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Fish Diversity in Linganamakki Reservoir Sharavathi River

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ABSTRACT

The reservoir was constructed across the river sharavathi, western Ghats in 1964 for the purpose of power generation. The water-spread area of about 326 sq. km has provided sufficient fishing ground for more than 200 permanently residing fishermen over 30 years. Record of over 43 species from the reservoir further strengthens the biodiversity value of the reservoir. The annual fish yield of the reservoir being about 200 tonnes draws an income of about 43,84,990 rupees to the fishermen and an individual annual earning of about Rs 22,042/-. Seeding pattern of exotic fishes during the last two decades reveals improper seeding and unscientific management practices. In this connection, the present study tries to identify the loopholes in reservoir fisheries and brings out the proper management strategies.

Key words : *Biodiversity, Conservation, Ecology, Fish diversity, Land use, Phytoplankton, Sharavathi, Western Ghats*

Introduction

Fishes are cold-blooded aquatic vertebrates, which breathe by means of pharyngeal gills, propelling and balancing themselves by means of fins (Jhingran, 1982). At present, nearly 22,000 fish species are known to man. Of these 40 % are inhabitants of fresh and inland waters. A majority of these fishes are found in the tropical waters. For instance, it has been estimated that the river Amazon and its tributaries may together harbour 3000 or more species of fishes. Whereas in India it is estimated that about 2500 fish species are found within which around 930 species are freshwater fishes. The fresh water fishes are distributed amongst approximately 20 orders, 100 families and 300 genera (Daniels, 2000).

The river Sharavathi is one of the west flowing rivers of Karnataka that traverses through the Western Ghats, which is one of the biodiversity hotspots, the catchment of the river has bountiful natural resources as well as enormous potential for hydroelectric power generation. Linganamakki dam has been constructed across the river with the sole purpose of hydroelectric power generation. The river receives many tributaries with Haridravathi near Pattarguppe and Yenne Hole' near Bharangi being the major ones. Along with them, the minor trubutaries like Nagodi Hole', Nandi Hole', Mavina Hole', Huruli Hole', and Birer Hole' also join this river. The water from Chakra and Savehaklu reservoirs of Chakra river has been diverted to this reservoir. Thus, the reservoir is the meeting point of all the above river streams and due to this vast fish diversity can be expected. In this context, the present study has been undertaken to ducument fish diversity, yield and suggest appropriate management strategies.

Objectives

The objectives of the study are to:

(i) Document the fish species and yield of the Linganamakki reservoir.
(ii) Suggest appropriate conservation and management strategies.

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Materials and Methods

Sampling : Lingadakai, Hasaramakki, Holebagilu, Madenur, Muppane and Hallibylu are the six sampling points selected in the reservoir for fish sampling. These sampling points were distributed over the entire reservoir. Sampling for hill stream fishes was carried out in these streams. Almost all these streams are excellent perennial streams and are distributed in the western Zone. Since the streams along eastern side dry up during summer season, samples were collected during post monsoon period. Apart from systematic sampling, opportunistic sampling was also carried out in many places so as to cover as many localities as possible.

Net sampling : Fish sampling was carried with the help of gill nets, cast nets and dragnets wherever applicable. The density and time duration of gill nets were standardised as far as possible. The nets of varying mesh sizes (1inch × 2 no., 2 inch × 2 no., and 5 inch × 1 no). were chosen and laid in an approximate area of 200 × 200 sq m. The length of the net was maintained to 100 metres. In case of cast net sampling, transects with an approximate length of 100 meters along the banks were laid with 20 castings in each location. Benthic habitats were sampled using hooks. Properly labeled samples were preserved in 4% formaldehyde solution. For identification of the specimens, standard keys (Talwar and Jhingran, 1991; Jayaram 1981; Jayaram, 1996; Day 1978) were used.

In the absence of historical data regarding fish species of the reservoir, fishermen supplemented the information. Their continous association with fishing over a long period was clearly reflected by their command over the information. Fishermen with fishing history of more than 30 years were contacted to get the historical as well as present aspects of fishing. Most of the fishermen participated enthusiastically in discussions and shared their views and experiences in fishing and the social aspects. Market information such as location, channels, seasonal demand etc., was collected from the fish merchants. The fisheries department has provided all the the available statistical data regarding seeding methods, annual income to the department licensing pattern, etc.

Results and Discussion

Fishery and livelihood: The reservoir has accommodated about 120 fishermen families. Nearly 70 families are permanenlty located along the banks of the reservoir and the remaining 50 families migrate to the reservoir during the monsoon season. These families have distinct social and cultural features.

