FISH GERMPLASM RESOURCES AND EXPLOITED FISHERIES OF THE RIVERS OF KERALA AND BIONOMICS OF 'RED CANARESE BARB', *HYPSELOBARBUS THOMASSI* (DAY 1874)

Thesis submitted to the

Cochin University of Science and Technology

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

by

RENJITHKUMAR C.R

Reg No: 3647

SCHOOL OF INDUSTRIAL FISHERIES

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

KOCHI – 682016, KERALA

APRIL - 2014

KERALA UNIVERSITY OF FISHERIES & OCEAN STUDIES

(Established on 20th day of November 2010 and governed by the
Kerala University of Fisheries and Ocean Studies Act. 2010
passed by the Kerala Law (Legislation 1) Department
vide notification No. 19540/Leg.1/2010/Law dated 28th January 2011)

Prof. B. Madhusoodana Kurup. PhD
Post Doc. (Wageningen University, The Netherlands)
Vice Chancellor

Panangad, Kochi – 682 506, Kerala, India
Phone:0484 2703781 (Direct), 2700598, 2700964
(Res) 0484- 2703944, 2700424 Fax: (91) (0) 484 2700337
E-mail: kurup424@gmail.com, madhukurup@hotmail.com
vckufos@gmail.com

Certificate

This is to certify that the thesis entitled **"FISH GERMPLASM RESOURCES AND EXPLOITED FISHERIES OF THE RIVERS OF KERALA AND BIONOMICS OF 'RED CANARESE BARB', *HYPSELOBARBUS THOMASSI* (DAY 1874)"** to be submitted by Mr. Renjithkumar C. R is an authentic record of research work carried out by her under my guidance and supervision in partial fulfillment of the requirement of the degree of Doctor of Philosophy of Cochin University of Science and Technology, under the Faculty of Marine Sciences.

Prof. (Dr.) B. Madhusoodana Kurup
(Supervising Guide)

Kochi - 682016
April 2014

Declaration

I, **Renjithkumar C.R** do hereby declare that the thesis entitled **"FISH GERMPLASM RESOURCES AND EXPLOITED FISHERIES OF THE RIVERS OF KERALA AND BIONOMICS OF 'RED CANARESE BARB', *HYPSELOBARBUS THOMASSI* (DAY 1874)"** is a genuine record of research work carried out by me under the guidance of **Dr. B. Madhusoodana Kurup,** Vice chancellor, Kerala University of Fisheries and Ocean Studies (KUFOS), Panangad, Cochin and no part of the work has previously formed the basis for the award of any degree, diploma, associate ship, fellowship or any other similar title or recognition of any university or institution.

Kochi - 682016
April 2014

Renjithkumar C.R

Acknowledgement

I wish to express my sincere thanks and deepest sense of gratitude to my guide Prof. (Dr). B. Madhusoodana Kurup, Vice Chancellor, Kerala University of Fisheries and Ocean Studies, Cochin for his unfailing guidance, intellectual inputs, invaluable suggestions, critical assessment and constant encouragement throughout the tenure of my research work.

I am also grateful to Prof. (Dr.) K..T Thomson, Director, School of Industrial Fisheries, Cochin University of Science & Technology for providing necessary facilities to carry out this work successfully.

I am highly thankful to Dr. M. Harikrishnan, Associate Professor, School of Industrial Fisheries for help in the statistical analysis of the data and invaluable help extended to work on various software packages of fish population dynamics.

I am thankful to Prof. (Dr). Ramachandran, Prof. (Dr.) Saleena Mathew, Prof. (Dr.) Ramakrishnan Korakkandy, Dr. John Mohan and Dr.Mini Sekharan of the School of Industrial Fisheries, for their advice, expertise and support during the research work.

I would be remiss not to mention my gratitude to a number of fishermen especially Sri Jhony, Kulathupuzha and many anonymous people all around Kerala who have aided and abetted me throughout my tenure in this work.

I would like to place on records my immense gratitude and appreciation to Dr. Prajith K.K, Dr. Antony, Dr.Sreedevi, Dr. Sherine, Dr. Saritha Thomas, Dr. Jyoni and Ms.Subhasree Shanker for their valuable help and support rendered for the sumptuous fulfillment of this research work.

I am happy to record to my sincere gratitude to the members of non-teaching and supporting staff, School of Industrial Fisheries for their help and co-operation throughout the course of my research work.

My heartfelt gratitude to my loving wife and family who has encourage me for the completion of my thesis.

Above all, I thank God almighty for his blessings showered upon me during the entire period of my PhD. Programme.

Renjithkumar C.R

Contents

Section II

BIONOMICS OF *HYPSELOBARBUS THOMASSI* (DAY 1874)

List of Tables

List of Figures

Abbreviations

ANACOVA	-	Analysis of covariance
BNP	-	Big Numbers Project
CBD	-	Convention on biological diversity
CEPF	-	Critical Ecosystem Partnership Fund
CIFRI	-	Central Inland Fisheries Research Institute
CUSAT	-	Cochin University of Science and Technology
FAO	-	Food and Agriculture organization
FISAT	-	FAO-ICLARM Stock Assessment Tools
ICES	-	International Council for the Exploration of the Sea
IUCN	-	International Union for Conservation of Nature
KSCSTE	-	Kerala State Council for Science & Technology
MEA	-	Millennium Ecosystem Assessment
VBGF	-	Von Bertalanffy growth formula
VPA	-	Virtual Population Analysis
WLS	-	Wild Life Sanctuary
UNCBD	-	United National Convention on Biological Diversity

Section I

FISH GERMPLASM INVENTORY AND EXPLOITED FISHERIES OF THE RIVERS OF KERALA

Chapter 1

INTRODUCTION AND REVIEW OF LITERATURE

Contents

1.1. Introduction

Biodiversity is the term used to describe life on earth — the variety of living things, the places they inhabit and the interactions between them. These interactions provide us with a number of essential natural services (ecosystem services) — such as food production, soil fertility, climate regulation, carbon storage — that are the foundation of human well-being. Biodiversity is essential for stabilization of ecosystem, protection of overall environmental quality for understanding intrinsic worth of all species on the earth (Ehrlich and Wilson, 1991). The relationship between biodiversity and human well-being is being promoted increasingly through the concept of ecosystem services provided by species (MEA, 2005; McNeely and Mainka, 2009). The services we use from ecosystems cannot be provided without biodiversity. According to the Convention on Biological Diversity (1992); Biological diversity (Biodiversity) means, "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems". It is predicted that about half of the estimated 13.6 million species on earth may become extinct by the year 2050 unless appropriate measures are taken to save them (Myers, 1999; Wilson, 1992). Loss of biodiversity has serious economic and social costs for any country and it is severe in freshwater than of marine ecosystem.

Freshwater biodiversity constitutes a vitally important component of the planet, with a species richness that is relatively higher compared to both terrestrial and marine ecosystems (Gleick,1996). It constitutes valuable natural resources in terms of scientific, cultural, educational and economic means. It provides a broad variety of valuable goods and services for human societies – some of which are irreplaceable (Covich *et al.*, 2004). Freshwater habitats in rivers, streams, springs and headwaters are heterogeneous due to variations in altitude, flow rates, dissolved oxygen, physical substrates and the riparian zones that provide food, shade and cover (Armantrout, 1990). The freshwater ecosystem supports various orders of animals, plants, fungi, vertebrates and invertebrates diversity and fish serving as prime indicators of ecosystem status (Karr *et al.*, 1986). Tribals and non tribals, depend on the fishes from their freshwater bodies for their livelihood (Gopi, 2000). Asia has the largest fisheries production of all the world's continents and many livelihoods are dependent upon freshwater biodiversity, which provides food security to the poorest of communities. Although comparatively better studied than the marine ecosystem, the rapidly increasing number of described species of freshwater fishes contributes nearly 50% of all the fish presently described (Froese and Pauly, 2010). Freshwater ecosystems are among the mostly heavily used, depended upon and exploited by humans for sustainability and well-being. From the rapid growth of human population, humans use the freshwater ecosystem so badly, that now produce large various worldwide negative ecological impacts. It is estimated that freshwater habitat, which are among the world's most threatened ecosystems, concentrate 25% of global vertebrates diversity (Groombridge, 1992). The main causes of the loss of biodiversity in freshwaters are habitat degradation and fragmentation, exotic species introduction and its invasion, water diversions, pollution and global climate change impacts (Gibbs, 2000; Saunders *et al.*, 2002). These impacts have caused severe declines in the range and abundance of many freshwater species and decline in biodiversity (Sala *et al*., 2000). Humans now capture 50% of available freshwater runoff, reservoirs trap 25% of the global sediment load before it reaches the oceans and several of the world's great rivers, including the Ganges–Brahmaputra, Yellow, Nile and Colorado have stopped flowing to the sea during dry periods (Postel, 2000; Jackson *et al.*, 2001; Vorosmarty and Sahagian, 2000). Globally, perhaps 10,000 to 20,000 freshwater species already are extinct or imperiled as a result of human activities (Strayer, 2006; IUCN, 2007). Brautigam (1999) reported that over 30% of freshwater fishes in US, 33% in Australia and 42% in Europe are extinct or at the risk of extinction.

Riverine habitats are least studied and likely many species still await discovery. It shows a high degree of endemism with most endemic fish species living in headwater streams or short stretches of river (Groombridge,1992; Kottelat and Whitten,1996). Fisheries is one of the major components in freshwater ecosystem because they provide good quality proteins. Freshwater fisheries around the world are seriously overexploited and large freshwater fishes are in global decline (Allan *et al.*, 2005; Dudgeon *et al*., 2006). As a result of this global crisis, documenting their causes and finding solutions have become a major part of contemporary in freshwater ecology.

India occupies only 2.4% of the world's land area but its contribution to the world's biodiversity is approximately 8% of the total number of species (Khoshoo, 1996). India is one of the mega diversity countries with respect to freshwater fish species (Molur and Walker, 1998) and occupies eighth and third positions in the world and Asia respectively (Dahanukar *et al*., 2004). The major resources of freshwater biodiversity of India include 29,000 km of rivers, 31,53,366 ha of reservoirs, 2, 02, 213 ha of flood plain wetlands and 7,20,000 ha of upland lakes (Sugunan and Sinha, 2001). Of the estimated 27,977 living species in the world (Nelson, 2006), India has 2,118 finfish species (Kapoor *et al.*, 2000) distributed in different ecosystems. 1042 species of freshwater fishes belonging to 71 families are reported from the Indian continent (Jayaram, 2009). In India, the number of fishes reported in rivers are: Ganga-192, Brahmaputra-179, Godavari and Mahanadi-105, Narmada and Tapti - 60, Krishna - 104 and Cauveri-139 (Yazdani, 1992). The aquatic resources of peninsular India comprising of five southern states, viz. Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Pondicherry, Goa and parts of Maharashtra and Orissa (Ayyappan, 1996). In India, the major hot spots of freshwater fish biodiversity are the Western Ghats and North East India (Kottelat and Whitten, 1996), comprising of the states of Assam, Manipur, Nagaland, Meghalaya, Mizoram and Tripura. Freshwater protected areas have played a major role in the rehabilitation and conservation of freshwater species (Sarkar *et al.*, 2005, 2008). The Eastern and Western Ghats cover 10% of this country's land area and are known to have about 55% of India's terrestrial and freshwater biodiversity (Jayaram, 1999). The Western Ghats is the richest region in India with respect to endemic freshwater fishes.

The most important topographic features of peninsular India is the Western Ghats along the western region of India, 8 °20' N Latitudes and 73° 77' E Longitudes, covers an area of 180,000 square kilometers (CEPF, 2007). It is one of 34 global biodiversity hotspots of the world (Bossuyt *et al.*, 2004). The Western Ghats, also known as the Sahyadri Hills stretch for 1,600 kilometers along the west coast of India, interrupted only by the 30 kilometers long Palghat Gap, through the states; Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra and Gujarat. The majestic presence of hill ranges of Western Ghats distinguishes Peninsular India as one of the unique biological regions of the world (Subhash, 1997). The freshwater rivers and streams in the Western

Ghats fall under five main categories or eco regions, viz., Narmada-Tapti, the Northern Deccan Plateau (Godavari River system), the Southern Deccan Plateau (Krishna River system), the Southern Eastern Ghats (Cauvery River system) and the Western Ghats (West flowing rivers) (Abell *et al.,* 2008).

The Western Ghats forms an important watershed for the entire peninsular India, being the source of 38 east flowing and 27 west flowing major rivers and their numerous tributaries. The west flowing rivers originate in the Western Ghats and drain into Arabian Sea while the east flowing rivers merge in to one of the three major river systems-Cauvery, Krishna or Godavari-before they drain in to Bay of Bengal. It is one of the richest hotspots of biodiversity, is unique for high rate of endemism (Myers, *et al.,* 2000; Gadgil, 1996) and has over 5000 species of flowering plants,139 mammal species, 508 bird species and 179 amphibian species (Shaji *et al.,* 2000). Compared to the other hotspots, it has the highest human population per unit area making it that much more challenging to conserve (Molur, 2009). The region is a repository of biodiversity evident from sprawl of description of new species in recent times and at least 325 globally threatened species occur here (Myers *et al.,* 2000). The region also has a spectacular assemblage of large mammals and is home to several nationally significant wildlife sanctuaries, tiger reserves and national parks. Twelve genera, *Betadevario*, *Dayella*, *Horabagrus*, *Horalabiosa*, *Hypselobarbus*, *Indoreonectes*, *Lepidopygopsis*, *Longischistura*, *Mesonoemacheilus*, *Parapsilorhynchus*, *Rohtee* and *Travancoria* are endemic to the Western Ghats (Dahanukar *et al.,* 2011). The southern region of the Western Ghats are now important components of global ornamental trade (Ponniah and Gopalakrishnan, 2000).

The state of Kerala is a narrow strip of land located at the southern extremity of the Indian Subcontinent, along the shore of the Arabian Sea covering a distance of about 580 km, with Karnataka state on the north and northeast and Tamil Nadu state on the east and south. Kerala's (8° 17’ 30" to

12° 47’ 40" N and 74° 51’57" to 77°24' 47" E) Western Ghats cover approximately an area of 20,000 sq. km. The Ghats region of Kerala covers nearly 21,856 km or 56% of the total geographical area and 42.7% of the entire Ghats region. The freshwater resources of Kerala include 44 rivers with a total length of 3100 km and catchment area 37,884 km², 30 reservoirs (2,96,35 ha) and irrigation tanks, channels and ponds of 4,000 ha with a total water spread area of 85,000 ha. Out of the 44 rivers systems, 41 are west flowing which join the Arabian sea at the west and 3 east flowing river systems viz., Kabbini, Bhavani and Pambar which confluent to the Bay of Bengal. The riverine water is the potential habitats for large variety of fish fauna, many of which are endemic to the state. In the world bank’s technical report, the streams of Kerala have been identified as one of the few sites in the world that show exceptional fish diversity and high degree of endemism with respect to freshwater fishes (Kottelat and Whitten,1996). Most of the rivers are small and being entirely monsoon-fed turn into rivulets in summer especially in the upper reaches.

The longest river Periyar with a total length of 244 km while the smallest river is Manjeswar with only 16 km. The catchment area of the river system is the largest for Periyar (5,398 km²) and the lowest for Ramapuram river system (52 km²). Physiographically, the state is divided in to three zones, the lowland, mid land and the highland. The highland forming the eastern boundary comprising of the high ranges of the Western Ghats; the low land is a narrow strip along the coast characterized by numerous lagoons and backwaters such as Vembanad, Ashtamudi, etc. which receive drainage from the rivers. Invariably, all the rivers are dependent on the forest in the upper reaches for sustained flow, which not only helps to reduce peak flow but also prolong the duration of the flow and prevent saline water intrusion in to the inland reaches during summer. All the west flowing rivers in Kerala produce into a continuous stretch of 30 backwaters extending to over 325 km lying parallel to the 600 km coastline.

Total world fish production from capture fisheries was quantified as 147.45 million tonnes (Ayyapan *et al.,* 2011). Asia has the largest fisheries production of all the world's continents and many livelihoods are dependent upon freshwater biodiversity, which provides food security to the poorest of communities. The Indian fisheries sector, which produced only 0.6 million tonnes of fish 50 years ago, now produces nearly 8.0 million tonnes (Ayyapan *et al.,* 2011). The country has an important role in the global fish production and it is the second largest producer of fish in the world. The importance of the fisheries sector in India is demonstrated by the fact that it employs more than five million people (Anon, 2000), contributes to food and nutritional security and employment, supports livelihoods and raises the socioeconomic status of poor fishing communities. With these vast and varied inland water resources, evidently India is one of the richest countries in world wealth. Indian inland fisheries production itself contributed 61 % (4.9 million tonnes) of the total fish production and marine fisheries contributed only 39 % of the total production. The major states contributing to the inland fish production are West Bengal (33%). Andhra Pradesh (9.09%), Bihar (8.71%), Assam (6.92%), Uttar Pradesh (6.49%), Orissa (6.01%), Tamil Nadu (4.82), Madhya Pradesh (4.07%), Karnataka (3.89%) and Maharashtra (3.4%) (Ayyapan *et al*., 2011). Inland fisheries of Kerala is having a vast potential of reservoirs, rivers, backwaters, ponds and tanks. The total annual production of Inland fisheries from Kerala was estimated to as 1,40,031 metric tonnes (Kerala Fisheries Statistics, 2012). The important freshwater fishes of Kerala coming under the following families: *Claridae, Cyprinidae, Siluridae, Belonidae, Ambassidae, Cichilidae, Gobidae, Channidae* etc (Kurup and Radhakrishnan, 2006). The percentage composition of various fish species landed in the different landing centers and inland fish markets of Kerala showed that freshwater fish species such as *Gibelion catla* (9%), *Cyprinus carpio* (9%), *Cirrhinus mrigala* (6%) and freshwater eel of the genus *Anguilla* were dominant ones after prawns (21%) and contribution of the fish production from different districts shows that Ernakulam (32%), Alappuzha (18%), Thrissur (11%) and Palakkad (10%) were the major ones (Kurup and Radhakrishnan, 2006).

The aquatic environment of the country are experiencing severe threats to both biodiversity and ecosystem stability and these environmental threats could be manmade or natural or in combination with two of them. Such threats are wide ranging including habitat alterations, overexploitation of resources, reduction of natural habitat area, construction of dams, reclamation of river beds, unsustainable fishing, introduction of non-native fishes, global climatic variations, etc (Ayappan *et al.,* 2011). Anthropogenic activities are the main cause of deterioration of quality and shrinkage of many aquatic ecosystems of India especially in Western Ghats (Menon, 1999). Damming of rivers and construction of reservoirs generally bring out the conditions most unfavorable for rheophylic species owing to rapid changes in fast moving habitats in the uplands (Dhanze and Dhanze, 1994; Maitland, 1993). Dubey and Ahmad (1995) described that dams and barrages have negative impact not only on endemic and migratory food fishes such us *Tor tor* but also several small species such as *Glyptothorax lonah, Nemacheilus dayi, Ompok pabda*, etc. Singh (2000) reported that the disappearance of *Puntius dubius*, a gravel spawner from Stanley reservoir in Tamil Nadu, was due to the smothering of breeding ground by fine silt. Disappearance of *Puntius carnaticus* from Trimoorthi and Amaravathi reservoirs have also been attributed to damming (Sreenivasan, 1976). Agricultural pesticides and industrial wastes invariably affect the aquatic ecosystem and cause mortality to fish resources. Indiscriminate discharge of effluents from Satpuda thermal power station resulted in excessive growth of macrophytes which changed the reproductive cycle of fishes in Sarni reservoir (Chatterjee and Sharma, 1994).

Freshwater fish diversity in Kerala is alarmingly declining due to industrial, agriculture and domestic pollution in the rivers, uncontrolled saline water intrusion, indiscriminate and unethical fishing practices using explosives, poisons, illegal fishing gears and outbreak of epidemic diseases to the fishes along with the exotic and alien species invasion, soil erosion in the streams, intensive agriculture in catchment areas, extensive deforestation and disappearance of riparian vegetation, increasing soil erosion in the streams and extensive sand mining (Kurup,1994a; Gopi, 2000; Ajithkumar *et al*., 2000). The principal constraint facing the freshwater fisheries in Kerala is the overexploitation of threatened fishes and biodiversity threats prevailing in the rivers. Destructive fishing method (use of small mesh sized net, poisoning, over fishing and catch of all life stages of fish) is one of the major concern for loss of fish diversity. There are reports on the use of poison in many rivers in Kerala (Kurup *et al*., 2004; Sebastian *et al*., 1999). The use of small meshed size fishing is prevalent in downstream sections of many of the rivers of state. This has resulted in the reduction in the average size constituting the fishery replacing the commercial species and indiscriminate killing of fishes irrespective of early life stage and brooders. Such practices, which are adopted for short-term profit ultimately leads to regular growth over fishing and consequent reductions in populations (Kurup *et al.*, 2004). A number of rivers in Kerala are dammed for hydroelectric power production and irrigation. Dams act as barriers for free migration of fish in the rivers (Kurup *et al.*, 2004; Kurup and Radhakrishnan, 2006). The distribution of many species has also adversely affected by the construction of dams to create artificial lakes and reservoirs (Daniels, 2001). Massive fish mortality due to effluent discharges from industries is a regular affair in some of the rivers such as Periyar and Chaliyar (Kurup, 1994a,2000). Kurup (2000) reported that the percentage reduction of population of many of the endemic freshwater fishes was in the range 20-70% during the past 10 years and species such as *Channa micropeltes* and *Horaglanis krishnai* crossed even 99% decline. Large-scale abstraction of water from freshwater bodies, sand mining and agriculture activities in catchment areas have resulted in excessive siltation, habitat destruction, shrinkage and drying up of rivers during summer.

Non-native species improve the diversity of fisheries compared to indigenous species and these species deliberately introduced to our native ecosystem may compete with native species. These exotic species are capable of spreading diseases, decreasing biodiversity through competition, predation and habitat degradation, genetic deterioration of wild populations through hybridization and gene introgression in short or long course of time (Casal, 2006; Singh and Lakra, 2006; García-Berthou, 2007; Lakra *et al.,* 2008). Jhingran (1989) observed that in Govindsagar reservoir, India; the landing of *Catla* which stood at 28% in 1977-78 decreased to 6.8% by 1987-88 by silver carp at almost replace (80%) indigenous *Catla.* 13 species of exotic fishes including *Clarias gariepinus, Cyprinus carpio, Oncorhynchus mykiss, Pangasianodon hypophthalmus, Oreochromis niloticus, Oreochromis mossambicus, Osphronemus goramy. Pterygoplichthys multiradiatus, Piaractus brachypomus, Trichopodus trichopterus, Xiphophorus maculatus, Poecilia reticulata* and *Gambusia affinis* are currently recorded from Western Ghats (Dahanukar *et al.,* 2011). Exotic fishes have been introduced for increasing the fishery in many Indian reservoirs (Arunachalam, 2005). Most of the reservoirs in South India are generally dominated by exotic fishes mostly tilapia species. Population decline of native fishes due to introduction of Tilapia, Chinese carps and Indian major carps have been reported in many Western Ghats reservoirs (Bijukumar, 2000; Sugunan, 2000; Daniels, 2003). Mozambique Tilapia, *Oreochromis mossambicus* was stocked in reservoirs of south India during the 1960s. Nile Tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) have become popular among aquaculturists in the country (Sugunan, 2000). Several non-native fish species are introduced in many rivers and reservoir of Kerala and colonize in those habitats. *Pterygoplichthys multiradiatus,* an armoured catfish was reported from Thrissur District (Ajithkumar *et al.*, 1998) and Thiruvananthapuram District in Kerala (Baiju, 2009), while the Guppy, *Poecilia reticulta* was reported from Chalakudy river (Raghavan *et al*., 2008b). African catfish *Clarias gariepinus* was reported from Manalur (Gopi and Radhakrishnan, 2001), Periyar lake (Radhakrishnan and Kurup, 2010) and Vembanad lake (Krishnakumar *et al.*, 2011). *C. gariepinus* was reported causing threats to native fishes in reservoirs of South India due to its voracious feeding and predatory habits and high growth rate (Singh and Lakara, 2006). Gopalakrishnan and Basheer (2000) have reported the ripe and 1+ year group specimens of transplanted Indian major carps in rivers of Kerala pointing towards their slow establishment in natural water bodies. Kurup and Ranjeet (2002) reported the invasion of exotic species such as *Cyprinus carpio* and *Oreochromis mossambicus* in Periyar lake of the Western Ghats river system of Kerala. This reserve encompasses 8 endemic fishes coming under critically endangered category. Indigenous species such as *Tor khudree* and *Hypselobarbus curmuca* which constituted more than 80% of the exploited fishery of the lake were drastically declined due to the invasion of the exotics where 80% of the fishery of the lake is constituted by these exotics in recent years (Kurup *et al.*, 2006).

Unless and until strict management measures are not taken up, most of these unique germplasm resources will disappear from the state in an immediate future. Efforts should be made to control the various types of anthropogenic interventions in the natural habitats of the fishes and strict regulations should be imposed in the introduction of non-native fish species in the natural waters. Conservation measures for protecting the fish diversity of the Western Ghats and Kerala are essential for sustainable exploitation in future. Yadav (1997, 2000 b, c) and Kharat *et al.* (2000) suggest certain conservation measures including formation of fish sanctuaries and construction of fish ladders in dams. *Insitu* conservation (conserving species within the natural habitat), *exsitu* conservation (conserving species outside the natural habitat), avoiding pollution of the water bodies, preventing siltation, minimizing harvest and exploring check on the growth of exotic species can minimize the catastrophic loss of fish species from the Western Ghats. Conservation efforts in the Kerala rivers are nevertheless piecemeal and reactive. The present conservation approach needs to be more focused and integrated with an ability to predict the elements of the river biota that are most vulnerable to extinction and to identify their ecological attributes. The aquatic biodiversity, fisheries and ecology of these rivers has not been inventoried thoroughly and most species are probably undescribed and it is time for scientific community to integrate and explore the stream and riverine biodiversity and ecology, to join hand to raise Western Ghats biodiversity and ecological information. Under these circumstances the exploitation of the freshwater resources in a scientific manner is a must in order to tackle the deficit food situation in the state. It is therefore become imperative to evolve a master plan for the development and conservation of the freshwater fisheries.

1.2. Review of literature

An exhaustive review of earlier studies of the diversity of freshwater fish and fisheries of world, India especially in Western Ghats and Kerala was done. This encompasses the literature related to fish germplasm, river wise species diversity, biodiversity status, endemism, magnitude of exploited fisheries, quantity of fish exploitation, craft and gear used for fisheries, biodiversity threats of rivers and non-native fish introduction. Nearly 600 relevant scientific papers, reports and books were visited towards accomplishing this.

The science of Ichthyology dates back to the time of Aristotle (BC 384-322). Aristotle who is known as 'Father of Zoology' had a perfect knowledge of general structure of fishes and their habitats. Pierra Belon (1517-1575 AD) described 110 species in the publication entitled '*De aquatilibus libri duo*' from Mediterranean in Europe. Rondelt (1507-1557) described about 197 marine and 47 freshwater fishes of Mediterranean. The renowned taxonomist Linnaeus Peter Artedi (1705-1734) is considered as the father of ichthyology. His work consists of the list of preceding workers and the external morphology and anatomy of fishes. He described 45 genera and 72 species. Linnaeus (1758, 1766- 68) contributed substantially to the taxonomy of fishes. Bloch's (1785-1795, 1797) work was unique with great number of illustrations of fishes. Lacepede's (1798-1803) *"Histoire des poissons"* and Cuvier and Valenciennes's (1822-1850) *"Historia naturella poissons"* are indispensable for any fisheries related studies. Nelson (1976, 1984 and 1994) presented a modern introductory systematic treatment, diversity and zoogeography of all major fish groups of the world.

Fishes have been a part of Indian culture and have appeared in mythology. One of the incarnations of "Lord Vishnu" is in the form of fish to recover 'Vedas' from 'Asuras'. In several temples of Kerala, there are ponds to protect fishes and there is a religious fete like "*Meenuttu"* (Feast for fish). The ancient Hindus knew greatly about the external features and habits of a variety of freshwater fishes of the Indo**,** Gangetic plain and fishes appeared in Ramayana (Hora, 1935a, 1948 a, b, 1950 a, 1951a,b,c**,** 1952, 1953 a, b). In 1127 AD the son of King Vikaramaditya VI, King Somesvara composed a book entitled '*Manasolatara*' where the first of all recorded sport fishes of India and grouped them into marine and riverine forms. In *Manasolatara*, King Somesvara classified fishes as scaled, scaleless, ascending rivers, marine and freshwater inhabitants.

Indian freshwater fish fauna description starts only from the 19th century. As Day (1875-1878) comments, the first Indian wrote on the Indian fishes is Bloch whose work entitled '*Auslandische fishe'* was published in 1785. This was continued by Schneider in 1801 and his work included many lndian marine forms. Lacepedes (1798-1803) '*Histoire dess Poissons'* contains many Indian forms of fishes. Cantor's work was published as *'Notes on the Indian fishes'* in the Journal of the Royal Asiatic Society during 1839-1850. McClelland (1839) published a memoir on Indian Cyprinidae in Asiatic Researches.

Scientific study on the systematics of Indian freshwater fish fauna started with Hamilton-Buchanan's (1822) '*Account of the fishes found in the river Ganges*' followed by McClelland (1839), Sykes (1839), Jerdon (1849), Cuvier and Valenciennes (1822-1850), Bleeker (1853), Blyth (1858,1860), Day (1865,1878), Beavan (1877) and Gunther (1864,1868). Hamilton and Buchanan's (1822) described 271 species of freshwater and estuarine fishes. McClelland (1839) published an account of 138 species of Indian cyprinids and Bleeker (1853) described 162 species of fishes. Jerdon (1849) published a book '*An account of the fishes of Southern India*' in two parts, one parts describes 22 fish species while the later accommodates 150 species of fishes. Beavan (1877) published a book on the freshwater fishes of India in which he gave a clue on the distribution pattern of some Malayan species found in Peninsular India. He described 392 fish species. Information on the fish fauna of Malabar region was made by Hamilton (1877) during his journey through South India. A comprehensive and authoritative account on the fishes of Indian region was published only during 1865 and 1889 by Francis Day. Day included 1340 species of freshwater and marine fishes in his work '*The fishes of India being a natural history of the seas and freshwater of India, Burma and Ceylon*'. Even today, the publication by Day remains as an important reference manual for the Ichthyology of Indian region.

The 20th century of Indian Ichthyology started the indomitable research of Hora. The publications of Hora are indispensable for any student of Indian Ichthyology. Hora published over 440 papers and erected three families, 28 genera and 139 species (Jayaram, 1976). Hora made mainly the revisionary studies during the thirties. He published his studies in various heading such as *"Notes on the fishes in Indian Museum"*. The survey and documentation carried out during 1920-1955 by Hora brought out information on the freshwater fishes of various river systems of India. Most of the works are concentrated in the North Eastern States of India. Misra (1947, 1952, 1953, 1962, 1969, 1976 a, b) published a series of checklists and aids for the identification of the fauna of India and adjacent countries. These studies were continued by the publication of Menon (1987, 1992) and Talwar (1995). Datta Munshi and Srivastava (1988) published the fauna of India volume dealing mainly with the taxonomy of fishes of India and adjacent countries. Jayaram (1981, 1991, 1999 and 2009) and Talwar and Jhingram (1991) supplemented information on the inland fish fauna of India. Other studies include Nath and Dey's Fish and fisheries of North Eastern India (2000), Viswanath's Fish fauna of Manipur (2000) and Field guide to species identification of Fishes of Northeast India (2002). Talwar and Jhingran (1991) were notable among them which gives many valuable information of the freshwater fish and fisheries of India.

Study on fish fauna of Western Ghats have been done by many scientists. Data on fish fauna of the Western Ghats scattered in various literatures. Studies of Acharya and Iftekhar (2000), Ajithkumar *et al. (*2000), Annandale (1919), Arunachalam (2000), Arunachalam *et al.* (2000a), Balasundran *et al.* (2000), Bhat (2003,2004), Dahanukar *et al.* (2004), Daniels (2001), Devi *et al.* (2005), Easa and Shaji (1996, 1997), Frazer (1942), Ghate and Wagh (1991, 1995, 2003), Gopalakrishnan and Ponniah (2000), Hora and Misra (1937, 1938, 1942), Indra and Remadevi (1981), Jadhav *et al.* (2011), Jayaram (1981), Johnsingh (2001), Johnson and Arunachalam (2009), Kalawar and Kelkar (1956), Kharat *et al.* (2000, 2003), Rajan (1955), Rao and Shachar (1927), Remadevi and Indra (1984, 1986), Remadevi (1992), Samant (1990), Sarkar and Yadav (1996), Shaji and Easa (1995 a, b, c, 1996 and 1997), Shaji *et al.* (1996,2000), Silas (1950, 1951, 1952, 1953), Singh and Yazdani (1988, 1991), Sreekantha *et al.* (2007), Suter (1944), Talwar and Jhingran (1991), Tilak and Tiwari (1976), Tilak (1987), Tonapi and Mulherkar (1963), Wagh (1999), Yazdani and Mahabal (1978), Yazdani and Singh (1990), Yazdani and Yadav (1995) and Yadav (1996, 1997, 2000 a) are notable among them.

Fish faunal studies of Kerala starts with outstanding works of Jerdon (1849) followed by Hamilton’s Journey through South India (1877). A systematic account of the fishes is available from Day's (1865) "*Fishes of Malabar*” during the 19th century, which is considered as germ for the publication of "*Fishes of India*". After Day's classical work (1878, 1889), the next fish fauna study in Kerala was that of Pillay (1929), in which he listed 369 species from Travancore region. John (1936) published information on fish and fisheries of Travancore. Hora and Law (1941) published a comprehensive list of 76 species of typical freshwater fishes of Travancore.

Other notable studies in the fish diversity, fisheries, craft and gear used and biodiversity threats in riverine fisheries initiated in early nineties. Notable among them are Ajithkumar *et al.* (1999, 2000), Antony (1977), Arun (1997), Arun *et al.* (1996), Beevi and Ramachandran (2009), Biju *et al.* (1996,1999,2000), Bijukumar and Sushama (2001), Chacko (1948), Cherian *et al.* (2001), Easa and Basha (1995), Easa and Shaji (1995,1996,1997), Goplakrishnan and Basheer (2000), Gopi and Radhakrishnan (1998, 2001), Gopi (2000,2001,2002), Gopinathan (1995), Inasu (1991), Indra and Remadevi (1981, 1990), Jayasree *et al.* (1993), John (1936), Kurup, (1990, 1994, 2000, 2002), Kurup and Kuriakose (1991), Kurup and Ranjeet (2002), Kurup *et al.* (2002a,2004,2006), Kurup and Radhakrishnan (2005, 2006), Manojkumar and Kurup (2002c), Menon (1997), Menon and Jacob (1996), Menon and Remadevi (1995), Menon *et al.* (1999), Mini (2000), Padmakumar and Krishnan (2000), Raju Thomas *et al.* (1998 a,b,c,1999,2000 a,b,2002), Raju Thomas and Biju (2000), Radhakrishnan (2006), Radhakrishnan and Kurup (2010), Raghavan *et al.* (2008 a, b), Renjithkumar *et al.* (2011), Remadevi and Indra (1981,1984,1986,1994,1999), Remadevi *et al.* (1996), Robin *et al.* (2011), Shaji and Easa (1996,1997,2000,2001,2002), Shaji *et al.* (1995,1996,2000), Silas (1949,1950,1951,1952),Thomas (2004),Thomas and Aziz (1999) and Zacharias *et al.* (1996).

Chacko (1948) listed 33 fish species from the Periyar Lake. Fishes from the Periyar Tiger Reserve was documented by Arun *et al.* (1996) and Zacharias *et al.* (1996). Zacharias *et al.* (1996) reported 35 fish species representing 21 genera and 11 families from Periyar Lake. Arun (1997) reported 27 species from Periyar lake- stream system, which includes 12 endemics to Western Ghats besides 3 species which were strictly endemic to Periyar Tiger Reserve. 36 species of fishes were identified from the Periyar Lake by Kurup *et al.* (2006). The authors also computed the fish landing from Periyar Lake at 2.32 tonnes. The fish fauna of Bhavani River was studied by Rajan (1955). Remadevi and lndra (1986) reported fish fauna of Silent Valley. Chalakudy and its associated streams harbour as many as 98 fish species of both food and ornamental value (Ajithkumar *et al.*, 1999; Biju *et al.*, 2000). Easa and Bhasha (1995) conducted a survey on the habitat and distribution of stream fishes in the Kerala part of the Nilgiri Biosphere Reserve and recorded 92 species. Shaji *et al.* (1995) documented the fish fauna of Aralam wildlife sanctuary in Kannur district of Kerala. The fish fauna of Pambar river and Chinnar wildlife sanctuary was studied by Easa and Shaji (1996). Raju Thomas (2002) studied the fish fauna of streams in South of Palghat gap and reported 117 species.

1.3. Objectives of the study

The available literature show that the rivers of Western Ghats and Kerala were embarked up on with rich fish diversity and harbor many endangered fish species. However, most of the publications were based on the taxonomic listing, new discovery and new distribution ranges of fishes with reference to a particular river or area. Not much work has been done in Kerala based the river wise fish germplasm resources, exploited fish production from rivers and the status of non-native fish invasion in these rivers. The present study was undertaken mostly aiming at to generate an authentic database on fish diversity of Kerala rivers and river wise fish germplsam based on available literature, exploited fisheries from various rivers of Kerala, species wise details of exploitation, details of various gears used for exploitation, catch details of non-native fishes from major rivers and also to prepare responsible fishery practices for sustainable utilization of resources.

The present study aims at

1) To prepare a comprehensive data base on river wise fish germplasm of all the rivers of Kerala and revalidate their biodiversity status and endemism based on available literature.
2) To quantify the exploited fishery resources of the rivers, species wise exploitation and craft and gear used for exploitation based on the season wise sampling.
3) To assess the status of non-native fish invasion in major rivers of Kerala and to quantify their exploitation level.
4) To Investigate the bionomics and resource characteristic of *Hypselobarbus thomassi*, an endemic food fish belonging to 'Critically Endangered' category under threatened fishes.
5) To prepare responsible fishing practices for the sustainable utilizations of the resources and their conservation.

1.4. Organization of Chapters

The thesis is organized under eleven chapters which begins with a general introduction of the topic vide chapter 1. Thenceforth, it is divided into two sections, while the former section gives a data base on fish germplasm and exploited fisheries of rivers of Kerala whereas the latter section embodies the findings of the bionomics and resource characteristics of *Hypselobarbus thomassi* (Day, 1874), an endemic food fish belonging to the threatened category as per IUCN categorization.

In the **First** chapter, the importance of the present study is emphasized, earlier works done on the freshwater fishes and their fisheries of rivers of Kerala have been reviewed, the data gaps on the freshwater fishes from the point of biodiversity conservation and management are highlighted. This chapter also embodies the general organization of thesis giving chapter wise details.

The **second chapter** deals with the fish germplasm resources of the rivers of Kerala. The river wise fish species inventory of Kerala rivers was prepared based on the scrutinization of the previous literature available for the last 20 years and also based on the results of the present study. About hundreds of research papers and thesis on the freshwater fish fauna of Kerala were consulted towards preparation of the database. Details regarding biodiversity status and endemism of fish species are also furnished. This is followed by the river wise germplasm inventory details for 40 river systems of Kerala. The river systems were compared for their nature and level of species diversity based on river index values. Species diversity in river systems were correlated with their geographical dimensions such as river length and catchment area and conclusions were drawn.

Chapter three encompasses the exploited fishery resources of eight rivers of Kerala viz., Pamba, Bharathapuzha, Periyar, Chalakudy, Achenkovil, Kallada, Meenachil and Muvattupuzha, focussing on species and gear wise exploitation. The exploited fishery of rivers were estimated based on the data generated from major landing centres, which were subject to regular systematic surveys and sampling during pre monsoon, monsoon and post monsoon seasons. This chapter deals with all primary and secondary fresh water fishes which were collected from the landing centres within the freshwater zone of different river systems.

Chapter four deals with comprehensive information on the intensity of non-native fish invasion in the major rivers of Kerala and their possible negative impacts upon fish and fisheries on the indigenous and endemic fish diversity of the state. Among the eight river surveyed, six rivers contributed to the fishery by the non-native fishes.

Chapter five embodies systematics, distinguishing characters, taxonomical account, distribution, synonymy and common/vernacular names of *Hypselobarbus thomassi*. The salient features of the fish along with its systematic position are described.

Chapter six deals with the qualitative and quantitative aspects of food composition in relation to sex, size and season, seasonal variation in feeding intensity as well as gastro somatic index. The index of preponderance was used to assess the food preferences of males, females and indeterminates.

Chapter seven provides information on the maturation and spawning of *Hypselobarbus thomassi* using different methods. The spawning season was delineated based on quantification of maturity stages, monthly percentage occurrence of fish with gonads in different stages of maturity, pattern of progression of ova during different months and the monthly variation of gonadosomatic index.

The relationship between total length (mm) and body weight (g) in both the sexes and indeterminates were studied and presented in **Chapter eight.** This chapter also describes about the relative condition factor (Kn) and ponderal index (K) of the fish along with seasonal and size-wise variation.

The results of age and growth studies carried out in male and female populations are given in **Chapter nine.** The growth parameters were estimated using the ELEFAN 1 programme in the FISAT software. Powell- Wetherall Method is used to estimate asymptotic length and the ratio of the coefficients of growth (Z/K) using length-frequency data based on Beverton and Holt.

Chapter ten deals with the population dynamics. Total mortality coefficient (Z), natural mortality coefficient (M), exploitation ratio, exploitation rate and length converted cohort analysis of *H. thomassi* population were described in this chapter.

Chapter eleven embodies summary and recommendations. The salient findings of the present study are consolidated under summary. Based on results of the present study, a few management measures relevant for the conservation of the rare and unique fish germplasm resources of the rivers of Kerala are also proposed.

In general, each chapter is subdivided into brief introduction and review, materials and methods, results and discussion. Tables, graphs and photographs are inserted at appropriate places. The list of references consulted are appended at the end of the thesis.

.....ꙮꙮ.....

Chapter 2

STATUS OF RIVER WISE FISH GERMPLASM OF KERALA

Contents

2.1. Introduction

Agenda 21 framed out by United Nation Convention on Biological Diversity (1993) reaffirms that there is sovereign rights for the member nations over their entire genetic resources. It also envisages conservation, sustainable use and equitable sharing of the benefits arising from the biological resources (Winter and Hughes, 1997; Narain, 2000). The changes in the relative abundance of individual or species within an aquatic community can negatively impact species richness, ecosystem biomass, the age of first maturity or food web dynamics underscoring the need to maintain the structure of aquatic communities (Shutter and Koonce, 1977; Rochet and Trenkel, 2003). Database on the fish biodiversity of a country/state/river is very essential for making tool for conservation, utilization and management of fish germplasm, declaration of aquatic sanctuaries and national parks, artificial propagation of endangered and endemic species and mitigation measures to control anthropogenic activities. Strengthening the database of diversity and distribution of freshwater fishes by extensive surveys and sampling are prerequisites of any conservation measures (Kurup, 1994). The precise number of existing fish species remains to be determined and the fish diversity catalogining and its appropriate management is a great challenge. A comprehensive information on the river wise fish germplasm resources and their biodiversity status are very essential for sustainable conservation of fish diversity of the country for their sustainable utilization since the available literature is very much scattered and unorganized.

The Western Ghats of India is recognized as one of the 34 global biodiversity hotspots of the world and the richest expression in diversity, abundance and endemism of freshwater fishes (Myers *et al.,* 2000; Anon, 1998; Dahanukar *et al.*, 2011). This region is abundant with many threatened fish species groups. The fish germplasm inventory, biodiversity status and endemism of river systems of Western Ghats were studied by many of the Indian scientists. Notable among them are those of Arunachalam (2000), Arunachalam *et al.* (2000a), Balasundaran *et al.* (2000), Bhat (2003,2004), Dahanukar *et al.* (2004), Daniels (2001), Devi *et al.* (2005), Gopalakrishnan and Ponniah (2000), Jadhav *et al.* (2011), Johnson (1999), Johnson and Arunachalam (2009), Kharat *et al.* (2003), Shaji and Easa (1996,1997), Shaji *et al.* (2000), Sreekantha *et al.*(2007), Wagh (1999), Yazdani and Mahabai (1978) and Yadav (1997, 2000,a). A consolidated list of 287 freshwater teleosts from Western Ghats was prepared by Shaji *et al*. (2000), with 192 endemic species (67% endemicity) and 17 species exotic / transplanted to the area. Dahanukar *et al.* (2004) listed 288 species of fishes belonging 12 orders, 41 families and 109 genera from Western Ghats rivers and streams. Johnson and Arunachalam (2009) listed 60 species of freshwater fishes from streams of Western Ghats. Recently Dahanukar (2011) in IUCN assessment programme of Western Ghats accommodated 290 species of freshwater fishes belonging to 11 orders, 33 families and 106 genera and also have a rich endemic fauna of 189 species. Several authors found new species of freshwater fishes and new distribution of species in a river or a particular region of river and resolve many taxonomic ambiguities of many species. Srivastava (2000) was successful in unraveling species specific profiles of many freshwater species using ultra thin isoelectric focusing and had suggested that the same technique could be applied to establish species identity of the region.

There are various scientific studies on the freshwater fish diversity, river wise germplasm and threat status of fresh water fishes in the various river systems of Kerala. Day’s (1865) ‘Fishes of Malabar’ is the first book which deals with comprehensive information on fishes of Kerala. Hora (1942) described fishes in Wayanad and the adjacent areas. Silas (1951) listed the fishes of Anamalai and Nelliampathy. Other notable studies on freshwater fish species inventory are those of Mukerjee (1931) and Rajan (1955) of Bhavani river, Easa and Shaji (1996) of Pambar river, Biju *et al.* (1996) of Manjeswaram river system, Ajithkumar *et al.* (1999) and Rajeev *et al.* (2008b) of Chalakkudy river system, Bijukumar and Sushama (2001) and Sushama *et al.* (2004) of Bharathapuzha river system, Lalmohan and Remadevi (2000) of Chaliyar river system, Cherian *et al.* (2001) of Trivandrum district, Varghese (1994) and Swapna (2009) of Achenkovil river system, Raju Thomas *et al.* (2004) of Periyar river system and Renjithkumar *et al.* (2011) of Pamba river system. The NBSAP (2002) has reported the presence of 159 freshwater fish species in Kerala. Raju Thomas *et al.* (2002) published the list of freshwater fishes of southern Kerala, highlighting the distribution of endemic and endangered fishes. Biju (2003) prepared a list of hill stream fishes of 19 rivers of Northern Kerala. Mini (2000) and Kurup *et al.* (2006) studied fish species of Periyar Lake. Radhakrishnan and Kurup (2010) listed 54 species of fishes from Periyar Tiger Reserve. Kurup *et al.* (2004) recorded 175 fish species from rivers of Kerala and evaluated their biodiversity status as per IUCN red data list categories. The authors surfaced various threats prone to fish diversity and also suggested relevant conservation and management measures required for the preservation of the freshwater fish biodiversity of Kerala. Kurup and Radhakrishnan (2006) reported 18 critically endangered and 34 endangered fishes from rivers of Kerala. Radhakrishnan (2006) reported 145 fish species from rivers of Kerala.

