintained by photosynthesis, respiration and bacterial decomposition, the three vital manifestations of the life processes in water, can lead to disastrous consequences. In Pool No. 1 overgrown with the macrophyte, *Chara zeylancia* and in Pool No. 3 with the blue green algae *Microcystis*, in great abundance, respiration and decomposition made deep inroads on the oxygen content of the water causing the death of the fish already referred to. The oxygen produced by chlorophyl-bearing plants during the day-time is not always sufficient to meet the demands of aerobic and anaerobic respiration. On a cloudy day when photosynthesis is limited, considerable oxygen deficiency may result overnight causing the death of fish as in Pool No. 1. In Pool No. 3 with an excessive growth of green plants, all the oxygen produced by day may be exhausted at night by respiration even during a bright season. On such occasions fishes generally die at night or during the early morning. In the presence of a pronounced thermal stratification and absence of turnover in the pond, oxygen depression may increase the incidence or mortality. The plants at the surface extract dissolved substances from sclution in the surface layers which cannot receive much replenishment from below on account of the thermal stratification. Following exhaustion of this food supply, the plants decay reducing the oxygen at the surface even faster than it is absorbed by the air.

From the above it is evident that a heavy growth of algae and macro-phytes in a fish pond is not only undesirable, but definitely harmful if their growth is not kept under strict control. There are many methods in vogue to eradicate excessive aquatic vegetation. Srinivasan and Chacko (1952) who have reviewed them, found that Dicotox (an ethyl ester of 2, 4-D) was successful in killing weeds like *Hydrilla verticillata* and *Vallisneria spiralis*. The decaying algae that float as a scum on the surface of the ponds should be removed periodically by dragging with a piece of cloth or net so as to prevent rapid exhaustion of oxygen by their bacterial decomposition.

TABLE No. IV.

Season and depth.	Temperature ° C.				pH.			
	2 p.m.	8 p.m.	2 a.m.	8 a.m.	2 p.m.	8 p.m.	2 a.m.	8 a.m.
June 1952—								
Surface ..	21·6	21·2	20·8	21·1	21·6	7·0	7·1	7·1
2m. ..	20·8	20·6	20·6	20·9	21·2	6·3	..	6·3
4m. ..	20·3	20·0	20·6	20·3	20·6	..	6·0	5·8
6m. ..	19·4	19·0	19·8	19·8	20·4	6·6	6·0	5·8
8m. ..	19·0	18·8	18·6	19·4	20·2	5·6	6·0	5·7
February 1953—								
Surface ..	20·4	19·6	18·3	18·6	21·0	6·5	6·3	6·4
2m. ..	19·2	18·4	18·2	18·2	20·4	6·3	6·3	6·3
4m. ..	19·2	17·8	17·1	18·0	19·0	6·1	6·2	6·1
6m. ..	19·5	17·8	16·6	17·5	18·4	6·1	6·1	6·0
8m. ..	..	..	..	..	..	..	..	..

Season and depth.	Dissolved Oxygen.							
	2 p.m.	8 p.m.	2 a.m.	8 a.m.	2 p.m.	8 p.m.	2 a.m.	8 a.m.
June 1952—								
Surface ..	6·4	6·6	5·5	6·4	7·6	5·3	4·6	4·7
2m. ..	6·1	6·6	6·4	6·2	7·5	5·3	4·4	3·4
4m. ..	2·9	1·4	1·2	1·5	6·0	1·8	3·5	2·4
6m. ..	0·1	0·1	Nil.	Nil.	5·9	2·6	0·3	0·4
8m. ..	Nil.	Nil.	Nil.	Nil.	5·3	0·4	0·3	0·4
February 1953—								
Surface ..	4·0	5·3	4·6	4·7	6·3	6·5	6·3	5·5
2m. ..	4·9	5·3	4·4	3·4	6·4	6·1	6·2	4·7
4m. ..	2·6	1·8	3·5	2·4	6·1	6·1	6·1	5·4
6m. ..	0·4	0·5	0·3	0·4	6·1	6·1	6·1	0·7
8m. ..	..	..	..	..	..	..	..	..

