ECOLOGY AND FISHERIES

OF MARKONAHALLI RESERVOIR

(KARNATAKA)

CENTRAL INLAND CAPTURE FISHERIES RESEARCH INSTITUTE : BARRACKPORE

Ecology and Fisheries of Markonahalli Reservoir

Bull No. 78 **March 1998**

Central Inland Capture Fisheries Research Institute
(Indian Council of Agricultural Research)
Barrackpore-743 101 West Bengal

Ecology and Fisheries of Markonahalli Reservoir

ISSN 0970-616 X

Composed at	:	**The Project Monitoring & Documentation Section** CIFRI Barrackpore
Assistance	:	Sefali Biswas
Cover design	:	P. Dasgupta
Published by	:	**The Director,** CIFRI Barrackpore
Printed at	:	Calcutta Laser Graphics (Pvt.) Ltd 71, Hari Ghosh Street Calcutta 700 006

FOREWORD

Reservoirs constitute the prime inland fishery resource of India and it has a significant role to play in the coming years in increasing the inland fish production of the country. This is the only inland fishery resource whose hectarage is bound to increase with required developmental activities of increased population. A substantial part of the estimated requirement of 6 million tonnes of inland fish by the year 2000 should come from the reservoirs. Unfortunately fisheries development in reservoirs has been neglected and very few reservoirs in India have been subjected to scientific investigations relevant to ecology and fisheries. Keeping this aspect in view studies were initiated by CIFRI in various reservoirs situated in different states of India. Markonahalli (Karnataka) was one such small reservoir where intensive investigation was carried out by scientists of CIFRI for a number of years which resulted in substantial yield increase. The valuable data generated is documented in this publication.

I am sure it will greatly help in understanding the ecology and population dynamics of the reservoirs in general. The recommendation given will be of immense use for developing scientifically and economically viable management strategies for this group of reservoirs in India.

M. Sinha
Director

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

Name	Designation	Duration
Shri Ch. Gopalakrishnayya	Principal Scientist & Project Leader	Nov. 1989 to July 1993
Dr. V.R. Desai	-do-	July 1993 to May 1995
Dr. M. Ramakrishniah	Sr. Scientist	April 1991 to March 1995
Dr. A.K. Laal	Sr. Scientist	April 1989 to May 1994
Dr. D.S. Krishna Rao	Sr. Scientist	April 1989 to April 1993
Dr. P.K. Sukumaran	Sr. Scientist	April 1989 to March 1995
Shri A. Hajra	Scientist (S.S)	July 1990 to Jan. 1992
Shri M. Chaudhury	Scientist (S.S)	Nov. 1989 to Dec. 1990
Shri M. Karthikeyan	Scientist (S.S)	March 1990 to April 1994
Shri M.F. Rahman	Tech. Officer	April 1989 to Dec. 1990
Shri P.S.C. Bose	Tech. Officer	June 1990 to Sept. 1991
Shri S.K.S.S. Hameed	Tech. Officer	Nov. 1989 to Feb. 1996

Final Report Prepared by

M. Ramakrishniah
D.S. Krishna Rao
P.K. Sukumaran
&
M. Karthikeyan

CONTENTS

INTRODUCTION

The capture fisheries of India, both inland and marine, have reached asymptotic levels of production shifting the emphasis to aquaculture to augment country's fish production . In recent years aquaculture has expanded manifold with impressive gains in yield. However, the limited availability of the resource, the capital intensive nature of the enterprise and its unfavourable impact on the environment, have put a limitation on its further expansion. Now, the time has come to turn the attention to reservoirs for further addition to country's fish production, for which great potential exists.

Fisheries development in reservoirs has been neglected for long resulting in low yields. Wherever some efforts are made in management the yields have been impressive. Improper understanding of reservoir ecology and production dynamics, lack of suitable models to predict fish yields before undertaking management and inadequate supply of quality fish seed for stocking have put serious constraints in the development of reservoirs. The present effort in Markonahalli reservoir is a step in addressing these problems.

Reservoirs are unique ecosystems combining the characteristics of lentic and lotic habitats. However, their trophic dynamics are distinctly different from either of them. It is widely mentioned that the reservoir productivity is governed by morphometric, edaphic and climatological factors. Numerous environmental factors influence productivity either individually or in synergy and it is often difficult to come up with a suitable predictive yield model combining all the parameters. Ryder's yield model, Morphoedaphic index (MEI), developed for lakes combines an edaphic factor, total dissolved solids (TDS), and a morphometric factor (mean depth). It is said that the model is a compromise between unmanageable complexity and ecological over-simplication. The simplicity of the model attracted the attention of the scientists and it was soon extended to man-made lakes in some countries. However, for Indian reservoirs the model was not found to be of much use. This situation is expected since in Indian reservoirs the total alkalinity and conductivity , the positive correlates of TDS, were found to be of limited value in predicting productivity, unlike in natural lakes.

It has been recognized that the extensive catchment of the reservoir plays a crucial role in the loading of organic matter and nutrients. The amount of loading of these allochthonous inputs is a function of the ratio of catchment area to reservoir area. In view of its importance as an index of allochthonous inputs, this ratio has been substituted for TDS in MEI and a yield model - Morpho drainage Index - has been developed for Indian reservoirs. The new model, has been used to predict the fish yield of Markonahalli reservoir in order to formulate management strategies.

Physiography of the Reservoir

Markonahalli reservoir (12 ° 55' N, 76° 56'15" E) is a minor irrigation project constructed on river Shimsha (an eastern tributary of river Cauvery) in the district of Tumkur, Karnataka state (Fig 1). The impoundment has been formed in 1939 to provide irrigation for about 4400 ha of land in the districts of Tumkur and Mandya. Some of the details of dam and reservoir morphometry are given below :

Length of the dam	: 1609 m
Length of masonry dam	: 139 m
Length of left earth dam	: 704 m
Length of right earth dam	: 766 m
Depth of spillage over waste weir	: 0.91 m
No. of scouring sluices	: 5
No. of volute siphons	: 2
Diameter of siphons	: 2.44 m
Sill level of scouring sluice	: 715.27 m (msl)

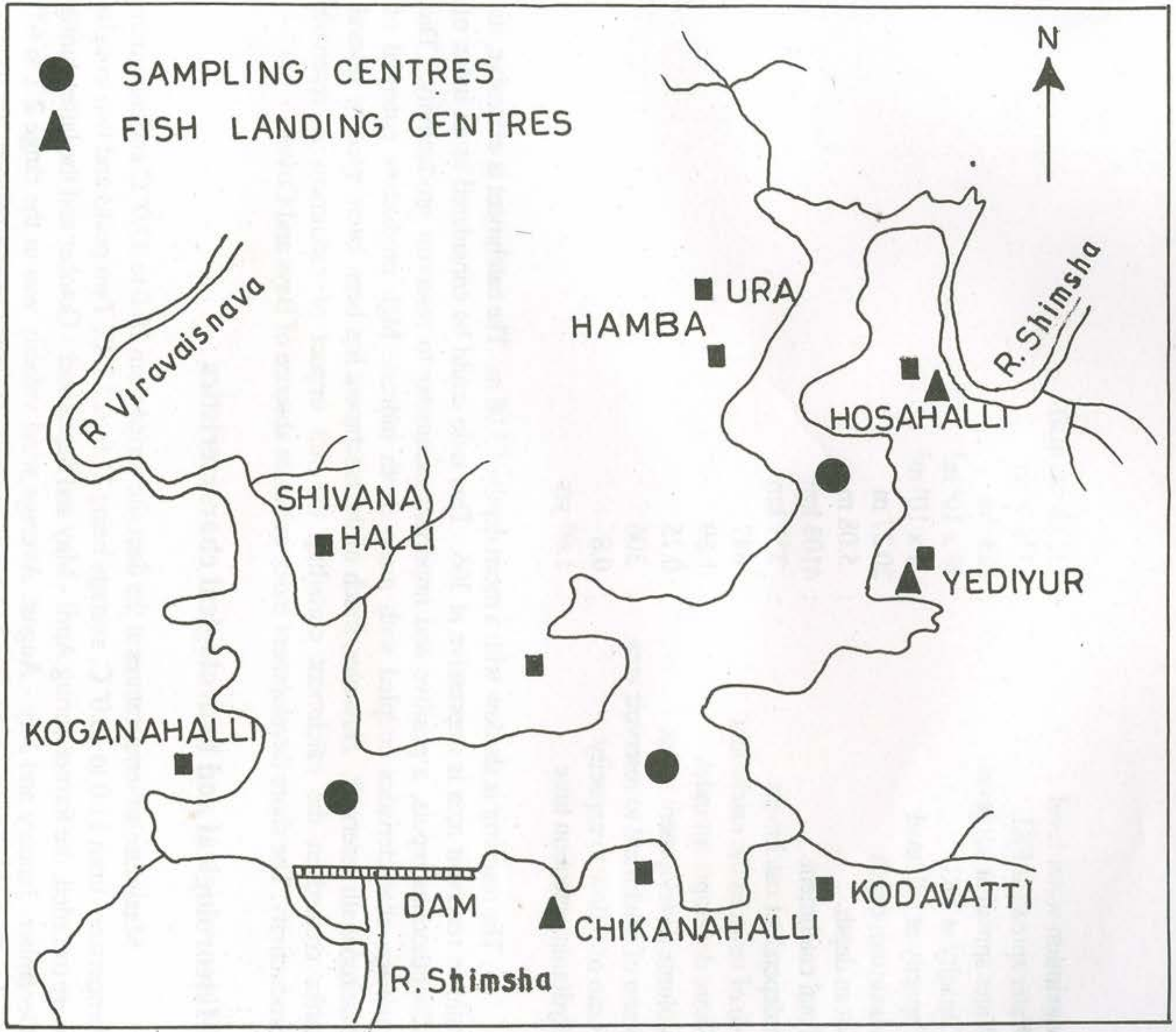


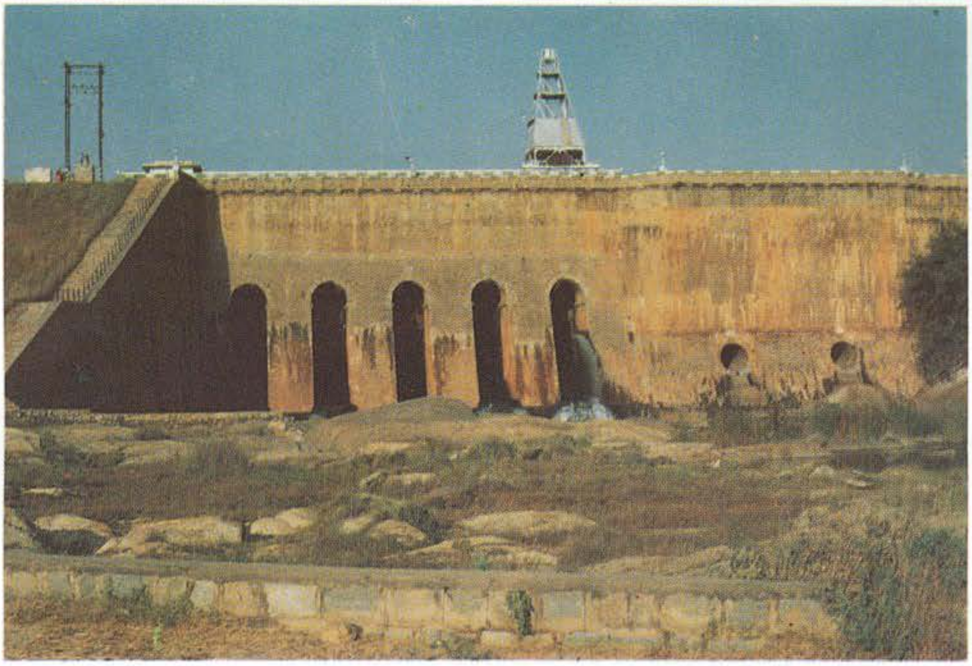
FIG. 1- MAP OF MARKONAHALLI RESERVOIR

Maximum water level	:	732.48 m (msl)
Water spread at FRL	:	1336.9 ha
Water spread at sill level	:	128 ha
Capacity at FRL	:	68×10^6 m^3
Capacity at sill level	:	4×10^6 m^3
Maximum depth	:	20.27 m
Mean depth	:	5.08 m
Total catchment	:	4103 km^2
Independent catchment	:	337 km^2
No.of tanks in the catchment	:	647
Shore development index	:	1.89
Volume development index	:	0.75
Ratio of catchment to reservoir area	:	306
Ratio of inflow to capacity	:	0.8
Hydraulic retention time	:	1.69 yrs