Menon (1997) gave an account of the rare and endangered fishes of Malabar region. The rivers of Waynad district were studied for their fish fauna by Arunachalam *et al*. (2000b). Fibin *et al.* (2010a) collected 43 freshwater fish species from Amarambalam Reserve Forest, Kerala.

There are 3 National Parks and 12 Sanctuaries in Kerala covering 2,328 sq km. Of the 15 protected areas of Kerala, the fish fauna of many of them are studied. They are Periyar Tiger reserve (Chacko, 1948; Indra and Remadevi, 1990; Zacharias *et al.*, 1996; Arun *et al.,* 1996; Radhakrishnan and Kurup, 2010), Silent valley national park (Remadevi and Indra, 1986), Kerala part of Nilgiri Biosphere Reserve (Easha and Basha, 1995), Aralam Wildlife Sanctuary (Shaji *et al.,* 1995), Chinnar Wildlife Sanctuary (Easa and Shaji 1996), Parambikulum WLS (Biju *et al.,* 1999), Eravikulam WLS (Raju Thomas *et al.,* 1999), Idukki and Neyyar WLS (Raju Thomas *et al.*, 2000b) and Chimmony and Peechi- Vazhani WLS (Raju Thomas *et al*., 2000a). Bjiu *et al.* (2004) reported 38 species from Aralam Wildlife Sanctuary, 34 from Wayanad Wildlife Sanctuary and 19 from Silent Valley National Park. Robin *et al.* (2011) reported 103 freshwater fish species from Ashambu Hill ranges of Southern Western Ghats.

A number of fish species were added during the past 10 years to the fish diversity of the Kerala as new records. More than 15 number of fish species are newly reported from Kerala part of Western Ghats region. *Horalabiosa arunachalammi,* a new fish species reported from Santhampara region of Periyar River by Johnson and Soranam (2001). *Monopterus digressus* (Gopi, 2002), which is the fourth Synbranchid species under genus from Kerala. Shaji and Easa (2002) reported *Mesonoemacheilus remadevi* a new loach species from Silent valley area of Bharathapuzha River. Arunachalam *et al.* (2002) described a new fish species from Panniyar stream of Periyar River (*Homaloptera santhamparaiensis*). *Nemacheilus periyarensis* was discovered from Thannikudy region of Periyar river (Kurup and Radhakrishnan, 2005). *Salarias reticulatus*

(*Entomacrodus vermiculatus*) was reported from Chalakudy river of Kerala (Kurup *et al.,* 2005). *Puntius pookodensis* reported from Pookode lake of Wayand district (Mercy and Eapen, 2007). *Puntius muvattupuzhaensis* was reported from Periyar and Muvatupuzha river of Kerala (Beevi and Ramachandran, 2005). Gopi (2010) discovered a new species under the family *Glyptothorax* from Valapattanam river (*Glyptothorax malabarensis*). *Homaloptera silasi, Garra emarginata* and *G. mlapparaensis* were the new fish species discovered from Periyar river of Kerala (Kurup and Radhakrishnan, 2010 a, b). *Tor remadevi* was discovered from Pambar river of Kerala (Kurup and Radhakrishnan, 2010 c). Radhakrishnan *et al.* (2010) described a new species, *Pseudolaguvia austrina* from Kunthi River, a tributary of Bharathapuzha River. *Pristolepis rubripinnis* a new fish species was discovered from Pamba and Chalakudy rivers (Ralf *et al.,* 2012 a). *Dario urops* was discovered from a tributary of Valapattanam river in Wayanad district (Ralf *et al.,* 2012 b). *Puntius madhusoodani* a new fish species from Manimala river under the group *Puntius* discovered by Krishnakumar *et al.* (2012).

In spite of conducting a great deal of work on the ichthyology of freshwater fishes of Kerala, it appears that no comprehensive work has so far been done to bring out holistic account of the systematics of freshwater fishes of Kerala (Zacharias *et al.,* 1996). Development of database on freshwater fish germplasm resources is very essential for biodiversity conservation. Kerala have a rich and varied freshwater diversity, however most of the studies were carried out either fragmental basis or regional basis. No attempts have been made yet to generate a proper inventory on germplasm diversity of freshwater fishes of Kerala rivers. Available literatures are confined to some major river systems and the biodiversity protected areas such us as Biosphere Reserves, National parks and Sanctuaries. Most of the studies are mainly confined to the taxonomy of fish, assemblage structure and fish germplasm diversity of some of the common rivers of Kerala. In Kerala there is no publication available which deal with the river wise fish germplasam. More over, though a number of new species have been discovered together with so many new records and extension ranges of fishes to Kerala. No concerted attempt was made to prepare a holistic account on the freshwater fishes of Kerala by incorporating the recent addition of new species and new distributional records, even in the most recent publications of freshwater fishes of the country (Talwar and Jhingran, 1991; Jayaram, 1981, 1999, 2009). Biodiversity status of the fish species based on IUCN 2011 criteria is a not yet assessed river wise. The endemism of river wise fresh water fishes of Kerala is also not properly evaluated which is very essential for the preservation of the unique fish germplasm resources. Hitherto, no effort was made to make comparison of different river systems based on the nature and level of species diversity and prioritise rivers having high biodiversity with great degree of endemism. Against this background, the present study was undertaken with the following objectives.

1) To build-up an authentic database on freshwater fish fauna of Kerala rivers.
2) To generate a river wise inventory of germplasm of freshwater fishes of Kerala.
3) To evaluate the biodiversity status of freshwater fishes following the recent IUCN criteria and delineate the degree of endemism of fishes inhabiting the rivers of Kerala.

2.2. Materials & Methods

The river wise fish species inventory of Kerala rivers was prepared by screening the available literature during the past 20 years. Besides these results, the research conducted as part of Kerala State Council for Science & Technology (KSCSTE) sponsored project "*Development of a database on fish germplasm, capture fisheries and biodiversity threats of rivers of Kerala*" carried out during January 2007- March 2010 at School of Industrial fisheries, Cochin University of Science & Technology was utilized for revalidation. Around hundreds of research papers and more than twenty thesis on the freshwater fish fauna of Kerala published during 1992-2012 were also consulted for accomplishing the mission. The fish diversity was also estimated based on the data generated from major fish landing centres of eight rivers of Kerala from where regular systematic surveys and sampling were conducted during pre-monsoon, monsoon and post-monsoon seasons during 2007-2010.

Data was collected on fish species diversity, fish germplasm resources and their biodiversity status. The endemic nature of the fishes was studied following Gopalakrishnan and Ponniah (2000), Gopi, (2000), Shaji and Easa, (2000) and Dahanukar and Raghavan (2013). Fishes were classified in to ornamental, cultivable and food fishes based on their colouaration, maximum size attained, growth rate, compatibility under aquarium and culture conditions and also based on secondary information (Gopalakrishnan and Ponniah, 2000; Kowtal, 1994; Sreenivasan, 1995, 1996; Chakraborty, 1996; Shaji and Easa, 2000). The river systems were compared against a set of parameters such as number of fish species reported from the river system, number of ornamental, cultivable and food fishes recorded, number of critically endangered, endangered and vulnerable fishes recorded during the study period, number of fishes which are endemic to the particular river system and also endemic to Kerala. Certain points were given to each of these items based on their importance as Total number of species (TS) =1., Total ornamental fishes (TOR)=1., Total food fishes (TF)=0.5., Total cultivable fishes (TC) = 1., Critically endangered fishes (CR)=5., Endangered fishes (EN)=3.,Vulneralbe fishes (VU) = 2., Near Threatened fishes (NT) = 1., Endemic fishes of Kerala (ENK)=10., Endemic fishes of a particular river system (ENR)=20 and the aggregate of these points for a particular river system is represented as a River index (RI). Based on these results the river systems were compared for their diversity and decisions were made whether a particular river system can be considered as a hot spot of diversity. The diversity was correlated with the total length and total catchment area of the river systems to find out the variation if any, in species richness with changes in these geometrical parameters of the river system.

There are several methods of determining species status and the most commonly used tool is the IUCN Red List Categories and Criteria (IUCN, 2011), which allows consistency in approach across different taxonomic groups.

2.2.1 IUCN Red list categorization

It helps in determining the relative risk of extinction and provides the basis for understanding if a species is Extinct, Threatened (Critically Endangered or Endangered or Vulnerable), Near Threatened, Least Concern or lacking sufficient basic data for assessment (Data Deficient).

EXTINCT (EX) - A taxon is Extinct when there is no reasonable doubt that the last individual has died.

EXINCT IN THE WILD (EW)- A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the wild when exhaustive surveys in known and/or expected habitat at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual.

CRITICALLY ENDANGERED (CR)- A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future as defined by the criteria.

ENDANGERED (EN)-A taxon is Endangered when it is not critically endangered but is is very high risk of extinction in the wild in near future as defined by the criteria.

VULNERABLE (VU) - A taxon is Vulnerable when it is not Critically endangered or Endangered but is facing a high rate of extinction in the wild in the medium term future as defined by criteria.

NEAR THREATENED (NT) - A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

LEAST CONCERN (LC) - A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

DATA DEFICIENT (DD) - A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.

NOT EVALUATED (NE) - A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

All taxa assessed as Critically Endangered, Endangered or Vulnerable are described as “threatened”.

2.3. Results

2.3.1. Inventory of freshwater fishes of Kerala

Fish germplasm resources

A total of 234 fresh water fish species belonging to 16 orders, 51 families and 104 genera were reported from 40 rivers of Kerala based on screening of the literature and present study. The list of fishes reported from various river systems, their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.1.

Among the orders, Cypriniformes was the largest in the numerical strength with 129 species followed by Perciformes with 42 species. Order Siluriformes dominated with 32 species, while Cyprinodontiformes was represented by 6 species and Beloniformes with 5 species. The numerical strength of different fish families reported from Kerala rivers is depicted in Fig.2.1. Family Cyprinidae was the largest family accommodating 26 genera and 98 species while the genus *Puntius* of this family ranked first among the genera in its numerical strength with 25 species. Loaches belong to the family Balitoridae ranked next to Cyprinidae with 9 genera and 26 species while genus *Nemacheilus* was represented by 12 species. Family Bagridae is having 14 species and genus *Mystus* of this family accommodated 9 species. Family Sisoridae is having only one genus, *Glyptothorax* represented by 7 species. Family Ambasside of the order Perciformes was having 8 species while family Channidae of same order consisted of 6 species. Aplocheilidae and Poecilidae of order Cyprinidontiformes consisted of 3 members each. 28 families were having single member each.

Periyar river harboured the highest number of freshwater fishes of 139 species, followed by Chalakudy (128), Bharathapuzha (120), Kabbini (90) and Achenkovil (86). Nine species were uniformly distributed in all the fourty rivers studied; *Rasbora daniconius* (in 40 rivers); *Puntius filamentosus, Devario malabaricus* and *Etroplus maculatus* (in 38 rivers); *Puntius vittatus, Puntius ticto, Devario aequipinnatus, Garra mullya* and *Aplocheilus lineatus* (in 37 rivers).

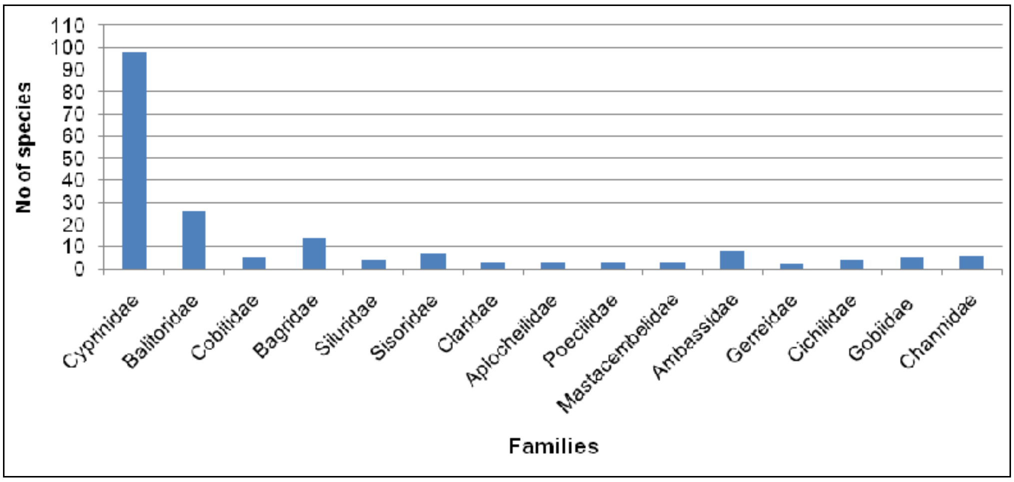


Fig.2.1. Numerical strength of major fish families reported from the river systems of Kerala

Biodiversity status

Biodiversity status of the freshwater fishes of Kerala were assessed as per IUCN criteria (2011). Among 234 species, 59 species were belonged to threatened and 131 were under non-threatened category. 9 species were categorized under data deficient (DD) group while 35 species were under non evaluated category (NE) (Fig.2.2).

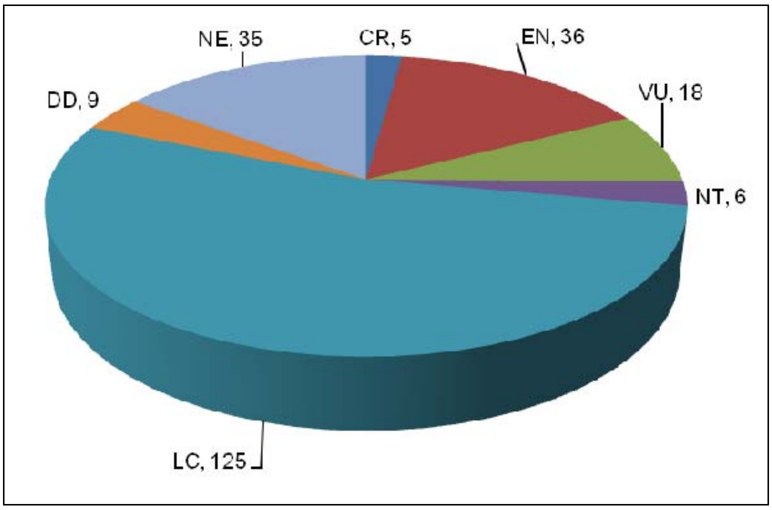


Fig.2.2. Biodiversity status of freshwater fishes in Kerala rivers

Among the threatened fish group, 5 species are critically endangered (CR), 36 species are endangered (EN) (Table.2.3) while 18 species under vulnerable (VU) category. Species such us *Hypselobarbus thomassi*, *Barbodes bovanicus, Barbodes wynaadensis, Horalabiosa arunachalami* and *Hemibagrus punctatus* were listed us critically endangered group (CR) (Table 2.2).

Endemism

While assessing the endemic nature of the fishes reported, it was found that 94 species were characterized by their distribution in the Western Ghats of Peninsular India (EN-WG), among them 36 were strictly endemic to Kerala waters (EN-K).16 species were found endemic to India (EN-I) and 32 species were endemic to Indian Subcontinent (EN-IS), whereas 10 species are Introduced (Intr.) or exotic in their status (Fig.2.2).

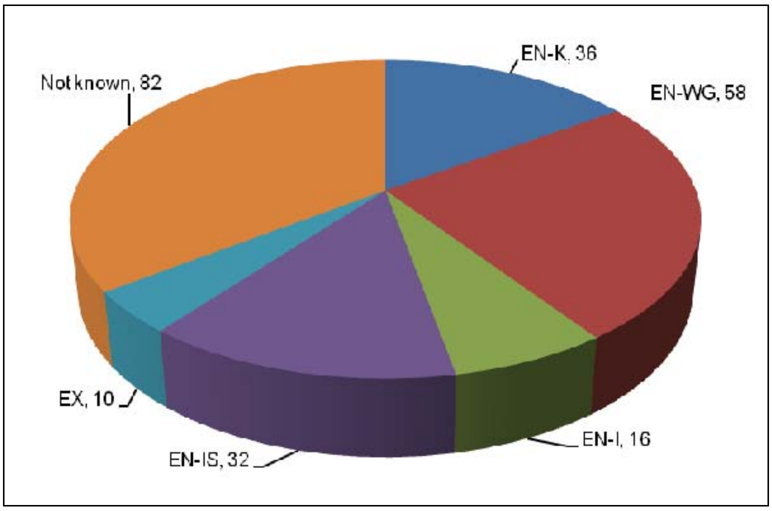


Fig.2.3. Degree of endemism of freshwater fishes in Kerala rivers

Cyprinus carpio, Ctenopharyngodon idella, Clarias gariepinus, Poecilia reticulata, Gambusia affinis, Xiphophorus maculatus, Oreochromis mossambicus, Oreochromis niloticus, Osphronemus goramy and *Oncorhynchus mykiss* were the introduced species reported from Kerala rivers (Table 2.4).

2.3.2. River wise fish germplasm inventory

2.3.2.1. Achenkovil river system

Fish germplasm resources

The fish germplasm comprised of 86 species of fishes belonging to 10 orders, 26 families and 49 genera were reported from Achenkovil river system. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.5. Among the orders, Cypriniformes and Perciformes ranked first and second with 34 and 19 species respectively while families Cyprinidae and Bagridae were found richest in accommodating maximum number of species with 34 and 10 species respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 11 species followed by *Mystus* (7 species). The numerical strength of different fish families reported from Achenkovil river is depicted in Fig.2.4.

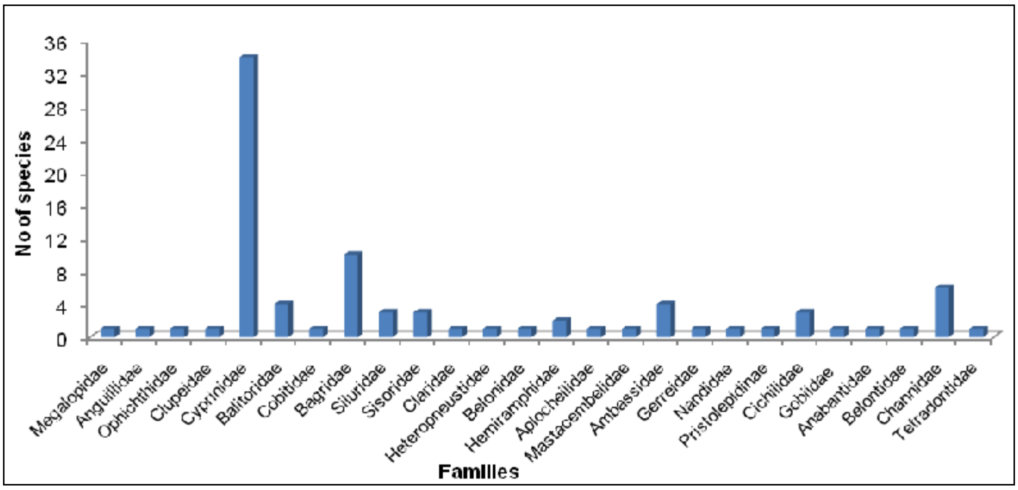


Fig.2.4. Numerical strength of various fish families reported from Achenkovil river system

Biodiversity status

17 species belonged to threatened category where 64 species were under non-threatened category. Among the threatened fish species, 9 were endangered (EN) and 8 species belongs to vulnerable (VU) category. 3 species

were categorized under data deficient (DD) group while 2 species were treated as non-evaluated category (NE) (Fig.2.5).

Endemism

31 species were found to be endemic to Western Ghats (EN-WG), among them 7 species were endemic to Kerala region (EN-K). 6 species were found endemic to India (EN-I) and 15 species were endemic to Indian Subcontinent (EN-IS) (Fig.2.6). *Cyprinus carpio* and *Oreochromis mossambicus* were the exotic species recorded from this river.

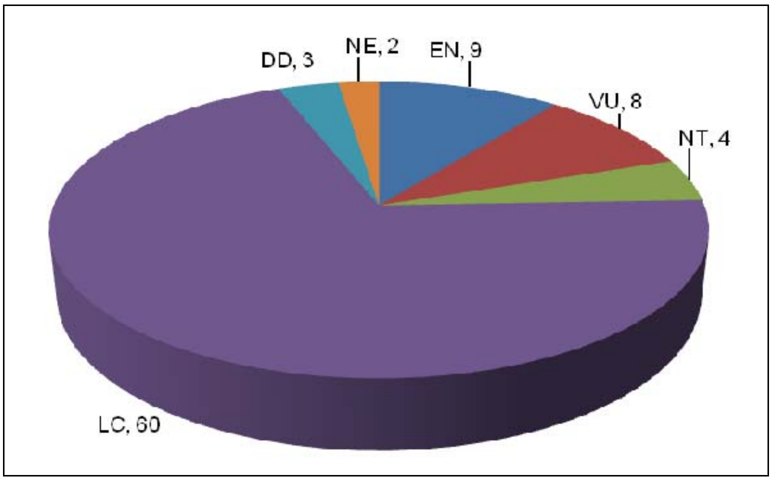


Fig.2.5. Biodiversity status of fishes in Achenkovil river system

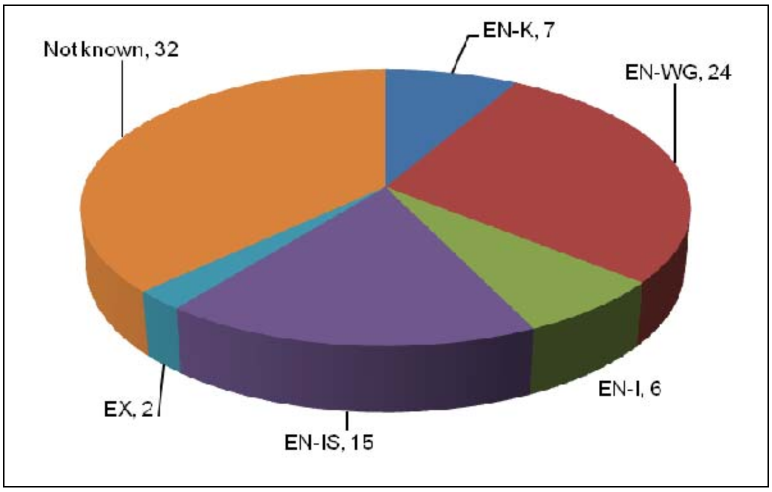


Fig.2.6. Endemic nature of fishes in Achenkovil river system

2.3.2.2. Anjarakandy

Fish germplasm resources

29 species of fishes belonging to 23 genera, 16 families and 8 orders were reported from Anjarakandy river system. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.6. Cypriniformes was the dominant group among orders with 12 species followed by Perciformes with 7 species. The numerical strength of different families of fishes reported from Anjarakandy river is given in Fig.2.7. Cyprinidae was the most dominant family contributing 11 species and 7 genera. Bagridae were found as second dominant family with 3 species. Genus *Puntius* showed the richest germplasm with a numerical strength of 5 species followed by *Mystus* (3 species).

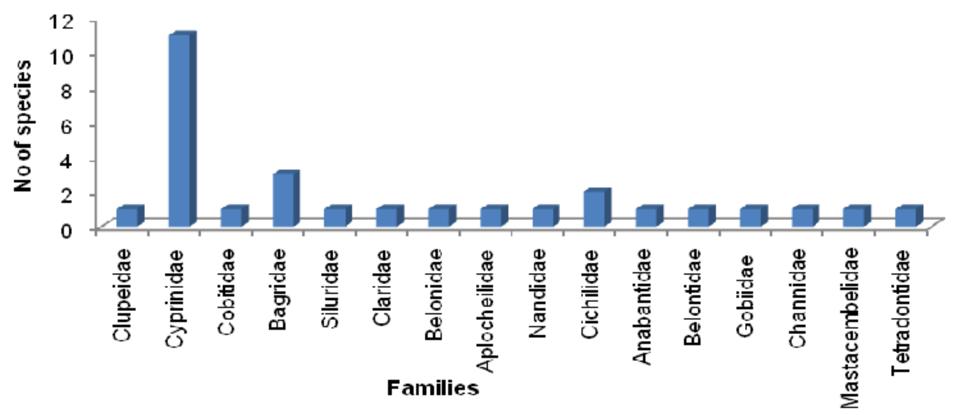


Fig. 2.7. Numerical strength of various fish families reported from Anjarakandy river system

Biodiversity status

Among the threatened fish species, one species (*Carinotetradon travancoricus*) was found under vulnerable (VU) category. 26 species were under non-threatened category. 2 species (*Puntius amphibius* and *Anabas testudineus*) were categorized under data deficient (DD) group (Fig.2.8).

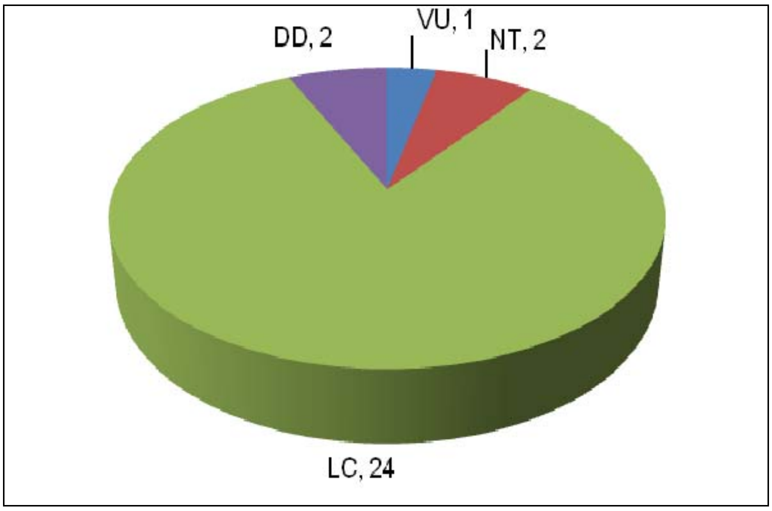


Fig.2.8. Biodiversity status of fishes in Anjarakandy river system

Endemism

Of the 29 species reported, 5 species were endemic to the Western Ghats hotspot (EN-WG), with one species (*Dayella malabarica*) strictly endemic to the Kerala region. 3 species each were endemic to India (EN-I) and Indian Subcontinent (EN-IS) (Fig.2.9). *Oreochromis mossambicus* was the exotic species encountered from this river.

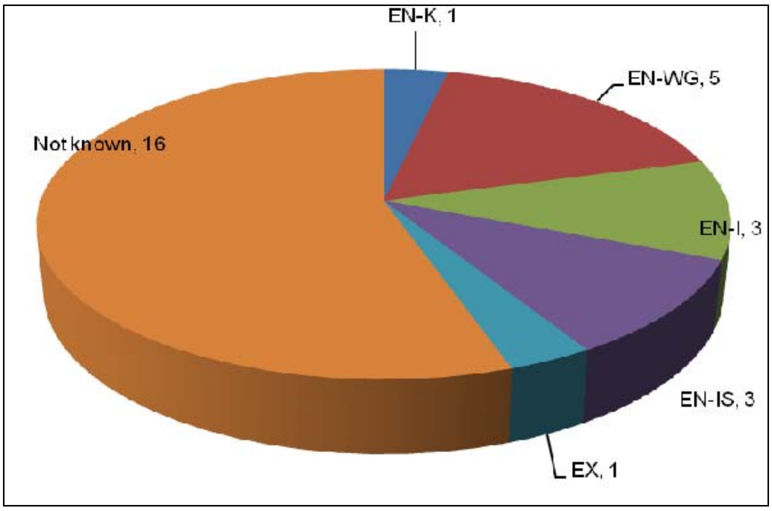


Fig.2.9. Endemic nature of fishes in Anjarakandy river system

2.3.2.3. Ayoor

Fish germplasm resources

A total of 19 species represented by 5 orders, 8 families and 14 genera were reported from Ayoor river system. The list of fishes reported from this river system together with their commercial name, biodiversity status based on recent IUCN criteria and the endemic nature of the fishes are shown in Table 2.7. Cypriniformes was the dominant order represented by 11 species followed by Perciformes (4 species). The family Cyprinidae dominated with a numerical strength of 11 species followed by Mastacembelidae with 2 species. The numerical strength of different families of fishes reported from Ayoor river is depicted in Fig.2.10.

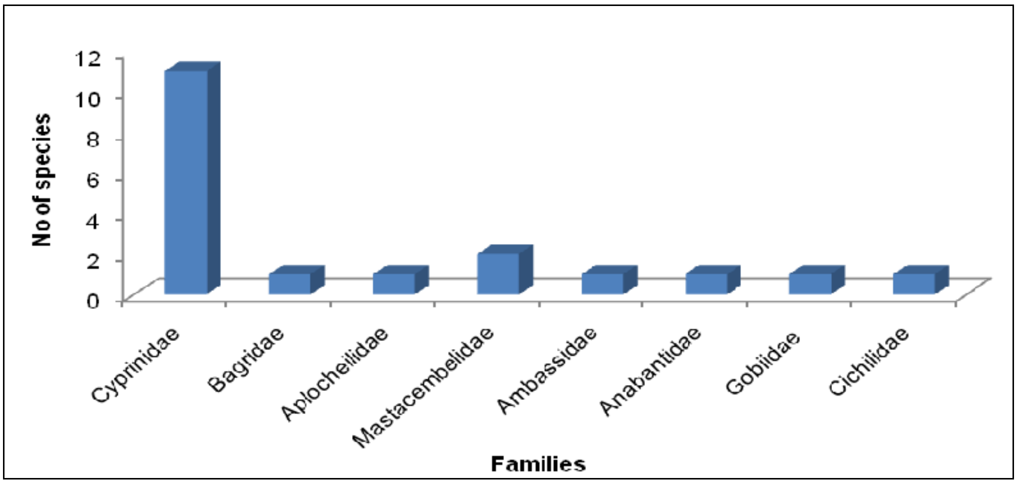


Fig.2.10. Numerical strength of various fish families reported from Ayoor river system

Biodiversity status

All fish species reported from this river system belong to the non-threatened category. 2 species were categorized under data deficient (DD) group (Fig.2.11).

Endemism

4 species were endemic to the Western Ghats (EN-WG). Among them *Macrognathus guentheri* was found endemic to Kerala state (EN-K). Four

species were endemic to the Indian region (EN-I) while 3 were endemic to Indian Subcontinent (EN-IS). No exotic fish species reported from this river system (Fig.2.12).

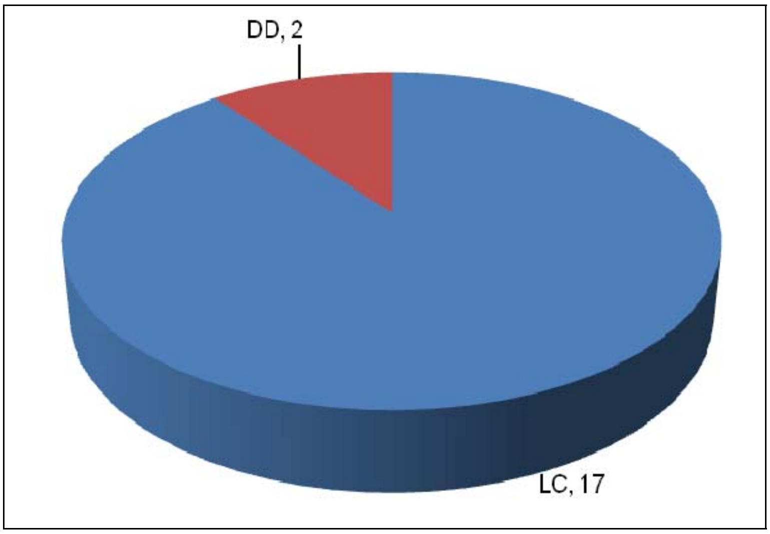


Fig.2.11. Biodiversity status of fishes in Ayoor river system

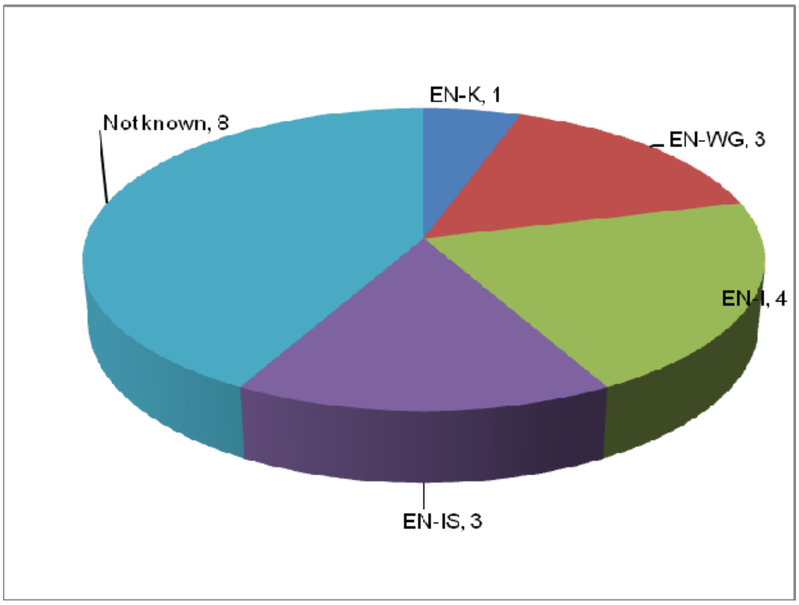


Fig.2.12. Endemic nature of fishes in Ayoor river system

2.3.2.4. Bharathapuzha

Fish germplasm resources

120 fish species belonging to 40 families and 73 genera were reported from Bharathapuzha river system. The list of fishes reported from this river system including their commercial name, biodiversity status based on IUCN criteria and nature of endemism are given in Table 2.8. Cypriniformes was the most predominant order, contributing 47 % of fish species, followed by Perciformes with 21%. Cyprinids were the most dominant group represented by 47 species belonging to 20 genera, followed by the catfishes of the family Bagridae (10 species from 4 genera) and loaches of the family Balitoridae (9 species from 5 genera). The numerical strength of different fish families reported from Bharathapuzha river is depicted in Fig.2.13. Genus *Puntius* showed the richest germplasm with a numerical strength of 14 species.

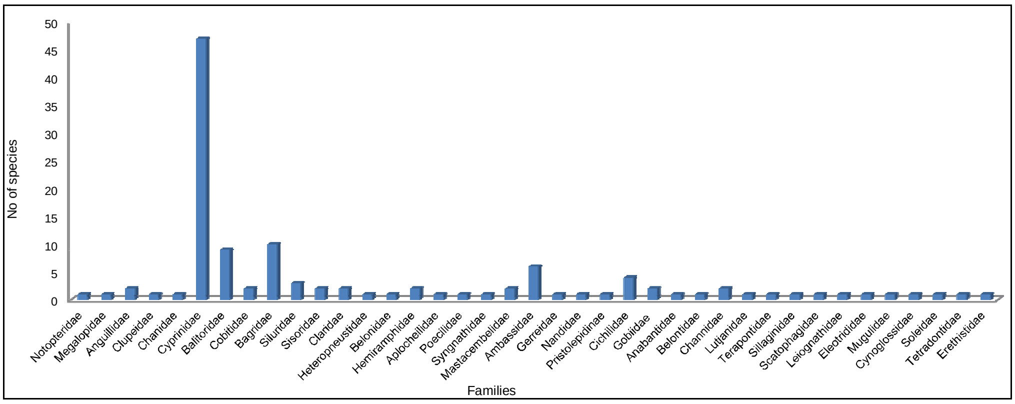


Fig.2.13. Numerical strength of various fish families reported from Bharathapuzha river system

Biodiversity status

The biodiversity status of the fishes showed that 20 species were threatened and 87 species were non-threatened category. Among the threatened fish species, 2 species were evaluated as critically endangered (*Barbodes bovanicus* and *Hemibagrus punctatus*), 10 species belonged to endangered (EN) and 8 species were vulnerable (VU). Data on 4 species were insufficient to place them under any threat category (DD) group, while 9 species were in non-evaluated category (NE) (Fig.2.14).

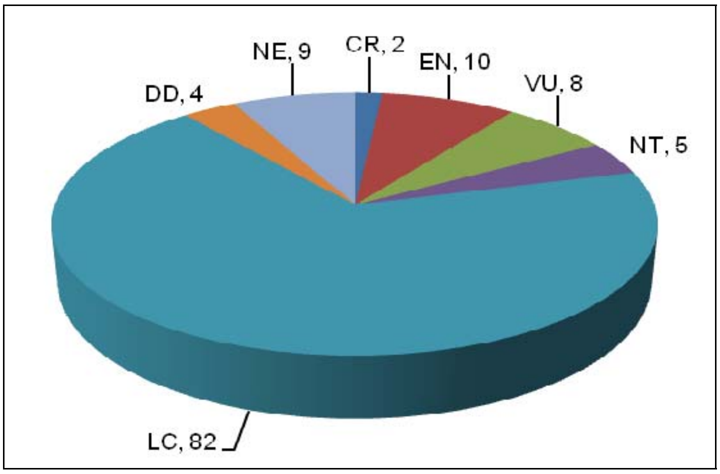


Fig.2.14. Biodiversity status of fishes in Bharathapuzha river system

Endemism

Of the 120 species, 44 were endemic to the Western Ghats (EN-WG), among them 11 species were strictly endemic to Kerala region (EN-K). 11 species were having a geographical distribution restricted to Indian waters (EN-I) where as 19 species were restricted to the Indian Subcontinent (EN-IS) (Fig.2.15). Three exotic species, viz, *Poecilia reticulata, Oreochromis mossambicus* and *O. niloticus* were also recorded.

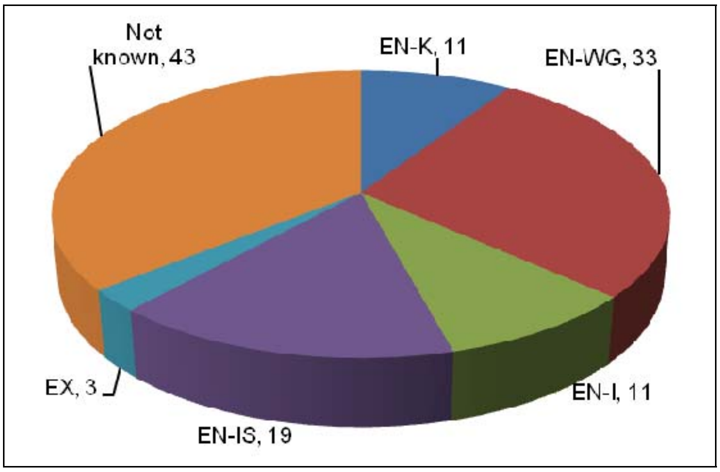


Fig.2.15. Endemic nature of fishes in Bharathapuzha river system

2.3.2.5. Bhavani

Fish germplasm resources

A total of 46 fish species belonging to 13 families and 27 genera were reported from Bhavani river system. The list of fishes along with their commercial name, biodiversity status based on IUCN criteria and the nature of endemism are shown in Table 2.9. Cypriniformes was the most dominant order representing 34 species, followed by Siluriformes (6 species). The family Cyprinidae representing the highest number of species with 25 members followed by Balitoridae with 8 species; Bagridae and Siluridae with 2 species each. All other families were represented by only a single species each. The numerical strength of different families of fishes reported from Bhavani river is depicted in Fig.2.16. Genus *Puntius* showed the richest germplasm with 7 species followed by *Nemacheilus* (5 species).

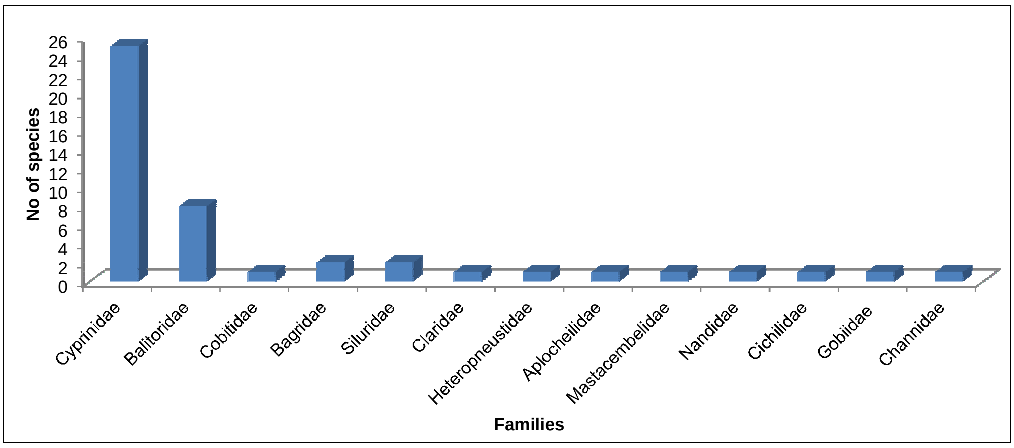


Fig.2.16. Numerical strength of various fish families reported from Bhavani river system

Biodiversity status

7 species found in Bhavani river were listed as threatened where as 39 species under non-threatened category. *Hypselobarbus dubius, Puntius arulius, Tor khudree, Barilius canarensis* and *Labeo potail* were listed as endangered (EN) while *Garra menoni* and *Balitora mysorensis* were vulnerable (VU) in their threat status (Fig.2.17).

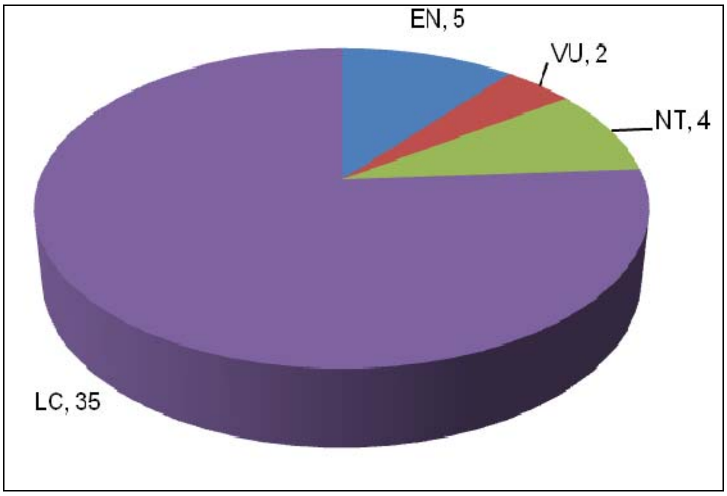


Fig.2.17. Biodiversity status of fishes in Bhavani river system

Endemism

19 species were endemic to the Western Ghats (EN-WG) of which 2 species; *Garra menoni* and *Homaloptera menoni* were strictly endemic to the Kerala region (EN-K). 6 species each were endemic to the Indian region (EN-I) and Indian Subcontinent (EN-IS) (Fig.2.18). *Oreochromis mossambicus* was the exotic fish recorded from this river system.

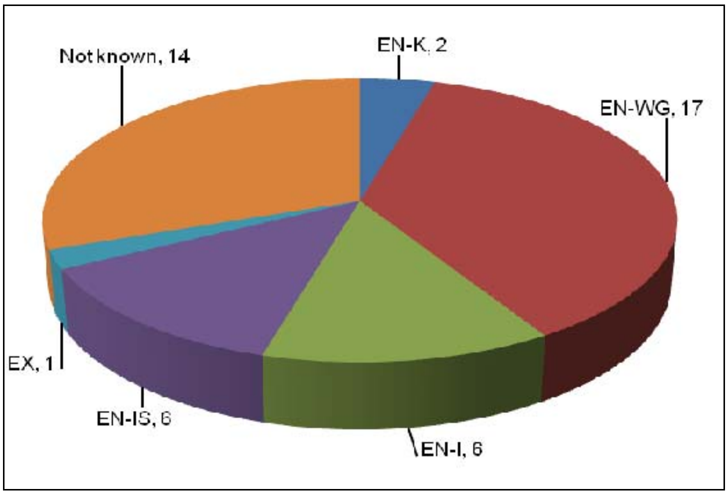


Fig.2.18. Endemic nature of fishes in Bhavani river system

2.3.2.6. Chalakudy river

Fish germplasm resources

128 species of fishes belonging to 14 orders, 43 families and 75 genera were reported from Chalakudy river system. The list of fishes recorded from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.10. Order Cypriniformes (54 species) was the most dominant group followed by Perciformes (29 species). The Cyprinidae with 46 species and 19 genera was the major dominant family followed by Bagridae (11 species of 3 genera). The numerical strength of different families of fishes reported from Chalakudy river is shown in Fig.2.19. Genus *Puntius* was having a numerical strength of 16 species followed by *Mystus* (8 species).

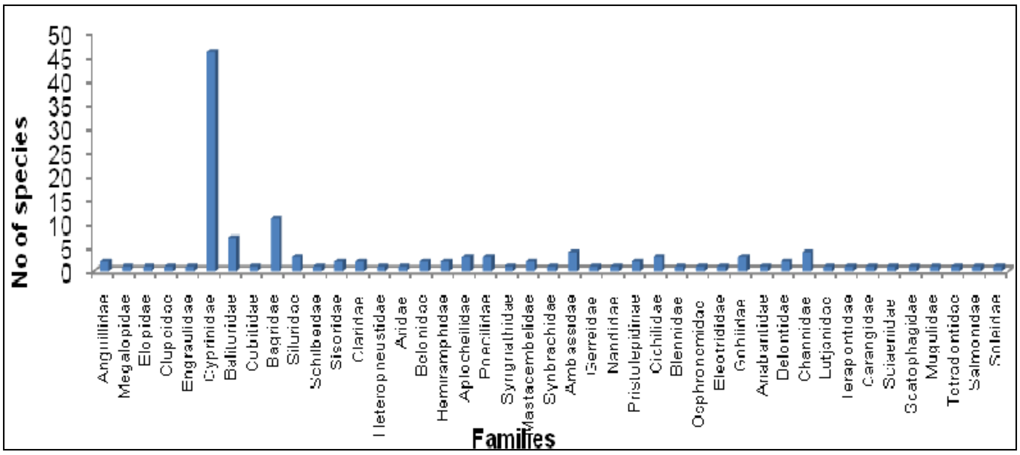


Fig.2.19. Numerical strength of various fish families reported from Chalakudy river system

Biodiversity status

22 species of fishes (17%) reported in Chalakudy river were listed as threatened. *Hypselobarbus thomassi* has been listed as critically endangered (EN) while 13 species as endangered (EN) and 8 species vulnerable (VU) in their threat status. 88 species were non-threatened, 4 species were Data deficient (DD) while 14 species were listed as non-evaluated (NE) category (Fig.2.20).

Endemism

Of the 128 fish species reported, 42 species were found to be confined to the water bodies of Western Ghats (EN-WG), among them 13 were endemic to Kerala rivers (EN-K). 8 species were endemic to the Indian region (EN-I) while 22 were endemic to Indian Subcontinent (EN-IS) (Fig.2.21). Seven exotic species, viz, *Cyprinus carpio*, *Poecilia reticulata*, *Gambusia affinis*, *Osphronemus goramy*, *Xiphophorus maculatus*, *Oreochromis mossambicus* and *Oncorhynchus mykiss* were reported from this river system.

