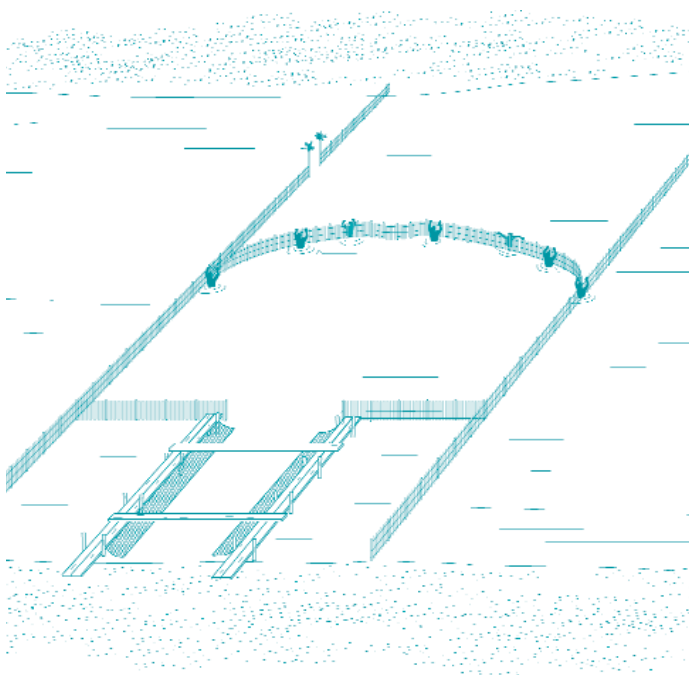


BIODIVERSITY STATUS OF FISHES INHABITING RIVERS OF KERALA (S. INDIA) WITH SPECIAL REFERENCE TO ENDEMISM, THREATS AND CONSERVATION MEASURES

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ABSTRACT

The identification of 175 freshwater fishes from 41 west flowing and 3 east flowing river systems of Kerala were confirmed. These can be grouped under 106 ornamental and 67 food fishes. The biodiversity status of these fishes was assessed according to IUCN criteria. The results showed that populations of the majority of fish species showed drastic reduction over the past five decades. Thirty-three fish species were found to be endemic to the rivers of Kerala. The distributions of the species were found to vary within and between the river systems and some of the species exhibited a high degree of habitat specificity. The diversity and abundance of the species generally showed an inverse relationship with altitude. The serious threats faced by the freshwater fishes of Kerala are mostly in the form of human interventions and habitat alterations and conservation plans for the protection and preservation of the unique and rare fish biodiversity of Kerala are also highlighted.

INTRODUCTION

Kerala is a land of rivers which harbour a rich and diversified fish fauna characterized by many rare and endemic fish species. The Western ghats are recognised as one of the 21 biodiversity hotspots of the world. A data base on fish biodiversity is essential as a decision making tool for conservation and management of fish germplasm, declaration of part of the rivers as aquatic sanctuaries, protection and preservation of endangered species and mitigation of anthropogenic activities so as to fulfil India's obligations under conventions on biological diversity with special reference to Articles 6 and 8 of UNEP (1992). Notable studies on the freshwater fish fauna of Kerala are those of Day (1865, 1878, 1889); Pillai (1929); John (1936); Hora and Law (1941); Silas (1951a, 1951b); Remadevi and Indra (1986); Pethiyagoda and Kottelat (1994); Kurup (1994); Kurup and Ranjeet (2002); Easa and Shaji (1995); Menon and Jacob (1996); Manimekalan and Das (1998); Ajithkumar *et al* (1999); Raju *et al.* (1999a and b) and Biju, Thomas and Ajithkumar (1999). In the present paper an attempt is made to prepare a consolidated list of freshwater fishes of Kerala and to assess their biodiversity status as per IUCN criteria. Their patterns of distribution have been delineated giving special emphasis to endemism and various anthropogenic threats which aggravate the degree of their endangerment. This communication also deals with various management plans relevant to the conservation of freshwater fish biodiversity of Kerala.

MATERIALS AND METHODS

Data on qualitative and quantitative abundance of fish species inhabiting various rivers were gathered during extensive surveys and sampling carried out as part of various externally aided research projects such as the ongoing NAT-ICAR project on Fish germplasm inventory evaluation and genebanking of freshwater fishes of Kerala, the ICAR sponsored population characteristics, bionomics and culture of *Labeo dussumieri* (1987-1990), the Kingdom of Netherlands financed project entitled exploited fishery resources of Vembanad lake (1988-1990). Experimental fishing was conducted from not less than 10 sites on each

river. Habitat diversity was given foremost importance during selection of locations within the river system. The sites for habitat inventory were selected based on channel pattern, channel confinement, gradient and streambed and bank materials. All the physical habitat variables in the selected reaches were studied (Anon. 2000). The position of the selected zones was determined using hand held GPS, altitude was estimated using electronic altimeter, conductivity and TDS using Lynx microprocessor based conductivity meter. Dissolved oxygen levels at each survey location were measured using Eutech cyberscan DO100 dissolved oxygen meter. Light intensity on the surface water and flow velocity was measured using Lux meter and water current meter, respectively. Total alkalinity and hardness were estimated based on Clesceri, Greenberg and Trussell (1989). The specimens were collected using various types of fishing methods such as cast nets (16 mm, 18 mm, 22 mm), gill nets (32 mm, 38 mm, 64 mm, 78 mm, 110 mm), drag nets (4 mm, 15 x 3 mtrs), scoop nets and other local contrivances. Collections were made from all selected locations during 8:00-18:00 h and 20:00-06:00 h. Visual observations were also carried out if the water was clear with a view to assess the distribution of the fish and abundance. Special care was taken to maintain uniformity in fish catch per unit effort (CPUE) (effort in hours) so as to compare the populations at selected locations of a river system. Density of fish populations at each location was estimated as abundance index

$$AI = \frac{(n(k))}{N \times \text{Total} \times \text{FU}} * 100$$

where AI = Abundance index, $n(k)$ = number of individuals of the species k caught at the study site and N = Number of individuals of all fish species caught at that site, FU = Fishing unit as described by Arun (1997). The Shannon-Weaver diversity index ($H = -\sum_{i=1}^n p_i \ln p_i$)

Where H = Diversity index, n_1 = number of individuals in species of a population or community, n = number of individuals in sample from a population for each river systems were calculated using the software Primer 5. Apart from this, the catches of the freshwater fishes from the landing centres and markets adjacent to the respective rivers were also inspected and specimens were collected for detailed examination. Samples were preserved in 8 percent formalin and kept for identification. Fishes were identified following Day (1878); Talwar and Jhingran (1991); Jayaram (1981, 1999); Kishori Lal Tekrival and Arunava Rao (1999). About 125 research papers on the freshwater fish fauna of Kerala available during the period 1965-2000 were also consulted towards compiling the past data of abundance and availability for assessing biodiversity status. The status of each species, whether threatened or endemic, was assigned based on IUCN categorization (NBFGR 1998).

