# FISH YIELD OPTIMIZATION IN THIRUMOORTHY RESERVOIR, TAMIL NADU

CENTRAL INLAND CAPTURE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
BARRACKPORE-743 101, WEST BENGAL

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Bull No. 95 February 2000

**Central Inland Capture Fisheries Research Institute**
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ISSN 0970-616 X



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| Composed at | : | **The Project Monitoring & Documentation Section** CIFRI, Barrackpore |
| Assistance | : | Sefali Biswas |
| Cover design | : | P. Dasgupta |
| Published by | : | **The Director,** CIFRI Barrackpore |
| Printed at | : | Toparts Private Ltd. 8/2, Dr. Biresh Guha Street Calcutta 700 017 |

# Foreword

The Institute is proud of the laudable results obtained by its Coimbatore Research Centre, Tamil Nadu in achieving a record fish production of 193 kg $ha^{-1}$ $yr^{-1}$ from Aliyar reservoir. The investigations have established the great production potentiality of such reservoirs, irrespective of their age. In order to confirm the viability of the techniques evolved, the Centre applied similar management practices in Thirumoorthy reservoir located in the Western Ghat region of Tamil Nadu. Interestingly, the high fish yield of 213.4 kg $ha^{-1}$ $yr^{1}$ obtained from this small reservoir has further affirmed the tremendous scope for enhancing the fish yield several-fold from such reservoirs. I am confident that the findings presented in this bulletin will be highly useful for persons actively engaged in the development of fisheries in such small reservoirs in the country.

The achievement made is the product of the excellent co-operation extended to the Centre by the Department of Fisheries, Tamil Nadu and the Tamil Nadu Fisheries Development Corporation Ltd. I place on record my sincere thanks to the authorities of the Government of Tamil Nadu for providing facilities like the fish farm, the seed, feed and a vehicle. I thankfully acknowledge the Public Works Department, Thirumoorthy Nagar, Tamil Nadu for providing the morphometric and meteorological data.

**M. Sinha**
***Director***

## List of Participants

| | |
|---|---|
| Shri C. Selvaraj, Principal Scientist & Project Leader | 1.4.1992 - 22.1.1997 |
| Shri V.K. Murugesan, Sr. Scientist | 1.4.1992 - 31.3.1997 |
| Dr. V.K. Unnithan, Sr. Scientist | 1.4.1992 - 28.4.1992<br>29.12.1992 - 5.3.1994 |
| Shri S. Manoharan, Technical Assistant | 4.6.1993 - 31.3.1997 |
| Shri C.K. Vava, Technical Assistant | 7.9.1992 - 5.3.1994 |

***Prepared by :***


**C. Selvaraj**
**V.K. Murugesan**
**S. Manoharan**
**M. Karthikeyan**

# Contents

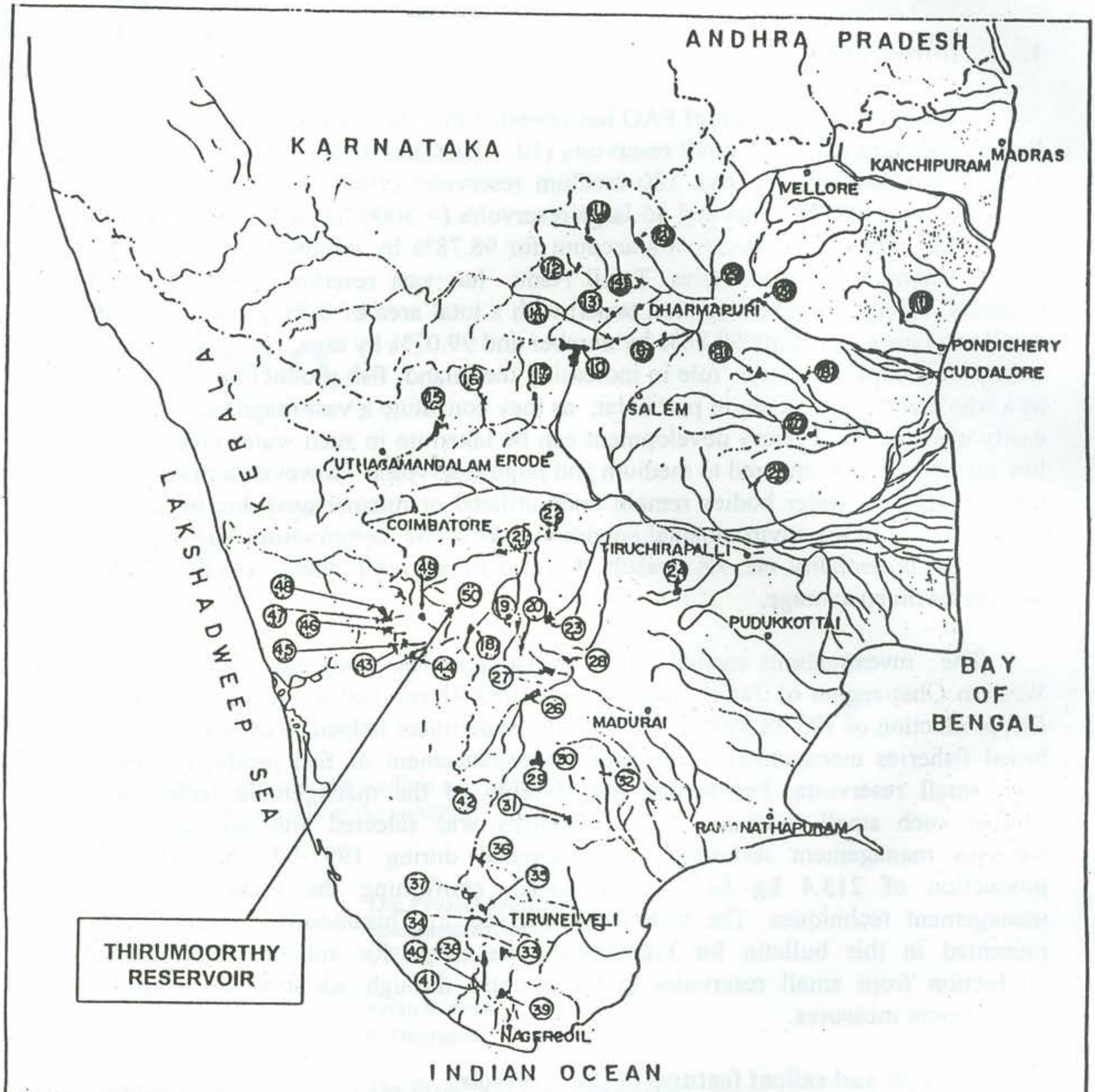
## 1. Introduction

The recent estimation of FAO has revealed that there are 19370 reservoirs in India, consisting of 19134 small reservoirs (10 – 1000 ha) with a total water area of 1.49 million hectares (m. ha), 180 medium reservoirs (1000 – 5000 ha) with a combined area of 0.53 m.ha and 56 large reservoirs (> 5000 ha) with a total area of 1.14 m.ha . Thus, small reservoirs account for 98.78% by number and 47.11% by area. Among the Indian States, Tamil Nadu has vast reservoir resource (8906 numbers including major irrigation tanks) with a total area of 0.36 m.ha. Of these, small reservoirs constitute 99.88% by number and 99.07% by area. Therefore, small reservoirs can play a major role in increasing the inland fish production of country as a whole and Tamil Nadu in particular, as they constitute a vast magnitude and are easily manageable. Fishery development can be taken up in such water bodies with low investment as compared to medium and large reservoirs. However, a majority of these productive water bodies remain underutilized or mismanaged due to lack of understanding of the environmental conditions, the biotic communities, the biogenic production potentiality, etc. As a result, these small reservoirs yield less than 50 kg fish per ha on an average.

The investigations carried out in Aliyar reservoir (646 ha), located at the Western Ghat region of Tamil Nadu, during 1985-91 resulted in an all-time record fish production of 193.58 kg $ha^{-1}$. Further, the experiment helped to evolve ecology-based fisheries management techniques for enhancement of fish production from such small reservoirs. For testing the viability of the management techniques, another such small reservoir at Thirumoorthy was selected and ecology-based fisheries management techniques were applied during 1991-97. A high fish production of 213.4 kg $ha^{-1}$ was obtained, confirming the viability of the management techniques. The techniques adopted in Thirumoorthy reservoir are presented in this bulletin for highlighting the scope for enhancement of fish production from small reservoirs in the country through adoption of scientific management measures.

## 2. Origin and salient features of the reservoir

Thirumoorthy reservoir was created by constructing an earthen dam of 2627.99 m long during 1962-67 across Palar river and Nagappa Naicker Odai in Bharathapuzha basin just below the hills of Thirumoorthy in the Western Ghat region




RESERVOIR LOCATION MAP

of Tamil Nadu. It is a tail-end reservoir under Parambikulam-Aliyar Project (PAP) with a water spread area of 388 ha at full reservoir level (F.R.L.) and 79.88 ha at dead storage level (D.S.L.). It is a small reservoir located at 10° 28' N and 77° 09' E, about 20 km south of Udumalpet town in Coimbatore District, Tamil Nadu. Apart from its own catchment area of 8029 ha, the reservoir receives water supply from Thoonakadavu reservoir which in turn receives water from Parambikulam and Peruvaripallam reservoirs. Water from Thoonakadavu is taken to Sarkarpathy power house through a horse-shoe type tunnel of 3850 m long. The tail race water from the power house feeds the Sethumadai canal, the Aliyar feeder canal and the contour canal. The contour canal (53.1 km long) empties its water into Thirumoorthy reservoir which has a gross capacity of 54.8 M. cu. m at FRL and effective net capacity of 49.39 M.cu.m. The reservoir water is supplied through two canals for irrigating 80826.79 ha in Udumalpet and Palladam taluks. The average water spread area of the reservoir is 234 ha. The ratio of catchment area to the reservoir area works out to 20.69, indicating a low allochthonous input.

## 3. Ecology

As the productivity of the reservoir depends on the climate, the edaphic and the morphometric features, studies were made of the following aspects.

### *3.1 Meteorological conditions*

The atmospheric air temperature and the rainfall at Thirumoorthy dam during 1992-96 were as given below:

| Years | Air Temperature (°C) | | Total Rainfall (mm) |
|---|---|---|---|
| | Range | Average | |
| 1992-93 | - | - | 790.3 |
| 1993-94 | 25.3-37.0 | 31.4 | 776.3 |
| 1994-95 | 25.0-32.0 | 28.8 | 913.8 |
| 1995-96 | 22.0-33.0 | 24.6 | 413.3 |

The average air temperature was moderate (24.6 to 31.4 °C) and favourable for biological productivity. As the reservoir is located in the rain-shadow region of the Western Ghats, the rainfall at Thirumoorthy during 1992-96 was low to moderate (413.3 to 913.8 mm) compared to the national average of 1050.0 mm.

### 3.2 *Water level, inflow and discharge*

The fluctuation in the water level was maximum (14.71m) in 1992-93 and minimum (8.35 m) in 1995-96. However, the yearly average depth (10.12 to 12.98 m) suggests that the reservoir belongs to medium depth category. While the annual inflow exceeded the annual discharge during 1993-94 and 1995-96, the trend was *vice-versa* during 1992-93 and 1994-95 (Table 1). The wide fluctuation in the water level as well as the inflow and discharge indicates that the reservoir water is flushed out frequently.

### 3.3 *Soil quality*

The bottom soil from Thirumoorthy reservoir was slightly acidic (pH: 6.4 to 6.8) with an average value of 6.5 during 1993-94. However, the soil quality improved to alkaline side in the subsequent years (Table 2) and was favourable for biological production. The specific conductance of the soil which was low (0.10 to 0.31 mmhos $cm^{-1}$) during 1993-95, increased significantly (3.9 to 4.2 mmhos $cm^{-1}$) during 1995-97. The organic carbon of the soil was high (1.56 to 4.10 %) during 1993-95, indicating high productivity. However, the same parameter decreased drastically (0.26 to 0.33 %) during 1995-97 probably because of higher rate of degradation due to lowering of water level coupled with increased euphotic zone. The basin soil contained 30.9 to 54.0 mg/100g of available nitrogen indicating medium productivity. The low available phosphorus content of the soil (0.2 to 0.8 mg 100 $g^{-1}$) suggested poor productivity.

### 3.4 *Water quality*

#### 3.4.1 *Physical qualities of water*

The temperature of water in the surface, middle and bottom layers ranged from 22.0 to 34.0 °C and the value decreased slightly with increase in depth. The water temperature showed direct relationship with air temperature. The mean water temperature ranging from 23.4 to 29.8 °C was favourable for the biological productivity. The reservoir water appeared turbid to fairly transparent with secchi disc reading varying from 45 to 238 cm, altering the euphotic zone and the photosynthetic activity.

### *3.4.2 Chemical qualities of water*

The chemical qualities of water which influence the biological productivity of the reservoir were as shown in Fig.1. The pH of surface water was higher than the middle and bottom layers. The alkaline condition of water in all the layers favoured higher biological productivity. The dissolved oxygen content of water which is the most important vital parameter was above 5.7 $mgl^{-1}$ in the three layers and supported the biotic community. While free carbon dioxide was recorded in certain months, it was absent in other months. Higher values were recorded at deeper layers than that of the surface. Presence of this gas facilitated better primary productivity. The alkalinity due to carbonates was negligible and it was mainly due to bicarbonates. The total alkalinity was less. The total dissolved solids and specific conductivity of water were also less. A direct relationship among the total alkalinity, the total dissolved solids and specific conductivity was observed. However, the low values for these parameters indicate low biological productivity of the reservoir.