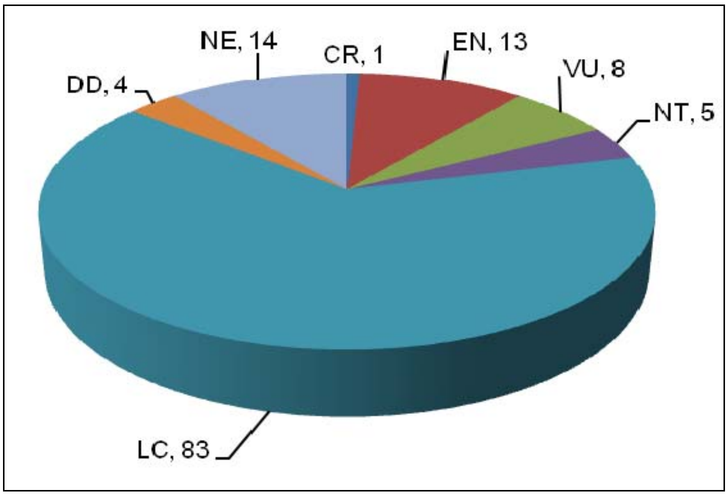


Fig.2.20. Biodiversity status of fishes in Chalakudy river system

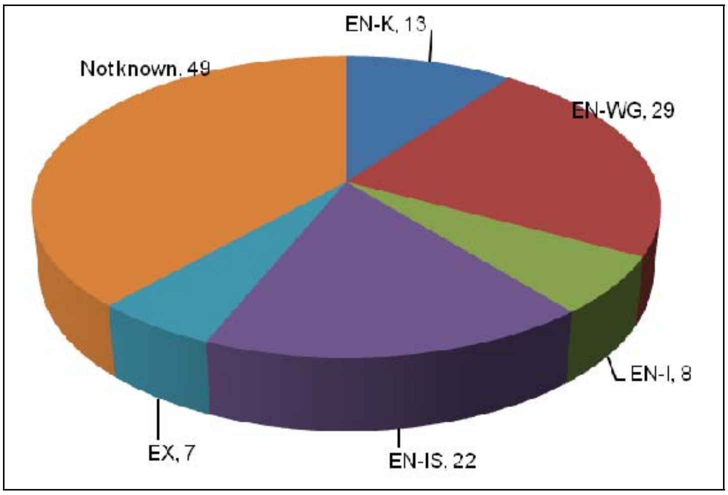


Fig.2.21. Endemic nature of fishes in Chalakudy river system

2.3.2.7. Chaliyar river

Fish germplasm resources

A total of 83 species representing 51 genera and 25 families were reported from Chaliyar river system. Cypriniformes was found to be the most dominant group (42 species) followed by Siluriformes (15 species). The list of fishes reported from this river together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.11. The family with the largest number of species is Cyprinidae with 34 followed by Bagridae (8 species). The numerical strength of different families of fishes reported from the river is shown in Fig.2.22. The predominant genus in this river was *Puntius* (11species) followed by *Mystus* (5species).

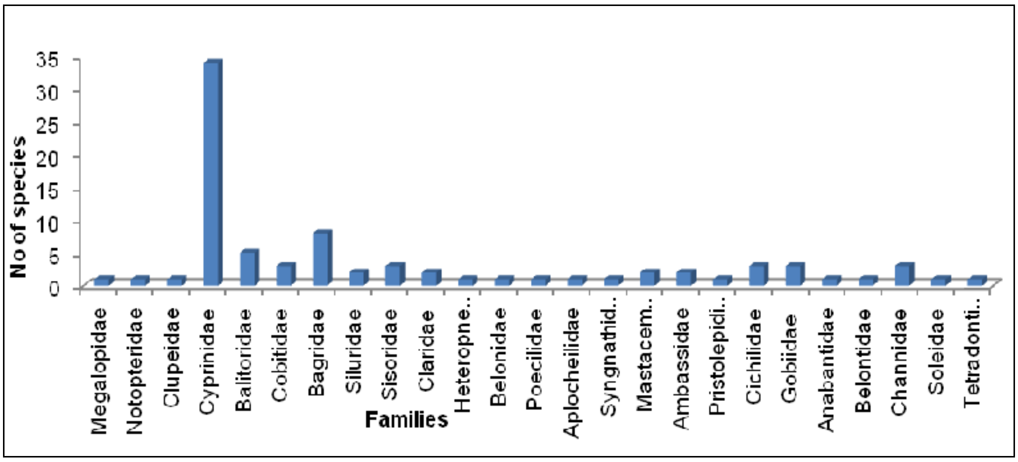


Fig.2.22. Numerical strength of various fish families reported from Chaliyar river system

Biodiversity status

Of the 83 species of fishes reported from this river, 13 species belonged to threatened category while 63 species under non-threatened category (Fig.2.23). Of the threatened fishes, 2 species, viz. *Barbodes wynaadensis* and *Hemibagrus punctatus* were critically endangered (EN), 7 species were endangered (EN) and 4 species were vulnerable (VU) in their status.

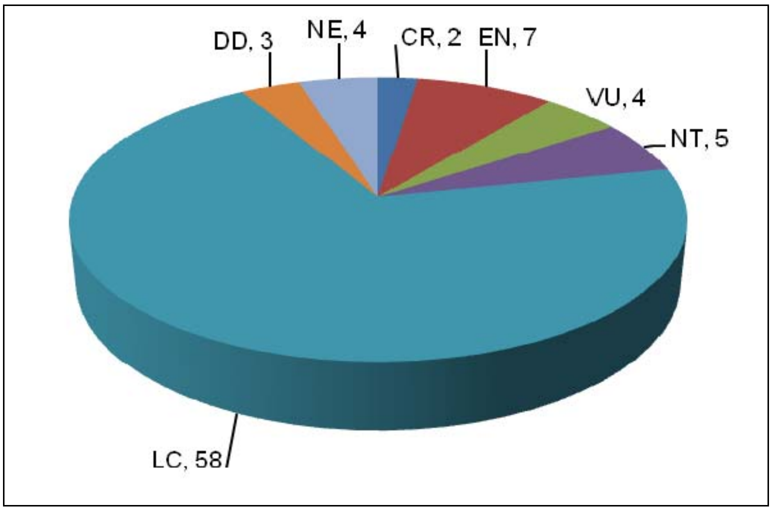


Fig.2.23. Biodiversity status of fishes in Chaliyar river system

Endemism

34 species were endemic to Western Ghats (EN-WG), among them 6 species were strictly endemic to Kerala waters (EN-K) (Fig.2.24). 4 species are having geographical distribution restricted to Indian waters (EN-I) whereas 13 species are restricted to the Indian Subcontinent (EN-IS). *Poecilia reticulata* and *Oreochromis mossambicus* were the exotic species recorded from this river system.

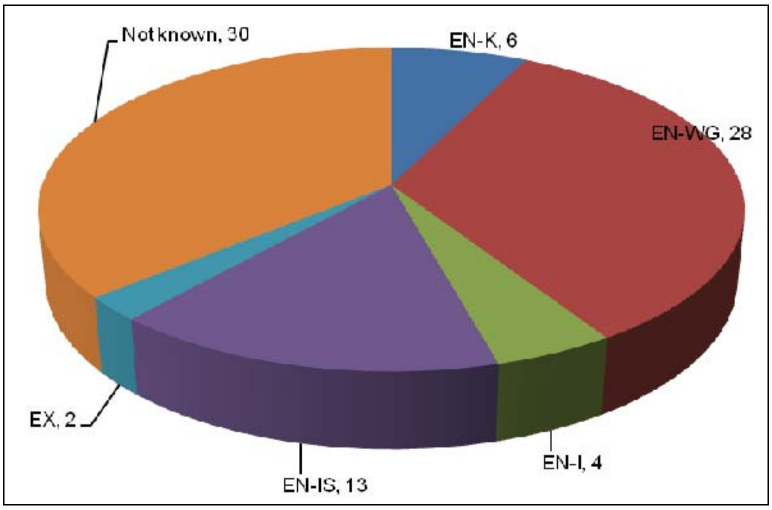


Fig.2.24. Endemic nature of fishes in Chaliyar river system

2.3.2.8. Chandragiri river

Fish germplasm resources

60 species of fishes belonging to 18 families and 36 genera were reported from Chandragiri river system. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.12. Order Cypriniformes and Siluriformes ranked first and second with 35 and 11 species respectively. Of these, family Cyprinidae showed the highest species richness (29 species) followed by Bagridae and Balitoridae (5 species each). Fishes belonging to genus *Puntius* was the dominant with a numerical strength of 13 species. The numerical strength of different families of fishes reported from the river is depicted in Fig.2.25.

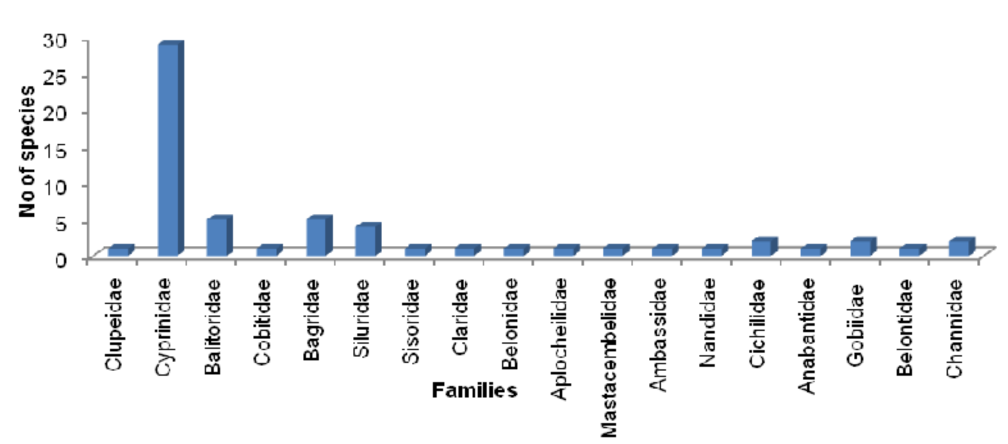


Fig.2.25. Numerical strength of various fish families reported from Chandragiri river system

Biodiversity status

6 species having the threatened status and 51 species were coming under non-threatened category (Fig.2.26). Of the total threatened fishes, viz. *Hypselobarbus curmuca*, *Puntius denisonii*, *Puntius arulius*, *Tor khudree* and *Pterocryptis wynaadensis* were belonging to endangered (EN) category, where *Batasio travancoria* belonged to vulnerable (VU) category. 2 species were categorized as data deficient (DD) group, while one species under non-evaluated category (NE).

Endemism

17 species were found endemic to Western Ghats (EN-WG) and 3 species, viz, *Dayella malabarica, Puntius denisonii* and *Osteobrama bakeri* were found strictly endemic to Kerala waters (EN-K). 6 species were having a geographical distribution restricted to Indian waters (EN-I) where as 8 species are restricted to the Indian Subcontinent (EN-IS). No exotic fishes were reported from this river system. No species was found strictly endemic to this river system (Fig.2.27).

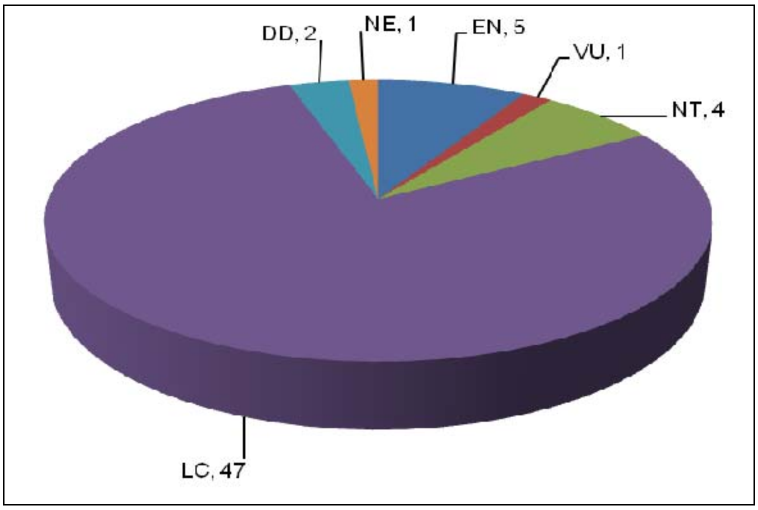


Fig.2.26. Biodiversity status of fishes in Chandragiri river system

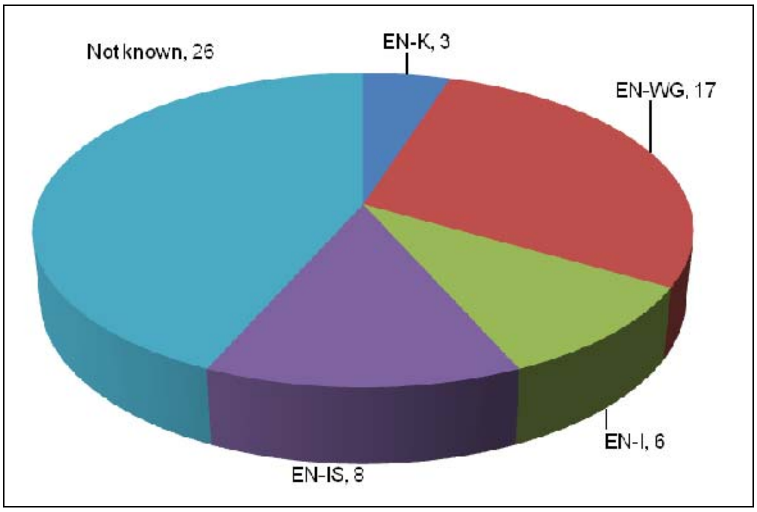


Fig.2.27. Endemic nature of fishes in Chandragiri river system

2.3.2.9. Chittari river

Fish germplasm resources

The fish gemplasm resources comprised of 24 species belonging to 6 orders, 14 families and 19 genera. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.13. The numerical strength of different families of fishes inhabiting in the river system is depicted in Fig.2.28. Family Cyprinidae was found to be richest in number of species (8 species) followed by Bagridae, Cichilidae and Siluridae (2 species each). Genus *Puntius* showed the richest germplasm with a numerical strength of 4 species.

Biodiversity status

No fish species belong to threatened category, while 19 species were non-threatened category. 2 species were categorized under data deficient (DD) group while one species under non-evaluated category (NE) (Fig. 2.29).

Endemism

4 species were demarcated as endemic to Western Ghats (EN-WG), among them, *Dayella malabarica* was strictly endemic to rivers of Kerala (EN-K) whereas six species were endemic to Indian Subcontinent (EN-IS) (Fig.2.30). No exotic fishes were reported from this river.

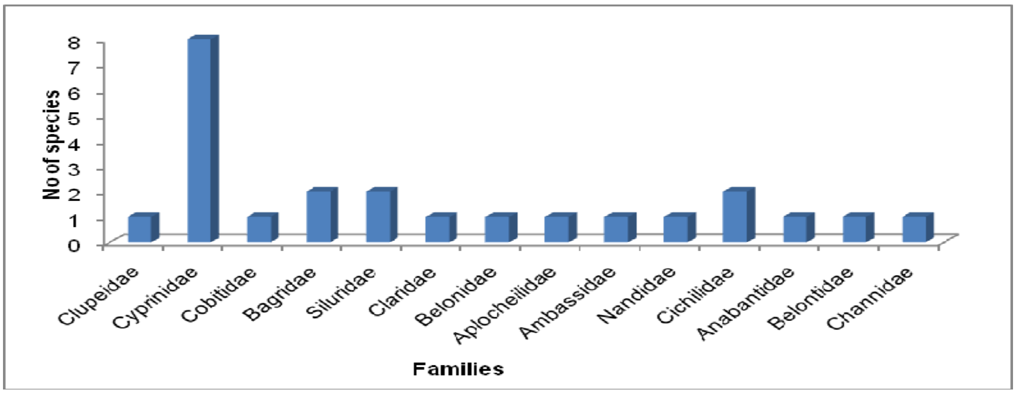


Fig.2.28. Numerical strength of various fish families reported from Chittari river system

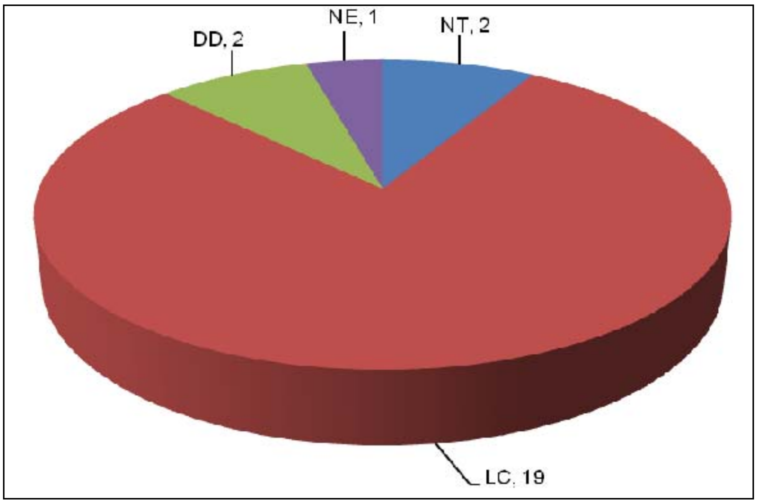


Fig.2.29. Biodiversity status of fishes in Chittari river system

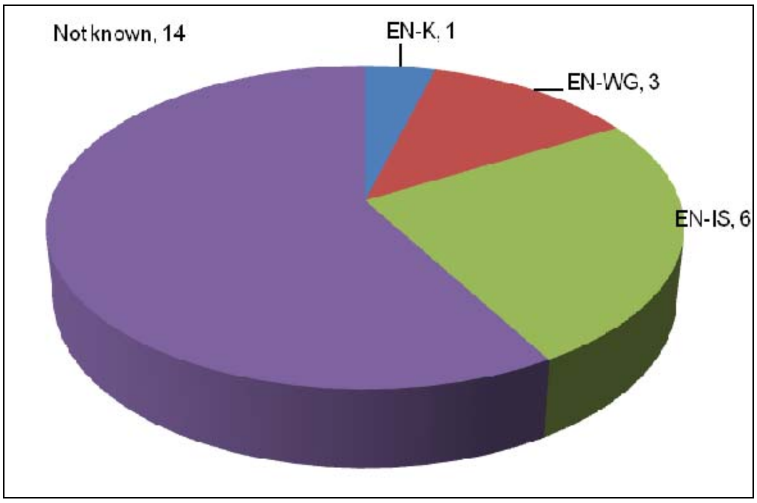


Fig.2.30. Endemic nature of fishes in Chittari river system

2.3.2.10. Ithikkara river

Fish germplasm resources

The present study revealed that 33 fish species belonging to 6 orders, 13 families and 20 genera were reported from Ithikkara river. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table.2.14. Cypriniformes and Perciformes ranked first and second with 17 and 7 species respectively. Families Cyprinidae and Bagridae were found richest in maximum number of species with 18 and 3 species respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 8 species followed by *Mystus* (3 species). The numerical strength of different families of fishes reported in Ithikkara river system is depicted in Fig.2.31.

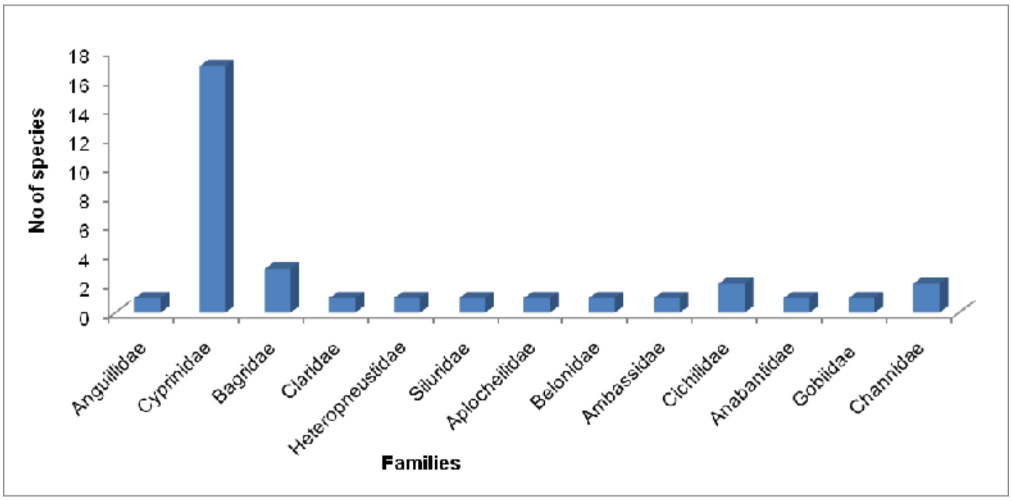


Fig.2.31. Numerical strength of various fish families reported from Ithikkara river system

Biodiversity status

One species belong to threatened and 30 species in non-threatened category. Within the threatened fishes, *Hypselobarbus curumuca* was endangered, 2 species were evaluated under data deficient (DD) group (Fig.2.32).

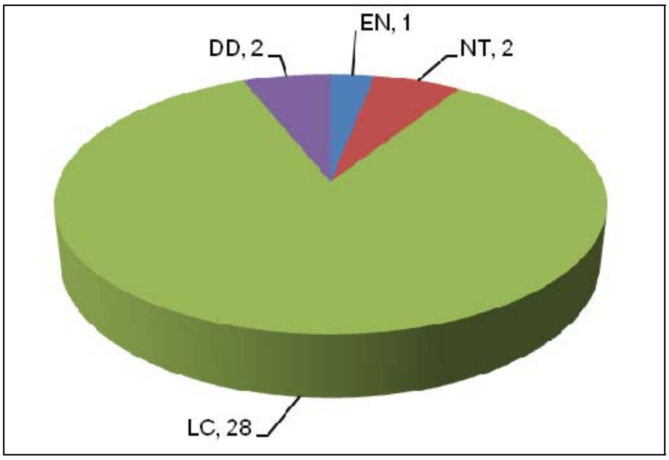


Fig.2.32. Biodiversity status of fishes in Ithikkara river system

Endemism

8 species were demarcated as endemic to Western Ghats (EN-WG), among them, *Puntius mahecola* was strictly endemic to rivers of Kerala (EN-K). 5 species were confined to Indian region (EN-I) and 6 species (EN-IS) were restricted to Indian Subcontinent (EN-IS) (Fig.2.33).

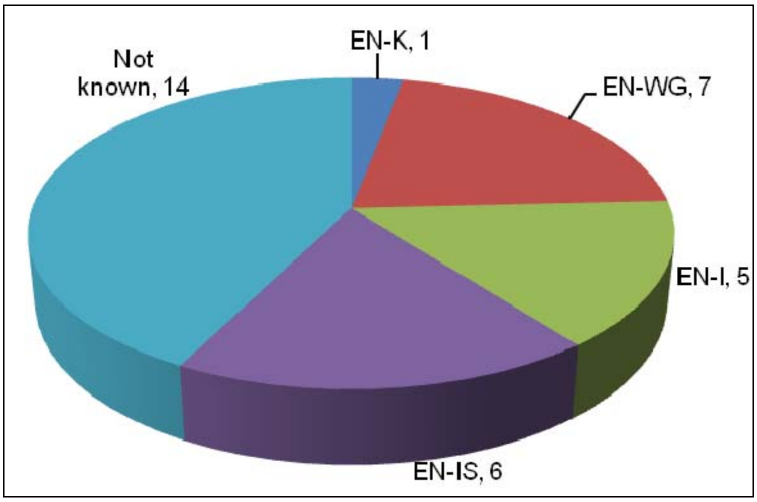


Fig.2.33. Endemic nature of fishes in Ithikkara river system

2.3.2.11. Kabbini river

Fish germplasm resources

The present study revealed that 90 species of fishes belonging to 8 orders, 20 families and 48 genera were reported from Kabbini river system. Order wise distribution showed that Cypriniformes represents 3 families, 23 genera and 54 species. Among them, family Cyprinidae represents 17 genera and 41 species and family Balitoridae represents 5 genus and 11 species. Order Siluriformes represents 5 families, 9 genera and 17 species. Family Bagridae represents 3 genera and 9 species and family Siluridae and Sisoridae represents 3 species each. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.15. Genus *Puntius* showed the richest germplasm with a numerical strength of 12 species followed by *Nemacheilus* (7 species). The numerical strength of different families recorded in the river system is depicted in Fig. 2.34.

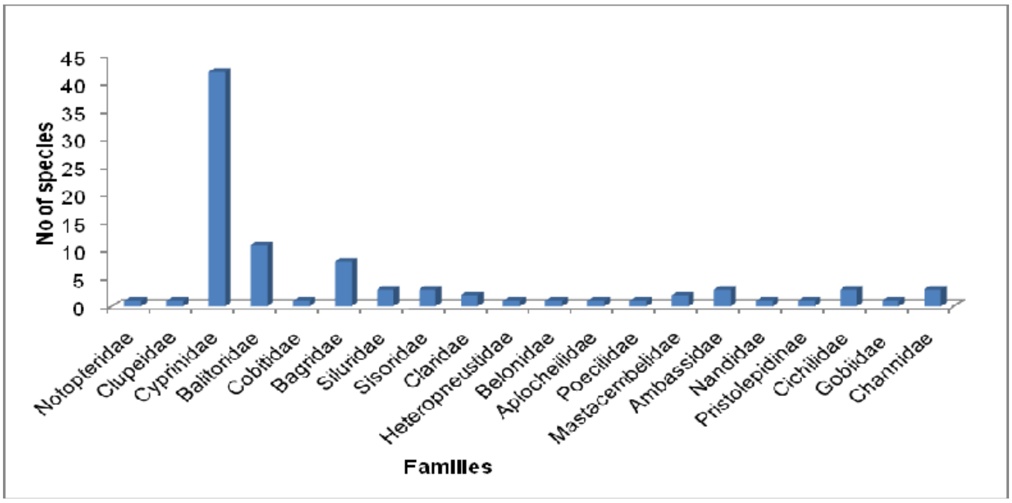


Fig.2.34. Numerical strength of various fish families reported from Kabbini river system

Biodiversity status

Within the threatened group, *Barbodes wynaadensis* and *Hemibagrus punctatus* were the critically endangered species (EN) while 11 species were endangered (EN) and 3 species were under vulnerable (VU) category (Fig. 2.35). 2 species were coming under data deficient (DD) group while 3 species were under non-evaluated category (NE).

Endemism

35 species were demarcated as endemic to Western Ghats (EN-WG), among them, *Dayella malabarica*, *Puntius mahecola* and *Macrognathus guentheri* were strictly endemic to rivers of Kerala (EN-K), where as 7 species were found endemic to Indian region (EN-I) and 16 species were endemic to Indian Subcontinent (EN-IS) (Fig.2.36). *Cyprinus carpio, Poecilia reticulata* and *Oreochromis mossambicus* were the exotic species reported.

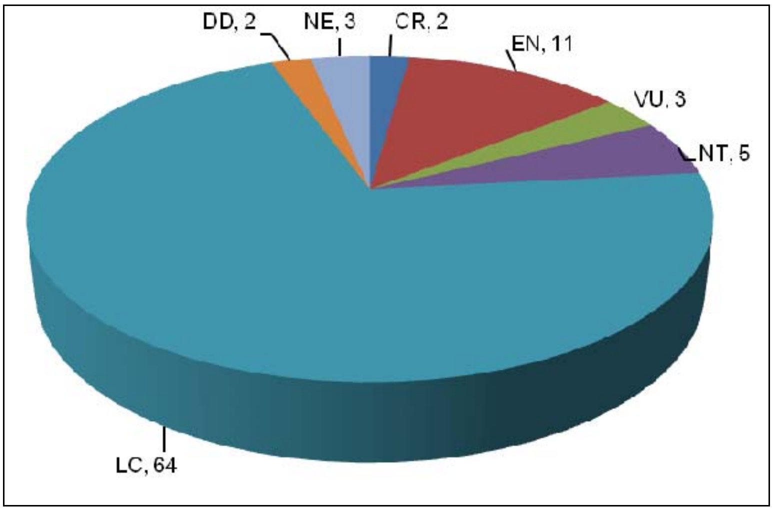


Fig.2.35. Biodiversity status of fishes in Kabbini river system

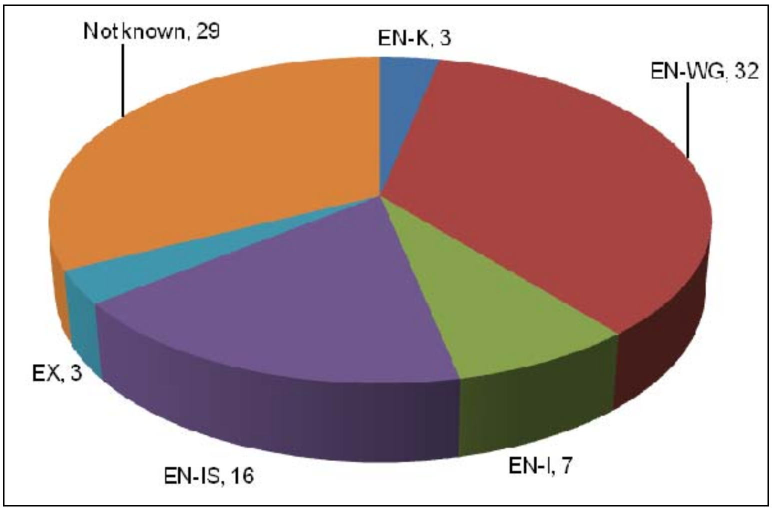


Fig.2.36. Endemic nature of fishes in Kabbini river system

2.3.2.12. Kadalundi

Fish germplasm resources

The fish germplasm resources comprised of 45 species of fishes belong to 9 orders, 21 families and 33 genera. Order Cypriniformes comprises 3 families and 20 species. Order Perciformes comprised of 8 families and 12 species. Cyprinidae was the most dominant family with 17 species followed by and Cichilidae (3 species). Genus *Puntius* showed the richest germplasm with a numerical strength of 7 species. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are showed in Table 2.16. The numerical strength of different families of fishes reported in Kadalundi river system is depicted in Fig. 2.37.

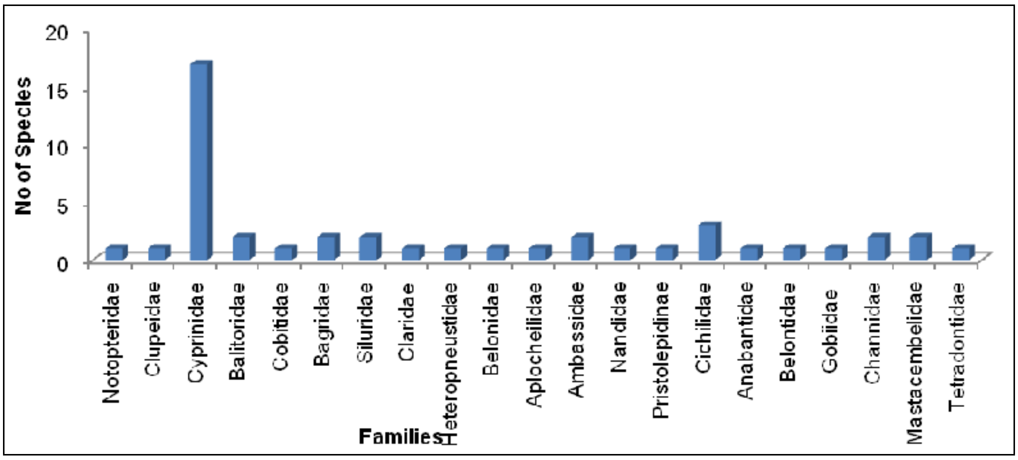


Fig.2.37. Numerical strength of various fish families reported from Kadalundi river system

Biodiversity status

The biodiversity status of the fishes assessed showed that 2 species belonging to threatened category, among them, *Hypselobarbus curmuca* was endangered (EN) and *Carinotetradon travancoricus* under vulnerable (VU) category. 2 species were under data deficient (DD) group (Fig.2.38).

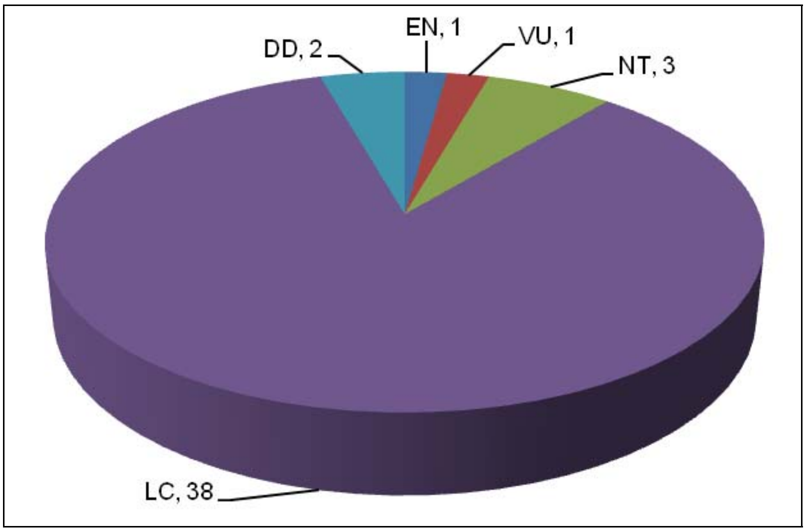


Fig.2.38. Biodiversity status of fishes in Kadalundi river system

Endemism

11 species were endemic to Western Ghats (EN-WG), among them, the distribution of 2 species were confined to Kerala waters (*Dayella malabarica* and *Mastacembelus guentheri*) (EN-K). 7 species were confined to Indian Subcontinent (EN-IS) and 5 species restricted to Indian region (EN-I). *Oreochromis mossambicus* was the only exotic fish reported from this river (Fig.2.39).

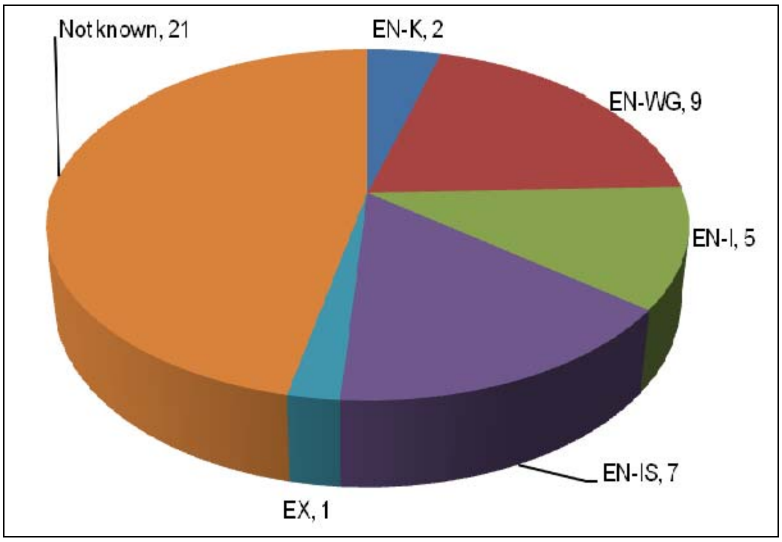


Fig 2.39. Endemic nature of fishes in Kadalundi river system

2.3.2.13. Kallada river

Fish germplasm resources

The total number of fish species recorded were 67 belonging to 39 genera and 22 families. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.17. Cypriniformes (35 species) was the most richest order followed by Perciformes (12 species), while the maxiumum species was under families Cyprinidae, represented by carps and true minnows (31 species) followed by Bagridae (6 species) and Ambassidae (4 species). *Puntius* group showed the richest germplasm with a numerical strength of 13 species followed by *Mystus.* The numerical strength of different families of fishes inhabiting Kallada river system is depicted in Fig. 2.40.

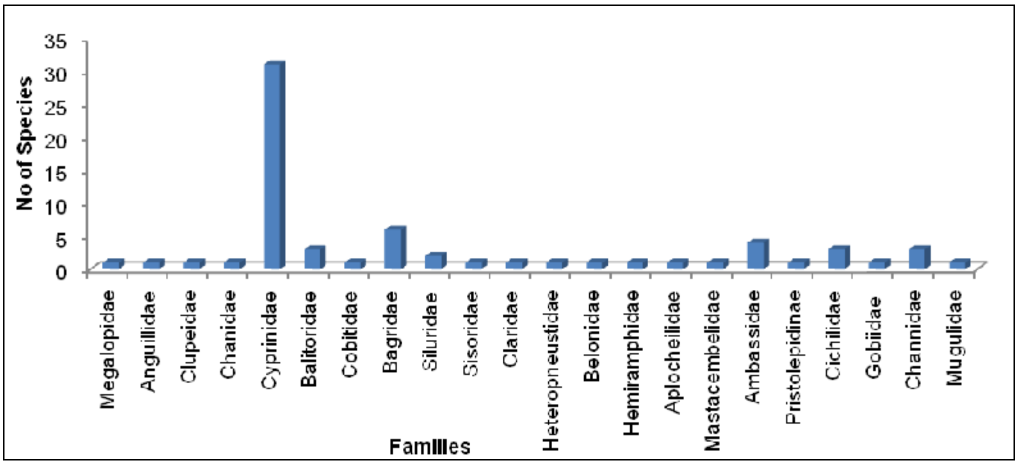


Fig.2.40. Numerical strength of various fish families reported from Kallada river system

Biodiversity status

Hypselobarbus thomassi was listed as critically endangered (CR) while 7 other species as endangered (EN) whereas 5 were as vulnerable (VU) in their threat status. 3 species belongs to data deficient (DD) category (Fig.2.41).

Endemism

25 species were condidered to be endemic to Western Ghats (EN-WG) of which 4 species were strictly endemic to rivers of Kerala (EN-K). *Dayella malabarica, Osteobrama bakeri, Puntius mahecola* and *Travancoria jonesi* were the species endemic to Kerala waters. 7 species were found endemic to Indian region (EN-I), while 11 were endemic to Indian Subcontinent (EN-IS) (Fig.2.42). *Oreochromis mossambicus* and *Cyprinus carpio* were the exotic species reported from this river.

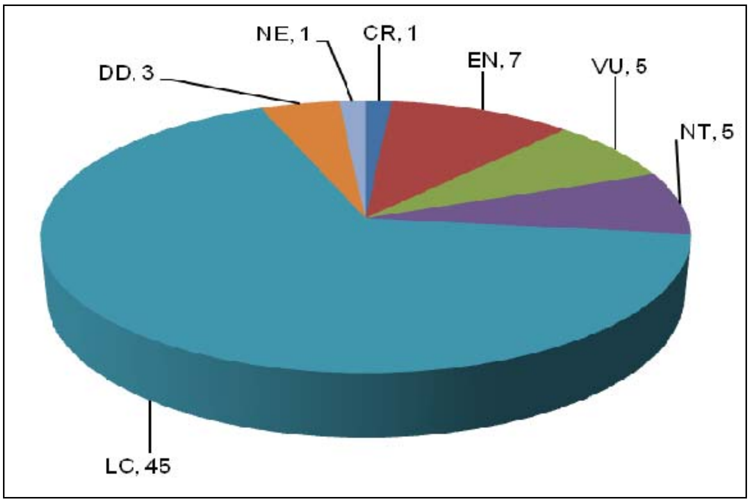


Fig.2.41. Biodiversity status of fishes in Kallada river system

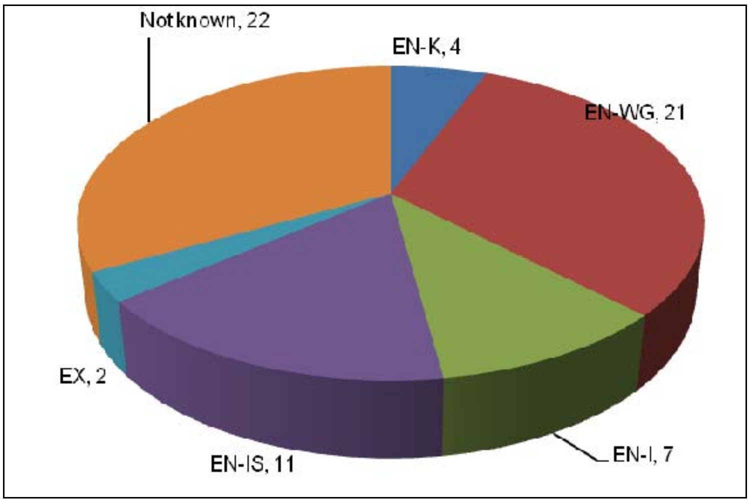


Fig.2.42. Endemic nature of fishes in Kallada river system

2.3.2.14. Kallai

Fish germplasm resources

The fish germplasm resources comprised of 33 species of fishes belong to 8 orders, 18 families and 24 genera. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.18. Order Cypriniformes and Perciformes ranked first and second with 12 and 10 species respectively. Family Cyprinidae was found richest by accomadating maxiumum number of species with 10 members. Genus *Puntius* showed the richest germplasm with a numerical strength of 5 species. The numerical strength of different families of fishes recorded in Kallai river system is depicted in Fig.2.43.

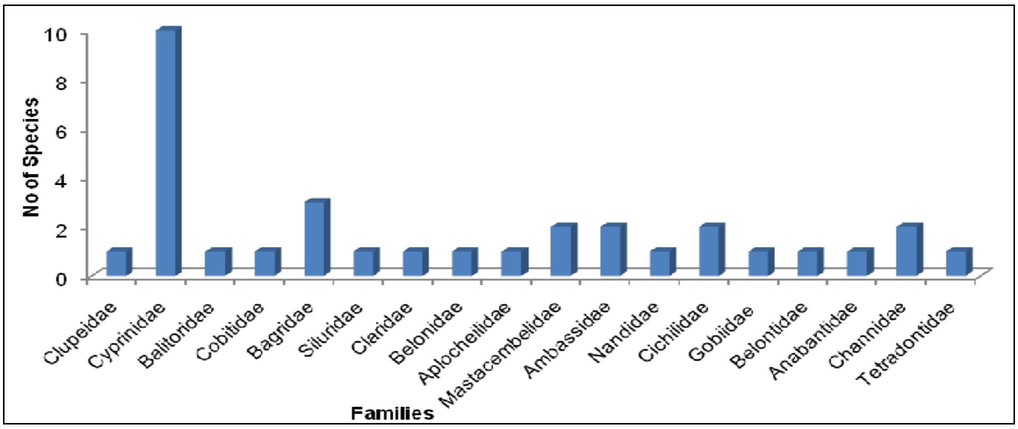


Fig.2.43. Numerical strength of various fish families reported from Kalllai river system

Biodiversity status

The results of the biodiversity assessment of fishes show that among threatened group there was only one species. *Carinotetradon travancoricus* was coming under vulnerable (VU) category. One species was categorized under data deficient group (DD) (Fig.2.44).

Endemism

7 species were found to be endemic to Western Ghats (EN-WG), among them *Dayella malabarica* and *Macrognathus guentheri* were endemic to rivers of Kerala (EN-K). 2 species were endemic to Indian region (EN-I) while 4 were endemic to Indian Subcontinent (EN-IS). No exotic fishes and endemic species were reported from this river system (Fig.2.45).

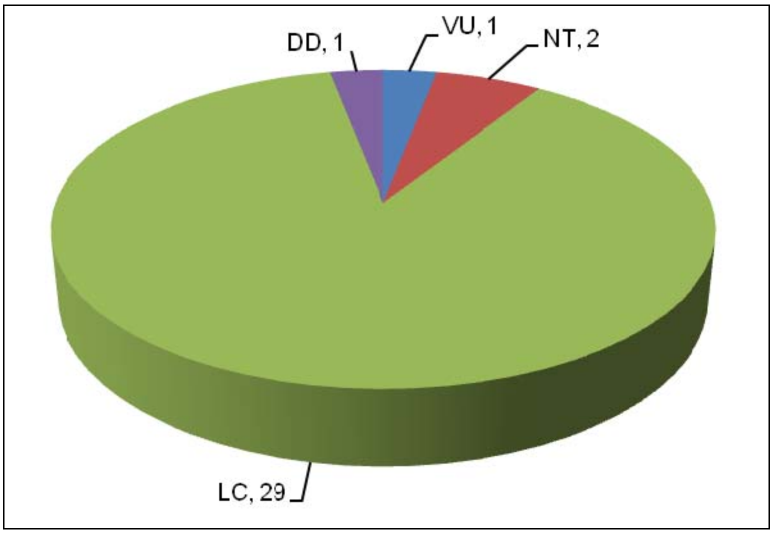


Fig.2.44. Biodiversity status of fishes in Kallai river system

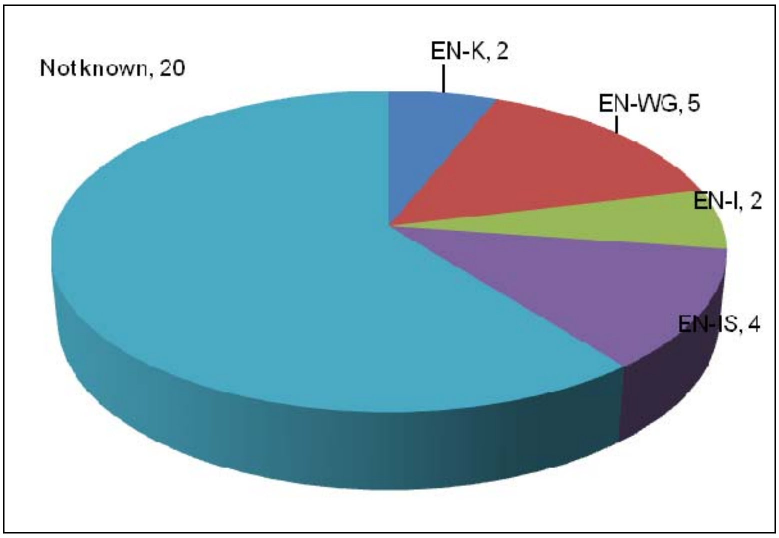


Fig.2.45. Endemic nature of fishes in Kallai river system

2.3.2.15. Karamana

Fish germplasm resources

40 fish species belonging to 7 orders, 14 families and 26 genera were reported from Karamana river system. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.19. Order Cypriniformes was the dominant order with 20 species followed by

Perciformes (10 species). Cyprinidae was the dominant family, representing 19 species under 9 genera followed by Bagridae and Cichilidae (3 species in 2 genera). Genus *Puntius* showed the richest germplasm with a numerical strength of 9 species. The numerical strength of different families inhabit in Karamana river system is depicted in Fig.2.46.

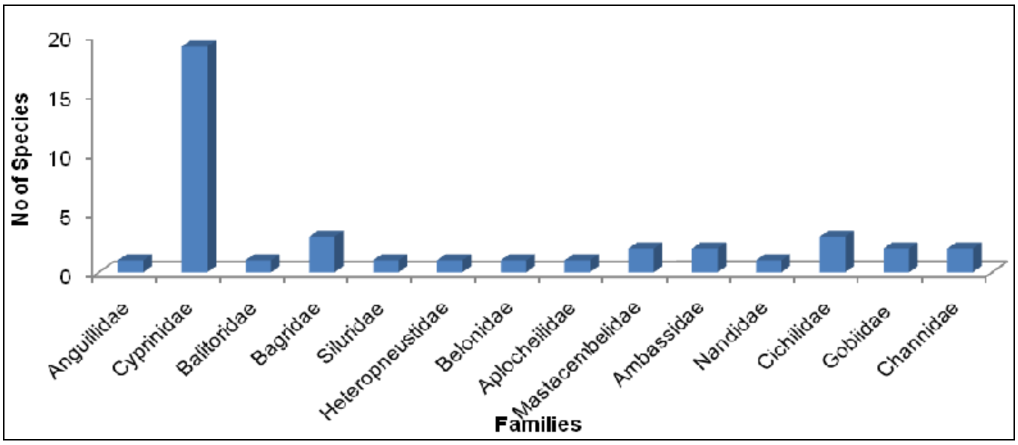


Fig.2.46. Numerical strength of various fish families reported from Karamana river system

Biodiversity status

5 species were threatened, among them, *Tor khudree, Hypselobarbus curmuca* and *Puntius arulius* belong to endangered (EN) while *Horabagrus brachysoma* and *Hypselobarbus kolus* were coming under vulnerable (VU) category. 34 species belonging to non-threatened category (Fig.2.47).