The reservoir is shallow with a mean depth of 5.08 m. The catchment is extensive, its ratio to reservoir area is impressive at 306. This ratio could be considered as an index of allochthonous inputs, a positive and important parameter to reservoir productivity. The drainage characteristics coupled with mean depth indicate high productive potential of Markonahalli reservoir. However, much of the catchment has been intercepted by several tanks created in the catchment curtailing the full impact of catchment in reservoir productivity. The shore development index indicates absence of Bays and Coves.

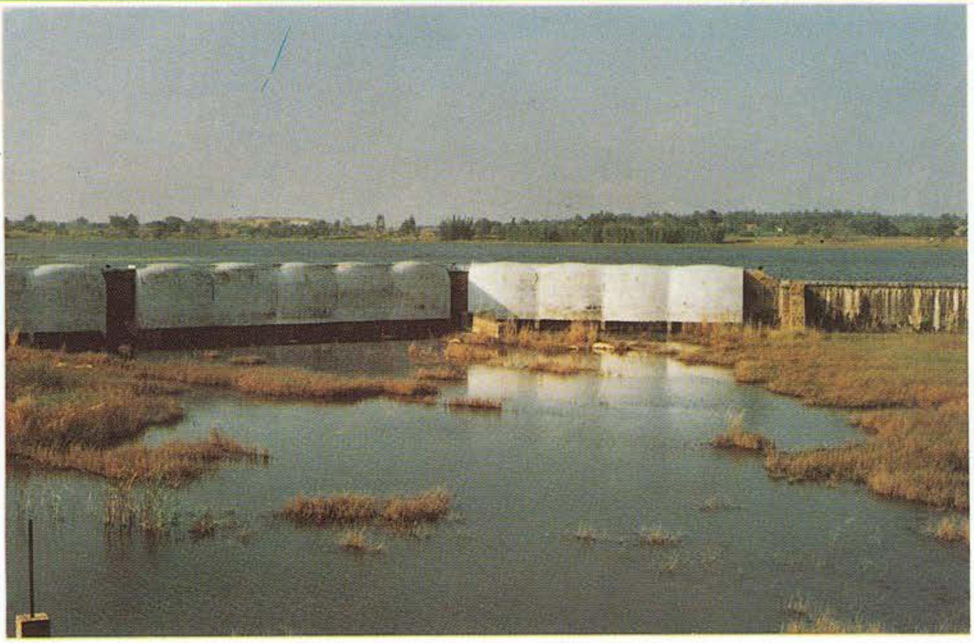
Meteorological and hydrological characteristics

Maximum air temperatures at the dam site varied from 29.0 to 37.0° C and minimum temperature from 11.0 to 20.0° C, average being 21.0 - 27.7° C. Two peaks and two troughs were recorded, the former during April - May and September - October and the latter during December- January and July - August. Average wind velocity was in the range 2.7 to 6.0 km/hr. The period between May and October generally recorded higher velocity winds.



The Markonahalli Dam

A view of the reservoir



Siphons at the waste-weir

Fish seed farm with dam in the background

The catchment of Markonahalli reservoir, situated in rain-shadow region of Western Ghats, is subjected to periodic droughts. The southwest monsoon is generally active in this part during its receding phase i.e. between September and October and much of the precipitation occurs during this period. The impact of northeast monsoon is also significant in some years. The average annual rainfall at the dam site is 677 mm. However, the data collected since 1940 showed no correlation between the rain fall at dam site and inflow of water into the reservoir ($r = 0.142$, $P<0.05$).

The area and capacity curves at different water levels of the reservoir are depicted in Fig. 2 whereas hydrological features are shown in Table 1. Water levels fluctuated annually depending on the inflow and water usage and with it the area of the reservoir. The fluctuations were in the range 725.43 to 726.35 m (area 450-560 ha) in 1990-91, 725.2 to 730.75 m (area 430-1210 ha) in 1991-92, 729.31 to 730.82 m (area 975-1205 ha) in 1992-93, 727.54 to 729.78 m (725-1020 ha) in 1993-94 and 725.14 to 727.97 m (430-770 ha) in 1994-95. The average area ranged from 518 ha in 1990-91 to 1110 ha in 1992-93 (Table 1). The reservoir generally recorded low water levels during July to September and higher levels during October to December.

The annual pattern of inflow and outflow of water in Markonahalli reservoir is depicted in Fig.3. Peak inflows generally occurred during October. The quantum of annual inflow in relation to capacity of the reservoir has shown marked fall over the decades from the inception of the reservoir. It was 4 times the capacity during 50s, 3 times during 60s and 70s, 2 times during 70s and 0.8 times during the period of investigation. This is attributable to the interception of the catchment by the tanks created in the catchment. Only during 1991-92 and 1992-93, the inflows were higher than the capacity and the reservoir attained full level. During 1994-95 water from Hemavathy project has been diverted into Markonahalli reservoir in November and December to augment inflows. This arrangement, if continued, is expected to moderate fluctuations in water levels and is congenial for productivity.

The outflows were generally maximum during August-September and again during November - December to meet the agricultural needs. Due to low inflows and higher outflows during August-September, reservoir levels were minimum in this period.

Table 1. Some hydrological and morphometric features of Markonahalli reservoir in different years

Year	Water level range(m)	Annual inflow (10^6 m^3)	Annual outflow (10^6 m^3)	Average area (ha)
1990-91	725.43-726.35	10.804	17.513	518
1991-92	725.20-730.75	73.100	35.900	818
1992-93	729.31-730.82	87.039	91.244	1110
1993-94	727.54-729.78	53.880	78.871	824
1994-95	725.14-727.97	57.740 *	63.480	667

** The inflow has been augmented during November and December by diverting water from Hemavathy project for the first time.*

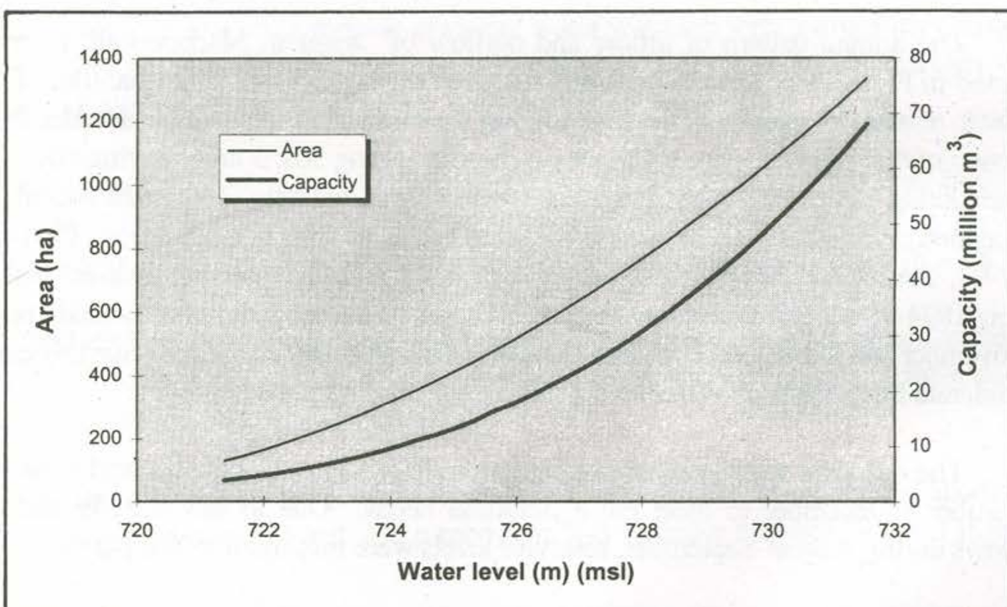


Fig 2. Area (ha) and capacity of Markonahalli Reservoir at different water levels.

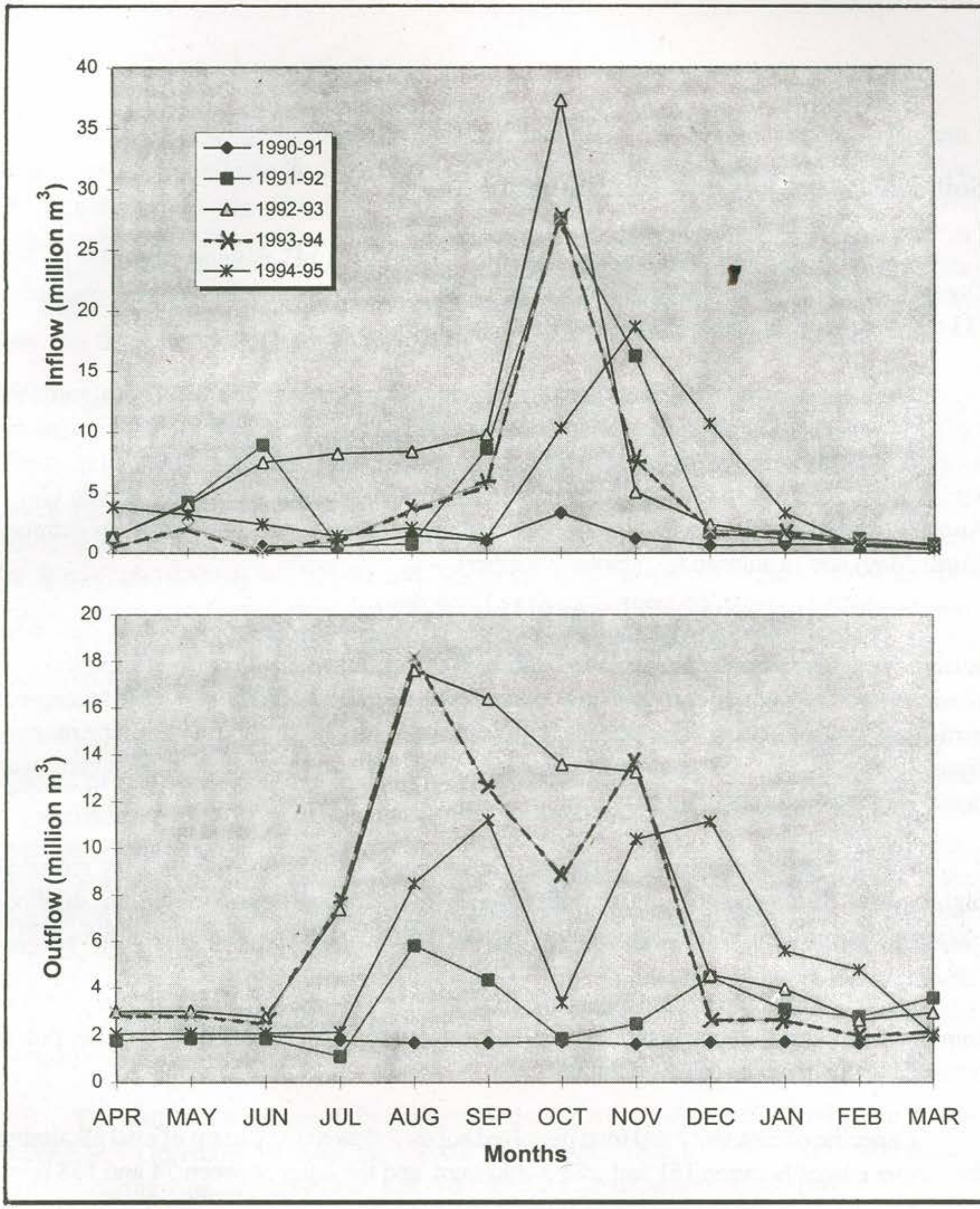


Fig 3. Monthly inflow and outflow in Markonahalli Reservoir for different years.