### *3.4.3 Diurnal variations in water quality*

Depth-wise diel variations in the water qualities at different seasons during 1993-95 are depicted in Fig.2. The water temperature was minimum at 0600 hrs and it raised with sun-rise and reached the maximum at 1200 hrs. The values declined at 1800 hrs and 2400 hrs. The water temperature decreased with the increase in depth and it showed direct relationship with air temperature. The pH of water increased at 1200 hrs, but declined at 1800 hrs and 2400 hrs. The pH in the lower strata was generally lower than that of the surface layer. The dissolved oxygen increased from the value at 0600 hrs to 1800 hrs up to 4 m depth due to photosynthetic activities and the values decreased gradually during night time due to respiratory activities. A meagre quantity of carbon dioxide was recorded at 0600 hrs in all the layers, but the gas decreased during day time upto 4 m depth due to utilization in the photosynthetic process. The value of free carbon dioxide increased in all the layers during night time due to respiratory activities of the biotic community. The total alkalinity was mainly due to bicarbonates and the values were low. The total dissolved solids and specific conductivity showed direct relationship.

**Table 1 : Reservoir depth, inflow and discharge during 1992-96**

| Parameters | 1992-93 | 1993-94 | 1994-95 | 1995-96 |
|---|---|---|---|---|
| Depth (m) | 3.08-17.79 (11.78) | 4.12-17.33 (10.12) | 7.60-17.40 (12.98) | 7.95-16.30 (12.19) |
| Inflow (Cumecs) | 5644.57 | 5000.50 | 6237.85 | 8287.07 |
| Discharge (Cumecs) | 5769.84 | 4277.80 | 6712.35 | 5419.26 |

*(Average in paranthesis)*

**Table 2 : Chemical characteristics of reservoir soil during different years**

| Year | pH | E.C (mmhos) | Available $N_2$ (mg/100g) | Available $P_2O_5$ (mg/100g) | Organic carbon (%) |
|---|---|---|---|---|---|
| 1993-94 | 6.4-6.8 (6.5) | 0.10-0.30 (0.17) | 30.9-53.0 (47.6) | 0.25-0.80 (0.40) | 1.56-2.61 (2.30) |
| 1994-95 | 7.1-7.5 (7.3) | 0.15-0.31 (0.19) | 42.0-54.0 (46.0) | 0.20-0.26 (0.22) | 3.00-4.10 (3.70) |
| 1995-96 | 7.3-7.5 (7.4) | 3.90-4.20 (4.00) | 43.0-48.0 (45.0) | 0.20-0.31 (0.25) | 0.26-0.30 (0.28) |
| 1996-97 | 7.9 | 4.00 | 44.0 | 0.29 | 0.33 |

*(Average in paranthesis)*

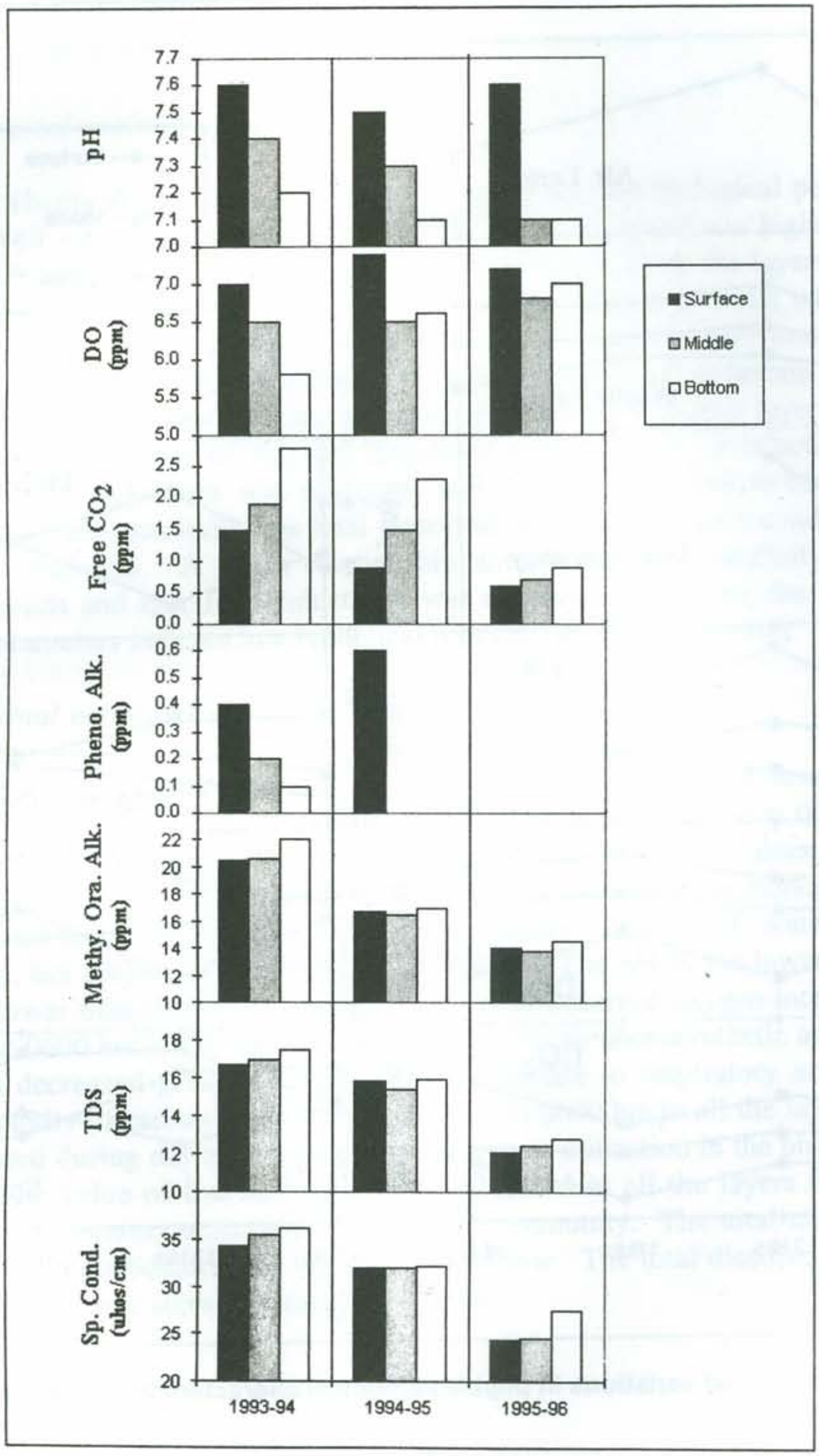



**Fig. 1 : Chemical qualities of water at different layers during 1993-96**

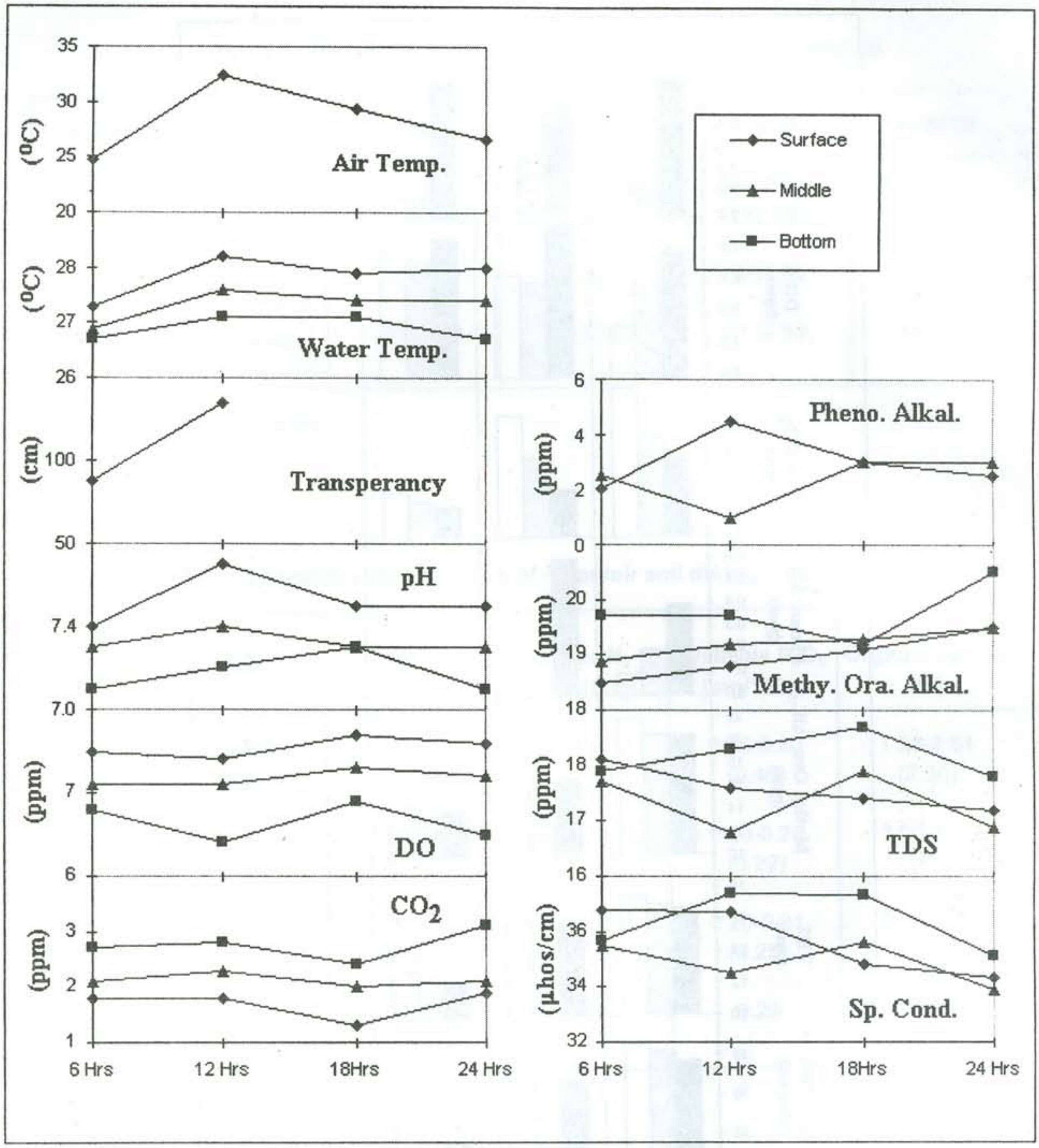



**Fig. 2 : Diurnal variations in physico-chemical characteristics of water**

### *3.5 Plankton*

Analysis of plankton samples collected from the surface and bottom layers revealed the dominance of phytoplankton (Table 3). As depicted in Fig. 3, there was a progressive increase in the phytoplankton population from 1993-94 to 1995-96. Among the phytoplankton, Bacillariophyceae was the dominant group during 1993-94 followed by Chlorophyceae and Myxophyceae. During 1994-95, Chlorophyceae was the dominant group, followed by Bacillariophyceae and Myxophyceae. Again, Chlorophyceae dominated the phytoplankton during 1995-96 followed by Bacillariophyceae and Myxophyceae. The zooplankton contribution ranged from 2.2 to 7.6 %. The zooplankton population also showed an increase from 1993-94 to 1995-96. The zooplankton was more at the bottom than at the surface during 1994-96. Among the zooplankton, generally Cladocerans were more, followed by copepods and rotifers. The total plankters ranged from 11684 to 20149 nos. $l^{-1}$ in the surface and from 4072 to 15701 nos. $l^{-1}$ in the bottom. The volume of plankton fluctuated from 2.0 to 6.0 ml/m$^3$.

Qualitative analysis revealed that Chlorophyceae consisted *of Hormidium, Selenastrum* and *Scenedesmus. Nitzschia, Melosira, Navicula, Synedra* and *Tabellaria* were encountered under Bacillariophyceae. Myxophyceae was constituted by *Microcystis, Nostoc* and *Anabaena*. Among the zooplankters, *Brachionus, Keratella, Cyclops, Diaptomus* and *Daphnia* were the genera frequently recorded.