TABLE No. V.—*Statement showing the hydrobiological conditions of fish ponds and tanks.*

Malabar district.

Name of the pond or tank.	*Koliyadichira.*	*Malamparamba house fish pond.*
Location	Wyanad	Kozhikode.
Date of sampling	15th December 1950.	16th December 1950.
Time of sampling	5·35 p.m.	12·5 p.m.
Area in acres	0·60	..
Depth in feet	..	..
Colour of water	Yellowish green ..	Greenish yellow.
Temperature in degree centigrade.	26·2	29·4
Turbidity in cms.	13·0	..
Dissolved oxygen—		
Mgs/litre	8·7	16·9
C.c./litre	6·073	12·796
Percentage saturation ..	103 per cent.	209·8 per cent.
Free carbon-di-oxide p.p. 100,000	Nil.	0·25
Carbonates p.p. 100,000 as CO_3	0·398	Nil.
Bi-carbonates p.p. 100,000 as HCO_3.	6·10	5·190
Chlorides p.p. 100,000 as CL_2 ..	1·50	0·6
pH	8·8	6·6
Silicates as SIO_2, p.p. 100,000 ..	0·30	0·26
Phosphates as PO_4, p.p. 100,000.	Trace	Trace.
Macrophytic vegetation	*Ranunculus, Aiaechynomene, Neptunia, Jussiaea, Limnanthemum, Hydrolea, Limnophila, Utricularia, Hygrophila, Polygonum, Ceratophyllum, Hydrilla, Vallisneria, Nipa, Cryptocoryne, Colocasia, Acorus, Alisma, Limnophyton, Eriocolon, Cyperus, Panicum, Oriza, Leersia, Azolla, Marsilea, Ricioa, Oscillatoria, Cladophore and Spirogyra.*	

TABLE No. V—*cont.*

Malabar district—cont.

Name of the pond or tank.	*Koliyadichira.*	*Malamparamba house fish pond.*
Phyto-planlaton	Blue green algae (*Aphanocapsa*, *Aphanizomenon*, *Merismopedia* and *Anabaena*) green algae (*Oocystis*, *Pediastrum*, *Desmidium*, *Micrasterias*, *Pleurotaenium*, *Tribonema* and *Ulothrix*) diatoms (*Cymbella*, *Epithemia*, *Frustulia*, *Navicula*, *Nitzschia*, *Pinnularia*, *Surirella*, *Staurogenia* and *Synedra*).	*Aphanocapsa*, *Coelastrum*, *Cosmarium*, *Melosira*, *Merismopedia*, *Mougeotia*, and *Hapalosiphon* *Lyngnema*.
Zoo-plankton	Larval stages of mayflies and dragon flies.	Brachionus, Rattulus and Nauplius.
Remarks	2,800 feet above sea level	

Coimbatore district.

Name of the pond or tank.	*Vengapadasamy tank.*	*Arjunanswami tank.*
Location	Coimbatore	Coimbatore
Date of sampling		
Time of sampling		
Area in acres		
Depth in feet	12 feet	10 feet.
Colour of water	Yellowish brown	Yellowish green.
Temperature in degree centigrade.	28·4 to 29·5	26·5 to 28·0
Turbidity in cms		
Dissolved oxygen—		
Mgs/litre		
C.c/litre		
Percentage saturation	1·68 to 4·19	1·26 to 4·33
Free carbon-di-oxide p.p. 100,000.	Nil	Nil
Carbonates p.p. 100,000 as CO_3		
Bi-carbonates p.p. 100,000 as HCO_3		
Chlorides p.p. 100,000 as Cl_2	3·2	9·2
pH	8·05	8·02 to 8·30
Silicates as SiO_2, p.p. 100,000		
Phosphates as PO_4, p.p. 100,000.		
Macrophytic vegetation		
Phyto-plankton	*Chlorococcales* dominant, fewer *blue-greens*, *diatoms*, *flagellates* and *Dinophyceae*.	*Chlorococcales* dominant fewer *blue-greens*, *diatoms*, *flagellates*, and *Dinophyceae*.
Zoo-plankton	*Copepods* and rotifers.	*Rotifers* dominant.
Remarks		

TABLE No. V—*cont.*

Salem district.