RESULTS

BIODIVERSITY STATUS OF THE FRESHWATER FISHES DELINEATED

One hundred and seventy five fish species under 13 orders, 29 families and 65 genera were collected and identified from the rivers and streams of Kerala. The name of the species, together with their commercial importance, status as per IUCN criteria and the river sources from where their occurrence has been recorded are shown in Table 1. This includes 25 new species recorded and described in the recent past. Of the 175 species, 4 species are exotic and alien. Among the species listed under threatened category, 18

were critically endangered while 38 species are endangered, whereas 28 species are vulnerable. There are 48 species under the non-threatened category, among which 21 are nearly threatened with low risk whereas 34 species belonged to low risk of least concern. (Figure 1). Among the 18 critically endangered species, 7 are confined to only a single locality while 5 species are found in 2 locations in the same river (Table 2). Among the endangered species, 5 are confined to a single location while 6 are from 2 locations of the same river system. The distributions of 15 species are found to be restricted to 2 rivers, while 12 species are recorded from 3 rivers (Table 3). Species such as *Lepidopygopsis typys*, *Silurus wynaadensis*, *Gonoproktopterus micropogon periyarensis*, *Osteochilichthys longidorsalis*, *Horaglanis krishnai* and *Labeo potail* are critically endangered and among them, *Silurus wynaadensis*, *Osteochilichthys longidorsalis*, *Horaglanis krishnai* and *Labeo potail* have shown a population reduction of 99 percent over the past two decades. The distributions of these fishes are restricted to one or two locations. *Silurus wynaadensis*, *Labeo potail* and *Osteochilichthys longidorsalis* are reported from the upstream locations of Kabbini and Chalakkudy rivers respectively where as *Horaglanis krishnai* is known to be only recorded from the subterranean wells of Kottayam district. While delineating the distribution pattern of freshwater fishes, it could be seen that more than 90 percent of the fishes so far reported from Kerala were encountered from the 5 major rivers. (Kabbini, Kallada, Bharathapuzha, Periyar and Chalakkudy).

Table 1: List of freshwater fish species reported from the Kerala part of Western Ghats

No	Name of Species	Ornamental/Food fish	IUCN Status	River Source
1	<i>Ambassis gymnocephalus</i>	Ornamental	LRlc	Chalakkudy
2	<i>Ambassis nalua</i>	Food fish*	DD	Travancore
3	<i>Amblypharyngodon chakaensis</i>	Ornamental*	CR	Veli Lake, Trivandrum
4	<i>Amblypharyngodon melettinus</i>	Ornamental**	DD	Achenkoil
5	<i>Amblypharyngodon microlepis</i>	Ornamental**	LRnt	Chalakkudy, Bharathapuzha
6	<i>Amblypharyngodon mola</i>	Ornamental*	LRlc	Kabbini River
7	<i>Anabas testudineus</i>	Ornamental*	VU	Achenkoil, Chalakkudy
8	<i>Anguilla bengalensis</i>	Food fish**	EN	Periyar
9	<i>Anguilla bicolor</i>	Food fish**	DD	Chalakkudy

No	Name of Species	Ornamental/Food fish	IUCN Status	River Source
10	<i>Aorichthys aor</i>	Food fish*	DD	Chaliyar River
11	<i>Aplocheilus blocki</i>	Ornamental*	DD	Valapatnam
12	<i>Aplocheilus lineatus</i>	Ornamental*	LRlc	Chalakkudy
13	<i>Awavous gutum</i>	Ornamental*	LRlc	Achenkoil, chalakkudy
14	<i>Balitora brucei</i>	Ornamental*	DD	Achenkoil
15	<i>Balitora mysorensis</i>	Ornamental*	DD	Bhavani, Bharathapuzha
16	<i>Barilius bakeri</i>	Ornamental**	LRnt	Periyar, Kabbini
17	<i>Barilius barna</i>	Ornamental*	LRnt	Bharathapuzha
18	<i>Barilius bendelesis</i>	Ornamental**	LRnt	Bharathapuzha
19	<i>Barilius canarensis</i>	Ornamental**	DD	Periyar
20	<i>Barilius gatensis</i>	Ornamental**	LRlc	Chalakkudy, Achenkil, Periyar, Manimala, Bharathapuzha, Kabbini, Meenachil
21	<i>Batasio travancoria</i>	Ornamental*	EN	Chalakkudy
22	<i>Bhavana australis</i>	Ornamental**	LRnt	Kabbini
23	<i>Catla catla</i>	Food fish***	VU	Achenkoil
24	<i>Chanda nama</i>	Ornamental*	LRlc	Achenkoil, Kabbini, Pamba
25	<i>Channa gachua</i>	Food fish**	VU	Travancore
26	<i>Channa leucopunctatus</i>	Food fish**	DD	Travancore
27	<i>Channa marulius</i>	Food fish***	LRnt	Pamba, Achenkoil
28	<i>Channa micropeltes</i>	Food fish**	CR	Pamba, Kallada
29	<i>Channa panctatus</i>	Food fish*	LRnt	Chalakkudy
30	<i>Channa striatus</i>	Food fish**	LRlc	Chalakkudy, Achenkoil, Kabbini, Kallada, Bharathapuzha
31	<i>Chela dadiburjori</i>	Ornamental**	DD	Bharathapuzha
32	<i>Chela fasciata</i>	Ornamental**	EN	Bharathapuzha
33	<i>Chela laubuca</i>	Ornamental**	LRlc	Kabbini
34	<i>Cirrhinus mrigala</i>	Food fish**	LRlc	Reaservoirs of Kerala
35	<i>Cirrhinus reba</i>	Food fish	VU	Kabbini
36	<i>Clarias dayi</i>	Food fish**	DD	Wynaad
37	<i>Clarias dussumieri</i>	Food fish**	VU	Chalakkudy
38	<i>Clarias gariepinus</i>	Food fish***	Intr.	Farms of kuttanad
39	<i>Crossocheilus latius latius</i>	Ornamental*	DD	Kabbini
40	<i>Crossocheilus periyarensis</i>	Food fish*	VU	Periyar
41	<i>Ctenopharyngodon idellus</i>	Food fish***	Intr.	Reservoirs of Chalakkudy and Periyar
42	<i>Cyprinus carpio</i>	Food fish***	LRlc	Achenkoil
43	<i>Danio aequipinnatus</i>	Ornamental**	LRlc	Valapatnam, Chaliyar
44	<i>Danio malabaricus</i>	Ornamental**	LRlc	Achenkoil, Kabbini, Kallada, Meenachil
45	<i>Dayella malabarica</i>	Ornamental*	CR	Chalakkudy
46	<i>Eleotris fusca</i>	Ornamental*	LRlc	Chalakkudy
47	<i>Esomus danricus</i>	Ornamental**	LRlc	Chalakkudy, Moovattupuzha
48	<i>Esomus thermoicos</i>	Ornamental**	LRlc	Bharathapuzha, Pambar
49	<i>Etroplus maculatus</i>	Ornamental*	LRlc	Bharathapuzha, Kabbini, Achenkoil, Pamba, Meenachil, Kallada
50	<i>Etroplus suratensis</i>	Food fish*	LRlc	Chalakkudy, Bharathapuzha
51	<i>Garra gotyla</i>	Ornamental*	VU	Kabbini

