SUMMARY

The study was carried out from 1998 February to 2002 February. Fish collections were taken from 105 sites of the 19 out of 24 rivers and Thutha and Malampuzha tributaries of Bharathapuzha of northern Kerala. Collections were also made from the protected areas namely, Silent Valley National Park, Aralam Wildlife Sanctuary and Wayanad Wildlife Sanctuary. Regular collections (once in three months) were made from Bharathapuzha river. Most of the samplings were done during the pre-monsoon period, and some during the post-monsoon and monsoon period. Surveys of India toposheets (1:50,000) were used to pinpoint the approachable sites for sampling.

The following chemical properties of water were measured adopting standard analytical methods: 1. Temperature (Diel digital thermometer), 2. pH (digital pH scan meter), 3. DO (Merck oxygen kit), 4. Conductivity (digital conductivity meter). The physical parameters considered for the study were: 1. Flow rate 2. Transparency (Visual method), 3. Width and depth of the streams, 4. Canopy or coverage 5. Altitude (Altimeter) and 6. Substrate distribution.

Current status and distribution of freshwater and hill stream fishes of northern Kerala

Freshwater fishes and hill stream fishes were classified into two categories threatened and non-threatened as per the IUCN criteria with some modifications. The criteria that are used in categorization of threat are: a) Restricted distribution, b) Area of occupancy, c) Total number of species recorded. Criteria adopted for the freshwater fish categorization was followed for the hill stream fishes also. The freshwater and hill stream fishes were classified into Critically Endangered, Endangered and Vulnerable (Threatened categories) and Low Risk-Least Concern and Low Risk-Nearly Threatened (Non-threatened categories).

A total of 96 species, belonging to 53 genera of 24 families and 8 orders of freshwater fishes were recorded from the study area. The most abundant family was
Cyprinidae with representatives from 17 genera (45 species), followed by the families Balitoridae and Bagridae, with members from 4 genera (9 species) and 3 genera (8 species) respectively. The most abundant genera were Puntius (13 species), Mystus (6 species) and Nemacheilus (6 species).

A total of 41 species are recorded from the hill streams of northern Kerala, except seven species of 41, 35 species are categorized among threatened category. 20 species are Endangered, 9 species are Critically Endangered and 5 species are Vulnerable.

Seven species are endemic to Kerala, and 31 species are endemic to the Western Ghats. Nine species are uniformly distributed. Of the six introduced species, two are found to be freely breeding in our waters, Oreochromis mossambica and Lebistes reticulata. The remaining four introduced species are common in the reservoirs but couldn’t establish themselves in the introduced waters.

Bharathapuzha river harbors highest number of freshwater fishes, where 77 species recorded, followed by Chaliyar (67), Kabini (59), Valapattanam (55), Chandragiri (50), Kariamgode (49).

Out of the total 96 species of freshwater fishes, ten species are collected from a single river in less than five numbers and so they are included under Critically Endangered category. Tor tor was an addition to the fish fauna of Kerala. The range of distribution of Chela fasciata, Horadandia attukorali and Amblypharyngodon mola has been extended to northern Kerala. Except Horadandia attukorali, all others were typical hill stream fishes. Six species out of 10, are the members of the family Cyprinidae, next highly threatened family was Balitoridae (2 members).

A total of twenty-three species are coming under the endangered category. Of these, 3 species were recorded only from a single river of the study area in less than 5 numbers and from less than five collection sites; 13 species are recorded from two rivers of the study area in less than 5 numbers and from less than five collection sites; rest of the 7 species were recorded from three rivers in less than 5 numbers and from less than five collection sites.
collection sites. The range of distribution of *Esomus thermoicos*, *Pangio goaensis* and *Horabagrus brachysoma* has been extended to northern Kerala. Record of *Labeo ariza*, *Labeo potail* and *Barilius bendelisis* was their first report from Bhavani river. The present study extended the range of distribution of *Puntius denisonii* to Chandragiri and Chaliyar rivers. The report of *Garra gotyla stenorrhyncus* was a rare record from a west flowing river, Chaliyar river is considered as a rare observation.

Nineteen species comes under the vulnerable category as they were recorded from only 4 - 8 rivers of the study area. The present study confirmed the occurrence of *Sicyopterus griseus*, *Chanda nama* and *Tetraodon travancoricus* in the rivers of northern Kerala, they were previously recorded only from southern Kerala. *Hypselobarbus kurali* was reported for the first time from Chandragiri, Kariyamgode, Valapattanam and Kuttiadi rivers. *Hypselobarbus curmuca* was recorded for the first time from Valapattanam, Kabini and Bhavani rivers. The present study extended the range of distribution of *Tor khudree* to some new areas like, Chandragiri, Neeleswaram, Kariyamgode, Kuppam, Kabini and Bhavani rivers.