Name of the pond or tank.	*Lady-seat Estate pond.*	*Scatforth Estate pond.*	*Sta. Jose Estate pond*
Location			
Date of sampling	17th May 1950.	18th May 1950.	18th May 1950.
Time of sampling	9·30 a.m.	11·10 a.m.	12 noon
Area in acres			
Depth in feet			
Colour of water		Yellowish	Dark green.
Temperature in degree Centigrade.	23·5	25·0	26·0
Turbidity in cms.	30	30	30
Dissolved oxygen—			
Mgs/Litre			
C.c/Litro	2·583	2·583	4·328
Percentage saturation	41·73	42·76	72·88
Free carbon-di-oxide p.p. 100,000.	0·11	0·55	Nil.
Carbonates p.p. 100,000 as CO_3.			0·58
Bi-carbonates p.p. 100,000 HCO_3.	3·001	6·962	1·200
Chlorides p.p. 100,000 as Cl_2.	1·4	0·9	1·4
pH	7·3	6·8	8·4
Silicates as S_1O_2 p.p. 100,000.	0·48	0·56	0·62
Phosphates as PO_4 p.p. 100,000.	Trace	Trace	Trace
Macrophytic vegetation			
Phyto-plankton	*Phacus*, *Diatoma*, *Fragillaria*, *Scenedesmus*, *Cyclotella*.	*Oscillatoria*, *Dictyosphaerium*, *Scenedesmus*, *Pediastrum*, *Netrium*, *Cyclotella*, *Amphora*, *Ceratium*, *Peridinium*, *Euglena* and *Trachelomonas*.	*Aphanocapsa*, *Scenedesmus*, *Saurastrum*, *Cosmarium*, *Pediastrum*, *Ankistrodesmus*, *Kirchnerella*, *Navicula*, *Pinnularia*, *Melosira* and *Ceratium*.
Zoo-plankton			
Remarks			

TABLE No. II—*Showing the hydrological conditions in the Yercaud Lake, Shevroy Hills, Salem district.*

Conditions.	November 1947 (8 a.m.)	January 1950.	May 1950.		July 1952 (8 a.m.).				February 1953.				March 1955.	
	Surface.	Surface.	Surface.	Bottom.	Surface.	1m	2m	3m	Surface.	1m	2m	3m	Surface.	Bottom.
Physical—														
Colour of water	Greenish.	Greenish.											Colourless.	
Turbidity in cms.	..	15·0	..	..	2·3	20	20	17	18	17	16	15	7·30	7·36
Temperature in degree centigrade.	21·4	16·2 to 22·5.	25·4	24·6	21·2	21·0	20·8	20·3	19·6	19·2	19·0	19·0	21·3–22·0	21·2–21·7.
pH	7·1	7·4 to 7·6	8·7	6·0	8·1	8·0	7·5	7·1	7·2	7·2	6·9	6·3	7·9–7·95	7·3–7·4
Chemical—														
Dissolved oxygen	3·9	3·96 to 7·83.	8·2	0·0	3·70	4·20	3·05	3·55	6·7	4·3	5·5	0·5	5·2–6·9	3·6–4·2
Free carbon-dioxide	1·3	1·04 to 1·06.	..	..	Nil.	Nil.	0·3	0·7	1·21	1·21	1·78	5·5	3·96–6·05	5·38–17·06
Carbonates as CO_3	Nil.	Nil.	..	..	1·5	1·5	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
Bi-carbonates as HCO_3 ..	..	22·01 to 37·71.	..	..	18·7	13·7	15·25	16·5	51·0	48·3	51·0	54·9	45·75	42·7
Chlorides as CL..	10·0	..	..	..	21·0	21·0	21·0	21·0	22·0	22·0	22·0	22·0	21·0	21·0
Silicates as SiO_2	..	6·4	..	..	Trace.	Trace.	Trace.	Trace.	11·2	11·2	11·6	12·0	2·0	2·7
Phosphates as PO_4	..	Nil.	..	..	1·9	1·9	2·0	2·0	Trace.	Trace.	Trace.	Trace.	30–48·0	44–56
Nitrates	..	Nil.	..	..	..	..	..	..	..	..	..	..	..	..