No	Name of Species	Ornamental/Food fish	IUCN Status	River Source
52	<i>Garra hughi</i>	Ornamental*	EN	Pambar
53	<i>Garra mcClellandi</i>	Ornamental*	EN	Chaliyar, Periyar tiger reserve
54	<i>Garra menoni</i>	Ornamental*	VU	Bharathapuzha, Pambar
55	<i>Garra mullya</i>	Ornamental*	LRlc	Pamba, Kallada, Meenachil, Bharathapuzha
56	<i>Garra periyarensis</i>	Food fish*	EN	Periyar
57	<i>Garra surendranathinii</i>	Ornamental***	EN	Periyar
58	<i>Glossogobius giuris</i>	Food fish*	LRlc	Chalakkudy, Bharathapuzha
59	<i>Glyptothorax anamalaiensis</i>	Ornamental***	CR	Anamalai hills
60	<i>Glyptothorax annandalei</i>	Ornamental*	EN	Kabbini
61	<i>Glyptothorax davissinghi</i>	Ornamental*	DD	Nilambur, Chaliyar
62	<i>Glyptothorax housei</i>	Ornamental**	DD	Kallada
63	<i>Glyptothorax lonah</i>	Ornamental**	LRnt	Kabbini
64	<i>Gonoproktopterus curmuca</i>	Food fish**	EN	Chalakkudy, Kallada, Bharathapuzha
65	<i>Gonoproktopterus dubius</i>	Food fish**	EN	Kabbini
66	<i>Gonoproktopterus kolus</i>	Food fish**	EN	Chalakkudy
67	<i>Gonoproktopterus micropogon periyarensis</i>	Food fish**	EN	Periyar
68	<i>Gonoproktopterus thomassi</i>	Food fish**	EN	Kallada
69	<i>Heteropneustes fossilis</i>	Food fish**	VU	Chalakkudy, Bharathapuzha, Kabbini
70	<i>Homalaptera menoni</i>	Ornamental**	EN	Bharathapuzha
71	<i>Homalaptera montana</i>	Ornamental**	CR	Anamalai hills
72	<i>Homaloptera pillai</i>	Ornamental**	VU	Bharathapuzha
73	<i>Horabagrus brachysoma</i>	Food fish**	EN	Chalakkudy, Kallada, Achenkoil
74	<i>Horabagrus nigricollaris</i>	Food fish**	CR	Chalakkudy River
75	<i>Horadandia atukorali</i>	Ornamental*	EN	Cherthala
76	<i>Horaglanis krishnai</i>	Ornamental*	CR	Kottayam
77	<i>Horalabiosa joshuai</i>	Ornamental*	CR	Silentvalley-Bharathapuzha
78	<i>Gonoproktopterus kurali</i>	Food fish**	EN	Periyar River
79	<i>Labeo ariza</i>	Food fish*	CR	Periyar
80	<i>Labeo calbasu</i>	Food fish**	LRnt	Chalakkudy
81	<i>Labeo dussumieri</i>	Food fish**	EN	Pamba, Achenkoil
82	<i>Labeo rohita</i>	Food fish**	LRlc	Achenkoil
83	<i>Lepidocephalus thermalis</i>	Ornamental*	LRlc	Periyar
84	<i>Lepidopygopsis typus</i>	Ornamental**	CR	Periyar
85	<i>Macrognathus aral</i>	Food fish*	LRnt	Periyar
86	<i>Macrognathus guentheri</i>	Food fish*	VU	Chalakkudy, Pamba, Periyar
87	<i>Macropodus cupanus</i>	Ornamental*	LRlc	Valapatnam
88	<i>Mastacembelus armatus</i>	Food fish*	LRlc	Pamba, Bharathapuzha, Kabbini, Kallada, Meenachil, Achenkoil
89	<i>Mastacembelus oatesi</i>	Food fish*	LRnt	Chalakkudy
90	<i>Megalops cyprinoides</i>	Food fish*	LRlc	Periyar
91	<i>Microphis concalus</i>	Ornamental*	VU	Uppala, Periyar, Moovattupuzha
92	<i>Mystus armatus</i>	Food fish*	LRlc	Bharathapuzha, Kabbini, Chalakkudy
93	<i>Mystus cavasius</i>	Food fish*	LRnt	Periyar, Bharathapuzha, Kabbini, Chalakkudy
94	<i>Mystus gulio</i>	Food fish*	LRlc	Periyar, Bharathapuzha, Kabbini, Kallada
95	<i>Mystus keletius</i>	Food fish*	DD	Periyar
96	<i>Mystus menoda</i>	Food fish*	DD	Achenkoil

No	Name of Species	Ornamental/Food fish	IUCN Status	River Source
97	<i>Mystus oculatus</i>	Ornamental**	LRlc	Kabbini
98	<i>Nandus nandus</i>	Ornamental**	LRnt	Pamba, Achenkoil, Chalakkudy
99	<i>Nemacheilus botia</i>	Ornamental***	LRnt	Travancore
100	<i>Nemacheilus denisoni denisonii</i>	Ornamental***	VU	Bharathapuzha, Pambar, Manimala
101	<i>Nemacheilus evezardii</i>	Ornamental*	EN	Kabbini
102	<i>Nemacheilus guentheri</i>	Ornamental*	LRlc	Bharathapuzha, Achenkoil, Pambar, Kabbini
103	<i>Nemacheilus keralensis</i>	Ornamental***	EN	Meenachil
104	<i>Nemacheilus menoni</i>	Ornamental**	EN	Periyar
105	<i>Nemacheilus monilis</i>	Ornamental***	EN	Kabbini
106	<i>Nemacheilus nilgiriensis</i>	Ornamental*	DD	Kabbini
107	<i>Nemacheilus pambarensis</i>	Ornamental***	DD	Chinnar
108	<i>Nemacheilus periyarensis</i>	Ornamental***	DD	Periyar
109	<i>Nemacheilus pulchellus</i>	Ornamental**	DD	Periyar
110	<i>Nemacheilus semiarmatus</i>	Ornamental***	VU	Pamba, Kallada
111	<i>Nemacheilus striatus</i>	Ornamental**	DD	Wynaad
112	<i>Nemacheilus triangularis</i>	Ornamental***	LRnt	Chalakkudy, Kallada, Meenachil
113	<i>Nemacheilus petrubenaescui</i>	Ornamental**	DD	Kabbini River
114	<i>Neolissochilus wynaadensis</i>	Food fish*	CR	Kabbini
115	<i>Notopterus notopterus</i>	Food fish**	LRnt	Kabbini
116	<i>Ompok bimaculatus</i>	Food fish**	VU	Periyar, Bharathapuzha, kabbini, Kallada
117	<i>Ompok malabaricus</i>	Food fish**	CR	Bharathapuzha
118	<i>Oreochromis mossambicus</i>	FOOD FISH**	Intr	Pamba, Achenkoil, Bharathapuzha, Kabbini, Kallada, Meenachil
119	<i>Osteochilus thomassi</i>	Food fish**	EN	Periyar
120	<i>Osteobrama bakeri</i>	Ornamental***	EN	Kallada, Achenkoil
121	<i>Osteobrama cotio peninsularis</i>	Ornamental*	VU	Periyar
122	<i>Osteochilichthys nashii</i>	Food fish**	VU	Kabbini
123	<i>Osteochilichthys longidorsalis</i>	Ornamental*	CR	Chalakkudy
124	<i>Osteochilus brevidorsalis</i>	Ornamental*	EN	Kabbini
125	<i>Pangasius pangasius</i>	Ornamental*	CR	Kuttanad
126	<i>Pangio baashai</i>	Ornamental*	DD	Chaliyar
127	<i>Pangio goensis</i>	Ornamental*	EN	Manimala
128	<i>Parambassis dayi</i>	Ornamental*	VU	Chalakkudy, Chaliyar , Pamba , Bharathapuzha
129	<i>Parambassis thomassi</i>	Ornamental**	LRnt	Bharathapuzha, Kabbini, Kallada, Meenachil, Pamba
130	<i>Pisodonophis boro</i>	Not categorised	EN	Periyar
131	<i>Pristolepis fasciata</i>	Ornamental**	DD	Travancore
132	<i>Pristolepis marginata</i>	Ornamental**	VU	Achenkoil
133	<i>Pseudambassis ranga</i>	Ornamental*	LRlc	Chalakkudy
134	<i>Pseudeutropius mitchelli</i>	Food fish*	DD	Bharathapuzha
135	<i>Puntius amphibius</i>	Ornamental*	LRlc	Chalakkudy, Bharathapuzha, Kabbini, Meenachil, Kallada
136	<i>Puntius barmanicus</i>	Ornamental*	DD	Pamba
137	<i>Puntius carnaticus</i>	Food fish***	LRnt	Kabbini
138	<i>Puntius chalakkudiensis</i>	Ornamental***	EN	Chalakkudy
139	<i>Puntius chola</i>	Ornamental**	VU	Kabbini
140	<i>Puntius conchoniis</i>	Ornamental***	VU	Kabbini
141	<i>Puntius denisonii</i>	Ornamental***	EN	Achenkoil