#### *3.5.1 Diel variation in plankton*

Diurnal studies showed that the phytoplankton was more in the surface layer at 1200 hrs for photosynthetic activities and their number reduced due to their downward migration at 1800 hrs and 2400 hrs (Fig.4). The zooplankton population was more in the surface at 0600 hrs and 2400 hrs, but migrated downwards at 1200 hrs and 1800 hrs due to their sensitivity to sunlight.

| Plankton | 1993-94 | | 1994-95 | | 1995-96 | |
|---|---|---|---|---|---|---|
| | Surface | Bottom | Surface | Bottom | Surface | Bottom |
| **Phytoplankton** | | | | | | |
| Chlorophyceae | 4307 | 1522 | 8652 | 8458 | 11707 | 7895 |
| Bacillariophyceae | 6300 | 1884 | 2744 | 2329 | 6153 | 5455 |
| Myxophyceae | 824 | 498 | 1175 | 701 | 1573 | 1158 |
| **Total** | **11431** | **3904** | **12571** | **11488** | **19433** | **14508** |
| **Composition (%)** | **97.8** | **95.9** | **96.3** | **93.8** | **96.4** | **92.4** |
| **Zooplankton** | | | | | | |
| Rotifera | 64 | 35 | 156 | 236 | 251 | 368 |
| Cladocera | 92 | 86 | 178 | 235 | 224 | 432 |
| Copepoda | 97 | 47 | 143 | 284 | 241 | 393 |
| **Total** | **253** | **168** | **477** | **755** | **716** | **1193** |
| **Composition (%)** | **2.2** | **4.1** | **3.7** | **6.2** | **3.6** | **7.6** |
| **Total Plankton** | **11684** | **4072** | **13048** | **12243** | **20149** | **15701** |
| Volume ($ml/m^3$) | 4 | 2 | 5 | 5 | 5 | 6 |

**Table 3.** ***Plankton distribution (nos./l) in the surface and bottom layers during 1993-96***

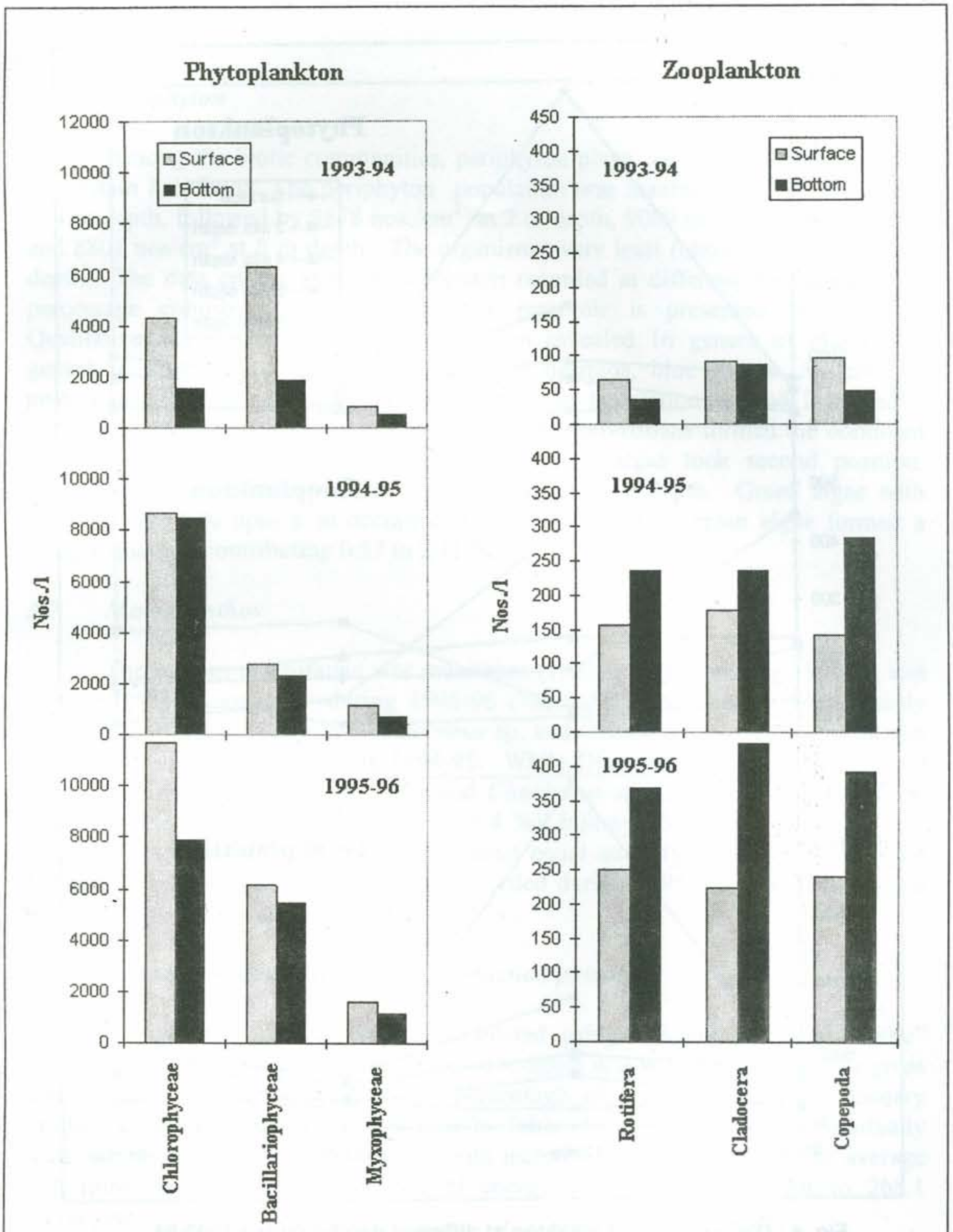



**Fig. 3 : Plankton distribution in the surface and bottom layers in different years**

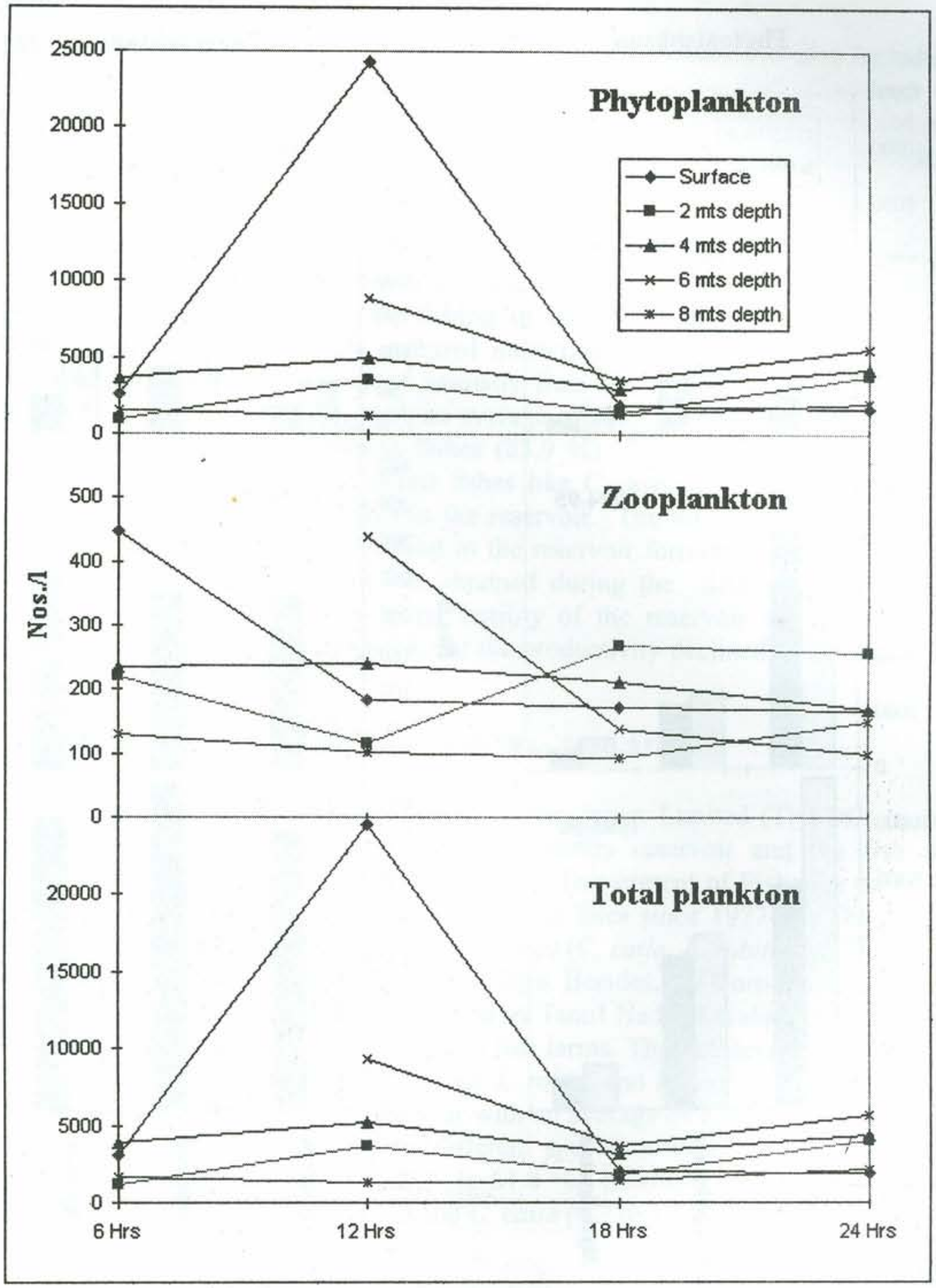



**Fig. 4 : Diel variation of plankton at different depths during 1993-94**

### *3.6 Periphyton*

Among the biotic communities, periphyton plays an important role as food for certain fish fauna. The periphyton population was maximum (10101 nos./$cm^2$) at 4 m depth, followed by 9878 nos./$cm^2$ at 2 m depth, 9009 nos./$cm^2$ at 6 m depth and 8801 nos/$cm^2$ at 8 m depth. The organisms were least (6668 nos/$cm^2$) at 10 m depth. The data on the average periphyton recorded at different depths and their percentage contribution at Thirumoorthy reservoir is presented in Table 4. Qualitative analysis of periphyton population revealed 16 genera of diatoms, 9 genera of green algae and 2 genera each of desmids, blue greens, rotifers and protozoans. Diatoms dominated in the periphyton population beyond 2 m and it increased with increase in depth. Next to diatoms, protozoans formed the dominant form upto 8 m depth and at 10 m depth, green algae took second position. Protozoans reduced in population size with increase in depth. Green algae with 14.43 to 24.38 % upto 8 m occupied third position. Blue green algae formed a meagre quantity contributing 0.57 to 2.11 %.

### *3.7 Macrobenthos*

The bottom macrofauna was maximum (1562 nos./$m^2$) during 1994-95 and minimum (1175 nos./$m^2$) during 1995-96 (Table 5). The benthos were mainly constituted by *Chironomus* sp., *Chaoborus* sp. and Oligochaetes. A few molluscan forms were also recorded during 1994-95. While Oligochaetes were slightly more (37.5 %) than *Chironomus* (36.1 %) and *Chaoborus* sp. (26.4%) during 1993-94, *Chaoborus* sp. was the dominant form (38.4 %), followed by *Chironomus* sp. (36.5 %) and Oligochaetes during 1994-95. Almost equal quantity of Oligochaetes (34.4 %) and *Chironomus* sp. (34.2 %) were recorded during 1995-96. The contribution by *Chaoborus* sp. during the year was 31.3 % .

### *3.8 Primary productivity and fish production potential*

The primary production was estimated using " Light and Dark bottle" technique upto 4 m depth, as the compensation depth was within this level. The gross and net primary production and the percentage of energy fixation by primary producers during 1993-96 are furnished in Table 6. The productivity gradually increased in the later years coinciding with increase in phytoplankton. The average fish production potential at 0.5 % of energy conversion works out to 268.1 kg/ha/year.

**Table 4 : Periphyton distribution (units/cm$^2$ and group-wise contribution percentage) at different depths**

| Periphyton Group | Depth | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2 m | | 4 m | | 6 m | | 8 m | | 10 m | |
| | Nos. | % | Nos. | % | Nos. | % | Nos. | % | Nos. | % |
| Green algae | 1425 | 14.43 | 2463 | 24.38 | 1410 | 15.65 | 1513 | 17.19 | 925 | 13.87 |
| Blue-green algae | 175 | 1.77 | 213 | 2.11 | 138 | 1.53 | 50 | 0.57 | 75 | 1.12 |
| Diatoms | 3265 | 33.04 | 3325 | 32.92 | 3763 | 41.77 | 4388 | 49.86 | 4125 | 61.86 |
| Protozoans | 3363 | 34.00 | 2750 | 27.23 | 2088 | 23.18 | 1875 | 21.30 | 875 | 13.12 |
| Rotifers | 150 | 1.52 | 225 | 2.23 | 275 | 3.05 | 275 | 3.12 | 180 | 2.70 |
| Others | 1500 | 15.24 | 1125 | 11.13 | 1335 | 14.82 | 700 | 7.96 | 488 | 7.33 |
| Total | 9878 | | 10101 | | 9009 | | 8801 | | 6668 | |

**Table 5 : Average distribution of Macrobenthos (Nos./m$^2$) during 1993-96**

| Macrobenthos | 1993-94 | | 1994-95 | | 1995-96 | |
|---|---|---|---|---|---|---|
| | Nos. | % | Nos. | % | Nos. | % |
| *Chironomus* sp. | 506 | 36.1 | 570 | 36.5 | 402 | 34.2 |
| *Chaoborus* sp. | 371 | 26.4 | 600 | 38.4 | 368 | 31.3 |
| Oligochaetes | 526 | 37.5 | 385 | 24.6 | 405 | 34.4 |
| Molluscs | - | - | 7 | 0.5 | - | - |
| Total | 1403 | | 1562 | | 1175 | |

**Table 6 : Primary production and the energy fixation during 1993-96**

| Particulars | 1993-94 | 1994-95 | 1995-96 |
|---|---|---|---|
| **Gross production (mg C/m$^3$/hr)** | 31.9 | 40.5 | 41.7 |
| **Net production (mg C/m$^3$/hr)** | 25.4 | 29.5 | 29.8 |
| **Respiration (mg C/m$^3$/hr)** | 5.5 | 12.6 | 13.9 |
| **Average productivity (mg C/m$^3$/day)** | 864.90 | 915.00 | 902.52 |
| **Average incident solar energy (Cal/m$^3$/day)** | 158.1 x 10$^4$ | 212.75 x 10$^4$ | 195.6 x 10$^4$ |
| **Energy fixed by primary production (%)** | 0.365 | 0.397 | 0.702 |