TABLE No. III.

Season and depth.	Temperature in ° C.						Dissolved $^{o}_{2}$.						pH.			
	6 p.m.	10 p.m.	2 a.m.	6 a.m.	10 a.m.	2 p.m.	6 p.m.	10 p.m.	2 a.m.	6 a.m.	10 a.m.	2 p.m.	6 p.m.	10 p.m.	2 a.m.	6 a.m.	10 a.m.	2 p.m.
May 1950—																		
Surface ..	23·3	27·1	26·4	25·4	26·9	28·8	8·0	5·8	5·2	8·2	8·5	7·0	8·9	8·85	8·7	8·7	8·7	8·9
Bottom ..	24·9	24·8	24·8	24·9	24·8	24·8	1·7	0·35	0·0	0·0	0·0	1·2	6·1	6·1	6·1	6·0	6·0	6·0
	8 a.m.	2 p.m.	8 p.m.	2 a.m.	8 a.m.	2 p.m.	8 a.m.	2 p.m.	8 p.m.	2 a.m.	8 a.m.	2 p.m.	8 a.m.	2 p.m.	8 a.m.	2 a.m.	8 a.m.	2 p.m
July 1952—																		
Surface ..	21·2	21·6	20·8	20·6	21·5	..	3·7	4·0	39·9	4·8	4·4	..	8·1	8·0	8·1	8·1	8·0	..
1m. ..	21·0	21·9	20·6	20·4	21·3	..	4·2	4·5	4·4	5·3	4·9	..	8·0	8·0	8·0	8·1	8·0	..
2m. ..	20·8	21·8	20·3	20·2	21·2	..	3·0	4·2	39·4	4·2	5·9	..	7·5	7·5	7·3	7·3	7·6	..
3m. ..	20·3	21·0	20·2	20·2	20·8	..	3·5	4·4	4·5	4·8	4·9	..	..	..	..	..	..	..
February 1953—																		
Surface ..	..	..	21·0	21·4	20·2	19·6	23·4	..	8·9	8·8	8·4	5·7	5·7	..	7·5	7·6	7·3	7·2	7·4
1m. ..	..	..	..	19·2	19·5	19·2	20·6	..	..	6·3	7·9	4·3	5·5	..	..	7·2	7·3	7·2	7·3
2m. ..	..	..	18·4	19·0	19·2	19·0	19·8	..	4·8	5·5	5·5	5·5	3·9	..	6·8	6·9	6·9	6·9	6·9
3m. ..	..	..	17·2	18·8	18·0	19·0	19·6	..	1·4	1·8	1·6	0·5	3·8	..	6·3	6·4	6·4	6·3	6·8

TABLE No. V—*cont.*

Madurai district.