No	Name of Species	Ornamental/Food fish	IUCN Status	River Source
142	<i>Puntius dorsalis</i>	Ornamental*	VU	Chalakkudy, Periyar, Moovattupuzha
143	<i>Puntius fasciatus</i>	Ornamental**	LRnt	Chalakkudy, Kabbini, Kallada, Meenchil,
144	<i>Puntius filamentosus</i>	Ornamental**	LRlc	Achenkoil, Pamba, Bharathapuzha, Kabbini, Meenchil, Kallada
145	<i>Puntius jerdoni</i>	Ornamental***	VU	Achenkoil
146	<i>Puntius lithopidos</i>	Ornamental**	EN	Periyar
147	<i>Puntius melanostigma</i>	Ornamental*	EN	Travancore, Kerala part of Nilgiri biosphere
148	<i>Puntius micropogon micropogon</i>	Food fish**	DD	Chalakkudy
149	<i>Puntius ophicephalus</i>	Food fish*	CR	Periyar River
150	<i>Puntius pinnuratus</i>	Ornamental*	DD	Kallada, Central Kerala
151	<i>Puntius sarana sarana</i>	Food fish**	VU	Bharathapuzha
152	<i>Puntius sarana subnasutus</i>	Food fish**	VU	Chalakkudy, Bharathapuzha, Kallada
153	<i>Puntius singhala</i>	Ornamental**	DD	Bharathapuzha
154	<i>Puntius sophore</i>	Ornamental**	LRnt	Periyar, Keecheri, Bharathapuzha
155	<i>Puntius thomassi</i>	Food fish**	EN	Kallada
156	<i>Puntius ticto</i>	Ornamental**	LRlc	Chalakkudy, Manimala, Bharathapuzha, Meenachil
157	<i>Puntius vittatus</i>	Ornamental**	VU	Kabbini, Chalakkudy
158	<i>Rasbora daniconius</i>	Ornamental**	LRnt	Most of all Rivers
159	<i>Salarias reticulatus</i>	Ornamental**	DD	Chalakkudy
160	<i>Oncorhynchus mykiss</i>	Food fish***	Intr	Pambar, Periyar, Bharathapuzha
161	<i>Salmostoma acinaces</i>	Ornamental**	VU	Chaliyar, Kabbini
162	<i>Salmostoma boopis</i>	Ornamental*	LRlc	Achenkoil, Bharathapuzha, Kabbini
163	<i>Salmostoma clupeoides</i>	Ornamental*	LRlc	Periyar, Kabbini
164	<i>Salmostoma Sardinella</i>	Food fish*	LRnt	Chalakkudy
165	<i>Schismatogobius deraniyagali</i>	Food fish*	DD	Chaliyar
166	<i>Sicyopterus griseus</i>	Ornamental**	EN	Chalakkudy
167	<i>Silonia childreni</i>	Not categorised	EN	Periyar River
168	<i>Silurus wynaadensis</i>	Food fish*	CR	Kabbini
169	<i>Tetradon travancoricus</i>	Ornamental**	VU	Chalakkudy
170	<i>Tor Khudree</i>	Food fish**	VU	Periyar, Kallada
171	<i>Tor mussullah</i>	Food fish**	CR	Chalakkudy
172	<i>Tor putitora</i>	Food fish**	EN	Kabbini
173	<i>Tor tor</i>	Food fish**	EN	Chandragiri
174	<i>Travancoria jonesi</i>	Ornamental**	EN	Chalakkudy
175	<i>Travancoria elongata</i>	Ornamental**	DD	Chalakkudy

*Important CR-Critically endangered

**Highly important EN-Endangered

***Very highly important VU-Vulnerable

LRnt-Low risk nearly threatened

LRlc-Low risk least concern

DD-Data deficient

Intr - Introduced

Table 2: Critically endangered fresh water fishes of Kerala and the regions where they are found

Species restricted to a single location					
SI No	Name of the Species	River source	Location	Habitat	Endemism
1	<i>Amblypharyngodon chakaensis</i>	Travancore	Veli lake	Lake	ENK
2	<i>Horabagrus nigricollaris</i>	Chalakkudy	Chalakkudy upper reaches	Pool-riffle	EWG
3	<i>Horaglanis krishnaii</i>	Subterranean wells	Kottayam	Subterranean channels	ENK
4	<i>Horalabiosa joshuai</i>	Pambar	Chinnar wild life sanctuary	Riffle	EWG
5	<i>Lepidopygopsis typus</i>	Periyar	Thannikkudy	Riffle	ENK
6	<i>Silurus wynaadensis</i>	Kabbini	Vythiri	Pool-riffle	ENK
Species restricted to a single river					
1	<i>Labeo ariza</i>	Periyar	—		EWG
2	<i>Neolissochilus wynaadensis</i>	Kabbini	Vythiri, Aranagiri	Pool-Riffle	ENK
3	<i>Ompok malabaricus</i>	Bharathapuzha	Kannadipuzha	Deep Pools	EWG
4	<i>Osteochilichthys longidorsalis</i>	Chalakkudy	Parambikulam, Vazhachal	Riffle	ENK
5	<i>Pangasius pangasius</i>	Pamba	Kuttanad	Pools	—
6	<i>Tor mussullah</i>	Chalakkudy	Vazhachal	Rapids	EWG
Species restricted to one or more rivers					
1	<i>Balitora mysorensis</i>	Bhavani	Bharathapuzha Mukkali Mannarkkad	Rapids	EWG
2	<i>Channa micropeltes</i>	Pamba, Kallada	Thenmala dam, Rose mala	Pool	ENK
3	<i>Dayella malabarica</i>	Chalakkudy, Achenkoil	Pulikkakkadavu, Mannar	Lacustrine	EWG
4	<i>Glyptothorax anamalaiensis</i>	Anamalai hillstrams	Noolpuzha	Pool riffle	EWG
5	<i>Homalaptera Montana</i>	Anamalai hills	Puthuthottam estate	Cascade	EWG
6	<i>Puntius ophicephalus</i>	Periyar, Pamba	Ummikuppanthodu	Rocky Pools	EWG

Table 3: Endangered fresh water fishes of Kerala and the regions where they are found