### 3.9 *Fish fauna*

The fishes encountered in the reservoir are listed according to their taxonomy:

Family : Cyprinidae

Sub-family : **Cyprininae**

*Catla catla* (Hamilton – Buchanan)
*Labeo rohita* (Hamilton – Buchanan)
*Cirrhinus mrigala* (Hamilton – Buchanan)
*Cyprinus carpio* var. *communis* (Linnaeus)
*Cyprinus carpio* var. *specularis* Lacépède
*Cyprinus carpio* var. *nudus* Bloch
*Labeo calbasu* (Hamilton – Buchanan)
*Labeo fimbriatus* (Bloch)
*Puntius carnaticus* (Jerdon)
*Puntius filamentosus* (Valenciennes)
*Puntius mahecola* (Valenciennes)
*Puntius sarana* (Hamilton)
*Tor* (*khudree*) *malabaricus* (Jerdon)

Sub-family : **Leuciscinae**

*Hypophthalmichthys molitrix* (Valenciennes)

Sub-family : **Rasborinae**

*Danio aequipinnatus* (McClelland)
*Amblypharyngodon mola* (Hamilton - Buchanan)
*Amblypharyngodon melettinus* (Valenciennes)

Sub-family : **Garrinae**

*Garra mecclellandi* (Jerdon)

Family : **Cichlidae**

*Oreochromis mossambicus* (Peters)
*Etroplus maculatus* (Bloch)

Family : **Anguillidae**

*Anguilla bengalensis* (Gray)

Family : **Bagridae**

*Mystus vitatus* (Bloch)
*Mystus malabaricus* (Jerdon)

Family : **Mugilidae**

*Rhinomugil corsula* (Hamilton-Buchanan)

Family : **Siluridae**

*Ompok bimaculatus* (Bloch)
*Ompok malabaricus* (Valenciennes)

Family : **Claridae**

*Clarias batrachus* (Linnaeus)

Family : **Gobiidae**

*Glossogobius giuris* (Hamilton –Buchanan)

Family : **Channidae**

*Channa striatus* (Bloch)

Family : **Mastacembelidae**

*Mastacembelus armatus* (Lacepede)

The fish fauna studies revealed poor species diversity. The intensive stocking of fast growing herbivorous carps during 1992-97 for enhancement of fish production per unit area discouraged the very existence of some of the indigenous fishes, resulting in disappearance of these fishes in the later period.

## 4. Fisheries Development

### *4.1 Fishery management during 1966-67 to 1976-77*

The Department of fisheries in Tamil Nadu was carrying out the fisheries development in Thirumoorthy reservoir during 1966-1977. Fish seed belonging to *C. mrigala, C. reba, L. fimbriatus, P. carnaticus, P. sarana, P. dubius, O. mossambicus* and *C. carpio* was stocked during 1966-69. A small consignment of

145 seed of *C. catla*, 1175 of *L. rohita* and 10640 *L. calbasu* was also included in the stocking material during 1969-70. Stocking of major carp seed was progressively increased. The stocking rate and species combination depended more on the availability of fish seed rather than any rationale. The annual stocking rate ranged from 323 to 2366 seed/ha with an average of 1009 nos.

Fishing commenced in 1968-69 through the departmental fishermen using coracles, gill-nets of different mesh size and cast nets. Later, private professional fishermen were also engaged for fishing in the reservoir on crop-sharing basis. Fishes of all size groups were captured indiscriminately. A total of 2697 kg to 25511.25 kg of fish was harvested annually from the reservoir. The yield per ha ranged from 11.5 to 109.0 kg, with an average production of 64.7 kg/ha. The yield was dominated by miscellaneous fishes (83.9 %). Major carps formed a minor fishery (16.1 %). Heavily stocked fishes like *C. mrigala, C. reba, Puntius sp., L.fimbriatus*, etc. did not establish in the reservoir. The minor constituent like *O. mossambicus* in the fish seed released in the reservoir formed a major fishery. The highest production (109 kg/ha) was obtained during the fifth year (1970-71) of impoundment probably due to initial fertility of the reservoir and trophic burst. However, the fertility did not sustain and the productivity declined in the subsequent years.

### *4.2 Fishery management during 1977-78 to 1990-91*

Tamil Nadu Fisheries Development Corporation Limited (TNFDC), a quasi Government organization, took over Thirumoorthy reservoir and the fish farm located in the vicinity of the reservoir from the Department of Fisheries on a long-term lease to develop its fishery on commercial lines since 1977-78. The TNFDC raised fry and early fingerlings of Gangetic carps (*C. catla, L. rohita* and *C. mrigala*) and the common carp, *C. carpio* in the fish farm. Besides, the Corporation purchased the seed from the Departments of Fisheries in Tamil Nadu, Kerala, Andhra Pradesh and West Bengal and also from the private fish farms. The fish seed consisting of *C. catla, C. mrigala, C. carpio, L.fimbriatus, L. rohita* and *H. molitrix* were stocked in the reservoir @ 850 to 2382 nos./ha/year with an average of 1515 nos./ha during the entire period (1977-91). Among the different species released in the reservoir, *L. rohita* was the dominant species (29.1 to 61.8 %), followed by *C.mrigala* (10.1 to 38.46 %), *C. carpio* (9.98 to 26.1 %) and *C. catla* (4.2 to 31.63 %).

Tamil Nadu Fisheries Development Corporation Ltd. followed almost the same method of exploitation, as done by the Department of Fisheries by engaging 10 to 15 share fishermen for exploitation of fishery wealth. There was a wide fluctuation in the fish yield of different years and there was no relationship between the stocking and the recovery. The annual average fish yield declined to 14.6 t (62.4 kg/ha) during 1977-91, but the contribution by major carps showed an improvement (57.2%).

### *4.3 Fisheries research and management during 1991-97*

Coimbatore Research Centre of Central Inland Capture Fisheries Research Institute (CICFRI) took up fisheries research and management of Thirumoorthy reservoir since September 1991. All the aspects of fisheries were investigated during 1992-97.

#### *4.3.1 Fish breeding and recruitment*

Sexual maturity of cultivated carps captured from Thirumoorthy reservoir was examined in the fish assembly centre. The study revealed that the gonads in major carps (*C. catla, L. rohita, C. mrigala* and *H. molitrix* ) develop upto IV stage of maturity and then resorb. The ripe or oozing specimens were rare indicating that these carps do not attain full sexual maturity in this reservoir probably due to lack of certain essential nutrients in the water as observed in Aliyar reservoir.

Operation of shore-seine nets and gill-nets with smaller mesh size in the marginal area of the reservoir to capture weed fishes brought young ones of *O. mossambicus, P. filamentosus, P. mahecola* and other trash fishes. Not a single young-one of cultivated carps of less than 60 mm length was captured in these nets during the entire period indicating that there is no recruitment of these fishes, warranting regular stocking of fast growing compatible species at optimum density and combination.

#### *4.3.2 Fish seed rearing*

Early fry of *C. catla. L. rohita, C. mrigala* and *C. carpio* obtained from the Tamil Nadu Fisheries Development Corporation Ltd. were reared in the nursery and rearing ponds of the Government Fish Farm (2.0 ha) located adjacent to the reservoir. The advanced fingerlings (above 100 mm long) were segregated using suitable nets of appropriate mesh size (32 mm nets for *C. catla* and *C. carpio* and 25 mm nets for

*L. rohita* and *C. mrigala*) and stocked in the reservoir in small instalments at intervals of 7 to 10 days. Thus, advanced fingerlings were stocked in the reservoir throughout the year so that the population level of cultivated carps was maintained by compensating the reduction due to exploitation, escapement and natural mortality.

*4.3.3 Fingerlings stocked during 1991-92 to 1996-97*

The stocking rate was reduced drastically to 215 fingerlings per ha during 1991-92. It was gradually increased in the subsequent years (Table 7). Among the species stocked, *L. rohita* was the dominant species in the first year (1991-92), followed by *C. catla* (34.4 %) and *C. carpio* (22.2 %). For want of adequate seed of *C. catla* during 1992-93, the rate of stocking in the species has gone down to 19.6 %. Since higher growth rate of the species was assessed through marking techniques, attempts were made to increase the rate of stocking from 19.6 % in 1992-93 to 39.0 % in 1996-97. The rate of stocking in *L. rohita* was gradually reduced from 43.3 % in 1991-92 to 14.3 % in 1995-96, as the growth rate of the species was poor. Since *C. mrigala* seed was not available for stocking in 1991-92, the rate of stocking of the species was only 0.1 %. To compensate this, *C. mrigala* formed the dominant species (31.3 % ) during 1992-93. However, the growth rate of the species was not satisfactory. Hence, the rate of stocking of this species was reduced in the subsequent years. The rate of stocking of *C. carpio* was 22.2 % in 1991-92 and 16.2 % in 1992-93. Since the growth performance of *C. carpio* was next only to *C. catla*, efforts were made to increase the species combination (32.0 to 48.2 %) in the subsequent three years. Seed of silver carp, *H. molitrix* was available only in 1992-93 and 1993-94 and this species was stocked @ 4.3 % and 4.0 % respectively. The stocking rate was ranging from 215 to 606 fingerlings/ha, with an average of 387 nos./ha during 1991-97 . The average stocking rate was maximum in *C. catla* (29.5 %) , followed by *C. carpio* (28.2 %), *L. rohita* (24.1 %), *C. mrigala* (16.9 %) and *H. molitrix* (1.2 %).

*4.3.4 Assessment of growth of cultivated carps through marking techniques*

Since fish production in the reservoir depends much on the growth rate of fish and population density, assessment of growth rate of difference species is a pre-requisite for fishery development. For monitoring the growth rate of fish, tagging and fin removal were tried at Thirumoorthy reservoir.

*4.3.4.1* *Tagging :* Imported T-bar floy anchor tags were used for tagging advanced fingerlings of cultivated carps. One tagged catla was recovered after a free-life period of one year and nine months. The fish had attained a length of 692 mm and weight of 6000 g as against the initial size of 204 mm/105 g, resulting in an increment of 488 mm/5895 g. The T-bar floy anchor tag had a mono-filament of 15 mm long, which was inadequate to accommodate the increment of body growth of marked fish. In the fish recovered, the T-bar floy anchor tag has gone inside the body of the fish leaving a portion of the tubular structure visible outside. To tide over this problem, indigenous tags (35 to 65 mm long) were procured from Tirupur, Tamil Nadu. Serially numbered labels prepared out of letro-embossing machine and tape were attached along with indigenous tags. A few lots of fingerlings of *C. catla, L. rohita, C. mrigala* and *C. carpio* were tagged with 65 mm long tags and released in the reservoir for further observation. The tags were getting entangled to the gill-nets operated in the reservoir and the fingerlings used to escape leaving behind the tags within a few days of their release in the reservoir. Hence, in the subsequent experiments, 35 mm long tags were used instead of 65 mm. In these experiments, the chances of entanglement came down drastically. However, the recovery of tagged fish from the reservoir was poor leading to discontinuation of tagging trials subsequently.

*4.3.4.2* *Fin removal as marking :* Fingerlings of *C. catla, L. rohita, C. mrigala*, and *C. carpio* were subjected to removal of right pelvic fin. The wounded area of marked fish was immediately cleansed with hydrogen peroxide and dry surgical cotton in order to remove the blood stain, body slime and moisture content. A little quantity of Furacin cream was applied on the injury and the marked fish was carefully released into the reservoir. The date-wise stocking of marked fish and their mean size are given below:

| Date of release | Species | Av. total length (mm) | Av. Total weight (g) | Nos. stocked |
|---|---|---|---|---|
| 31.03.93 | *C.carpio* | 85.1 | 8.8 | 4182 |
| 04.05.93 | *C.mrigala* | 107.8 | 10.0 | 4659 |
| 02.07.93 | *L.rohita* | 107.4 | 14.1 | 2302 |
| 14.12.93 | *C.catla* | 94.5 | 12.0 | 3172 |

The details of the marked fish captured from the reservoir through commercial fishing and their growth are presented below species-wise :

*A view of the Government Fish Farm*

*Carp seed netted out from the pond*

***Frame with suitable net for segregating fingerlings***

***Segregated fingerlings for reservoir stocking***

***Feeder canals from the reservoir for irrigation***

*Tagging of fingerlings with T-bar floy anchor tags*

*Common carp fingerlings with indigenous tags*

*Catla with pelvic fin removed*

*Common carp with pelvic fin removed*

*C. carpio* **:** The first specimen was captured during fourth month of its free-life span. A total of 76 specimens were recovered during the month and they had attained an average size of 325.5 mm/664.4 g, with a mean increment of 240.4 mm/655.6 g. This species registered an average growth of 320.0 mm/1213.0 g during 7th month of their free-life period. The fish attained a mean size of 436.9 mm/1538.0 g, 498.2 mm/2512.0 g and 590.0 mm/3500.0 g with an average growth increment of 351.7 mm/1529.4 g, 413.0 mm/2503.7 g and 504.8 mm/3491.1 g in the first, second and third year respectively. The number of marked fish recovered per month in the species was maximum (134 – 214) between 5th and 9th months, but declined in the subsequent months. Altogether, 1128 specimens (26.9 %) were recovered from the reservoir during a period of 42 months. Of these, 932 specimens (83 %) did not have regeneration of the right pelvic fin. Though deformed fins were noticed in the rest of the specimens (17 %), the marked fish could be easily identified from the variation in the length, breadth and number of rays compared to the normal fin in the same specimen.