Soil characteristics and water quality

Soil texture was sandy loam, slightly alkaline with pH ranging from 7.0 to 7.9. Organic carbon was fairly rich (1.1 to 1.64%) while available nitrogen moderate (33.69/100 g) and available P was poor (0.2 mg/100 g).

The physico-chemical characteristics of water are presented in Table 2. No significant variation was noted in physical and chemical parameters among different sampling stations which is attributable to the low mean depth and absence of protected bays. Water temperature varied from 21.0° to 28.0° C with two troughs; one coinciding with rainy season (July-August) and the other with winter (December-January), and two peaks in summer (April-May) and in autumn (September-October).

Transparency varied significantly between the years depending on flood and water level. Lowest transparency was recorded during 1990-91 (range 30-42 cm). This period was characterised by poor inflow and low water level and the turbidity was due to organic particulate matter. During other periods, clarity of water was high with transparency ranging from 45 to 259 cm. Except for few months (June, July and October) transparency was generally high all through the year.

Water was alkaline with pH values in the range 7.5 to 8.5. April to May recorded higher pH (8.5) which was reduced subsequently by monsoon flows resulting in dilution. However, during 1992-93, these values remained high with narrow oscillation. (8.5 - 8.7).

Total alkalinity was moderately high (range 82 to 144 ppm) with maximum values in summer (May) due to concentration of ions and minimum during September - October due to influx of water and consequent dilution.

Specific conductivity and total dissolved solids followed the pattern of total alkalinity, the former ranged between 151 and 283 μ mhos/cm and the latter between 74 and 138 ppm.

Table 2 . Water quality parameters (Range and average) of Markonahalli Reservoir

Parameters	1990-91	1991-92	1992-93
Temp. (°C)	21.0 - 28.2 (24.8)	21.0 - 25.0 (23.2)	22.0 - 28.0 (25.5)
Transp. (m)	0.30 - 0.42	0.45 - 2.04 (1.23)	1.67 - 2.59 (2.15)
DO (mg/l)	6.2 - 8.8 (7.1)	5.5 - 8.5 (7.2)	6.0 - 10.9 (8.1)
pH	8.5 - 8.7 (8.5)	7.4 - 8.5 (7.7)	7.9 - 8.7 (8.6)
Total alkalinity (mg/l)	129.0 - 143.7 (137.3)	100.0 - 132.0 (112.5)	82.0 - 0135.0 (109.0)
Sp.cond. (m mhos/cm)	167.0 - 283.0 (230.1)	154.0 - 207.0 (186.5)	151.0 - 211.0 (179.0)
TDS (mg/l)	81.0 - 138.0 (115.9)	75.0 - 104.0 (91.9)	74.0 - 104.0 (91.0)
Silicate (mg/l)	5.0 - 6.8 (5.8)	3.6 - 10.0 (6.2)	1.0 - 6:0 (3.8)
Total P (m g/l)	-	-	T- 160.0 (57.0)
Total react.P (mg/l)	T	T	T
Nitrate -N (mg/l)	T	T	T

(Figures in parantheses are average values)

Dissolved oxygen was recorded in the range 5.5 to 10.9 ppm. Higher values occurred during October to December, contributed by influx of water, lower water temperature and increased phytosynthetic activity.

Essential nutrients, phosphates and nitrates, were in low concentration and often in traces. The probable reasons could be (i) poor loading from catchment (ii) quick turn-over and (iii) extensive growth of submerged aquatic vegetation locking up the nutrients.

Silicates occurred in the range 1 to 10 ppm with mean values 3.6 to 5.8 ppm. Post monsoon months generally recorded higher values and lower values invariably occurred during pre-monsoon months.

Depth-profile distribution of physico-chemical parameters

Figure 4 depicts vertical distribution of physical and chemical parameters. Water column exhibited isothermal conditions for most part of the year. This was due to shallow conditions, high velocity winds (May-September) and influx of flood water (September-November) which kept the water column well mixed. However, thermocline was noted between 4 and 5 m during February 1993 for a short period (Fig 4).

Weak chemical stratification generally occurred during February to April and again from October to December. Oxycline was moderate during March with values decreasing from 8.8 ppm at surface to 4.0 ppm at bottom in lentic zone. In other months it was feeble with a difference of not more than 2.0 ppm from surface to bottom. Shallowness, submerged aquatic weeds and prevailing winds might have prevented the formation of strong oxycline, which is generally expected in productive reservoirs.

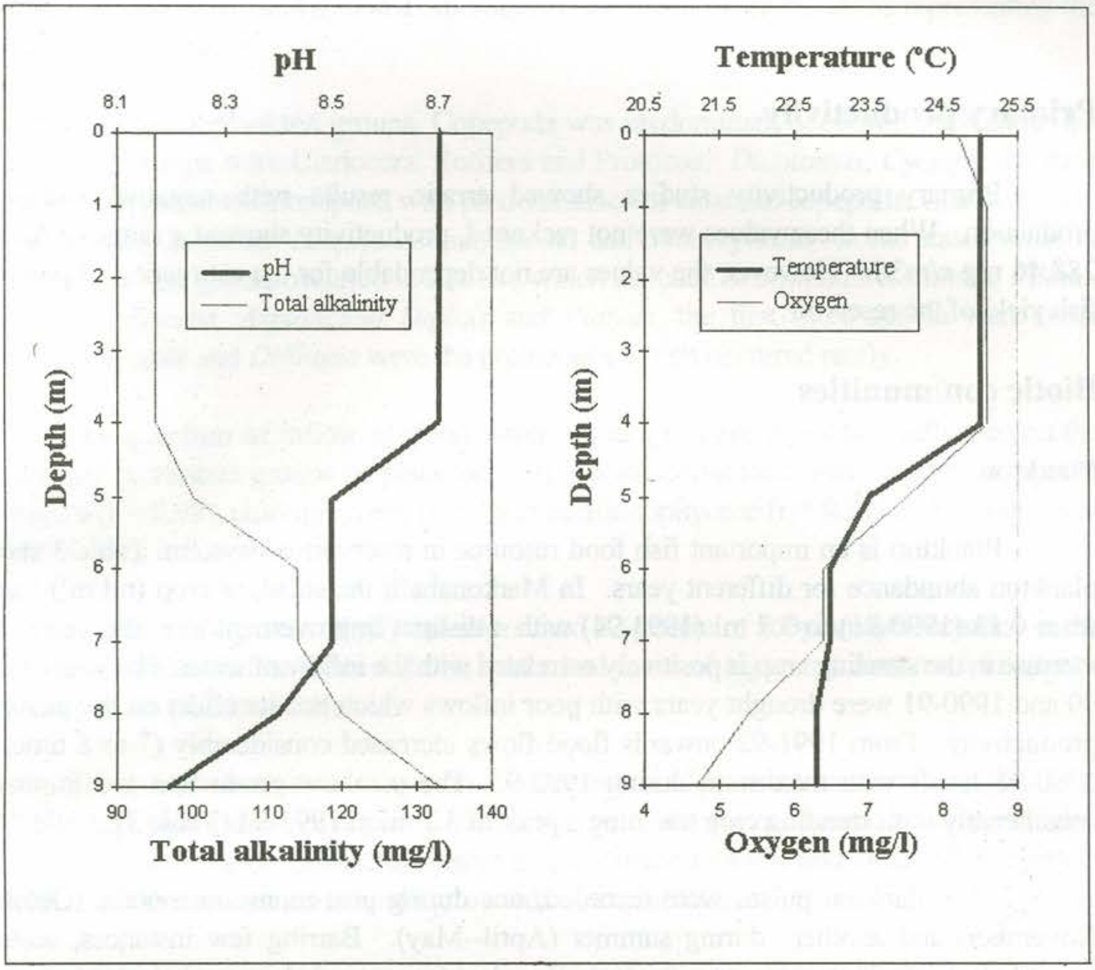


Fig 4. Thermal and chemical stratification in Markonahalli Reservoir during February 1993.

Primary productivity

Primary productivity studies showed erratic results with negative values of production. When these values were not reckoned, productivity showed a range of 62.5 to 288.46 mg c/m3/hr. However, the values are not dependable for the estimation of potential fish yield of the reservoir.

Biotic communities

Plankton

Plankton is an important fish food resource in reservoir ecosystem. Table 3 shows plankton abundance for different years. In Markonahalli the standing crop (ml/m^3) varied from 0.13 (1990-91) to 3.7 ml (1993-94) with a distinct improvement over the years. The increase in the standing crop is positively correlated with the inflow of water. The years 1989-90 and 1990-91 were drought years with poor inflows which had its effect on the plankton productivity. From 1991-92 onwards flood flows increased considerably (7 to 8 times of 1990-91 level) with maximum during 1992-93. The plankton production too improved considerably with standing crop touching a peak of 3.7 ml in 1993-94 (Table 3).

Two plankton pulses were recorded, one during post-monsoon months (October-November) and another during summer (April--May). Barring few instances, sectoral variation in plankton was non-existent. Zooplankton recorded overwhelming presence forming 69.32% of the total counts. Abundance of various groups are depicted in Fig. 5.

Among phytoplankton, Dinophyceae represented by *Ceratium hirundinella* was the most dominant group. *Ceratium* occurred throughout the year with peak during winter. Next in the order of abundance was Chlorophyceae. Important genera in this group were *Spirogyra, Pediastrum, Ulothrix, Staurastrum, Chaetophora* and *Pachycladon*. The group

Bacillariophyceae was frequently represented by *Navicula, Pinnularia, Rhopaloidea, Mastagloia, Gyrosigma* and *Synedra. Microcystis* and *Nostoc* were the forms representing the group Myxophyceae.