Endemism

13 species were endemic to Western Ghats region (EN-WG) while *Puntius mahecola* and *Macrognathus guentheri* were strictly endemic to Kerala waters (EN-K). 4 were endemic to the Indian region (EN-I) and 6 species were endemic to Indian Subcontinent (EN-IS) (Fig. 2.48). No species was found strictly endemic to this particular river system. *Oreochromis mossambicus* was the exotic fish reported from this river system.

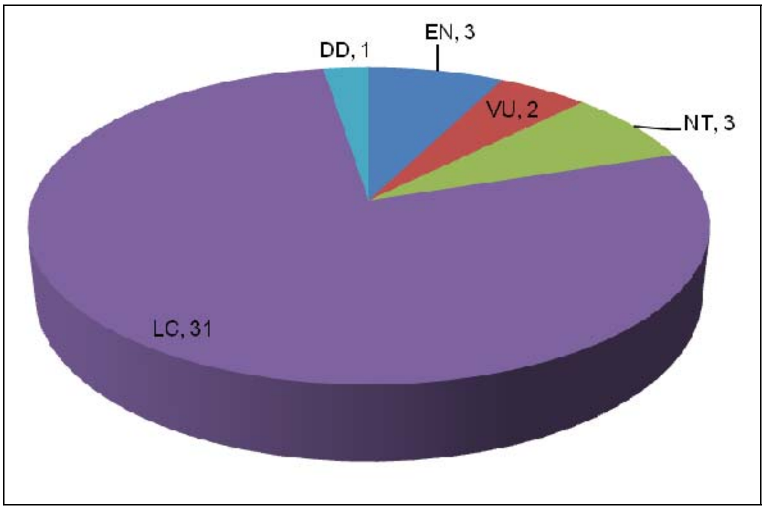


Fig.2.47. Biodiversity status of fishes in Karamana river system

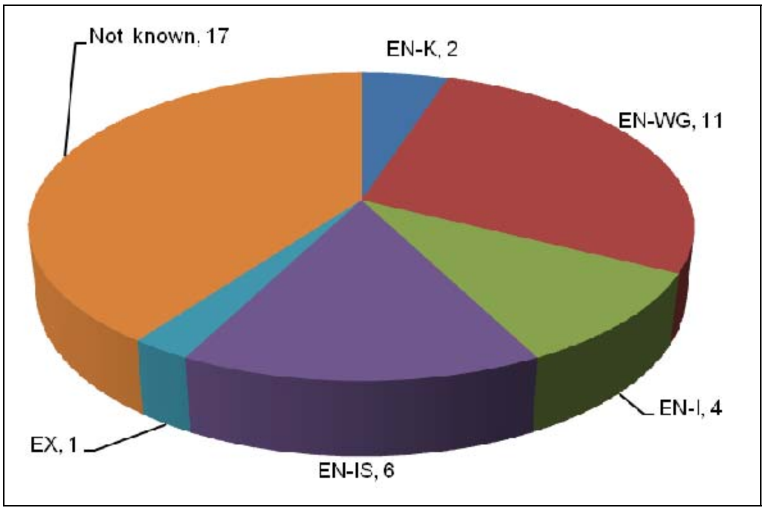


Fig.2.48. Endemic nature of fishes in Karamana river system

2.3.2.16. Karuvannur

Fish germplasm resources

The present study revealed that 52 fish species belonging to 8 orders, 19 families and 32 genera have so far being reported from Karuvannur river system. Cypriniformes represents 3 families, 12 genera and 23 species followed by Perciformes (7 families, 7 genera and 12 species). Cyprinidae was the richest family represented by 10 genera and 20 species. Family Bagridae was the second richest family represented by 3 genera and 6 species.

Puntius group formed the richest germplasm with a numerical strength of 10 species. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.20. The numerical strength of different families of fishes reported from Karuvannur river system is depicted in Fig.2.49.

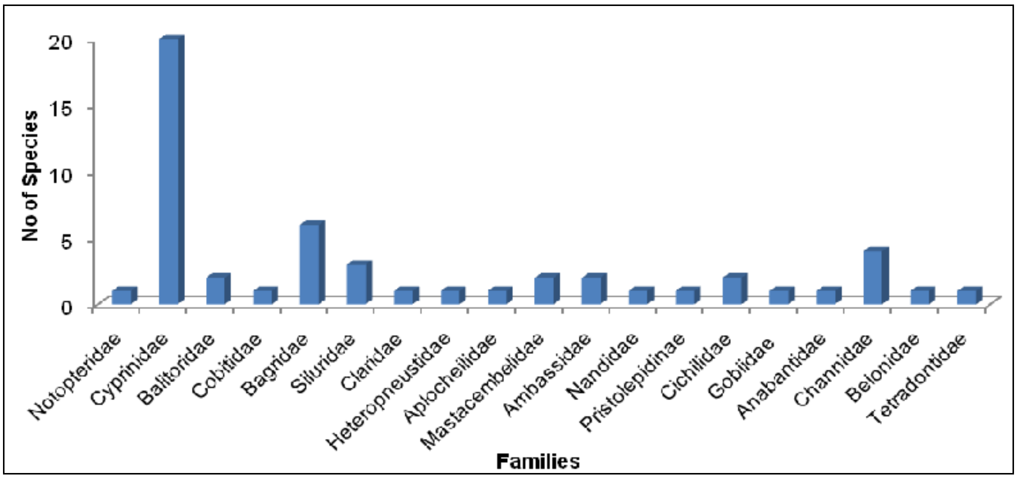


Fig.2.49. Numerical strength of various fish families reported from Karuvannur river system

Biodiversity status

4 species were threatened, among them, *Hemibagrus punctatus* was evaluated as critically endangered (EN) while *Puntius arulius* belongs to endangered group (EN). *Horabagrus brachysoma* and *Carinotetradon travancoricus* belonged to vulnerable (VU) category. 2 species each were belong to data deficient (DD) and non-evaluated category (NE) (Fig. 2.50).

Endemism

15 species were restricted to the Western Ghats region (EN-WG) while *Osteobrama bakeri* and *Macrognathus guentheri* were restricted to Kerala region (EN-K). Four species were endemic to Indian region (EN-I) while 9 were restricted to Indian Subcontinent (EN-IS) (Fig.2.51).

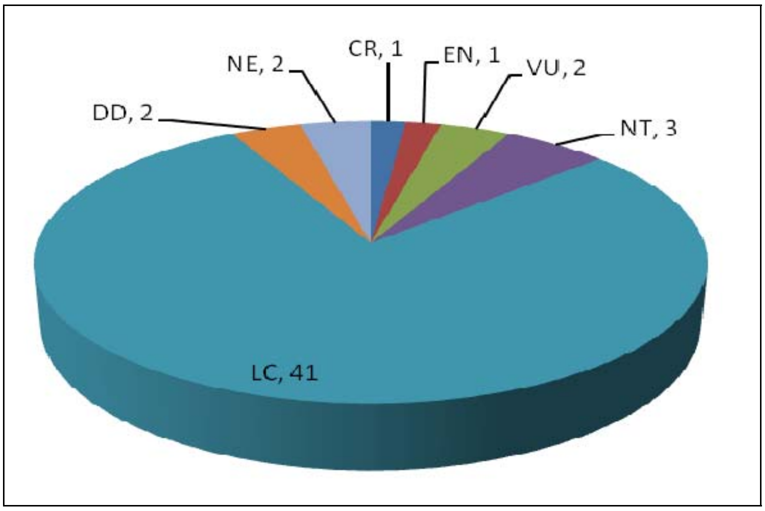


Fig.2.50. Biodiversity status of fishes in Karuvannur river system

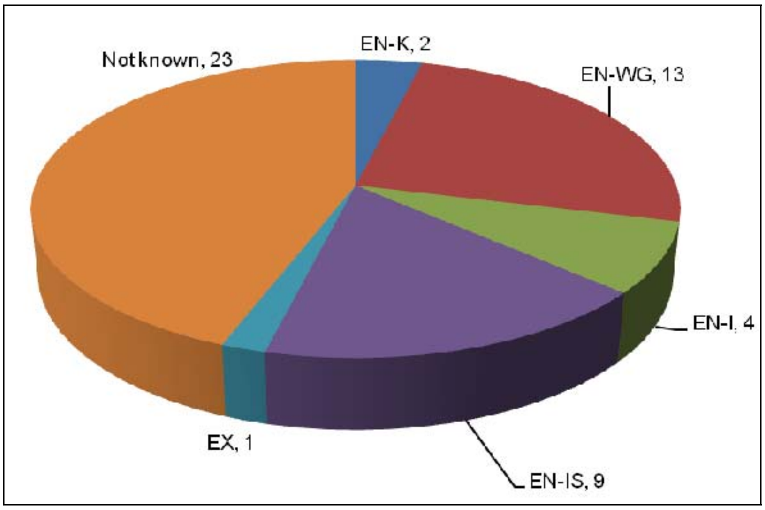


Fig.2.51. Endemic nature of fishes in Karuvannur river system

2.3.2.17. Kariangode

Fish germplasm resources

63 species of fishes belonging to 10 orders, 23 families and 39 genera were reported from Kariangode river system. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.21. Fish fauna of Kariangode dominated by order Cypriniformes with 30 species followed by Perciformes with 13 species.

Order Siluriformes represented by 12 species while Synbranchiformes represented by 2 species. Family Cyprinidae showed the highest number of species (26 species) followed by Bagridae and Siluridae (4 species each). Genus *Puntius* showed the richest germplasm with a numerical strength of 11 species. The numerical strength of different families of fishes reported in the river system is depicted in Fig.2.52.

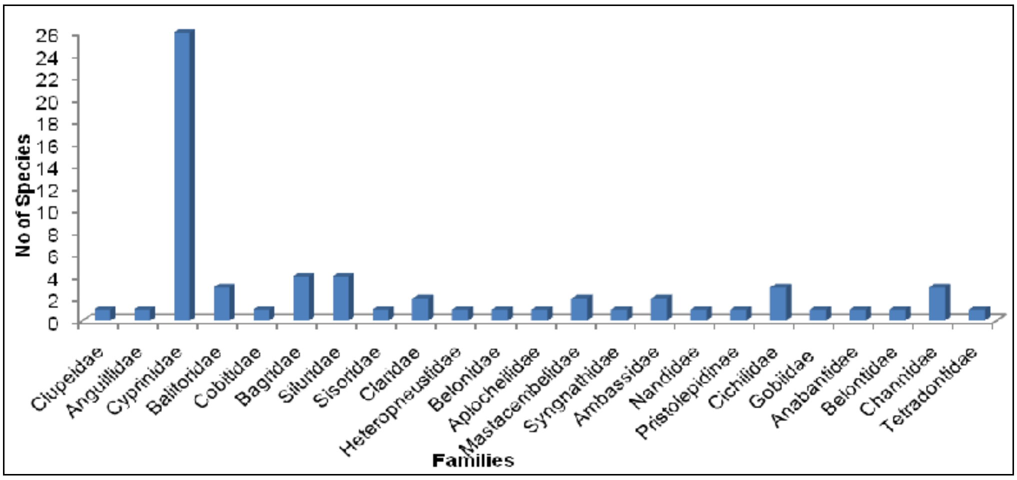


Fig.2.52. Numerical strength of various fish families reported from Kariangode river system

Biodiversity status

9 species reported in the river were under threatened and 51 species under non-threatened category. Within the threatened fishes, *Hypselobarbus curmuca, Puntius denisonii, Puntius arulius, Tor khudree, Barilius canarensis, Garra hughi* and *Pterocryptis wynaadensis* were endangered (EN), whereas *Horabagrus brachysoma* and *Carinotetradon travancoricus* were categorized under vulnerable (VU) category (Fig.2.53). 2 species were under data deficient (DD) category.

Endemism

23 species were found endemic to Western Ghats (EN-WG), among them, *Dayella malabarica, Osteobrama bakeri, Puntius denisonii* and *Macrognathus guentheri* were strictly endemic to Kerala waters (EN-K).

6 species have a geographical distribution confined to Indian waters (EN-I), while 10 species were endemic to Indian Subcontinent (EN-IS) (Fig.2.54). *Oreochromis mossambicus* was the only exotic fish reported from this river.

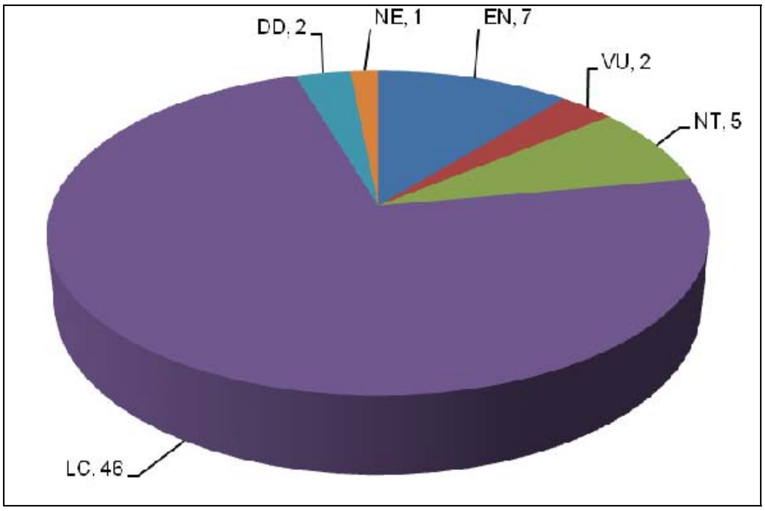


Fig.2.53. Biodiversity status of fishes in Kariangode river system

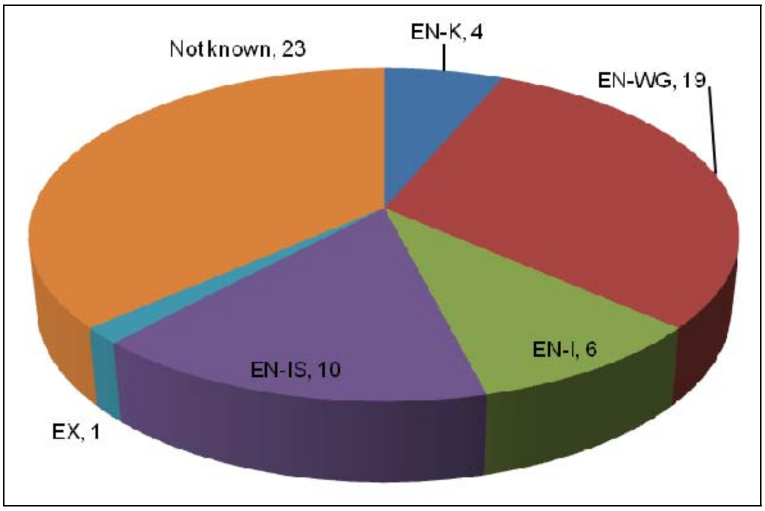


Fig.2.54. Endemic nature of fishes in Kariangode river system

2.3.2.18. Keecheri

Fish germplasm resources

The fish germplasm resources comprised of 39 species belong to 6 orders, 15 families and 24 genera. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.22. Order Cypriniformes and Perciformes ranked first and second with 15 and 12 species respectively. Family Cyprinidae was found to be the richest family representing 14 species. Genus *Puntius* showed the richest germplasm with a numerical strength of 7 species. The numerical strength of different families of fishes reported in Keecheri river system is depicted in Fig.2.55.

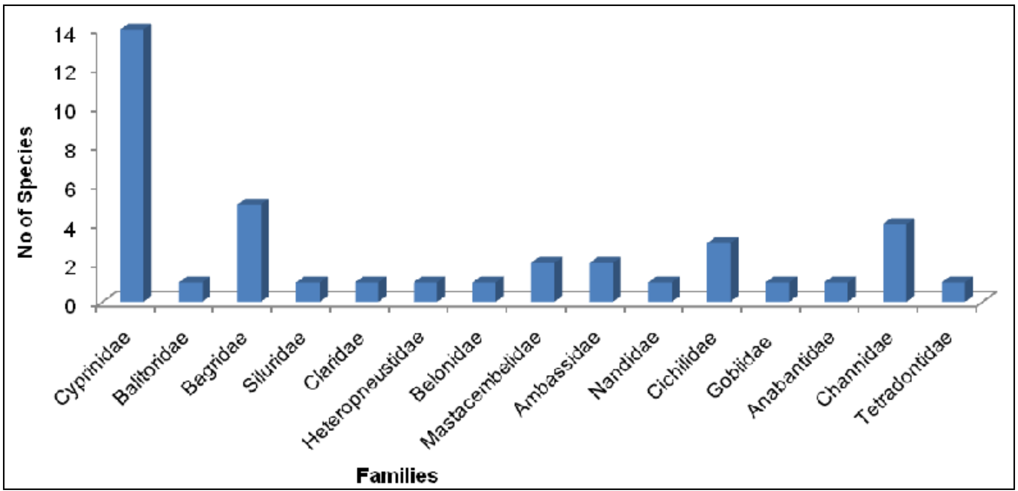


Fig.2.55. Numerical strength of various fish families reported from Keecheri river system

Biodiversity status

Horabagrus brachysoma and *Carinotetradon travancoricus* belonged to threatened category under the vulnerable (VU) group. 34 species belong to non-threatened category. 2 species were categorized as data deficient (DD) while only one species under non-evaluated category (NE) (Fig.2.56).

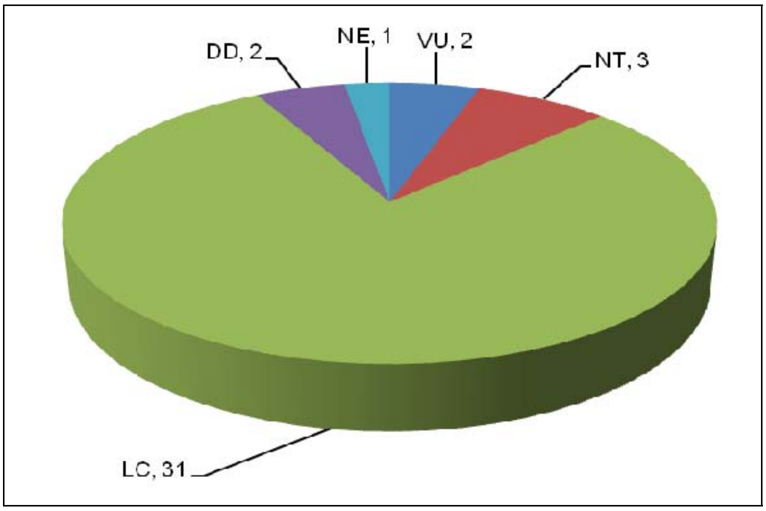


Fig.2.56. Biodiversity status of fishes in Keecheri river system

Endemism

9 species are endemic to Western Ghats (EN-WG), among them, *Macrognathus guentheri* was endemic to Kerala region. 3 species were found endemic to Indian region (EN-I) while 8 are endemic to Indian Subcontinent (EN-IS) (Fig.2.57).

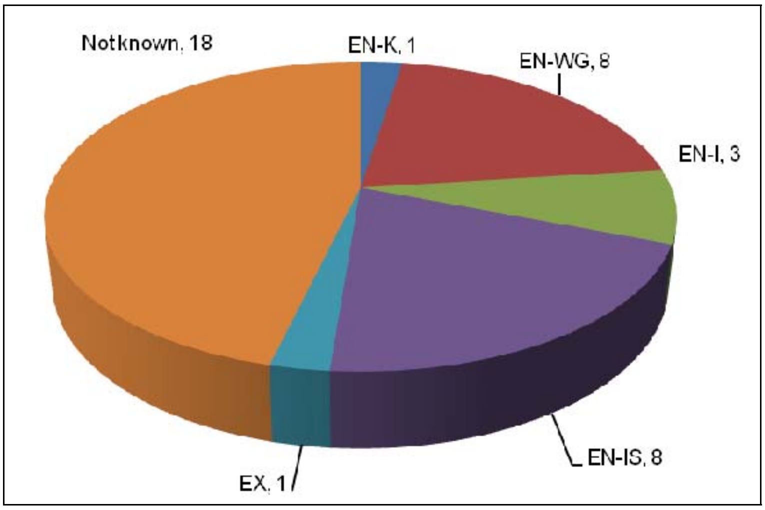


Fig.2.57. Endemic nature of fishes in Keecheri river system

2.3.2.19. Kuppam

Fish germplasm resources

During the study, 56 species of fishes belong to 8 orders, 22 families and 36 genera were reported from Kuppam river. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.23. Family Cyprinidae showed the highest species richness (21 species) followed by Bagridae (6 species). Fishes belong to genus *Puntius* showed the richest germplasm with a numerical strength of 9 species. The numerical strength of different families of fishes reported in Kuppam river system is depicted in Fig.2.58.

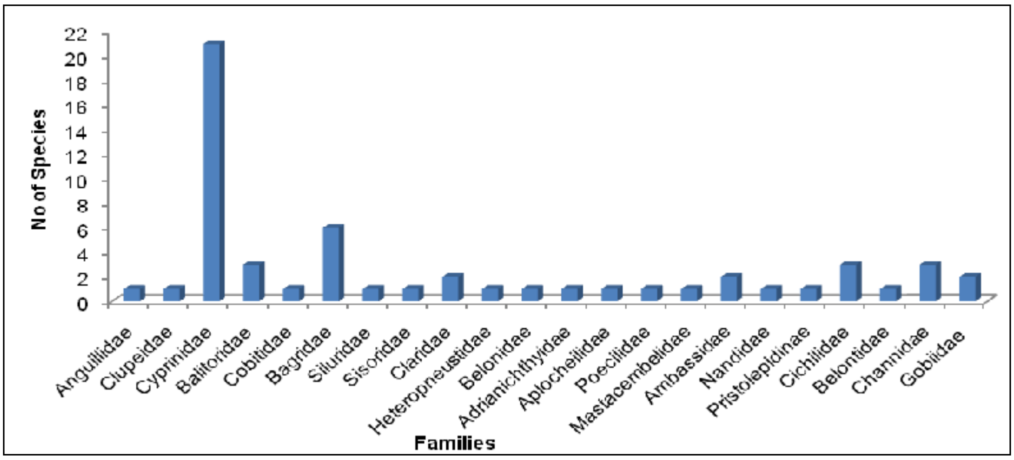


Fig.2.58. Numerical strength of various fish families reported from Kuppam river system

Biodiversity status

6 species belong to threatened category while 47 under non-threatened category. *Hypselobarbus curmuca, Puntius arulius, Tor khudree* and *Garra hughi* were having the status of endangered (EN) while *Batasio travancoria* and *Horabagrus brachysoma* were belonged to vulnerable (VU) category. One species as data deficient (DD) group while 2 species belonged to non-evaluated category (NE) (Fig.2.59).

Endemism

18 species were restricted to Western Ghats (EN-WG), among them *Dayella malabarica* was endemic to Kerala waters (EN-K). 6 species were endemic to Indian waters (EN-I), while 10 species were endemic to Indian Subcontinent (EN-IS). *Oreochromis mossambicus* and *Poecilia reticulata* were found as exotic species (Fig.2.60).

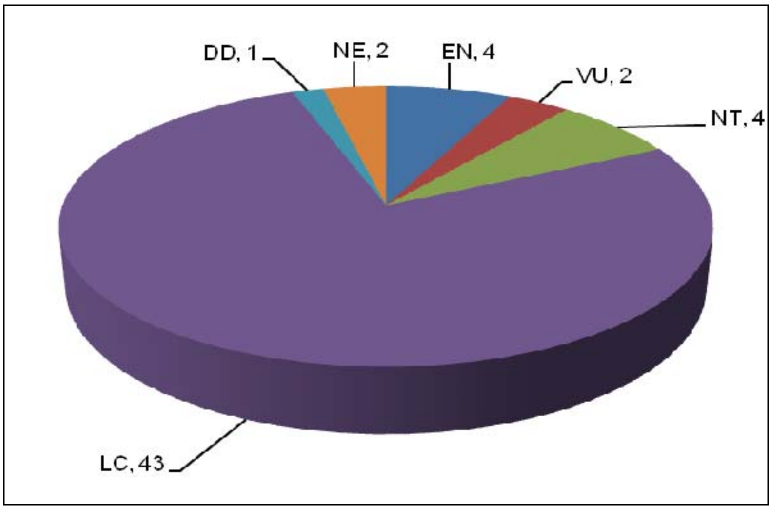


Fig.2.59. Biodiversity status of fishes in Kuppam river system

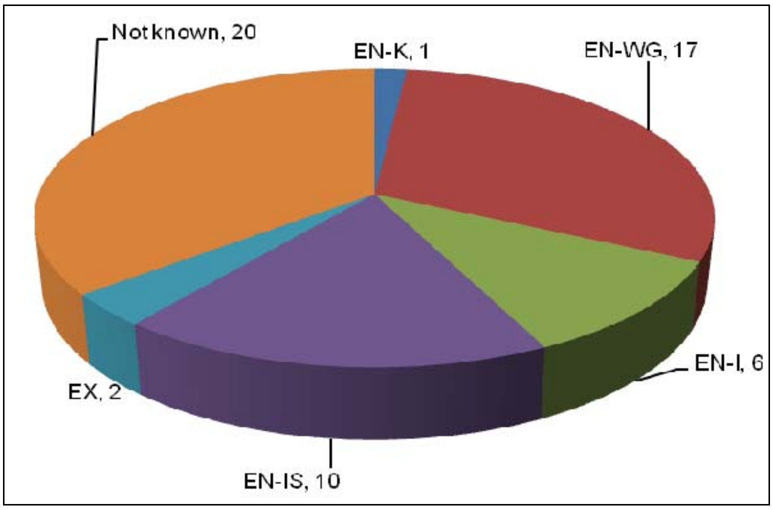


Fig.2.60. Endemic nature of fishes in Kuppam river system

2.3.2.20. Kuttiadi

Fish germplasm resources

The fish germplasm comprised of 41 species belonging to 9 orders, 20 families and 31 genera. The list of fishes reported from this river system together with their commercial name, local name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.24. Cypriniformes (17 species) was the most dominant order followed by Perciformes (9 species). Cyprinidae was the most dominant group represented 14 species belonging to 7 genera followed by Bagridae and Siluridae (3 species each). Genus *Puntius* showed the richest germplasm with a numerical strength of 7 species. The numerical strength of different families of fishes reported in Kuttiadi river system is depicted in Fig.2.61.

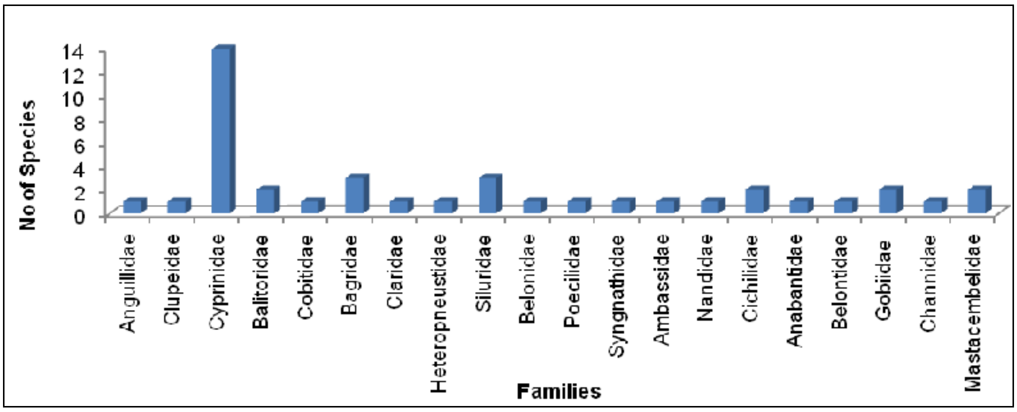


Fig.2.61. Numerical strength of various fish families reported from Kuttiadi river system

Biodiversity status

2 species were as threatened while 37 under non-threatened. Of the threatened fishes, *Pterocryptis wyanadensis* and *Puntius arulius* were endangered (EN). One species each were categorized under data deficient (DD) and non evaluated category (NE) (Fig.2.62).

Endemism

9 species were endemic to Western Ghats (EN-WG) of which *Dayella malabarica* and *Macrognathus guentheri* were strictly endemic to rivers of Kerala (EN-K). 3 species having a geographical distribution confined to Indian waters (EN-I) while 9 species were endemic to Indian Subcontinent (EN-IS) (Fig.6.23). No species was found strictly endemic to this river system. *Poecilia reticulata* and *Oreochromis mossambicus* were the exotic fishes reported from this river.

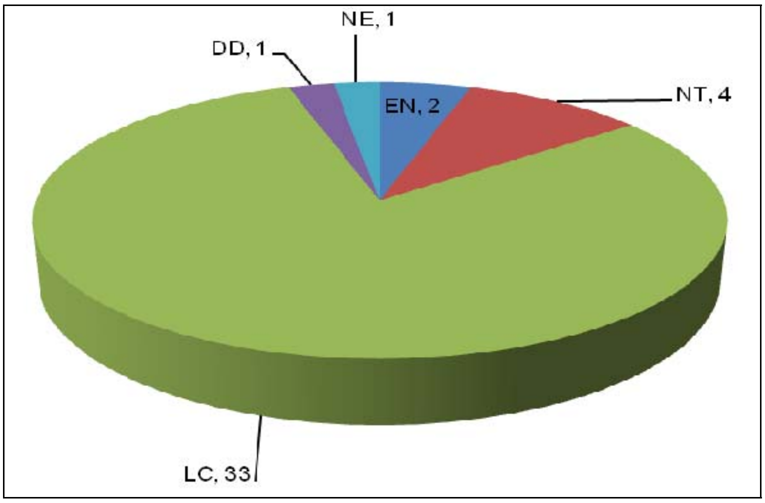


Fig.2.62. Biodiversity status of fishes in Kuttiadi river system

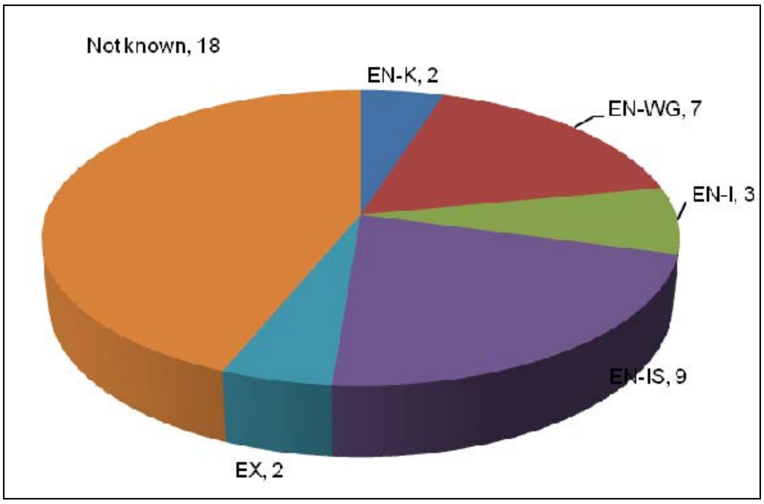


Fig.2.63. Endemic nature of fishes in Kuttiadi river system

2.3.2.21. Mahe

Fish germplasm resources

32 fish species belonging to 8 orders, 17 families and 24 genera were reported from Mahe river system. The most abundant order was Cypriniformes (15 species) followed by Perciformes (8 species) and Siluriformes (4 species). The family with the maximum number of representatives was Cyprinidae with 13 species followed by Bagridae, Cichilidae and Gobiidae (2 species each). Genus *Puntius* showed the richest germplasm with a numerical strength of 7 species. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.25. The numerical strength of different families of fishes inhabit in Mahe river system is depicted in Fig.2.64.

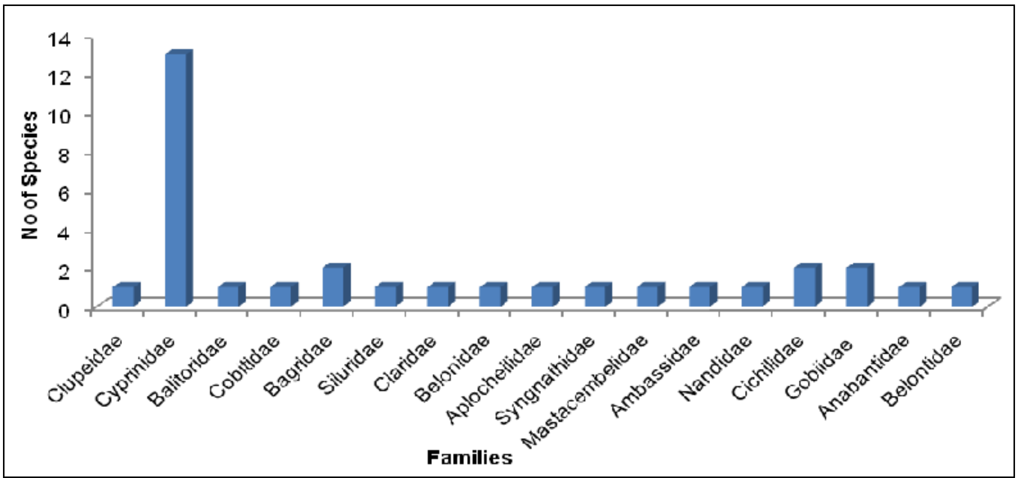


Fig.2.64. Numerical strength of various fish families reported from Mahe river system

Biodiversity status

One species was threatened and 30 under non-threatened. Among the threatened fish, *Puntius arulius* was endangered (EN). One species was categorized under data deficient (DD) group (Fig.2.65).

Endemism

6 species were restricted to Western Ghats region (EN-WG), among them, *Dayella malabarica* was restricted to Kerala only (EN-K). 4 species were having a geographical distribution restricted to Indian waters (EN-I), where as 8 species were restricted to the Indian Subcontinent (EN-IS) (Fig.2.66). *Oreochromis mossambicus* was the only exotic fish species reported. No species was found strictly endemic to this river system.

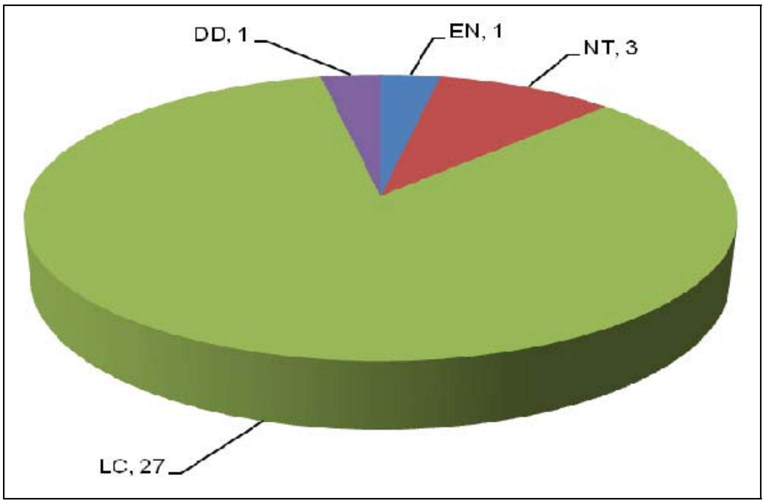


Fig.2.65. Biodiversity status of fishes in Mahe river system

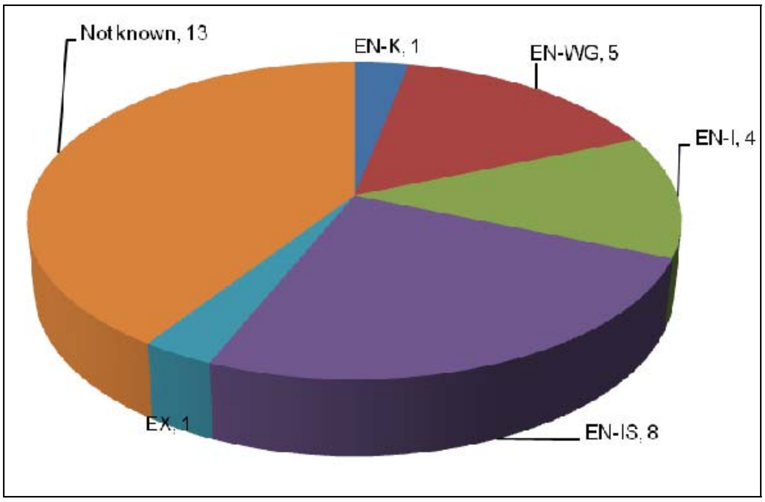


Fig.2.66. Endemic nature of fishes in Mahe river system

2.3.2.22. Mamom

Fish germplasm resources

The fish germplasm comprised of 16 species of fishes belonging to 4 orders, 7 families and 12 genera. Order Cypriniformes and Perciformes ranked first and second with 10 and 3 species respectively, while family Cyprinidae was found richest in maximum number of species with 10 species. Genus *Puntius* showed the richest germplasm with a numerical strength of 5 species. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.26. The numerical strength of different families of fishes reported in Mamom river system is depicted in Fig.2.67.

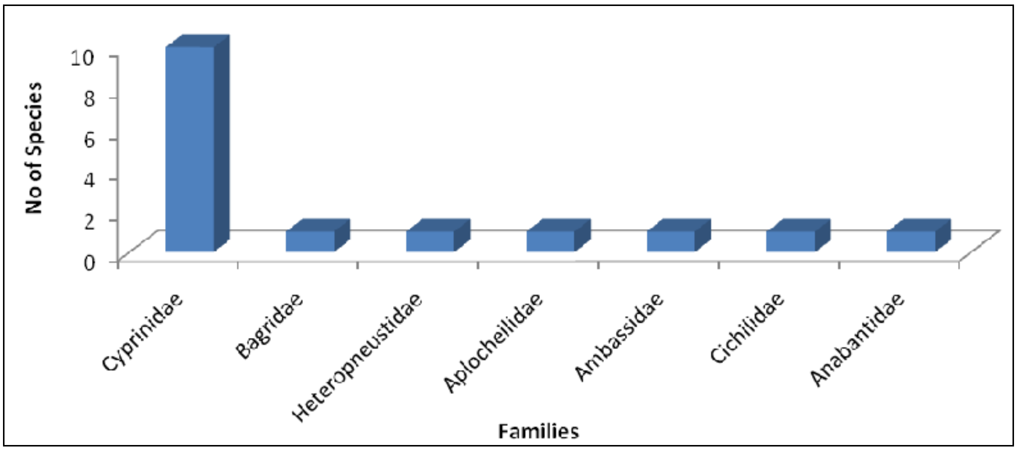


Fig.2.67. Numerical strength of various fish families reported from Mamom river system

Biodiversity status

Hypselobarbus curmuca was the only threatened species coming under Endangered (EN) category, while 13 species belonged to non-threatened category. *Puntius amphibius* and *Anabas testudineus* were the species under data deficient (DD) category (Fig.2.68).

Endemism

3 species were endemic to Western Ghats (EN-WG) and no species was found strictly endemic to Kerala waters. 4 species have a geographical distribution in Indian region (EN-I) while 3 species were endemic to Indian sub continent (EN-IS) (Fig.2.69).

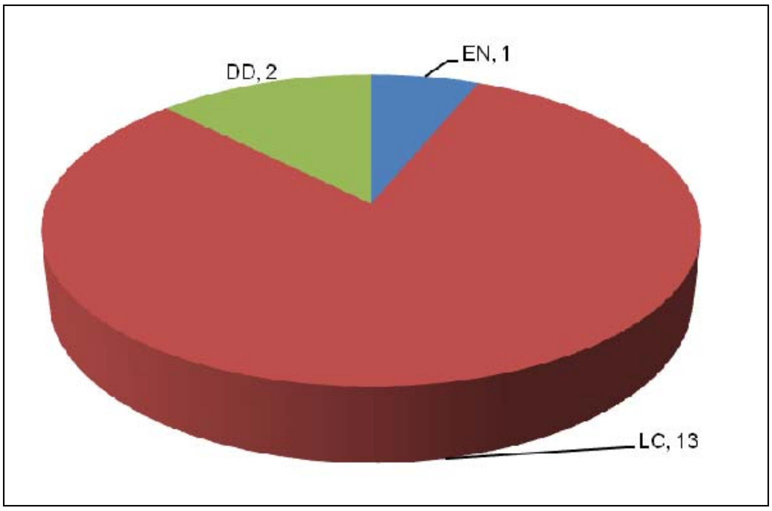


Fig.2.68. Biodiversity status of fishes in Mamom river system

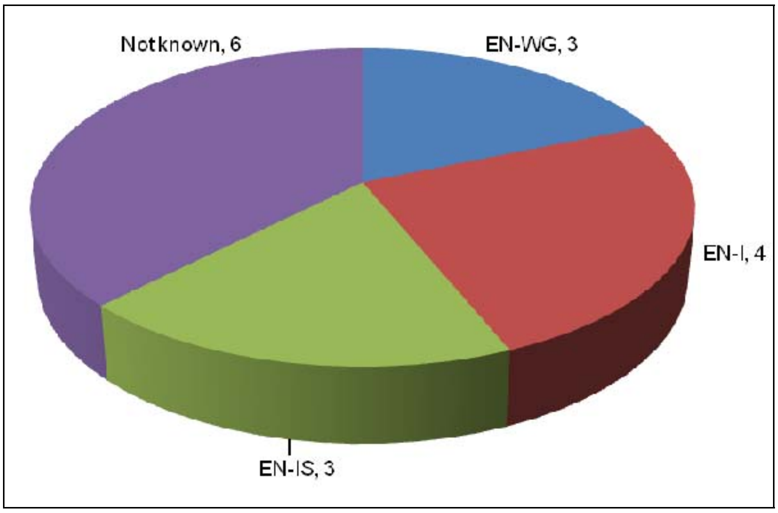


Fig.2.69. Endemic nature of fishes in Mamom river system

2.3.2.23. Manimala

Fish germplasm resources

A total of 56 species of fishes belonging to 7 orders, 18 families and 32 genera were reported from Manimala river system. Order Cypriniformes ranked first with 31 species followed by Siluriformes with 11 species. Family Cyprinidae dominanted with 26 species followed by Bagridae (6 species), Cichilidae and Balitoridae (3 species each). Genus *Puntius* showed the richest germplasm with a numerical strength of 12 species followed by *Mystus* (4 species).

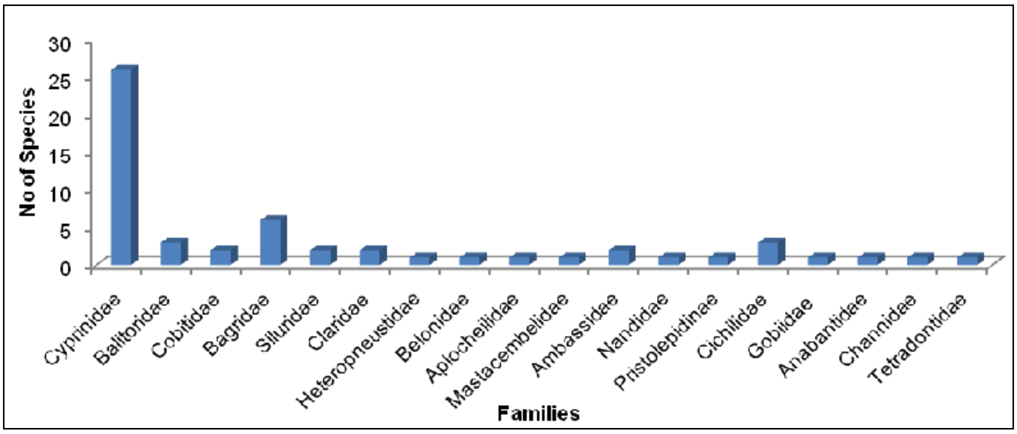


Fig.2.70. Numerical strength of various fish families reported from Manimala river system

The list of fishes reported from this river system together with their commercial name, local name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.27. The numerical strength of different families of fishes reported in Manimala river system is depicted in Fig.2.70.

Biodiversity status

7 species belonged to threatened category while 46 species as non-threatened. Under the threatened group, *Hypselobarbus curmuca*, *Puntius arulius*, *Puntius denisonii* and *Barilius canarensis* were having the status of endangered (EN) while *Horabagrus brachysoma*, *Carinotetradon travancoricus*

and *Batasio travancorica* were under vulnerable (VU) category (Fig.2.71). 2 species were categorized under data deficient (DD) and one species under non evaluated category (NE).

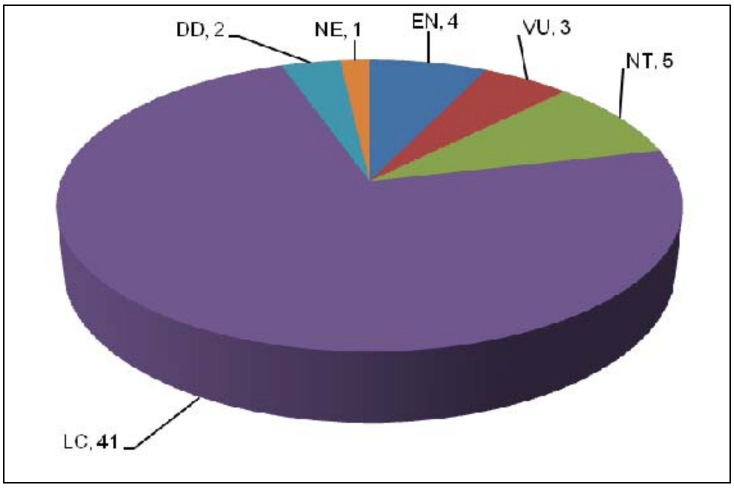


Fig.2.71. Biodiversity status of fishes in Manimala river system

Endemism

20 species were endemic to Western Ghat region (EN-WG) of which *Puntius denisonii* and *Osteobrama bakeri* were strictly endemic to Kerala waters (EN-K). 6 species were found as endemic to Indian waters (EN-I) where as 9 species were endemic to Indian Subcontinent (EN-IS) (Fig.2.72). *Oreochromis mossambicus* was the exotic fishes reported from this river.

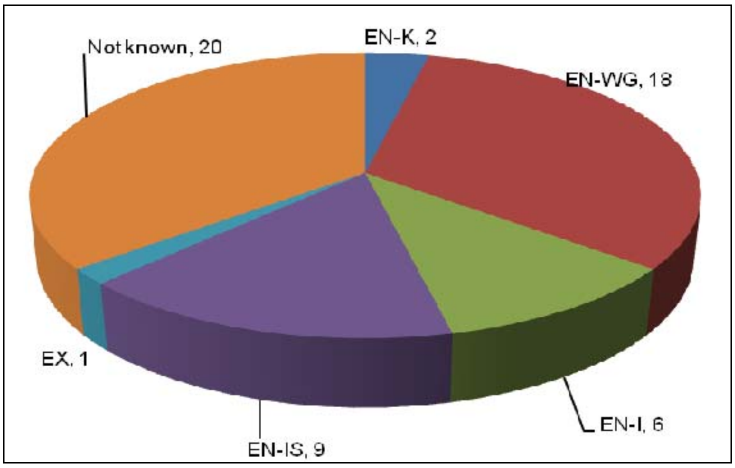


Fig.2.72. Endemic nature of fishes in Manimala river system

2.3.2.24. Manjeswar

Fish germplasm resources

20 species of fishes belonging to 7 orders 11 families and 15 genera were reported from Manjeswar river system. Cypriniformes and Perciformes were the most abundant familes with 7 species each. Cyprinidae was the most dominant family (7 species) followed by Cichilidae (3 species). Genus *Puntius* showed the richest germplasm with a numerical strength of 3 species. The list of fishes reported from this river system together with their commercial name, local name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.28. The numerical strength of different families of fishes reported in the river system is depicted in Fig.2.73.