*C. catla* **:** Fifteen specimens were harvested during 5th month of their free-life span. The mean length and weight of these specimens were 381.2 mm/800.0 g, with an average increment of 286.7 mm/788.0 g. This species attained an ideal marketable size of more than 1 kg in weight only during 6th month when 39 specimens with an average size of 419.3 mm/1166.6 g and an average increment of 324.8 mm/1154.6 g were harvested from the reservoir. This species attained an average size of 528.4 mm/2345.0 and 694.1 mm/5807.1 g in the first and second year respectively. A total of 1370 fish (43.2 %) was recaptured during a period of 34 months. The recovery of marked fish was well distributed almost in all the months up to 31 months, but the number declined in the subsequent months. Majority (99.5 %) of the marked fish in this species landed without regeneration of right pelvic fin. However, a few (0.5%) had smaller fins having 1 to 6 rays.

*C. mrigala* **:** The first marked specimen of *C. mrigala* which appeared in the fish landings during 13th month of its free-life period had a total length of 425.0 mm and a total weight of 700 g, recording a growth of 317.2 mm/690.0 g. During 14th month, 11 specimens were harvested with an average size of 436.5 mm/1036.3 g. At the end of the 2nd year, the species attained a total length of 532.7 mm and weight of 1555.0 g, with an average increment of 424.9 mm/1545.0 g. The species reached a size of 596.0 mm/2112.6 g with a mean growth of 488.2 mm/2102.6 g at the end of

3rd year. Altogether, 1365 marked fish (29.3 %) were recovered in the species during the period of 43 months. Of these recoveries, 92.1 % did not have regeneration of right pelvic fin. While single deformed ray was encountered in 58 specimens (4.6 %), 2, 3 and 4 rays were recorded in 26 (2.1 %), 9 (0.7 %) and 6 (0.5 %) specimens respectively.

***L. rohita* :** The first marked specimen of the species was captured during 14th month of its release in the reservoir. The fish had attained a total length of 382.0 mm and a total weight of 550.0 g, registering a growth of 274.6 mm/535.9 g. The recovery of marked fish was a rare occurrence upto 30th month. However, regular landings in this species were encountered from 31st month onwards. Specimens weighing more than 1 kg were recorded only after 33 months of free-life span. The growth increment of this species was <500 g in the first year, 650 g in the 2nd year and 1000 g in the 3rd year. A total of 133 marked fish (5.8 %) was captured during a period of 42 months. While the right pelvic fin was totally absent in 130 specimens (7.7 %), deformed fins with a few incomplete rays were observed in the rest.

The growth rate was the highest in *C.catla*, followed by *C. carpio, C. mrigala* and *L. rohita* (Fig. 5a). The growth rate of marked fish was identical with that of the normal (unmarked) fish (Fig. 5b) indicating that the removal of the pelvic fin in carps has not affected the growth rate of fish. Similarly, the high recovery of marked fish suggests that it has not hampered the survival also. The study confirms that the removal of pelvic fin as a marking technique is a suitable method for assessing the growth of fish in the open waters.

#### *4.3.5 Food and feeding habits of commercially important fishes*

The food and feeding in four commercially important fishes, *viz*., *C. catla, H. molitrix, L. rohita* and *O. mossambicus* from the reservoir were studied by analysis of gut contents. The study revealed that all these four species were predominantly phytophagous in nature. Green algae dominated the food items in all the species, with maximum percentage in *O. mossambicus* (55 %), followed by *H.molitrix* (45 %), *L. rohita* (36 %) and *C. catla* (34 %). Blue-green algae occupied the second position among the food items in three species other than *C. catla* in which the contribution by crustaceans was substantial (28 %), followed by blue-green algae (18 %). With 32 % crustaceans and rotifers, *C. catla* revealed its preference for zooplankton. However, in phytoplankton dominated reservoir like Thirumoorthy, the fish is forced to consume a substantial quantity of phytoplankton (55 %). The phytophagous fish, *H. molitrix* had consumed algae and diatoms to an extent of

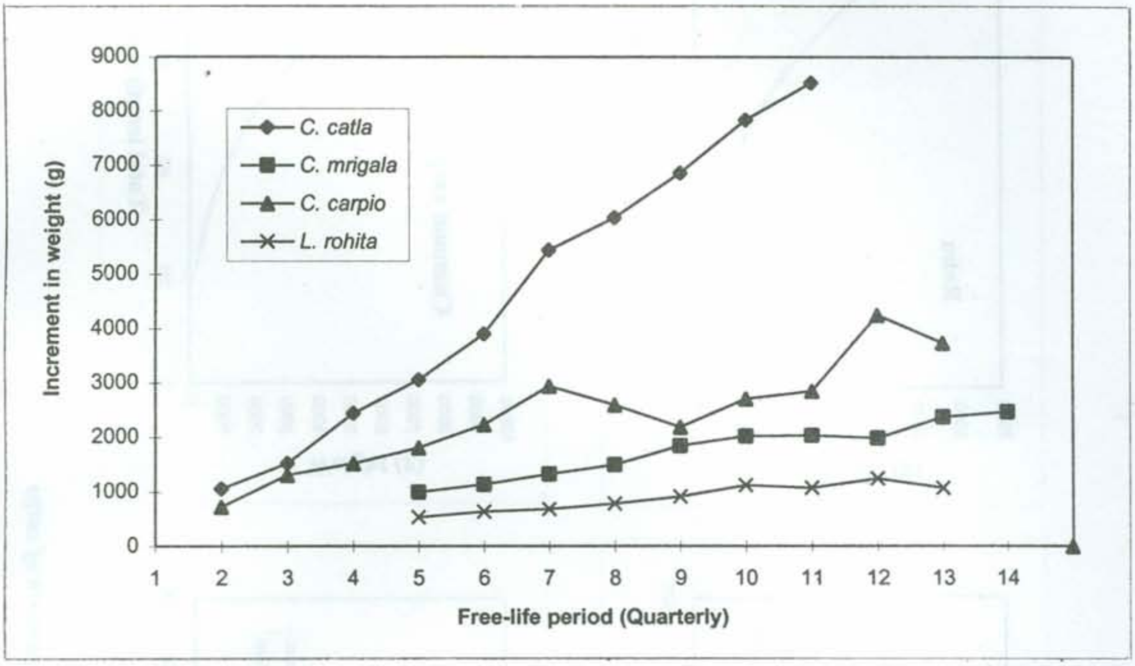



**Fig. 5a.** ***Growth of marked catla, rohu, mrigala and common carp***

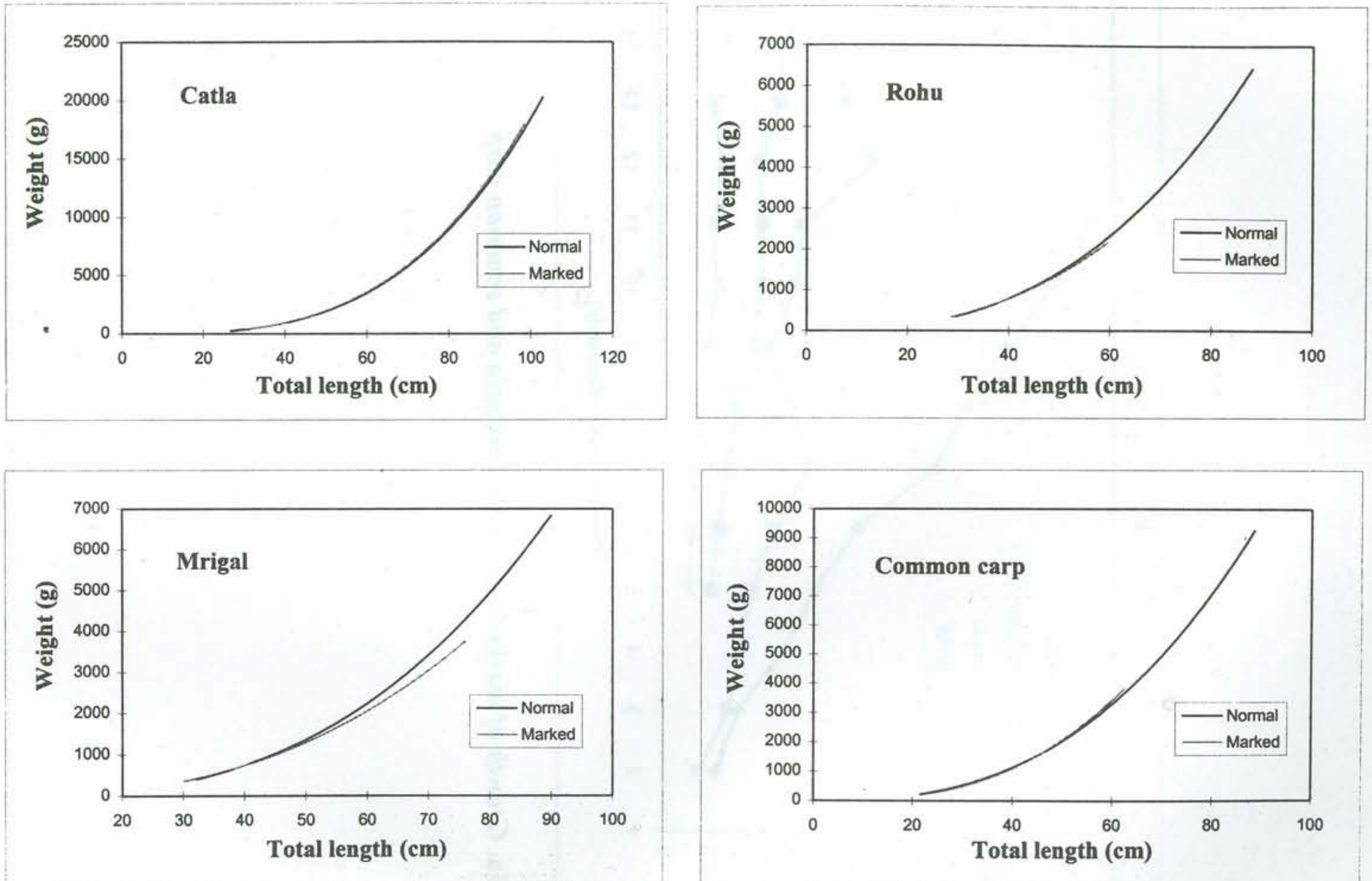
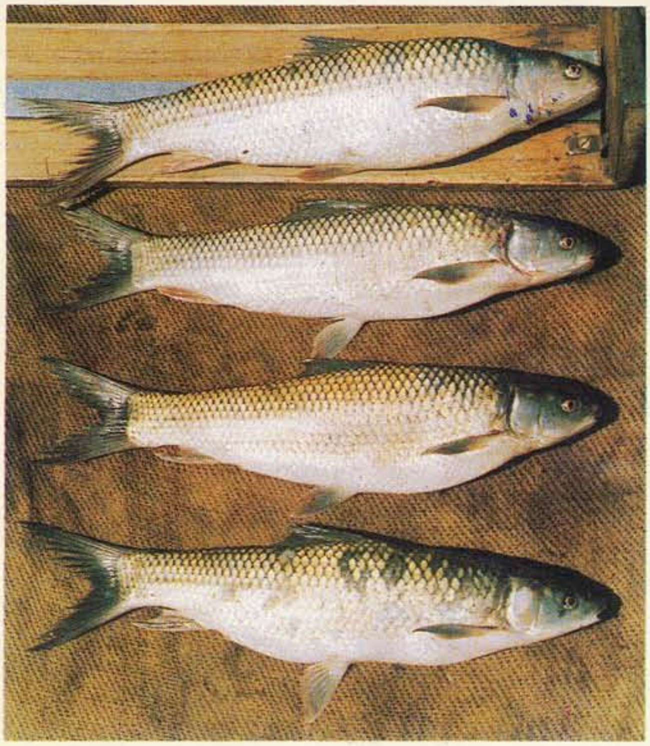



**Fig 5b.** ***Impact of removal of pelvic fin on the growth of carps***

***Marked catla recovered from the reservoir***

***Marked specimens recovered in a day***



***Marked mrigal recovered from the reservoir***

***Stocked species forming the major fishery***

**Catla :**

Male : $\log W = -4.198368 + 3.026427 \log L$ (n=260, r=0.94)
*(0.0706)*

Female: $\log W = -4.875806 + 3.193736 \log L$ (n=774, r=0.97)
*(0.0274)*

Pooled : $\log W = -5.111697 + 3.242872 \log L$ (n=329, r=0.96)
*(0.0160)*

Regression lines of males and females are significantly different at 5%.