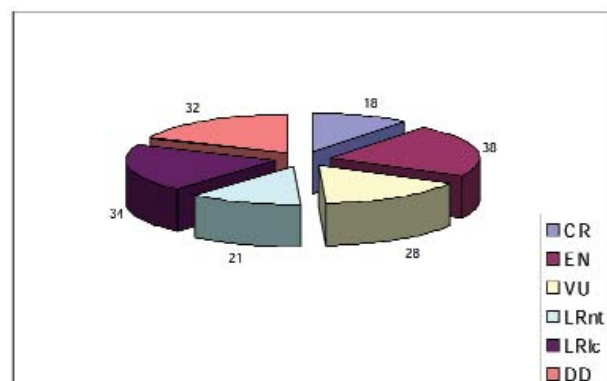
Species restricted to a single river system					
SI No	Name of the Species	River source	Location	Habitat	Endemism
1	<i>Chela fasciata</i>	Bharathapuzha	Thootha	Riffle	ENK
2	<i>Garra hughi</i>	Pambar	Chinnar wild life sanctuary	Riffle	EWG
3	<i>Glyptothorax davissinghi</i>	Chaliyar	Nilambur	—————	EWG
4	<i>Gonoproktopterus micropogon periyarensis</i>	Periyar	Thannikkudy	Run	ENK
5	<i>Homalaptera menoni</i>	Bharathapuzha	Silent Valley	Riffle	EWG
6	<i>Horadandia attukorali</i>	Cherthala	Kollam, Cherthala	Pools at low lands	EWG
7	<i>Osteo chilus thomassi</i>	Periyar	—————	—————	EWG
8	<i>Osteochius brevidorsalis</i>	Kabbini	Noolpuzha	Riffle-pool	EWG
9	<i>Puntius thomassi</i>	Kallada	Kulathupuzha	Rapid	EWG
10	<i>Silonia childreni</i>	Periyar	Periyar lake	Pool	EWG
11	<i>Travancoria elongata</i>	Chalakkudy	Vazhachal	Rapid	EWG
12	<i>Travancoria jonesi</i>	Chalakkudy	Parambikulam	—————	EWG
13	<i>Tor putitora</i>	Kabbini	Kalindi	Riffle
Species restricted to two river systems					
1	<i>Anguilla bengalensis</i>	Periyar, Kabbini	Neryamangalam Panamaram	Pools	EWG
2	<i>Esomus thermoicos</i>	Bharathapuzha, Pambar	—————	Pools and Ponds	EWG
3	<i>Garra mcClellandi</i>	Chaliyar, Periyar, Bharathapuzha	Thekkadi Mannarkkad	Riffles and Runs	EWG
4	<i>Garra surendranathinii</i>	Periyar, Chalakkudy	Thannikkudy, Parambikulam	Riffles and runs	ENK
5	<i>Gonoproktopterus kolus</i>	Chalakkudy, Periyar	Parambikulam, Palakkayam	Runs and Pools	EWG
6	<i>Gonoproktopterus thomassi</i>	Kallada, Chalakkudy	Kulathupuzha	Run	EWG
7	<i>Gonoproktopterus kurali</i>	Periyar, Kallada	Periyar lake, Thenmala	Runs, Pools	EWG
8	<i>Labeo dussumieri</i>	Pamba, Achenkoil	Pavukkara, Prayikkara	Pools at low lands	ENK
9	<i>Nemacheilus evezardii</i>	Kabbini, Pambar	Begur, Chinnar wid life sanctuary	Rapids	EWG
10	<i>Nemacheilus monilis</i>	Kabbini, Pambar	Begur	Rapid	EWG
11	<i>Osteobrama bakeri</i>	Kallada, Achenkoil	Ottakkal, Prayikkara	Runs, Pools	ENK
12	<i>Pangio goensis</i>	Manimala, Chaliyar	—————	—————	EWG
13	<i>Puntius lithopidos</i>	Travancore, Periyar	—————	—————	EWG

SI No	Name of the Species	River source	Location	Habitat	Endemism
14	<i>Puntius melanostigma</i>	Travancore, Kerala part of Nilgiri biosphere	————	Run	EWG
15	<i>Sicyopterus griseus</i>	Chalakkudy, Bharathapuzha	Vanchikkadav Mannarkkadu	Riffle, pools	EWG
Species found in more than two river systems					
1	<i>Batasio travancoria</i>	Chalakkudy, Pamba, Kallada, Manimala	————	————	ENK
2	<i>Glyptothorax annamalaensis</i>	Anamalai hills	————	————	EWG
3	<i>Glyptothorax annandali</i>	Kabbini, Bharathapuzha and Moovattupuzha Rivers	————	————	EWG
4	<i>Gonoproktopterus curmuca</i>	Chalakkudy, Kallada, Bharathapuzha	Malakkappara, Thenmala, Mannarkkasdu	Runs and Pools	EWG
5	<i>Horabagrus brachysoma</i>	Chalakkudy, Kallada, Achenkoil, Periyar	Punalur, Prayikkara, Parumala	Runs and Pools	ENK
6	<i>Puntius denisonii</i>	Achenkoil, Bharathapuzha, Chandragiri	Chuttippara, Mannarkkad Kasargod	Rocky Pools	ENK

ENDEMIC FRESHWATER FISH DIVERSITY OF KERALA

Of the 175 fish species reported, 33 species were found to be confined to the water bodies of Kerala (Table 4, Figure 1). This group includes species such as *Puntius denisonii*, *Nemacheilus keralensis*, *Oseobrama bakeri*, *Chela laubuca*, *Gonoproktopterus micropogon periyarensis*, *Silurus wynaadensis*, *Neolissochilus wynaadensis*, *Puntius ophicephalus*, *Garra surendranathinii*, *Garra menoni*. The distribution of these species varies both within a river system and also between river systems and many of these fishes have a highly restricted distribution. While assessing the biodiversity status of these fishes, it appeared that 9 species are critically endangered while 10 are endangered. *Lepidopygopsis typus*, *Labeo potail* and *Gonoproktopterus micropogon periyaresis* are critically endangered and species such as *Puntius denisonii*, *Osteobrama bakeri*, *Chela fasciata*, are endangered according to the IUCN criteria. Currently many of the endemic, high value ornamental fishes are exploited

for commercial purposes from the wild, thus aggravating their degree of endangerment. However, the quantities of these fishes exploited for trade purposes are not available. The rehabilitation of populations of endemic fishes through standardisation of captive breeding techniques and massive seed ranching are necessary for restoration and replenishment of their stock.



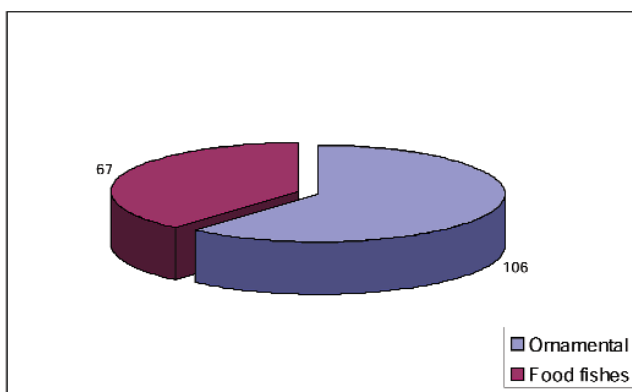
■ **Figure 1.** Biodiversity status of the freshwater fishes of Kerala based on IUCN

Table 4: List of Endemic freshwater ornamental fishes of Kerala and their biodiversity status and regional distribution