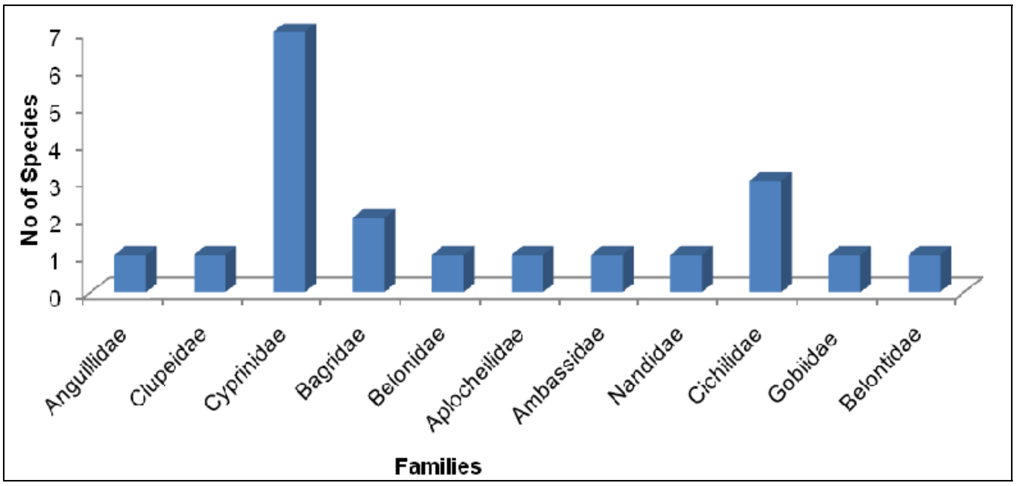


Fig.2.73. Numerical strength of various fish families reported from Manjeswar river system

Biodiversity status

All the species reported from this river system belonged to non-threatened category while one species categorized under data deficient (DD) (Fig. 2.74).

Endemism

2 species were endemic to Western Ghats (EN-WG), among them *Dayella malabarica* was restricted to Kerala region (EN-K). 3 species were endemic to Indian region (EN-I) while 6 were restricted to Indian Subcontinent (EN-IS). *Oreochromis mossambicus* was the exotic fish species reported. No species could found strictly endemic to this particular river system (Fig.2.75).

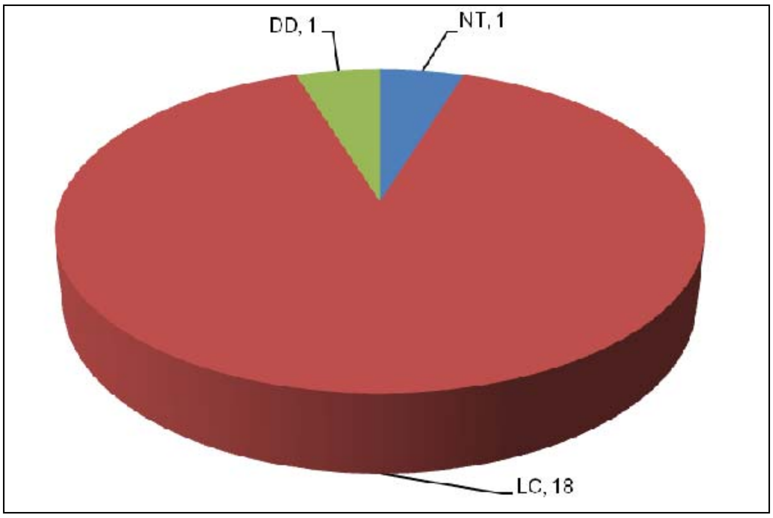


Fig.2.74. Biodiversity status of fishes in Manjeswar river system

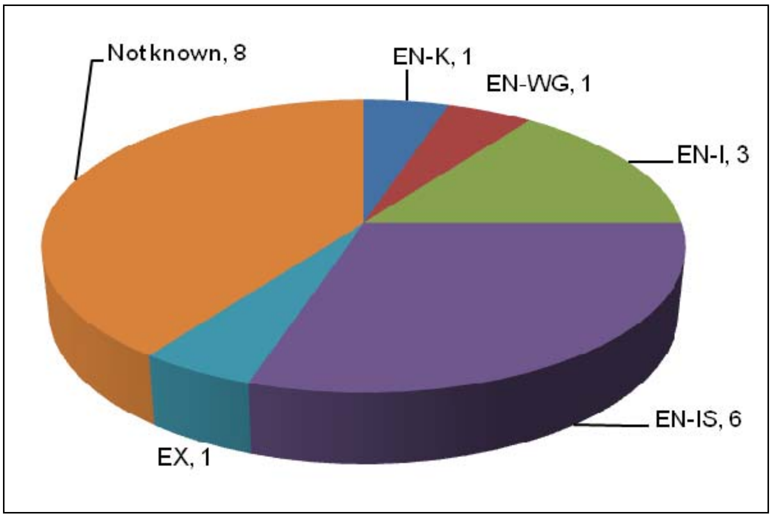


Fig.2.75. Endemic nature of fishes in Manjeswar river system

2.3.2.25. Meenachil

Fish germplasm resources

51 species of fishes belonging to 9 orders, 18 families and 31 genera were reported from Meenachil river. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.29. Cypriniformes was ranked first among the various orders with 27 species followed by Siluriformes and Perciformes (9 species each). Cyprinidae was the most dominant family represented by 25 species belonging to 11 genera. Speices richeness showed that genus *Puntius* showed the richest germplasm with a numerical strength of 12 species. The numerical strength of different families of fishes reported from Meenachil river system is depicted in Fig.2.76.

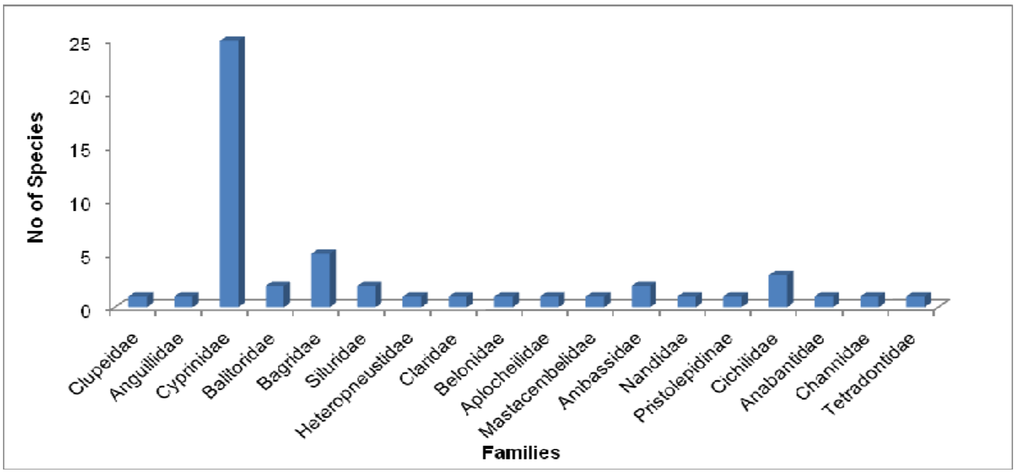


Fig.2.76. Numerical strength of various fish families reported from Meenachil river system

Biodiversity status

4 species (*Puntius ophicephalus, Puntius arulius, Puntius denisonii* and *Hypselobarbus curmuca*) were endangered (EN) and 3 under vulnerable (VU) (*Nemacheilus keralensis, Horabagrus branchysoma* and *Carinotetradon travancoricus)* category (Fig.2.77). 2 species were categorized under data deficient (DD) group.

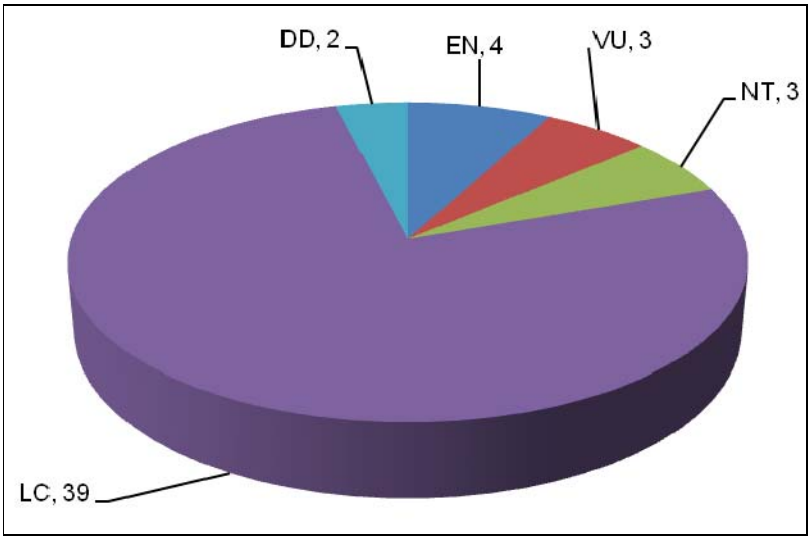


Fig.2.77. Biodiversity status of fishes in Meenachil river system

Endemism

19 species were endemic Western Ghats (EN-WG) and among them *Dayella malabarica, Puntius denisonii* and *Mesonoemacheilus keralensis* having restricted distribution in Kerala (EN-K). 3 species were endemic to Indian region (EN-I) while 10 were restricted to Indian Subcontinent (EN-IS). *Oreochromis mossambicus* was found as the only introduced species (Fig.2.78).

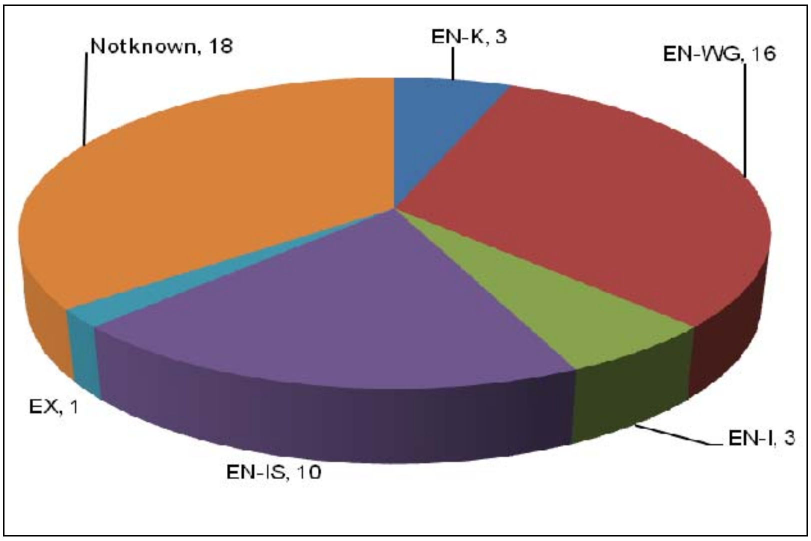


Fig.2.78. Endemic nature of fishes in Meenachil river system

2.3.2.26. Mogral

Fish germplasm resources

The fish germplasm resources comprised of 22 species of fishes belonging to 7 orders, 13 families and 19 genera were reported from Mograll river system. Order Cypriniformes ranked first with 10 species followed by Perciformes with 6 species. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.30.

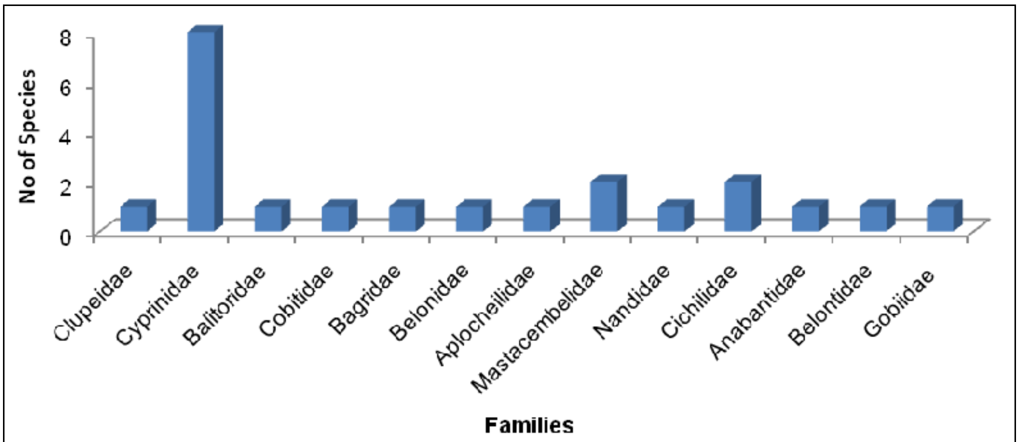


Fig.2.79. Numerical strength of various fish families reported from Mogral river system

Cyprinidae was the dominant family with 8 species (36%) followed by Mastacembelidae and Cichilidae (2 species each). Genus *Puntius* showed the richest germplasm constituted with 3 species. The numerical strength of different families of fishes inhabit the river system is depicted in Fig.2.79.

Biodiversity status

No species was coming under threatened category. 21 species were non-threatened category while one species categorized under data deficient (DD) group (Fig.2.80).

Endemism

4 species were endemic to Western Ghats region (EN-WG), among them, *Dayella malabarica* and *Macrognathus guentheri* were restricted to Kerala region (EN-K). 2 species were having a geographical distribution restricted to Indian waters (EN-I) whereas 4 species were restricted to Indian Subcontinent (EN-IS). Only one species, *Oreochromis mossambicus* belonged to exotic (EX). No species was found strictly endemic to this particular river system (Fig.2.81).

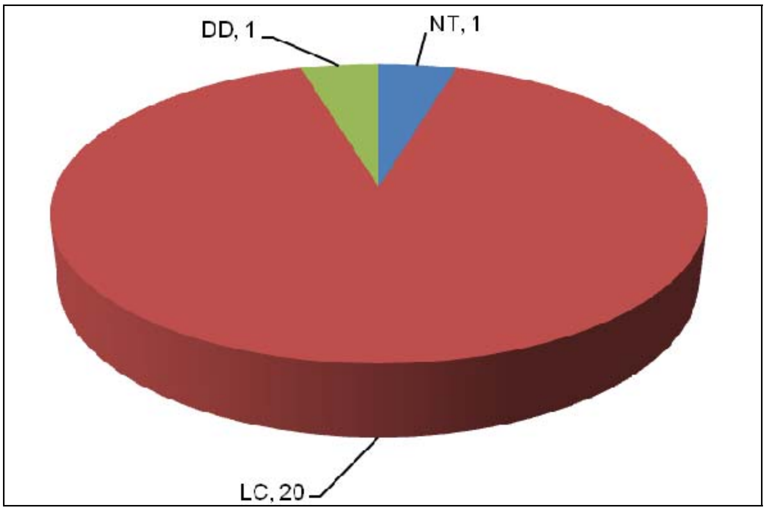


Fig.2.80. Biodiversity status of fishes in Mogral river system

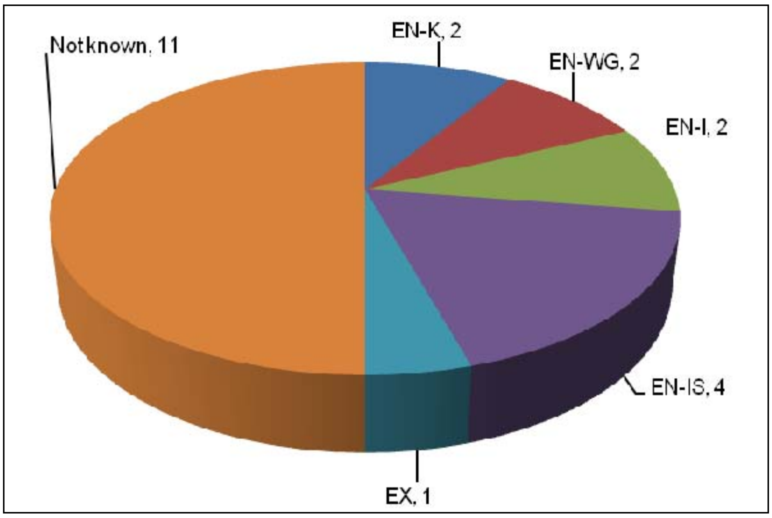


Fig.2.81. Endemic nature of fishes in Mogral river system

2.3.2.27. Muvattupuzha river

Fish germplasm resources

The fish germplasm resources comprised of 85 species belonging to 10 orders, 23 families and 46 genera. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.31. Order Cypriniformes ranked first with 42 species followed by Siluriformes and Perciformes (16 species each). Family Cyprinidae was the most dominant group represented by 37 species belonging to 17 genera, followed by Bagridae. (8 species) and Balitoridae (5 species). Genus *Puntius* was the most dominant fish group with a numerical strength of 14 species followed by *Mystus* (7 species). The numerical strength of different families of fishes reported in Muvattupuzha river system is depicted in Fig.2.82.

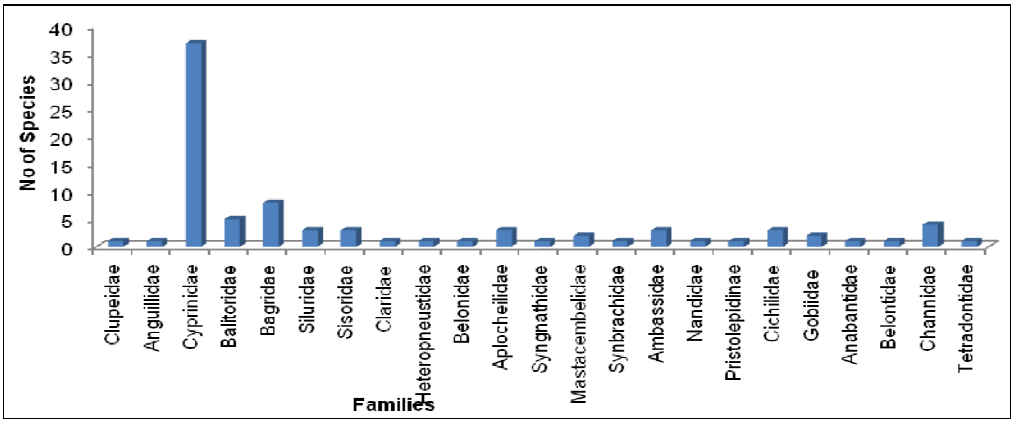


Fig.2.82. Numerical strength of various fish families reported from Muvattupuzha river system

Biodiversity status

7 species were categorized as endangered category (EN) while 6 species under vulnerable (VU) group. *Hypselobarbus curmuca*, *Puntius arulius*, *Puntius crescents*, *Tor khudree*, *Barilius canarensis*, *Glyptothorax madraspatanus* and *Glyptothorax housei* were the endangered species. 4 species were categorized under data deficient (DD) and 3 species under non evaluated category (NE) (Fig.2.83).

Endemism

33 species were found endemic to Western Ghats (EN-WG), among them 8 species were endemic to Kerala waters (EN-K). Endemic species like *Dayella malabarica, Puntius mahecola, Puntius muvattupuzhaensis, Osteobrama bakeri, Laubuca fasciatus, Nemacheilus keralensis, Pseudosphromenus dayi* and *Mastacembelus guentheri* constitute 8% of the total fish diversity in Muvattupuzha river. The distribution of 8 species is confined to Indian waters (EN-I) where as 16 were restricted to the Indian Subcontinent (EN-IS) (Fig.2.84).

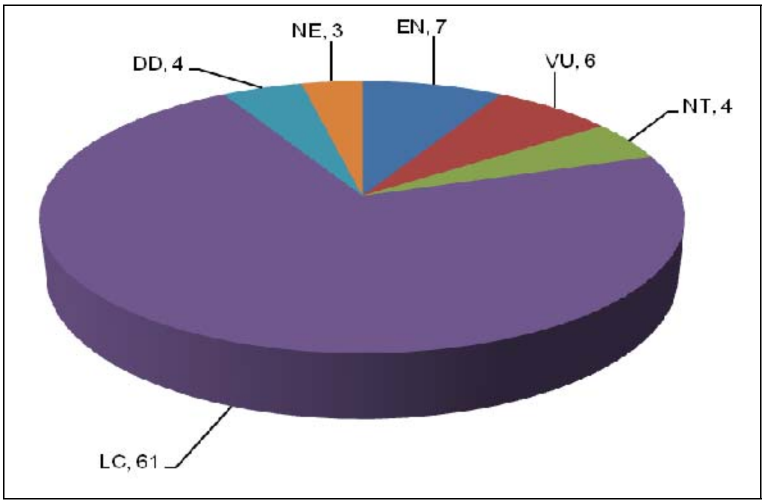


Fig.2.83. Biodiversity status of fishes in Muvattupuzha river system

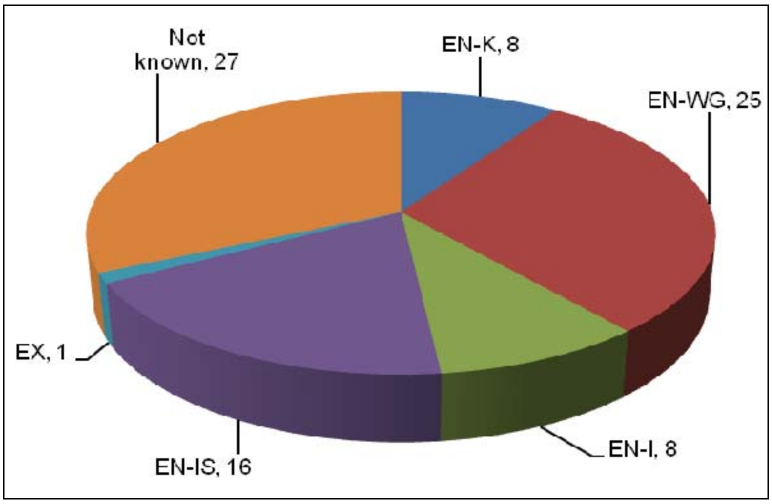


Fig.2.84. Endemic nature of fishes in Muvattupuzha river system

2.3.2.28. Neyyar

Fish germplasm resources

57 species of fishes belonging to 8 orders, 19 families and 34 genera were reported from Neyyar river. Cypriniformes was the most predominant order with 26 fish specis followed by Perciformes with 13 species. Cyprinidae was the most abundant family with 24 species and Bagridae second with 6 species. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.32. Genus *Puntius* showed the richest germplasm with a numerical strength of 9 species. The numerical strength of different families of fishes inhabit in Neyyar system is depicted in Fig.2.85.

.

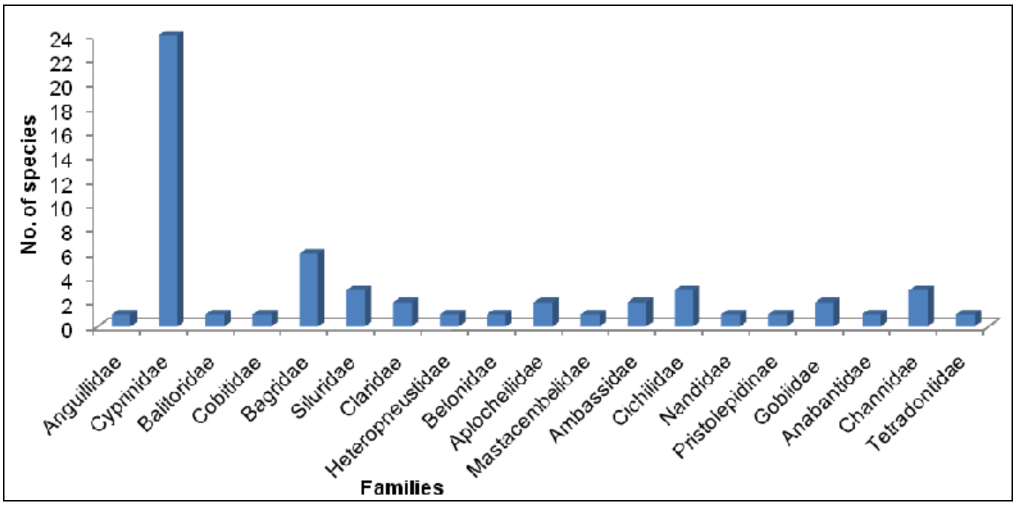


Fig.2.85. Numerical strength of various fish families reported from Neyyar river system

Biodiversity status

Hypselobarbus curmuca, Puntius arulius, Garra hugi and *Tor khudree* listed as endangered (EN), while *Horabagrus brachysoma* and *Carinotetradon travancoricus* were vulnerable (VU) category. 3 species were evaluated as data deficient (DD) while one species were under the non evaluated group (NE) (Fig.2.86).

Endemism

17 species were found to be endemic to Western Ghats (EN-WG) and among them, *Puntius mahechola* was strictly endemic to Kerala (EN-K). 7 species were confined to in Indian region (EN-I) while 11 species (EN-IS) were restricted to Indian Subcontinent (Fig 2.57). No species was found strictly endemic to this river system (Fig.2.87).

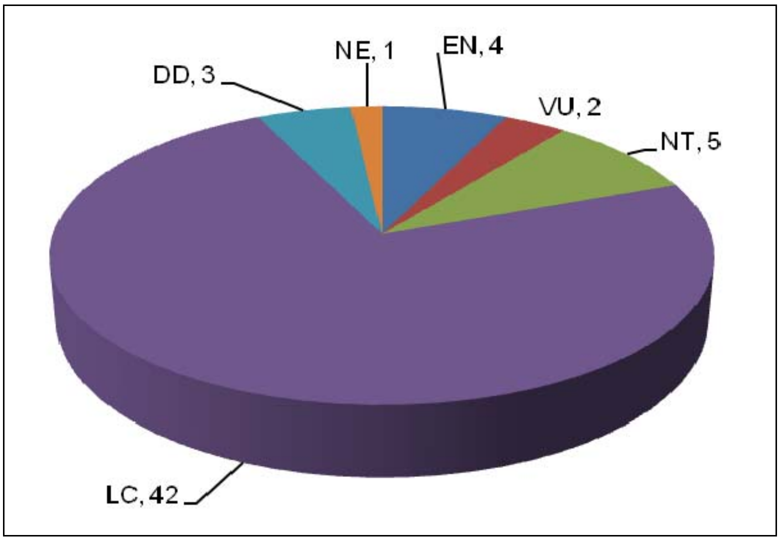


Fig.2.86. Biodiversity status of fishes in Neyyar river system

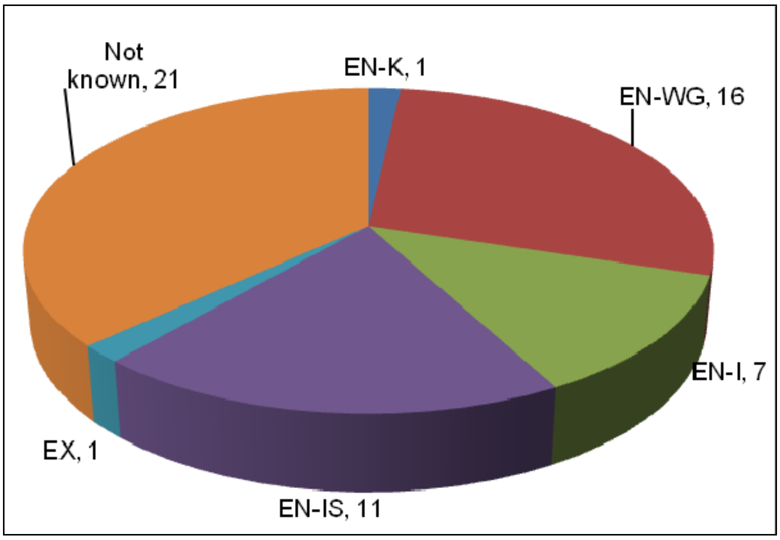


Fig.2.87. Endemic nature of fishes in Neyyar river system

2.3.2.29. Nileswar

Fish germplasm resources

The fish germplasm resources comprised of 44 fish species belonging to 9 orders, 20 families and 29 genera. Order Cypriniformes was dominated with 20 species followed by Perciformes with 10 species while order Silurifomes with 7 species. Family Cyprinidae was found to be richest in maximum number of species with 17 number followed by Bagridae and Cichilidae (3 species each). Genus *Puntius* is characterized with richest germplasm with a numerical strength of 8 species. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.33. The numerical strength of different families of fishes reported in the river system is depicted in Fig.2.88.

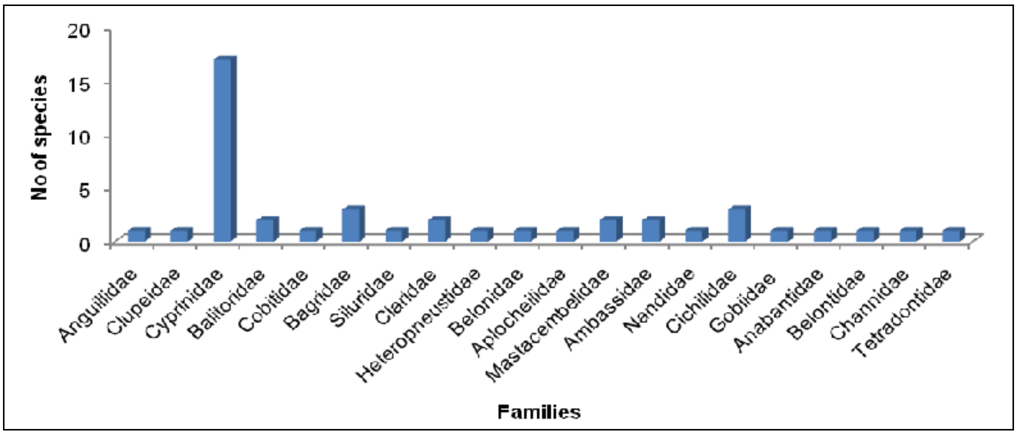


Fig.2.88. Numerical strength of various fish families reported from Nileswar river system

Biodiversity status

3 species belonged to threatened which require special concern for conservation while 39 species were under non-threatened category. Of the threatened fishes, 2 species viz, *Puntius arulius* and *Tor khudree* were endangered (EN) and *Carinotetradon travancoricus* were vulnerable (VU) in their status. 2 species were categorized under data deficient (DD) group (Fig.2.89).

Endemism

12 species were endemic to Western Ghats (EN-WG). Among them, *Dayella malabarica* and *Macrognathus guentheri* were strictly endemic to rivers of Kerala (EN-K). 4 species were having a geographical distribution restricted to Indian waters (EN-I) while 8 species were endemic to the Indian Subcontinent (EN-IS). One species belongs to exotic (EX) viz, *Oreochromis mossambicus* while no species was found strictly endemic to this river system (Fig.2.90).

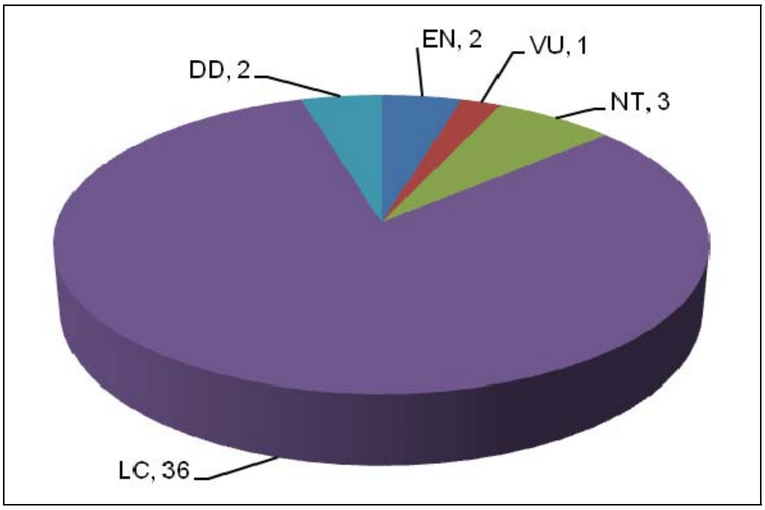


Fig.2.89. Biodiversity status of fishes in Nileswar river system

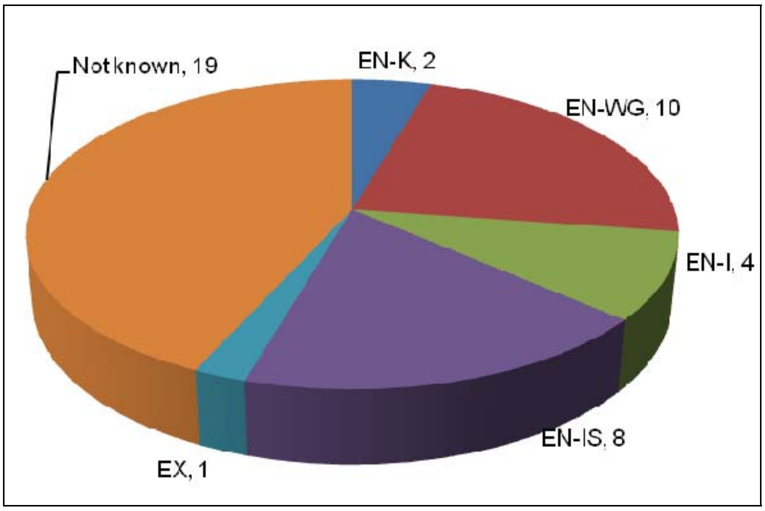


Fig.2.90. Endemic nature of fishes in Nileswar river system

2.3.2.30. Pallikkal

Fish germplasm resources

The fish germplasm resources of Pallikkal river comprised of 22 species belonging to 4 orders, 9 families and 15 genera. Order Cypriniformes ranked first in the numerical strength with 13 species followed by Siluriformes and Perciformes with 4 species each. Among the families, Cyprinidae and Bagridae were representing with 13 and 2 species respectively.

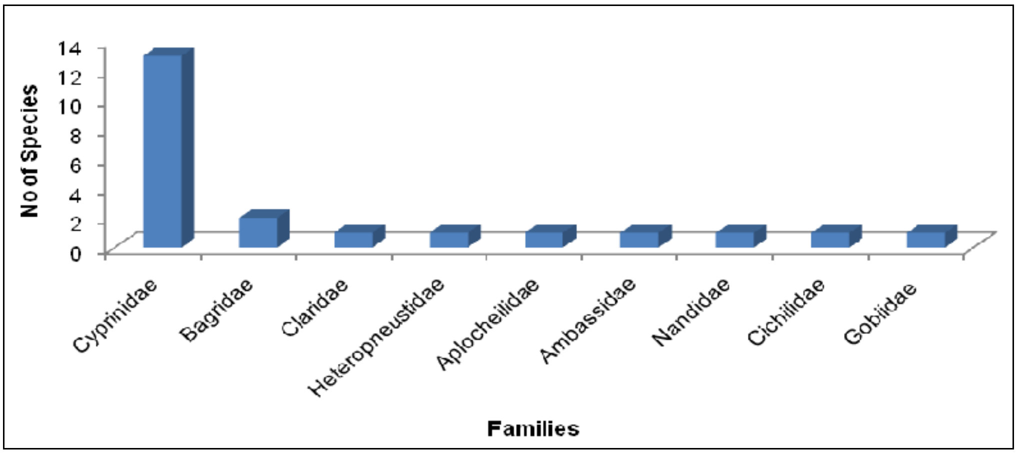


Fig.2.91. Numerical strength of various fish families reported from Pallikal river system

Genus *Puntius* showed the richest germplasm with a numerical strength of 6 species. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are shown in Table 2.34. The numerical strength of different families of fishes recorded in Pallikkal river system is depicted in Fig.2.91.

Biodiversity status

Among the threatened fishes, *Puntius arulius* was assessed as endangered species. 20 species belong to non-threatened category while one species was categorized as data deficient (DD) group (Fig.2.92).

Endemism

Puntius arulius, Salmophasia boopis, Barilius gatensis, Parambassis thomassi and *Mystus oculatus* were demarcated as endemic to Western Ghats (EN-WG). 4 species were found endemic to India (EN-I) while 5 species were endemic to the Indian Subcontinent (EN-IS). None was found strictly endemic to this river system (Fig.2.93).

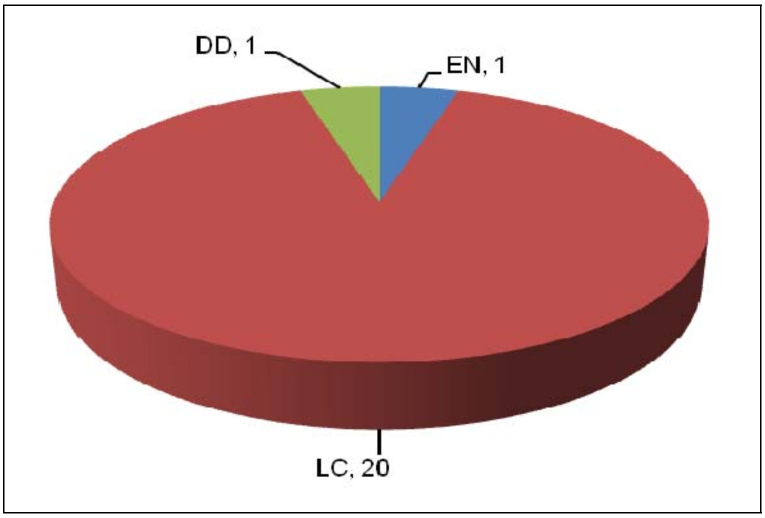


Fig.2.92. Biodiversity status of fishes in Pallikkal river system

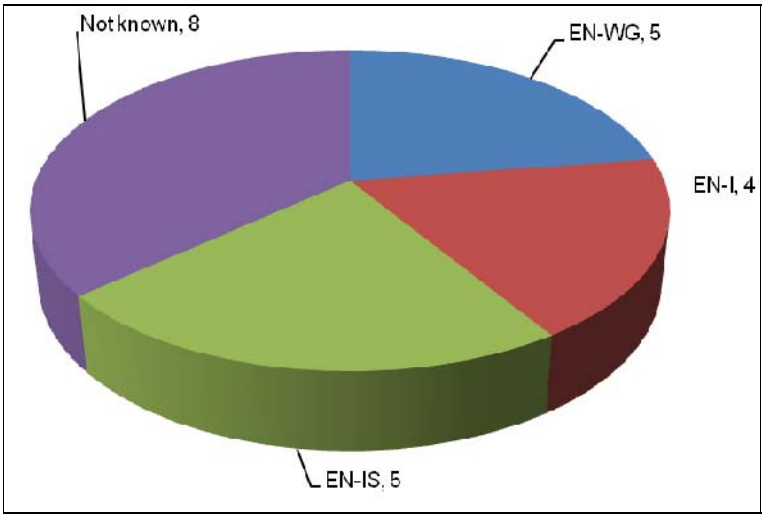


Fig.2.93. Endemic nature of fishes in Pallikkal river system

2.3.2.31. Pamba

Fish germplasm resources

76 species of fishes belonging to 24 families and 43 genera were reported from Pamba river system. Cypriniformes was represent by 3 families, 17 genera and 38 species, among them, family Cyprinidae represents 14 genera and 32 species and Balitoridae represents 2 genera and 5 species. Order Perciformes represents 9 families, 10 genera and 16 species. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.35. Family Channidae represents 1 genera and 4 species while family Amabssidae, Pristolepidinae, Cichilidae and Gobiidae represent 2 species each, In the present study familiy Cyprinidae showed maximum diversity (42%) followed by Bagridae (9%). Genus *Puntius* formed the richest germplasm having 10 species. The numerical strength of different families of fishes reported in this river system is depicted in Fig.2.94.

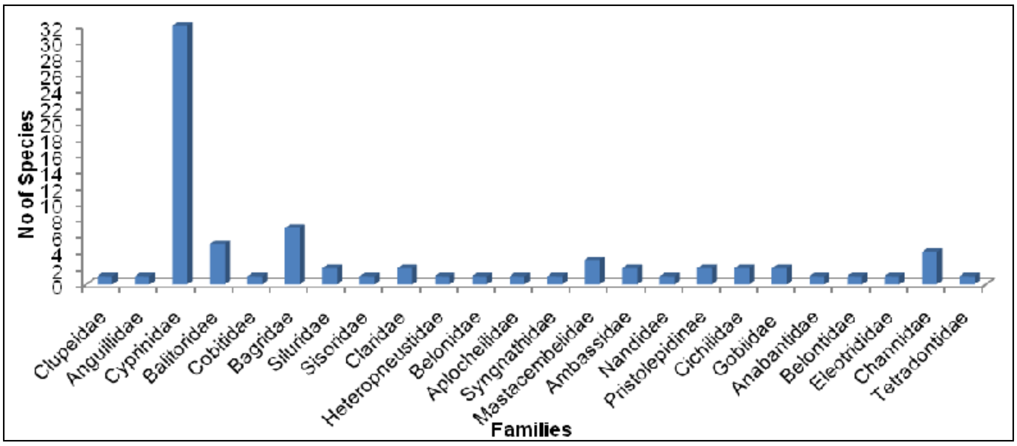


Fig.2.94. Numerical strength of various fish families reported from Pamba river system

Biodiversity status

13 species belong to threatened category while 57 speices were under non-threatened category. Within the threatened group, *Hypselobarbus*

curmuca, Puntius denisonii, Puntius arulius, Tor khudree, Garra hughi, Garra surendranathanii and *Glyptothorax madraspatanus* were assessed as endangered (EN) species, where as 6 species were belonged to vulnerable (VU) category (Fig.2.95). 2 species were data deficient (DD) while 4 species under not evaluated (NE) category.

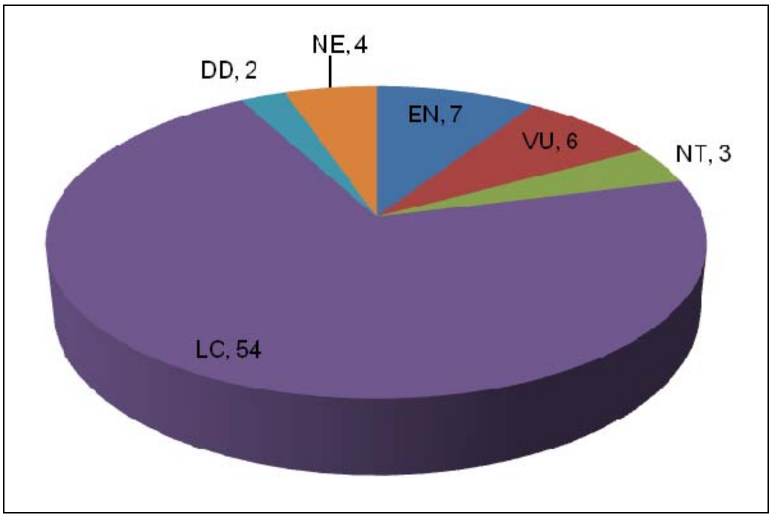


Fig.2.95. Biodiversity status of fishes in Pamba river system

Endemism

25 species were restricted to the Western Ghats region (EN-WG) alone, among them, 6 species were restricted to Kerala region (EN-K) only. *Dayella malabarica, Osteobrama bakeri, Puntius denisonii, Nemacheilus menoni, Garra surendranathanii* and *Mastacembelus guentheri* were the species which are endemic to Kerala rivers. 5 species were endemic to Indian region (EN-I) while 17 are restricted to Indian Subcontinent (EN-IS). *Cyprinus carpio* and *Clarias gariepinus* were exotic species recorded from this river system. No species was found strictly endemic to this river system (Fig.2.96).

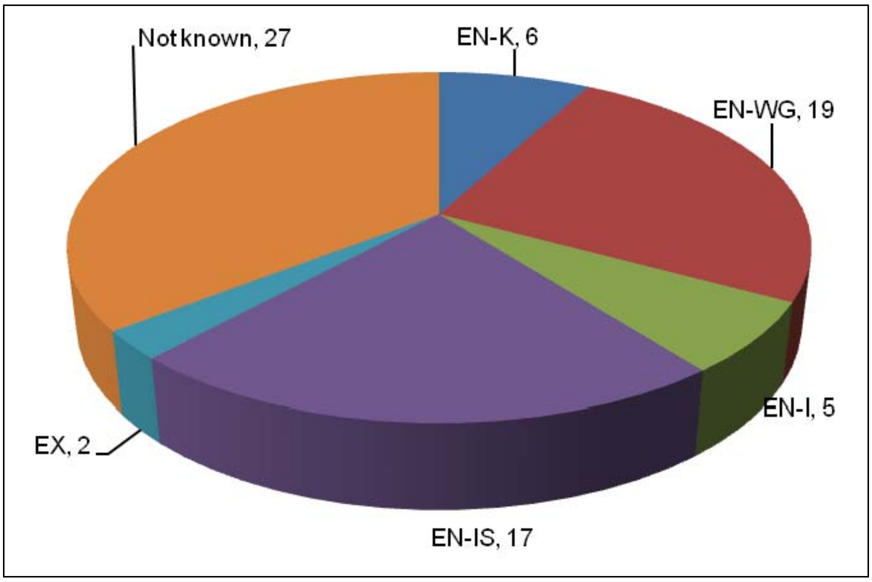


Fig.2.96. Endemic nature of fishes in Pamba river system

2.3.2.32. Pambar

Fish germplasm resources

The fish germplasm resources comprised of 48 species belonging to 4 orders, 13 families and 27 genera. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.36. Order Cypriniformes and Siluriformes occupied first and second with 34 and 9 species respectively. Families Cyprinidae and Bagridae were found richest with 25 and 8 species respectively. Genus *Nemacheilus* showed the richest germplasm with a numerical strength of 6 species. *Oreochromis mossambicus* was the only exotic fish species reported from this river. The numerical strength of different families of fishes reported in Pambar river system is depicted in Fig.2.97.

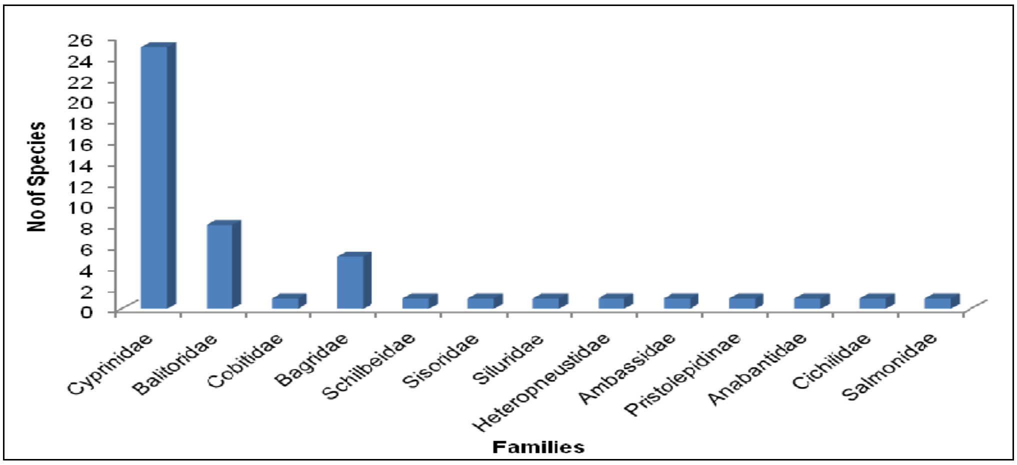


Fig.2.97. Numerical strength of various fish families reported from Pambar river system

Biodiversity status

10 species belonged to threatened category and 35 species under non-threatened category. Among the threatened fishes, *Puntius arulius, Tor khudree, Hypselobarbus curmuca, Garra hughi, Nemacheilus pulchellus, Horalabiosa joshaai* and *Pseudeutropius mitchelli* were listed as endangered (EN), while *Garra menoni, Mesonoemacheilus pambarensis* and *Batasio travancoria* were categorized as vulnerable (VU). One species was under data deficient (DD) group while 2 species belonged to non evaluated category (NE) (Fig.2.98).