Table 1. Yearly data on seeds introduced in the reservoir

Sl. No.	Year	Seeds in Lakh			
		Catla	Rohu	Mrigal	Common Carp
1.	1983-1984	1.643	0	0	2.21
2.	1984-1985	1.278	0	0	1.62
3.	1985-1986	6.8	0	0	7.42
4.	1986-1987	6.81	0	0	2.48
5.	1987-1988	7.87	0	0	0
6.	1988-1989	4.754	0	0	0
7.	1989-1990	2.95	0	0	3.55
8.	1990-1991	0.85	2.783	0.312	8.41
9.	1991-1992	0	0	0	4.6
10.	1992-1993	0	0.42	0	5.4
11.	1993-1994	1.2	5.75	0	15.058
12.	1994-1995	5.3345	7.0685	0	11.418
13.	1995-1996	7.266	11.07	0.35	10.605
14.	1996-1997	0	26.362	0.72	9.86
15.	1997-1998	3	21.885	6.03	1.25
16.	1998-1999	2.448	19.016	1.12	1.4
17.	1999-2000	12.115	14.374	0	0
18.	2000-2001	0	0	0	5
19.	2001-2002	0	0	0	3

They live entirely demarcated from the outer world and their links are limited to merchants. Generally all these communities are very poor. Most of them are uneducated and the new gereration has got 3-4 years of basic education. The involvement of children in fisheries is often noted in the entire area. These children withdrawn from schools and are involved in fishing.

Management Stucture: The Deputy Director of Fisheries regulates the fishery in Linganamakki reservoir. Obtaining yearly license is compulsory for all the fishermen for fishing in the reservoir. The fee structure for gill net with a length of 500 m is Rs. 1000/- per year, cast net Rs. 300/- per year and hooks Rs. 100/- per year. The departmental data shows that at present about 200 license holders are in the reservoir area. Thus, the department is earning 1.65 lakh rupees of revenue annually from this source.

Even though the seeds are to be introduced early during the monsoon seasons, in order to avoid overflow and washing off of the seeds, they are introduced after the monsoon season. The year wise seeding pattern for the last 20 years is given in Table 1. The quantity of seeds introduced depends on availability and the department gives least reference to the rreservoir. During the last two years, seeding quantity has reduced to a minimum.

Fishermen Co-operative Society: Fishermen Co - operative Society, which is located in Sagar taluk (Shimoga district, Karnataka State) has presently 412 members belonging to fishermen and fish merchants with their share being Rs. 13,895/- and the Government's share being Rs. 10,000/-. But the fishing activities in the reservoir are more or less under the control of merchants . The society's effort to take control over fish marketing is in vain as the fishermen sell fish to merchants instead of selling to the society. This kind of a system is governed by the mutual dependence of fishermen and merchants. From the beginning the fishermen and merchants are closely linked due to flexible credit and services. As fish catch is highly fluctuating over the season, fishermen borrow loans from the merchants for smooth running of their livelihood and the reimbursement is in the form of fish during rainy season. The loans are as high Rs. 60.000/-.

The Department has banned the use of dragnets; there are certain fishermen using dragnets for netting large quantity of fish with less effort. The department lacks infrastructure such as manpower to monitor such unauthorised activities. Fishing with hooks and lines is a hobby to many people residing near the reservoir.

Early monsoon is the best season for the fishermen. During this period, the quantity of fish collected varies between 20-50 kg/day/trip. As soon as the fishermen reach the base with the harvest, merchants collect the fishes on the spot. During other seasons, as the fish catch reduces to 1-2 kg./day, merchants shift to sea fish. Thus, during such seasons, women sell the collected fish in the nearby villages. Since the data on quantity of fish harvested is not available, the exact quantification and yearly harvest cannot be estimated. As per the fishermen, the fish catch per unit effort is decreasing continuously.

Characteristics of the Reservoir

Temperature: The reservoir has recorded a temperature range of 23.3°-34°C. The higher values were recorded in the streams and near the shallow banks of the reservoir during the summer period. These extreme conditions make these areas unsuitable for fish species. But the reservoir temperature is optimal for the organisms.

Dissolved oxygen : The hilly terrain favours the oxygenation of the stream water due to high undulations and continuous mixing. The dissolved oxygen concentration ranges from 4.8 to 8 mg/L. The DO Pattern shows systematic variations. The lowest

Table 2. Physico-chemical characteristics of Linganamakki reservoir water samples.

Sl.No.	Parameter	Range
1.	Colour	Colourless to brown
2.	Temperature	23.3-34 °C
3.	Turbidiy mg/L	5-125 mg/L
4.	Transparency cm	3-284 cm
5.	Electrical conductivity	0.003-0.44 m µho/cm
6.	Total Suspended Solids	21.3-110 mg/L
7.	Total Dissolved solids	13.77-84.03 mg/L
8.	Alkalinity	8-75 mg/L
9.	pH	6.52-8.41
10.	Dissolved Oxygen	4.8-8 mg/L
11.	Potassium	0.01-9.5081 mg/L
12.	Sulphate	0.34-32.02 mg/L
13.	Phosphate	0.001-0.0929 mg/L
14.	Nitrate	0.004-1.6226 mg/L

concentration was during the dry periods and it increases during monsoon period reaching the peak. This could be due to DO rich water inflow from streams and reservoir, which results in continuous mixing during monsoon periods. Whereas during non monsoon periods, there will be negligible inflow and the reservoir reaches stagnation. Also, the sample collected near Talakalale, which is the outlet point of the reservoir, showed comparatively lower values than other places. This low concentration may be due to the consumption of oxygen by various biotic communities. In the fisheries point of view, the lower values during dry seasons may be harmful, since these values represent the DO at the surface. Naturally it decreases with the depth.

The results of the physico-chemical analysis of the reservoir water samples are as given in Table 2. Overall these values represent the oligotrophic nature of the reservoir and some interference was seen in some of the streams wherein extreme values were obtained.