Among zooplankton groups, Copepoda was predominant occurring throughout the year. Other groups were Cladocera, Rotifera and Protozoa. *Diaptomus, Cyclops* and their larval forms represented Copepoda with predominance of calanoid copepods. Cladocera was represented by *Bosmina, Diaphanosoma, Moina* and *Simocephalus* in the stated order of dominance. Eight genera occurred in Rotifera which included *Brachionus, Keratella, Filinia, Polyarthra, Lecane, Asplanchna Diplois* and *Platyas*; the first three genera were more prevalent. *Arcella* and *Difflugia* were the protozoans which occurred rarely.

The quantum of inflow of flood water appears to have a positive influence on the abundance of various groups of plankton. Significant correlation was noted in respect of cladocera ($r = 0.98$), chlorophyceae ($r = 0.92$) bacillariophyceae ($r = 0.92$) and dinophyceae ($r = 0.93$) with inflow.

A total of 30 genera of phytoplankton and 22 genera of zooplankton recorded in the reservoir are presented in Table 4. Lotic sector had more of algae and diatoms while lentic had more of zooplankton forms.

The species diversity H (Shannon-Weaver index) of plankton was in the range 2.18 to 2.57 bits/ individual through different years (Fig. 6). Lotic sector showed uniformly higher values while lentic sector approached higher ranges during 1990-91 and 1992-93. The values indicated that the ecosystem is tending towards eutrophication.

Bottom biota

In the lentic zone bottom deposits consisted predominantly of sand and gravel. Lotic zone and the river course are silt laden. Benthic population was poor and was in the range 19 to 456 no/m^2. The soil texture (sand and gravelly) and steep water level fluctuations, probably contributed to the poor biota. Populations were always higher in lotic sector.

Table 3. Plankton abundance in units (no./m^3) and volume (ml/m^3) in Markonahalli reservoir (1989-90 to 1993-94)

Year	Lentic		Intermediate		Lotic		Average	
	No.	Volume	No.	Volume	No.	Volume	No.	Volume
1989-90	30500	0.2	17250	0.2	44100	0.1	30616	0.17
1990-91	54900	0.2	37750	0.1	36200	0.1	42950	0.13
1991-92	190000	2.8	112700	2.1	215550	2.7	173016	2.53
1992-93	126850	1.5	120150	2.5	139000	2.1	128666	2.03
1993-94	396700	4.1	478050	3.6	372550	3.5	415766	3.7

Table 4. Plankton encountered in Markonahalli reservoir (1989-90 to 1993-94)

Phytoplankton	Zooplankton
Myxophyceae	**Protozoa**
Microcystis sp.	*Arcella sp.*
Nostoc sp.	*Difflugia sp.*
Chlorophyceae	**Rotifera**
Spirogyra sp.	*Keratella spp.*
Ulothrix sp.	*Brachionus spp.*
Cosmarium sp.	*Polyarthra sp.*
Pachycladon sp.	*Lecane sp.*
Oedogonium sp.	*Trichocerca sp.*
Glenodinium sp.	*Chromogaster sp.*
Ankistodesmus sp.	*Asplanchna sp.*
Closteriopsis	*Diplois sp.*
Staurastrum sp.	*Platyias sp.*
Gleobotrys sp.	*Colurella sp.*
Actidesmium sp.	*Pleurosigma sp.*
Bacillariophyceae	*Polyphemus sp.*
Navicula spp.	*Filinia spp.*
Synedra sp.	**Cladocera**
Desmidium sp.	*Bosmina spp.*
Asterionella sp.	*Moina brachiata*
Mastogloia sp.	*Daphnia spp.*
Rhizosolenia sp.	*Simocephalus sp.*
Ephithemia sp.	*Diaphanosoma spp.*
Pinnularia spp.	**Copepoda**
Fragilaria sp.	*Diaptomus spp.*
Amphora sp.	*Cyclops spp.*
Diatomella sp.	Larval copepods
Denticula sp.	
Rhopalodia sp.	
Opephora sp.	
Camphylodiscus sp.	
Caloneis sp.	
Dinophyceae	
Ceratium sp.	

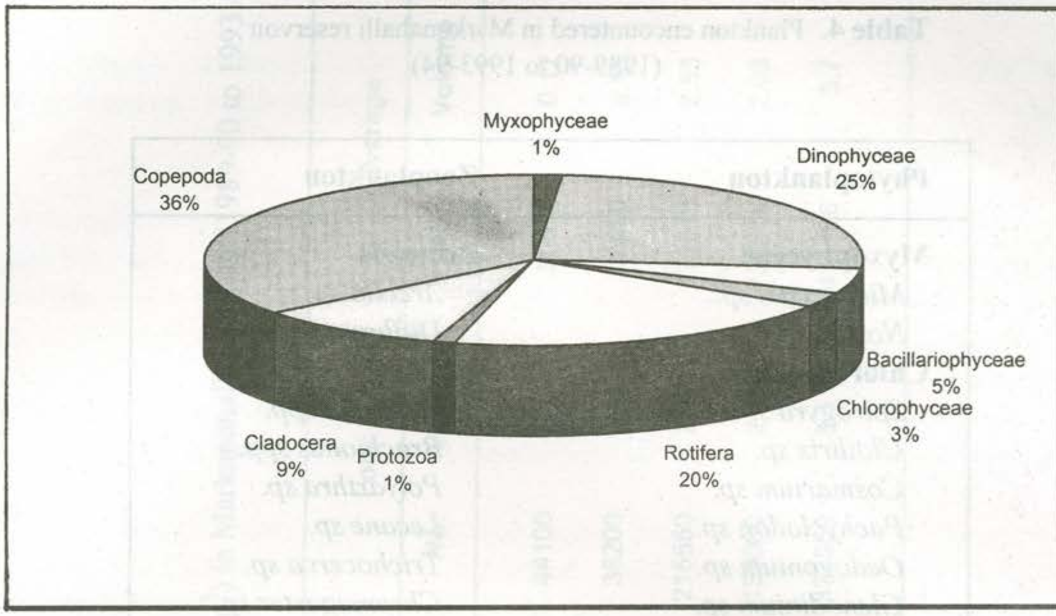


Fig 5. Percentage composition of different groups of plankton in Markonahalli Reservoir.

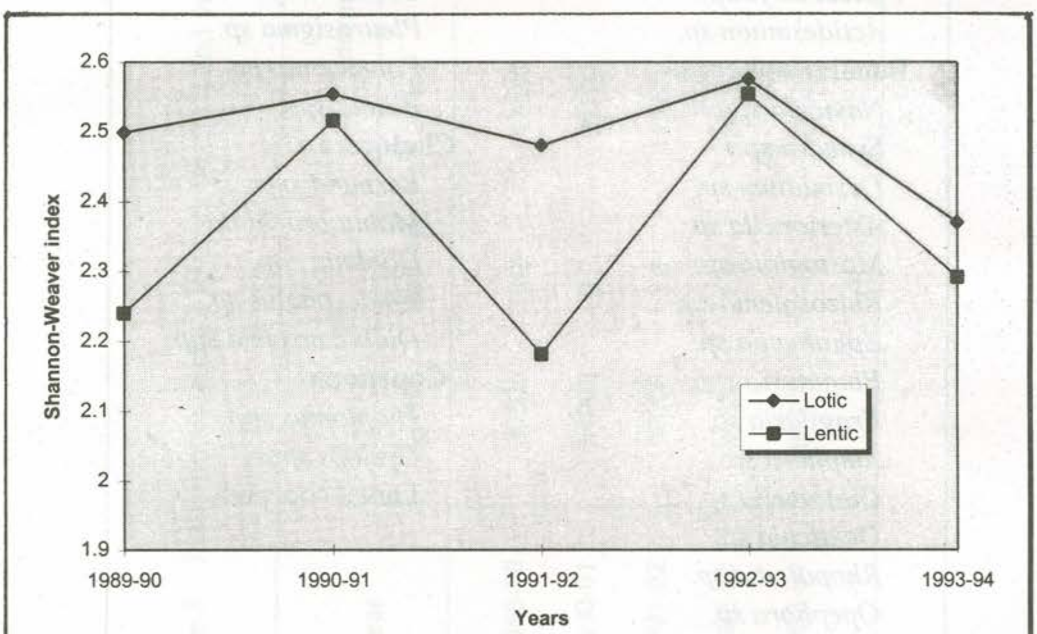


Fig 6. Species diversity of plankton in Markonahalli Reservoir.

Molluscs accounted for more than 90% of the benthic population, followed by larval insects and aquatic oligochaetes. Molluscs encountered were *Lamellidens marginalis, L. corianus, Viviparus bengalensis, Melania striatella tuberculata, M. plotea scabra, Bithynia stenothyroides, Lymnea luteola, L. acuminata* and *Indoplanorbis exustus*. Insect larvae were represented by *Chironomus* spp. and *Ephemeralla* spp. and oligochaetes by *Tubifex.*

Periphyton

Periphytic communities settled on submerged substrata were collected for a period of two years and the average values for different months are depicted in Fig. 7. Two peaks in periphytic abundance were evident, one during May and the other in September. Bacillariophyceae contributed to the maximum forming 90.20% of the populations followed by Chlorophyceae 8.68%. All other groups were insignifiicant. Twenty one diatom genera were recorded, important forms being *Navicula, Pinnularia, Cymbella, Synedra, Fragilaria* and *Gyrosigma*. Many of the species were not encountered in plankton. No significant difference in species diversity between sectors was noted.

Periphytic community is an important fish food resource in Markonahalli reservoir as *L. rohita* the dominant fishery mainly sustained on this community.

Aquatic plants and associated fauna and flora

Dense aquatic vegetation was noted in most parts of the reservoir barring dam zone. The aquatic weed biomass (wet weight) was estimated in the range of 200 to 1200 g/m^2, the intermediate sector recording the highest. The macrophytes occurring in the order of abundance were *Potamogeton pectinatus, Vallisneria, Hydrilla verticillata* and *Ceratophyllum. Potamogeton* was dominant in the lentic sector and *Vallisneria* in intermediate and lotic sectors. Large tracts of the reservoir with macrophytes get exposed every year during August-September when water levels touch minimum. They again establish after October-November when the reservoir gets filled up and water levels stabilize.