SI. No.	Scientific name of the species	Status as per IUCN	Regional distribution
1	<i>Horadandia attukorali</i>	EN	Pathiramanal islands
2.	<i>Amblypharyngodon chakaensis</i>	CR	Veli lake, Trivandrun
3.	<i>Barilius bakeri</i>	LRnt	Western ghats of Kerala
4.	<i>Gonoproktopterus micropogon periyarensis</i>	EN	Periyar lake
5.	<i>Puntius chalakudiensis</i>	EN	Chalakkudy River
6.	<i>Puntius ophicephalus</i>	CR	Head waters of Periyar
7.	<i>Osteobrama bakeri</i>	EN	Kottayam ,Nilambur
8	<i>Neolissochilus wynadensis</i>	CR	Head waters of Cauveri River
9.	<i>Crossocheilus periyarensis</i>	CR	Western Ghats of Kerala
10.	<i>Garra hughi</i>	EN	Cardamom and Palani hills, Western ghats)
11.	<i>Garra menoni</i>	VU	Kunthi River, Silent valley
12	<i>Garra periyarensis</i>	EN	Periyar Tiger Reserve, Periyar
13	<i>Garra surrendranathinii</i>	EN	Upstreams of Chalakkudy, Pamba and Periyar
14	<i>Lepidopygopsis typus</i>	CR	Periyar River
15	<i>Homaloptera menoni</i>	VU	Bhavani River
16	<i>Homaloptera pillai</i>	VU	Kunthi River, Silent Valley
17	<i>Travancoria elongata</i>	DD	Chalakkudy River
18	<i>Travancoria jonei</i>	EN	Upstreams of Periyar, Chalakkudy Rivers
19	<i>Nemacheilus keralensis</i>	EN	Western ghats of Kerala
20	<i>Pangio bashaii</i>	DD	Chalikkal River, A tributary of River Chaliyar
21	<i>Batasio travancoria</i>	EN	Western ghats of Kerala
22	<i>Horabagrus brachysoma</i>	EN	Rivers and backwaters of Kerala
23	<i>Horabagrus nigricollaris</i>	CR	Chalakkudy River, Kerala
24	<i>Chela laubuca</i>	DD	Kabbini
25	<i>flyptothorax anamalaiensis</i>	CR	Base of Anamalai hills of Kerala part of Western Ghats
26	<i>Glyptothorax housei</i>	DD	Anamalai hills
27	<i>Horaglanis krishnii</i>	CR	Kottayam district
28	<i>Pristolepis marginata</i>	VU	Mnanthavadi River, Kerala
29	<i>Channa micropeltes</i>	CR	Kallada River and Thenmala dam
30	<i>Silurus wynaadensis</i>	CR	Kabbini River, Wynaad
31	<i>Dayella malabarica</i>	EN	Parambikulam, Chalakkudy River
32	<i>Nemacheilus periyarensis</i>	DD	Mlappara,Periyar
33	<i>Salarias reticulates</i>	DD	Thumburmuzhi,Chalakkudy

ORNAMENTAL, CULTIVABLE AND FOOD FISHES OF KERALA

Of 175 species identified from the diverse river systems of Kerala, 106 are ornamental while 67 species are food fishes (Figure 2). Among the 106 ornamental species, 10 species including *Puntius denisonii* (Red line torpedo fish), *Puntius arulius* (Arulibarb), *Puntius conchoni* (Rosy barb), *Puntius filamentosus* (Tiger barb), *Puntius ticto ticto* (Ticto barb), *Puntius vittatus* (Koolie barb), *Puntius fasciatus* (Melon barb), *Parambassis thomassi* (Glass fish), *Hrabagrus brachysoma* and *Horabagrus nigricollaris* (Yellow cat fishes) have already secured positions in the national and international markets as ornamental fishes. The rest of the species have tremendous potential for development as candidates for the international ornamental fish market. Captive breeding and seed production technology of most of these fishes are not yet standardised and this forms the major bottleneck for their introduction in domestic and international trade. *Puntius carnaticus* and *Gonoproktopterus thomassi* have already been identified as potential candidate species suitable for aquaculture and can be developed as substitutes for Grass and Chinese carps in composite farming. 67 species of potential food fishes were recorded from the Kerala part of the Western Ghats, including species like *Mastacembeles armatus*, *Gonoproktopterus curmuca*, *Gonoproktepterus micropogon periyarensis*, *Channa marulius*, *Channa striatus*, *Mystus guliio*, *Mystus cavasius*, *Anguilla bengalensis* and *Puntius sarana subnasutus*.



■ **Figure 2.** Percentage of ornamental relative to food fish species reported from Kerala

FISH DIVERSITY AND ALTITUDE

Examination of fish biodiversity at various altitudes from 6 rivers of Kerala showed that species diversity was inversely related to altitude (Table 5). In the Bharathapuzha river system between altitudes of 0-774 m the Shannon-Weaver diversity index varied from 0-2.9 and the diversity indices showed maximum value between altitudes of 0-65 m while it was lowest at altitudes ranging from 580-645 m. The presence of quite large numbers of waterfalls in this region might have contributed to the biodiversity decline of this reach. In the Chalakudy River system the diversity index ranged between 1.76- 3.8 between altitudes of 0-1032 m. The highest diversity was found between 0-65 m while it was lowest at reaches between 516-580 m. In the Pamba River system the Shannon Weaver diversity index ranged between 0.67-2.64 between altitudes of 0-161 m. The diversity was highest at altitudes between 0-65 m while it was lowest from 903-968 m. In the Periyar River system between altitudes of 0-839 m the diversity ranged between 1.55-3.056. Highest fish diversity was observed in the lower stretch (0-65 m), while the diversity was poor at 194-452 m due to the commissioning of some mega hydroelectric projects. In the Kallada River system the diversity was highest in the stretch between 258-323 m altitude. Interestingly, in lower stretches with an altitude of 0-65 m the diversity was poor due to habitat alteration on account of various human interventions. The fish diversity in the entire river system was in the range between 0.99-2.25. In the Kabbini river system the study was confined only in the upstream habitats having an altitude of 710-968 m and the diversity index in this stretch ranged between 1.24-3.57. The remaining parts of the river system pass through Karnataka state. At Kabbini the highest fish diversity was observed at an altitude ranging between 710-774 m, while it was lowest at altitudes ranging from 903-968 m. The results of this study revealed that fish diversity was highest in the lower stretches of the Chalakudy River system (0-65 m) while it was lowest in the upstream reaches of the Bharathapuzha River system at an altitude between 581-600 m (Table 5). Among the six river systems studied, the Chalakudy and Kabbini River systems showed the highest diversity index

ranging between 1.76-3.8 and 1.24-3.37 respectively. In contrast, in the upstream reaches of the Periyar River system, between 774-968 m biodiversity showed an unusually increasing trend. This is due to the dominance of some critically endangered endemic species such as *Lepidopygopsis typus*, *Gonoproktopterus micropogon periyarensis* and *Crossocheilus periyarensis* which show high degrees of habitat selectivity and can sustain themselves only in the microhabitats prevailing in these areas. Abundance of *L. typus* showed a positive correlation with amount of bedrock substrate, chute type microhabitat, overhanging boulders, overhanging vegetation, total shade and stream cover. Optimum habitat of *G. micropogon periyarensis* was found as midchannel pools with comparatively good depth, overhanging vegetation, slope and excellent shade while that of *C. periyarensis* is lateral pools and scour-out pools with enough woody debris, overhanging vegetation and tree cover. According to Freeman,

Bowen and Crance (1997), animals preferably occupy areas that best support survival, growth or reproduction. It may, therefore, be inferred that altitude has a clear-cut influence on the type of habitat prevailing in different reaches of the river systems. Survey and sampling conducted at six major river systems of Kerala also discloses that out of the 7 types of channel reaches, regime reaches showed the highest species diversity followed by pool-riffle and cascade. The contribution of regime reaches decreases with increasing altitude; meanwhile cascade and pool-riffle reaches are invariably high in the upstream habitats. Though beyond an altitude of 645 m, the contribution of these habitats shows a decrease and the river reaches are mostly represented by bedrock and step-pool type of habitats, the species diversity in these habitats are relatively minimal, with the presence of a few species characterised by very peculiar morphological adaptations which can only survive in these regions.