Name of pond or tank.	*Perumal koil tank.*	*Lotus pond, Rajaji Park.*	*Ornamental pond.*	*Water works pond.*	*Race Course pond.*
(1)	(2)	(3)	(4)	(5)	(6)
Location	Madurai	Madurai	Madurai	Madurai	Madurai.
Date of sampling	11th March 1951.	10th March 1951.	10th March 1951.	10th March 1951.	10th March 1951.
Time of sampling	6 a.m.	..	..	..	..
Area in acres	..	..	..	..	0·25
Depth in feet	9 feet	1·25	10 feet	10 feet	10 feet.
Colour of water	..	..	Greenish	..	..
Temperature in degree centigrade	28·6	31·6	28·6	28·6	32·1
Turbidity in cms.	14	9	7	8	6
Dissolved oxygen, Mgs./litre	16·2	7·1	10·1	10·2	5·8
C.c./litre	11·308	4·956	..	..	..
Percentage saturation	198·5	123·7	123·7	128·4	..
Free carbon-di-oxide p.p. 100,000	..	..	..	..	..
Carbonates p.p. 100,000 as CO_3	..	..	7·05	0·07	..
Bi-carbonates p.p. 100,000 as HCO_3	10·5	8·1	..	..	2·1
Chlorides p.p. 100,000 as Cl_2	16·78	46·95	1·2	43·31	7·32
pH	23·0	21·0	60·39	10·0	4·0
Silicates as S_2O_2 p.p. 100,000	9·3	9·8	8·4	7·9	7·5
Phosphates as PO_4	2·28	3·44	32·4	2·0	1·40
acrophytic vegetation	Trace.	0·092	0·093	Trace.	0·059
M	..	*Vallisneria, Waterlilies* and *Wolffia.*	..	*Nymphaea sp. Hydrilla* and *Vallisneria.*	..
Phyto-plankton	*Microcystis* ..	*Lyngbia, Anabaena, Cosmarium, Mougeotia, Spirogyra, Navicula* and *Euglena.*	*Gomphospheria, Aphanocapsa, Oscillatoria, Dictyosphaerium, Scendesmus, Staurastrum, Oocystis, Naviculu. Surirella* and *Euglena.*	*Microcystis, Oscillatoria, Cylindro spermum, Anabaena, Lyngbia, Cadophora, Oedogonium, Pandorina, Rhopalodia. Navicula, Euglena* and *Peridinium.*	*Botryoccus, Microcystis, Oscillatoria, Pediastrum, Staurastrium, Coelastrum* and *Scenedesmus.*
Zoo-plankton	Rotifers (*Brachionus*) and flagellates (*Trachelomanas*).	*Brachionus, Nauplius,* and *Cypridopsis.*	..	..	..
[illegible]	..	..	..	..	..

TABLE No. V.—*cont.*

Tirunelveli district.

Name of the pond or tank.	*Kallidaikurichi demonstration tank.*
Location	Kallidaikurichi *demonstration tank.*
Date of sampling	13th March 1951.
Time of sampling	..
Area in acres	0·25.
Depth in feet	8.
Colour of water	..
Temperature in degree centigrade	32·2.
Turbidity in cms.	18.
Dissolved oxygen—	
Mgs/Litre	5·3.
C.c./Litre	..
Percentage saturation	..
Free carbon-di-oxide p.p. 100,000	0·29.
Carbonates p.p. 100,000 as CO_3	..
Bi-carbonates p.p. 100,000 as HCO_3	6·41.
Chlorides p.p. 100, 000 as Cl_2	1·0.
pH	6·0.
Silicates as SIO_2 p.p. 100,000	0·52.
Phosphates as PO_4 p.p. 100,000	Trace.
Macrophytic vegetation	*Trapa bispinosa.*
Phyto-plankton	*Aphanocapsa, Oscillatoria Anabaena, Oedogonium, Ankistrodesmas, Meloxira, Navicula Synedra and Gomphonema.*
Zoo-plankton	..
Remarks	..

Chingleput district.

Name of the pond or tank.	*Rajmapet tank.*	*Muthialpet tank.*
Location	Kancheepuram.	Kancheepuram.
Date of sampling	11th June 1947 and 19th May 1949.	11th June 1947 and 19th May 1949.
Time of sampling	10 to 12 a.m.	1 to 3 p.m.
Area in acres	..	..
Depth in feet	..	..
Colour of water	..	..
Temperature in degree centigrade.	30·1 to 31·8	30·8 to 32·5.
Turbidity in cms.	..	..
Dissolved oxygen—		
Mgs./litre	2·33 to 4·6	4·47 to 7·2.
C.c./litre	..	..
Percentage saturation	0·08 to 0·09	0·37 to 0·59.
Free carbon-di-oxide p.p. 100,000.	..	..

TABLE No. V.—*cont.*

Chingleput district—cont.