Rainfall: The region receives more than 250 cm of rain annually. More than 80% of this rainfall takes place during the monsoon months of June to August.

Mean Depth: The water in the dam stays at a height of 55.16m from the lowest riverbed, which is almost equal to the maximum depth of the reservoir. Further, the total capacity of the reservoir is 152 TMcft with area of submergence 326.34 sq.km at full reservoir level of 554.43m. From this data the mean depth of the reservoir comes to about 41.73 meters. This is an excellent representation of a hydel reservoir of hilly region, having deep basin compared to those in the plains with shallow water spread area.

Catchment Area: A close relationship exists between land and water and also aquatic and terrestrial ecosystems. Here an attempt has been made to compare the landuse pattern between western and eastern part of the study area based on remote sensing analysis. The original streamiline of river Sharavathi is considered as the dividing line for these two parts. Table 3 shows the individual share of landuse under each landscape element . It is clear that the green cover in terms of evergreen to semi-evergreen, deciduous and plantation areas is quite high in the western side compared to the eastern side. Similarly, on the eastern side the wasteland and agricultural land is high compared to western side. The catchment area of Sharavathi river is quite low compared to any other rivers of the plain. Naturally, the low catchment area contributes to low nutrients to the reservoir. Table 4 shows the ratio of catchment area and water spread area of some of the reservoirs of Karnataka. This table shows that Linganamakki has the lowest value indicating a small catchment area.

Table 3. Land use pattern of the study area

Type of land	Western part		Eastern part	
	Area (sq. km)	% area	Area (sq.km)	% area
Evergreen to semi evergreen forests	109.56	17.27	259.62	9.83
Deciduous forest	110.12	17.36	444.48	16.82
Plantations	206.46	32.54	573.88	21.72
Wasteland + Agricultural area	208.31	32.83	1363.49	51.63
Total Area	634.45		2641.47	

Pollution: Apart from agriculture, all other activities are negligible considering pollution factor. In the catchment area agriculture is the main activity with significant usage of fertilisers and pesticides. These pesticides ultimately reach the reservoir due to run-off. Even though there is no possibility of a high pesticide concentration in the reservoir water, in the higher order organisms like fishes, it becomes significant due to bio-magnification process. Thus , it shows that there is a great need for measuring the effect of pesticides on aquatic organisms.

Phytoplankton status: As such there are no reports on phytoplankton blooms in the reservoir. Phytoplankton sampling was carried out during three summer months in sixteen sampling sites comprising both streams as well as the reservoir. The results revealed a diverse phytoplankton population. The diversity and species richness was more in streams compared to the resevoir.

Zooplankton status: The studies on zooplankton recorded a total of 39 species in different localities of the river basin. Due to the extreme complex nature the species, richness is always very low in the lotic system compared to the lentic water system.

Estimation of the reservoir yield

Systematically managed database is highly useful in assessing the yield of any reservoir. But in the present case, such a database is not available with the Fisheries Department. The unorganised market

Table 4: Comparison of catchment area and water spread area.

Name of the Reservoir	Catchment area (sq.km)	Water spread area (sq.km)	Catchment area Water spread area
Linganamakki	1991.71	322.56	6.174696
Tungabhadra	28168	378.14	74.49093
Krishnarajasagara	10619	129.24	82.16496
Markonahalli	4103	13.36	307.1108
Hemavathy	2810	75.17	37.38193
Supa	1067	123.00	8.674797

Source : 1. Statistical bulletin of Fisheries1998-99
2. http://www.fao.org/DOCREP/003/VR930E/V5930EO6.htm

channels further complicated the data collection from the fish landing centres. Thus, in the absence of any historical information from any sources regarding the fish yield of the reservoir, yield estimation could be crude. However, an attempt has been made here based on the present field data.

Five sampled localities were selected to assess the yield of the reservoir. Lingadakai, Hasaramakki, Muppane, Holebagilu, and Madenur are the spots where sampling was carried out along with active fishermen. Information was collected as in natural conditions without disturbing the fishermen at any stage. This could probably represent the actual field

Table 5. Fish-catch observed at different locations (field data)

Locality	Catch/unit effort during non-monsoon season (kg/person/day)	Catch/unit effort during monsoon season (kg/person/day)
Lingadakai	1.3	No fishermen
Hasaramakki	1.75	4.3
Muppane	2.8	5.25
Holebagilu	2.1	8.4
Madenur	1.6	5.6

condition and fishing patterns of the fishermen. Multiple sampling in the same locality further helped in averging the yield which is listed in Tables 5 and 6 respectively.

This data represents fishing using gill nets and hooks as a majority of the fish catch is carried out through them. Ideal fishermen were selected for the sample data with the consideration of standard effort and time. In the design, 10% of extra fishermen were considered for the monsoon season. During the field visits it was observed that especially the migratory fishermen were in groups of 10 or more, in which few of the fishermen had fishing licenses. Remaining fishermen had no valid fishing license. To supplement this kind of illegal fishing 10% extra has been considered. After the monsoon season, most of these migratory fishermen move to some other reservoirs. Thus, unauthorised fishing reduces during non-monsoon seasons.