Table 5: Shannon-Weaver diversity index at different altitudes in six major river systems of Kerala

Altitude Range (m)	Name of the river system					
	Bharathapuzha	Chalakkudy	Pamba	Periyar	Kallada	Kabbini
0-65	2.9	3.8	2.64	3.056	0.99	-
65-129	1.76	2.73	2.33	-	-	-
129-194	1.86	-	-	2.68	2.13	-
194 -258	-	3.28	2.2	1.55	1.8	-
258-323	1.9	2.21	2.4	1.69	2.25	-
323-387	1.76	-	-	-	1.5	-
387-452	-	2.58	1.44	1.88	-	-
452-516	1.9	2.97	-	-	-	-
516-581	-	1.76	-	2.05	1.44	-
581-645	0	-	1.62	1.88	-	-
645-710	-	-	-	2.27	1.37	-
710-774	1.2	2.24	-	1.81	1.45	3.37
774 -839	-	2.74	1.72	2.76	-	3.25
839-903	-	2	-	2.66	-	1.24
903-968	-	-	0.67	2.79	-	2.84
968-1032	-	2.75	-	-	-	-
1032-1097	-	-	-	-	-	-
1097-1161	-	-	2.44	-	-	-

HABITATS OF CRITICALLY ENDANGERED SPECIES

Microhabitat details of 7 critically endangered and endemic species are shown in Table 6. In the Kabbini River system the habitat of *Silurus wynaadensis* species is characterized by an average sinuosity of 1.21 while the entrenchment ratio, w/d ratio and the slope are 0.09, 5.3 and 0.09 respectively. The dominant substrate is sand and the stream comes under the A1 type in Rosgen's classification (Anon. 2000). The microhabitat of *Neolissochilus wynaadensis* is also located in the same river, where the average sinuosity, entrenchment ratio, w/d ratio and slope range between 1.2-1.6, 0.09-1.2, 3.2-5.3 and 0.06-0.09 respectively. Substrate is dominated by sand and the stream comes under the A5 type in Rosgen's classification. The Periyar River system requires special conservation measures due to the presence of five endemic and critically endangered species in its upstream region. *Lepidopygopsis typus*, *Nemacheilus menoni*, *Garra periyarensis* and *Gonoproktopterus micropogon periyarensis* were found in microhabitats characterised by a sinuosity ranging between 1-1.4 while the entrenchment ratio, w/d ratio and slope are in the range of 1-1.1, 0.87-28 and 0.1-0.15 respectively. The substratum is dominated by bedrock. The streams fall into both A1a+ and F1b classes. The sinuosity, entrenchment ratio, w/d ratio and slope are in the range of 1-1.3, 1-1.09, 1.14-28 and 0.1-0.15 respectively in the micro-

habitat of *Crossocheilus periyarensis*. The substrate is dominated by bedrock and the species found only in A1a+ type streams.

BIODIVERSITY THREATS TO THE FRESHWATER FISHES OF KERALA

The available information on the freshwater fishes of Kerala is mostly on systematics, distribution and abundance (Pillai, 1929; John 1936; Chacko 1948; Menon 1951, 1993; Kurup 1994; Easa and Shaji 1995; Zacharias, Bharadwaj and Jacob 1996; Ajith Kumar *et al* 1999; Raju Thomas *et al* 1999; Biju *et al* 2000; Kurup 2001; Kurup and Ranjeet 2002). The present database is compared against past data to determine the degree to which the fishes have become depleted over the last 50 years. Anthropogenic activities are the main cause for the alarming decline of fish populations in most of the rivers of Kerala. Unsustainable and unethical fishing by using fish poisons, dynamiting and a wide array of prohibited fishing methods are rampant in the uplands and lowlands of most rivers. Habitat destruction of natural spawning and breeding grounds of the fishes through sand extraction and construction of physical obstructions across rivers has contributed to the population decline and the endangerment of the freshwater fishes. Many of the species reported as endangered are now found only in areas protected under Forest and Wildlife jurisdiction, which clearly indicates the reasons for their endangerment.

Table 6: Major physical habitat variables at the area of occurrence of some critically endangered species

Name of the species	Habitat variables					
	Entrenchment ratio	W/D ratio	Slope	Sinuosity	Dominant substrate	Stream type (Rosgen's II level)
<i>Silurus wynaadensis</i>	0.09	5.3	0.09	1.21	Sand	A1
<i>Neolissochilus wynaadensis</i>	0.09-1.2	3.2-5.3	0.06-0.09	1.2-1.6	Sand	A1
<i>Lepidopygopsis typus</i>	1-1.1	0.87-28	0.1-0.15	1-1.4	Bed rock	A1a+ and F1b
<i>Nemacheilus menoni</i>	1-1.1	0.87-28	0.1-0.15	1-1.4	Bed rock	A1a+ and F1b
<i>Garra periyarensis</i>	1-1.1	0.87-28	0.1-0.15	1-1.4	Bed rock	A1a+ and F1b
<i>Gonoproktopterus micropogon periyarensis</i>	1-1.07	0.87-28	0.1-0.15	1-1.4	Bed rock	A1a+and F1b
<i>Crossocheilus periyarensis</i>	1-1.09	1.14-28	0.1-0.15	1-1.3	Bed rock	A1a+F 1b

The various types of destructive fishing activities practiced along the river systems of Kerala are summarized below.

Use of small meshed fishing gears

The use of small meshed fishing gears is prevalent in downstream sections of most of the rivers including the Achenkoil, Kallada and Pamba. Such practices, which are adopted for short-term profit, kill the fry and fingerlings of the fishes thus ultimately leading to regular growth over fishing and consequent reductions in populations.

Fishing using chemical and herbal poisons

Diverse types of fish poisons both of plant chemical origin are widely used in upstream, middle and downstream parts of most rivers.

Use of chemicals as poisons

Copper sulphate and bleaching powder are widely used in areas of rivers where water velocity is low. Fishes become inactivated or intoxicated and fishes including fingerlings are easily caught.

Use of insecticides as poisons

Insecticides and pesticides are used as a fish catching method, specifically for fishes that are either nocturnal or dwelling in small caves or crevices.

Seeds, bark and leaves of plants as poisons

Leaves, stems and seeds of different types of plants are used as poisons in shallow or low velocity waters. The seeds of palm, Othalathumkaya, Vakkanakkaya are regularly used for fishing.

Dynamiting

Dynamiting is a major method for catching food fishes but is less commonly used to catch ornamental varieties since it kills fishes instantaneously.

Electro-fishing

Electro-fishing is increasing in popularity in the down streams of the rivers like the Achenkoil and

Pamba. It is mainly targeted at larger fishes; however, smaller, ornamental fishes are also killed by this method.

Destruction and modification of habitats

Destruction of fish habitat is another major cause of the decline in the ornamental fish population. Dams, bunds and levees act as barriers for free migrations of fish in the rivers. Deforestation accelerated the decline of fish populations due to excessive siltation and soil erosion.

Introduction of exotic species

The introduction of exotic and alien species to the natural waters of Kerala has resulted in competition for food and space and ultimately in the decline of indigenous species. In Periyar Lake, which is well known as one of the biodiversity hotspots of Kerala, exotic species such as *Cyprinus carpio* have already established breeding populations and contribute more than 70 percent of the exploited stock. A high percentage of diet overlap exists between native fish species like *Tor khudree*, *Gonoproktopterus curmuca*, *Lepidopygopsis typus* and exotic species like Tilapia (*Oreochromis mossambicus*) and Common carp (*Cyprinus carpio*) (Table 7). Percentage contribution of exotics in the landing showed clear cut preponderance over indigenous fish species by weight (Figure 3). Tilapia has established its populations in almost all rivers of Kerala. The exotic high yielding African catfish (*Clarias gariepinus*) is another potential danger to the indigenous species. Alien species such as Catla (*Catla catla*), Rohu (*Labeo rohita*) and Mrigal (*Cyrrhinus mrigala*) have been cultured in most of the reservoirs and ponds of Kerala and consequently a gradual reduction of the endemic populations in these water bodies.