Endemism

25 species were found endemic to Western Ghats region (EN-WG), among them, *Tor remadevi, Garra menoni, Mesonoemacheilus pambarensis* and *Pseudeutropius mitchelli* were confined to rivers of Kerala (EN-K). 4 species were confined to Indian region (EN-I) while 7 species (EN-IS) restricted to Indian Subcontinent (Fig.2.99).

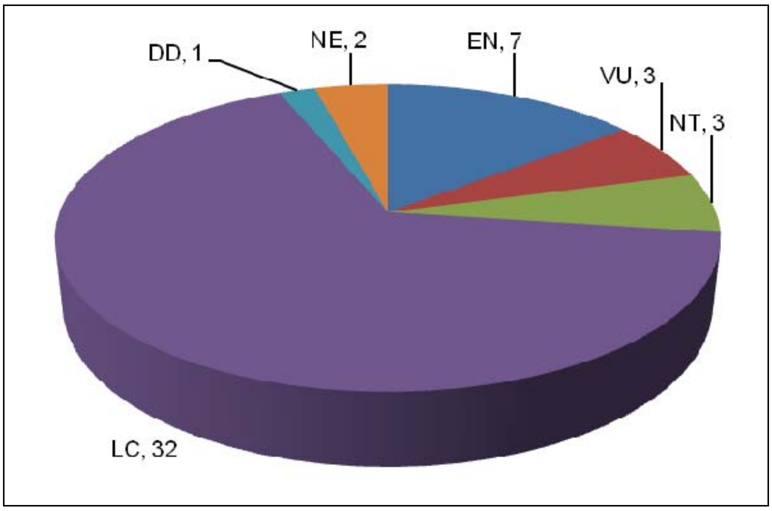


Fig.2.98. Biodiversity status of fishes in Pambar river system

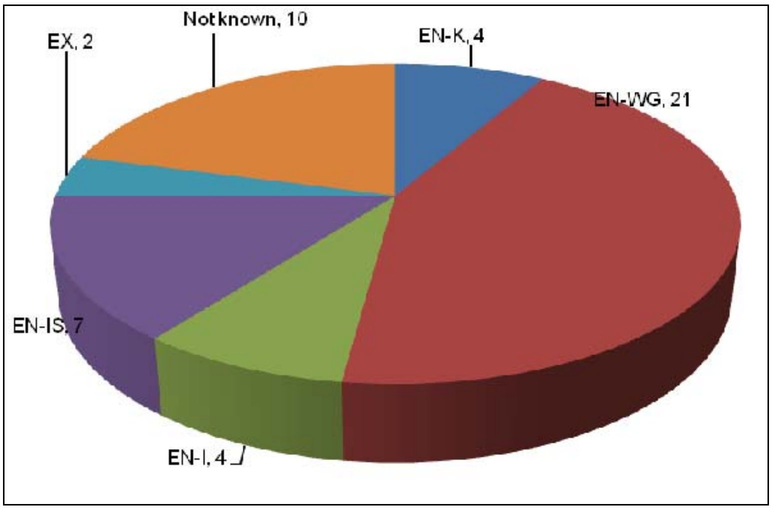


Fig.2.99. Endemic nature of fishes in Pambar river system

2.3.2.33. Periyar

Fish germplasm resources

The fish fauna of Periyar river comprised of 139 fish species belonging to 11 orders, 29 families and 66 genera. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.37. Cypriniformes was represented by 3 families, 31 genera and 81 species, among them, Family Cyprinidae represents 23 genera and 66 species and

Balitoridae represents 6 genera and 14 species. Order Perciformes was represented by 9 families, 12 genera and 21 species. Family Cichilidae represents one genus and 5 species, family Ambassidae represents 2 genera and 3 species, Gobiidae represents 3 genera and 3 species, while Cichilidae represents 2 genera and 3 species. Order Silurifomes constitute 6 families, 9 genera and 21 species. Bagaridae was represented 3 genera and 10 species, while family Siluridae represents 2 genera and 3 species. Genus *Puntius* showed the richest germplasm with a numerical strength of 17 species followed by *Garra* (9 species). Percentage wise species composition showed that order Cypriniformes which is accomadating 57.85%, followed by Siluriformes and Perciformes (15% each). The numerical strength of different families of fishes inhabit in Periyar river system is depicted in Fig.2.100.

Biodiversity status

33 species belong to threatened while 87 species as non-threatened category. Among them, *Horalabiosa arunachalami* and *Hypselobarbus thomassi* were the critically endangered (CR) fish species (Fig.2.101). 18 species belonged to endangered (EN) and 13 under vulnerable (VU) category. 6 species were categorized under data deficient (DD) group while 13 species under non evaluated category (NE).

Endemism

61 fish species were endemic to Western Ghats (EN-WG). Among them, 26 species were strictly endemic to Kerala waters (EN-K). *Cyprinus carpio*, *Ctenopharyngodon idella*, *Clarias gariepinus*, *Poecilia reticulata*, *Oreochromis mossambicus* and *Oncorhynchus mykiss* were the exotic species recorded from this river. The distribution of 8 species is confined to Indian waters (EN-I), where as 25 species were restricted to the Indian Subcontinent (EN-IS) (Fig.2.102).

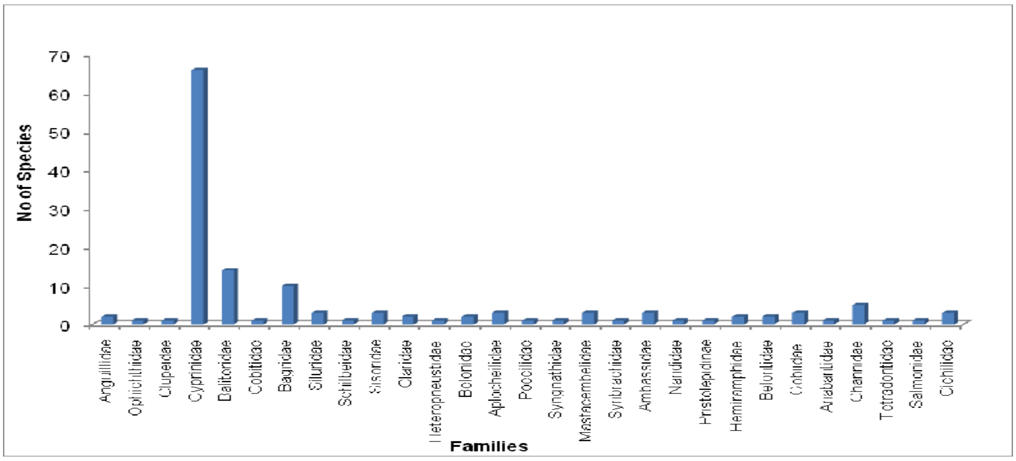


Fig.2.100. Numerical strength of various fish families reported from Periyar river system

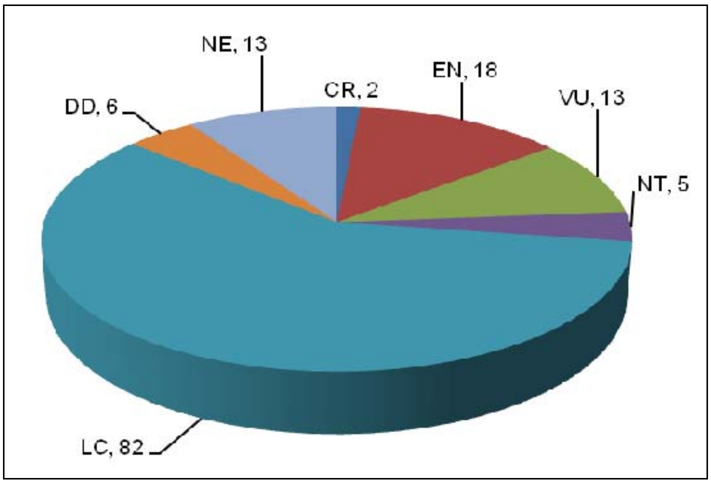


Fig.2.101. Biodiversity status of fishes in Periyar river system

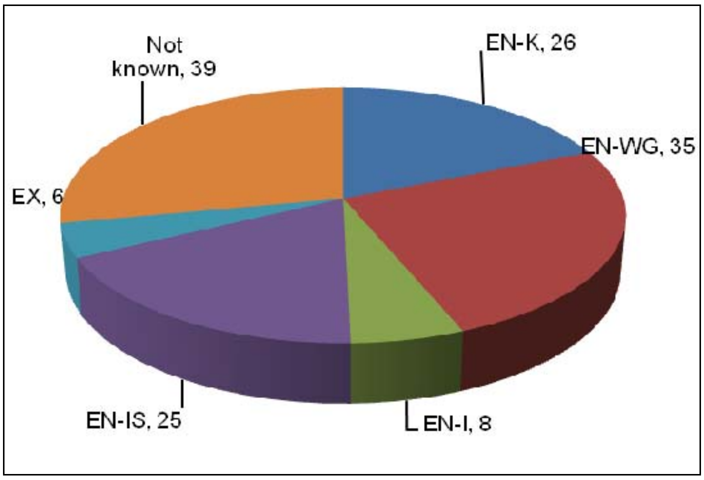


Fig.2.102. Endemic nature of fishes in Periyar river system

2.3.2.34.Peruvamba

Fish germplasm resources

The fish germplasm resources comprised of 22 species belonging to 5 orders, 11 families and 17 genera. Order Cypriniformes and Perciformes ranked first and second with 11 and 5 species respectively, while family Cyprinidae was found richest in accomadating maximum number of species with 10 members. Genus *Puntius* showed the richest germplasm with a numerical strength of 4 species. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.38. Numerical strength of different families of fishes reported in the river system is depicted in Fig.2.103.

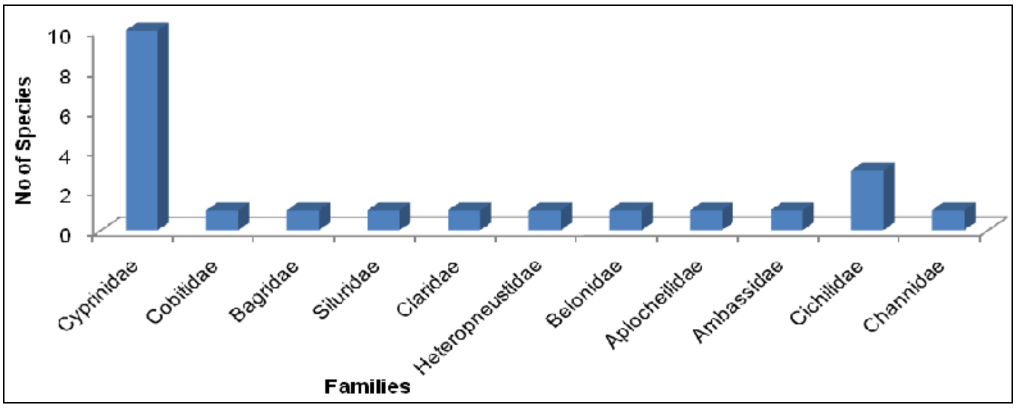


Fig.2.103. Numerical strength of various fish families reported from Peruvamba river system

Biodiversity status

18 species were categorized as non-threatened category while one species as data deficient (DD) group (Fig.2.104).

Endemism

4 species were endemic to Western Ghats (EN-WG) while *Oreochromis mossambicus* represented as the introduced (EX) group. 4 species were found to be endemic to Indian waters (EN-I) (Fig.2.105).

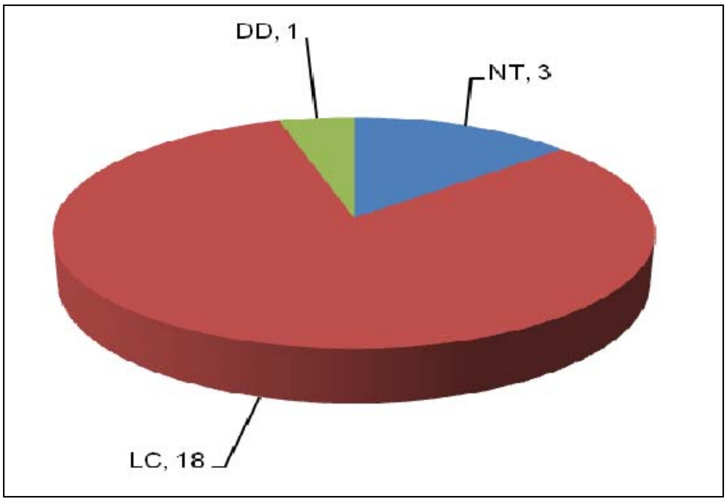


Fig.2.104. Biodiversity status of fishes in Peruvamba river system

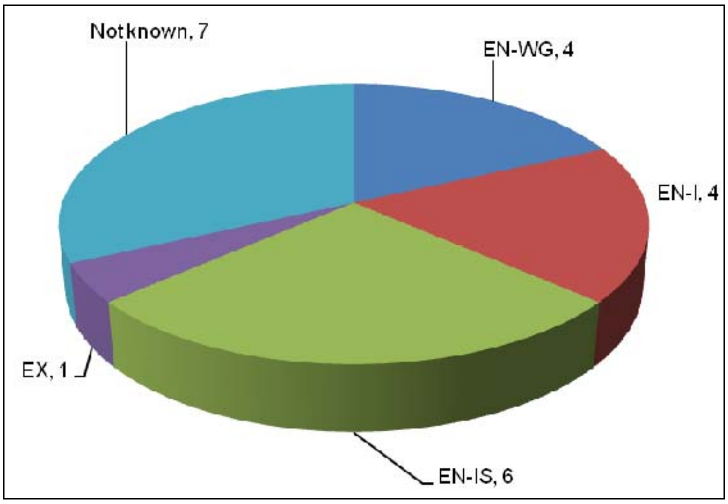


Fig.2.105. Endemic nature of fishes in Peruvamba river system

2.3.2.35. Puzhakkal

Fish germplasm resources

37 species of fishes belong to 9 orders, 19 families and 24 genera were reported from Puzhakkal river system. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.39. Order Cypriniformes and Perciformes ranked first and second with 14 and 11 species respectively. The numerical strength of different families of fishes

reported in the river system is depicted in Fig.2.106. Family Cyprinidae was found to be richest with maximum number of species having 12 species followed by Bagridae and Channidae (3 species each). Genus *Puntius* showed the richest germplasm with a numerical strength of 7 species followed by *Mystus* and *Channa* (3 species).

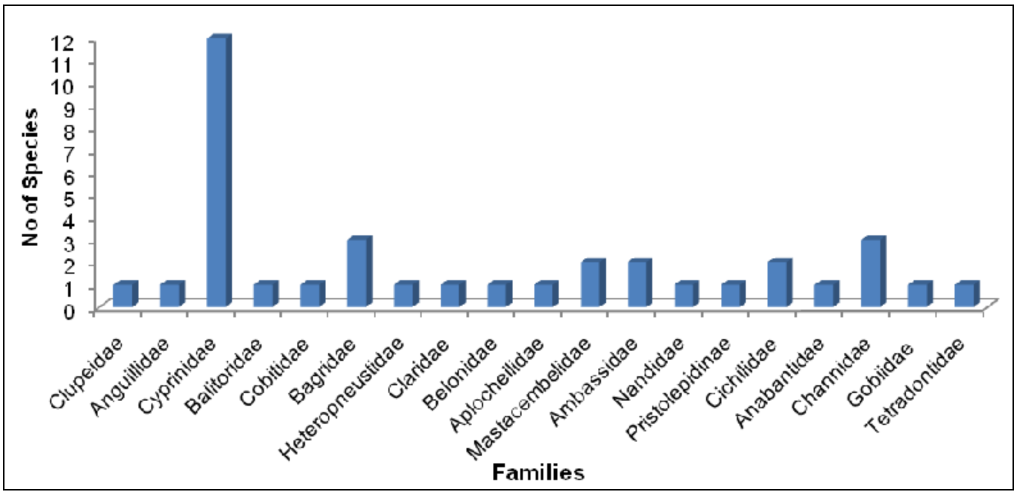


Fig.2.106. Numerical strength of various fish families reported from Puzhakkal river system

Biodiversity status

Among the threatened fishes, *Carinotetradon travancoricus* was the only species coming under vulnerable (VU) species while 33 species were belonged to non-threatened category. 2 species were categorized under data deficient (DD) group while one species belonged to non-evaluated category (NE) (Fig.2.107).

Endemism

9 species were endemic to Western Ghats (EN-WG) of which *Dayella malabarica* and *Macrognathus guentheri* were endemic to the rivers of Kerala (EN-K). 3 species were confined in Indian region (EN-I) and 5 species were restricted to Indian Subcontinent (EN-IS). No exotic species was reported from this river (Fig.2.108).

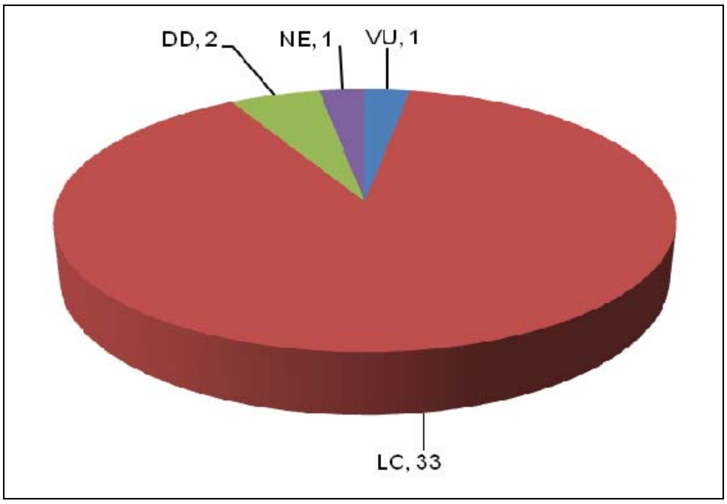


Fig.2.107. Biodiversity status of fishes in Puzhakkal river system

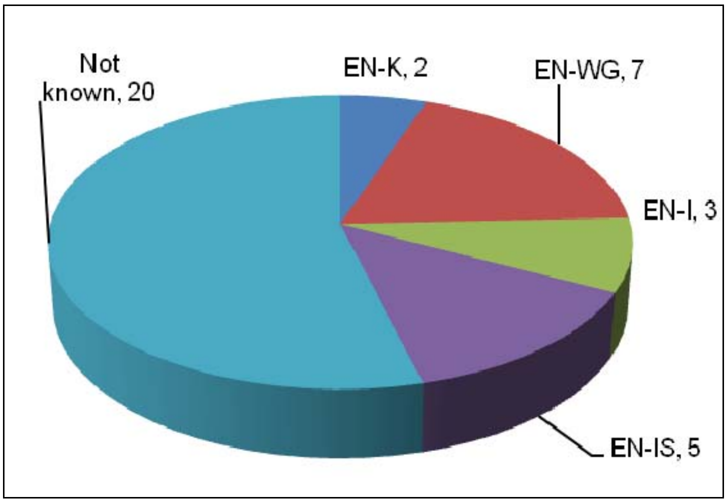


Fig.2.108. Endemic nature of fishes in Puzhakkal river system

2.3.2.36. Shiriya

Fish germplasm resources

The present study revealed that a total of 35 species of fishes belong to 8 orders, 17 families and 23 genera were reported from Shiriya river system. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.40. Order Cypriniformes ranked first with 14 species followed by Perciformes (9 species). Family

Cyprinidae was found as the richest with 12 species. Genus *Puntius* showed the richest germplasm with a numerical strength of 7 species. The numerical strength of different families of fishes reported in Shiriya river system is depicted in Fig.2.109.

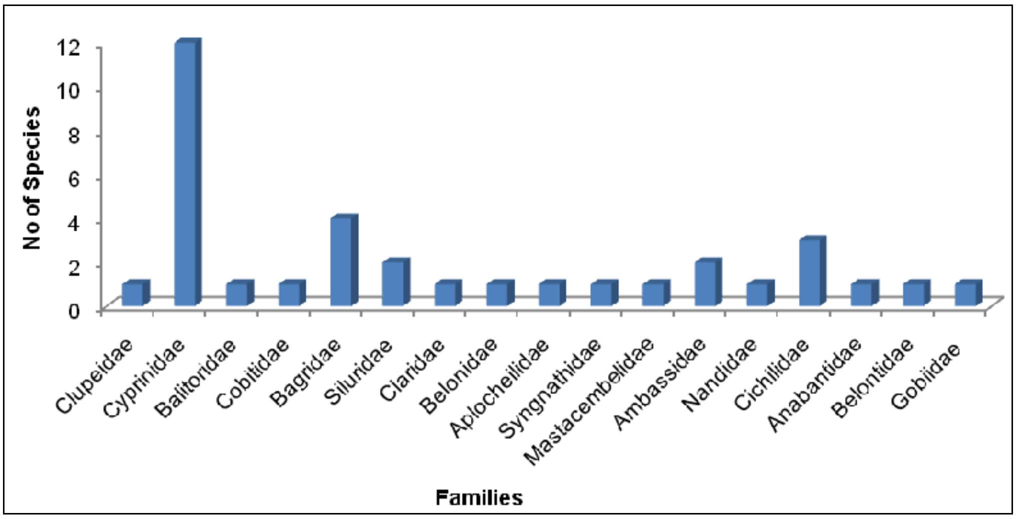


Fig.2.109. Numerical strength of various fish families reported from Shiriya river system

Biodiversity status

Among the threatened group, *Pterocryptis wynaadensis* belongs to endangered (EN) category. 2 species were categorized under data deficient (DD) group (Fig.2.110).

Endemism

7 species were endemic to Western Ghats (EN-WG), among them the distribution of *Dayella malabarica* was confined to Kerala waters (EN-K). 4 species were found endemic to Indian region (EN-I), while 8 species (EN-IS) were endemic to Indian Subcontinent. No species was found strictly endemic to this river system (Fig.2.111).

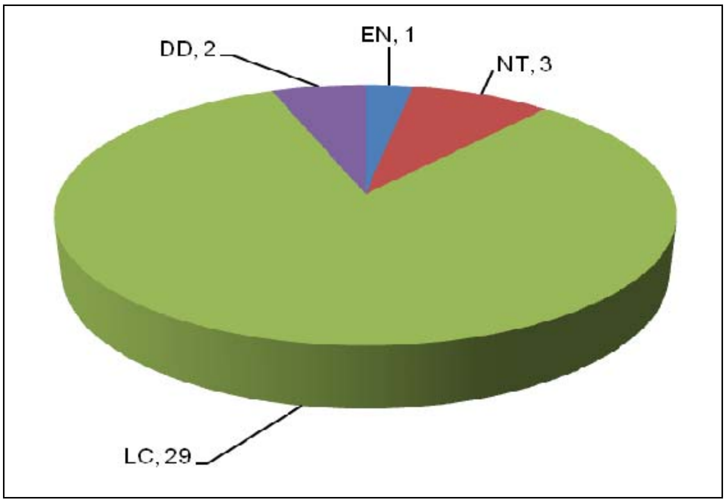


Fig.2.110. Biodiversity status of fishes in Shiriya river system

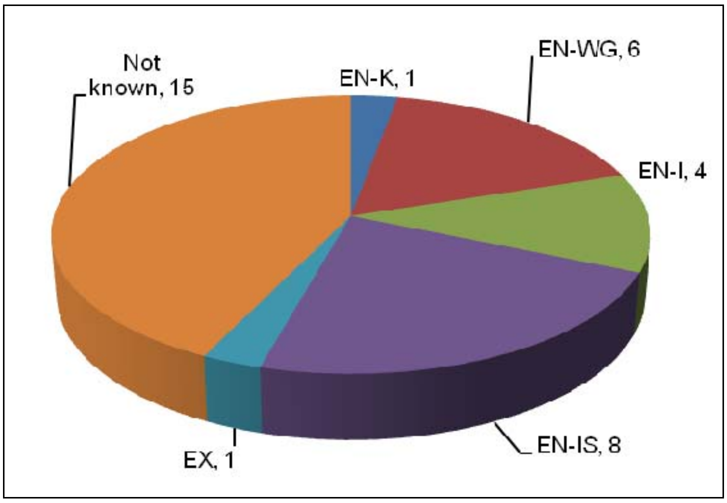


Fig.2.111. Endemic nature of fishes in Shiriya river system

2.3.2.37. Tirur

Fish germplasm resources

34 species of fishes belong to 7 orders, 16 families and 22 genera were reported from Tirur river system. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.41. Order Cypriniformes and Perciformes ranked first with 11 species each. Family Cyprinidae was found richest with 11 species. Bagridae and

Cichilidae were having 3 species each. Genus *Puntius* showed the richest germplasm with a numerical strength of 6 species. The numerical strength of different families of fishes inhabiting in this river is depicted in Fig.2.112.

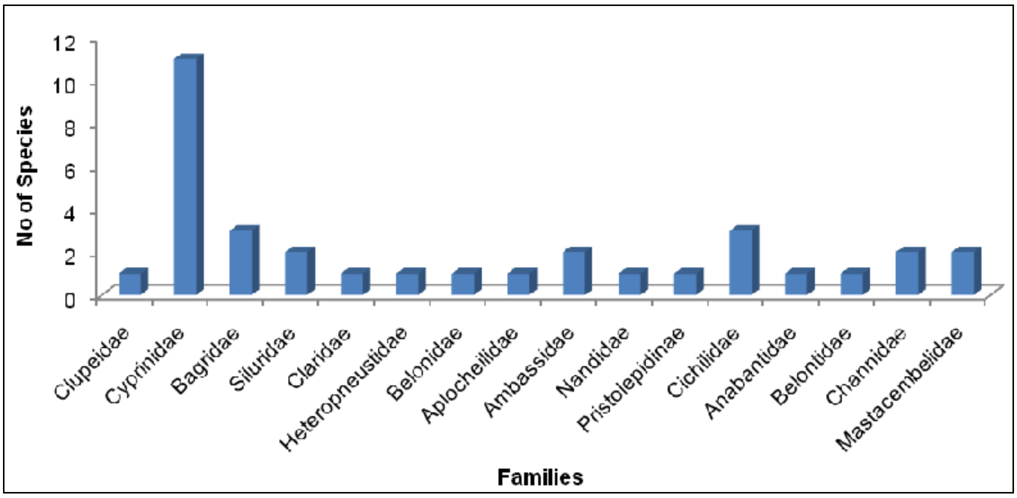


Fig.2.112. Numerical strength of various fish families reported from Tirur river system

Biodiversity status

31 species were under non-threatened category. 2 species were categorized under data deficient (DD) group while one species were under non evaluated category (NE) (Fig. 2.113).

Endemism

7 species were endemic to Western Ghats (EN-WG), among them, the distribution of *Dayella malabarica* and *Macrognathus guentheri* were confined to Kerala waters (EN-K). 3 species were confined to Indian region (EN-I) and 7 species were restricted to Indian Subcontinent (EN-IS) (Fig.2.114).

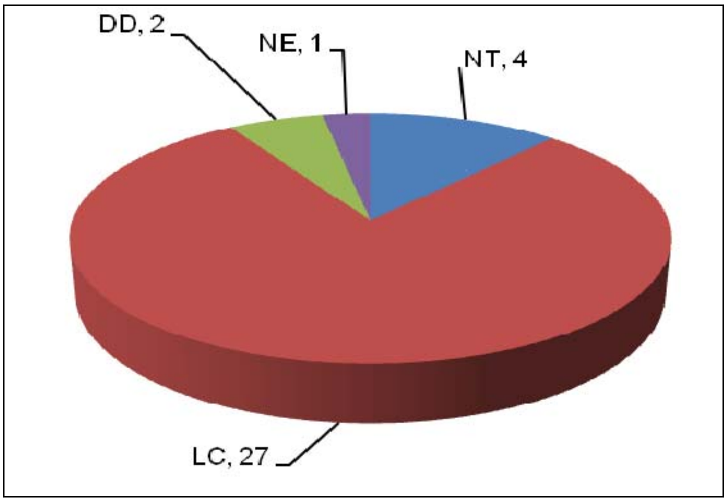


Fig.2.113. Biodiversity status of fishes in Tirur river system

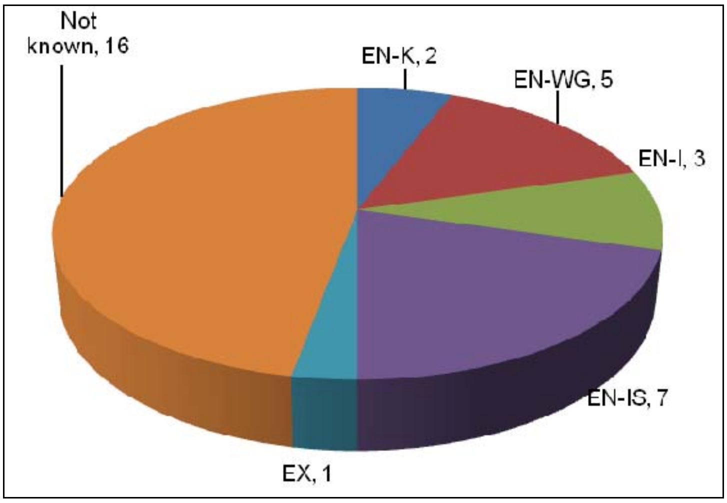


Fig.2.114 Endemic nature of fishes of Tirur river system

2.3.2.38. Vamanapuram

Fish germplasm resources

50 species of fishes belonging to 6 orders, 16 families and 30 genera were reported from Vamanapuram river system. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.42. Order Cypriniformes and Perciformes ranked first and second with 28 and 12 species respectively. Family Cyprinidae was found richest with

22 species followed by Balitoridae and Bagridae (4 species each). Genus *Puntius* showed the richest germplasm with a numerical strength of 10 species followed by Bagridae with 4 species. The numerical strength of different families of fishes reported in the river system is depicted in Fig.2.115.

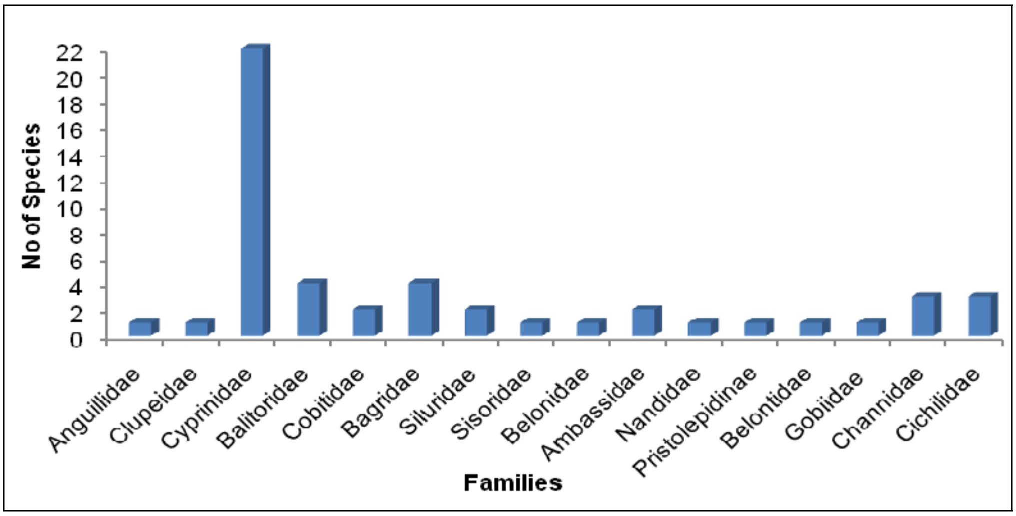


Fig.2.115. Numerical strength of various fish families reported from Vamanapuram river system

Biodiversity status

7 species belong to threatened category while 42 were under non-threatened category. Among the threatened group all species coming under endangered (EN) category. One species were categorized under data deficient (DD) group (Fig.2.116).

Endemism

19 species were endemic to Western Ghats (EN-WG) while distribution of 3 species were restricted to Kerala waters (EN-K). 5 species were confined to Indian region (EN-I) and 7 species (EN-IS) were restricted to Indian Subcontinent (Fig.2.117). *Oreochromis mossambicus* was the only exotic species reported from this river system.

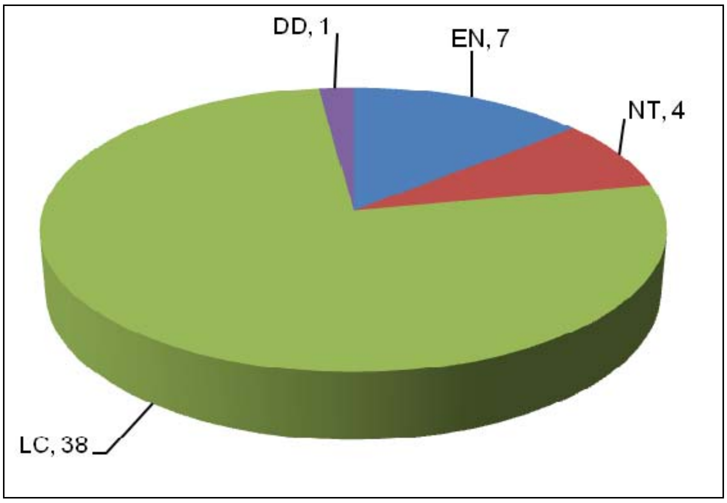


Fig.2.116. Biodiversity status of fishes in Vamanapuram river system

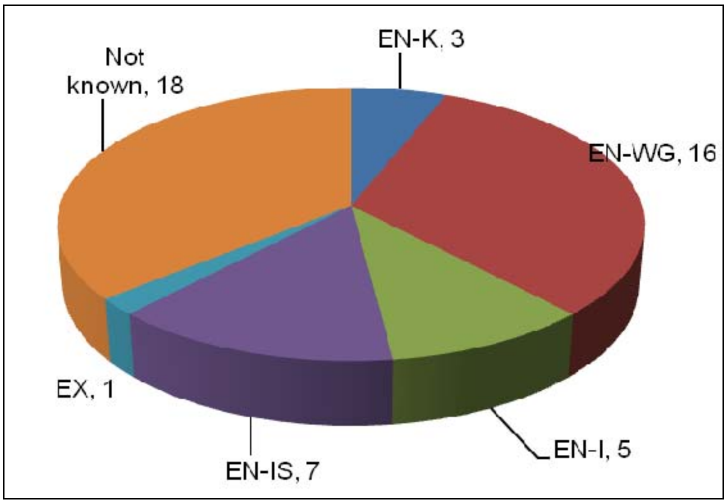


Fig.2.117. Endemic nature of fishes in Vamanapuram river system

2.3.2.39. Valapattanam

Fish germplasm resources

The fish germplasm resources comprised of 73 species belonging to 11 orders, 25 families and 48 genera. The list of fishes reported from this river system together with their commercial name, biodiversity status based on IUCN criteria and the endemic nature of the fishes are given in Table 2.43. The numerical strength of different families of fishes inhabiting in this river system is depicted in Fig.2.118. Order Cypriniformes and Perciformes ranked first and second with 33 and 16 species respectively while families, Cyprinidae and Bagridae were found richest in accomodating maximum number of species with 29 and 6 respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 11 species.

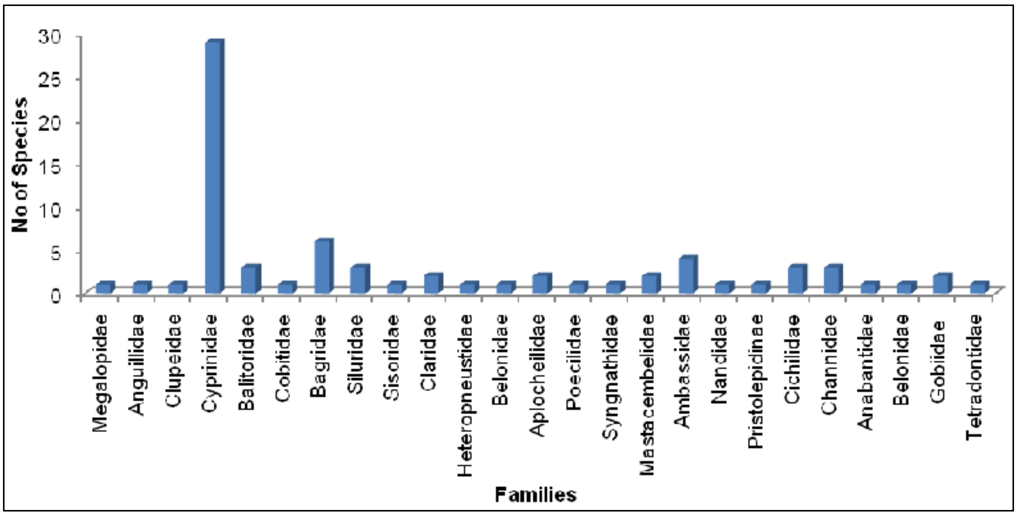


Fig.2.118. Numerical strength of various fish families reported from Valapattanam river system

Biodiversity status

8 species belong to threatened while 59 were under non-threatened category. With in the threatened group, 5 species were endangered (EN) while 3 species under vulnerable (VU) category. 4 species were categorized under data deficient (DD) group (Fig.2.119).

Endemism

25 species were endemic to Western Ghats (EN-WG) while 6 were strictly endemic to Kerala (EN-K). 13 species were endemic to the Indian Subcontinent (EN-IS) and 5 species were endemic to the Indian region (EN-I) (Fig.2.120).

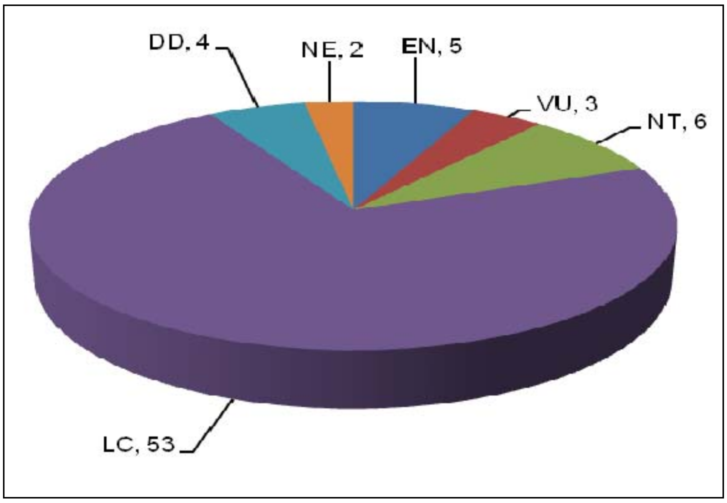


Fig.2.119. Biodiversity status of fishes in Valapattanam river system

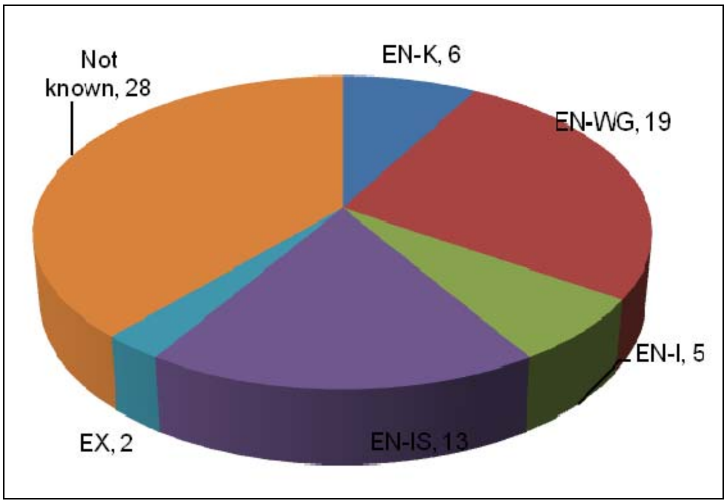


Fig.2.120. Endemic nature of fishes in Valapattanam river system

2.3.2.40. Uppala

Fish germplasm resources

The fish germplasm resources comprised of 27 species of fishes belong to 9 orders, 15 families and 20 genera. Among the orders Perciformes ranked first with 10 species followed by Cypriniformes with 8 species. Family Cyprinidae was found richest accomodating a maximum number of 8 species. Genus *Puntius* showed the richest germplasm with a numerical strength of 4 species. The list of fishes reported from this river system together with their commercial name, biodiversity status based on recent IUCN criteria and the endemic nature of the fishes are given in Table.2.44. The numerical strength of different families reported in Uppala river system is depicted in Fig 2.121.

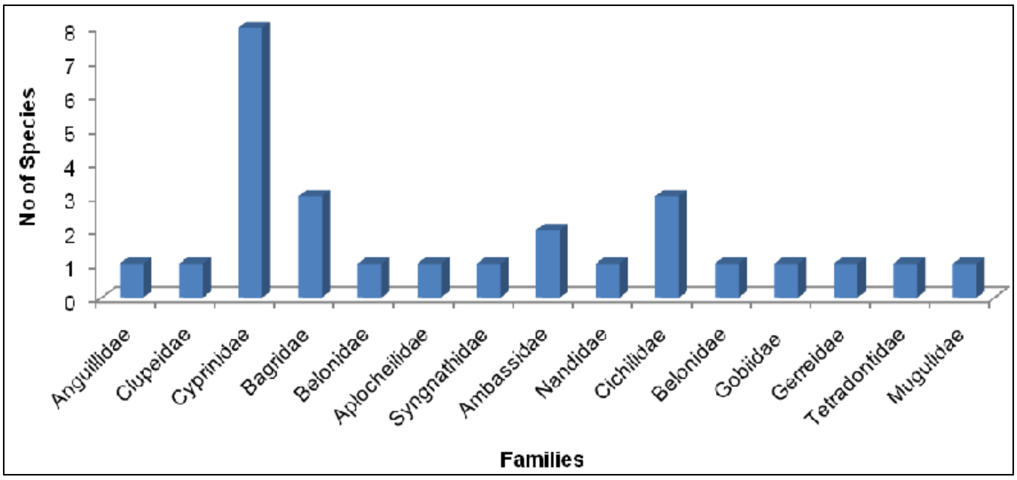


Fig.2.121. Numerical strength of various fish families reported from Uppala river system

Biodiversity status

25 species reported from this river system belonged to non-threatened. One species each were categorized under data deficient (DD) and non evaluated category (NE) (Fig.2.122).

Endemism

3 species were found endemic to Western Ghats (EN-WG), among them *Dayella malabarica* was restricted to Kerala waters (EN-K). The distribution of 4 species confined to Indian waters (EN-IS) whereas 7 were restricted to Indian Subcontinent (EN-IS) (Fig 2. 122). *Oreochromis mossambicus* was the only exotic species (EX) reported from this river system. No species was found strictly endemic to this river system (Fig.2.123).

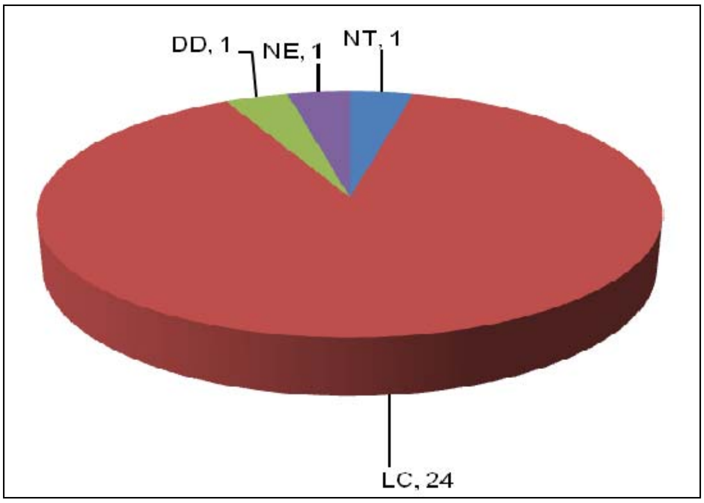


Fig.2.122. Biodiversity status of fishes in Uppala river system

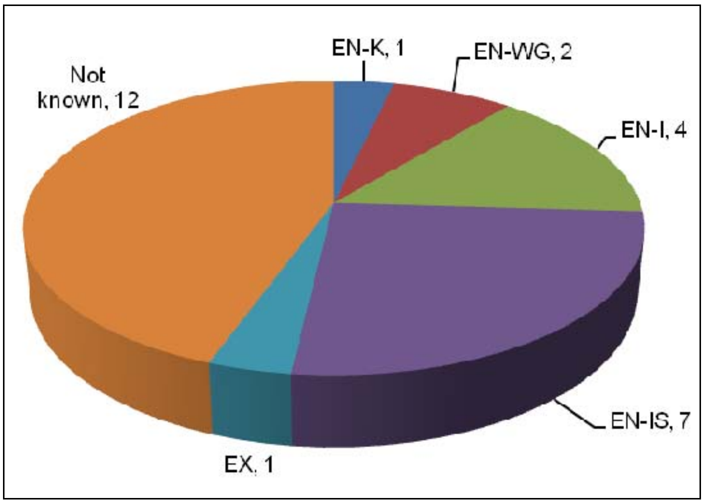


Fig.2.123. Endemic nature of fishes in Uppala river system

2.3.3. Nature and level of fish species diversity-A comparative study among river systems of Kerala

While comparing the fish diversity of various river systems of Kerala, Periyar river system showed richest fish species diversity in terms of total number of species, number of ornamental fish species and cultivable fishes, degree of endemism, fish species endemic to the particular river system, number of endangered and threatened species and was also characterised by the highest river index value of 841 (Table.2.45). Chalakudy river system occupied second position and recorded an index value of 442. This is followed by Bharathapuzha river system with an index value 439 which abounds 10 endemic species of Kerala besides 3 species endemic to this particular river system. Chaliyar river stands next with an index value of 277, is endowed with 6 endemic species of Kerala and 2 species endemic to this river system. Muvattupuzha, Achenkovil, Kabbini, Pamba and Vamanapuram rivers showed relatively rich species diversity as indicated by their indices values 274, 261, 245, 244 and 222.5 respectively while Kallada, Pambar and Kariangode rivers have moderate species diversity with indices values of 203, 200 and 188, respectively. All other rivers were having low indices values due to their low species diversity (Fig.2.124). It would thus appear that Chalakudy, Bharathapuzha and Periyar belonged to “excellent” as hot spots of fish diversity while Achenkovil, Chaliyar, Kabbini, Kallada, Muvattupuzha, Pambar and Pamba were ‘Good’ whereas 13 river systems were ‘moderate’. 16 river were found as ‘poor’ owing to their poor representation of species diversity. The areas harbouring rich species diversity and deserving immediate protection were demarcated for each rivers. While comparing the rivers based on the river index values per km^2 of the catchment area of the rivers, a different picture is emerging (Fig.2.125). Kallai river showed highest (0.88) which is followed by Uppala (0.78), Tirur (0.73), Ayoor (0.68) and Nileswar (0.62). Bharathapuzha and Kabbini (0.10 each), Chaliyar, Meenachil, Pamba (0.11 each), Kadalundi, Karamana (0.12 each) were showing lowest index values per km^2. The large and highly diversified river system such as Periyar (0.16), Bharathapuzha (0.10), Pamba (0.11) and Achenkovil (0.17) were showing only low indices values.