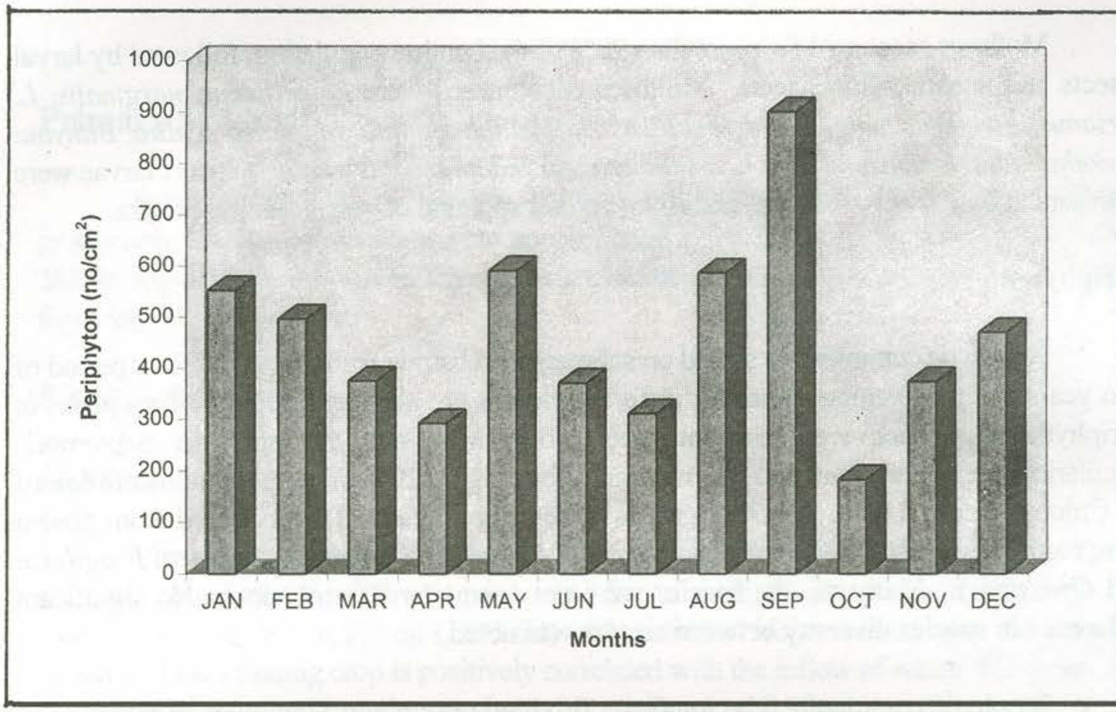


Fig 7. Average monthly abundance of periphyton in Markonahalli Reservoir

A variety of fauna and flora were found to be associated with macrophytes. Among flora, diatoms like *Nitzchia, Synedra, Gomphonema, Navicula, Pinnularia* and *Mastogloia*, the myxophyceaen *Merismopedia* were found on the macrophytes. Macro-invertebrates *viz. Viviparus bengalensis, Melania striatella tuberculata, M. plotea scabra, Indoplanorbis exustus, Corbicula peninsularis* among mollusca, insects and insect larvae, nematodes, oligochaetes and the cladoceran *Chydorus* were found to be associated with the weeds.

Micro and macro fauna and flora associated with macrophytes form an important food niche in the ecosytem.

Fish fauna

Fish fauna of Markonahalli reservoir is characterised by low species diversity. Only twenty eight species belonging to ten families have been recorded from the reservoir, out of which twenty three are indigenous, four stocked and one exotic species. Family Cyprinidae was represented by fifteen species (including the stocked ones) followed by Channidae (3 species) and Siluridae (2 species). Other families were represented by single species. The classified list of fish is given below:

Family : **Notopteridae**

1. *Notopterus notopterus* (Pallas)

Family : **Cyprinidae**

2. *Chela (chela) cachius* (Hamilton-Buchanan)
3. *Salmostoma clupeoides* (Bloch)
4. *Puntius sophore* (Hamilton-Buchanan)
5. *P. ticto* (Hamilton-Buchanan)
6. *P. sarana sarana* (Hamilton-Buchanan)
7. *P. chola* (Hamilton-Buchanan)
8. *P. dorsalis* (Jerdon)

9. *Parluciosoma daniconius* (Hamilton-Buchanan)
*10. *Catla catla* (Hamilton-Buchanan)
*11. *Cirrhina mrigala* (Hamilton-Buchanan)
12. *Cirrhina reba* (Hamilton-Buchanan)
*13. *Labeo rohita* (Hamilton-Buchanan)
14. *L. calbasu* (Hamilton-Buchanan)
15. *L. bata* (Hamilton-Buchanan)
*16. *Cyprinus carpio var communis* Linnaeus

Family : **Siluridae**

17. *Wallago attu* (Schneider)
18. *Ompok bimaculatus* (Bloch)

Family : **Bagridae**

19. *Mystus cavasius* (Hamilton-Buchanan)

Family : **Channidae**

20. *Channa marulius* (Hamilton-Buchanan)
21. *C. striatus* (Bloch)
22. *C. punctatus* (Bloch)

Family : **Gobiidae**

23. *Glossogobius giuris* (Hamilton-Buchanan)

Family : **Heteropneustidae**

24. *Heteropneustes fossilis* (Bloch)

Family : **Poecilidae**

25. *Gambusia affinis* (Baird & Girard)

Family : **Ambassidae**

26. *Chanda nama* Hamilton-Buchanan
27. *Chanda ranga* Hamilton-Buchanan

Family : **Mastacembelidae**

28. *Mastacembelus armatus* (Lacepede)

Fishery

Fishing effort

The fishery of Markonahalli reservoir is being exploited through licencing system. The Department of Fisheries, Karnataka, is the agency responsible for the development and management of the reservoir. The department issues licences levying an annual fee and regulates fishing effort allowing each unit a length of 300 m gill net of mesh size above 62 mm (2.5").

Fishing effort (in terms of coracle days) and catch for different months are shown in Fig. 8. It was not possible to monitor the number of nets operated by each fishermen as co-operation from them was not forthcoming. When the reservoir was taken up for investigations in 1990, fishing effort was low with 4-5 coracles operating. Low effort appear

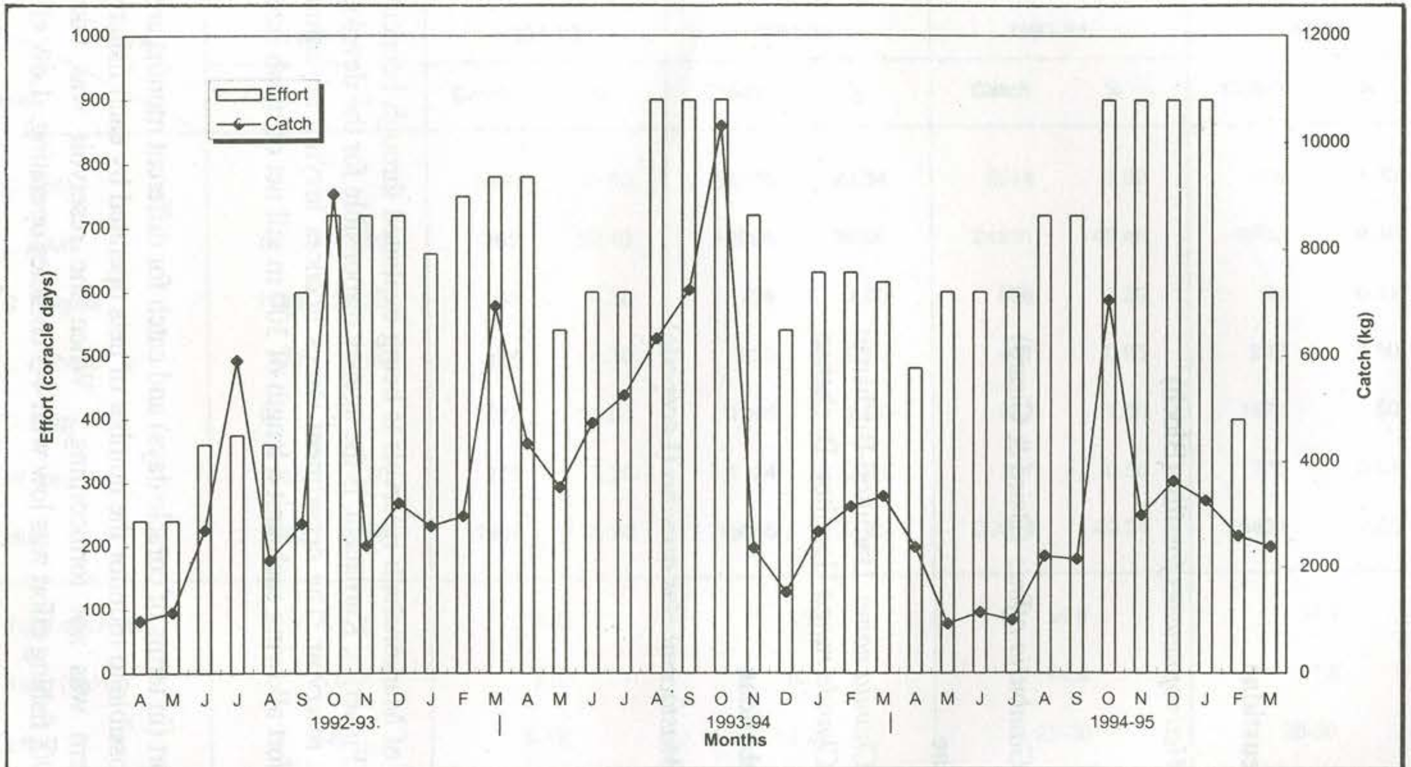


Fig 8. Effort and catch in Markonahalli Reservoir through months (1992-95)

Coracles at the landing place

Catch from the reservoir

A fisher selling his day's catch

Fisher folk at the landing centre

to be due to the poor catches consisting of indigenous fish. However, from 1991-92 the number of fishing units went up gradually reaching a peak of over 30 units in 1993-94. The increase in effort was mainly due to the occurrance of major carps in the catches from 1992 which brought good returns to fishermen. Though the length of the gill net allowed for each party was 300 m, nobody adhered to the limit either in length or mesh size.

Gill net is the main gear of exploitation. In certain seasons long lines are also used on a small scale. Coracle is the main fishing craft as in other reservoirs of peninsular India. It is manned by two people, generally from the same family. Women members in some families actively participated in fishing. Only few parties are full-time fishermen engaged in fishing throughout the year. Others are part-time operators dividing their time between agriculture and fishing. Hence, effort was not uniform throughout the year (Fig. 8).

Trends in the catch and catch composition

Total catch and composition for different years are shown in Table 5. The catch was only 4.1 t in 1990-91 and 5.2 t in 1991-92. However, during 1992-93 the landings rose sharply to 46.0 t, a nine-fold increase from previous year. The increasing trend was maintained in 1993-94 with a catch of 54.8 t, but declined to 34.9 t in 1994--95. The yield (per hectare) fluctuated from 5.6 kg in 1990-91 to 74.8 kg in 1993-94. The impressive hike in fish yield was achieved from the stocking support coupled with increase in effort.

Trends in the catch of major fish species are depicted in Fig 9. In 1990-91, major carps consisting of *C. mrigala* (29.2%), *L. rohita* (15.1%) *and L. calbasu* (11.6%) together accounted for about 56% of the catch. Miscellaneous group formed 37.6% and *W. attu* 6.5%. Under the miscellaneous group are included indigenous species such as *Notopterus notopterus, Cirrhina reba, Puntius sarana, Mystus cavasius, Glossogobius giuris*, *Channa marulius, Ompok bimaculatus* and *Mastacembelus armatus*.