Name of pond or tank.	*Rajampet tank.*	*Muthialpet tank.*
Carbonates p.p. 100,000 as CO_3	..	..
Bi-carbonates p.p. 100,000 as HCO_3.	..	..
Chlorides p.p. 100,000 as Cl_2.	17·0 to 17·4	14·0 to 32·0
pH	7·1 to 7·4	7·4 to 7·5.
Silicates as SIO_2 p.p. 100,000.	1·34	2·34.
Phosphates as PO_4 p.p. 100,000.	Trace	0·12.
Macrophytic vegetation	*Chara, Ceratophyllum, Vallisneria.*	*Vallisneria and Hydrilla.*
Phyto-plankton	Blue-greens (*Merismopedia, Anabaena, Oscillatoria*, Euglenophyceae (*Euglena, Phacus*), *Diatoms* (*Navicula, Cuspidata, Naviculasp, Denticula*) Green algae (*Oladophora*, on snail, *Stigeoclonium* on dead. Leaves and stones.	Blue (greens, *Lyngbya*), *Oscillatoria, Anabaena, Chroococcus, Navicula sp, Synedra-Rhoicospheria, Gomphonema.* Green algae (*Cladophora* on snail, *Stigeoclonium* on dead leaves and stones *Oedogonium, Chlorogonium*
Zoo-plankton	*Rotifers*-Common-*Copepods* and *Cladocerans rare, Copepod nauplii-Rare.*	*Rotifera*—few.
Remarks	..	..

TABLE No. V.—*cont.*

Anantapur district.

Name of pond or tank.	*Neelamma konaru.*	*Lakshamma konaru.*	*Malligavadu konaru.*	*Bryathpanna konaru.*	*Mekalawandla konaru.*	*Pululagana konaru.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Location	Anantapur	Anantapur	Anantapur	Anantapur	Anantapur	Anantapur.
Date of sampling	25th July 1950.	25th July 1950.	25th July 1950.	25th July 1950.	25th July 1950.	25th July 1950.
Time of sampling	2–20 p.m.	2–25 p.m.	2–35 p.m.	2–45 p.m.	3–15 p.m.	3–30 p.m.
Area in acres						
Depth in feet	6 feet	20 feet	2 feet	1½ feet	5 feet	
Colour of water	Clean	Brownish (clean)	Whitish	Whitish dark	Green dark	Green.
Temperature in degree centigrade	27·6	25·3	27·7	28·9	26·3	
Turbidity in cms.	28	25	29	28	19	
Dissolved oxygen. Mgs./litre	12·4	2·3	10·3	8·2	6·4	
Dissolved oxygen. C.c./litre	8·66	1·599	7·189	8·700	4·467	
Dissolved oxygen. Percentage saturation.	149·6	26·6	124·4	100·9	75·5	
Free carbon-di-oxide p.p. 100,000		0·88	0·28	0·39	0·72	
Carbonates p.p. 100,000 as CO_3	4·26					
Bi-carbonates p.p. 100,000 as HCO_3	33·63	56·27	50·09	53·69	46·47	
Chlorides p.p. 100,000 as CL_1	2·3	2·3	9·0	11·0	1·6	
pH	8·6	7·95	7·95	7·95	7·90	
Silicates as S_1O_3 p.p. 100,000	3·48	2·76	1·64	1·64	1·80	
Phosphates as PO_4 p.p. 100,000	Trace	Trace	Trace	Trace	Trace	
Macrophytic vegetation	*Hydrilla, Cyperus.*	*Wolffia*		*Lemna, Ottelia, Chara.*		
Phyto-plankton	*Zygnema, Pediastrum, Pandorina, Amphora, Nitzschia, Pinularia* and *Cymbella.*	*Spirogyra,*	*Oscillatoria, Micrasterias, Zygnema, Spirogyra, Nitzschia, Surirella, Amphora* and *Mastogloia.*	*Oscillatoria, Zygnema* and *Nitzschia.*	*Microcystis* and *Nitzschia.*	*Merismopedia* and *Pediastrum.*
Zoo-plankton	*Brachionus, Cyclops, Nauplius, Cypris, Dipteran* larvae and *Odonata* larvae.	*Brachionus, Rattulus, Polyarthra, Daphnia, Bosmina, Cypris, Diaptomus, Cyclops, Nauplius, Dipteran* larvae and *Gyrinus.*		*Brachionus, Cypris* and *Odonata* larvae.	*Polyhartha, Synchaeta, Diaptomus, Cyclops* and *Nauplius.*	*Brachionus, Rattulus, Diaptomus, Cyclops, Cypris* and *Nauplius.*
Remarks						

TABLE No. V—*cont.*

Kurnool District.