The merchants pay on an average of Rs. 22 per kg of fish. As per the estimate yield of the reservoir, the annual revenue obtained by the fishermen on spot becomes Rs. 43,84,990. Individually the permanent fishermen earn annually Rs. 22042/-.

The reservoir fish yield is estimated to be 610.76 kg/sq. km at full reservoir level. Even though the monsoon period is shorter than the non-monsoon period, about 68.23% of the total fish-catch takes place during monsoon. During monsoon period the increase in fish catch can be attributed to the tapping of the breeding season. Usually, fishermen shift to shallow areas as the water level rises during the monsoon season. This indicates that they are tapping the breeding grounds of most of the fishes. The fishermen have attributed the increase in introduced fish catch to reduction in turbidity during monsoon season.

Ecological Profile

The present study of fish diversity in the Linganamakki reservoir recorded 51 species from 32 genera and 16 families. The departmental ducuments have recorded 22 commercial fish species in the Linganamakki reservoir. Besides, sampling limitations, the present study could not record six species namely *Hypophthalmichthys molitrix, mystus seenghala, Labeo calbasu, Channa punctatus, channa striatus and Tor tor.* The local fishermen iden-

Table 6. Estimation of Reservoir Fish Yield

Monsoon yield	200
■ Total authorized fishermen during monsoon season	
■ Considering 10% extra as unauthorized fishermen, the total number of fishermen engaged in fishing are	220
■ The product of total mumber of fishermen and average individual fish catch gives the total monsson fish catch per day (220x5.8875) as	1295.25 kg
■ Considering 3.5 months as monsoon period, total fish catch over this period becomes	136001.25kg
Non-monsoon yield	
■ Assuming 60% of the total fishermen remain engaged in fishing activities and only 5% of the total unauthorized fishermen remain for non-monsoon season, total fishermen engaged are	165
■ Total non-monsoon fish catch per day is (170x1.91)	324.7 kg
■ Total non-monsoon fish catch (total non-monsoon period is 8.5 months from which 2 month are deducted for non-fishing days) is	63316.5 kg
Total yearly fish catch from the reservoir is	199317.75 kg

Table 7. Species and riparian vegetation

Locality	Species	Description with respect to Vegetation
Nandihole	*Oreochromis mossambica, Danioaequipinnatus, Salmostoma boopis, Aplocheilus lineatus*	The sampled locality had bsolutely no vegetation on both sides.
Haridravathi	*Danio aequipinnatus, Aplocheilus lineatus*	On one side paddy fields with two trees. On the other side small Acacia plantation.
Mavinahole	*Aplocheilus lineatus, Mystus malabaricus, Puntius dorsalis, Garra gotyla stenorhynchus, Chanda nama,* Cirhina sp., *Danio aequipinnatus*	Lophopetalum wightianum, *Hopea wightianum* other trees covered over the river.
Sharavathi River	*Danio aequipinnatus, Aplocheilus lineatus, Garra gotyla stenorhynchus, Chanda nama, Salmostoma boopis*	No vegetation other than bamboo. But significant water flows in the river.
Hilkunji River	*Danio aequipinnatus, Aplocheilus lineatus, rasbora daniconius, Salmostoma boopis, Chanda nama, Cirhina species*	Hopea wightianum Bamboo on one side and paddy fields on other side. But significant water flows in the river.

tified only *Hypophthalmichthys miolitrix*, which was once found in the reservoir and is presently not found. Whereas, they could not recall the presence of the remaining five species in the past. It seems that these species were not found in the reservoir at least for the past 30 years or so. Still, it may need further clarifications to comment on the same.

Among the introduced species only *Cyprinus carpio* is abundantly found and to certain extent the *Labeo rohita*. But the catch of *Cirhina mrigala* and *Catla catla* has reduced in the last two to three years. Even a majority of *cyprinus carpio* and *lebeo rohita* individuals are very large indicating the presence of only the seeds introduced several years back . The native fishermen opined that the native carnivorous fishes like *Wallago attu, Channa marulius, Heteropneustes fossilis*, and more importantly *Ompok bimaculatus* are becoming rare.

Figures 1 and 2 clarify the clear dominance of the species belonging to the family *cyprinidae*. Generically Puntius dominates. Basically, the order *Cyprin-*