Table 5. Fish catch (kg) and species composition in Markonahalli reservoir

Species \ Years	1990-91		1991-92		1992-93		1993-94		1994-95	
	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%
C. catla	-		1030	19.80	10736	23.34	5514	9.89	465	1.33
L. rohita	615	15.10	1165	22.40	16955	36.86	24891	45.46	6852	19.66
C. mrigala	1190	29.20	68	1.30	735	1.60	656	1.20	39	0.11
L. calbasu	472	11.60	224	4.30	323	0.70	467	0.85	280	0.80
C. carpio	-		572	11.00	1046	2.27	983	1.80	1572	4.50
W. attu	265	6.50	275	5.20	1124	2.44	307	0.56	220	0.63
Misc.	1532	37.60	1867	35.90	15085	32.79	22033	40.24	25421	72.95
Total catch (t)	4.1		5.2		46.0		54.8		34.9	
Yield (kg/ha)	5.6		7.0		62.8		74.8		47.5	
Effort (No. of coracles)	4-6		6-12		12-25		25-30		20-30	

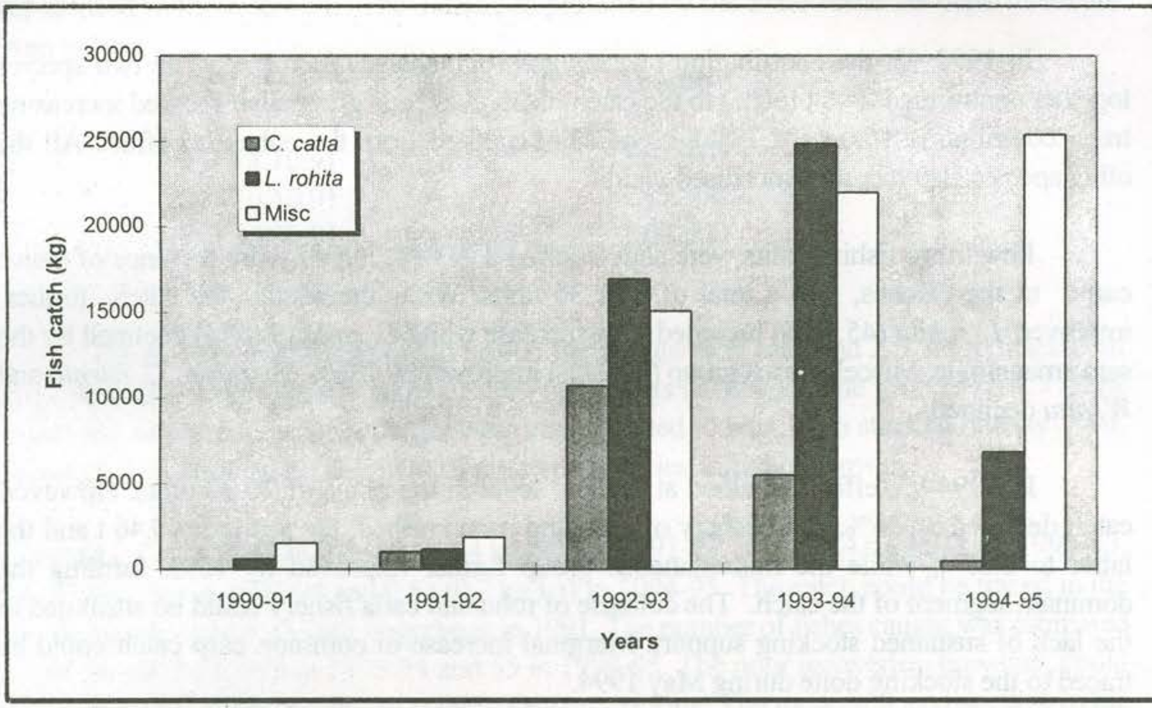


Fig 9. Trends in the catches of important fishes in Markonahalli Reservoir (1990-95).

In 1991-92, though the fishing effort was doubled, catch increased by only 25%. The contribution of carps and miscellaneous fishes remained unchanged from the level of previous year. However, the species composition changed with *C. catla* appearing in the catches for the first time forming 19.8%. The catch of *L. rohita* almost doubled while that of *C. mrigala* reduced to insignificance from 29.2% to 1.3%. *C. carpio* accounted for 11.0% and *L. calbasu* 4.3%. The occurrance of catla and increased landings of rohu could be traced to the stocking of these species in 1991.

In 1992-93, the contribution of catla and rohu sharply increased. The two species together contributed 27.6 t (60%) to the catch. Miscellaneous group also showed increasing trend contributing 15.0 t (32.79%), obviously benefited from the enhanced effort. All the other species also recorded increased yields.

Few more fishing units were added during 1993-94, lured by the presence of major carps in the catches, to a total of over 30 units. With the result, the catch further improved. *L. rohita* (45.46%) recorded 47% increase while *C. catla* (9.89%) declined by the same magnitude. Miscellaneous group (40.24%) improved by 136%. However, *C. carpio* and *W. attu* declined.

In 1994-95, effort remained at higher level in the range of 20-30 units. However, catch declined by 36%. The fishery of catla and rohu crashed, the former to 0.46 t and the latter to 6.85 t, while the miscellaneous group further improved by 15%, forming the dominant segment of the catch. The collapse of rohu and catla fishery could be attributed to the lack of sustained stocking support. Marginal increase in common carp catch could be traced to the stocking done during May 1994.

Stock characteristics *vis a vis* stocking

Stocking in Markonahalli reservoir has been erratic and empirical. The Fisheries department of Karnataka is deficient in fish seed production and the reservoir stocking is given low priority. However, in October 1991 the seed was procured from Andhra Pradesh and stocked in the reservoir. The details, as provided by the State Fisheries department are given below.

Date	Species	Quantity
13.10.91	*C. catla*	3,03,610
16.10.91	*C. catla*	1,40,000
16.10.91	*L. rohita*	1,63,000

The stocking rate works out to be 605 fingerlings/ha in catla and 222 fingerlings/ha in rohu. Besides stocking of 4.5 lakhs of rohu fingerlings (614/ha) in the year 1992, 2.7 lakhs fingerlings of common carp (368/ha) were also reported to have been stocked in May 1994. The impact of stocking on the yield of different species is given below.

C. catla : Catla contributed 1.0 t (1.4 kg/ha) in 1991-92, 10.7 t (14.6 kg/ha) in 1992-93, 5.4 t (7.4 kg/ha) in 1993-94 and 0.5 t (0.7 kg/ha) in 1994-95. The catch could be traced to the reported stocking of 4.43 lakh fingerlings in 1991. The number of fishes caught was estimated at 4492 in 1992-93, 995 in 1993-94 and 55 in 1994-95. The poor recoveries, however, could not be explained in the absence of reliable data on stocking. The mounting average size in the catch in successive years - 526 mm (2.4 kg) in 1992-93, 713 mm(5.3 kg) in 1993-94 and 820-870 mm (8-10 kg) in 1994-95, clearly indicated absence of recruitment. This is to be expected as no stocking of catla has been done after 1991. The fish was subjected to high fishing intensity as indicated by the exploitation rate estimated at 78%. In the absence of sustained stocking support the catches of catla diminished. The growth of catla in the reservoir has been impressive and the fish is capable of giving much higher yields.

The performance of the species makes it indispensable for stocking the reservoir on continuing basis.

L. rohita : Rohu contributed 1.2 t (1.6 kg/ha) in 1991-92, 17.0 t (23 kg/ha) in 1992-93, 24.9 t (34 kg/ha) in 1993-94 and 6.9 t (9.4 kg/ha) in 1994-95. The performance of rohu in the reservoir could be termed `excellent' by capture fishery standards. The impressive catches could be traced to the reported stocking of 1.6 lakh fingerling in 1991 and 4.5 lakh in 1992. The average size in the catch for different years were - 471 mm (1.4 kg) in 1992-93, 593mm (2.8 kg) in 1993-94 and 560 mm (2.4 kg) in 1994-95. The number of fishes recovered in the catches were estimated to be 12,180 in 1992-93, 8,820 in 1993-94 and 2,823 in 1994-95. The performance of 1991 stock appears to be good, inspite of low stocking density. However the impact of stocking in 1992 to the catch has been very feeble and casts an element of doubt on the reported magnitude of stocking. Like catla, rohu also has been subjected to intensive fishing with exploitation rate at 71% and high mortality rate.

Rohu is very important for enhancing the yield of Markonahalli reservoir and need to be stocked on continuing basis.

C. carpio : Common carp contributed between 0.6 and 1.05 t up to 1993-94. In 1994-95, the catch recorded marginal increase to 1.5 t (2.0 kg/ha) and this could be attributed to the reported stocking of this species in May 1994. Though the species appears to have been stocked for several years during 80's, it failed to establish as a sustainable fishery in the reservoir. Its failure is rather enigmatic as the reservoir offers suitable breeding habitat for the fish in the form of submerged aquatic vegetation. Probably the predatory population such as *W. attu, C. marulius* (predation at juvenile stage) and *Gambusia* (predation at larval stage) had its effect on the recruitment of *C. carpio*.

The growth of the fish is fairly good and is capable of higher yields. In the absence of natural recruitment, the fish needs stocking support.

C. mrigala : Mrigal was probably stocked during eighties. During 1992-93, its contribution ranged from 0.39 t (1994-95) to 1.2 t (1990-91). Only stray specimen of large size (5.7 kg) appeared in the catch.

The species needs stocking support.

L. calbasu : The species is endemic to the system. It contributed a maximum of 0.47 t in 1991-92 and 1993-94. The increased effort had no impact on the catch. The low stock abundance is due to feeble recruitment.

The fish is not likely to do well in the face of competition from C. carpio.

Miscellaneous fishes : *N. notopterus, M. cavasius, C. reba, G. giuris, P. sarana, O. bimaculatus* and murrels constituting this group, responded positively to the enhanced effort with quantum jumps in the catch and formed the dominant fishery in 1994-95 as the stocking support of prime carps waned. There are clear indications of natural breeding and successful recruitment of these fishes. As they fetch low price in the market, effort will not be directed exclusively for this group. When the abundance of prime carps reduced, fishing effort is generally reduced affecting the catch of this group.

Vital statistics of fish populations

Recruitment, growth and mortality rates constitute the vital statistics of populations. Natural recruitment in prime carps is not dependable in the reservoir due to constraints imposed on the biotope. Hence, artificial recruitment has to be generated through stocking which is vital to obtain maximum sustained yields. In Markonahalli reservoir stocking has been erratic for reasons stated earlier. Age and growth of catla and rohu have been estimated based on length frequency distribution of 1991 stock in the catch. Mortality rate (z) and exploitation rates were estimated by Jone's length-based cohort analysis.

C. catla : The length frequency distribution of catla during 1992-93 and 1993-94 is given in Fig.10. On the basis of modal progression the size attained at different ages has been estimated as 490 mm in 1st year, 740 mm in 2nd year and 860 mm in 3rd year. The empirical growth equation of von Bertalanffy (VBG) has been calculated as,

$$l_t = 1040\,(1 - e^{-0.61(t + 0.087)})$$

Total mortality rate ranged between 0.5 and 3.97 (ave. 1.96) for different size groups. Exploitation rate has been estimated to range from 0.38 to 0.92 (ave. 0.78). Larger size groups (440-620 mm in 1992-93 and 690-730 mm in 1993-94) were subjected to higher rate of mortality. It is evident that the stocks of catla have been fished intensively.