Name of the pond or tank.	*Nandyal Town pond.*
Location	Nandyal.
Date of sampling	27th July 1950.
Time of sampling	7-10 a.m.
Area in acres	..
Depth in feet	..
Colour of water	Brownish.
Temperature in degree centigrade	25·5.
Turbidity in cms.	3.
Dissolved oxygen—	
Mgs./litre	..
C.c./litre	2·161.
Percentage saturation	36·1.
Free carbon-di-oxide p.p. 100,000	1·27.
Carbonates p.p. 100,000 as CO_3.	Nil.
Bicarbonates p.p. 100,000 as HCO_3	20·41.
Chlorides p.p. 100,000 as CL.	2·9.
pH	7·5.
Silicates as SIO. p.p. 100,000	1·2.
Phosphates as PO_4 p.p. 100,000	Trace.
Macrophytic vegetation	*Nelumbium, Ipomea* and *Cyperus* and
Phyto-plankton	*Micrasterias, Spirogyra Zygnema.*
Zoo-plankton	Copepods (*Diaptomus* and *Cyclops, Nauplius* larvae *daphnids* (*Simocephalus, Diophanosma*) Rotifers (*Brachionus, Salphina, Euchlanis* and *Rattulus*) and Dipteran larvae.
Remarks	..

Visakhapatnam District.

Name of the pond or tank.	*Dykes tank.*	*Park tank.*
Location	Visakhapatnam	Vizayanagaram.
Date of sampling	22nd April 1950	18th April 1950.
Time of sampling	10 a.m.	4-15 p.m.
Area in acres	2·5	1·5
Depth in feet	8 feet	8—15 feet.
Colour of water	..	..
Temperature in degree contigrade	30·6	34·0
Turbidity in cms.	5·5	10
Dissolved Oxygen—		
Mgs./litre	..	..
C.c./litre	7·330	3·560
Percentage saturation	132·7	..
Free carbon-di-oxide p.p. 100,000	..	..
Carbonates p. p. 100,000 as Co_3	1·8	3·0

TABLE No. V—*cont.*

Visakhapatnam District—cont.

Name of the pond or tank.	*Dykes tank.*	*Park tank.*
Bi-carbonates p.p. 100,000 as HCO_3	14·95	36·295
Chlorides p.p. 100,000 as Cl_3	120·0	410·0
PH	8·8	9·20
Silicates as SIO_2 p.p. 100,000	4·0	·88
Phosphates as PO_4 p.p. 100,000	5·0	7·5
Macrophytic vegetation	*Hydrilla, Ipomea,* waterlilies and grass.	....
Phyto-plankton	*Microcystis, Lyngbia, Oscillatoria, Chroococcus, Merismopedia, Pandorina, Pediastrum Oedogonium, Scenedes mus, Eudorina Cosmarium, Teiraedon, Characium, Chaeto-phora, Spirogyra Closterium, Mougeotia, Gyro—sigma, Navicula, Cymbella, Fragilaria,* and *Synedra.*	*Microcystis, Oscillatoria, Aphanocapsa, Spirulina-Chroococcus, Aba, baena, Glaeocapsa, Oocystis, Syenedesmus, Cosmarium* and *Amphora.*
Zoo-plankton	..	..
Remarks	..	..

Srikakulam District.

Name of the pond or tank.	*Market tank (Basavaraja Banda).*	*Illispuram tank (Bukkuvani Banda).*
Location	Srikakulam	Srikakulam.
Date of sampling	24th April 1950	24th April 1950.
Time of sampling	..	....
Area in acres	1·2	0·75.
Depth in feet	12—14 feet	6 feet.
Colour of water	Greenish	Brownish.
Temperature in degree contigrade	30·1	31·9
Turbidity in cms.	14 c.m.	20 c.m.
Dissolved Oxygen—	..	..
Mgs./litre	..	220.
C.c./litre	200	..
Percentage saturation	0·220	1·2
Free carbon-di-oxide p.p. 100,000	..	20.130
Carbonates p.p. 100,000 as CO_3	25·625	..
Bi-carbonates p.p. 100,000 as HCO_3	..	..