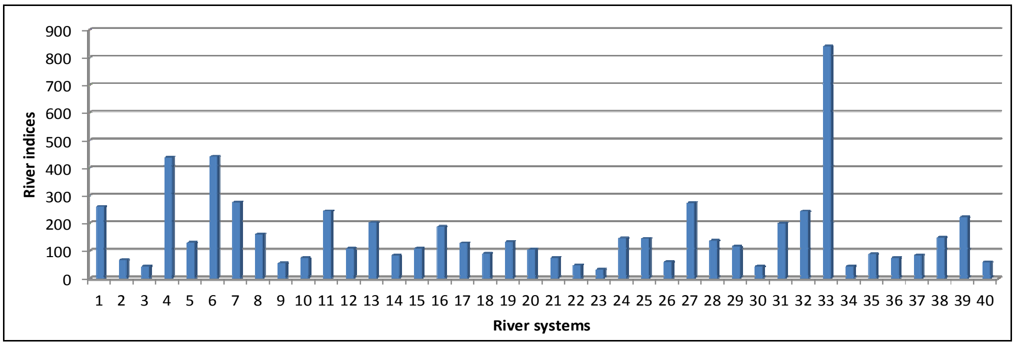


Fig.2.124. Comparison of river system of Kerala based on river index values

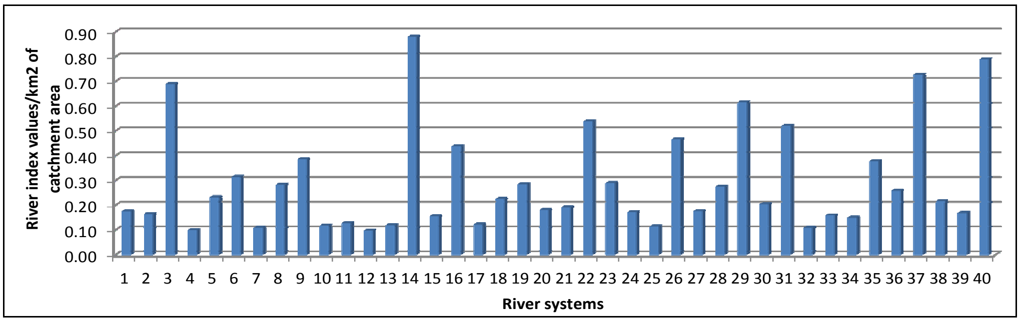


Fig.2.125. Comparison of river system of Kerala based on river index values/km2 of the catchment area

1	Achenkovil	11	Kabbini	21	Mahe	31	Pambar
2	Anjarakandy	12	Kadalundi	22	Manjeswar	32	Pamba
3	Ayoor	13	Kallada	23	Mamom	33	Periyar
4	Bharathapuzha	14	Kallai	24	Manimala	34	Peruvamba
5	Bhavani	15	Karamana	25	Meenachil	35	Puzhakkal
6	Chalakudy	16	Kariangode	26	Mogral	36	Shiriya
7	Chaliyar	17	Karuvannur	27	Muvattupuzha	37	Tirur
8	Chandragiri	18	Keecheri	28	Neyyar	38	Vamanapuram
9	Chittari	19	Kuppam	29	Nileswar	39	Valapattanam
10	Ithikkara	20	Kuttiadi	30	Pallikkal	40	Uppala

2.3.4. Distribution of freshwater fishes of Kerala-A comparison between river systems

While comparing the fishes from different rivers based on their distribution, it was found that species such as *Rasbora daniconius* was found abundant in all the rivers. *Puntius filamentosus, Devario malabaricus* and *Etroplus maculatus* were reported in 38 rivers whereas *P. vittatus, P. ticto, Devario aequipinnatus, Garra mullya* and *Aplochelius lineatus* were found in 37 rivers. *Xenetodon cancila* and *Glossogobius giuris* were encountered from 35 and 34 rivers respectively. *Puntius amphibius, Amblypharyngodon melettinus, Mystus armatus* and *Parambassis thomaasi* were recorded from 33 rivers while *M. oculatus* was distributed in 33 rivers. Species such as *Barilius gatensis, Lepidocephalichthys thermalis, Ompok bimaculatus, Clarias batrachus* and *Heteropneustes fossilis* were recorded in 29 rivers while *Nemacheilus triangularis* and *Mystus malabaricus* were found in 28 rivers. *Dayella malabarica, Salmophasia boopis* and *Channa striatus* were recorded in 27 rivers. Species such as *Cirrhinus reba, Labeo azira, Labeo nigriscens, Hypselobarbus periyarensis, Hypselobarbus micropogon, Osteobrama cotio penisularis, Puntius chalakkudiensis, Puntius exclamatio, Puntius madusoodani, Barbodes bovanicus, Tot tor, Tor putitora, Tor malabaricus, Tor remadevi, Crossocheilus periyarensis, Salmophasia balookee, Amblypharyngodon mola, Devario fraseri, Dario urops, Laubuca laubuca, Lepidopygopsis typus, Garra travancoria, Garra periyarensis, Garra mlapparaensis, Garra annandalei, Garra nilamburensis, Horalabiosa arunachalami, Homaloptera santhamparaiensis, Homaloptera silasi, Homaloptera pillaii, Homaloptera menoni, Nemacheilus periyarensis, Nemacheilus nilgiriensis, Nemacheilus mooreh, Nemacheilus petrubanarescuii, Mesonoemacheilus remadevii, Mesonoemacheilus pambarensis* and *Longischistura striata* were found only in a single river system. The distribution of the fishes in different river systems of Kerala are shown in Fig.2.126 and Table 2.46

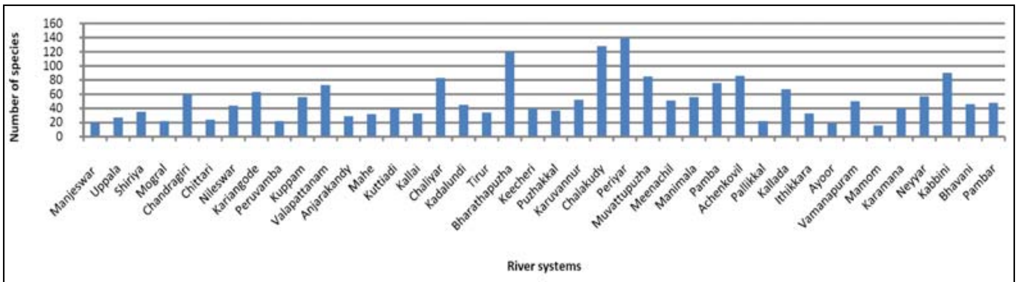


Fig.2.126. Fish species diversity in different river systems of Kerala

2.3.5. Species diversity Vs Length of river system

The species diversity values (in terms of total no. of species reported from a river system) were plotted against length of the river system and the scatter diagram so obtained showed an increasing trend line graph which clearly indicates that there exist a direct relationship between species diversity and length of the river system (Fig.2.127). The highest diversity was shown by Periyar river system (139 species) (Fig.2.128), which has a length of 244km whereas Bharathapuzha having a total length of 209 km is endowed with 120 species while Chalakudy river system with 144 km length abound 128 fish species. Lowest species diversity was observed in Mamom, Ayoor, Manjeswaram river systems (16, 19 and 20 respectively), the respective lengths are 27, 17 and 16 km. It can therefore, be concluded that, higher the length of the river system, higher the species diversity and vice versa. In contrast, while plotting the species diversity in terms of number of species in the unit area of the river system against the length of the river system, an inverse relationship was found (Fig.2.129). It appeared that by every increase in length of the rivers, the species diversity per unit area showed a reduction. The results revealed that in larger river systems such as Periyar, Bharathapuzha, etc. the species diversity available in unit area of the river system is very low when compared to smaller river systems. The results of the index values further confirm that the smaller river systems are endowed with high species diversity per km^2 area.

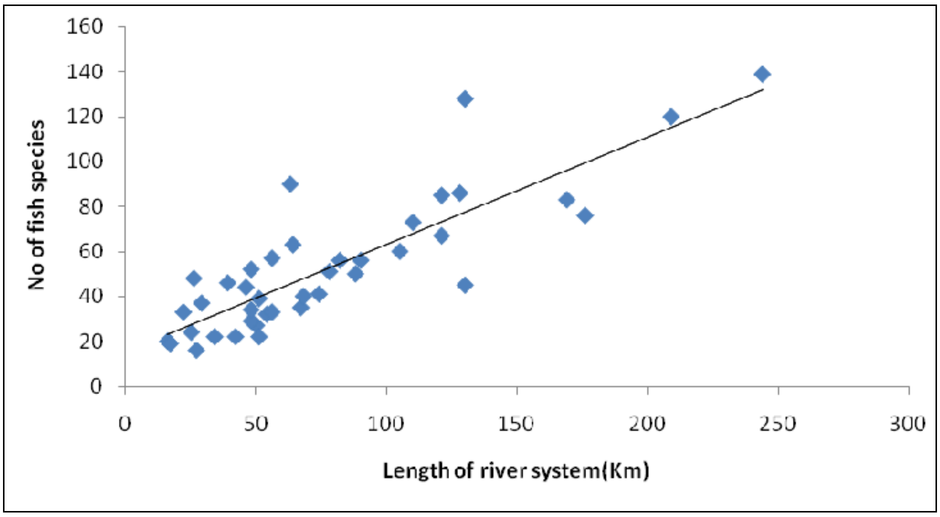


Fig.2.127. Species diversity vis-a-via total length of the river system

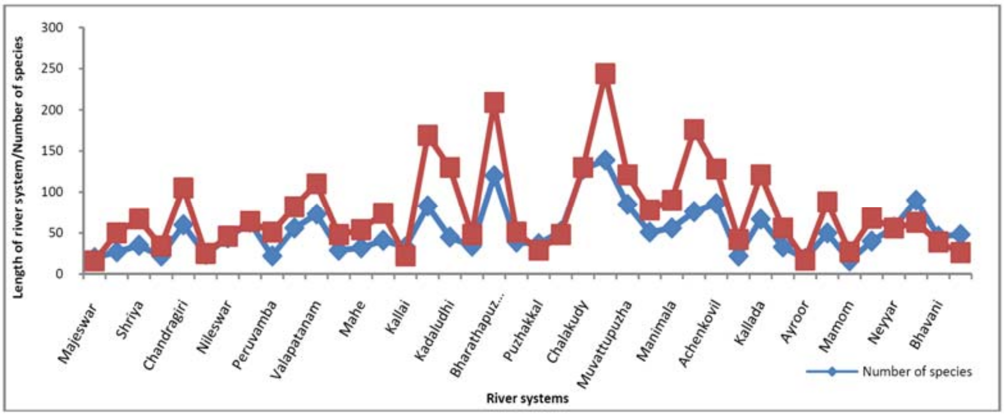


Fig.2.128. Species diversity vs total length of the river system

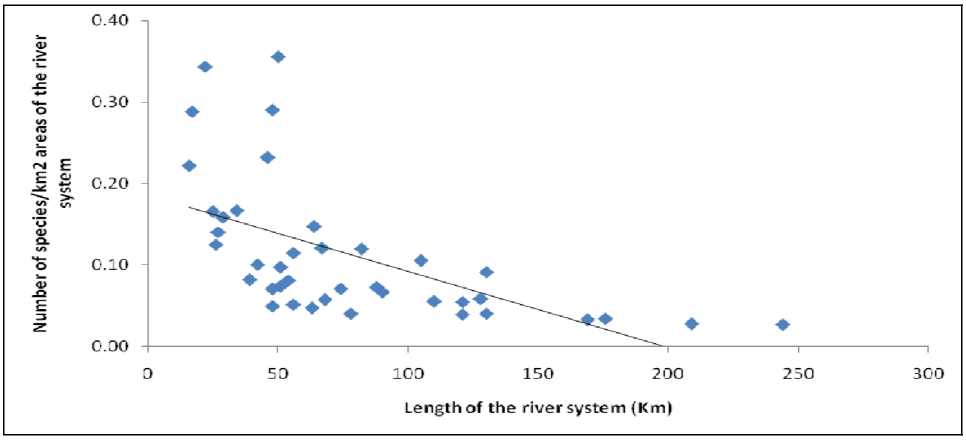


Fig.2.129. Species diversity/Km2 vis-à-vis total length of the river systems

2.3.6. Species diversity Vs Catchment area of the river system

The species diversity (in terms of total no. of species reported from a river system) was plotted against the increasing order of catchment area of the river systems in a scatter diagram (Fig.2.130) and the results revealed that species diversity generally increases with increase in catchment area. Periyar and Bharathapuzha river systems which are having the largest catchment areas (5284 and 4400 km^2 respectively) harbour a large number of species (139 and 120) whereas rivers having smaller catchment areas such as Ayoor, Uppala and Manjeswar (66, 76 and 90 km^2 area respectively) showed lesser number of species (19,27 and 20 respectively). However, when the species diversity in unit area were plotted against the increasing order of catchment area, an inverse trend are observed in the scatter diagram (Fig.2.131) and this would indicates that the unit diversity in terms of number of species of a particular river system also decreases with increase in catchment area. Lower values (0.03 each) were obtained for larger river systems such as Periyar, Bharathapuzha (catchment areas 5284 and 4400 km^2 respectively) in contrast it was high (0.36, 0.34 and 0.29) for smaller river systems such as Uppala (76 km^2), Kallai (96km^2) and Ayoor (66km^2). It can therefore be concluded that species diversity increases with increase in catchment area of the river system while the species diversity in unit area of the river system decreases with increase in catchment area.

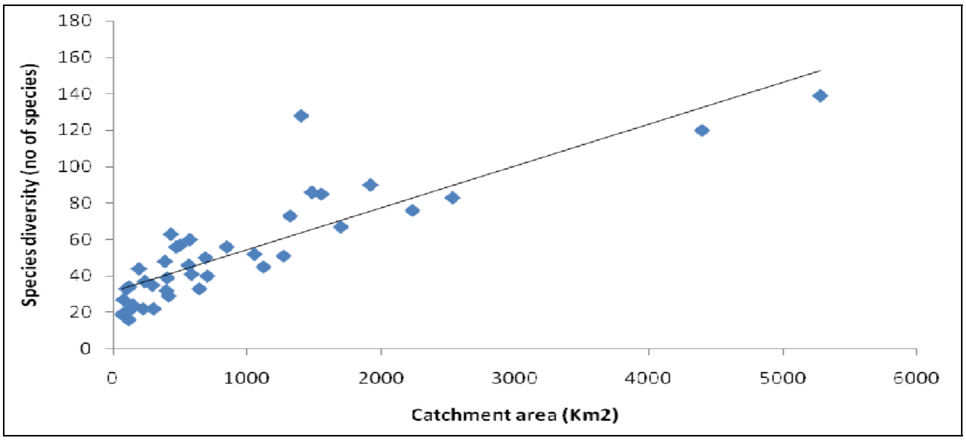


Fig.2.130. Species diversity vis-à-vis total catchment area of the river system

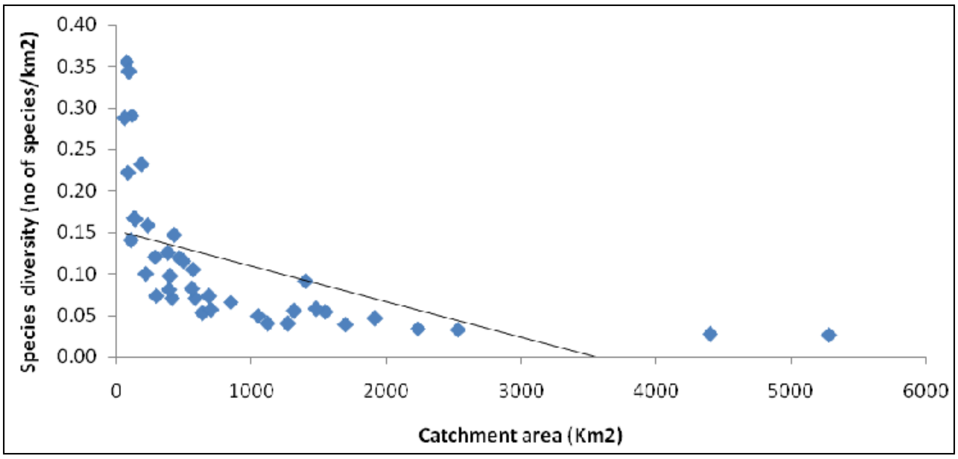


Fig.2.131. Species diversity/km2 vis-à-vis catchment area of the river system

2.4. Discussion

The Western Ghats and the associated rivers and streams of Kerala are very rich in freshwater fish diversity because of the latitudinal and altitudinal gradient phenomenon. (Kottelat and Whitten,1996; Shaji *et al.,* 2000; Dahanukar *et al.,* 2004). It is one of the 34 designated biodiversity hotspots of the world (Bossuyt *et al.,* 2004). Rivers of South India are one of the most fertile fields of icthyobiodiversity and the recent intensive investigation on the icthyodiversity could help to locate new species or find out new facts regarding the status and distribution of fishes already described (Menon, 1999). In the World Bank technical report, streams of Kerala have been reported as one of the few sites in the world showing exceptional biodiversity and high degree of endemism of freshwater fishes (Kottelat and Whitten, 1996). However, many of these fish species have already threatened or endangered due to variety of anthropogenic pressures (Kurup *et al.,* 2004). Dahanukar *et al.* (2004) opined that, uniqueness in species diversity in southern region of Western Ghats is due to the connectivity of the rivers of southern Ghat region alone and not with the rivers of central and northern Ghat region, thus restricting the dispersal of the species only to the southern region. The results of the present study on the freshwater fish germplasm resources, biodiversity assessment and endemism fully concur with the findings of Kottelat and Whitten (1996).

234 freshwater fish species belonging to 16 orders, 51 families and 104 genera were reported from 40 rivers of Kerala in the present study. According to Mathews (1998), the number of species per family in temperate river assemblages are high whereas in tropical river assemblages, though there are very few species per family, the number of families are very high. In Kerala three among the 51 families such us Cyprinidae (98 species), Balitoridae (26) and Bagridae (14) together accounted for 60% of the total species reported. Family Cyprinidae comprising carps and minows are the most dominant family

of the freshwater fishes of Asia than any other freshwater fish family and this family also represents as world's largest primary freshwater fish family (Roberts, 1989; Nelson, 1994). The results of present investigation confirmed that the fish fauna of Kerala shares similarity with many south-east Asian countries. Many of the reported species in this study such us Cyprinids (*Barilus, Garra, Labeo, Cyprinus, Puntius*), Murrels (*Channa* sp), Cat fishes (*Clarias, Mystus*), Mastacembelids (*Mastacembelus*) and Anguillidae (*Anguilla* sp) are all invariably common in south-east India. Dahanukar *et al.* (2004) collected 288 species from Western Ghats, among them, Cypriniformes were the most predominant order (57% of fish species) followed by Siluriformes (18%). Family Cyprinidae (45%) appeared as the richest family followed by Balitoridae (9%). In the present study, 59% of the fish species belongs to order Cypriniformes, which evince the preponderance of this order in the rivers of Kerala. During the recent IUCN categorization of freshwater fishes of Western Ghats, Dahanukar *et al.* (2011) reported 290 species belonging to 11 orders and 33 families. Cypriniformes (178 species) stands in terms of species number followed by Siluriformes (50 species).

Days (1865), in his memorial treatise (The Fishes of Malabar) had listed 228 species from Malabar. Pillay (1929) and John (1936) listed 236 species and 124 species respectively from Travancore. Hora and Law (1941) recorded 76 species occurring in the freshwater of Travancore, while Silas (1949) collected 33 fish species belonging to 23 genera and 16 families from Travancore. Menon (1997) listed 18 threatened fishes from Malabar, among them 7 were rare while 11 were endangered. In the present study, 59 fish species were found threatened which included 5 critically endangered, 36 endangered and 18 vulnerable species. High number of threatened fish species in the fish diversity is an indication of the high rate of endangerment of the fish fauna had undergone in Kerala rivers during the past. The result of biodiversity assessment on threatened fishes is fully agrees with that of Radhakrishnan (2006) who reported 145 fish species belonging to

12 orders, 28 families and 66 genera from of Kerala rivers. According to the author, 59 species belonged to threatened (8 were critically endangered, 36 endangered and 15 vulnerable) while 68 as non-threatened fishes whereas 3 were transplanted from other countries. Cyprinidae was the richest family with 21 genera (67 species) followed by Balitoridae and Bagridae while *Puntius* (17 species) and *Garra* (12 species) were the richest genera. 52 species were endemic to Western Ghats, among them 21 were endemic to Kerala. Gopi (2000) reported 207 fish species from rivers of Kerala based on the data computed from literature. Shaji and Easa (2000) reported 207 species, among them 41 were ornamental, of which 9 are strictly endemic to Kerala waters. Kurup (2000) reported 170 freshwater fishes from Kerala among them, 18 were critically endangered species, 13 of them are endemic to the state while Ajithkumar *et al.* (2000) reported 115 fish species belonging to 58 genera, 27 families and 10 orders from Kerala part of Western Ghats. Subsequently Kurup *et al.* (2004) based on survey and sampling from rivers, listed 175 fish species under 13 orders, 29 families and 65 genera. The authors classified, 18 as critically endangered, 38 endangered, 28 vulnerable, 21 low risk nearly threatened and 34 species low risk least concern species. The authors also reported 33 endemic fish species to the rivers of Kerala. In the present study, nearly 16% of the fishes were found as endemic to Kerala region. Easa and Basha (1995), based on their study on the stream fishes of Kerala part of Nilgiri Biosphere Reserve, reported 91 species under 24 families and 46 genera which also include *Cyprinus carpio, Poecilia reticulata* and *Oreochromis mossambicus* which are exotic in their origin.

There are studies which were done in a specific stream or a group of streams at a geographical entity also showed the uniqueness and diversity within them (Russell *et al.,* 2003). Raju Thomas *et al.* (2002) recorded 117 fish species belonging to 58 genera, 27 families and 10 orders from rivers flowing through Southern Kerala, which comprisessd of 5 critically endangered and 31 endangered species including 11 species which are endemic to Kerala. An endemic fish is a fish species found exclusively in a country or a drainage system where it is native. Endemism enhances the conservation value of the species (Molur and Walker, 1998). Biju (2003) reported 96 species belonging to 53 genera of 24 families and 8 orders from 20 rivers of Northern Kerala. The most abundant family was Cyprinidae with 17 genera (45 species), followed by the families Balitoridae and Bagridae, with members from 4 genera (9 species) and 3 genera (8 species) respectively. Seven species were endemic to Kerala and 40 species were endemic to the Western Ghats.

83 freshwater fish species belonging to 12 orders, 25 families and 51 genera were reported from Chaliyar river system including two introduced (*Poecilia reticulata* and *Oreochromis mossambicus*) in the present study and this in comparsion with Radhakrishnan (2006) are very high. The author reported only 40 species belonging to 4 orders and 15 families from this river. However, Easa and Shaji (1995) recorded a total number of 50 species belonging to 21 families and 34 genera from this river, among them 4 are endemic to Western Ghats (*Puntius denisonii*, *Osteobrama bakeri*, *Batasio travancoria* and *Carinotetradon travancoricus*) including one new species (*Pangio bashi*). These authors reported *Microphis cunculus* one of the estuarine species from hill stream area of the river. The occurrence of these species, especially from Chaliyar river indicates that hill stream can also be a good habitat for the species. Raghunathan (1995) in the same year, identified 49 species belonging to 27 genera from this river. His study was mainly concentrated to the estuarine region and reported 21 estuarine and marine fish species. In freshwater region of this river, there were only 28 species (Raghunathan,1995).

Easa and Shaji (1996) reported 11 species of fishes from Chinnar wildlife sanctuary of Pambar river including two endangered fish species viz, *Garra menoni* and *Barilius bendelisis.* In the present study 48 species belong to 4 orders, 13 families and 27 genera were reported from Pambar river system including two strictly endemic fishes viz, *Mesonoemacheilus pamabarensis* (Kurup *et al*., 2004; Remadevi and Indra, 1994) and *Tor remadevii* (Kurup and Radhakrishnan, 2010). Raju Thomas *et al.* (1999) reported three exotic species viz, *Oncorhynchus mykiss, Oreochromis mossambicus* and *Cyprinus capio* from this river. These are 'serious pests' and not rediscovered as part of previous studies from this river. So this is a matter of grave concern from the biodiversity point of view.

Bijukumar and Sushama (2001) reported 61 species of fishes under 11 orders, 30 families and 50 genera from Bharathapuzha river system, among them 13 were secondary freshwater fishes. Of these, *Batasio travancoria* and *Carinotetradon travancoricus* are endemic to Kerala while *Corica soborna*, *Chela dadiburjori* and *Lepidocephalus guntea* are new records. Among 61 species of fishes, 24.59% were noted under the "very rare" and 31.15% 'under rare' category. The authors also confirmed the occurrence of *Barilius bendelisis* in Kerala. 120 species of fishes under 15 orders, 40 families and 73 genera were reported from Bharathapuzha river system in the present study including three exotic species (*Poecilia reticulata*, *Oreochromis mossambicus* and *Oreochromis niloticus*) and 18 secondary freshwater' fishes. The river showed a rich diversity of IMC (*Gibelion catla, Cirrhinus mrigala, Labeo rohita*). On the other hand, Shaji and Easa (2002) reported a new loach species, *Mesonoemacheilus remadevi* from Silent valley area of Bharathapuzha river. Bijukumar (2008) reported the invasion of *Oreochromis niloticus* (Nile Tilapia) which was the first report from natural waters of Kerala. Quite recently *Pseudolaguvia austrina,* new fish species was reported from Bharathapuzha river (Radhakrishnan *et al.*, 2010).

From Chandragiri river system, 60 species under 7 orders, 18 families and 36 genera were reported including three species ie. *Dayella malabarica, Puntius denisonii* and *Osteobrama bakeri* which are strictly endemic to Kerala waters (EN-K). Biju (2003) recorded 50 species from this river including one exotic species; *Oreochromis mossambicus*. Rajan (1995) recorded 45 species from the head waters of Bhavani river. In the present study 46 species of fishes under 5 orders, 13 families and 27 genera were recorded, including 2 species which are strictly endemic to the state. *Garra menoni* and *Homaloptera menoni* are the endemic fishes. Easa and Basha (1995) reported 19 species from Bhavani river and 16 species from Muthikkulam Siruvani area, a part of this river and 24 species were recorded from this river system. *Homaloptera menoni* is a new addition from the Siruvani area and *Oreochromis mossambicus* and *Balitora mysorensis* are new additions to Bhavani river (Shaji and Easa, 1996). Recently, Radhakrishnan (2006) reported only 16 species from this river including one new distribution range of extension to this river by *Hypselobarbus dubius*. Mukerjee (1931) reported *Callichrous bimaculatus*, *Aoria punctatus*, *Barbus arulius*, *Barbus carnaticus*, *Barbus micropogon mysorensis, Devario aequipinnatus, Barbus gatensis*, *Scaphiodon brevidorsalis* and *Scaphiodon nashii* from Bhavani.

128 species of fishes belonging to 14 orders, 43 families and 75 genera were reported from Chalakudy river system in the present study. The total number of fish species of this river system including those reported during the past (Silas, 1951; Thobias, 1973; Antony, 1977; Inasu, 1991; Pethiyagoda and Kottelat, 1994; Biju *et al*., 2000) thus worked out to be 98. Ajithkumar *et al*. (1999) reported 98 fish species belonging to 34 families and 10 orders from this river including 12 secondary freshwater fishes. *Salarias reticulatus* (*Entomacrodus vermiculatus*) was one new species discovered from Chalakudy river (Kurup *et al*. 2005). Recenlty, Raghavan *et al*. (2008b) reported 71 fish species including 3 species, *Homaloptera montana*, *Horabagrus nigricollaris* and *Osteochilus longidorsalis* which are strictly endemic to this river. The author also reported the presence of four exotic species in this river system.

Raju Thomas *et al*. (2000a) reported 37 freshwater fishes from Peechi-Vazhani Wildlife sanctuaries, drained by Karuvannur and Keecheri river.

Probably their collection was mainly from Peechi and Vazhani reservoirs which include *Cyprinus carpio, Gibelion catla, Labeo rohita* and *Cirrhinus mrigala* which were stocked in the reservoir towards increasing the fish production. After two years, Raju Thomas (2002) also reported another alien fish *Ctenopharyngodon idella* (grass carp) from this river system. In the present study 52 species of fishes belong to 8 orders, 19 families and 31 genera and 39 species of fishes belonged to 6 orders, 15 families and 25 genera were reported from Karuvannnur and Keecheri river systems respectively.

90 species of fishes belongs to 8 orders, 20 families and 48 genera were reported from Kabbini river system including 36 endemic species to Western Ghats. Hora (1942) listed 63 fish species and Arunachalam *et al*. (2000b) reported 37 species from Wayanad district. Shaji and Easa (1996) studied the fish diversity of this river and collected 58 species belonging to 17 families and 31 genera including 25 endemic fishes of Western Ghats. The authors also reported *Osteochilus brevidorsalis*, *Labeo potail*, *Brachydanio rerio, Nemacheilus nilgiriensis* and *N. petrubanarescui* for the first time from Kerala rivers and exotic and transplanted species such as *Cyprinus carpio, Oreochromis mossambicus, Poecilia reticulata* and *Labeo rohita* from this river. Biju (2003) reported 59 species from this river, however *Cyprinus carpio* was not in the list. Radhakrishnan (2006) reported 53 species including one critically endangered fish, *Barbodes wynaadensis* from this river system.

In the present study, 86 species of fishes under 10 orders, 26 families and 49 genera were reported from Achenkovil river system including 7 endemic (EN-K) fishes such us *Dayella malabarica, Osteobrama bakeri, Puntius denisonii, Laubuca fasciata, Garra surendranatahnii, Puntius chalakkudiensis* and *Hyporhamphus xanthopterus.* Varghese (1994) recorded 64 species from Achenkovil drainage including many marine and brackish water species. However, no exotic fish species was listed in the study.

Radhakrishnan (2006) reported 49 species including one introduced fish i.e., *Oreochromis mossambicus*. Recently, Fibin *et al.* (2011a) accounted 46 freshwater fish species belonging to 17 families and 31 genera from upstream parts of Achenkovil river (Achenkovil reserve forests) which accomodates three endemic fish species to Kerala region (*Garra surendrananthanii*, *Laubuca fasciata* and *Puntius chalakkudiensis*). The author reported *Puntius chalakkudiensis,* an example showing extension range of an endemic fish species in Kerala river from Chalakudy to Achenkovil.

Despite these sporadic attempts of fish faunistic listing of a particular river system or a few rivers, majority of the studies were carried out with a view to list the fish fauna of ecologically sensitive, biodiversity rich or geographically significant regions of Kerala. The Periyar lake and stream system were subjects of series of studies for its ichthyofaunal diversity by many scientists. 139 species of freshwater fishes under 11 orders, 29 families and 66 genera were reported from Periyar river system in the present study, which is comparing with previous studies, is very high and extremely rich. The Periyar tiger reserves is one of the biodiversity rich areas in Western Ghats from where Periyar river originate, harbour many endemic and threatened species of fishes (Silas,1950,1952; Zacharias *et al.* 1996). Chacko (1948) reported 33 species from Periyar Lake and stream system. This in comparison with present report shows that many fish species might have disappeared in recent years from this lake due to various man made intervention. The fishes so disappeared include *Puntius melanostigma, P. arulius, P. pinnaratus and Barilius bendelesis*, *Garra lampta*, *Chela boopis*, *Mystus vittatus* and *Notopterus notopterus*, which looks very serious concerns from the biodiversity conservation point. Interestingly, many species which are not listed by Chacko (1948) were encountered in the present study. Indra and Remadevi (1990) described 19 species of fishes belong to 8 families from Thekkadi Wild life reserve. Menon and Remadevi (1995) described

Hypselobarbus kurali from streams of Periyar river. Later, Menon and Jacob (1996) described 38 fish species from Periyar Lake including one new fish *Crossocheilus periyarensis* and rediscovered the barb, *Puntius ophiocephalus.* Arun (1997) reported 27 species from Periyar lake-stream system which included 12 endemic species of Western Ghats besides 3 species which are strictly endemic to Periyar Tiger Reserve. According to the author, 16 species were disappeared from Periyar lake-stream system and among the existing species, *Garra mullya, G. mcclelandi* and *Hypselobarbus curmuca* are the most abundant species while species such as *Travancoria jonesi, Channa gauchua, C. striatus* and *Glyptothorax madraspatnus* are very rare in recent years. Arun *et al.* (1996) reported the occurrence of two exotic species for the first time in this lake. According to Zacharia *et al.* (1996), the distribution of the above two exotic species were strictly restricted to the lentic waters of the reservoir and the author reported 35 fish species from this lake. Subsequently, Kurup and Ranjeet (2002) reported that the invasion of the exotic species be cause threats to the indigenous and endemic fish fauna of the lake. More recently, Radhakrishnan and Kurup (2010) reported 54 species under 6 orders and 19 families from Periyar Tiger Reserve and adjoining streams. Among them, six species are found only in Periyar Tiger Reserve. These include four species of cyprinid viz., *Hypselobarbus periyarensis, Lepidopygopsis typus, Crosscheilus periyarensis* and *Garra periyarensis* and two species of Balitorids; *Nemacheilus periyarensis* and *N. menoni.* In the past 10 years there are numerous discoveries of species from Periyar river. The fish species described new to science are *Homaloptera silasi, Garra emerginata* and *G. mlapparaensis* (Kurup and Radhakrishnan, 2010a,b), *Puntius muvattupuzhaensis* (Beevi and Ramachandran, 2009), *Nemacheilus periyarensis* (Kurup and Radhakrishnan, 2005) and *Homaloptera santhamparaiensis* (Arunachalam *et al.*, 2002).

Shaji *et al.* (1995) reported 33 species belong to 15 families from 5 localities of Aralam wild life sanctuary part of Valapatnam river system. They also reported the extension ranges of *Osteochilus nashii*, *Puntius denisonii* and *Nemacheilus nilgiriensis* to Valapatnam river. In the present study, 73 species of fishes under 11 orders, 25 families and 48 genera were reported from Valapatanam river system including 5 fish species which are strictly endemic to Kerala waters viz, *Dayella malabarica, Puntius denisonii, Laubuca fasciata, Glyptothorax malabarensis* and *Macrognathus guentheri*. Biju (2003) and Radhakrishnan (2006) reported 55 and 46 fish species respectively from this river. *Glyptothorax malabarensis,* an endemic species to Western Ghats of India, was reported from hill stream of Aralam Wildlife Sanctuary of Valapattanam River (Gopi, 2010). *Dario urops* reported described from the upstream part of Valapattanam River (Ralf *et al.,* 2012b).

Radhakrishnan (2006) reported 41 species belonging to 4 orders, 12 families and 25 genera from Kallada river including one new addition to this river viz, *Hypselobarbus thomassi*. 67 species of fishes under 11 orders, 22 families and 39 genera were reported from Kallada river system in the present study. Robin *et al.* (2011) recently reported 43 species belonging to 19 families and 32 genera from this river. Radhakrishnan (2006) reported 55 species and the author reported only one exotic fish, *C. carpio* from river Pamba. In the present study, 76 species of fishes belong to 10 orders 24 families and 43 genera were reported from Pamba river system including two exotic species ie, *C. carpio* and *Clarias gariepinus*. Recently, *Pristolepis rubripinnis* a new species was described from the Pamba river (Ralf *et al.,* 2012 a).

The global distribution pattern of biological diversity showed that the tropics at lower latitudes harbour relatively more species per unit area (Gaston, 2000). In Western Ghats, the amphibian and angiosperm species diversity is rich at the southern part than the northern and central regions (Daniels, 1992).

A similar zoogeographical distribution pattern was emerged in the case of freshwater fishes also (Dahanukar *et al.*, 2004). The geographical region of Kerala is known to have one of the highest levels of diversity as well as endemism within the Western Ghats (Ponniah and Gopalakrishnan, 2000). Fish assemblage variability is a function of many interacting factors including geoclimatic region, hydrologic regime, channel type, species composition, biotic versus abiotic regulation and disturbance history, frequency and magnitude (natural and anthropogenic) (Schlosser, 1985; Grossman *et al.* 1998).

At the global scale, Oberdorff *et al*. (1995) reported that drainage basin area, mean annual discharge, and net primary production accounted for most variation in fish species richness in large river basins. At continental and regional scales, river basin area (Welcomme, 1979; Livingstone *et al.*, 1982; Hugueny, 1989), river surface area (Eadie *et al.*, 1986), basin discharge (Livingstone *et al.*, 1982; Oberdorff *et al*., 1997), energy availability (Oberdorff *et al.*, 1995, 1997), and climate (McAllister *et al.*, 1986; Oberdorff *et al.*, 1997) as well as historical factors such as dispersal history (Hugueny, 1989) and glaciation (Oberdorff *et al.*, 1997) were used to explain patterns in species richness. Lake (1982) reported that catchment size is one of the main factors determining fish species richness while studying the relationship between the number of fish species and catchment area and stream length in small streams in southeastern Australian fish communities. Total area of stream surface increases with drainage area, yielding concomitant increases in numbers of individuals and species (Preston, 1962). Furthermore, the fusion of small, low-order (Strahler, 1957) streams with increasing drainage area forms larger streams, which provided additional habitats. Generally, large areas are colonized by more dispersing organisms and support larger populations, reducing the likelihood of extinction (MacArthur and Wilson, 1967; Wright, 1983). Since basin discharge, basin area and river surface area are all measures of river size or area, they can be expected to correlate with species richness with the relationships attributed to species-area theory (MacArthur and Wilson, 1967; Eadie *et al.*, 1986; Oberdorff *et al.*, 1995). However, larger water bodies are also expected to provide greater spatial heterogeneity or habitat complexity than smaller waters (Guegan *et al.*,1998). The species-area relationship, therefore, incorporates a species-habitat complexity relationship, making it difficult to determine whether increased species richness in larger waters results from greater area, greater heterogeneity, or both. The results of the present study fully agree with the above obervation. The rich species diversity was found associated with increase in length and catchment area as observed in respect of Periyar, Bharathapuzha, Pamba, Chalakudy, Chaliyar and Achenkovil which are the largest river systems of Kerala while poor species diversity was seen in Mahe, Ayoor, Mogral, Pallikkal and Puzhakkal which are comparatively smaller. Interestingly, Kabbini river system is an exception to this situation, though the length of this river system is only 63 km, it abounds 90 species. This is because Kabbini is a major tributary of biodiversity rich Cauveri river system in Tamil Nadu. Minckley *et al.* (1986) based on grid study on the Oregon rivers opined that increased freshwater connectivity produces a greater species pool and greater local species richness of freshwater fish. While comparing the species diversity in terms of river index values computed in the present finding, it was seen that, the larger river systems such as Periyar, Chalakkudy and Bharathapuzha were at the apex positions in terms of total number of species observed, number of commercially important fishes, number of threatened fishes, number of endemic fishes of Kerala and the number of species endemic to the particular river system. The index values were generally high for these major river systems and were low for river systems having smaller length, catchment areas and also less habitat diversity. However, with a unit increase in length of the river system, the diversity in terms of species richness in unit area of the river system is found to be decreasing. It can therefore be inferred that there is a clear gradient for diversity from one direction of the river system to the other and reciprocating a reduction in species diversity was observed which is inversely proportional to the distance from the sea. Basic theories of stream fish ecology suggest that down streams of the river systems are more rich than their middle and upstreams (Horwitz, 1978; Schlosser, 1987; Rahel and Hubert, 1991; Kuehne, 1962; Gorman and Karr, 1978; Karr *et al.*, 1986; Paller, 1994). The above authors explained that the downstream addition of species occurs as a result of increased living space in larger streams, increased habitat diversity such as access to floodplain habitats and backwaters, and greater habitat stability such as reduced flow variability. The results of the present study show that, in large river systems the species diversity available per unit area for the entire river system is invariably low when compared to smaller river systems. This can be well attributed to the fact that the smaller river systems encompass mainly the species rich downstream regions, thus resulting in high species diversity per unit area while the large river systems cover a vast comparatively low species rich midland and highland areas which in turn would result in low diversity per unit area for the entire river system. It is well known that substrate, depth and current are some of the most important physical features which are profoundly determining the distribution of fishes in stream communities (Sheldon, 1968; Gorman and Karr, 1978; Schlosser, 1982; Angermeier and Karr, 1983; Angermeier and Schlosser, 1989) and the combination of such environmental features, producing a mosaic of microhabitats can explain the downstream increase in species richness (Gorman and Karr, 1978).

Table 2.1 List of fish species reported together with common name, biodiversity status and nature of endemism

Order	Family	Sl No	Species	Common name	Biodiversity status (IUCN)	Endemism
Osteoglossiformes	Notopteridae	1	*Notopterus notopterus*	Grey featherback	LC	Not known
Elopiformes	Megalopidae	2	*Megalops cyprinoides*	Indo pacific tarpon	DD	Not known
	Elopidae	3	*Elops machnata*	Lady fish	LC	Not known
Anguilliformes	Anguillidae	4	*Anguilla bicolor*	Shortfin eel	LC	Not known
		5	*Anguilla bengalensis*	Indian long fin eel	LC	Not known
	Ophichthidae	6	*Pisodonophis boro*	Rice-paddy eel	LC	Not known
Clupeiformes	Clupeidae	7	*Dayella malabarica*	Day's Round Herring	LC	EN-K
	Engraulidae	8	*Stolephorus commersonii*	Commerson's anchovy	NE	Not known
Gonorhynchiformes	Chanidae	9	*Chanos chanos*	Milk fish	NE	Not known
Cypriniformes	Cyprinidae	10	*Cirrhinus reba*	Reba Carp	LC	EN-IS
		11	*Cirrhinus mrigala*	Mrigal	LC	EN-IS
		12	*Gibelion catla*	Catla	LC	EN-IS
		13	*Cyprinus carpio*	Common carp	VU	EX
		14	*Ctenopharyngodon idella*	Grass carp	NE	EX
		15	*Labeo calbasu*	Karnataka labeo	LC	Not known
		16	*Labeo rohita*	Rohu	LC	EN-IS
		17	*Labeo dussumieri*	Malabar labeo	LC	Not known
		18	*Labeo fimbriatus*	Fringed-lipped penisula carp	LC	EN-IS
		19	*Labeo ariza*	Arizo labeo	LC	EN-IS
		20	*Labeo potail*	Deccan labeo	EN	EN-WG
		21	*Labeo kontius*	Pigmouth carp	LC	EN-I
		22	*Labeo nigriscens*	Not known	LC	Not known
		23	*Hypselobarbus curmuca*	Curumuca barb	EN	EN-WG
		24	*Hypselobarbus kurali*	Kurali	LC	EN-WG
		25	*Hypselobarbus thomassi*	Red canarese barb	CR	EN-WG

		26	*Hypselobarbus periyarensis*	Periyar Barb	EN	EN-K
		27	*Hypselobarbus kolus*	Kolus barb	VU	EN-WG
		28	*Hypselobarbus dubius*	Niligiris barb	EN	EN-WG
		29	*Hypselobarbus micropogon*	Korhi barb	EN	EN-WG
		30	*Osteobrama cotio peninsularis*	Penisular Osteobrama	DD	EN-I
		31	*Osteobrama bakeri*	Malabar Osteobrama	LC	EN-K
		32	*Osteochilus nashii*	Nash's barb	LC	EN-WG
		33	*Osteochilichthys thomassi*	Konti barb	LC	EN-I
		34	*Osteochilus longidorsalis*	Long Finned Barb	EN	EN-K
		35	*Osteochilichthys brevidorsalis*	Kantaka barb	LC	EN-WG
		36	*Puntius amphibius*	Scarlet-banded barb	DD	Not known
		37	*Puntius ophicephalus*	Channa barb	EN	EN-K
		38	*Puntius denisonii*	Red Line Torpedo Barb	EN	EN-K
		39	*Puntius arulius*	Longfin barb	EN	EN-WG
		40	*Puntius conchonius*	Rosy barb	LC	Not Known
		41	*Puntius filamentosus*	Black-spot barb	LC	EN-I
		42	*Puntius fasciatus*	Melon barb	LC	EN-I
		43	*Puntius vittatus*	Kooli barb	LC	EN-IS
		44	*Puntius ticto*	Ticto barb	LC	Not known
		45	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not known
		46	*Puntius jerdoni*	Jerdon's carp	LC	EN-WG
		47	*Puntius chola*	Chola barb	LC	EN-IS
		48	*Puntius dorsalis*	Long-snouted barb	LC	EN-I
		49	*Puntius mahecola*	Wynaad barb	DD	EN-K
		50	*Puntius parrah*	Parrah barb	LC	EN-WG
		51	*Puntius sophore*	Spotfin swamp barb	LC	Not known
		52	*Puntius bimaculatus*	Red side barb	LC	Not Known
		53	*Puntius muvattupuzhaensis*	Muvattupuzha Barb	DD	EN-K

		54	*Puntius chalakkudiensis*	Miss Kerala Look Alike	EN	EN-K
		55	*Puntius punctatus*	Not known	LC	EN-WG
		56	*Puntius assimilis*	Mahecola Barb	VU	EN-WG
		57	*Puntius crescentus*	Not known	EN	EN-WG
		58	*Puntius exclamatio*	Not known	EN	Not known
		59	*Puntius madusoodani*	Not known	NE	Not known
		60	*Puntius nigripinnis*	Not known	NE	Not known
		61	*Barbodes carnaticus*	Carnatica barb	LC	EN-WG
		62	*Barbodes bovanicus*	Bovany Barb	CR	EN-WG
		63	*Barbodes wynaadensis*	South indian barb	CR	EN-WG
		64	*Tor khudree*	Deccan mahseer	EN	Not known
		65	*Tot tor*	Golden mahseer	NT	Not known
		66	*Tor putitora*	Putitor mahseer	EN	Not known
		67	*Tor malabaricus*	Malabar Mahseer	EN	EN-WG
		68	*Tor remadevi*	Not known	NE	EN-K
		69	*Crossocheilus periyarensis*	Periyar Latia	EN	EN-K
		70	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
		71	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
		72	*Salmophasia balookee*	Bloch razorbelly minnow	LC	EN-I
		73	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
		74	*Amblypharyngodon microlepis*	Indian carplet	LC	EN-IS
		75	*Amblypharyngodon mola*	Mola carplet	LC	EN-IS
		76	*Barilius bakeri*	Malabar baril	LC	EN-WG
		77	*Barilius gatensis*	River carp baril	LC	EN-WG
		78	*Barilus bendelisis*	Hamilton's barila	LC	Not Known
		79	*Barilius canarensis*	Jerdon's baril	EN	EN-WG
		80	*Devario malabaricus*	Malabar danio	LC	EN-IS
		81	*Devario aequipinnatus*	Giant danio	LC	EN-IS

