ECOLOGY-BASED FISHERIES MANAGEMENT IN ALIYAR RESERVOIR

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

Ecology-based fisheries management in Aliyar reservoir

Prepared by
C. Selvaraj
V. K. Murugesan
V. K. Unnithan

Bull. No. 72 **Feb. 1997**

(Issued on the occasion of Golden Jubilee Celebrations)

Central Inland Capture Fisheries Research Institute
(Indian Council of Agricultural Research)
Barrackpore 743101 west Bengal

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(Golden Jubilee Bulletin of CIFRI)

C. Selvaraj, V. K. Murugesan & V. K. Unnithan

ISSN 0970-616 X

Edited and composed at : **The Project Monitoring & Documentation Section**
CIFRI Barrackpore

Published by : **The Director,** CIFRI Barrackpore

Printed at : The Calcutta Laser Graphics (Pvt.) Ltd
71, Hari Ghosh Street
Calcutta 700 006

FOREWORD

Small reservoirs constitute one of the most significant inland fisheries resources of the country. Primarily meant for irrigation, flood control and drinking water purposes, they are unique semi-controlled water bodies forming an important resource for fish production. Small reservoirs taken up by CIFRI as models for fishery development could lead to evolution of practical guidelines to be adopted all over the country. Production-oriented, ecologically relevant strategies adopted in selected reservoirs not only help assessing their biotic potential, but also invite attention of fishery managers who are enthusiastic about emulating these results in similar water bodies under their jurisdiction. Such pilot studies, therefore, bear significant relevance especially in the context of the depressingly low average fish yield now being realised from small reservoirs of India.

It was with this objective that the CIFRI took up Aliyar reservoir under the All India Co-ordinated Project on Ecology and Fisheries of Freshwater Reservoirs. After the Co-ordinated Project was terminated, the work on the reservoir continued as a Mission Project of the Institute with a target of attaining a sustained fish yield of 150 kg/ha/yr. I am proud to place on record that the untiring efforts and vision of the scientists engaged in the Project culminated in a record yield of 193 kg/ha/yr from the reservoir, surpassing the target by a big margin. This achievement is particularly significant in the context of the general notion that Aliyar was an unproductive oligotrophic water body.

The Project has not only boosted up the yield from the reservoir but also provided a new dimension to the concept of small reservoir fisheries management. It has now been established that higher yield is not a mere function of high stocking rate, but rests more on the size, method and composition of stocking. This bulletin presents the salient findings and achievements made under the project.

I place on record my full appreciation for the excellent and dedicated work done by Shri C. Selvaraj, Shri V.K. Murugesan and Dr. V.K. Unnithan who took pains to compile and analyse the data meticulously and to prepare this bulletin. The unflinching cooperation received from the Department of Fisheries, Tamil Nadu and the Tamil Nadu Fisheries Development Corporation is worth mentioning. Without their support in the form of facilities such as farm, inputs, boat and vehicle, the project would have found it difficult to achieve the target. The morphometric and meteorological data received from Public Works Department, Tamil Nadu and the Agricultural Research Station (Tamil Nadu Agricultural University), Aliyar Nagar are thankfully acknowledged. I trust that the Aliyar model would be adopted in innumerable small reservoirs of the country.

Dr. M. Sinha
Director
CIFRI

The following Scientific and Technical staff of Central Inland Fisheries Research Institute participated in the Project

Name	Designation	Time spent
Shri C. Selvaraj	Principal Scientist & Project Leader	17.01.83 - 31.03.92
Shri V.K. Murugesan	Senior Scientist	13.06.85 - 31.03.92
Shri P.K. Aravindakshan	Senior Scientist	01.04.85 - 15.07.87
Dr. M. Kaliyamurthy	Senior Scientist	01.04.85 - 22.06.87
Dr. Mathew Abraham	Senior Scientist	20.08.82 - 10.04.87
Dr. K. Gopinathan	Senior Scientist	27.09.82 - 18.12.85
Dr. V.K. Unnithan	Senior Scientist	16.10.91 - 31.03.92
Shri R.N. Seth	Senior Scientist	19.11.90 - 12.04.91
Dr. K.O. Joseph	Senior Scientist	29.08.85 - 23.05.87
Shri R.C. Singh	Technical Asst. T-5	29.08.88 - 13.04.90

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INTRODUCTION

The small reservoirs in India are known to have the capacity to hold substantially high fish production potential. However, the quantum of fish realised from these water bodies remains unimpressive. The low yield stems from the inadequate knowledge of the intrinsic production dynamics of these biotopes and poor adoption of scientific management strategies. Being located at different geo-climatic regions of the country, the reservoirs differ from one another greatly in their morphoedaphic characters. Consequently, their ecology also differs from one another in varying degrees influencing the suitability of general guidelines for fisheries management. Nevertheless, researches conducted in selected reservoirs, selected as types, help us in arriving at common strategies for a group of reservoirs. Aliyar reservoir is one such water body that could represent several of Indian reservoirs. Therefore, ecology-based fisheries investigations were carried out in this reservoir over a period of nine years (1983-92) and the package was evolved to manage its fisheries with a scientific basis. Thhe reservoir was considered to be oligotrophic with a low production potentiality based on the limnological investigations. Through a scientific approach, this apprehension was set at rest and the yield from the reservoir was enhanced to 193 kg/ha/yr from the average yield of 26.2 kg realised earlier.

During the course of the investigations, the project gathered a wealth of information that have a long-lasting bearing on the fisheries management of small reservoirs. The criteria adopted to achieve a high fish yield are described in this Bulletin.

Backgound

Soon after the formation of the reservoir in 1962, the State Fisheries Department took up the reservoir for fisheries management through stocking. The stocking was done at a very high density ranging from 303 to 2452 nos./ha, with a mean value of 1272 nos./ha. The medium and minor carps including *Puntius carnaticus, P. dubius, P. kontius, Labeo fimbriatus, L. calbasu, Cirrhinus reba, C. cirrhosa and Acrossocheilus hexagonolepis* mainly contributed to the bulk of the seed stocked (85.5-100.0%) against the meagre quantity of the major carps. The reservoir was stocked even with murrels, tilapia and chanos.

The seed stocking was normally completed within the limited period between August and October and the high density led to heavy competition between the members of the same cohort as they grew. As a result, the individual fish registered a poor growth rate and the contribution to the fishery was meagre. The small size at stocking time made them an easy prey to the carnivores in the ecosystem. The policy of stocking never had an ecology base or a consideration to the production potential of the reservoir. Neither it took care of the growth rate nor the feeding habits of the different species in the ecosystem.

The fishermen operated gillnets of even very small mesh size, leading to an indiscriminate harvest. As a result, majority of the stocked fishf were not allowed to reach optimum size for the harvest and they were not able to dominate over the trash fish in the reservoir.

The yield from the reservoir ranged from 2.67 to 54.53 kg/ha/yr with an average value of 26.21 kg over a long period from 1964-65 to 1984-85. The bulk of the yield consisted of uneconomic varieties, fetching poor revenue to the Department as well as to the fishing communities. The fishermen did not find fishing in Aliyar remunerative even at a higher share of 50% of their catch. The departmental fishing had to be discontinued as the units controlled by them brought ashore disappointingly low quantity of fishes.

Scientific approach in fishery management

CIFRI took up fisheries management in 1983 with the aim to assess the biotic potential of the reservoir and to manage its fishery to the best of the limit permitted by the ecosystem. Understanding the ecological process in the reservoir, revising the stocking policy and a strategic change in the harvest pattern were, in general, the predetermined objectives of the intervention. Basic facilities like farm, inputs, data on fisheries and vehicle were provided by the State.

DESCRIPTION OF THE RESERVOIR

Aliyar reservoir was created in 1962 consequent upon the construction of masonary dam across Aliyar river in Bharathapuzha basin in Tamil Nadu. This is one among the seven reservoirs under Parambikulam-Aliyar Project (PAP) interconnected through a contour canal. In addition to the contour canal feeding, the reservoir also receives water through Aliyar, Chinnar and Sithar streams. The project intends to divert the West flowing streams of the Anamalai hill ranges in the Western Ghats towards east for irrigation and power generation. The reservoir irrigates 14155.4 ha of agricultural land in Pollachi taluk in Coimbatore District. The water released into Aliyar river goes to Palghat region of

Kerala state. The geographic location of the reservoir is shown in Fig. 1. Some of the important morphometric features of the reservoir are given below :

Catchment area	:	46880 ha
Length of shoreline at FRL	:	16.0 km
River bed level (MSL)	:	283.46 m
Full Reservoir Level (MSL)	:	320.04 m
Maximum depth	:	36.58 m
Dead storage level	:	293.0 m
Mean depth	:	18.2 m
Average water level fluctuation	:	21.0 m
Area at dead storage level	:	2.5 ha
Maximum area at FRL	:	646.0 ha
Average area (DSL + FRL)/2	:	324.25 ha
Capacity at FRL	:	10942.8 ha.m
Volume development	:	1.2

The water level in the reservoir showed a variation between 2.66 and 34.03 m in the course of six years (1986-92). The annual fluctuation varied from 8.42 m to 27.5 m with corresponding fluctuations in the waterspread area and capacity of the reservoir. The dam profile and water spread in relation to depth are shown in Figs. 2 and 3 respectively. The total annual inflow ranged from 3158.45 to 3960.67 cumecs against the total annual outflow of 3235.27 to 4904.84 cumecs. The total annual rainfall at the reservoir area varied from 509.1 to 1059.2 mm during 1983-92. The inflow and outflow being distributed over the most part of the year, the reservoir maintains more or less a lotic environment.

LIMNOLOGY AND PRODUCTIVITY

Ecology-based management is the key to obtaining the best sustained rate of fish yield from a reservoir. Consequent to the creation of a dam, the hydrology of the impounded river both upstream and downstream alters radically, and a new aquatic environment is created. There is a sudden transformation of the lotic environment to a lacustrine one. The productivity of the reservoir, thus formed, becomes increasingly influenced by the morphological, edaphic and the surrounding climatological features. The inherent water and soil quality, inflow of allochthonous nutrients from catchment and other sources, the quantum of water released from thhe reservoir, etc., influence the productive potential to considerable extent. Therefore, the understanding of the reservoir in context of these parameters becomes a basic prerequisite. Inevitably, the fishery investigations at Aliyar, thus had its beginning in unravelling the biotic and abiotic phenomena as influencing

parameters on the biotic potential of the reservoir. The catchment area of Aliyar being comprised mostly of hill ranges of the Western Ghats with limited forest cover and negligible agriculture, the inflow of nutrients from catchment area is meagre. The important observations with respect to abiotic and biotic parameters of the reservoir are outlined below :

Physico-chemical parameters

Water: The water samples were collected from lentic, intermediate and lotic sectors during 1983-87 to study the chemical stratification and to assess the productivity status of the resevoir. Depth-wise samples were collected for every 4 m in lentic sector and 3 m in intermediate sector. The range of average values are given in Table 1. While notable thermocline or chemocline was absent in the reservoir, there was a discernible increase in the values of specific conductance, bicarbonate, total alkalinity and free carbon dioxide from surface to bottom.

The values of dissolved oxygen and pH showed a klinograde distribution. The stratification was more pronounced during the first and last quarters of the year due to lesser turbulance influenced by wind and inflow. Higher values of specific conductivity, total alkalinity and dissolved organic matter were mostly noted in the lentic sectior. Ammonia was present only in the bottom waters of the profoundal region of the lentic sector. Carbonate alkalinity was absent during most of the days and seasons. The water was generally poor in the nitrate (nil-0.04 ppm), phosphate, calcium and magnesium, but moderate to high values were obtained for silicates.

The temperature, pH, transparency and dissolved oxygen levels were congenial to productivity. Carbon-di-oxide, though depicted low values, was present on most of the occasions and at almost all depths. This favoured an increased rate of photosynthesis. Higher transparency enhanced the euphotic zone, ensuring a high water column taking part in the primary production process. Low to moderate levels of phosphates and nitrates probably indicated their constant utilization. The *alkaliphobic* condition of the water and the low values of calcium and magnesium are to be considered non-conducive to higher productivity. On the whole, there was no sign of the eutrophication process in Aliyar reservoir. An evaluation of the changes in the water qualities of the reservoir over two decades since its formation was done based on the values observed during 1965-66 by Sreenivasan (1970). There was a significant change in the values of oxyygen at the bottom layers compared to the earlier records of less than 1.0 ppm during February to May.

Overflowing spillways

The reservoir at dam side

The maximum vertical difference in May 1965 was 9.1 ppm. This could have been influenced by the higher organic load due to the decay of vegetation during the initial fertility of the reservoir. The minimum value of oxygen recorded during the present investigation was 4.2 ppm indicating the less demand for oxygen for organic decomposition and thereby the stability of the ecosystem health. The alkalinity, the conductivity and the pH did not show significant change in values over the years. Based on the water characteristics, the reservoir continues to be oligotrophic even after two decades of its formation.