The length-weight relationship of catla has been calculated as,

$$W = 0.00012\ L^{2.6842} \quad (r = 0.9564)$$

L. rohita : The length- frequency distribution of rohu for 1992-93, 1993-94 and 1994-95 is given in Fig.11. Rohu occurred in the catch in the size range 190 to 770 mm with modes at 390 and 470 during 1992-93, 630 mm during 1993-94, 500 and 700 mm during 1994-95. On the basis of progression of modes the lengths attained at successive years were estimated at 450mm in 1st year, 640 mm in 2nd year, and 740 mm in 3rd year. The VBG equation has been calculated to be :

$$l_t = 829\,(1 - e^{-0.77(t + 0.017)})$$

Total mortality rates ranged between 0.46 to 3.6 for different size groups, the average being 1.82. Similarly the exploitation rate was in the range 0.34 to 0.91 (ave. 0.72) indicating that the stocks were intensively fished. The higher rates of exploitation were recorded in size groups 380-620 mm in 1992-93 and 560-680 in 1993-94.

The length-weight relationship of rohu has been calculated as,

$$W = 0.00001\ L^{3.0539} \quad (r = 0.9615)$$

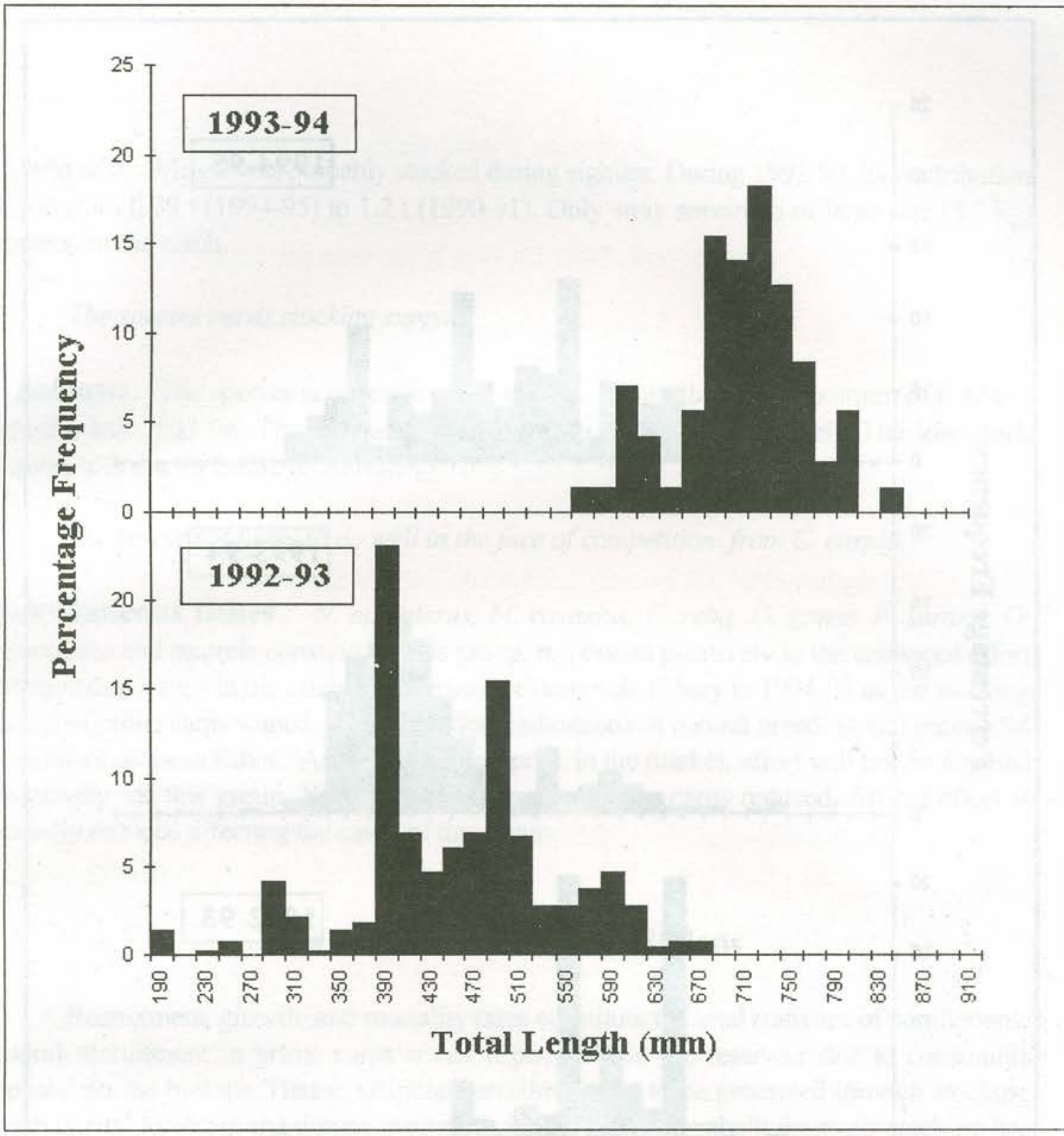


Fig 10. Length-frequency distribution of *C. catla* in Markonahalli Reservoir

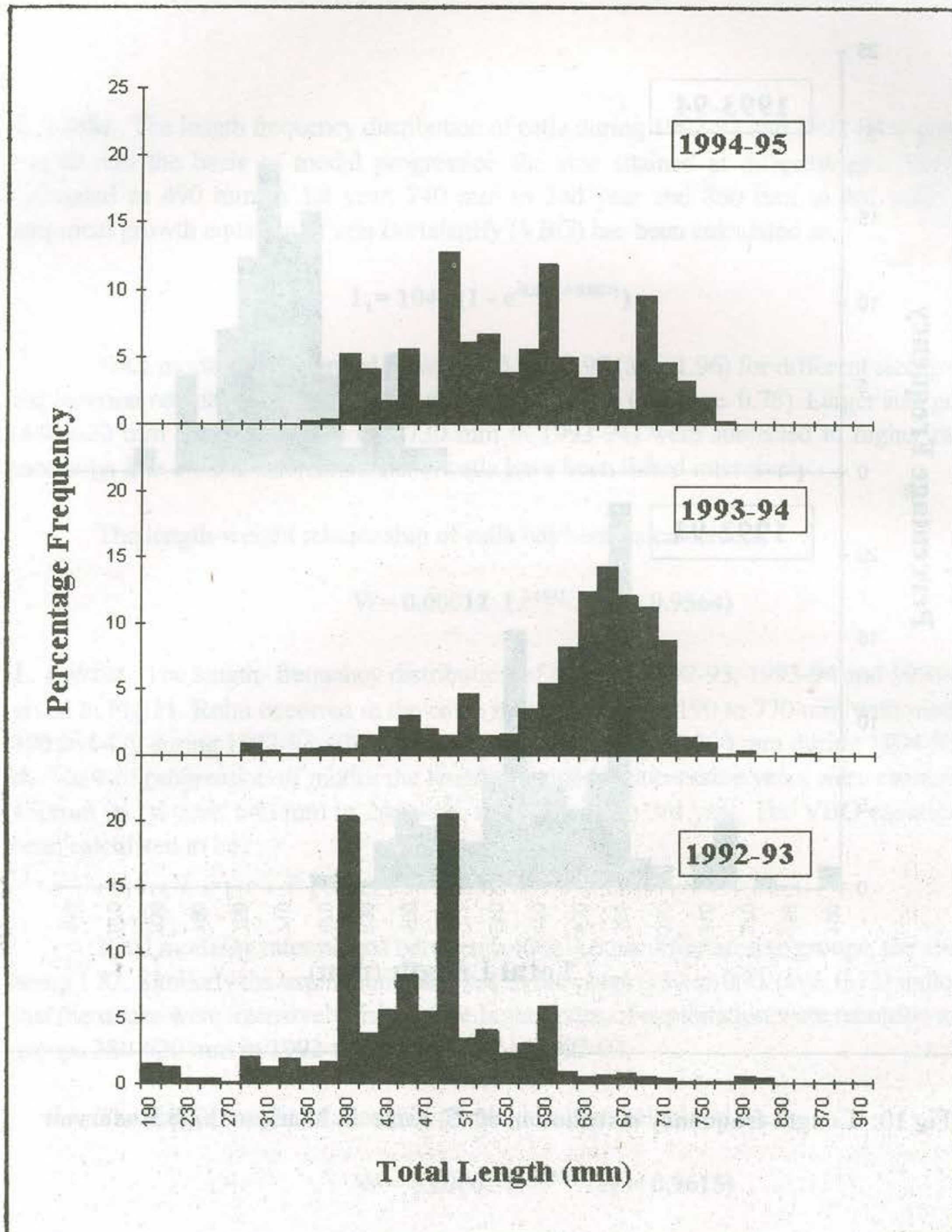


Fig 11. Length-frequency distribution of *L. rohita* in Markonahalli Reservoir.

C. carpio : The fish has been poorly represented in the catch and it was not possible to identify modal progression. However, the seed stocked in May 1994 appeared in the catch in October 1994 at modal lengths of 300 and 360 mm. This may be the growth in 5 months which could be considered as very good.

The length weight relationship of *C. carpio* has been calculated as,

$$W = 0.000037 L^{2.9593} \quad (r = 0.9653)$$

Other carps, *C.mrigala* and *L. calbasu* occurred sporadically rendering the age estimation difficult.

Vital statistics of population of catla and rohu have clearly indicated that both the species have good growth rate in the reservoir and are essential to enhance the fish yields. Markonahalli is one of the few reservoirs where *L. rohita* has performed extreamly well. High rates of exploitation are generally expected in small impoundments with low mean depth. This aspect need not be viewed with concern, especially when stocking support is maintained on continuing basis.

Breeding and recruitment

As mentioned earlier, the reservoir is situated in the rain-shadow region and southwest monsoon had its effect towards the receding phase. Fig. 2 clearly shows that peak inflows of water occurred during October in every year. During July and August, the critical months for major carp breeding, inflows were scanty. These inflows are inadequate for major carps to migrate up-stream and breed. Under such circumstances, the chances of major carps breeding in the reservoir are meagre. Even if sporadic breeding occurs at the head end of the reservoir there are very little possibilities of survival and recruitment. Among commercial fishes, feeble recruitment was noted only in respect *L. calbasu* and *W. attu.*

The indigenous fish such as *N. notopterus, C. reba, P. sarana, M. cavasius, G. giuris* and murrels which could breed under conditions of meagre inflow of flood water, have shown successful recruitment. The continuous increase in the catches of this group in response to the enhanced effort is a positive sign of their successful recruitment.

Though the hydrological conditions of Markonahalli reservoir are not ideal for major carp breeding, presence of submerged vegetation (*Hydrilla, Vallisneria and Potamogeton*) provide suitable conditions for breeding of common carp. However, recruitment of common carp was not significant. Probable reasons could be presence of predaceous fishes such as *Gambusia* (predation of larval stages), *W. attu, C. marulius* and *C. striatus*.

In the absence of recruitment in carps of economic importance, it is imperative to stock them annually to get maximum sustainable yields.

Utilisation of fish food resources by various species of fish

Plankton, bottom biota, periphyton, macrovegetation and detritus are the major fish food resources available in the reservoir. Depending on the food habits of fishes the following categories have been recognised in the reservoir.

Plankton feeders : *C. catla* is the only species feeding on plankton, especially zooplankton. Weed fishes *C. nama* and *C. ranga* utilised this food niche to some extent. As such there is no major species of fish utilising phytoplankton which is dominated by *Ceratium, Ulothrix* and *Pediastrum.* Though *Ceratium* occurs in the guts of some bottom feeders, it is mostly picked up from the bottom along with bottom deposits.