44 species belongs to the non-threatened category and they were recorded from more than nine rivers in the study area. Most of the fishes of this category were the inhabitants of rivers and streams flowing through the low and middle lands. 11 species were seen only in the low lands, 11 were seen plenty both in low and middle lands, 3 species were common in mid land rivers, 4 species were residents of both hill streams and middle lands, 7 species were distributed from low lands to hilly areas, while 6 species were restricted to hill streams. Two species were primarily hill stream fishes but were distributed in other habitats also.

A total of 56 species, belonging to 15 families, were recorded from the protected areas of northern Kerala. Members of the family Cyprinidae contributed more to the total fish fauna. 9 species are uniformly distributed throughout these protected areas. The largest number of species were recorded from Aralam wildlife sanctuary and least was from Silent Valley National Park.
Habitat preference of selected hill stream fishes

In the present study substrate distribution is considered as the main tool in predicting the actual habitat of a fish. Most of the hill stream fishes preferred a rocky substrate as their principal streambed material. Habitat of a fish in different river systems has shown almost a similar substrate composition at their habitats. *Hypselobarbus jerdoni* preferred a habitat with cobble, boulder and bedrock as their major bed materials in both Chandragiri and Bharathapuzha rivers. *Barbodes carnaticus* also preferred the same substrate composition as that of *H. jerdoni* at their collection sites. *Puntius denisonii* was noticed as an inhabitant of the habitats with sand and gravel as the major substrate. It was not recorded from the bedrock area of Valapattanam and Chaliyar rivers. While its’ presence at the rocky habitats was recorded in Chandragiri river, but that type of occurrence is temporary only. *Puntius dorsalis*, preferred the habitats with cobble and gravel dominating the river bed. At the collection sites of *Garra gotyla stenorhynchus* cobbles dominated the stream bed in all the rivers systems. Cobbles were the major substrate type of genus *Nemacheilus*, mainly because that type of substrates provides an interstitial spaces to live and hide.

Eventhough, most of the hill stream fishes preferred habitats with rocky bottom, some of them preferred entirely different habitats of the hilly areas. *Pangio goaensis* was noticed in a habitat with sand as the major component. *Horabagrus brachysoma* preferred a habitat with sand, mud and gravel as the major substrate. *Esomus thermoicos* did not prefer a rocky bottomed habitat. Thus substrate composition in a habitat determines the type of the fish that it can harbours.

Food and feeding habits and length-weight relationship

The dietary analyses of fishes indicate the trophic segregation pattern among the members of the fish community in the area. The gut content analyses of the following
four species viz., *Bhavania australis*, *Tor khudree*, *Osteobrama bakeri* and *Nemacheilus guentheri* are carried out.

The gut content analysis of *Bhavania australis* revealed the presence of the food items which are classified into 7 groups and 40% was formed by algal matter. The highest value for Index of preponderance was shown by Algal matter (49.88) followed by sand particles (23.17) and the lowest value was for animal matter (0.61). Present study revealed that it is a benthic omnivore which mainly feeds on benthic insects, insect larvae, copepods, cladocerans and unicellular and filamentous algae.

Gut content analysis of *Tor khudree* has showed that Semidigested animal matter alone contributed the major part of its food material (52.3%). Other animal protein substitutes such as crustaceans, insect larvae and fish remains are in the ratio of 0.74:5.2:3.2 respectively. Semidigested plant matter contributes (24.9) while other gut contents such as diatoms, filamentous algae, sand, detritus and miscellaneous elements contributes 7.4, 1.24, 0.75, 2.99 and 1.24% respectively in the gut content. From the study it was revealed that *Tor khudree* is an omnivore with more preference to carnivorous food. Presence of sand and detritus in the gut content also supports its bottom feeding habits.

Microinvertebrates like copepods, cladocera etc. constitute 29.48% of the total food items consumed by *Osteobrama bakeri*. The highest value for Index of preponderance was shown by microinvertebrates (39.49) followed by Algal matter (18.25) and the lowest value was for miscellaneous (4.80). The present study revealed that it is omnivorous and mainly feeds on aquatic plants, insect larvae, copepods, cladocerans and unicellular and filamentous algae.

Benthic microinvertebrates like cladocera and copepods constitutes 52% of the consumed food materials of *Nemacheilus guentheri*. The highest value for Index of preponderance was shown by benthic microinvertebrates (71.96%) followed by Detritus (11.06), Algal matter (7.14) and the lowest value were for miscellaneous matter (0.87%).
Observations on the food and feeding habits of *Nemacheilus guentheri* revealed that it is a benthic omnivore which mainly feeds on benthic insects, larvae and nymphs, detritus and algal matter.