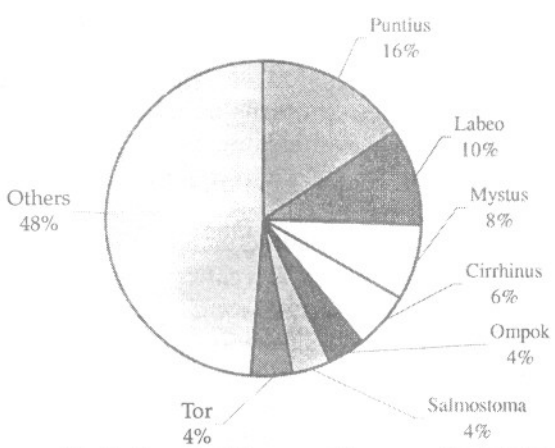

Fig.1. Generic richness with respect to species

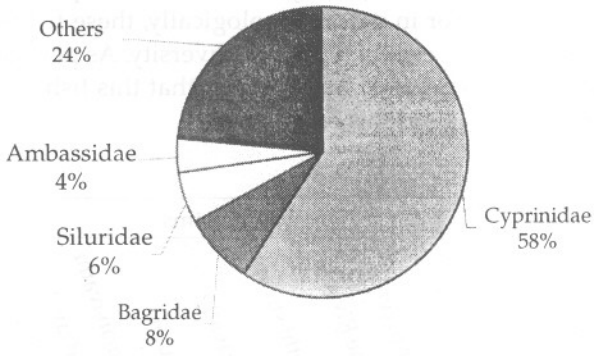

Fig.2. Family richness with respect to species

idae is one of the largest orders in ichthyology. Importantly the *Labeo genus* with relatively high commercial value has recorded five species, without a record of *Labeo calbasu*. There was a single species of the huge genus *Nemacheilus*. The species distribution of this species was limited to some of the western hill streams like Nagodi, Kouthi, Birer and Yenne Hole'. *Lepidocephalus termalis* was obtained only in a hill stream near Biligaaru. Species belonging to the family *Ambassidae* (Glass Fishes) are more or less equally distributed in the reservoir and was sparse in streams. In general, the wide habitat spectrum generically the *Puntius* and at family level the *Cyprinidae* has resulted in their richness in the study area. Among the hill stream fishes, *Rasbora daniconius* and *Danio aequipinnatus* are common and found in almost all the sampled localities.

Influence of riparian vegetation on fish distribution

During the field visits it was observed that riparian vegetation plays a determinant role in species composition. As the summer arrives there will be a great variation in temperature during the day and night. The rain fed streams especially in the eastern part of the study area shows considerable reduction in the flow. The less flow makes them sensitive to any variation in atmospheric temperature. The sparse riparian vegetation further worsens the condition by directly exposing the stream to sunlight. During this condition, the habitats for most of the fishes become unsuitable and they move to those places where there is considerable vegetation along the bank, which will maintain the stream temperature. The summer sampling of these hill streams confirmed these facts as no fishes other than *Danio aequipinnatus* and *Aplocheilus lineatus* were found in open areas. Where there is conopy cover, both species-wise and individual fish were concentrated However, this effect was comparatively less in the western part of the area as there is more canopy over, more flow and lesser temperature.

Locality-wise and season-wise species distribution

During the field visits, it was observed that the western river, Yenne Hole is mainly dominated with the native species (Refer Tables 7 and 8). Fishes like *Cirhina reba* and *Labeo fimbriatus* dominate the fish catch supported by species like *Ompok bimaculatus*, and *Mystus species*. Tor species were found in Hallibylu region of the river system. Thus, generally in this locality, the season-wise species composition remains more or less the same. Further, the south western part again shows similar trends of Yenne Hole . But here the Tor species were not recorded during sampling. In both the cases, the natural terrain is a series of hills and in between the hills the valley. These valleys being shallow areas are excellent localities for the indigenous monsoon breeders and thus large number of such fishes can be found in this river system.

The deeper regions like Holebagilu, Hasaramakki and Medenur have major fish catch of introduced species during monsoon season. As the monsoon season ends the catch of introduced species reduces and indigenous species dominate. This condition prevails until there is water inflow into the reservoir due to rainfall. The checklist of the fishes of linganamakki reservoir with their geographical distribution is given in Annexure1.

Threats to the fisheries

Effect of Introduction : The data on seeding (refer Table 1) reveals that no scientific approach is adopted while seeding. Without determinig the carrying capacity and productivity of the reservoir enormous amount of seeds were introduced during the early 90s. In the absence of any baseline data on fisheries, it is hard to quantify the impact due to improper introduction. Even then by looking at the present condition it becomes clear that it has negatively affected the total fish fauna.

Introduction of Tilapia (*Oreochromis mosambica*): This is slowly gaining its phase in Linganamakki reservoir. As per the local fishermen, the catch of

Tilapia is increasing over the years. The catch starts at the post monsoon period and during November, it dominates the entire catch. Due to the least demand for this fish in local markets, fishermen treat this fish as an unwanted catch. Scientifically, this fish is regarded as a hardy, territorial and a powerful competitor in nature. Ecologically, these fishes have adverse effect on the fish diversity. As per the fishermen, the maximum weight that this fish can attain is 0.5 kg in this reservoir.