Bottom feeders : Under this category comes majority of fishes in the reservoir such as *L. calbasu, C. mrigala, C. reba, P. dorsalis* and *M. cavasius*. Detritus formed the major food item in *L. calbasu, C. mrigala. M. cavasius* was found to utilise the small molluscs, besides detritus and insects. In *C. reba, P. dorsalis, C. mrigala* and *L. calbasu* diatoms occurred in the diet in varying quantities. These diatoms were periphytic in nature and do not occur in plankton.

Periphyton feeders : *L. rohita* is the most important species feeding on periphyton. Periphytic diatoms such as *Pinnularia, Navicula, Nitzschia, Synedra, Fragilaria* along with organic detritus accounted for the major portion of the diet of rohu. Periphyton also occurred in the diet of *C. reba* and *P. dorsalis.*

Insect feeders : Insects formed the main diet of *N. notopterus* both in young and adult fishes. *O. bimaculatus* and *M. armatus* and *G. giuris* also had insect diet in varying quantities. Small insect larvae and terrestrial insects were taken by *Gambusia*. The extensive mats of submerged aquatic vegetation harboured insect fauna which is in-turn favoured fishes like *N. notopterus* and *Gambusia.*

Fish feeders : *W. attu, C. marulius* and *C. striatus* are the main piscivores in the reservoir. Small amount of fish diet was also recorded in *N. notopterus, M. armatus* and *O. bimaculatus*.

Abundance of *Gambusia* and its probable effects on the indigenous fish fauna

A dragnet (4 m x 2 m) of 3 mm mesh was operated every month in the marginal areas of all zones of the reservoir to sample pre-recruits and weed fishes. Number of hauls and time of each haul have been kept constant as for as possible. The number of fishes caught in the dragnet has been counted species-wise and expressed as No. per effort to study the abundance of individual species. The results are presented in the Fig. 12.

Gambusia affinis, *Salmostoma clupeoides*, *Puntius ticto*, *P. sophore, Rasbora daniconius*, *Chanda nama* and *C. ranga* occurred in the dragnet catches. No pre-recruits of commercial fishes were obtained. *G. affinis* overwhelmed the collections and accounted for 90 to 99% of the weed fish populations in different months. It was particularly dominant during January to July with peaks in April and July.

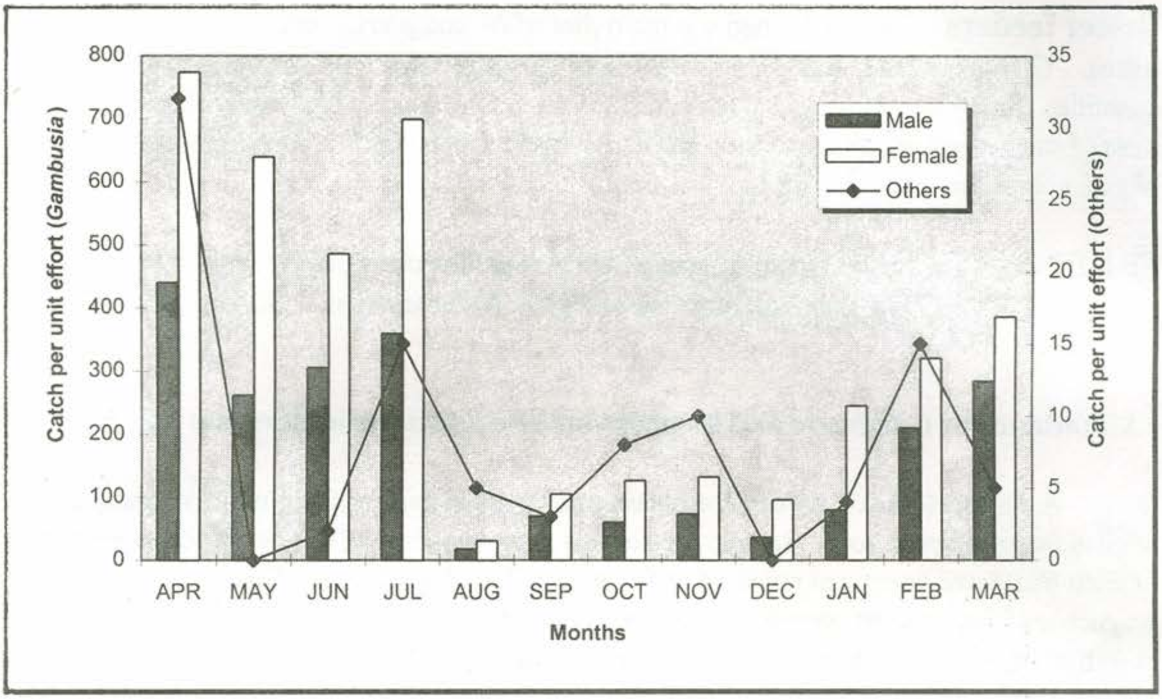


Fig 12. Catch (in number) per unit effort of *Gambusia affinis* (male & female) and other fishes in dragnet collections in Markonahalli Reservoir.

The ecological conditions of Markonahalli reservoir, with large tracts of submerged weeds formed an ideal habitat for the proliferation of *Gambusia*. The weed infested areas, besides affording protection from predators, harboured insects, insect larvae and crustaceans which were foraged by the fish. Other factors contributing to its abundance could be, overwhelming presence of females bringing out several broods in a year and hardy nature of the fish withstanding all types of foul conditions.

It has been stated that *Gambusia* is a dangerous fish to introduce into places where it does not occur naturally. It is reported to be destructive in a new habitat not only to endemic species of similar size but even to much larger fishes. In Markonahalli it appears to have adverely affected weed fish populations and the species diversity. The cyprinid fishes which generally dominate inland water bodies are represented by just eleven species in the reservoir. The scarcity of carp minnows and other fishes could be attributed to the overwhelming presence of *Gambusia*, competing for food and space. Though direct evidence is wanting, the failure of *C. carpio* to naturalise inspite of favourable conditions for its breeding and the meagre abundance of weed fishes could probably be traced to the predatory habits of *Gambusia* which is reported to prey on eggs and larvae of fishes.

Discharge of factory effluents

A paper factory is situated at the village Thattere, 2 km above the Markonahalli reservoir. It was commissioned in 1984 and produces 15 t of paper per day. The factory utilises 2,25,000 gallons of water per day and the effluents are discharged into the river Shimsha through a canal, which ultimately discharged into the reservoir. However, during the dry period these effluents do not reach the reservoir as much of it is lost due to seepage and evaporation. But, during the rainy season, the residues get washed into the reservoir with the inflow.

A study was conducted in November 1993, on the possible effects of the effluents on the ecology of the reservoir. The study indicated that the effect was felt only at the out-fall, showing zero level of dissolved oxygen and high alkalinity (240 ppm). In bottom fauna only few molluscs were noted. However, 100 m below the out-fall dissolved oxygen recovered to normal levels and good concentration of bottom invertebrates were recorded. In the lotic sector more or less normal conditions prevailed. The higher flood inflows in November probably minimised the effects of effluents in the reservoir.

Parasitic infestation

Large number of fishes, other than major carps, were found to be infested with digenetic trematode parasite, *Isoparorchis hypeselobagri* during 1990 and 1991 when the reservoir had low water level. The infection was particularly high in *N. notopterus*, *O. bimaculatus, M.cavasius* and *M. armatus*. However, in 1992 & 93 the infection abated to a great extent which has coincided with large inflow and higher water levels.

Productivity status and fish yield potential

The reservoir has some positive morphometric and ecological factors favourable for production. The low mean depth and the extensive catchment with a high ratio of catchment to reservoir area (an index of allochthonous in-puts) and moderately high alkalinity are positive factors. Phosphates and nitrates, considered to be essential nutrients for production, are in traces. Going by this the reservoir may be put under the category, `low productive'. However, in man-made lakes nitrates and phosphates are generally recorded in low concentration, even in high fish yielding reservoirs and could not be counted as reliable indices of reservoir productivity. Oxycline formation in water column, depending on its strength is found to be a dependable index. However, in Markonahalli the formation of a strong oxycline is inhibited by certain factors as discussed earlier.

The results of primary production due to phytoplankton are erratic and did not provide a clue to productivity of the reservoir. Production through higher aquatic plants has been left un-utilised. The production of plankton is of moderate magnitude while that of bottom fauna is of low order. However, periphyton appears to be fairly rich.

Morphoedaphic index (MEI), a predictive yield model developed by Ryder for Canadian lakes, has found wide application to predict fish yield of inland water bodies. The model combines an edaphic factor, the total dissolved solids (TDS), and a morphometric factor the mean depth, through a regression on fish yield. In Indian reservoirs, alkalinity and its correlated factors, conductivity and TDS are found to be not dependable parameters to assess the productivity. This makes the morphoedaphic model unsuitable and it also failed to predict fish yields in Indian reservoirs with any degree of accuracy.

Such a situation is not unexpected due to the fact that in reservoirs allochthnous inputs (coarse and particulate organic matter) play a greater role in productivity. Under such conditions morphometric and drainage factors such as mean depth, reservoir area and extent of catchment proved to be better indices.

In view of their utility, the MEI model has been modified incorporating the parameter, ratio of catchment to reservoir area and the modified model developed with data from 17 reservoirs has the following form,

$$\mathbf{Y = 4.012\ MDI^{0.902} \quad (r = 0.77^{**})}$$

where,

Y = Fish yield/ha (calculated for area at FRL),

$$\text{MDI} = \text{Morphodrainage index} = \frac{\text{Catchment area}}{(\text{reservoir area x mean depth})}$$

Using this model the yield potential of Markonahalli reservoir has been estimated at 160 kg/ha for FRL area. The same has been considered as an achievable target at average area of the reservoir, in view of the large scale interception of the catchment and periodic droughts.

The fish yield of Markonahalli has touched 75 kg/ha in 1993-94 with stocking support of only catla and rohu in 1991. Potential yield could not be achieved in the absence of sustained stocking support and uncovered food niches. To realise the yield potential on sustainable basis a series of management measures are recommended.

Recommendations for management

As the fisheries department of the State is finding it difficult to raise the stocking size to the desired level of over 100 mm, fingerlings of atleast 50-75 mm may be stocked at the rate of 400/ ha.

Catla, rohu, mrigal and common carp should be stocked in the proportion of 2:3:1:2 respectively.

Stocking should be done during October/November when the reservoir gets filled up.

P. pulchellus would be a useful addition to the stocking to utilise the aquatic vegetation. Recycling of aquatic vegetation would add to the overall productvty of the reservoir.

The effort may remain at about 30 coracle units and the total net length for each unit be 300 m with minimum mesh bar at 50 mm.

Operation of smaller meshes of 25 mm bar may be permitted during July- December to exploit indigenous fish stocks. These nets, however, should not be allowed during January - June.

No closed season for fishing need be observed.

The department should help fishermen to organise a co-operative society with responsibility to manage the reservoir.

It is important to maintain data on stocking and catch statistics. Reliable data base is an essential component for the development of reservoirs in the state.

Most of the people engaged in fishing are not professional fishermen and seem to be ignorant of proper rigging and mending of nets. A short training programme to licence holders on maintenance of gear would enhance their efficiency.

The effluents of Manaylux paper factory should not be discharged into the reservoir during low flood flows. Such disharges, without adequate flushing may cause oxygen depletion resulting in fish kill.

****