Water quality

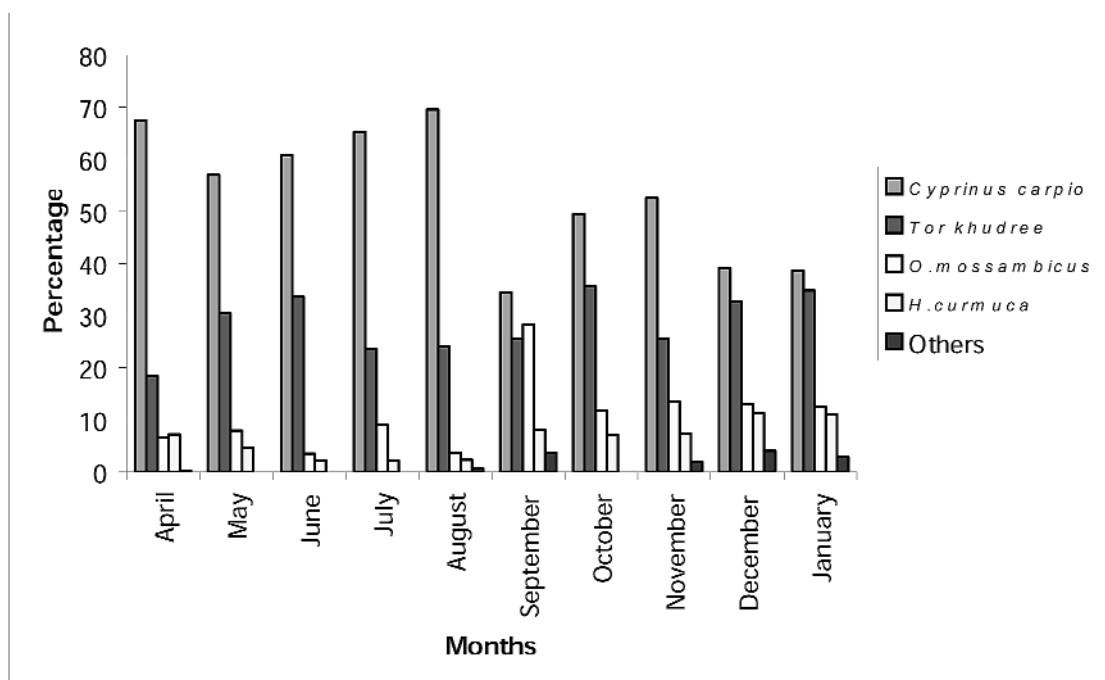
Agriculture in the catchment area has aggravated water pollution by the application of pesticides and insecticides as well as having brought about a reduction in the available space for the free movement of the fishes. Over 200 medium and large-scale industries

and 2 000 small-scale industries discharge effluents containing heavy metals such as mercury, zink and cadmium above the permitted level. There are regular mass mortalities of fish in the major rivers. The ammonia content of effluents discharged into these rivers was reported to be 432-560 ppm. Pollutants such as

acids, alkalis, fluorides and radioactive materials were detected in the effluent waters of the industries at the Cochin area as a result of which the Eloor-Varappuzh areas of the Cochin backwaters are being transformed into a barren contaminated zone. According to the data compiled by the KWBS, 10 types of pesticides with a

Table 7: Diet overlap of fish species in Periyar Lake, (Underlined figures indicates high overlap)

Fish species	<u>O.mossambicus</u>	<u>Tor khudree</u>	<u>G.curmuca</u>	<u>C.carpio</u>	<u>G.micropogan periyarensis</u>
<i>O.mossambicus</i>	-	0.78	0.48	0.33	0.21
<i>Tor khudree</i>	-	-	0.39	0.57	0.27
<i>G.curmuca</i>				0.42	0.35
<i>C.carpio</i>					0.32
<i>G.micropogan periyarensis</i>					



■ Figure 3. Percentage catch composition by weight of fish species from April 2002 to January 2003

total quantity of 490 tons are used in Kuttanad, the rice bowl of Kerala and samples of sediments and clams collected from the lower Kuttanad region had high concentrations of organic pesticides (Nair 200).

Over fishing

Over fishing of potential ornamental species without assessing their population size could lead to their extinction in the near future. Unfortunately, with the targeting of half a dozen fishes for the domestic and international trade, the stock size of these fishes has declined drastically and, as a result, most of them are now endangered. In addition, the spreading of fish diseases, especially in the downstream reaches of the rivers has resulted in mass mortalities of fishes such as barbs. Ever since from the outbreak of EUS in 1991, its recurrence had been invariably reported during the past 12 years from different water bodies of Kerala, thus acting as another major biodiversity threat to the inland fishes of Kerala.

MANAGEMENT MEASURES RELEVANT FOR CONSERVATION OF THE FRESHWATER FISHES OF KERALA

Management measures aimed at conserving freshwater fish biodiversity should be inserted into the fishery policies of the Govt. of Kerala. In addition the information given can be utilized by central and state government agencies, such as the Western Ghat Development Authority, Kerala Fisheries Management Society, local NGOs etc. who are deeply involved in implementing various measures for the protection of the fish biodiversity of the state.

Further measures should include:

The data base on population size and geographical distribution of endangered and endemic species should be strengthened by undertaking extensive micro geographical surveys. The knowledge of area of distribution and information on the micro geographical characteristics of the habitats of these ecologically sensitive fishes will be inputs for establishment of aquatic reserves for the conservation of the species.

Information regarding migration, breeding behaviour and spawning grounds of threatened fishes should be generated through extensive surveys and analysis. Such a database is essential for both *ex situ* and *in situ* conservation of the species.

Techniques should be developed for the captive breeding and broodstock development of fishes of potential economic importance. These should be standardised and the commercial scale exploitation of the species only be encouraged after standardising these techniques. Such information should be extended to the small and large-scale aquarists for the enhancement of ornamental fish exports.

Broodstock maintenance centres and hatcheries should be established exclusively for indigenous endangered and critically endangered fishes for their *in situ* conservation and aqua ranching as a substitute for their natural recruitment.

Investigation on the invasive nature of exotic species in the natural habitats should be carried out with a view to establish how many of them could achieve natural breeding populations and also to what extent their feeding spectrum habits overlap with that of the indigenous fishes. The functioning of the committee constituted under Govt. of India to quarantine and control the exotic species introduction to the country should be made more effective. The introduction of exotic and alien species of fishes in open waters for the purpose of resource augmentation, as is currently practiced in many of the freshwater dams of Kerala, should be discouraged and before any exotic species are introduction, its potential threat to local species should be studied and the introduction shall be subjected to the establishment of non threatening nature of the species.

CONCLUSION

The present study shows that the rivers and streams of Kerala have exceptional fish biodiversity with a high degree of endemism due to the presence of many rare and localised forms. These areas are conspicuous among the biodiversity hot spots of the world and therefore call for protection and preservation as

bio reserves. Long-term management plans are needed to conserve and preserve this treasury of fish germplasm. Measures should include standardisation of captive breeding and seed production technology of endangered and critically endangered fishes and their massive ranching in the rivers. Efforts should be made to regulate various human interventions that are being imposed in the freshwater habitats of the fishes and strict regulations should be imposed on the introduction of exotic and alien fish species in the natural waters. The present study also revealed that the physical habitat variables play a leading role in the distribution of fishes in streams and the habitat alteration brought about in various rivers contribute significantly to the endangerment of freshwaters in the rivers of Kerala.

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