Table 1. Physico-chemical characteristics of water of Aliyar reservoir during 1983-87

Parameters	Range
Water temp. (°C)	21.2-32.5
Transparency (cm)	108.0-182.0
pH	6.6-6.8
Dissolved oxygen (ppm)	4.2-11.6
Specific conductivity ($\mu mhos^{-1}$)	38.7-109.6
Carbonate alkalinity (ppm)	Nil-14.0
Bicarbonate alkalinity (ppm)	16.0-58.0
Total alkalinity (ppm)	16.0-58.0
Free Carbondioxide (ppm)	Nil-10.0
Ammonical Nitrogen (ppm)	Nil-0.2
Phosphates (ppm)	Trace-0.4
Silicates (ppm)	Trace-0.2
Calcium (ppm)	2.8-24.0
Magnesium (ppm)	4.0-18.0
Dissolved organic matter (ppm)	1.2-6.2
	0.9-3.6

Soil: The soil samples were collected from all representative areas of the reservoir, *viz.*, lentic, lotic and intermediate sectors. On an average, the mechanical composition of the soil consisted of 24.1% sand, 29.0% silt and 46.9% clay. Lotic sector had less clay compared to those of lentic and intermediate sectors. The soil composition data are presented in Table 2.

Table 2. Physico-chemical characteristics of soil (1983-8)

Sand (%)	24.1
Silt (%)	29.0
Clay (%)	46.9
pH	6.42
$CaCO_3$ (%)	0.48
Organic carbon (%)	0.82
Nitrogen (%)	0.06
C/N ratio	13.9
Available N_2 (mg/100 g)	29.2
Available $P_2 O_5$ (mg/100 g)	3.30

The basin soil was slightly acidic with a pH of 6.42. The levels of avaialble phosphate, available nitrogen and C/N ratio indicated that the reservoir supported a medium level productivity. There was no significant change in its nutrient status over the period of four years and the chemical composition was not visibly influenced by the inflow from catchment area.

Biotic communties

Periphyton

The periphytic organisms on suspended glass slides, wooden planks and submerged stones from various sectors of the reservoir were collected. The values are given in Table 3.

Table 3. Quantitative abundance of periphyton (units/mm²)

Year	*Lentic zone*	*Intermediate zone*
1985	5-65	8-58
1986	17-36	15-20
1987	7-24	7-14