Table 8. Locality-wise species composition

Scientific Name	Reservoir						Hill Streams									
	Holebagilu	Madenur	Hallibylu	Muppane	Hasaramakki	Lingadaka	Huruli River	Nagodi river	Birer River	Yenne River	Kouthi stream	Sharavathi	Hilkunji	Sharmanavathi	Haridravathi	Nandihole
Amblypharyngodon mola				*												
Aplocheilus lineatus			*			*	*	*	*	*	*	*	*	*		
Barilius canarensis									*		*					
Catla catla	*	*														
Chanda nama	*	*			*	*	*						*			
Channa marulius			*	*								*				
Cirhina fulungee			*	*	*	*						*		*		
Cirhina mrigala	*	*														
Cirrhinus reba			*	*	*									*		
Clarius byatracus	*															
Cyprinus carpio	*	*	*		*							*				
Danio aequipinnatus			*				*	*	*	*	*	*	*	*	*	*
Garra gotyla stenorynchus		*	*	*	*	*	*					*		*		*
Glossogobius giuris		*														
Heteropneustis fossilis					*											
Labeo fimbriatus			*	*	*											
Labeo rohita	*	*	*									*				
Lepidocephalichthys thermalis									*		*					
Mastacembalus arnatus			*		*	*						*				
Mystus cavesius	*	*		*	*	*	*									
Mystus keletius	*	*		*	*	*	*									
Mystus malabaricus	*	*		*	*	*	*									
Namacheilus rueppelli								*	*							
Ompok bimaculatus	*	*	*	*	*	*						*				
Ompok sp.				*	*	*										
Oreochromis mossambica					*											*
Pseudambasis ranga	*	*		*	*	*	*									
Pseudeutropius atherenoides				*		*	*									
Puntius arulius											*					
Puntius dorsalis		*		*												
Puntius fasciatus							*	*	*	*	*					
Puntius filamentosis	*	*		*	*	*				*	*					
Puntius kolus				*	*											
Puntius narayani		*		*												
Puntius parrah				*												
Puntius ticto				*												
Rasbora daniconius							*	*	*	*	*	*	*		*	*
Salmostoma boopis	*	*	*	*	*							*	*		*	
Tor khudree			*									*				
Tor mussullah	*															
Wallago attu				*	*											
Xenentodon cancila	*															

Endangered Mahseers: *Tor Khudree* and *Tor mussullah* are the two species present in the reservoir. These fishes breed during post monsoon period and their habitat is rocky pools. Presently, mahseers are endangered in the Indian context. Their commercial value and habitat destruction might be the major factors. In the Linganamakki Reservoir, mahseers were recorded in Hallibylu of Sharavathi Wildlife sanctuary area. In other areas also these fishes are rarely found. These fishes prefer rocky bottom areas with optimum temperature. In the present condition, the silt deposition at the bottom of the reservoir is slowly disturbing their habitat along with the fishing pressure.

Cyprinus carpio (Common carp) fishery: During monsoon period, common carp is the major fish catch in deeper areas like Holebagilu, Madenur and Hasaramakki areas. During other seasons, this fish catch almost reduces to zero. Since, Common carp is a bottom dweller, high transparency of the reservoir makes it to move to the bottom surface. During monsoon season, the transparency reduces and common carp comes to the water surface. *Cyprinus carpio* is regarded as one of the major competitors to native species of fishes for food and habitat. In the present case, this fish may affect benthic fishes like *Wallago attu*, *Ompok bimaculatus* and *Channa marulius* indirectly. Growth is quite fast in *Cyprinus carpio* and it consumes the lower level organisms like phytoplankton and other aquatic insects. The decrease in population of these lower level organisms due to continuous feeding by common carp may affect the population of other fishes with similar food habits. The decrease in such fishes may in turn affect the food requirement of carnivorous fishes and result in decrease in their population.

Role of predatory fish in total fish catch: Depending on the fish catch composition it can be concluded that, predatory fishes like *Wallago attu* and *Channa marulius* are least in number. Only *Ompok* bimaculatus catch is quite encouraging (Tables 7 and 8). This probably might be due to excessive introduction of introduced species like *Cyprinus carpio* during the last decade, which led to competition among the bottom dwellers. Only Yenne Hole tributary showed considerable fish catch of predatory fishes wherein the catch of introduced species was not found. In this locality, 13 hooks were placed and out of six, 4 *Wallago attu* and 2 *Channa marulius* were caught. This indicates the presence of predatory fishes in this area.

Diseases: Fishermen recall the widespread out break of a Epizootic Ulcerative Syndrome (EUS) desease about 5 years back , featured by sever ulcerative skin lesions, which ultimately caused the death of the fish. Reports on out break of EU in Shimoga district show that during Dec 1993- Jan 1994 the disease had caused mortality in the major and minor irriagation tanks. Even though the disease affected the bottom dwellers like Channa spp., minor carps and catfish, interestingly, it has not affected the Indian major carps like Catla, Rohu, Mrigal and common carp in Karnataka (Mohan and Shankar, 1994). This disease might be one of the main reasons for extinction of many species. According to the local fishermen, fish species like *Wallago attu, Heteropneustes fossilis* and *Channa marulius* were severely affected by this disease and there is a remarkable decline in their population. Presently, there are no reported episodes of this disease outbreak in the reservoir. Still, sampling at Lingadakai found one sample of *Garra gotyla stenorynchus* with such lesions on the body.

Mastacembelus armatus: Recently, another parasitic infection to the species *mastacembelus armatus* was observed in areas like Hasaramakki. The infection showed mumerous lesions within the abdomen with approximate diameter of 1-2 cm. After the death of the fish during fishing, nearly 2 inch long thread like worms were penetrating out of the abdomen. With the present available information, it can be concluded that the fish is acting as a host for those parasites, which are in a stage of completing their life cycle. Since, there were no deaths of the diseased fishes, it further justifies the argument. The infection was at its peak during the summer season and affected almost all the fishes of the species. During this perod, the commercial use of this fish had almost stopped in this area. However, the suitability of the fish as food and the reason for the first time occurrence during June 2002 remain unanswered.