**Rohu :**

As the regression lines of male and female were not significantly different (5%), a combined length-weight relationship was estimated as follows:

Males + Females : $\log W = -2.716250 + 2.562379 \log L$ (n=532, r=0.88)
*(0.0591)*

Pooled : $\log W = -3.199315 + 2.674011 \log L$ (n=2183, r=0.88)
*(0.0312)*

**Mrigal :**

Male : $\log W = -2.978466 + 2.613155 \log L$ (n=473, r=0.88)
*(0.0664)*

Female : $\log W = -3.682319 + 2.790151 \log L$ (n=1536, r=0.91)
*(0.0335)*

Pooled : $\log W = -3.555862 + 2.752883 \log L$ (n=3461, r=0.90)
*(0.0233)*

Regression lines of males and females are significantly different at 5%.

**Common carp :**

Male : $\log W = -2.417219 + 2.560358 \log L$ (n=687, r=0.85)

*(0.0598)*

Female: $\log W = -2.754938 + 2.659322 \log L$ (n=1800, r=0.91)

*(0.0287)*

Pooled : $\log W = -2.746206 + 2.650619 \log L$ (n=3275, r=0.89)

*(0.0231)*

Regression lines of males and females are significantly different at 5%.

**Silver carp :**

As the regression lines of male and female were not significantly different (5%), a combined length-weight relationship was estimated as follows:

Males + Females: $\log W = -4.707737 + 3.068857 \log L$ (n=245, r=0.95)

*(0.0622)*

Pooled : $\log W = -5.381747 + 3.220536 \log L$ (n=310, r=0.97)

*(0.0441)*

The length-weight relationship of cultivated carps in Thirumoorthy reservoir is depicted in Figs. 6 & 7.

*4.3.8 Condition factor ($K_n$) of cultivated carps*

The condition factor which reveals the well-being of the fishes was calculated for cultivated carps captured from the reservoir through months. While the condition factor was calculated separately for males and females in catla, mrigal and common carp, it was calculated for males and females together in case of rohu and silver carp. The relative condition factor during different months was varying from 0.984 (August) to 1.109 (November) in catla males and from 1.057 (June) to 1.195 (February) in females. Similarly, the value ranged from 0.91 (February) to 1.104 (July) in mrigal males and from 0.985 (December) to 1.1187 (June) in females. The relative condition factor of catla and mrigal are depicted separately for males and

86%, with meagre quantity of crustaceans (8%) and rotifers (2%), indicating that silver carp is not competing with catla to the extent as usually feared by fishery managers.

*4.3.6 Sex ratio in commercially important carps*

A total of 1092 catla, 604 rohu, 987 mrigal, 1638 common carp and 79 silver carp were examined for estimating the sex ratio. The ratio between the male and the female in these species was as given below:

| **Species** | **Male : Female** |
|---|---|
| *C. catla* | 1 : 1.57 |
| *L. rohita* | 1 : 1.85 |
| *C. mrigala* | 1 : 1.87 |
| *C. carpio* | 1 : 1.70 |
| *H. molitrix* | 1 : 1.30 |

The study revealed that the females are preponderant in the population.

*4.3.7 Length-weight relationship of different species*

The length-weight data of different species, collected during 1993-95 were analysed. The length-weight relationships of *C. catla*, *L. rohita*, *C. mrigala*, *C. carpio* and *H. molitrix* were estimated for both male and female separately as well as for pooled data of males, females and indeterminates. Comparison of fitted regression lines were made using Analysis of Covariance (ANCOVA) for each of above mentioned species and it was observed that the regressions of males and females were found to differ significantly in case of catla, mrigal and common carp. However, the regressions in respect of rohu and silver carp were not significantly different and hence, the length-weight data on males and females for both these species were combined and then the length-weight relationships were estimated. The results have been summarised below. The figures within brackets indicate the standard error of respective regression coefficients.

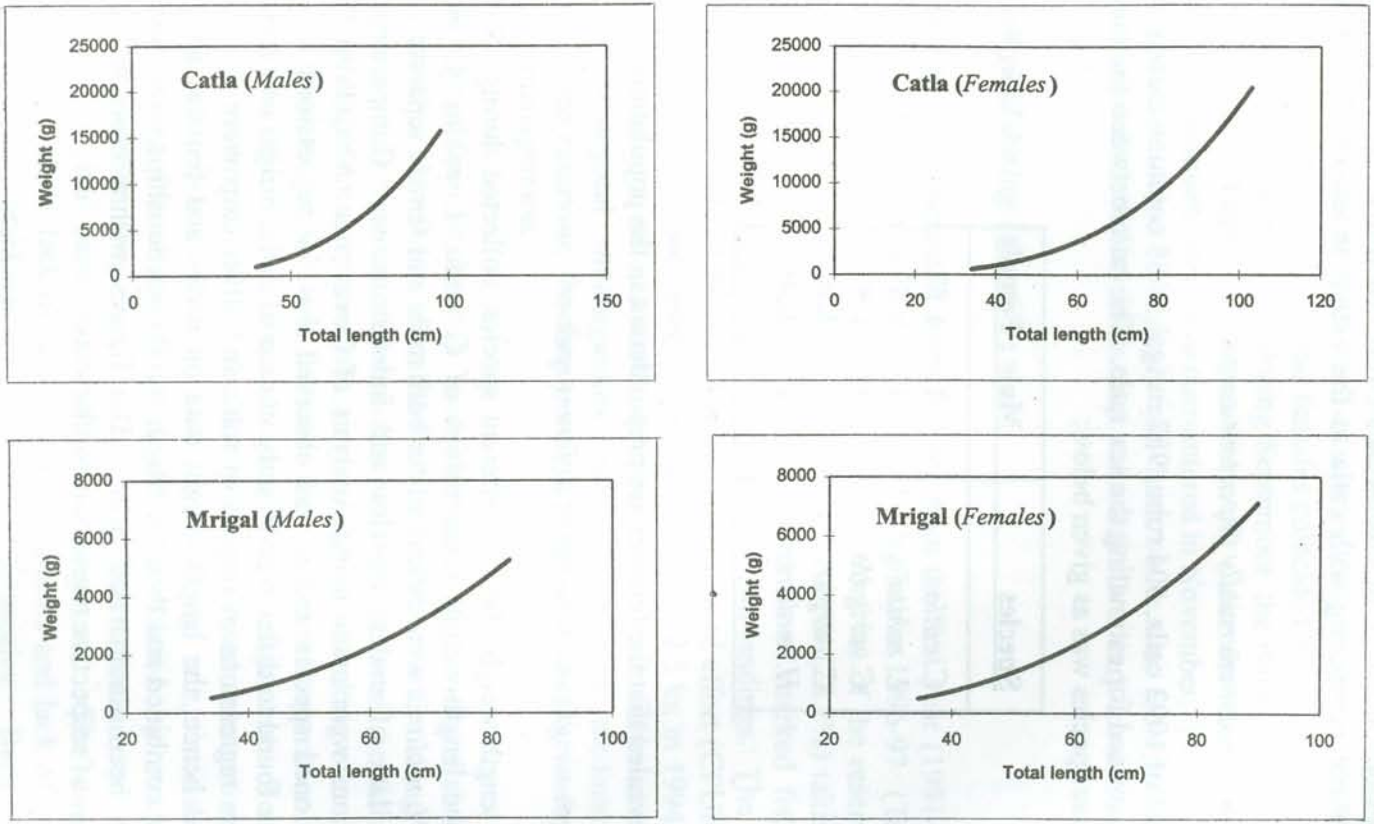



Fig. 6. *Length-weight relationship of Catla and Mrigal*

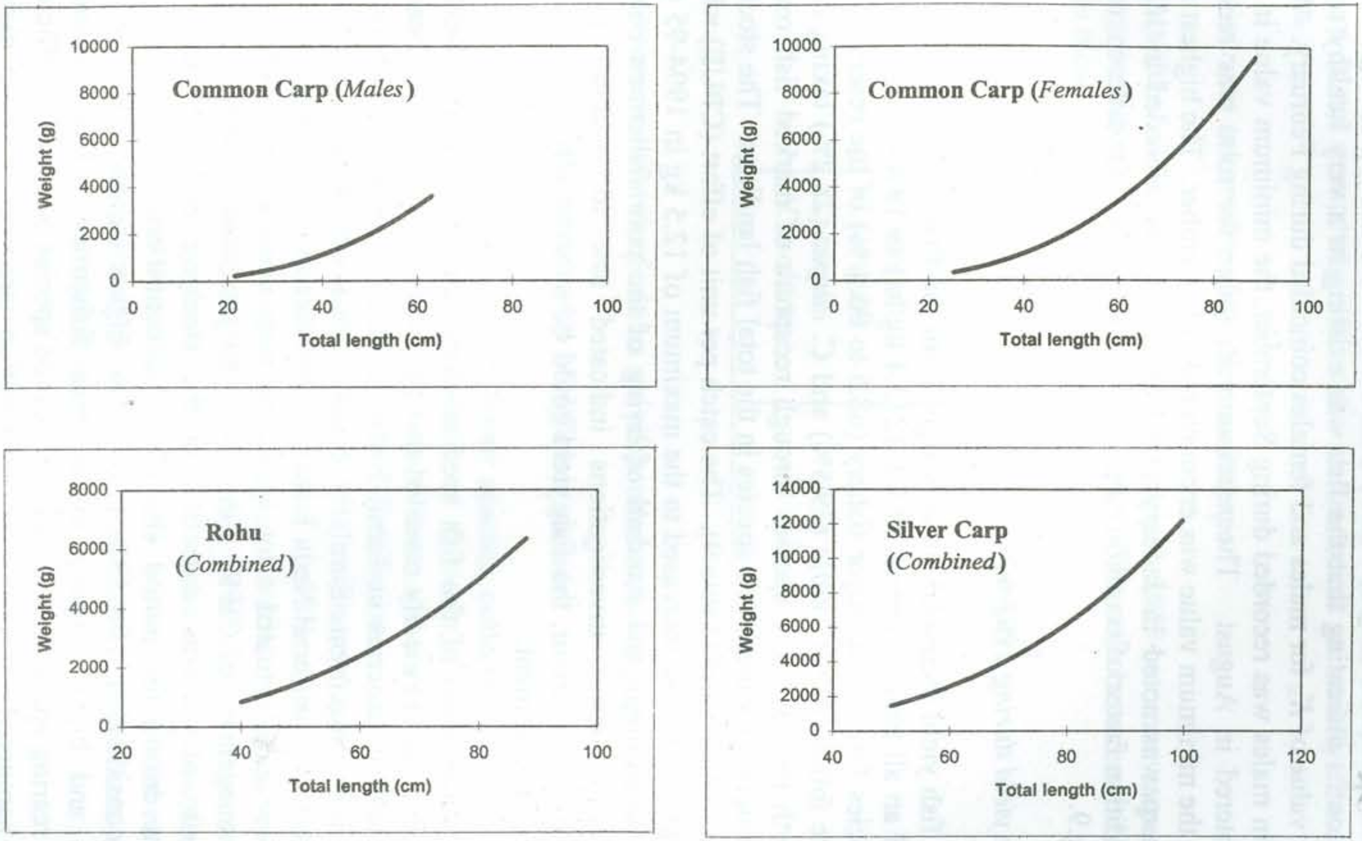



**Fig. 7.** ***Length-weight relationship of Common Carp, Rohu and Silver Carp***

females through months (Fig.8). The $K_n$ value for common carp was greater than 1 in all the months indicating that the fish was existing in a very healthy condition. The highest value of $K_n$ for males and females coincided during February. While the least value in males was recorded during September, the minimum value in females was encountered in August. The maximum $K_n$ value for rohu was recorded in August and the minimum value was encountered in November. The highest $K_n$ value for silver carp was noted in January and least value was recorded in July. The relative condition factor of common carp, rohu and silver carp for different months is given in Fig.9.

*4.3.9 Fish yield during 1991-97*

The fish yield increased steadily right from the first year (1991-92) onwards and reached an all-time record of 49.9 t (213.4 kg/ha) in 1996-97 (Table 8). The stocked species formed the major fishery (88.5 to 96.4 %) of the reservoir. Higher stocking rate followed in *C. catla* (29.5%) and *C. carpio* (28.2%) taking clue from higher growth rate of these species through recapture of marked fish resulted in higher contribution by these two species in the total fish landings. The stocking had direct impact on the yield (Table 9). The catch per unit of effort (CPUE) which was low (5.65 kg) in 1991-92 increased to the maximum of 12.5 kg in 1994-95 (Fig.10), improving the earnings and standard of living of the poor fishermen community. Though the ecological investigations indicated low to medium production potentiality of the reservoir, the fish yield could be substantially increased through better fishery management.