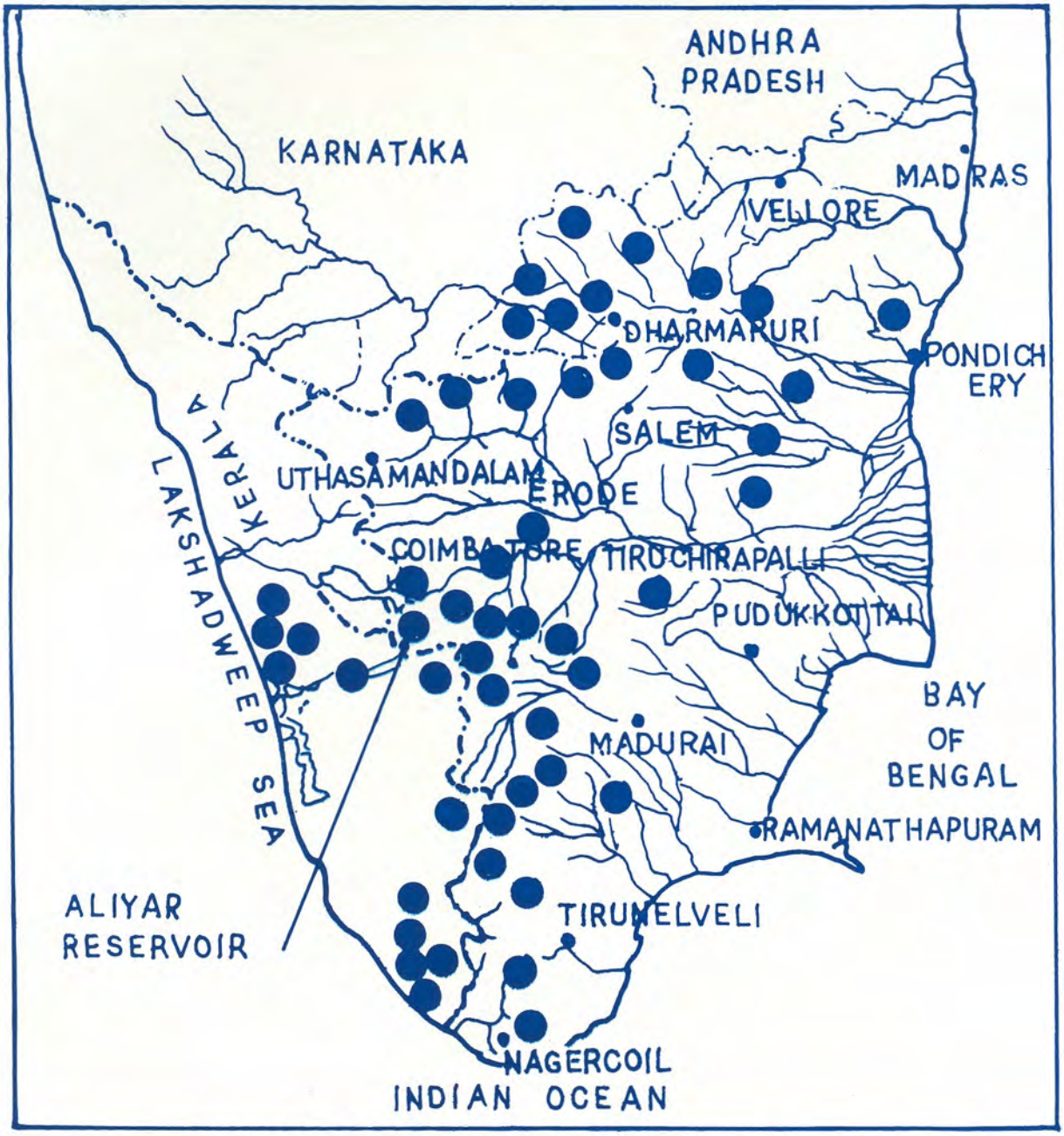


Fig. 1 Map showing location of Aliyar and other reservoirs in Tamil Nadu

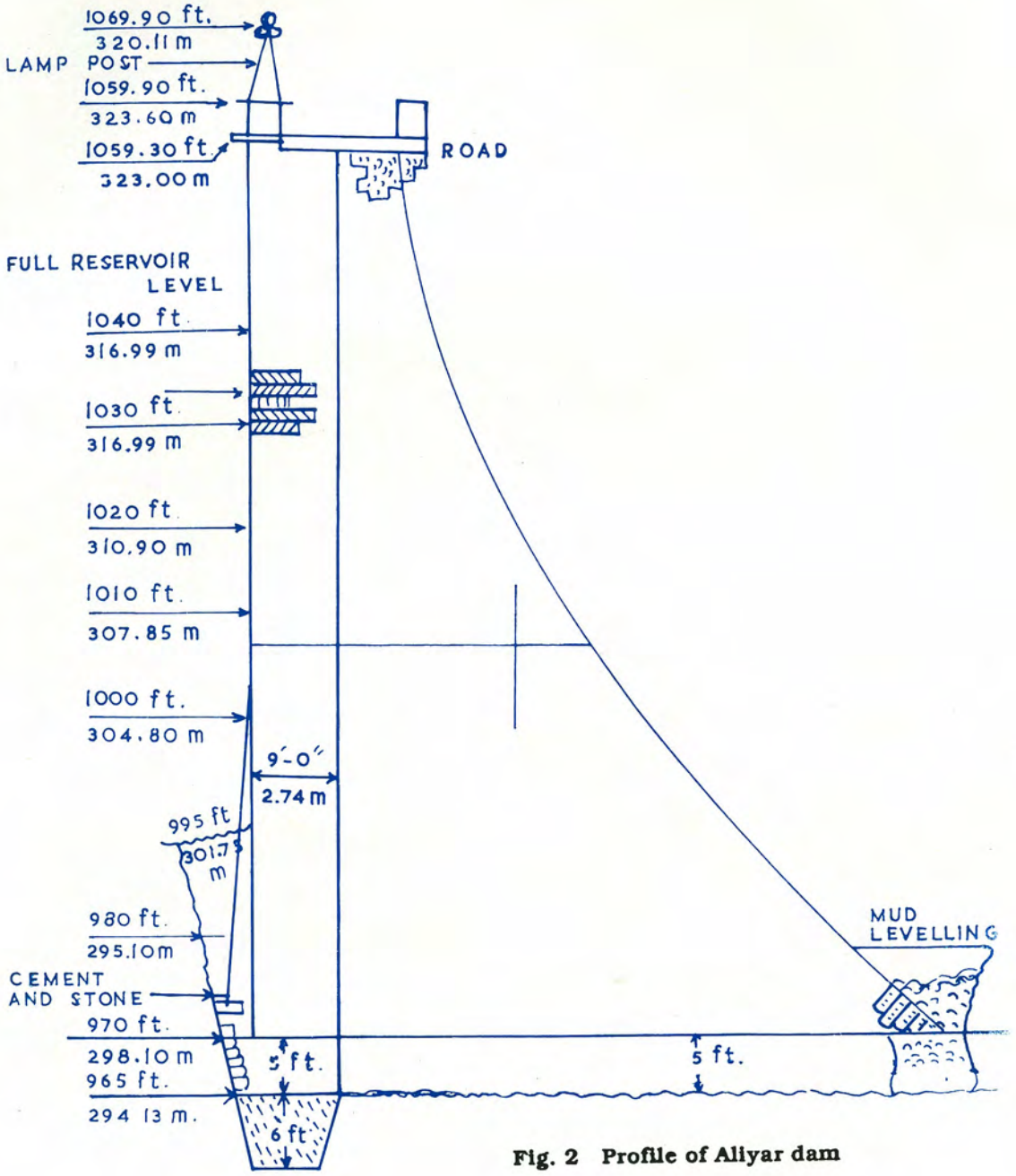


Fig. 2 Profile of Aliyar dam

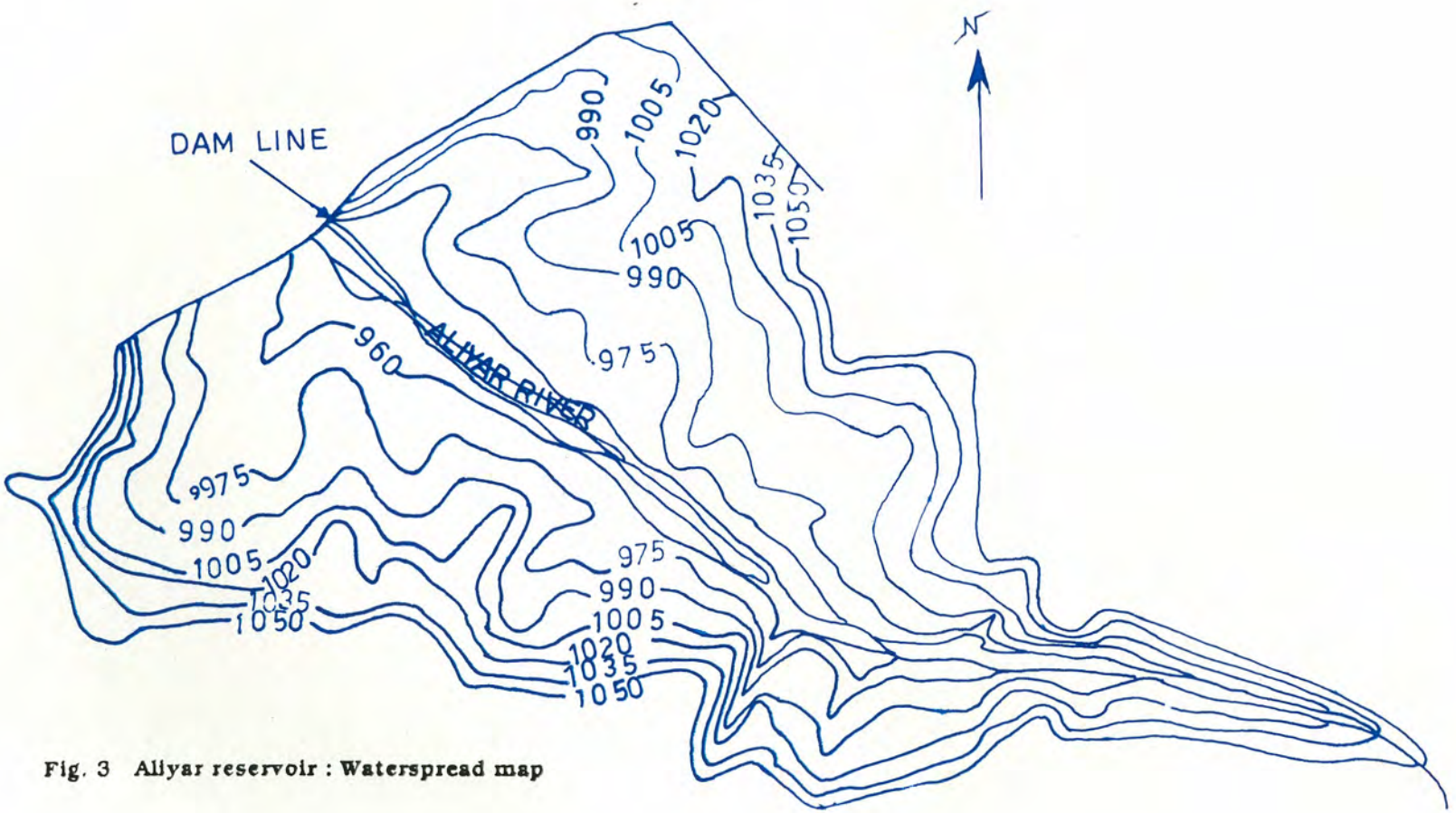


Fig. 3 Aliyar reservoir : Waterspread map

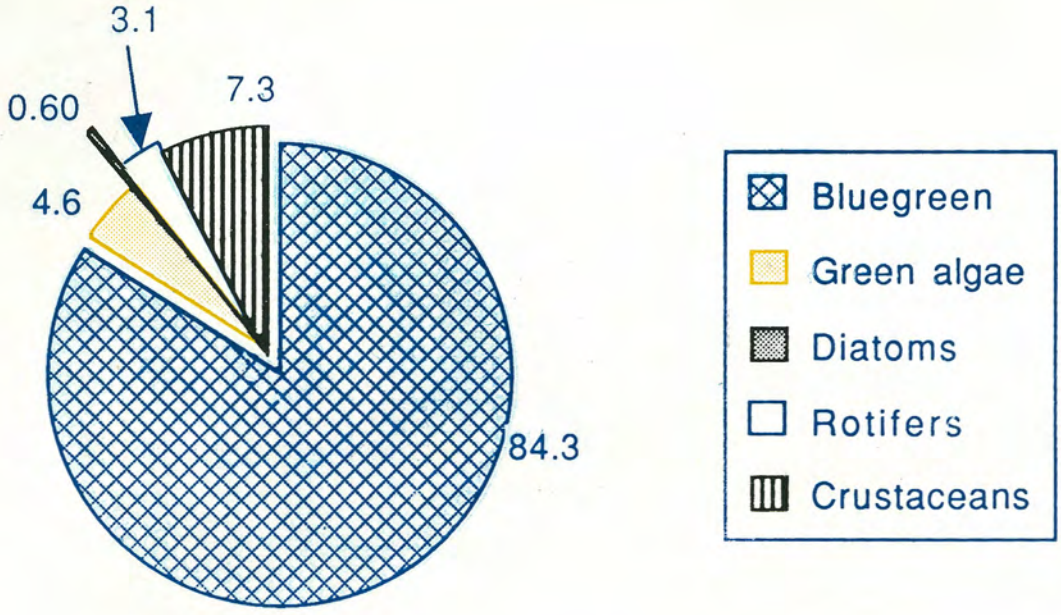


Fig. 4 Percentage composition of various planktonic groups in Aliyar reservoir during 1983-86

The concentration did not exhibit any correlation with the average depth of the reservoir or other physico-chemical properties of the water. Ciliates and filamentous algae had a higher representation among the periphytic organisms.

Plankton

The analysis of the plankton samples during 1983 to 1986 indicated that the average annual abundance for the whole reservoir was 10.8 ml/m^3 with a range of 6.4 to 26.5 ml/m^3 of water. The average annual values of plankton density obtained for the years 1983-86 was in conformity with the general trend in reservoirs that the littoral areas are more productive compared to the deeper zones. In the lotic profundal, although it is named as profundal, the depth range was between 2 and 4 m, and as such, it exhibited practically all the features of the littoral zone and harboured a rich plankton population.

The pattern of seasonal fluctuation in plankton abundance was analysed and only one distinct peak was observed during all the years except 1983. This peak could be categorised as a summer peak, although the period, to some extent, overlapped with the South-West monsoon.

Plankton in relation to water level

The abundance of the plankton in Aliyar reservoir, dominated by the blue green algae, showed inverse relationship with the water level in the reservoir. The low mean depth of a particular year coincided with a higher density of plankton, mainly contributed by *Microcystis*. The low mean depth of 2.6 m prevailed in March-June 1983 resulted in a spurt of *Microcystis* bloom to the extent of 95.95 ml/m^3 (Table 4).

During the year 1984, the monthly average of the depth remained high (6.1-14.9 m) and there was no bloom during the year. In 1985 and 1986 also, the spurts unmistakably coincided with the lowest mean depth for the years. Correspondingly seasons having higher mean depth coincided with low density of plankton population in the reservoir. Apart from seasonal studies, the observations on average annual abundance of plankton also substantiated that the year that had least water level produced the highest concentration. The relatively high water temperature of the reservoir (21.3-32.2°C) also favoured the dominance and abundance of the *Microcystis*.

Since blooms often prove highly detrimental to the health and survival of the fish in the water body, the water level management assumes importance. In reservoirs like

Aliyar, the maintenance of minimum water level is to be ensured so that the healthy environment to the fish stock is safeguarded and they are protected from algal blooms and subsequuent ill-effects including the depletion of dissolved oxygen.

Qualitative abundance of plankton

The members of the planktonic community recorded from Aliyar reservoir is listed in Table 5. The abundance of various groups in terms of percentage is given in Fig. 4. Numerically, the whole plankton population was dominated throughout the year by a single form - *Microcystis* - to the extent of 84.32%. The only other biota worthh mentioning were the filamentous algae *Mougeotia*, the copepod Cyclops (2.9%) and the rotifer *Keratella* (2.5%). The diversity of species in the reservoir was poor and thhe sectoral variation was negligible. The year round distinct dominance of *Microcystis* could suppress developmennt of a species-rich diverse plankton population in this reservoir.

Table 5. Plankton species of Aliyar reservoir

Group	Species
Chlorophyceae	*Mougeotia* sp. *Pediastrum* sp. *Staurastrum* sp.
Myxophyceae	*Microcystis* sp., *Anabaena* sp.
Bacillariophyceae	*Asterionella* sp., *Syndedra* sp., *Navicula* sp.
Dinophyceae	*Ceratium* sp.
Protozoa	*Actinosphaerium* sp., *Cyclotella* sp.
Rotifers	*Keratella* sp., *Brachionus* sp., *Filinia* sp.
Cladocera	*Daphnia* sp.
Copepoda	*Cyclops* sp., *Diatomus* sp., nauplii

Bottom macrofauna

Bottom macrofauna of Aliyar was studied for four years based on monthly samples collected at 2 m depth upto 10 m and subsequently at every 5 m depth. All the three sectors *viz.*, lentic, intermediate and lotic sectors were studied for the benthic population. The average qualitative and quantitative abundance of the bottom macrofauna is listed in Table 6. The reservoir, on the whole, had an average of 258 nos./3.18 g of bottom macrofauna, of which the oligochaetes contributed maximum (47.8%) by number as well as weight (86.8%). The shallow area had a poor abundance and their concentration in general increased with the increase in the depth of the reservoir. Maximum abundance was at 30 m depth with 2331 nos. weighing 48.45 g/m^2.

Primary productivity

Reservoirs in the country located between the latitude 11° N and 32°N receive solar energy to the extent of approximately 17,00,000-21,30,000 cal/m^2/day. The rate of conversion of that incident solar energyy to chemical energy depends on the primary producers available in the ecosystem. Studies in selected reservoirs indicate that the conversion of this solar energy to chemical energy ranges from 0.20 to 0.69%. The primary productivity level on the chemical energy fixed by the primary producers for

Table 6. Average contribution by various groups to the total bottom fauna of Aliyar reservoir

Groups	Nos./m^2	%	Wt. (g/m^2)	%
Oligochaetes	124	47.8	2.76	86.8
Chironomus	59	23.0	0.29	9.2
Chaoborus	75	29.2	0.13	4.2
Total	**258**	**100.0**	**3.18**	**100.0**

subsequent availability to the consumers of Aliyar reservoir was estimated during 1983-86 (Table 7). Based on the data for 1983-84, the average rate of energy transformation in Aliyar reservoir was estimated at 13,580 cal/m^2/day. Located at 10° N latitude, the incident solar energy of visible light at Aliyar reservoir works out at 21,50,000 cal/m^2/day. Thus, 0.64% of available light energy was fixed by the producers in the reservoirs.

Considering that only about 40-62% of the energy fixed by the producers are stored by them and the rest are utilised for respiration and metabolic activities, the quantum of the energy finally converted into fish flesh depends on the qualitative and quantitative abundance of the inhabitant biotic communities within the impoundment. The

Table 7. Primary productivity (g C/m²/day) in Aliyar reservoir during 1984-86

Year	Gross production	Net production
1984	0.278-0.572	Nil-0.206
1985	0.380-0.506	0.149-0.206
1986	0.366-0.699	0.206-0.385

peak yield from the reservoir @ 193.8 kg/ha in 1989-90 represents a conversion efficiency of 0.47% of the available primary energy in the reservoir. The rate of energy conversion at primary producer level as well as at thhe fish production level at Aliyar is considered higher that many other Indian reservoirs.

FISH FAUNA

The reservoir harboured a total of 44 endemic species and seven introduced species. The taxonomic status of these species is as follows :

Introduced species

Family : **CYPRINIDAE**

Sub-family : **Cyprininae**

Catla catla (Hamilton-Buchanan)
Cirrhinus mrigala (Hamilton-Buchanan)
Ctenopharyngodon idella (Valenciennes)
Cyprinus carpio communis (Linnaeus)
Labeo rohita (Hamilton-Buchanan)

Sub-family : **Leuciscinae**

Hypophthalmichthys molitrix (Valenciennes)

Family : **CICHLIDAE**
Oreochromis mossambicus (Peters)

Endemic species

Family : **NOTOPTERIDAE**
Notopterus notopterus (Pallas)

Family : **ANGUILLIDAE**
Anguilla bengalensis bengalensis (Gray)

Family : **CIPRINIDAE**

Sub-family : **Cyprininae**
Cirrhinus cirrhosus (Block)
Cirrhinus reba (Hamilton-Buchanan)
Cyprinus carpio var. Nudus Bloch
Cyprinus carpio var. Specularis Lacepede
Gonoproktopterus (Puntius) curmuca (Hamilton-Buchanan)
G. (Puntius) dubius (Day)
Labeo boga (Hamilton-Buchanan)
L. calbasu (Hamilton-Buchanan)
L. fimbriatus (Bloch)
L. kontius (Jerdon)
Puntius carnaticus (Jerdon)
P. chola (Hamilton-Buchanan)
P. denisonii (Day)
P. dorsalis (Jerdon)
P. filamentosus (Valenciennes)
P. mahecola (Valenciennes)
P. sarana (Hamilton-Buchanan)
P. ticto (Hamilton-Buchanan)
P. punctatus (Day)
P. melanampyx (Day)
Tor (khudree) malabaricus (Jerdon)
Salmostoma chela untrachi (Day)

Sub-family : **Rasborinae**
Amblypharyngodon melettinus (Valenciennes)
Barilius gatensis (Valenciennes)
Danio aequipinnatuus (McClelland)
Perluciosoma daniconius (Hamilton-Buchanan)

Sub-family : **Garrinae**
Garra mecclellandi (Jerdon)

Family : **BAGRIDAE**
Mystus malabaricus (Jerdon)

Family : **SILURIDAE**
Ompok bimaculatus (Bloch)
O. malabaricus (Valenciennes)

Family	:	**SISORIDAE**
		Glytothorax housei Herre
Family	:	**CLARIDAE**
		Clarias batrachus (Linnaeus)
Family	:	**HETEROPNEUSTIDAE**
		Heteriobeystes fissukus (Bloch)
Family	:	**BELONIDAE**
		Xenentodon cancila (Hamilton-Buchanan)
Family	:	**NANDIDAE**
Sub-family	:	**Pristolepidinae**
		Pristolepis (malabaricus) marginata (Jerdon)
Family	:	**CICHLIDAE**
		Etroplus canarensis (Day)
		E. maculatus (Bloch)
Family	:	**GOBIIDAE**
		Glossogobius giuris (Hamilton-Buchanan)
Family	:	**CHANNIDAE**
		Channa marulius (Hamilton-Buchanan)
Family	:	**MASTACEMBELIDAE**
		Macrognathus guentheri (Day)
		Mastacembelus armatus (Lacepede)

FOOD AND FEEDING HABITS OF FISHES

The approach to food studies had an :

i) orientation towards identifying the niches of these fishes in Aliyar reservoir.

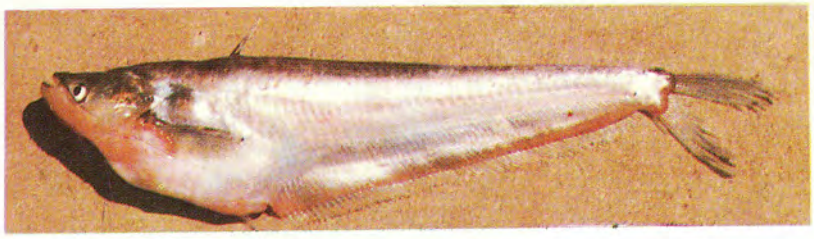
ii) the extent of competition for food between the species through the overlapping food spectra;

iii) adaptation in respect of their feeding habit to the food resources available in the water body;

iv) and the extent of the utilization of the food resources by the inhabited fish species.