Destruction at the breeding ground: Species of *Garra, Puntius, Labeo, Cirrhinus, Mystus,* and *Pseudeutropius* etc. are regarded as resident species. These fishes breed within the reservoir or migrate to smaller distance in search of shallow weedy areas for breeding. Most of the people residing along the bank go for fishing during the monsoon season. This is the season when a large quantum of fish can be caught. These people use traditional techniques to capture these fishes. These are the localities where large congregations of the spawning fishes are

caught and destroyed. Even some fisherman move to shallow upstream areas during monsoon to exploit the breeding grounds. Probably this is a prime factor that retards the population of these migratory fishes. Most of the streams along the western side are observed to be excellent breeding grounds for the native fishes.

Over exploitation and improper fishing system : The over exploitation of the reservoir plays a major role in extinction of the species. The department deliberately issues the license to any number of fishermen. Many fishermen from Tungabhadra dam migrate to this area during rainy season and catch huge quantity of fish. This has adversely affected the livelihood of permanent local fishermen. Over exploitation of the reservoir for fishing has resulted in excessive mortality and reduction in effective population size of the fish. Monsoon is the breeding season for most of the fishes and the fishing activity is at its peak during this season.

Management strategy

Restrictions to net usage: Fishing activity is at its peak during the monsoon season. A majority of the total fish catch is during the monsoon season. Since monsoon is the breeding season for most of the fishes, it is advisable to ban fishing of native fishes. This can be achieved by restricting the net sizes being used by the fishermen. Only large sized gill nets should be allowed during monsoon, which are useful to catch introduced fishes. Even after the monsoon season, the present restriction on minimum net size should be strictly followed so as to catch only mature fishes.

Conserving the breeding areas: As discussed earlier, shallow and steam joining areas are the breeding grounds for most of the fish species. In this connection, fishing activities should be totally restricted in shallow areas during June to September. The breeding area should be demarcated and these areas should be kept under continuous monitoring. Especially, the Yenne Hole' tributary entirely, from Sasichouka to Valagere, Nagodi river joining areas upto Hasaramakki ares, Nagara to Hosanagar area especilly the river junctions of Hilkunji and Sharavathi rivers, Haridravathi and Sharmanavathi river joining area which are found to be excellent breeding habitats for the fishes during monsoon season. In total, over the entire reservoir area, there are several sensitive breeding areas wherein fullest protection to the fishes should be given. The fishes that breed within the reservoir can be protected by selective fishing, which is determined by the net size selection.

Permanently stopping migrating fishermen : The Department should reconsider revenue-oriented approach, while issuing licenses to the fishermen. Licenses should be issued to permanent fishermen residing near the reservoir, who are solely dependent on the reservoir for their livelihood. The present status of fisheries in the reservoir and moderate reservoir productivity indicates the depletion of fish resource. In order to reduce the fishing pressure, it is advisable to avoid migratory fishermen from fishing. Since their fishing perod is monsoon , large quantities of breeding fishes are destroyed by over fishing.

Strengthening the indigenous fish population : Culture techniques for endangered species should be developed to protect and rehabilitate the endangered species taking into account the critical need to conserve genetic diversity. Presently the reservoir is not in a position to stand alone with the indigenous species. Even though there is great demand for the indigenous fishes like *wallago attu, Ompok bimaculatus* and *Channa marulius,* other than *Ompok bimaculatus,* all other commercially valuable fishes are in trace quantities. The predation nature of these fishes creates controversy over strengthening them. Other than these fishes, *Tor khudree,Tor mussullah,* species of *Cirhina,* species of *Labeo, Mastacembelus armetus,* species of *Mystus* ect., even though have tremendous potential to grow need to be strengthened either by external input or improving their breeding grounds.

Proper introduction : At present the reservoir is in such a state that native fishes alone cannot withstand the fishing pressure due to collapse in native fish stock. Probably, an external system in the form of introduction and extraction is the optimum solution available in the present context. In the last two to three years, the quantity of seeds introduced has declined. However, there is a great ecological concern over the introduction of new species. Integrity of aquatic communities and ecosystems should be conserved by appropriate management techniques. In particular, efforts should be made to minimise the harmful effects of introducing new species into waters. In this regard, the carrying capacity of aquatic environments should be well studied and the quan-

tification of introduction should be made in order to eliminate the adverse effect on native fish fauna.

Removal of *Oreochromis mossambica* (Tilapia): In the present condition, removal of new species *Oreochromis mossambica* is advantageous to reservoir fishery. This fish is regarded as a highly dominating species in the reservoir, which has the ability to overtake most of the species in competition for food and habitat. The presence of Tilapia decreases the population of other fish species. Thus, it is beneficial to minimise its population through selective fishing.

Strict supervision: The department lacks trained staff for strict supervision of the fishing activity. They should be strengthened through increasing their nimber and proper training. This can enlighten the scientific approach in them towards fisheries management.

Activating the Cooperative Society: Another major necessity is to activate the Cooperative Society, which is presently passive. All fishing activities should be carried out through the society. Frequent meetings among the fishermen, merchants and the departmental staff can strenghten the society. Here, banning the temporary fishermen can simplify the task of activating the cooperative society.

Propera management of data: There is no scientific information available about fisheries in Linganamakki Reservoir. This severly affects the decision-making. Without any statistical data, it is impossible to maintain the fishing activity in a healthy state. Thus it is of prime importance to maintain at least the data pertaining to total yield statistics, species-wise yield, physicochemical analysis of reservoir water representing the entire water body and disease episodes which is very useful during any planning stage.