The comparison of the fish seed stocking and the total fish catch during different years (Fig.11) clearly revealed that the high rate of stocking practiced by the Department of fisheries in Tamil Nadu has not improved the fishery and that there was a mismanagement. Similarly, in spite of heavy stocking of major carp seed during 1978-91 by the Tamil Nadu Fisheries Development Corporation Ltd., the fish yield was low and fluctuated a lot, indicating poor management. However, under scientific management of CIFRI , the fish yield increased substantially year after year, in spite of drastic reduction in the stocking rate, indicating efficient management during the period (Fig.12). The contribution by stocked varieties increased considerably (Fig.13), leading to higher revenue to the fisheries corporation and higher earning to the poor fishermen. The constraints like inadequate rearing space, lack of seed of desired species and lack of efficient gears and crafts hampered stocking and exploitation strategies. Better management

**Table 8 : The fish yield (kg) during 1991-92 to 1996-97**

| Species | 1991-92 | 1992-93 | 1993-94 | 1994-95 | 1995-96 | 1996-97 |
|---|---|---|---|---|---|---|
| **Group I** | | | | | | |
| *C. catla* | 5142.15 | 9088.70 | 12962.70 | 15416.40 | 17766.60 | 20075.70 |
| *L. rohita* | 6517.70 | 6502.90 | 3097.15 | 3108.60 | 4432.00 | 7614.40 |
| *C. mrigala* | 3178.50 | 5151.80 | 4660.95 | 5573.10 | 5887.30 | 7140.20 |
| *C. carpio* | 329.80 | 1067.10 | 6314.40 | 7690.70 | 7905.95 | 8314.20 |
| *H.molitrix* | 182.60 | 649.95 | 205.90 | 64.90 | | |
| **Group II** | 1783.25 | 1469.05 | 2040.40 | 2154.80 | 1442.10 | 2454.70 |
| Major carps (Spoiled) | 941.50 | | 1140.40 | 1074.00 | 1636.70 | 1669.50 |
| **Total (kg)** | **18075.50** | **23929.50** | **30421.90** | **35082.50** | **39070.65** | **47268.70** |
| **Contribution (%)** | **88.5** | **89.9** | **96.4** | **91.0** | **91.7** | **94.7** |
| **Group III** | 1632.15 | 1201.15 | 607.40 | 1785.20 | 1540.30 | 859.50 |
| **Group IV** | 644.70 | 1255.60 | 444.80 | 1640.80 | 1958.40 | 1771.00 |
| **Special Group** | 75.50 | 224.25 | 69.65 | 64.00 | 31.00 | 34.70 |
| **Total (kg)** | **2352.35** | **2681.00** | **1121.85** | **3490.00** | **3529.70** | **2665.20** |
| **Contribution (%)** | **11.5** | **10.1** | **3.6** | **9.0** | **8.3** | **5.3** |
| **Total yield (kg)** | **20427.85** | **26610.50** | **31543.75** | **38572.50** | **42600.35** | **49933.90** |
| Yield/ha/year | 87.3 | 113.7 | 134.8 | 164.8 | 182.1 | 213.4 |
| CPUE (kg) | 5.65 | 7.01 | 9.18 | 12.5 | 10.63 | 10.27 |

Group I : Major carps of more than 1 kg
Group II : Major carps of less than 1 kg
Group III : Larger tilapia
Group IV: Smaller tilapia and other fishes

Special Group : Eels and Murrels

**Table 9 : The stocking and yield relationship (%) in cultivated carps**

| Year | *C. catla* | | *L. rohita* | | *C. mrigala* | | *C. carpio* | | *H. molitrix* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Stock | Yield | Stock | Yield | Stock | Yield | Stock | Yield | Stock | Yield |
| 1991-92 | 34.4 | 28.4 | 43.3 | 36.1 | 0.1 | 17.6 | 22.2 | 1.8 | - | - |
| 1992-93 | 19.6 | 37.9 | 28.6 | 27.2 | 31.3 | 21.5 | 16.2 | 4.5 | 4.3 | - |
| 1993-94 | 22.6 | 42.6 | 23.7 | 10.2 | 17.7 | 15.3 | 32.0 | 20.8 | 4.0 | - |
| 1994-95 | 24.9 | 43.9 | 20.3 | 8.9 | 21.0 | 15.9 | 33.8 | 21.9 | - | - |
| 1995-96 | 31.6 | 45.5 | 14.3 | 11.3 | 5.9 | 15.1 | 48.2 | 20.2 | - | - |
| 1996-97 | 39.0 | 42.5 | 24.2 | 16.1 | 19.5 | 15.0 | 17.3 | 17.6 | - | - |
| Average | 29.5 | 40.1 | 24.0 | 18.3 | 16.9 | 16.7 | 28.2 | 14.5 | 1.2 | 0.8 |