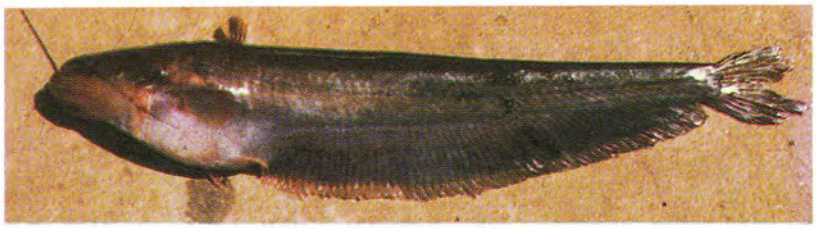
Percentage composition of various food items in the gut of various fish species was estimated on monthly basis during the years 1983-86. The food composition of the target species are given in Table 8.

RESTORATION OF SPECIES STATUS



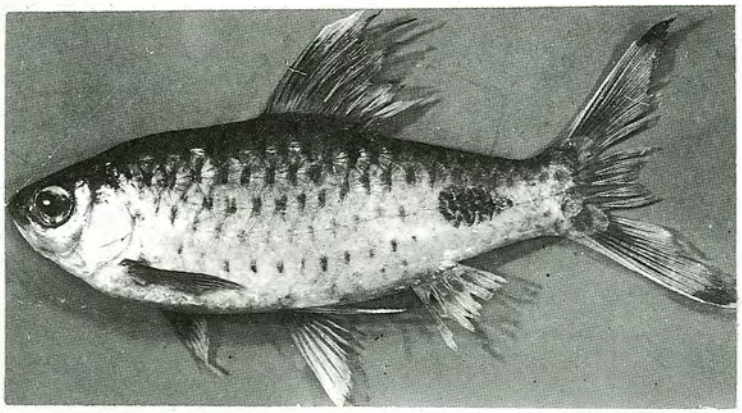
O. bimaculatus

Ompok malabaricus (Valenciennes) : Detailed study of the morphological and meristic characters of *Ompok* species in Aliyar reservoir has re-established the species status of *Ompok malabaricus*, distinctly separate from the *Ompok bimaculatus*. With the restoration of the species status of *O. malabaricus*, now it has been established the existence of four valid species of the genus *Ompok*, namely, *O. bimaculatus*, *O. malabaricus*, *O. pabda* and *O. pabo* in the freshwaters of India.



O. malabaricus

RESTORATION OF SPECIES STATUS



***P. filamentosus* (male)**

Puntius mahecola (Valenciennes) : Detailed morphometric studies of fresh specimens from Aliyar reservoir have also revealed that the specimens of *Puntius mahecola* can easily be differentiated from those of *P. filamentosus*, and that it is untenable to include the specimens of *P. mahecola* either as the females or the synonym under *P. filamentosus*.

***P. mahecola* (male)**

Cirrhinus mrigala: The blue green algae, dominated by *Microcystis*, constituted thhe major food item of the fish, closely followed by the detritus. The detritus along with the decayed organic matter constituted almost half of the gut contents (41.8-49.4%) indicating the bottom feeding habit of the species.

Labeo rohita: Detritus formed the bulk (56.1-58.8%) of thhe gut contents. Blue green algae dominated by *Microcystis* (14.6%) and the decayed organic matter (10.2%) occupied the second and third positions.

Catla catla: Guts of catla also had blue green algae as the dominant item (43.8-48.1%), followed by thhe detritus (21.3-24.7%). The zooplankton were restricted to 12.7-24.5% consisting of copepods and rotifers. Algal component had as high as 80.0% representation in August 1985.

Cyprinus carpio: The algal components dominated with 36.6 - 62.6% among the gut contents. Detritus also had significant contribution (9.2-31.6%) indicating its bottom browsing habit. Zooplankton and diatoms also formed the components of its diet to some extent.

Labeo fimbriatus: The fish proved to be an absolute bottom feeder mainly subsisting on detritus (42.9-59.0%) followed by the decayed organic matter, sand and silt.

Labeo calbasu: Only blue green algae (36.2-55.0%) detritus (30.0-42.0%) and decayed organic matter (15.0-15.1%) formed the food of the species. Preference to bottom fe ding is evident through its food analysis.

Feeding in relation to plankton composition in the reservoir

Blue green algae constituted almost 40.0% or more of food components in case of fishes like catla, mrigal, common carp, calbasu and mahseer. This is not surprising in a reservoir in which 85-90% of the plankton population is constituted by the blue green algae. Among the major species, exception was found only in case of rohu and fimbriatus which showed a definite affinity to detritus. In both these species, planktonic forms of copepods, rotifers and diatoms had negligible contribution. On the other hand, the fish in which blue green algae dominated among the food items, other planktonic forms like diatoms, copepods and rotifers also had a significant contribution. Therefore, it may not be rational to establish that the higher share of blue green algae among the food components of these fishes are due to preferential feeding in a reservoir where blue green algae dominated the plankton population. Moreover, as the studies on the digestibility of

the *Microcystis* in the guts of the fishes did not form a part of the present work plan, it is difficult to comment on the utilization of the blue green algae by the said species. It is more rational to conclude that the fishes at Aliyar relied more on the detritus for their nourishment. As such, a significant competition among the species could be restricted to the availability of detritus.

The detritus and decayed organic matter constantly being added to the bottom through the death and decay of planktonic forms from the water column, their availability as a limiting factor to the well being of the stocked fishes may not be a reality. Hence, catla among the plankton feeders and mrigal and common carp among the bottom feeders should form a reasonable proportion in the stocking composition to be adopted for the reservoir.

BREEDING BIOLOGY OF FISHES

Maturity was studied to establish their breeding success or otherwise in the reservoir. The derivations from these studies, along with the information on the growth performance of the species in the reservoir expected to provide reliable guidelines for evolving a judicious stocking policy so that near to optimum rate of energy conversion in terms of fish production was ensured.

Studies on the maturation of different species in Aliyar reservoir were carried out with species reference to the major carps. The investigations have revealed that the gonads of the major carps reached only upto IV stage of maturity in the reservoir and then they underwent resorption, failing to breed in the reservoir. Only in case of *C. mrigala,* a few specimens in the Vth stage of maturity in June were also encountered.

The failure of major carps to reach the ripe stage in the reservoir was further demonstrated by the low gonado-somatic index (GSI) and fecundity. The maximum GSI observed was only 6.2 for catla, 9.8 for mrigal and 10.5 for rohu. Only in case of common carp, a higher value of GSI (16.0) was recorded. The fecundity was as low as 0.39-2.10 lakhs for mrigal and 0.62-2.20 for common carp.

GROWTH

Fin clipping and tagging were resorted to for assessing the age-related growth in the reservoir ecosystem. However, the marked fish often developed fungal or bacterial infection resulting even in mortality. This inherent problem was circumwent by evolving a suitable course of treatment.

Treatment to the wound caused by marking

In order to select suitable drugs and to evolve the best course of treatment to avert infection and subsequent mortality of marked fish, experiments were conducted in the fish farm using fingerlings of catla, rohu, mrigal and common carp and several drugs were screened for the purpose. Twenty-five marked fish were used for each treatment and each lot of treated fish was held in separate ponds. The rate of healing and the percentage of survival assessed for about 10 days formed the criteria for selecting the drug. Single application of 0.5% solution of acriflavin, potassium permanganate or tetracycline was ineffective. Repeated application of the above drugs on alternate days improved the rate of healing. In addition to the external application of the drugs, intramuscular injection of oxytetracyline solution (@ 1 ml/kg of fish) further improved the position. However, treatment of individual fish on alternate days was cumbersome. Further experiments with creams (lorexane, furacin and betadine) and ointment (terramycin) indicated that furacin was the most effective drug in healing of the wound even with a single application at the time of marking. Cleaning the wounded area with hydrogen peroxide and dry surgical cotton helped easy adherence of the cream to the wound.

Tagging

Serially numbered tags were made with the letro-embossing tape and machine the tape was passed on to a nylon twine of code No. 210/1/3 and fastened to the fish at the posterior region of the dorsal fin above the lateral line. A bent surgical needle was employed to pass the twine through the fish body and the free ends were made into a knot and fused with the help of flame. The tag material and the tagging needles were dipped in antibiotics before hand. Further, the tagged fish were treated with hydrogen peroxide and furacin cream. The healthy fish were released in the reservoir (Table 9) for studying their survival and growth.

Out of 248 tagged fingerlings of catla released in the reservoir, 19 nos. (7.66%) were recovered after a free life period of 14-183 days. The growth rate was maximum (5.78 mm/20.71 g) in a specimen caught in just 14 days. The growth per day ranged from 1.23 to 5.78 mm/5.49 g with a mean value of 2.07 mm/12.51 g.

In case of *L. rohita,* only 2 specimens (0.77%) were recovered. The average growth per day in the species was 0.575 mm in length and 3.2 g in weight. There was no record for the recovery of *C. mrigala.*

Table 9. Details of tagged fish released in Aliyar reservoir

Species	Initial size range		Nos. stocked
	Total length (mm)	Weight (g)	
C. carpio	140-266	50-245	249
C. catla	128-360	20-625	248
L. rohita	134-334	30-440	260
C. mrigala	175-350	35-400	128

Altogether, 20 specimens (8.03%) in *C. carpio* were recovered after a free-life period of 62-137 days. These specimens gained a size range of 90-190 mm/380-1130 g during the above period, the growth rate per day ranging from 1.06-1.95 mm/4.85-9.73 g with a mean value of 1.57 mm/7.56 g respectively. Seven specimens (2.81%) caught without tags but with marks of tagging had attained a size ranging from 288 to 420 mm in length and from 550 to 1200 g in weight in a period of 70-100 days. The total recovery of tagged fish in the species was 10.84%. Three tags were also collected from the gill nets indicating that tags may get lost in reservoir when the tag gets entangled in a net or twigs.

Fin clipping

This type of marking helps recognising a group/cohort of fish, when done in a lot within a short span of time. Clipping experiments were initiated in 1983. Different fins were clipped at different batches to distinguish the specific batch at the time of recovery. The species-wise details of clipped fingerlings released in Aliyar reservoir are given in Table 10. The observation on recovered specimens (83-84 lot) revealed that *C. catla* exhibited phenomenal growth of 1.05 mm in length and 10.89 g in weight per day, whereas *C. mrigala* showed a growth rate of 0.66 mm in length and 1.62 g in weight and *L. rohita* 0.61 mm in length and 1.42 g in weight per day (Table 11).

During 1985-86, fingerlings of *C. catla, L. rohita, C. mrigala and C. carpio* were clipped off either their dorsal, pelvic or caudal fin at 50% length and held in the ponds for observation. In this experiment, there was regeneration of clipped fins almost in all the species. Within two months of clipping, it became difficult to identify them from the normal lot. Hence, in the subsequent experiments, the entire fin was removed right from their base, using a pair of sharp sterilised scissors.

Table 10. Species-wise details of clipped fingerlings released in Aliyar reservoir

Species	Number	Length (mm)		Weight (g)
		Range	Average	
1983-84				
C. catla	3213	51-132	65.88	3.75
L. rohita	3100	54-141	65.60	3.31
C. mrigala	3028	57-95	70.45	4.83
1987-88				
C. catla	500	100-172	118.2	17.5
L. rohita	500	102-225	161.0	52.0
C. mrigala	650	100-137	116.6	14.0
C. carpio	600	84-140	118.1	23.0

Table 11. Details of clipped specimens (1983-84 lot) recovered from the reservoir

Species	Recovery		Free life span days	Total length (mm)	Weight (g)	Av. increment in size/day	
	Nos	%				Length (mm)	Weight (g)
C. catla	14	0.44	178-825	375-815	80-11850	1.05	10.89
L. rohita	10	0.32	605-892	420-508	750-1600	0.61	1.42
C. mrigala	3	0.10	623-777	443-480	850-1400	0.66	1.62

With a view to studying the effect of fin-clipping on the growth of fish, either dorsal fin or left pelvic fin were clipped in two separate lots of 25 fingerlings of *C. catla*. Equal number of unclipped fish of the same age and size were also stocked with the marked fish and maintained in the same pond for a period of 5 months. While the growth of dorsal fin-clipped fish recorded a slightly lower growth rate than the control.

Five hundred fingerlings, each of *C. catla* and *L. rohita*, 650 fingerlings of *C. mrigala* and 600 of *C. carpio* were directly released in Aliyar reservoir during December 1987 to February 1988 after clipping the left pelvic fin and treating the wound. The fish

harvested from the reservoir were closely examined daily for the recovery of clipped fins. A total of 623 marked fish (catla 24 nos., 4.8%; rohu 43 nos., 8.6%; mrigal 483 nos., 71.2% and common carp 93 nos., 15.5%) were recovered from the reservoir (Table 12).

Table 12. Growth of different species of fish in Aliyar reservoir based on the recovery of fin-clipped specimens.