Educating the local fishermen : Fishermen should be properly educated on the importance of fish diversity and the associated interconnections between different species. This can considerably decrease improper fishing practices by understanding their negative impacts on fish resources.

Conclusions

The above discussion clearly shows that the development of Linganamakki reservoir fisheries on scientific lines has not yet picked up its momentum. Unplanned and unscientific approach in management has resulted in a range of effects. In the present circumstances it necessitates the introduction, with careful evaluation of reservoir carrying capacity. It necessitates an immediate remedial action towards conservation of the valuable fish resources in a sustainable manner.

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Table 9. The checklist of the fishes of Linganamakki Reservoir with their geographical distribution

Species	Distribution
Amblypharyngodon mola	Pakistan, India: except Kerala, Bangladesh and Burma
Aplocheilus lineatus	India: Western and south-eastern regions
Barilius canarensis	India: Karnataka and Kerala of the Western Ghats
Brachydanio rerio	Pakistan; India: eastern parts from West bengal to Krishna river system; Bangladesh and Nepal
Catla catla	Northern India, Pakistan, Nepal Bangladesh and Burma
Chanda nama	Pakistan, India, Nepal, Bangladesh, and Burma
Channa marulius	Pakistan, India, Sri Lanka, Bangladesh, Nepal, Burma, Thailand and China
Cirhina fulungee	India: Maharashtra and Karnataka; Probably other parts of peninsular India
Crhina mrigala	Pakistan and Northern India
Cirrhinus reba	Indus plain, India, Nepal and Bangladesh
Clarius batrachus	Pakistan, India, Nepal, Sri Lanka, Bangladesh, Burma, Indonesia, Singapore, Borneo, Philippines
Cyprinus carpio	Central Asia
Danio aequipinnatus	India, Nepal, Sri Lanka, Bangladesh, Burma and Thailand
Garra gotyla stenorynchus	India: Cauvery and Krishna drainages, Western Ghats.
Glosssogobius giuris	Indo-west Pacific
Gonoproktopterus Kolus	India: Krishna, Godavari and Cauvery river Systems, S.India
Heteropneustis fossilis	Pakistan, India, Bangladesh, Sri Lanka: Burma; Thailand and Laos
Labeo fimbriatus	Pakistan, India: West Bangal and Eastern Ghats
Labeo Kawrus	Western Ghats up to the Deccan.
Labeo Porcellus	India: Western Ghats of the Bombay region and Sri Lanka.
Labeo rohita	Pakistan, North and Cental India, Bangladesh, Nepal and Burma
Labeo sp.	
Lepidocephalichthys thermalis	Coastal district of Kerala, Karnataka and Maharashtra, SriLanka
Macropodus cupanus	Eastern India, Sri Lanka, Western Burma, Malay Peninsula and Sumatra
Mastacembalus armatus	Pakistan, India, Sri Lanka, Nepal Burma, Thailand, Malaysia and China
Mystus cavesius	Pakistan, India, Sri Lanka, Nepal, Bangladesh, Burma and Thailand
Mystus Keletius	India: Tamilnadu, Western Ghats of Kerala and Karnataka and Sri Lanka
Mystus malabaricus	India: Western Ghats
Nemacheilus ruippelli	India: Western Ghats of Maharashtra and Karnataka.
Ompok bimaculatus	Afghanistan, Pakistan, India, Sri Lanka, Bangladesh, Burma Thailand, Java, Sumatra, Borneo, China
Ompok sp.	
Oreochromis mossambica	East Africa, An Introduced species in India, Pakistan and Sri Lanka
Osteocheilus nashii	Western Ghats of Karnatak and Kerala.
Pseudambasis ranga	Pakistan, India, Bangladesh, Burma, Thailand and Malaysia
Pseudeutropius atherenoides	Pakistan, India: Peninsular not below Cauvery and eastern Himalaya, Bangladesh, Nepal, Burma.
Puntius arulius	India: Tamilnadu, Kerala and The Cauvery river System
Puntius dorsalis	India: Cauvery and Krishna river System (South India); Sri Lanka
Puntius Fasciatus	Peninsular India
Puntius filamentosis	India: Goa, Karnataka, Kerala and Srilanka, Burma and Thailand
Puntius Narayani	Cauvery river (Karnataka)
Puntius parrah	India: Kerala, Karnataka and Tamilnadu
Puntius sp.	
Puntius ticto	Pakistan, India, Nepal, Sri Lanka, Bangladesh ,Burma and Thailand
Rasbora daniconius	Pakistan, India, Sri Lanka, Bangladesh, Burma and Mekong.
Salmostoma boopis	Western Ghats: South Canara and Poona
Tor Khudree	India: Madhya Pradesh, Deccan and entire peninsular India and Sri Lanka
Tor mussullah	Peninsular India: Krishna/Godavari rivers and its principal river systems
Wallago attu	Pakistan, India, Sri Lanka, Nepal, Bangladesh, Burma, Thailand, Vietnam, Cambodia, Malayasia, Sumathra, Java
Xenentodon cancila	Pakistan, India, Bangladesh, Sri Lanka, Burma and Thailand