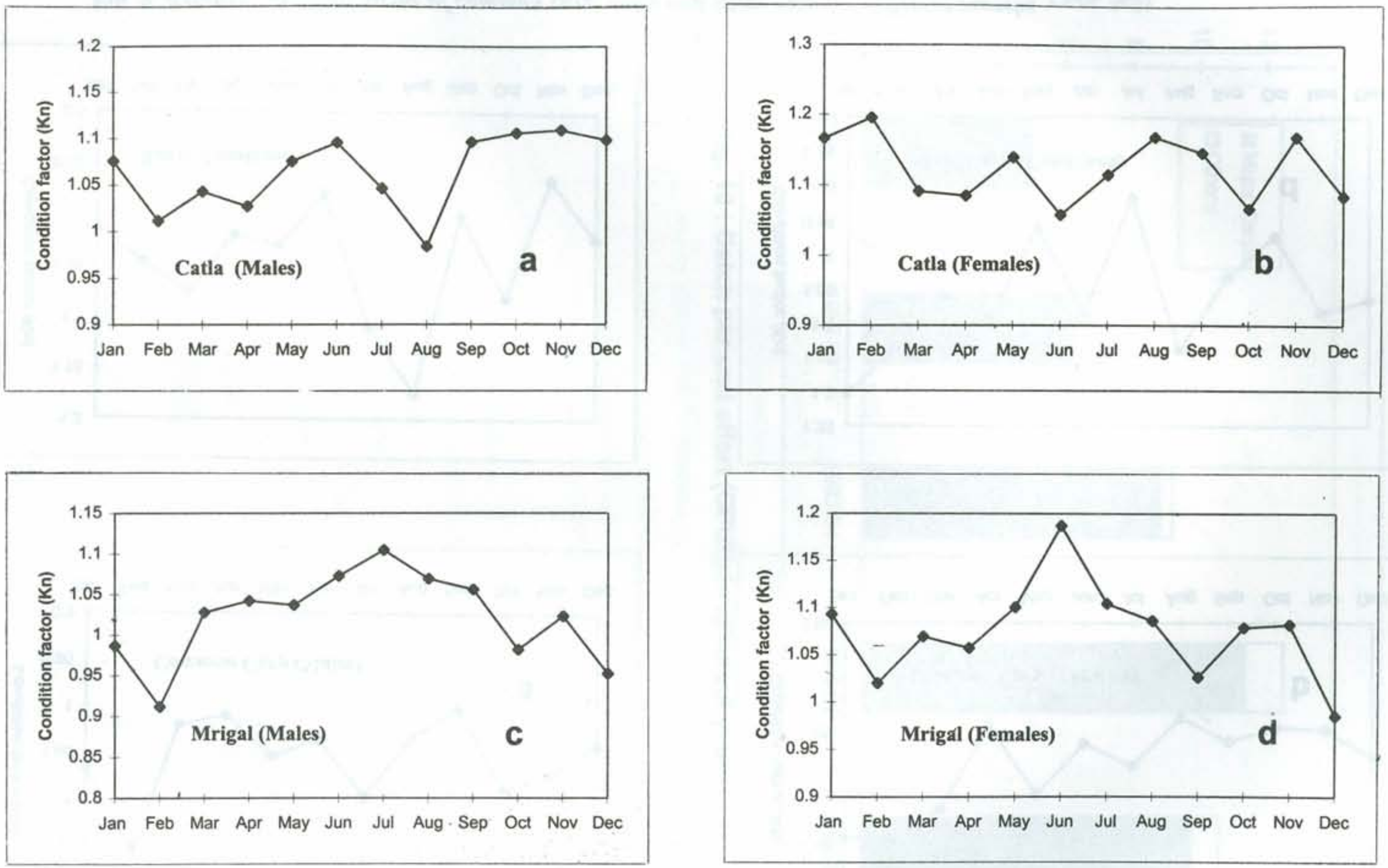



**Fig. 8.** ***Relative condition factor of catla and mrigal for different months***

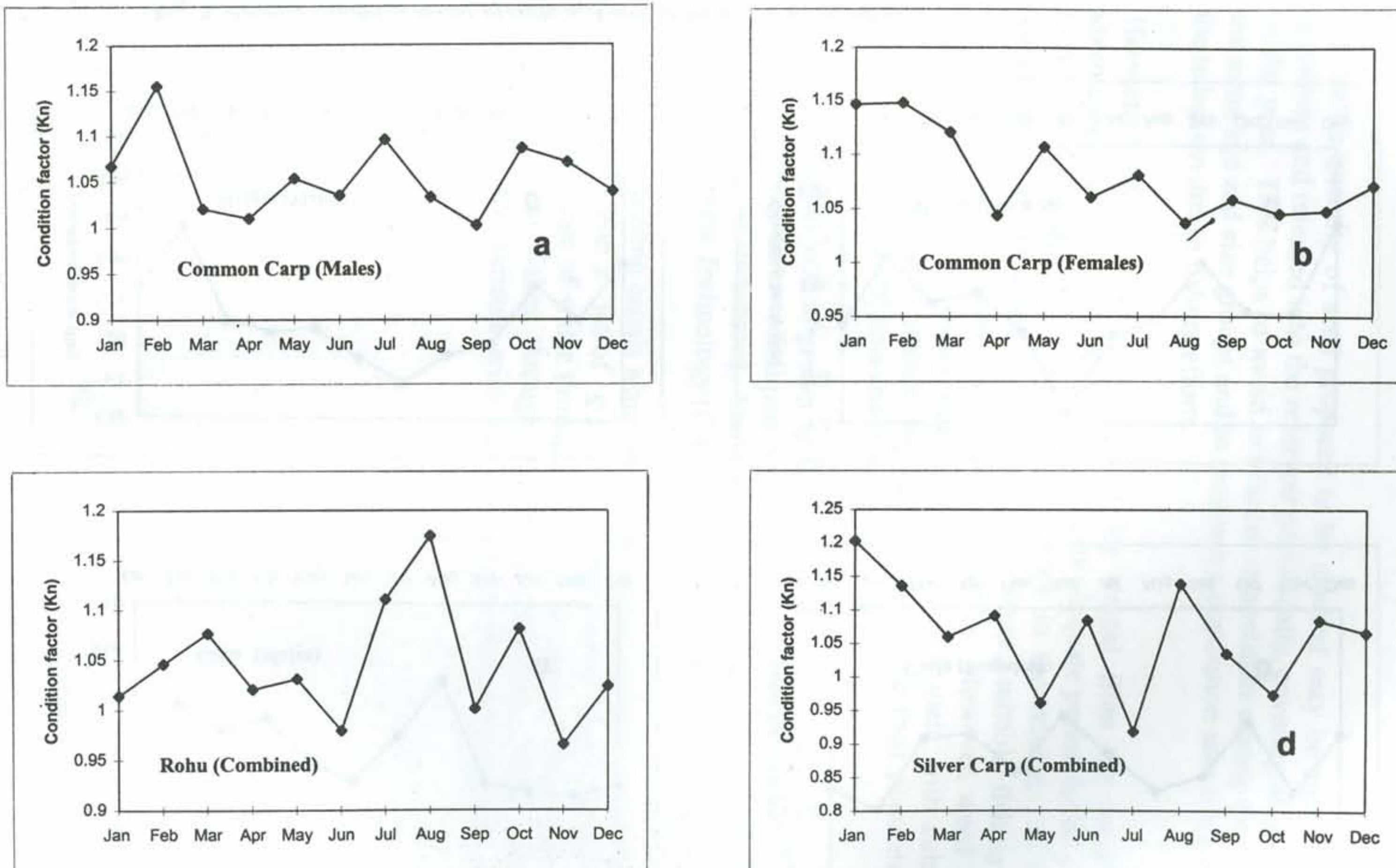



**Fig. 9.** ***Relative condition factor of common carp, rohu and silver carp for different months***

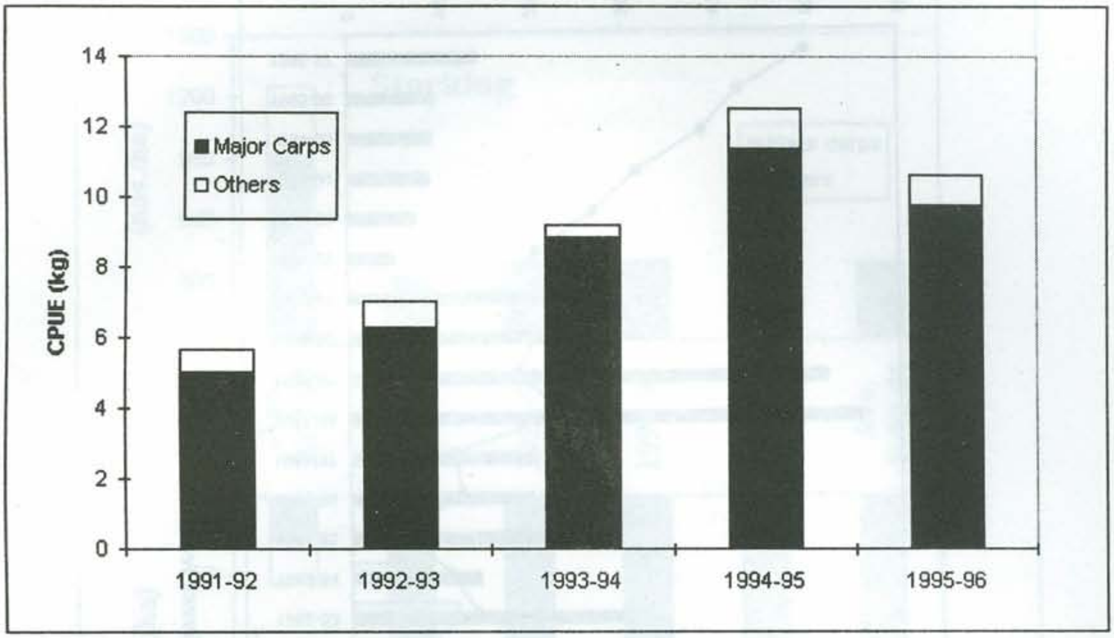



**Fig. 10 : Catch per unit effort (CPUE) in different years**

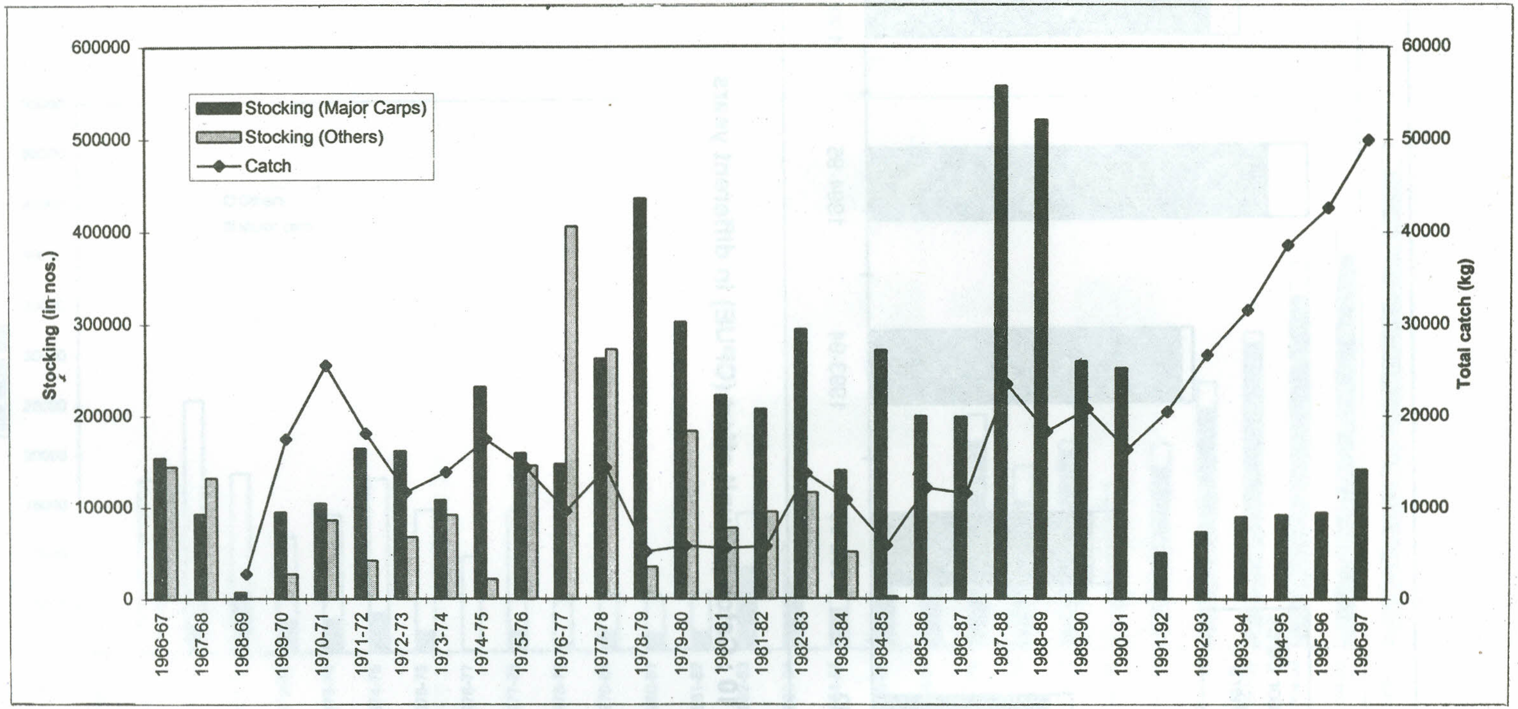



**Fig. 11.** ***Stocking (in nos.) and total fish catch (in kg) during different years***

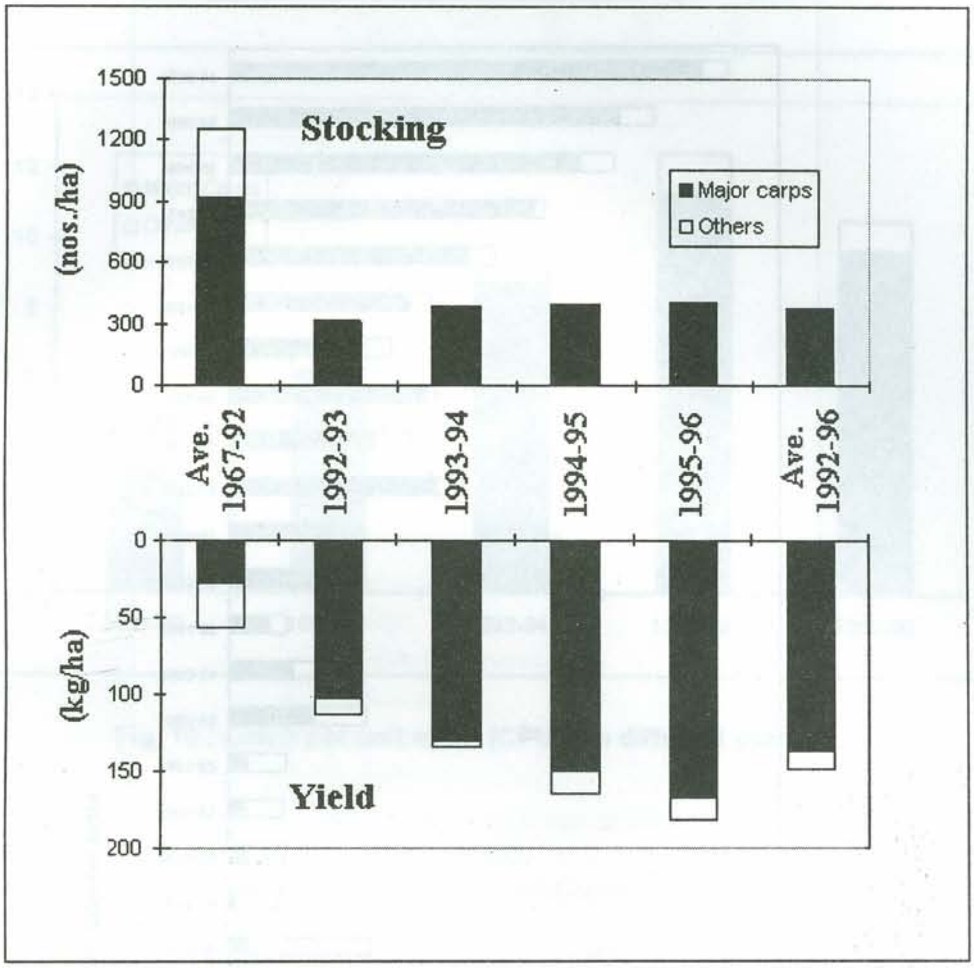



Fig. 12 : Impact of stocking on the yield before and after CIFRI's management

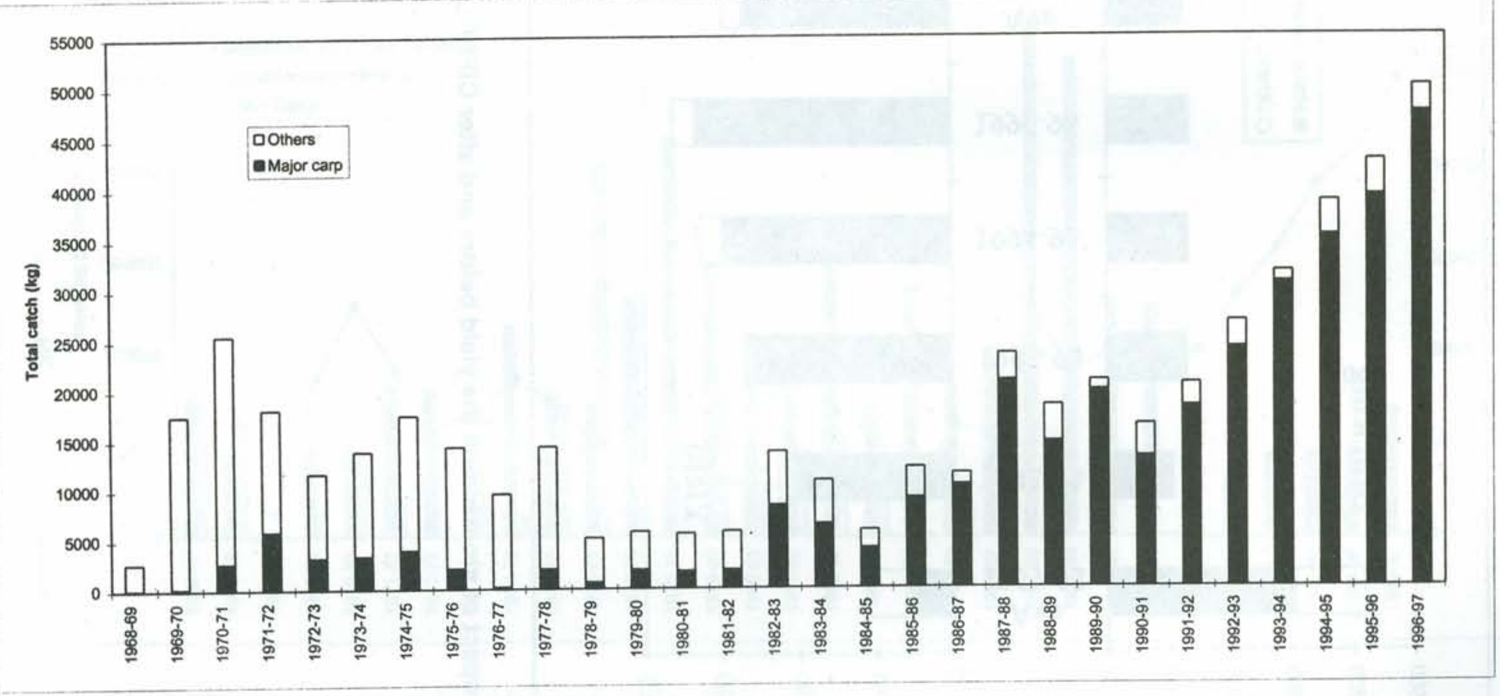



Fig. 13. *Contribution by major carps and others in different years*

techniques in these aspects would enhance the fish yield further towards the assessed potentiality of 268.1 kg/ha/year.

## 5. Recommendations

Based on the investigations carried out at Thirumoorthy reservoir and the results obtained, the following recommendations are made for future follow up action.

1. Recruitment studies revealed that the fast growing carps which were released into the reservoir for propagation do not attain sexual maturity and breed in the reservoir. In the absence of natural recruitment of cultivable carps, it becomes essential to stock the reservoir with quality fish seed from extraneous source so that the fish food organisms will be utilized by these fishes and form a fishery of our choice. Failure to do so will encourage weed fish and other minor carps to utilize the rich food resources and multiply their progeny. To avoid economical loss, it is essential to stock the reservoir with seed of fast growing herbivorous fishes.

2. While stocking, care must be taken to release healthy fingerlings of more than 100 mm in length to avoid attack by predatory fishes and also by weed fishes.

3. The following species-mix is suggested for Thirumoorthy reservoir based on the rate of growth and food availability for achieving optimum fish production.

| | | |
|---|---|---|
| *C. catla* | = | 40 - 50 % |
| *L. rohita* | = | 5 - 10 % |
| *C. mrigala* | = | 10 - 15 % |
| *C. carpio* | = | 20 - 30 % |
| *H. molitrix* | = | 2 - 5 % |

4. As stocking of advanced fingerlings in healthy condition resulted in higher survival and recovery of grown-up fish for marketing, the stocking density could be reduced to around 380 nos./ha. As such, a total of 90000 advanced fingerlings appeared to be sufficient for Thirumoorthy reservoir.

5. The entire quantity of seed proposed to be stocked may be split into small quantities and released into the reservoir periodically, covering all the months of the year. This helps to avoid unhealthy competition among the fishes of the same age and size groups and to maintain a population size compensating the reduction due to fishing efforts.

6. Harvesting of fishes of more than 1 kg weight from the reservoir is advantageous in certain aspects. The fish gets adequate period for its growth. A fish of more than 1 kg fetch higher price in the market. It is also considered to be ideal size for marketing. Hence, suitable fishing gears should be operated to capture the stocked varieties. However, weed fishes, minor carps, predatory fishes and tilapia which compete with cultivated carps for food and space should be exploited to reduce their population by operating small mesh gill-nets and other suitable gears.

7. As effective exploitation of grown up fishes from the reservoir is an integral part of the management techniques for enhancing fish yield, new gears and techniques must be introduced. Assistance could be sought from the Central Institute of Fisheries Technology (CIFT), ICAR, Cochin in this respect.

8. Fishing in the irrigation canals when water discharge is reduced or completely stopped revealed that a lot of grown up fishes escape from the reservoir along with discharge of water through the canal net work. To prevent the loss of grown up fishes through downward migration along with the discharge of water, suitable wire mesh structures should be erected in the outlet canals.