No. of fish recovered	Avg. period of free life (months)	Mean increment during the period		Increment per month	
		Length (mm)	Weight (g)	Length (mm)	Weight (mm)
C. catla					
8	6.4	25.6	1151	4.0	179.8
11	15.1	38.8	2046	2.5	135.5
3	23.1	49.5	3715	2.2	160.8
2	32.8	52.2	4482	1.6	136.6
L. rohita					
5	22.1	29.2	978	1.32	44.3
23	30.2	33.8	1276	1.12	42.3
13	35.7	36.4	1479	1.02	41.4
2	43.3	42.7	1848	0.99	42.6
C. mrigala					
39	20.9	37.6	1219	1.8	58.3
98	26.8	41.4	1403	1.5	52.4
175	31.6	43.1	1473	1.4	46.6
133	38.4	45.8	1850	1.2	48.2
5	45.5	46.6	2146	1.1	47.0
13	48.0	49.5	2206	1.0	47.6
C. carpio					
28	4.8	25.4	947	5.3	197.3
60	7.9	26.7	1254	3.3	158.7
3	4.1	29.1	1510	2.4	124.8
2	20.7	29.4	1177	1.4	56.9

The pattern of regeneration of fins showed differences in case of dorsal and pelvic fin-clipping. While more than 16 types of regeneration were encountered in dorsal fin, only 7 types were recorded in pelvic fins. These differed from the normal unclipped ones

TAGGING/FIN-CLIPPING

Clipping of pelvic fin

A tagged catla

TAGGING/FIN-CLIPPING

Recovered major carps and common carp without regeneration or with partial regeneration of clipped fin

in its length, breadth, number of rays and shape. Fin-clipping gave better results among the methods of marking and recapture adopted in Aliyar reservoir. The critical analysis of the data on the growth rate of different species of fish in Aliyar reservoir indicate that *C. catla* and *C. carpio* attained a marketable size of more than one kg within a period of 6 months. Whereas, *L. rohita* takes about two years and *C. mrigala* about 20 months for reaching this size. Further, 79.2% of recovered *C.catla* was harvested within a period of 15 months of stocking and that 94.6% of recovered *C. carpio* within 8 months. These observations suggest that the fingerlings of these two species should be stocked at frequent intervals to compensate the rapid harvest of these species and to maintain a steady level of population in the reservoir all through the year.

FISH DISEASES AND THEIR TREATMENT

Fin rot : Major carps in general, and *C. catla* in particular, suffered due to fungal/bacterial infection in their fins. A bath in salt solution (3-5%) followed by terramycin/tetracycline solution (200 ppm) on alternative days helped to regain their health.

Red spot disease : A red-spot disease due to bacterial infection was recorded in *C. catla*. Treatment with oxytetracycline helped to ward of the infection.

Argulus infection : The brood fish often suffered due to heavy infection by the ectoparasite *Argulus* sp. Among the several pesticides scanned for their efficacy in eradicating *Argulus*, Cypermethrine was found to be the most effective one. This pesticide killed the parasite within a few minutes. Other conventional methods such as treatment with BHC or salt solution, provision of substratum (twigs, polythene fibres, tin sheets, etc.) And removal of parasites along with their young ones and eggs proved ineffective.

Epizootic ulcerative syndrome (EUS) in fishes in Aliyar reservoir

Fishes in Aliyar reservoir suffered due to Epizootic Ulcerative Syndrome. Hundreds of dead fishes were seen along the shores of the reservoir during last week of December 1991. The casuality was maximum in *Puntius filamentosus* followed by *Mystus malabaricus, P. carnaticus, Ompok bimaculatus, O. malabaricus, P. sarana, Etroplus maculatus, Mastacembelus armatus, Glossogobius giuris, Xenentodon cancila* and *Channa marulius*. Among the Indian major carps landed in the commercial catches, a good number of *Cirrhinus mrigala* was affected by the disease. However, the disease subsided naturally within two months.

Management measures taken to prevent spread of the disease were :

1. The dead fishes on the shores of the reservoir were removed and burried almost daily.

2. Further stocking of fingerlings in the reservoir was suspended till the disease disappeared.

3. All the ponds were treated with lime @ 300 kg/ha and drawing of water from the reservoir was avoided as far as possible to avoid the spreading of the disease to the fish farm.

4. Fishermen were asked to treat all their nets in 5% formalin before using them in other reservoirs.

SEED PRODUCTION

Although Indian major carps were being stocked in Aliyar reservoir since 1963-64 and silver carp since 1981-82, the fishes did not attain full sexual maturity and spawn in the reservoir. Hence, stocking of quality fish seed every year to replenish the stock has to be resorted to. In other reservoirs like Upper Aliyar, Thirumoorthy, Sholayar and Amaravathi also located in the same belt of Western Ghat region, there is no natural recruitment of major carps within the reservoir. As such, the major carp fisheries of these reservoirs have to depend on the seed stocked from extreneous sources, primarily in the fish farm located in the vicinity of these reservoirs.

However, effort for the breeding of major carps was failure on commercial scale in the Government Fish Farm at Aliyar Nagar. A critical study on the reporductive biology of major carps indicated that a direct relationship existed between the gonadal development and the specific conductivity and alkalinity of the farm water drawn from the reservoir. A sudden drop in electrical conductivity and total alkalinity values seemed to have arrested the progress in gonadal development. A comparison of hydrological features, particularly specific conductivity and total alkalinity in some other reservoirs under the same geoclimatic conditions of Tamil Nadu like Bhavanisagar and Sathanur (Table 13) where the values of specific conductivity and alkalinity are high and the major carps are reported to breed successfully gives further support to the view that higher levels of specific conductivity and total alkalinity are essential for proper maturation.

Induced maturation and breeding

With a view to raise brood fish to full maturity and to breed them in ponds, two cemented ponds of 0.1 ha each were stocked with yearlings of *C. catla, L. rohita, C. mrigala, C. carpio, H. molitrix* and *C. idella* and the ponds were initially fertilized with raw cowdung @ 5000/kg/ha and lime @ 200 kg/ha. The quality of water in the pond was monitored at fortnightly intervals and the ponds were manured with cowdung @ 1000 kg/ha and lime @ 100 kg/ha as and when required. Occasionally, the ponds were also manured with a mixture of urea, single super phosphate and muriate of potash (6:2:1) @ 30 kg/ha. A mixture of groundnut oil cake and rice bran (1:1) was provided daily @ 5-10% of the body weight of the stock as supplemental feed. During the second year, HCG was administered to the brood fish at monthly intervals to accelerate the gonadal development. The ponds were periodically manured with organic (cowdung) or inorganic (triple super phosphate, urea and muriate of potash) fertilizers, lime and agricultural premix containing micronutrients so as to improve the water quality in terms of higher total dissolved solids, total alkalinity, pH, calcium and other essential nutrients. Although majority of the Indian major carps did not mature beyond IVth stage, a few Indian major carps and the Chinese carps attained sexual maturity in the second year and they were bred through hypophysation techniques.

Canal breeding of major carps

In the absence of modern facilities for fish breeding, a canal along with a small chamber at the end for collecting eggs was constructed with running water facilities for breeding 3 to 5 sets of major carps in each operation. The system required only a meagre investment of Rs. 3000/-, but demonstrated its potentiality for mass scale production of carp seed. Subsequently, cemented cisterns and Chinese type hatcheries were constructed at the farm to breed the major carps and to hatch the eggs.

Higher hatching and survival rates

The low electrolyte water proved to be detrimental to egg incubation and embryonic development. Experiments were conducted to test the impact of untreated reservoir water having low electrolyte content and the water treated with lime, superphosphate and cowdung on fertilized eggs of carps. In the experiments where treated and matured water was used for water hardening and hatching purposes, an average hatching rate of 47.02% and survival rate of 74.03% were observed against nil level of hatching in untreated water. Further experiments were conducted using waters of different alkalinity levels *viz,* 25 mg/l, 90 mg/l, 100 mg/l and 120 mg/l, using silver carp

eggs. A hatching upto 65% and a larval survival rate upto 96.6% were obtained at 90-120 mg/l alkalinity levels. Results were highly discouraging with untreated reservoir water. The studies also clearly indicated that the average alkalinity level of 28 mg/l of the reservoir.

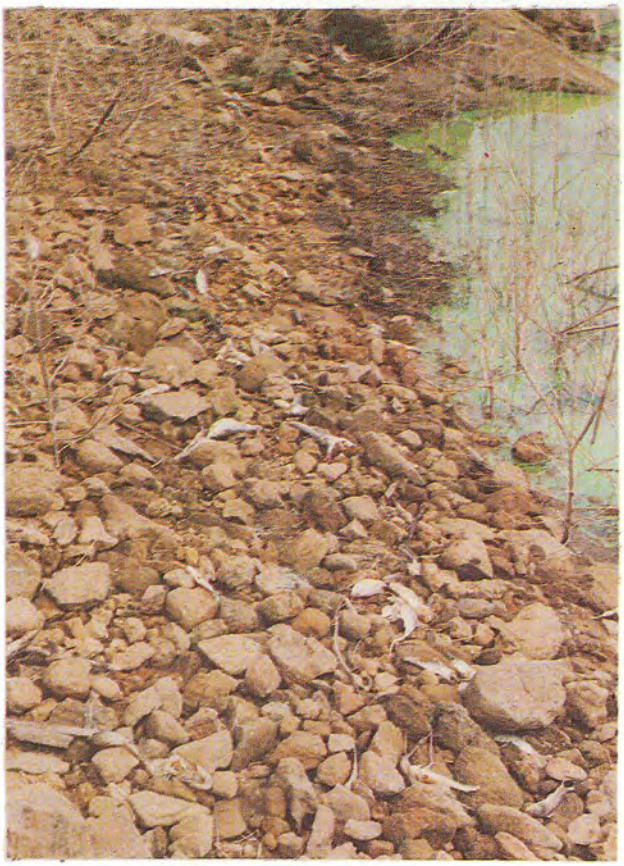
Surplus seed

Because of earlier failures in breeding and seed production of major carps in Aliyar farm, the Department of Fisheries, Tamil Nadu and the Tamil Nadu Fisheries Development Corporation Ltd. (TNFDC) had discontinued the fish breeding operations at Aliyar and confined the farm into a seed rearing centre. However, with the identification of causative factors for the failure and the adoption of remedial measures, the farm became operational as a breeding centre in addition to the seed rearing. Consequently, CIFRI produced a total of 94.29 lakhs of spawn in the farm of which 65.54 lakhs were handed over to the TNFDC Ltd. during 1985-91 (Tables 14 and 15). Thus, an unproductive farm became the source of seed not only for Aliyar reservoir, but also for other reservoirs and water bodies nearby.

Table 14. Carp spawn production (in lakhs) during 1985-91

Year	Catla	Rohu	Mrigal	Common carp	Silver carp	total
1985-86	10.5	-	1.5	-	-	12.00
1986-87	3.0	-	6.68	-	7.61	17.29
1987-88	7.0	8.1	1.40	2.45	-	18.95
1988-89	6.35	0.75	5.0	1.50	-	13.65
1989-90	6.6	6.4	0.05	4.50	-	14.55
1990-91	8.1	9.75	-	-	-	17.85
Total	**41.55**	**25.00**	**14.63**	**8.45**	**7.61**	**97.24**

EPIZOOTIC ULCERATIVE SYNDROME AT ALIYAR RESERVOIR

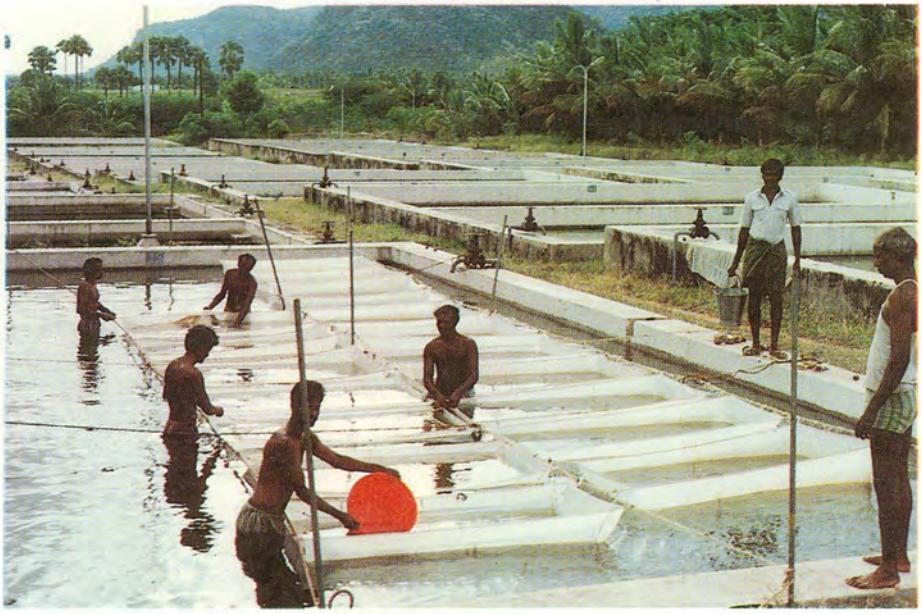


Dead fishes washed ashore

A mrigal with a lot of ulcerations

Affected minor carps and catfishes

FISH BREEDING AND SEED RAISING



Fish breeding operations under improved water conditions at the fish farm in the vicinity of the reservoir

SEGREGATION OF FINGERLINGS

Unassorted seed netted out of ponds

Net for segregating advanced fingerlings

Segregated seed (above 100 mm size) ready for stocking

Table 15. Quantity of spawn (lakhs) handed over to TNFDC Ltd.