TABLE No. V—*cont.*

Srikakulam District—cont.

Name of the pond or tank.	*Market tank (Basavaraja Baudu).*	*Illisparam tank (Bukkwani Baudu).*
Chlorides p.p. 100,000 as Cl_2 ..	200·6	220·0.
Ph	7·4	8·8
Silicates as SiO_2 p.p. 100,000 ..	2·86	0·68
Phosphates as PO_4 p.p. 100,000 ..	5·35	1·077
Macrophytic vegetation	..	*Ipomea, Hygrilla Marsilia, Pistiaa* and *Nejdunia.*
Phyto-planikton	*Oscillatoria, Microcystis, Glococapsa, Pediastrum, Ulothrichaceae, Navicula, Amphora, Chaetophora, Stigeoclonium* and *Peridinium.*	*Nitzchia, Oscillatoria, Pediastrum, Gyrosigma, Euglena* and *Peridinium.*
Zoo-plankton	..	..
Remarks	..	..

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TABLE No. V—*cont.*

Bellary district.

Name of the pond or tank.	*Kyathuraju tank.*	*Venkannu bhavi.*	*Murari tank.*	*Gangalamuny tank.*
(1)	(2)	(3)	(4)	(5)
Location	Adoni	Adoni	Adoni	Adoni.
Date of sampling	28th July 1950.	29th July 1950.	29th July 1950.	29th July 1950.
Time of sampling	5 p.m.	9–10 a.m.	9–50 a.m.	12 noon.
Area in acres	10	0·11	3	1½
Depth in feet	6—10 feet	20—32 feet	8 feet	15 feet.
Colour of water	Yellowish	Dark green	Dark green	Greenish.
Temperature in degree centigrade	27·2	26·2	26·0	26·0
Turbidity in cms.	9	17	2·1	66·0
Dissolved oxygen—Mgs./litre	7·5	8·6	12·1	5·6
C.c./litre	5·235	6·003	8·446	3·909
Percentage saturation	89·9	101·4	142·1	66·4
Free carbon-di-oxide p.p. 100,000	..	0·94	..	0·22
Carbonates p.p. 100,000 as CO_3	2·45	..	..	..
Bi-carbonates p.p. 10,000	9·89	55·04	..	11·13
Chlorides p.p. 10,000 as Cl_2	1·2	120·0	..	0·9
pH	8·6	7·9	..	7·9
Silicates as $S_i O_2$ p.p. 100,000	1·18	2·68	..	1·0
Phosphates as PO_4 p.p. 100,000	..	..	..	..
Macrophytic vegetation	*Chara, Najas, Ottelia, Colocasia.*	..	*Grass Marsilia* and *Ottelia.*	..
Phyto-plankton	*Microcystis, Ocillatoria, Spirogyra, Mougeotia, Pandorina, Scenedesmus, Pediastrum, Botryococcus, Cymbella, Fragularia, Nitzschia, Pinnularia, Surirella.*	*Microcystis, Spirogyra* and *Mougeotia.*	*Microcystis, Anabaena, Spirogyra, Pediastrum, Rhizoclonium,* and *Nitzschia.*	*Oscillatoria, Spirogyra, Pediastrum, Rhizoclonium, Scenedesmus* and *Nitzchia.*
Zoo-plankton	*Euglena, Brachionus, Euchlanis, Noteus, Polyarthra, Philodina, Notholca, Bosmina* and *Nauplius.*	*Euchlanis, Philodina, Diaptomus, Cyclops* and *Nauplius.*	*Diaptomus, Cyclops, Nauplius, Telphusia, Diaptomus, Cyclops, Nauplius, Bosmina, Daphnia* and *Telphusia.*	*Volvox, Brachionus, Noterus, Notholca, Diaptomus, Cyclops.*
Remarks	..	..	..	..

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