Length-weight relationship of *Tor khudree* and *Labeo ariza* were carried out. The present study shows that the fluctuation in relative condition factor of *Labeo ariza* in relation to size may be influenced by the number of spawning that have taken place in six to seven years of life period. In this event the fish appeared to have spawned 3-4 times as the fish attains sexual maturity when it is about two years old. The length-weight relationship of the fish never followed the cube law as the values of slope were recorded always higher than 3 in this case. In *Tor khudree*, the b values were slightly above the isometric value of 3, indicating that the weight increased by a power more than 3 with unit increase in body length.

Fish conservation studies

I. Evaluation of fish assemblages

A total of 100 species were recorded by earlier workers from the rivers of Northern Kerala. In the present study a total of 96 species of fishes were recorded from northern Kerala, 14 species recorded by earlier workers were not recorded in the present study (missing species). Two of the 'missing species' are 'single records', i.e., not recorded by any other worker after their first record, either from the same or any other place. They are *Pangio bashai* and *Glyptothorax devissinghi*. Two of these 'missing species' are commercially important and are exploitatively fished for food (*H.periyarensis* and *Channa micropeltus*). Use of various destructive methods of fishing such as explosives or poison in the rivers may be the reason for their disappearance. Dynamiting also destroys or alters the habitats of the fishes. It was observed that these commercially important species were mostly found in the lowland areas. Another threat faced by this group of fish was habitat loss by sand mining, which disturbed and destroyed the breeding grounds. This was observed in all the major rivers.

Twelve of the 'missing species' were hill stream fishes. These species were affected mainly due to alteration in their habitats. All these species were smaller in size and were
not commercially important. Pollution and deforestation were the other threats. Many of the highland areas in Kerala are occupied by rubber, coffee, tea and cardamom plantation, and pesticides and herbicides runoff from these plantation affecting the fish fauna.

In the present study 10 species that are not recorded by earlier workers are reported. Of these 2 species are new additions to the fish fauna of Kerala, viz., Tor tor and *Esomus thermoicos*, 3 species viz., *Puntius parrah*, *P. sophore*, *Barilius bendelisis* are widely distributed along the lowland waters. Earlier workers did not list *Dayella malabarica*, but this species is included in the list due to its record from moderately high altitudes. With the inclusion of these species to the earlier list the total number of typical freshwater fishes recorded from Kerala is coming to 110.

The present study recorded nine introduced species, of which 3 were not of Indian origin. *Cyprinus carpio communis*, *Catla catla* and *Labeo rohita* were abundant in many reservoirs, and were also recorded in the lowland areas during the monsoon, after the shutters of dams were opened. *Oreochromis mossambica* was widely distributed and were noticed even in the hill streams, but were not recorded from the very steep streams with high current velocity. *Poecilia (Lebistes) reticulata*, an aquarium fish, was also recorded from the Periyar river. Rainbow trout (*Salmo gairdnerii*) was recorded from the high altitude areas of Eravikulam National Park, Chinnar WLS and Konalar streams, Grass Hills, Valparai. These results show that the population of local species is showing an alarming decrease in their number. Absence of natural enemies of the introduced species may be the major cause for their increased survival.

**II. Ecologically sensitive areas**

The selection of ecologically sensitive or index areas is equally important for a long-term monitoring programme. The first stage in the selection of ecologically sensitive areas for long-term monitoring is the development of criteria, which will satisfy the conservational needs of the natural populations and habitats existing in that area. In the present study the four criteria were adopted. Major ecologically sensitive areas selected for long term monitoring are; 1) Kunthi river, subtributary of Bharathapuzha river; 2)
Punchola river, subtributary of Bharathapuzha, 3) Bhavani river; 4) Vytiri river, tributary of Kabini river.

**Major recommendations**

1. Control sand mining during the breeding season of fish, look for alternative material for construction purposes.

2. Carry out detailed studies on the factors causing fish diseases.

3. Long term monitoring of water quality of selected rivers to investigate the nature, extent and source of pollution.

4. Introduction of exotic species into natural streams should be controlled; research into the mechanisms of interactions between native and introduced fishes in the state should taken up.

5. Construct fish passage structures for the fish migration during monsoon, more importance should be given to construction of smaller check dams than larger ones.

6. Repopulate the affected area with the natural species created by artificial breeding.

7. Riparian vegetation should be protected to reduce erosion and to protect the morphology of the hill streams.