Year	Catla	Rohu	Mrigal	Common carp	Silver carp	total
1985-86	10.50	-	1.5	-	-	12.00
1986-87	3.0	-	6.68	-	7.61	17.29
1987-88	3.25	5.60	-	-	-	8.85
1988-89	2.70	-	3.75	-	-	6.45
1989-90	3.30	4.30	-	0.45	-	8.05
1990-91	4.05	8.85	-	-	-	12.90
Total	**26.80**	**18.75**	**11.93**	**0.45**	**7.61**	**65.54**

Raising of advanced fingerlings

With the responsibility of stocking of the reservoir transferred to CIFRI in 1985-86, the seed of Indian and exotic major carps were raised in the fish farm located in the vicinity of the reservoir. The spawn produced through induced breeding was reared in nursery ponds of 0.01 ha each following low stocking densities ranging from 0.1 to 0.5 million/ha in view of the poor quality of water and lack of modern facilities till they attained the size of 20-40 mm. The fry were then transferred to rearing ponds of 0.1 ha each at the rate of 1.0 to 3.0 lakhs/ha and reared, following mono- and mixed species culture systems. With proper rearing techniques, the fry grew to fingerlings of more than 100 mm in 2-4 months. However, higher stocking density and provision of minimum ration help maintaining the seed under stunted growth condition, making the seed available for stocking the reservoir throughout the year.

The cost of production in different species ranged from 20 to 30 paise/fingerling on feed and seed inputs alone. If the rental value for the ponds, and operational costs such as electricity, labour, etc. are included, it worked out to about Re. 0.50. As such, a comparative evaluation established that stocking with seed of above 100 mm size was more economical than stocking at an earlier stage, taking into account the post-stocking survival and recovery rate from the reservoir.

Segregation of grown-up fingerlings

The process of segregating the seed above 100 mm size by hand-picking was laborious and time-consuming. Besides, the fry and fingerlings gathered in the dragnet experienced severe stress due to the crowded condition, often resulting in considerable mortality. To simplify the process of segregation, a rectangular box type filter net with 15 mm mesh bar was fabricated and fixed to an aluminium frame. When the mixed lot of the fry and fingerlings were transferred to the segregating filter net, smaller ones escaped through the mesh, leaving behind only fingerlings of more than 100 mm in length. The fingerlings retained in the segregating net could then be counted without delay and this ensured stocking of healthy fingerlings in the reservoir.

STOCKING

The practice of stocking the reservoir with seed of medium and minor carps was totally dispensed with, and only the fingerlings of Indian and exotic major carps of more than 100 mm in length were stocked in the reservoir. The stocking schedule was modified and the policy of annual stocking in one lot was switched over to periodic stocking spread over different months of the year (Fig. 5). The reservoir was stocked almost every week in split quantities.

Rate of stocking and species composition

With the increase in size of the fingerlings, the seed could withstand the handling stress and a high rate of survival in thhe reservoir was ensured. Consequently, the stocking density was drastically reduced to 236 nos/ha in 1985-86. In the species composition, *C. catla* with 33.6% was the dominant species, followed by *L. rohita* (24.5%), *C. mrigala* (21.7%), *C. carpio* (19.9%) and *H. molitrix* (0.2%). A low stocking density of 227 fingerlings/ha was continued during 1986-87 with slight modification in the species composition. *C. catla* (32.4%) again dominated in the species composition, but *C. carpio* (25.1%) was given a higher representation taking a cue from the faster growth rate of the species observed in the reservoir.

The share of *C. mrigala* more or less remained unchanged (19.8%) but *L. rohita* was reduced to 16.9% since the average weight of this species in the landings was found to be lesser, signalling its reduced growth rate. The reduction in the number of rohu was compensated by a higher percentage (66.1) of *H. molitrix.*

During 1987-88, the stocking density had to be increased to 637 fingerlings/ha, as the reservoir was drained to a level of 2.6 m during 1986-87 and almost the entire fish population was either captured or perished at this low water level. During subsequent years, the stocking density of about 300 nos/ha was resorted to as standard requirement for the reservoir. Silver carp was given a low priority in consideration of its probable adverse impact on the prized catla. Only in 1991-92, the stocking rate was reduced drastically to 176 nos/ha in view of the under exploitation due to inadequate fishing by the fishermen leading to over population and the appearance of Epizootic Ulcerative Syndrome.

Thus, there has been a conspicuous reduction in the stocking density ranging from 176to 637 nos/ha/year, with an average density of only 316 nos/ha/yr during the whole period of 1985-92 (Table 16). On an average, *C. catla* with an average share of 39.1% dominated in the stock, followed by *C. Carpio* (20.2%), *C. mrigala* (19.3%), *L. rohita* (19.0%) and *H. molitrix* (2.1%).

With the view to assessing the growth potentiality of grass carp in a reservoir without aquatic plants, a small quantity (1956 nos) of fingerlings were also stocked during 1989-91 and only a few specimens were recovered from the reservoir. The rate of stocking and species ratio had thus a conspicuous bearing on the ecological conditions of the reservoir, growth potential of the stocked species and the overall biogenic capacity of the reservoir.

Silver carp vs. catla in Aliyar reservoir

Silver carp was first introduced in the reservoir by the State Fisheries Department in 1981 and then onwards it used to contribute to the fishery at a low magnitude. Food studies revealed that the species subsisted mainly on the phytoplankton, the dominant group among the fish food items in the reservoir. Altogether, 14712 fingerlings were stocked in Aliyar reservoir during the course of seven years from 1985-92. A total of 1645 fish weighing 3855.25 kg was harvested, the recovery being 11.18%. The weight of harvested silver carp over the years ranged from 0.6 to 6.65 kg with a mean weight of 2.34 kg.

While the percentage of silver carp in the total stocking was 2.1 the rate of recovery was 11.2%, with an average weight of 2.34 kg. Comparatively, *C. catla* with a stocking rate of 29.3 to 59.9% gave an average weight of 2.98 kg. The recovery percentage by number was also higher (14.15%), indicating that catla proved to be superior and was not considerably influenced by silver carp. As Aliyar for most part of

the year maintains a lotic character with regular inflow of the water drawn from Upper Aliyar and Parambikulam reservoirs, the phytoplankton population gets continuously replenished through the incoming water. It is therefore logical to conclude that compared to the predominantly lentic reservoirs, *C. catla* and *H. molitrix* are less influenced by the shortage of food resources in Aliyar. Silver carp has lesser chance in this reservoir to dominate over domestic species since, like other carp, it does not breed in this reservoir. The observations suggest that silver carp can safely be stocked in Aliyar reservoir in restricted quantities.

EXPLOITATION OF FISHERIES

The responsibility of fishery exploitation rests with the Tamil Nadu Fisheries Development Corporation Limited which engages fishermen for fishing on sharing the crop basis. Changing the fishing practices to the use of nets of above 500 mm mesh bar was not easy with these illiterate fishermen. Even when they were getting a higher yield under thhe new guidelines, they often failed to harvest quantities desirable. Since three batches of fishermen are engaged in rotation on a quarterly basis, there is wide variation in their efficiency in fishing. This was proved an impediment in stocking more seed in the reservoir and in the better management of the fishery. The experience at Aliyar exemplifies the fact that the fishermen are to be taken into an integral part of the fishery management system if a target based on optimum exploitation is to be fulfilled. Improving their efficiency in fishing and provision for adequate quantity of right kind of nets require serious consideration.

Trend in yield

The fish yield from the reservoir increased to 25.19 tonnes (77.75 kg/ha) in the very first year of the scientific management. The fish yield further increased to 37 tonnes (114.22 kg/ha) in 1986-87 due to rduction in water level making it easy to harvest the fish. However, there was a decline in the fish harvested in 1987-88 as old stock of fish in the reservoir were exploited during the previous year and the new stock required some growth period for reaching harvestable size of more than 1 kg. The production jumped to 54.18 tonnes (167.23 kg/ha) 1988-89 and to 62.72 tonnes (193.58 kg/ha) in 1989-90. Because of reduction in the number of fishing days and for want of sincere efforts in exploitation, the fish yield declined to 49.6 tonnes (153.14 kg/ha) in 1990-91 and 46.036 tonnes (142.09 kg/ha) in 1991-92. The enhancement in yield the reservoir after the adoption of scientific management (during 1985-92) in comparison to that of earlier years (1964-85) is presented in Fig. 6. Fish yield data versus stocking for the period (1964-92) (Fig. 7) amply testifies that a higher yield from from the reservoir is possible even at a reduced

Transportation from farm to reservoir

Seed being released into the reservoir

A days landing

Experimental fishing in collaboration with CIFT, Cochin

Coracle - the craft used at Aliyar

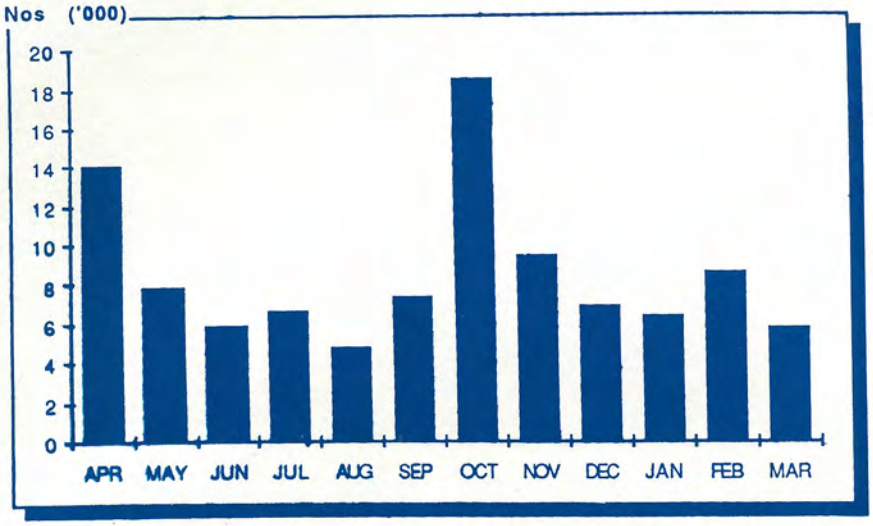


Fig. 5 Average monthly distributions of stocking of fingerlings (nos. in thousands) in Aliyar reservoir during 1985-92

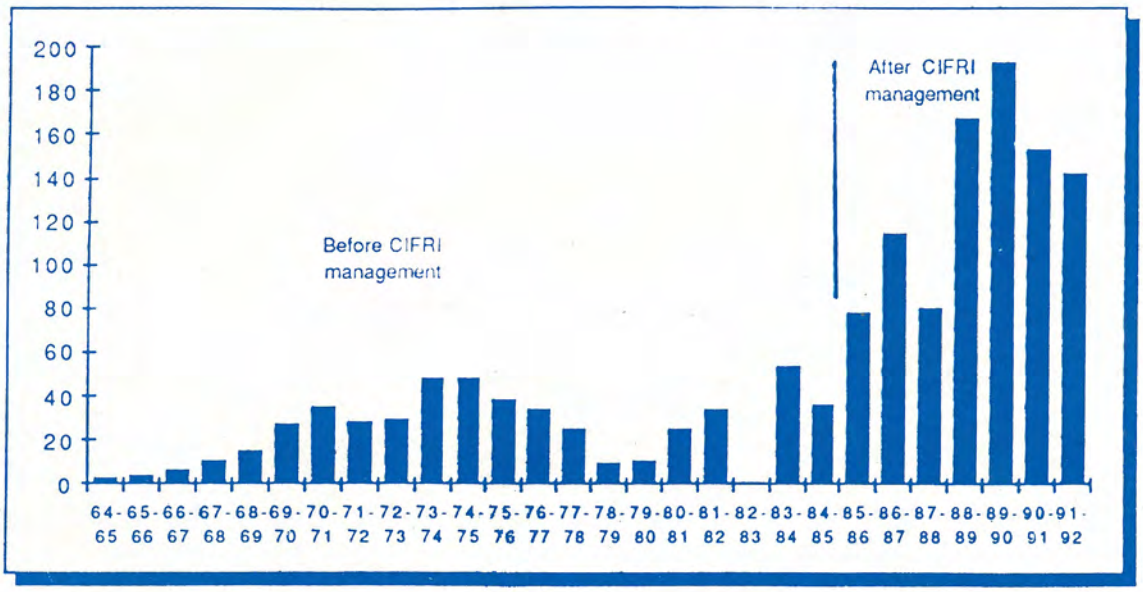
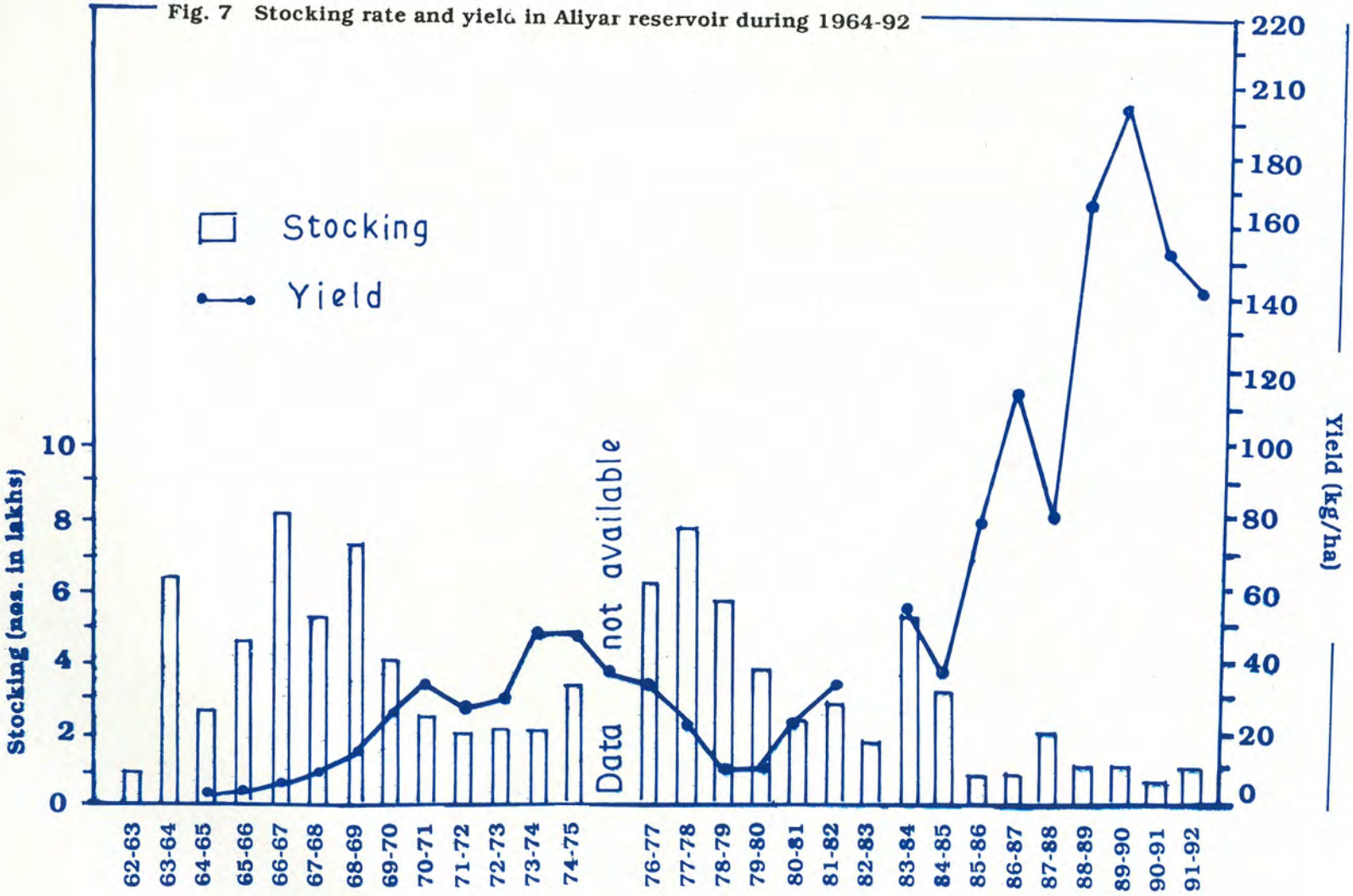


Fig. 6 Fish yield (kg/ha/yr) from Aliyar reservoir during 1964-92

Fig. 7 Stocking rate and yield in Aliyar reservoir during 1964-92



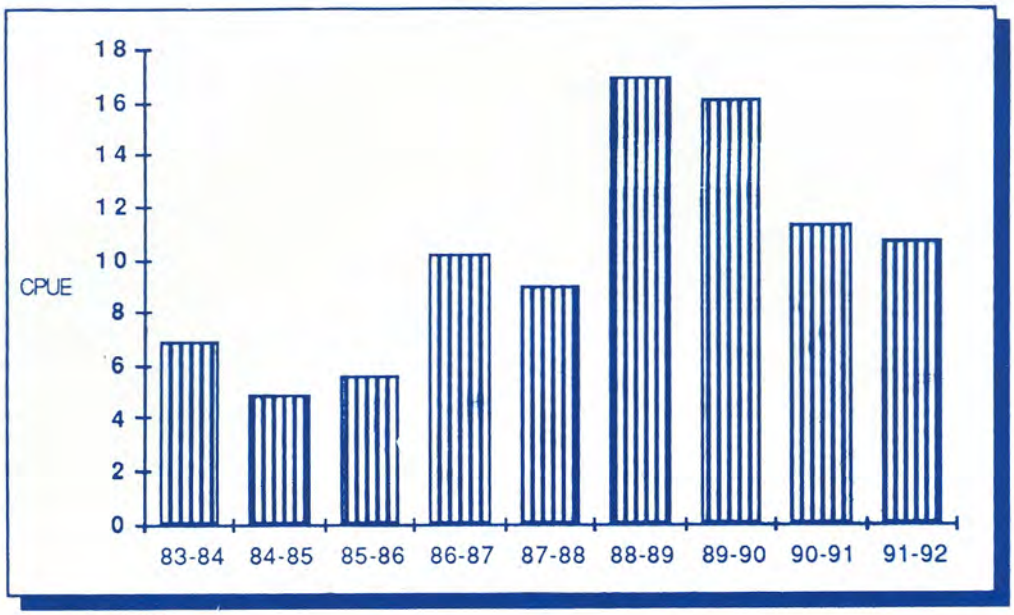


Fig. 8 Percentage composition of commercial fish catch at Aliyar reservoir before (1964-85) and after (1985-92) CIFRI management

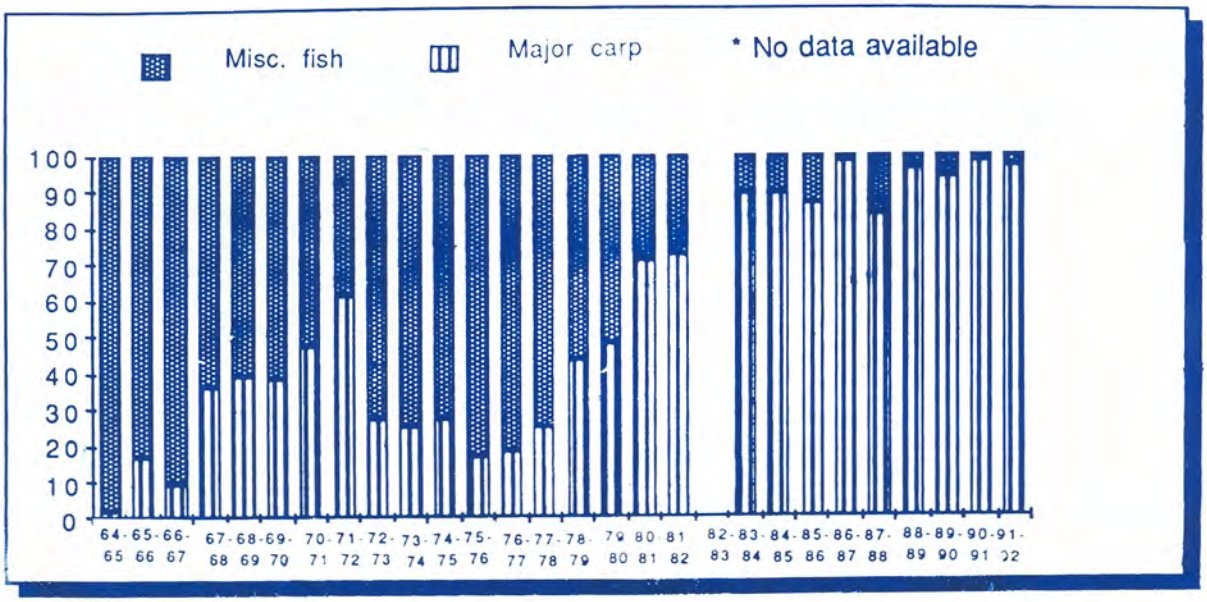


Fig. 9 Catch per unit effort (kg/coracle days) at Aliyar reservoir during 1983-92

stocking rate. The contribution by major carps also increased substantially, the percentage ranging from 84 to 99 during 1985-92 (Table 17 and Fig. 8). The average weight was maximum (2.90 kg) in the case of *C. catla*, followed by *H. molitrix* (2.34 kg), *C. idella* (1.9 kg), *C. mrigala* (1.82 kg), *L. rohita* (1.39 kg) and *C. carpio* (1.28 kg) Table 18).

Among the different species, the percentage contribution was the highest (46.53%) in case of *C. mrigala* in 1983-84, followed by *C. carpio* (21.07%), *C. catla* (15.2%) and *L. rohita* (6.96%). However, due to thhe change in the stocking policy, giving emphasis for catla and common carp, the percentage contribution by different species to the total yield changed considerably (Table 19). *C. mrigala* which was occupying prominent position in 1983-84 was pushed down to the third place with the contirbution of 9.54% by 1988-89. On the contrary, *C. catla* which occupied the third place was relegated to the first position with its contribution rising to 62.88%.

Many endemic medium and minor carps used to form a fishery during 1963-85. The fish yield then was constituted by more than 16 species. With the stocking emphasis on major carps, the fishery in later years was restricted to 7 or 8 species only. The major carps could compete and establish in the ecosystem and ultimately keep the density of the medium and minor carps under control.

Recapture of stocked fishes

Harvesting data for the period 1985-92 indicate a recovery rate of 20.8% of fishes by number from the reservoir (Table 20). Relative contribution was maximum in case of mrigal followed by catla, rohu, common carp and silver carp. Only four numbers of grass carp were recovered. Against species-wise stocking, the percentage of recovery was the highest (29.2%) in *C. mrigala* followed by *L. rohita* (25.7%), *C. carpio* (22.2%), *C. catla* (14.1%), *H. molitrix* (11.2%) and *C. idella* (0.2%). If the mortality was as highh as about 80% in a reservoir which is small in size and largely devoid of major predatory fish populations, especially when the stocking size was above 100 mm size, it is highly improbable that a survival of 50% or more is feasible from the reservoirs as usually projected. This has to be noted seriously while calculating stocking requirements for the reservoirs based on growth rate and survival.

Catch per unit effort and revenue

The average catch per unit effort was low (4.95 kg) in 1984-85 and the value gradually increased to a maximum of 16.91 kg in 1988-89 (Fig. 9). The month-wise data of CPUE during 1983-92 are presented in Table 21.Consequent to better management, the

catch per unit effort at Aliyar reservoir went up much higher than those in other reservoirs. The fishermen who were once reluctant to fish at Aliyar evinced keen interest in the reservoir due to an assured better income from fishing. Even at a lowered share of 33.3% of their catch, the fishermen community found it more remunerative in fishing in Aliyar reservoir. The revenue to the Corporation from the reservoir increased by 69% at current market price with the change in management strategy (Table 22). The fishermen who were earning less than Rs. 400.00 per month earned more than Rs. 1600.00 (300% increase) per month.

Table 22. Average annual yield and revenue from Aliyar reservoir before and after adoption of Scientific management measures by CIFRI (at current Department rate)

	1962-85	*1985-92*
Total yield (kg)	8,493.20	42,985.10
Major carps (kg)	3,929.80	40,161.00
Revenue (@ Rs. 20/- per kg)	78,596.00	8,03,220.00
Other fishes (kg)	4,563.40	2,824.10
Revenue (@ Rs. 10/- per kg)	45,634.00	28,241.00
Total Revenue	1,24,230.00	8,31,461.00
Increase in Revenue	-	669%

Management versus age of the reservoir

The man-made reservoirs are known to be highly productive during the first few years of their formation. In contrast to this tendency, the fish yield remained poor at its initial fertility stage at Aliyar reservoir. The records indicated that the yield was as low as 2.67-6.91 kg/ha/yr during the initial years of the reservoir formation between 1964 and 1967 and that Aliyar could not make use of this trophic burst in the reservoir. Even with rational stocking, the production increased to 10.31 kg/ha/yr in 1967-68 and reached thhe maximum of 48.74 kg/ha/yr in 1974-75. With scientific management during 1985-92, though the stocking density was drastically reduced, the yield increased substantially (193.58 kg/ha/yr in 1989-90) indicating that the small reservoirs identical to Aliyar could be developed at any stage irrespective of their age.

RECOMMENDATIONS FOR DEVELOPING FISHERIES OF SMALL RESERVOIRS IN GENERAL AND ALIYAR IN PARTICULAR

1. The water from the reservoir may get drained off almost totally for irrigation, resulting in heavy destruction of fish population and subsequent loss of sizeable revenue. This calls for better coordination between Public Works Department and Fisheries Department so that at least a minimum water level of 8 m is always maintained in the reservoir.

2. The biological and field investigations undertaken by CIFRI centre indicated that there was no natural spawning and recruitment of major carps in Aliyar reservoir. The reservoir has to depend solely on regular stocking with advanced fingerlings from extraneous sources.

3. Considering the low survival of fish seed in open systems, there is need for raising advanced fingerlings (more than 100 mm size) of Indian and exotic major carps and also common carp for stocking the reservoir. Care must be taken to stock only healthy fingerlings in order to avoid predatory pressure and loss even due to the attack of trash fishes such as *Puntius filamentosus, P. mahecola* etc.

4. While stocking the Aliyar reservoir, the following species composition may be maintained.This could also form a general guideline for other small reservoirs in the region.

C. catla	:	30-40%
L. rohita	:	10-20%
C. mrigala	:	10-15%
C. carpio	:	20-30%
H. molitrix	:	Less than 5%

5. The fingerlings should be stocked in small quantities at intervals of 10-15 days covering all the months of the year so that at no point of time there is extra competition for food and space in the reservoir.

6. A stocking rate of 200-300 fingerlings (of above 100 mm size) per hectare per annum is recommended.

7. A recovery rate of about 20% only may be taken into account while calculating the seed requirement of the reservoir.

8. Gill nets of more than 50 mm mesh bar only should be operated in the reservoir to ensure the major carps of more than 1.0 kg are harvested. There is no need to observe any closed season for fishing in perennial small reservoirs having no natural recruitment.

9. Since trash fishes, minor carps and predatory fishes compete with major carps for food and space, their population in the reservoir must be kept under check through regular operation of small meshed (20-30 mm) gill nets along the littoral areas of the reservoir.

10. The practice of releasing farm-bred crocodiles in small reservoirs for their conservation needs to be discouraged in fishery oriented reservoirs since they devour the fish stock and damage the nets bringing huge loss in revenue to the poor fishermen.

11. The fish yield from the reservoir fluctuates conspicuously depending upon the efficiency of the fishermen. The Department/Corporation should help fishermen for procuring proper nets in adequate quantities so that fishing efficiency is sustained all through. Unless stocked fish are exploited constantly, density of population in the reservoir becomes high, affecting their growth and survival. Efficient exploitation is also essential in context of the revenue and the economic gain to the fishermen.

12. The studies have brought to light the need for collaborative research project by the Scientists of CIFRI and CIFT for evolving techniques for the proper exploitation of the fishes of marketable size. The timely exploitation of the harvestable fishes would form an integral part of the management techniques adopted for enhancing the fish yield from the small reservoirs.

13. Since the ponds in Aliyar fish farm receive their water supply from Aliyar reservoir which is poor in essential nutrients, total dissolved salts (TDS), calcium content, etc., it is not conducive as such for seed rearing or brood fish maintenance. To improve the chemical quality of water the ponds should be treated with lime, organic or inorganic fertilizers. A low stocking of 1.5 lakhs fry per ha is recommended in ponds for raising fingerlings for stocking the reservoir. Mixed culture of *C. catla, L. rohita* and *H. molitrix* is found to be advantageous. Since collection of *C. mrigala* and *C. carpio* poses problem, these species could be reared in separate ponds of smaller size. Fingerlings of more than 100 mm in length are seggregated using a filter net having a mesh size of 30 mm (15 mm mesh bar) and stocked in the reservoir.

14. The sharp and irregular fluctuations in water level preclude the possibility of taking up pen culture for raising the seed for stocking the reservoir. Therefore, it is advisable to resort to raising seed in floating cages in small reservoirs.

Table 4. Seasonal abundance of plankton (ml/m^3) of Aliyar reservoir during 1983-86.

Months	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Av
1983	5.15	15.50	10.33	13.46	24.38	95.95	14.91	13.84	5.33	4.05	4.92	4.96	19.90
												8.20	6.40
1984	3.57	3.57	6.11	7.75	5.34	4.95	4.57	7.14	5.41	6.72	-	7.60	10.10
1985	6.12	5.05	-	10.10	8.24	18.06	21.76	10.82	7.16	9.21	8.13	1.20	7.10
1986	4.00	3.03	2.16	2.62	10.33	22.24	12.10	13.17	6.20	-	2.00		

Table 8 : Annual average percentage composition of different food items in the guts of fishes from Aliyar reservoir during 1983-86

Species	Blue green algae	Diatoms	Copepods	Rotifers	Detritus	Decayed Organic matter	Sand/silt	others
L. rohita	14.6	Nil	8.2	4.3	58.8	10.2	2.2	1.7
C. catla	43.8 - 48.1	3.6 - 9.8	7.7 - 12.8	5.0 - 11.7	21.3 - 24.7	Nil - 14.7	Nil	Nil - 0.5
C. mrigala	38.52 - 42.2	11.22 - 11.8	2.82 - 11.5	Nil - 3.9	34.6 - 38.2	7.2 - 38.0	Nil	Nil
C. carpio	36.6 - 62.6	5.2 - 11.1	10.6 - 11.8	6.7 - 6.8	9.2 - 31.6	0.0 - 4.5	Nil	Nil - 3.3
L. fimbriatus	4.7 - 12.4	Nil - 1.2	Nil	Nil - 2.8	42.9 - 59.0	7.7 - 14.2	7.3 - 24.6	Nil - 9.6
L. calbasu	36.2 - 55.0	Nil	Nil	Nil - 4.5	30.0 - 42.0	15.0 - 15.1	Nil	Nil
T. khudree	50.0	Nil	15.0	5.0	30.0	Nil	Nil	Nil

Table 13 : Data on hydrological features of some reservoirs in Tamil Nadu

Reservoirs	Surface water temp. (°C)	Diss. Oxygen (ppm)	Sp. Conduc. ($Uscm^{-1}$)	pH	Total alkalinity (ppm)	Silicate (ppm)	Nitrate (ppm)	Phosphate (ppm)	Calcium (ppm)	References
Aliyar	26.7	7.6	54.6	6.9	37.2	7.0	0.05	0.04	7.1	Srenivasan (1977)
Upper Aliyar	25.7	7.2	38.7	7.1	36.0	5.6	Traces	0.03	5.8	
Thirumoorthy	28.5	7.2	65.8	7.3	46.0	9.0	Nil	Nil	10.0	
Amaravathy	26.5	8.8	41.1	7.0	58.0	14.5	Nil	Traces	Traces	Natarajan *et al.* (1981)
Sholayar	22.6 - 24.2	8.0 - 8.2	40.0 - 70.0	6.7 - 7.1	22.0 - 32.0	6.0	-	0.0	Nil	
Bhavanisagar	29.0	6.0 - 10.7	263.4	7.2 - 8.1	162.0 - 340.2	1.8	0.06	0.04	11.2 - 18.3	
Sathanur	-	-	658.0	7.9	292.0	0.42	0.08	0.06	36.0	

Table 16 : Fingerlings stocked in Aliyar reservoir during 1985-92

Years	Catla		Rohu		Mrigal		Common carp		Silver carp		Grass carp		Total	Nos./ha
	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%	Nos.	%		
1985-86	25729	33.6	18764	24.5	16608	21.7	15243	19.9	131	0.2	-	-	76475	236
1986-87	23777	32.4	12248	16.6	14556	19.8	18409	25.1	4509	6.1	-	-	73499	227
1987-88	71030	34.4	37670	18.3	47475	23.0	45300	21.9	5031	2.4	-	-	206515	637
1988-89	30041	29.3	26561	26.3	23998	23.7	20547	20.3	-	-	-	-	101147	312
1989-90	47176	44.9	15785	15.0	16584	15.8	18746	17.8	4905	4.7	1944	1.8	105140	325
1990-91	34055	59.9	5805	10.2	4645	8.2	12240	21.5	136	0.2	12	0.02	56893	176
1991-92	49000	50.0	19444	20.0	14580	15.0	14580	15.0	-	-	-	-	97604	301
Average	**40115**	**39.1**	**19469**	**19.0**	**19778**	**19.3**	**20724**	**20.2**	**2102**	**2.1**	**279**	**0.3**	**102467**	**316**

Table 17 : Fish yield from Aliyar reservoir during 1985-92 (kg)

Year	Contribution by major carps								Miscellaneous fish		Total yield	Yield per ha
	C. catla	*L. rohita*	*C. mrigala*	*C. carpio*	*H. molitrix*	*C. idella*	Total	%	Weight	%		
1985-86	8652.3	2576.5	6130.5	4964.8	1.8	-	22325.9	87.0	3266.0	13.0	25691.9	77.75
1986-87	8728.8	6639.8	14460.8	6807.9	23.0	-	36660.3	99.0	346.5	1.0	37006.8	114.22
1987-88	4464.0	4912.5	5948.5	5468.0	1173.0	-	21966.0	84.0	4175.0	16.0	26141.0	80.68
1988-89	34069.8	46460.0	5171.5	7669.4	599.0	-	93969.7	96.3	2032.0	3.7	96001.7	167.23
1989-90	32946.0	7062.9	10284.9	8281.8	738.0	-	59313.6	94.6	3406.5	5.4	62720.1	193.58
1990-91	14160.3	12151.8	17428.7	4572.4	735.6	4.9	49053.57	98.9	564.9	1.1	49618.6	153.14
1991-92	15784.8	10585.95	14294.25	3500.7	585.45	2.7	44753.45	97.2	1282.8	2.8	46036.25	142.09

Table 18 : Number of fish harvested and their average weight (kg) during 1985-92

Year	*C. catla*		*L. rohita*		*C. mrigala*		*C. carpio*		*H. molitrix*		*C. idella*	
	Nos.	Av. wt.	Nos.	Av. wt.	Nos.	Av. wt.	Nos.	Av. wt.	Nos.	Av. wt.	Nos.	Av. wt.
1985-86	1256	6.57	1721	1.50	3848	1.59	3157	1.57	3	0.60	-	-
1986-87	2823	3.09	5009	1.33	5834	2.48	4066	1.67	4	5.75	-	-
1987-88	2941	1.52	3329	1.48	3615	1.65	5437	1.01	947	1.24	-	-
1988-89	11477	2.97	2639	1.76	2606	1.98	6195	1.24	126	4.75	-	-
1989-90	9374	3.52	4458	1.58	5982	1.72	6516	1.27	111	6.65	-	-
1990-91	5370	2.64	8992	1.35	10476	1.66	3655	1.25	353	2.08	3	1.63
1991-92	6434	2.43	8862	1.20	8053	1.78	3238	1.08	101	5.80	1	2.70
Total	39725	2.98	35010	1.39	40414	1.82	32264	1.28	1645	2.34	4	1.90

Table 19. Contribution by different species to the total yield

Sl.No.	Species	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92
1.	*C. catla*	15.20	21.88	32.76	23.59	17.08	62.88	52.53	28.54	34.29
2.	*L. rohita*	6.96	8.80	10.23	17.94	18.79	8.56	11.26	24.29	22.99
3.	*C. mrigala*	46.53	36.65	24.34	39.08	33.76	9.54	16.40	35.11	31.05
4.	*C. carpio*	21.07	23.09	19.71	18.40	20.92	14.16	13.20	9.22	7.60
5.	*H. Molitrix*	-	-	0.01	0.06	0.49	1.11	1.18	1.48	1.27
6.	*C. idellus*	-	-	-	-	-	-	-	0.01	1.01
7.	*L. calbasu*	0.07	0.05	0.06	0.08	-	-	-	-	-
8.	*L. fimbriatus*	1.30	1.27	0.72	0.21	0.03	0.23	0.11	0.05	-
9.	*P. dubius*	0.01	0.03	-	-	-	-	-	-	-
10.	*P. carnaticus*	0.62	0.70	0.02	-	-	-	-	-	-
11.	*P. sarana*	0.36	2.10	-	-	-	-	-	-	-
12.	*O. mossambica*	4.60	1.32	0.36	0.18	15.70	3.50	4.43	0.79	1.50
13.	*Ompok spp.*	1.91	2.57	0.57	0.16	0.06	-	-	-	-
14.	*L. kontius*	0.01	-	-	-	-	-	-	-	-
15.	*C. marulius*	0.13	0.13	0.08	0.21	0.12	-	0.02	-	0.02
16.	*T. khudree*	0.16	0.05	0.03	0.02	-	-	-	-	-
17.	***Miscellaneous***	1.07	1.36	10.82	0.07	-	-	-	-	-

Table 20 : Total quantity of fingerlings stocked and fish harvested from Aliyar reservoir during 1985-92

	C. catla	*L. rohita*	*C. mrigala*	*C. carpio*	*H. molitrix*	*C. idellus*	Total
Total No. of fingerlings stocked	2.80,808	1,36,277	1,38,446	1,45,065	14,712	1,956	7,17,273
No. Of fish harvested	39,725	35,010	40,414	32,264	1,645	4	1,49,062
Average recovery (%)	14.1	25.7	29.2	22.2	11.2	0.2	20.8

Table 21 : Catch per unit effort (kg) during the period from 1983-84 to 1991-92

Year	Total yield	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Average
1983-84	17636.85	8.72	18.04	13.29	6.93	4.37	4.86	3.93	4.60	2.75	2.12	3.72	5.60	7.01
1984-85	11837.50	8.60	7.34	6.82	3.54	3.88	3.04	3.29	3.90	2.78	3.53	6.23	7.96	4.95
1985-86	25191.85	4.53	5.18	9.54	8.96	5.64	5.10	3.97	3.67	4.27	3.10	3.60	3.00	5.64
1986-87	37006.65	3.02	4.13	12.60	8.93	6.86	5.15	2.24	2.95	2.76	2.30	34.91	31.30	8.02
1987-88	26141.25	5.50	7.71	6.88	3.62	7.05	4.81	5.91	9.87	23.51	12.28	8.87	9.93	9.05
1988-89	54181.16	21.53	11.54	18.18	17.18	18.30	10.29	20.29	21.60	14.25	17.27	18.30	14.73	16.91
1989-90	62720.25	21.00	18.92	37.09	17.51	9.95	19.37	11.74	12.90	13.81	14.08	10.45	8.13	16.12
1990-91	49618.40	14.24	8.13	17.49	20.50	10.57	9.95	9.47	13.45	10.59	6.63	6.77	8.37	11.32
1991-92	49036.25	7.10	4.87	8.54	22.02	14.79	15.22	9.20	6.09	8.59	12.28	12.42	9.07	10.74