		82	*Devario fraseri*	Fraser danio	VU	EN-WG
		83	*Dario urops*	Not known	NE	Not known
		84	*Laubuca dadiburjori*	Dadio	LC	EN-WG
		85	*Laubuca fasciata*	Malabar hatchet chela	VU	EN-K
		86	*Laubuca laubuca*	Indian glass barb	LC	Not Known
		87	*Esomus danrica*	Flying barb	LC	EN-IS
		88	*Esomus thermoicos*	Srilankan Flying barb	LC	EN-IS
		89	*Danio rerio*	Zebra danio	LC	EN-IS
		90	*Rasbora daniconius*	Slender barb	LC	Not known
		91	*Lepidopygopsis typus*	Peninsular Hill Trout,Periyar trout	EN	EN-K
		92	*Garra mullya*	Mullya garra	LC	EN-I
		93	*Garra hughi*	Cardamon garra	EN	EN-WG
		94	*Garra menoni*	Silent Valley Algae Eater	VU	EN-K
		95	*Garra travancoria*	Not known	NE	Not known
		96	*Garra periyarensis*	Periyar Stone Sucker	VU	EN-K
		97	*Garra surendranathanii*	Periyar Garra	EN	EN-K
		98	*Garra ceylonensis*	Stone stucker	NE	Not known
		99	*Garra emarginata*	Not known	NE	EN-K
		100	*Garra mlapparaensis*	Not known	NE	EN-K
		101	*Garra mcclellandi*	Cauvery garra	LC	EN-WG
		102	*Garra stenorhynchus*	Nilgiris garra	LC	EN-WG
		103	*Garra annandalei*	Annandale garra	LC	EN-IS
		104	*Garra nilamburensis*	Not known	NE	Not known
		105	*Horalabiosa joshuai*	Lipped Algae Eater	EN	EN-WG
		106	*Horalabiosa arunachalami*	Not known	CR	EN-K
		107	*Horadandia atukorali*	Green carplet	LC	EN-IS
	Balitoridae	108	*Homaloptera santhamparaiensis*	Santhampara Loach	EN	EN-K

		109	*Homaloptera silasi*	Not known	NE	Not known
		110	*Homaloptera pillaii*	Silent Valley Loach	LC	EN-K
		111	*Homaloptera montana*	Anamalai loach	EN	EN-WG
		112	*Homaloptera menoni*	Not known	LC	EN-K
		113	*Balitora mysorensis*	Slender stone loach	VU	EN-WG
		114	*Bhavania australis*	Western Ghat loach	LC	EN-WG
		115	*Travancoria jonesi*	Travancore loach	EN	EN-K
		116	*Travancoria elongata*	Periyar Loach	EN	EN-K
		117	*Nemachelius denisoni*	Not known	LC	EN-I
		118	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
		119	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
		120	*Nemacheilus menoni*	Periyar Blotched Loach	VU	EN-K
		121	*Nemacheilus periyarensis*	Periyar Reticulated Loach	VU	EN-K
		122	*Nemacheilus keralensis*	Kerala Loach	VU	EN-K
		123	*Nemacheilus pulchellus*	Not known	EN	EN-WG
		124	*Nemachelius semiarmatus*	Dotted Loach	LC	EN-WG
		125	*Nemacheilus monilis*	Spotted Loach	LC	EN-WG
		126	*Nemacheilus nilgiriensis*	Not known	LC	EN-WG
		127	*Nemacheilus mooreh*	Not known	LC	EN-I
		128	*Nemacheilus petrubanarescui*	Not known	EN	EN-WG
		129	*Mesonoemacheilus remadevii*	Devi's Loach	LC	EN-K
		130	*Mesonoemacheilus pambarensis*	Pambar Banded Loach	VU	EN-K
		131	*Indoreonectes evezardi*	Not known	LC	EN-WG
		132	*Longischistura striatus*	Not known	EN	EN-WG
		133	*Acanthocobitis botia*	Mottled loach	LC	Not Known
	Cobitidae	134	*Lepidocephalichthys thermalis*	Common spiny loach	LC	Not Known
		135	*Lepidocephalichthys guntea*	Guntea loach	LC	EN-I

		136	*Botia striata*	Zebra loach	EN	EN-WG
		137	*Pangio bashai*	Not known	NE	Not known
		138	*Pangio goaensis*	Indian coolie -loach	LC	EN-WG
Siluriformes	Bagridae	139	*Batasio travancoria*	Malabar batasio	VU	EN-WG
		140	*Horabagrus nigricollaris*	White collared imperial catfish	EN	EN-K
		141	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
		142	*Mystus cavasius*	Gangetic mystus	LC	Not Known
		143	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
		144	*Mystus vittatus*	Striped dwarf catfish	LC	EN-IS
		145	*Mystus armatus*	Kerala mystus	LC	EN-IS
		146	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
		147	*Mystus montanus*	Wynaad mystus	LC	EN-I
		148	*Mystus oculatus*	Malabar mystus	LC	EN-WG
		149	*Mystus keletius*	Keletius mystus	LC	EN-IS
		150	*Mystus bleekeri*	Day's bleekeri	LC	EN-IS
		151	*Hemibagrus menoda*	Menoda catfish	LC	EN-IS
		152	*Hemibagrus punctatus*	Nilgiri mystus	CR	EN-WG
	Siluridae	153	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
		154	*Ompok malabaricus*	Goan catfish	LC	EN-I
		155	*Wallago attu*	Boal	NT	Not Known
		156	*Pterocryptis wynaadensis*	Malabar Silurus	EN	EN-WG
	Schilbeidae	157	*Pseudeutropius mitchelli*	Malabar patashi	EN	EN-K
	Sisoridae	158	*Glyptothorax annandalei*	Annandale's sucker catfish	LC	EN-IS
		159	*Glyptothorax anamalaiensis*	Anamalai Sucker Catfish	EN	EN-WG
		160	*Glyptothorax housei*	Not known	EN	EN-WG
		161	*Glyptothorax madraspatanus*	Southindian/Travancore sucker catfish	EN	EN-WG
		162	*Glyptothorax lonah*	Mountain Catfish,Deccan suker fish	LC	EN-I
		163	*Glyptothorax davissinghi*	Not known	EN	EN-K

		164	*Glyptothorax malabarensis*	Not known	DD	EN-K
	Clariidae	165	*Clarias batrachus*	Magur	LC	Not known
		166	*Clarias gariepinus*	North African catfish	NE	EX
		167	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
	Heteropneustidae	168	*Heteropneustes fossilis*	Stinging catfish	LC	Not known
	Aridae	169	*Nemapteryx caelata*	Engraved catfish	NE	Not known
	Erethistidae	170	*Pseudolaguvia austrina*	Not known	DD	Not Known
Beloniformes	Belonidae	171	*Xenentodon cancila*	Freshwater garfish	LC	Not known
		172	*Strongylura strongylura*	Spottail needlefish	NE	Not known
	Adrianichthyidae	173	*Oryzias setnai*	Malabar ricefish	LC	EN-I
	Hemiramphidae	174	*Hyporhamphus limbatus*	Congaturi halfbeak	LC	Not known
		175	*Hyporhamphus xanthopterus*	Vembanad halfbeak	VU	EN-K
Cyprinidontiformes	Aplocheilidae	176	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
		177	*Aplocheilus blocki*	Dwarf panchax	LC	EN-IS
		178	*Aplocheilus panchax*	Panchax minow	LC	Not known
	Poecilidae	179	*Poecilia reticulata*	Guppy	NE	EX
		180	*Gambusia affinis*	Mosquitofish	NE	EX
		181	*Xiphophorus maculatus*	Southern platyfish	NE	EX
Gasterosteiformes	Syngnathidae	182	*Microphis cuncalus*	Crocodile-tooth pipefish	LC	EN-IS
Synbranchiformes	Mastacembelidae	183	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
		184	*Mastacembelus armatus*	Spiny eel	LC	Not known
		185	*Macrognathus aral*	One-stripe spiny eel	LC	EN-IS
	Synbrachidae	186	*Ophisternon bengalense*	Bengal eel	LC	Not known
Perciformes	Ambassidae	187	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
		188	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
		189	*Pseudambassis ranga*	Indian glassy fish	LC	Not known
		190	*Pseudambassis baculis*	Himalayan glassy perchlet	LC	Not Known
		191	*Ambassis gymnocephalus*	Bald glassy perchlet	LC	Not Known

		192	*Ambassis ambassis*	Commerson's glassy	LC	Not Known
	-	193	*Chanda nama*	Elongate glass-perchlet	LC	EN-IS
		194	*Ambassis miops*	Flag-tailed glass perchlet	LC	Not known
	Gerreidae	195	*Gerres filamentosus*	Whiptail silver-biddy	LC	Not known
		196	*Gerres limbatus*	Saddleback silver-biddy	NE	Not known
	Nandidae	197	*Nandus nandus*	Mottled nandus	LC	Not known
	Pristolepidinae	198	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
		199	*Pristolepis rubripinnis*	Not known	NE	Not known
	Cichilidae	200	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
		201	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
		202	*Oreochromis mossambicus*	Tilapia	NT	EX
		203	*Oreochromis niloticus*	Nile tilapia	NE	EX
	Blennidae	204	*Entomacrodus vermiculatus*	Vermiculated blenny	NE	Not Known
	Osphronemidae	205	*Osphronemus goramy*	Giant gouramy	LC	EX
	Eleotrididae	206	*Eleotris fusca*	Dusky sleeper	LC	Not known
		207	*Bunaka gyrinoides*	Not known	LC	Not known
	Gobiidae	208	*Sicyopterus griseus*	Clown Goby	LC	EN-IS
		209	*Awaous stamineus*	Not known	NE	Not known
		210	*Awaous guamensis*	Scribbled goby	LC	Not known
		211	*Glossogobius giuris*	Tank goby	LC	Not known
		212	*Schismatogobius deraniyagalai*	Redneck goby	DD	Not Known
	Anabantidae	213	*Anabas testudineus*	Climbing perch	DD	Not known
	Belontidae	214	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not known
		215	*Pseudosphromenus dayi*	Not known	VU	EN-K
	Channidae	216	*Channa striata*	Banded snake head	LC	Not known
		217	*Channa marulius*	Giant snake head	LC	Not known
		218	*Channa orientalis*	Asiatic snakehead	NE	Not known
		219	*Channa gachua*	Dwarf snakehead	LC	Not known

		220	*Channa punctata*	Spotted snake head	LC	Not known
		221	*Channa diplogramma*	Malabar snake head	VU	EN-WG
	Leiognathidae	222	*Nuchequula blochii*	Twoblotch ponyfish	NE	Not known
	Lutjanidae	223	*Lutjanus argentimaculatus*	Mangrove red snapper	NE	Not known
	Terapontidae	224	*Terapon jarbca*	Jarbua terapon	LC	Not known
	Carangidae	225	*Caranx hippos*	Crevalle jack	NE	Not known
	Sillaginidae	226	*Sillago vincenti*	Estuarine whiting	NE	Not known
	Sciaenidae	227	*Macrospinosa cuja*	Cuja bola	NE	Not known
	Scatophagidae	228	*Scatophagus argus*	Spotted scat	LC	Not known
Mugiliformes	Mugilidae	229	*Mugil cephalus*	Flat head mullet	LC	Not known
		230	*Chelon planiceps*	Tade gray mullet	NE	Not known
Pleuronectiformes	Cynoglossidae	231	*Cynoglossus macrostomus*	Malabar tongue sole	NE	Not known
	Soleidae	232	*Brachirus orientalis*	Oriental sole	NE	Not known
Tetradontiformes	Tetradontidae	233	*Carinotetraodon travancoricus*	Malabar puffer fish	VU	EN-WG
Salmoniformes	Salmonidae	234	*Oncorhynchus mykiss*	Rainbow trout	NE	EX

CR - Critically endangered
EN - Endangered
VU - Vulnerable
NT - Near Threatened
LC - Least concern
DD - Data deficient
NE - Not evaluated

EN - K-Endemic to Kerala
EN - WG-Endemic to Western Ghats
EN -I- Endemic to India
EN -IS - Endemic to Indian Subcontient
EX - Exotic

Table 2.2. Critically Endangered freshwater fish species of Kerala

Sl No	Species
1	*Hypselobarbus thomassi*
2	*Barbodes bovanicus*
3	*Barbodes wynaadensis*
4	*Horalabiosa arunachalami*
5	*Hemibagrus punctatus*

Table 2.3. Endangered freshwater fish species of Kerala

Sl No	Species
1	*Labeo potail*
2	*Hypselobarbus curmuca*
3	*Hypselobarbus periyarensis*
4	*Hypselobarbus dubius*
5	*Hypselobarbus micropogon*
6	*Osteochilus longidorsalis*
7	*Puntius ophicephalus*
8	*Puntius denisonii*
9	*Puntius arulius*
10	*Puntius chalakkudiensis*
11	*Puntius crescents*
12	*Puntius exclamatio*
13	*Tor khudree*
14	*Tor putitora*
15	*Tor malabaricus*
16	*Crossocheilus periyarensis*
17	*Barilius canarensis*
18	*Lepidopygopsis typus*
19	*Garra hughi*
20	*Garra surendranathanii*
21	*Horalabiosa joshuai*
22	*Homaloptera santhamparaiensis*
23	*Homaloptera montana*
24	*Travancoria jonesi*
25	*Travancoria elongata*
26	*Nemacheilus puchellus*
27	*Nemacheilus petrubanarescuii*
28	*Longischistura striata*
29	*Botia striata*
30	*Horabagrus nigricollaris*
31	*Pterocryptis wynaadensis*
32	*Pseudeutropius mitchelli*
33	*Glyptothorax anamalaiensis*
34	*Glyptothorax housei*
35	*Glyptothorax madraspatanus*
36	*Glyptothorax davissinghi*

Table 2.4. Exotic freshwater fish species of Kerala

Sl No	Species
1	*Cyprinus carpio*
2	*Ctenopharyngodon idella*
3	*Clarias gariepinus*
4	*Oncorhyncus mykiss*
5	*Oreochromis niloticus*
6	*Oreochromis mossambicus*
7	*Osphronemus goramy*
8	*Xiphophorus maculatus*
9	*Poecilia reticulata*
10	*Gambusia affinis*

Table 2.5. List of fish species reported from Achenkovil river system

Sl. No.	Species	Common name	IUCN status	Endemism
1	*Megalops cyprinoides*	Indo pacific tarpon	DD	Not Known
2	*Anguilla bengalensis*	Indian mottled eel	LC	Not Known
3	*Pisodonophis boro*	Rice-paddy eel	LC	Not Known
4	*Dayella malabarica*	Day's Round Herring	LC	EN-K
5	*Gibelion catla*	Catla	LC	EN-IS
6	*Cyprinus carpio*	Common carp	VU	EX
7	*Labeo rohita*	Rohu	LC	EN-IS
8	*Labeo dussumieri*	Malabar labeo	LC	Not Known
9	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
10	*Hypselobarbus dubius*	Nilgiris barb	EN	EN-WG
11	*Hypselobarbus kurali*	Kurali	LC	EN-WG
12	*Osteobrama bakeri*	Malabar Osteobrama	LC	EN-K
13	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
14	*Puntius bimaculatus*	Red side barb	LC	Not Known
15	*Puntius denisonii*	Red Line Torpedo Barb	EN	EN-K
16	*Puntius fasciatus*	Melon barb	LC	EN-I
17	*Puntius filamentosus*	Black spot barb	LC	EN-I
18	*Puntius sarana subnasutus*	Olive barb	LC	Not Known
19	*Puntius chalakkudiensis*	Miss Kerala Look Alike	EN	EN-K
20	*Puntius ticto*	Two-spot barb	LC	Not Known
21	*Puntius vittatus*	Kooli barb	LC	EN-IS
22	*Puntius chola*	Chola barb	LC	Not Known
23	*Puntius jerdoni*	Jerdon's carp	LC	EN-WG
24	*Barbodes carnaticus*	Carnatic carp	LC	EN-WG
25	*Tor khudree*	Deccan Mahseer	EN	Not Known
26	*Laubuca fasciata*	Malabar hatlet chela	VU	EN-K
27	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
28	*Salmophasia boopis*	Boopis Razorbelly Minnow	LC	EN-WG

29	*Barilius bakeri*	Malabar Baril	LC	EN-WG
30	*Barilius gatensis*	River-carp baril	LC	EN-WG
31	*Devario malabaricus*	Malabar Danio	LC	EN-IS
32	*Amblypharyngodon melettinus*	Silver Carplet	LC	Not Known
33	*Amblypharyngodon microlepis*	Indian Carplet	LC	EN-IS
34	*Rasbora daniconius*	Slender barb	LC	Not Known
35	*Garra mullya*	Mullya garra	LC	EN-I
36	*Garra hughi*	Cardamon garra	EN	EN-WG
37	*Garra ceylonensis*	Stone stucker	NE	Not Known
38	*Garra surendranathanii*	Periyar Garra	EN	EN-K
39	*Balitora mysorensis*	Slender stone loach	VU	EN-WG
40	*Bhavania australis*	Western Ghat loach	LC	EN-WG
41	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
42	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
43	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
44	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
45	*Mystus cavasius*	Gangetic mystus	LC	Not Known
46	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
47	*Mystus armatus*	Kerala mystus	LC	EN-IS
48	*Mystus keletius*	Keletius mystus	LC	EN-IS
49	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
50	*Mystus oculatus*	Malabar mystus	LC	EN-WG
51	*Mystus montanus*	Wynaad mystus	LC	EN-I
52	*Hemibagrus menoda*	Menoda catfish	LC	EN-IS
53	*Batasio travancoria*	Malabar batasio	VU	EN-WG
54	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
55	*Ompok malabaricus*	Goan catfish	LC	EN-I
56	*Wallago attu*	Boal	NT	Not Known
57	*Clarias batrachus*	Magur	LC	Not Known
58	*Glyptothorax annandalei*	Annandale's sucker catfish	LC	EN-IS
59	*Glyptothorax housei*	Not known	EN	EN-WG
60	*Glyptothorax madraspatanus*	Travancore sucker catfish	EN	EN-WG
61	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
62	*Xenentedon cancila*	Freshwater garfish	LC	Not Known
63	*Hyporhamphus xanthopterus*	Vembanad halfbeak	VU	EN-K
64	*Hyporhamphus limbatus*	Congaturi halfbeak	LC	Not Known
65	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
66	*Mastacembelus armatus*	Spiny eel	LC	Not Known
67	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
68	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
69	*Pseudambassis baculis*	Himalayan glassy perchlet	LC	EN-IS
70	*Gerres filamentosus*	Whiptail silver-biddy	LC	Not Known
71	*Chanda nama*	Elongate glass-perchlet	LC	EN-IS
72	*Nandus nandus*	Mottled nandus	LC	Not Known
73	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
74	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS

75	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
76	*Oreochromis mossambicus*	Tilapia	NT	EX
77	*Anabas testudineus*	Climbing perch	DD	Not Known
78	*Glossogobius giuris*	Tank goby	LC	Not Known
79	*Pseudosphromenus cupanus*	Spiketail paradise fish	LC	Not Known
80	*Channa striata*	Banded snake head	LC	Not Known
81	*Channa orientalis*	Walking snakehead	NE	Not Known
82	*Channa marulius*	Giant snake head	LC	Not Known
83	*Channa diplogramma*	Malabar snake head	VU	EN-WG
84	*Channa punctata*	Spotted snake head	LC	Not Known
85	*Channa gachua*	Dwarf snakehead	LC	Not Known
86	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.6. List of fish species reported from Anjarakandy river system

Sl.No	Species	Common name	IUCN status	Endemism
1	*Dayella malabarica*	Day's Round Herring	LC	EN-K
2	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not known
3	*Puntius amphibius*	Scarlet-banded barb	DD	Not known
4	*Puntius filamentosus*	Black-spot barb	LC	EN-I
5	*Puntius ticto*	Ticto barb	LC	Not known
6	*Puntius vittatus*	Kooli barb	LC	Not known
7	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
8	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
9	*Barilius bakeri*	Malabar baril	LC	EN-WG
10	*Devario aequipinnatus*	Giant danio	LC	EN-IS
11	*Rasbora daniconius*	Slender barb	LC	Not known
12	*Garra mullya*	Mullya garra	LC	EN-I
13	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not known
14	*Mystus armatus*	Kerala mystus	LC	EN-IS
15	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
16	*Mystus oculatus*	Malabar mystus	LC	EN-WG
17	*Clarias batrachus*	Magur	LC	Not known
18	*Wallago attu*	Boal	LC	Not known
19	*Xenentodon cancila*	Freshwater garfish	LC	Not known
20	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
21	*Mastacembelus armatus*	Spiny eel	LC	Not known
22	*Nandus nandus*	Mottled nandus	LC	Not known
23	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
24	*Oreochromis mossambicus*	Tilapia	NT	EX
25	*Glossogobius giuris*	Tank goby	LC	Not known
26	*Anabas testudineus*	Climbing perch	DD	Not known
27	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not known
28	*Channa marulius*	Giant snake head	LC	Not known
29	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.7. List of fish species reported from Ayoor river system

Sl.No.	Species	Common name	IUCN status	Endemism
1	*Puntius amphibius*	Scarlet-banded barb	DD	Not known
2	*Puntius filamentosus*	Black-spot barb	LC	EN-I
3	*Puntius fasciatus*	Melon barb	LC	EN-I
4	*Puntius ticto*	Ticto barb	LC	Not known
5	*Puntius vittatus*	Kooli barb	LC	Not known
6	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
7	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
8	*Devario malabaricus*	Malabar danio	LC	EN-IS
9	*Devario aequipinnatus*	Giant danio	LC	EN-IS
10	*Rasbora daniconius*	Slender barb	LC	Not known
11	*Garra mullya*	Mullya garra	LC	EN-I
12	*Mystus oculatus*	Malabar mystus	LC	EN-WG
13	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
14	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
15	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
16	*Mastacembelus armatus*	Spiny eel	LC	Not known
17	*Macrognathus guentheri*	One-stripe spiny eel	LC	EN-K
18	*Glossogobius giuris*	Tank goby	LC	Not known
19	*Anabas testudineus*	Climbing perch	DD	Not known

Table 2.8. List of fish species reported from Bharathapuzha river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Notopterus notopterus*	Grey featherback	LC	Not Known
2	*Megalops cyprinoides*	Indo pacific tarpon	DD	Not Known
3	*Anguilla bengalensis*	Indian long fin eel	LC	Not Known
4	*Anguilla bicolor*	Shortfin eel	LC	Not Known
5	*Dayella malabarica*	Day's Round Herring	LC	EN-K
6	*Chanos chanos*	Milk fish	NE	Not Known
7	*Gibelion catla*	Catla	LC	EN-IS
8	*Cirrhinus mrigala*	Mrigal	LC	EN-IS
9	*Labeo rohita*	Rohu	LC	EN-IS
10	*Labeo fimbriatus*	Fringed-lipped penisula carp	LC	EN-IS
11	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
12	*Hypselobarbus kolus*	Kolus	VU	EN-WG
13	*Osteobrama bakeri*	Malabar osteobrama	LC	EN-K
14	*Osteochilichthys brevidorsalis*	Kantaka barb	LC	EN-WG
15	*Osteocheilus nashii*	Nash's barb	LC	EN-WG
16	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
17	*Puntius conchonius*	Rosy barb	LC	Not Known
18	*Puntius chola*	Chola barb	LC	Not Known
19	*Puntius parrah*	Parrah barb	LC	EN-WG
20	*Puntius vittatus*	Kooli barb	LC	EN-IS
21	*Puntius denisonii*	Red Line Torpedo Barb	EN	EN-K
22	*Puntius fasciatus*	Melon barb	LC	EN-I
23	*Puntius filamentosus*	Black-spot barb	LC	EN-I
24	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
25	*Puntius ticto*	Ticto barb	LC	Not Known
26	*Puntius dorsalis*	Long-snouted barb	LC	EN-I
27	*Puntius arulius*	Longfin barb	EN	EN-WG
28	*Puntius sophare*	Spotfin swamp barb	LC	Not Known
29	*Puntius jerdoni*	Jerdon's carp	LC	EN-WG
30	*Barbodes bovanicus*	Bovany Barb	CR	EN-WG
31	*Barbodes carnaticus*	Carnatic barb	LC	EN-WG
32	*Tor khudree*	Deccan mahseer	EN	Not Known
33	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
34	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
35	*Amblypharyngodon microlepis*	Indian carplet	LC	EN-IS
36	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
37	*Barilius bakeri*	Malabar baril	LC	EN-WG
38	*Barilus bendelisis*	Hamilton's barila	LC	Not Known
39	*Barilius gatensis*	River carp baril	LC	EN-WG

40	*Barilius canarensis*	Jerdon's baril	EN	EN-WG
41	*Devario malabaricus*	Malabar danio	LC	EN-IS
42	*Devario aequipinnatus*	Giant danio	LC	EN-IS
43	*Labuca fasciata*	Malabar hatchet chela	VU	EN-K
44	*Laubuca dadiburjori*	Dadio	LC	EN-WG
45	*Esomus thermoicos*	Srilanka flying barb	LC	EN-IS
46	*Esomus danrica*	Flying barb	LC	EN-IS
47	*Rasbora daniconius*	Slender barb	LC	Not Known
48	*Garra mullya*	Mullya garra	LC	EN-I
49	*Garra menoni*	Silent Valley Algae Eater	VU	EN-K
50	*Garra surendranathanii*	Periyar Garra	EN	EN-K
51	*Garra annandalei*	Annandale garra	LC	EN-IS
52	*Garra mcclelladi*	Cauvery garra	LC	EN-WG
53	*Bhavania australis*	Western Ghat loach	LC	EN-WG
54	*Nemacheilus denisoni*	Not known	LC	EN-I
55	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
56	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
57	*Mesonoemacheilus remadevii*	Devi's Loach	LC	EN-K
58	*Horalabiosa joshuai*	Lipped Algae Eater	EN	EN-WG
59	*Balitora mysorensis*	Slender stone loach	VU	EN-WG
60	*Homaloptera montana*	Anamalai loach	EN	EN-WG
61	*Homaloptera pillaii*	Silent Valley Loach	LC	EN-K
62	*Indoreonectes evezardi*	Not known	LC	EN-I
63	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
64	*Lepidocephalichthys guntea*	Guntea loach	LC	EN-I
65	*Pseudolaguvia austrina*	Not known	DD	EN-K
66	*Batasio travancoria*	Malabar batasio	VU	EN-WG
67	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
68	*Mystus armatus*	Kerala mystus	LC	EN-IS
69	*Mystus vittatus*	Striped dwarf catfish	LC	EN-IS
70	*Mystus cavasius*	Gangetic mystus	LC	Not Known
71	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
72	*Mystus montanus*	Wynaad mystus	LC	EN-I
73	*Mystus oculatus*	Malabar mystus	LC	EN-WG
74	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
75	*Hemibagrus punctatus*	Nilgiris catfish	CR	EN-WG
76	*Clarias batrachus*	Magur	LC	Not Known
77	*Ompok malabaricus*	Goan catfish	LC	EN-I
78	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
79	*Wallago attu*	Boal	NT	Not Known
80	*Glyptothorax madraspatanus*	Travancore sucker catfish	EN	EN-WG
81	*Glyptothorax housei*	Not known	EN	EN-WG

82	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
83	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
84	*Hyporhamphus xanthopterus*	Vembanad halfbeak	VU	EN-K
85	*Hyporhamphhus limbatus*	Congaturi halfbeak	LC	Not Known
86	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
87	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
88	*Poecilia reticulata*	Guppy	NE	EX
89	*Microphis cuncalus*	Crocodile-tooth pipefish	LC	EN-I
90	*Mastacembelus armatus*	Spiny eel	LC	Not Known
91	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
92	*Ambassis ambassis*	Commerson's glassy	LC	Not Known
93	*Ambassis gymnocephalus*	Bald glassy perchlet	LC	Not Known
94	*Gerres filamentosus*	Whiptail silver-biddy	LC	Not Known
95	*Chanda nama*	Elongate glass-perchlet	LC	EN-IS
96	*Pseudambassis ranga*	Indian glassy fish	LC	Not Known
97	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
98	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
99	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
100	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
101	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
102	*Oreochromis mossambicus*	Tilapia	NT	EX
103	*Oreochromis niloticus*	Nile tilapia	NE	EX
104	*Anabas testudineus*	Climbing perch	DD	Not Known
105	*Nandus nandus*	Mottled nandus	LC	Not Known
106	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not Known
107	*Glossogobius giuris*	Tank goby	LC	Not Known
108	*Sicyopterus griseus*	Clown Goby	LC	EN-IS
109	*Channa striata*	Banded snake head	LC	Not Known
110	*Channa marulius*	Giant snake head	LC	Not Known
111	*Sillago vincenti*	Estuarine whiting	NE	Not Known
112	*Lutjanus argentimaculatus*	River snapper	NE	Not Known
113	*Scatophagus argus*	Spotted scat	LC	Not Known
114	*Chelon planiceps*	Tade gray mullet	NE	Not Known
115	*Eleotris fusca*	Dusky sleeper	LC	Not Known
116	*Cynoglossus macrostomus*	Malabar tongue sole	NE	Not Known
117	*Terapon jarbua*	Jarbua terapon	LC	Not Known
118	*Nuchequula blochii*	Twoblotch ponyfish	NE	Not Known
119	*Brachirus orientalis*	Oriental sole	NE	Not Known
120	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.9. List of fish species reported from Bhavani river system

Sl.No.	Species	Common name	IUCN Status	Endemism
1	*Labeo ariza*	Arizo labeo	LC	EN-IS
2	*Labeo potail*	Deccan labeo	EN	EN-WG
3	*Hypselobarbus dubius*	Niligiris barb	EN	EN-WG
4	*Puntius filamentosus*	Black-spot barb	LC	EN-I
5	*Puntius fasciatus*	Melon barb	LC	EN-I
6	*Puntius arulius*	Longfin barb	EN	EN-WG
7	*Puntius chola*	Chola barb	LC	Not Known
8	*Puntius ticto*	Ticto barb	LC	Not Known
9	*Puntius dorsalis*	Long-snouted barb	LC	EN-I
10	*Puntius sophore*	Spotfin swamp barb	LC	Not Known
11	*Barbodes carnaticus*	Carnatic barb	LC	EN-WG
12	*Osteochilius nashi*	Nash's barb	LC	EN-WG
13	*Tor khudree*	Deccan mahseer	EN	Not Known
14	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
15	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
16	*Barilius bakeri*	Malabar baril	LC	EN-WG
17	*Barilius gatensis*	River carp baril	LC	EN-WG
18	*Barilius canarensis*	Jerdon's baril	EN	EN-WG
19	*Barilius bendelisis*	Jerdon's baril	LC	Not Known
20	*Devario malabaricus*	Malabar danio	LC	EN-IS
21	*Devario aequipinnatus*	Giant danio	LC	EN-IS
22	*Rasbora daniconius*	Slender barb	LC	Not Known
23	*Garra stenorhynchus*	Nilgiris garra	LC	EN-WG
24	*Garra mullya*	Mullya garra	LC	EN-I
25	*Garra menoni*	Silent Valley Algae Eater	VU	EN-K
26	*Bhavania australis*	Western Ghat loach	LC	EN-WG
27	*Nemacheilus denisoni*	Not known	LC	EN-I
28	*Nemacheilus semiarmatus*	Dotted Loach	LC	EN-WG
29	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
30	*Nemacheilus monilis*	Spotted Loach	LC	EN-WG
31	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
32	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
33	*Balitora mysorensis*	Slender stone loach	VU	EN-WG
34	*Homaloptera menoni*	Not known	LC	EN-K
35	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
36	*Wallago attu*	Boal	NT	Not Known
37	*Mystus armatus*	Kerala mystus	LC	EN-IS
38	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
39	*Clarias batrachus*	Magur	LC	Not Known
40	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
41	*Aplochelius lineatus*	Malabar killie	LC	EN-I
42	*Mastacembelus armatus*	Spiny eel	LC	Not Known
43	*Oreochromis mossambicus*	Tilapia	NT	EX
44	*Nandus nandus*	Mottled nandus	LC	Not Known
45	*Glossogobius giuris*	Tank goby	LC	Not Known
46	*Channa marulius*	Giant snake head	LC	Not Known

Table 2.10. List of fish species reported from Chalakudy river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Megalops cyprinoides*	Indo pacific tarpon	DD	Not Known
2	*Elops machnata*	Lady fish	LC	Not Known
3	*Anguilla bengalensis*	Indian long fin eel	LC	Not Known
4	*Anguilla bicolor*	Shortfin eel	LC	Not Known
5	*Dayella malabarica*	Day's Round Herring	LC	EN-K
6	*Cyprinus carpio*	Common carp	VU	EX
7	*Gibelion catla*	Catla	LC	EN-IS
8	*Cirrhinus mrigala*	Mrigal	LC	EN-IS
9	*Labeo rohita*	Rohu	LC	EN-IS
10	*Labeo dussumieri*	Malabar labeo	LC	Not Known
11	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
12	*Hypselobarbus kolus*	Kolus	VU	EN-WG
13	*Hypselobarbus thomassi*	Red canarese barb	CR	EN-WG
14	*Osteobrama bakeri*	Malabar osteobrama	LC	EN-K
15	*Osteochilus longidorsalis*	Long Finned barb	EN	EN-WG
16	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
17	*Puntius parrah*	Parrah barb	LC	EN-WG
18	*Puntius bimaculatus*	Red side barb	LC	Not Known
19	*Puntius chola*	Chola barb	LC	Not Known
20	*Puntius dorsalis*	Long-snouted barb	LC	EN-I
21	*Puntius vittatus*	Kooli barb	LC	EN-IS
22	*Puntius denisonii*	Red Line Torpedo barb	EN	EN-K
23	*Puntius fasciatus*	Melon barb	LC	EN-I
24	*Puntius filamentosus*	Black-spot barb	LC	EN-I
25	*Puntius jerdoni*	Jerdon's carp	LC	EN-WG
26	*Puntius ticto*	Ticto barb	LC	Not Known
27	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
28	*Puntius crescents*	Not known	EN	EN-WG
29	*Puntius punctatus*	Not known	LC	EN-WG
30	*Puntius assimilis*	Mahecola Barb	VU	EN-WG
31	*Puntius mahecola*	Wynaad barb	DD	EN-K
32	*Barbodes carnaticus*	Carnatica barb	LC	EN-WG
33	*Tor khudree*	Deccan mahseer	EN	Not Known
34	*Amblypharyngodon microlepis*	Indian carplet	LC	EN-IS
35	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
36	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
37	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
38	*Barilius bakeri*	Malabar baril	LC	EN-WG
39	*Barilus bendelisis*	Hamilton's barila	LC	Not Known
40	*Barilius gatensis*	River carp baril	LC	EN-WG
41	*Barilius canarensis*	Jerdon's baril	EN	EN-WG

42	*Devario malabaricus*	Malabar danio	LC	EN-IS
43	*Devario aequipinnatus*	Giant danio	LC	EN-IS
44	*Laubuca dadiburjori*	Dadio	LC	EN-WG
45	*Laubuca fasciata*	Malabar hatchet chela	LC	EN-K
46	*Esomus danrica*	Flying barb	LC	EN-IS
47	*Esomus thermoicos*	Srilanka flying barb	LC	EN-IS
48	*Rasbora daniconius*	Slender barb	LC	Not Known
49	*Garra mullya*	Mullya garra	LC	EN-I
50	*Garra surendranathanii*	Periyar Garra	EN	EN-K
51	*Horadandia atukorali*	Green carplet	LC	EN-IS
52	*Bhavania australis*	Western Ghat loach	LC	EN-WG
53	*Travancoria jonesi*	Travancore loach	EN	EN-K
54	*Travancoria elongata*	Periyar Loach	EN	EN-K
55	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
56	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
57	*Nemacheilus pulchellus*	Not known	EN	EN-WG
58	*Homaloptera montana*	Anamalai loach	EN	EN-WG
59	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
60	*Pseudeutropius mitchelli*	Malabar patashi	EN	EN-K
61	*Batasio travancoria*	Malabar batasio	VU	EN-WG
62	*Horabagrus nigricollaris*	White collared imperial catfish	EN	EN-K
63	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
64	*Mystus cavasius*	Gangetic mystus	LC	Not Known
65	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
66	*Mystus armatus*	Kerala mystus	LC	EN-IS
67	*Mystus montanus*	Wynaad mystus	LC	EN-I
68	*Mystus vittatus*	Striped dwarf catfish	LC	EN-IS
69	*Mystus keletius*	Keletius mystus	LC	EN-IS
70	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
71	*Mystus oculatus*	Malabar mystus	LC	EN-WG
72	*Wallago attu*	Boal	NT	Not Known
73	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
74	*Ompok malabaricus*	Goan catfish	LC	EN-I
75	*Glyptothorax lonah*	Mountain Catfish	LC	EN-I
76	*Glyptothorax annandalei*	Annandale's sucker catfish	LC	EN-IS
77	*Clarias batrachus*	Magur	LC	Not Known
78	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
79	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
80	*Hyporhamphus xanthopterus*	Vembanad halfbeak	VU	EN-K
81	*Hyporhamphus limbatus*	Congaturi halfbeak	LC	Not Known
82	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
83	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
84	*Aplocheilus blocki*	Dwarf panchax	LC	EN-IS
85	*Aplocheilus panchax*	Panchax minow	LC	Not Known

86	*Poecilia reticulata*	Guppy	NE	EX
87	*Microphis cuncalus*	Crocodile-tooth pipefish	LC	EN-IS
88	*Gambusia affinis*	Mosquitofish	NE	EX
89	*Xiphophorus maculatus*	Southern platyfish	NE	EX
90	*Mastacembelus guentheri*	Malabar spiny eel	LC	EN-K
91	*Mastacembelus armatus*	Spny eel	LC	Not Known
92	*Ophisternon bengalense*	Bengal eel	LC	Not Known
93	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
94	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
95	*Ambassis gymnocephalus*	Bald glassy perchlet	LC	Not Known
96	*Gerres filamentosus*	Whiptail silver-biddy	LC	Not Known
97	*Chanda nama*	Elongate glass-perchlet	LC	EN-IS
98	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
99	*Pristolepis rubripinnis*	Not known	NE	Not Known
100	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
101	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
102	*Oreochromis mossambicus*	Tilapia	NT	EX
103	*Osphronemus goramy*	Giant gouramy	LC	EX
104	*Entomacrodus vermiculatus*	Vermiculated blenny	NE	Not Known
105	*Eleotris fusca*	Dusky sleeper	LC	Not Known
106	*Glossogobius giuris*	Tank goby	LC	Not Known
107	*Sicyopterus griseus*	Clown Goby	LC	EN-IS
108	*Anabas testudineus*	Climbing perch	DD	Not Known
109	*Channa striata*	Banded snake head	LC	Not Known
110	*Chann marulius*	Giant snake head	LC	Not Known
111	*Channa gachua*	Dwarf snakehead	LC	Not Known
112	*Channa orientalis*	Walking snakehead	NE	Not Known
113	*Nandus nandus*	Mottled nandus	LC	Not Known
114	*Scatophagus argus*	Spotted scat	LC	Not Known
115	*Stolephorus commersonnii*	Commerson's anchovy	NE	Not Known
116	*Oncorhynchus mykiss*	Rainbow trout	NE	EX
117	*Nemapteryx caclata*	Engraved catfish	NE	Not Known
118	*Terapon jarbua*	Jarbua terapon	LC	Not Known
119	*Caranx hippos*	Crevalle jack	NE	Not Known
120	*Lutjanus argentimaculatus*	Mangrove red snapper	NE	Not Known
121	*Macrospinosa cuja*	Cuja bola	NE	Not Known
122	*Mugil cephalus*	Flat head mullet	LC	Not Known
123	*Strongylura strongylura*	Spottail needlefish	NE	Not Known
124	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not Known
125	*Pseudosphromenus dayi*	Not known	VU	EN-K
126	*Awaous guamensis*	Scribbled goby	LC	Not Known
127	*Branchiurus orientalis*	Oriental sole	NE	Not Known
128	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.11. List of fish species reported from Chaliyar river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Megalops cyprinoides*	Indian pacific tarpon	LC	Not Known
2	*Notopterus notopterus*	Grey featherback	LC	Not Known
3	*Dayella malabarica*	Day's Round Herring	LC	EN-K
4	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
5	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
6	*Puntius chola*	Chola barb	LC	Not Known
7	*Puntius denisonii*	Red Line Torpedo Barb	EN	EN-K
8	*Puntius fasciatus*	Melon barb	LC	EN-I
9	*Puntius filamentosus*	Black-spot barb	LC	EN-I
10	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
11	*Puntius ticto*	Ticto barb	LC	Not Known
12	*Puntius vittatus*	Kooli barb	LC	Not Known
13	*Puntius arulius*	Longfin barb	EN	EN-WG
14	*Puntius conchonius*	Rosy barb	LC	Not Known
15	*Puntius sophore*	Spotfin swamp barb	LC	Not Known
16	*Barbodes wynaadensis*	South indian barb	CR	EN-WG
17	*Barbodes carnaticus*	Carnatica barb	LC	EN-WG
18	*Osteochilus nashii*	Nash's barb	LC	EN-WG
19	*Osteochilichthys brevidorsalis*	Kantaka barb	LC	EN-WG
20	*Osteobrama bakeri*	Malabar osteobrama	LC	EN-K
21	*Tor khudree*	Deccan mahseer	EN	Not Known
22	*Amblypharyngodon microlepis*	Indian carplet	LC	EN-IS
23	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
24	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
25	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
26	*Barilius bakeri*	Malabar baril	LC	EN-WG
27	*Barilius gatensis*	River carp baril	LC	EN-WG
28	*Barilius canarensis*	Jerdon's baril	EN	EN-WG
29	*Esomus danrica*	Flying barb	LC	EN-IS
30	*Devario malabaricus*	Malabar danio	LC	EN-IS
31	*Devario aequipinnatus*	Giant danio	LC	EN-IS
32	*Laubuca fasciata*	Malabar hatchet chela	LC	EN-K
33	*Aplochelius lineatus*	Malabar killie	LC	EN-I
34	*Brachirus orientalis*	Oriental sole	NE	Not Known
35	*Rasbora daniconius*	Slender barb	LC	Not Known
36	*Garra stenorhynchus*	Nilgiris garra	LC	EN-WG
37	*Garra mullya*	Mullya garra	LC	EN-I
38	*Garra mcclellandi*	Cauvery garra	LC	EN-WG
39	*Garra nilamburensis*	Not known	NE	Not Known
40	*Balitora mysorensis*	Slender stone loach	VU	EN-WG
41	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG

42	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
43	*Nemacheilus semiarmatus*	Dotted Loach	LC	EN-WG
44	*Bhavania australis*	Western Ghat loach	LC	EN-WG
45	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
46	*Pangio bashai*	Not known	NE	Not Known
47	*Pangio goaensis*	Indian coolie -loach	LC	EN-WG
48	*Batasio travancoria*	Malabar batasio	VU	EN-WG
49	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
50	*Mystus cavasius*	Gangetic mystus	LC	Not Known
51	*Mystus oculatus*	Malabar mystus	LC	EN-WG
52	*Mystus armatus*	Kerala mystus	LC	EN-IS
53	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
54	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
55	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
56	*Glyptothorax annandalei*	Annandale's sucker catfish	LC	EN-IS
57	*Glyptothorax anamalaiensis*	Anamalai Sucker Catfish	EN	EN-WG
58	*Glyptothorax davissinghi*	Not known	EN	EN-K
59	*Hemibagrus punctatus*	Nilgiri mystus	CR	EN-WG
60	*Heteropneustes fossilis*	Stining catfish	LC	Not Known
61	*Xenentedon cancila*	Freshwater garfish	LC	Not Known
62	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
63	*Clarias batrachus*	Magur	LC	Not Known
64	*Wallago attu*	Boal	NT	Not Known
65	*Poecilia reticulata*	Guppy	NE	EX
66	*Microphis cuncalus*	Crocodile-tooth pipefish	LC	EN-IS
67	*Mastacembelus armatus*	Spiny eel	LC	Not Known
68	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
69	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
70	*Chanda nama*	Elongate glass-perchlet	LC	EN-IS
71	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
72	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
73	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
74	*Oreochromis mossambicus*	Tilapia	NT	EX
75	*Glossogobius giuris*	Tank goby	LC	Not Known
76	*Sicyopterus griseus*	Clown Goby	LC	EN-IS
77	*Anabas testudineus*	Climbing perch	DD	Not Known
78	*Schismatogobius deraniyagalai*	Redneck goby	DD	Not Known
79	*Channa marulius*	Giant snake head	LC	Not Known
80	*Channa orientalis*	Asiatic snakehead	LC	Not Known
81	*Channa striata*	Banded snake head	LC	Not Known
82	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not Known
83	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.12. List of fish species reported from Chadragiri river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Dayella malabarica*	Day's Round Herring	LC	EN-K
2	*Labeo nigriscens*	Not known	LC	Not Known
3	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
4	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
5	*Puntius vittatus*	Kooli barb	LC	Not Known
6	*Puntius denisonii*	Red Line Torpedo Barb	EN	EN-K
7	*Puntius fasciatus*	Melon barb	LC	EN-I
8	*Puntius filamentosus*	Black-spot barb	LC	EN-I
9	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
10	*Puntius arulius*	Longfin barb	EN	EN-WG
11	*Puntus chola*	Chola barb	LC	Not Known
12	*Puntus conchonius*	Rosy barb	LC	Not Known
13	*Puntius sophore*	Spotfin swamp barb	LC	Not Known
14	*Puntius ticto*	Ticto barb	LC	Not Known
15	*Puntius dorsalis*	Long-snouted barb	LC	EN-I
16	*Puntius jerdoni*	Jerdon's carp	LC	EN-WG
17	*Osteobrama bakeri*	Malabar osteobrama	LC	EN-K
18	*Osteochilius nashi*	Nash's barb	LC	EN-WG
19	*Tor khudree*	Deccan mahseer	EN	Not Known
20	*Tot tor*	Tor mahseer	NT	Not Known
21	*Salmophasia acinaces*	Silver razorbelly minnow	LC	Not Known
22	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
23	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
24	*Barilius bakeri*	Malabar baril	LC	EN-WG
25	*Barilius gatensis*	River carp baril	LC	EN-WG
26	*Danio rerio*	Zebra danio	LC	EN-IS
27	*Devario aequpinnatus*	Giant danio	LC	EN-IS
28	*Devario malabaricus*	Malabar danio	LC	EN-IS
29	*Rasbora daniconius*	Slender barb	LC	Not Known
30	*Garra mullya*	Mullya garra	LC	EN-I
31	*Indoreonectes evezardi*	Not known	LC	EN-WG
32	*Nemacheilus triagularis*	Zodiac Loach	LC	EN-WG
33	*Nemacheilus denisoni*	Not known	LC	EN-I
34	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
35	*Bhavania australis*	Western Ghat loach	LC	EN-WG
36	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
37	*Batasio travancoria*	Malabar batasio	VU	EN-WG
38	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
39	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
40	*Mystus armatus*	Kerala mystus	LC	EN-IS
41	*Mystus oculatus*	Malabar mystus	LC	EN-WG
42	*Ompok bimaculatus*	Indian butter catfish	NT	Not Known
43	*Ompok malabaricus*	Goan catfish	LC	EN-WG

44	*Wallago attu*	Boal	NT	Not Known
45	*Pterocryptis wynaadensis*	Malabar Silurus	EN	EN-WG
46	*Glyptothorax annandalei*	Annandale's sucker catfish	LC	EN-IS
47	*Clarias batrachus*	Magur	LC	Not Known
48	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
49	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
50	*Mastacembelus armatus*	Spiny eel	LC	Not Known
51	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
52	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
53	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
54	*Nandus nandus*	Mottled nandus	LC	Not Known
55	*Anabas testudineus*	Climbing perch	DD	Not Known
56	*Sicyopterus griseus*	Clown Goby	LC	EN-IS
57	*Glossogobius giuris*	Tank goby	LC	Not Known
58	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not Known
59	*Channa striata*	Banded snake head	LC	Not Known
60	*Channa orientalis*	Walking snakehead	NE	Not Known

Table 2.13. List of fish species reported from Chittari river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Dayella malabarica*	Day's Round Herring	LC	EN-K
2	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not known
3	*Puntius amphibius*	Scarlet-banded barb	DD	Not known
4	*Puntius ticto*	Ticto barb	LC	Not known
5	*Puntius vittatus*	Kooli barb	LC	Not known
6	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
7	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
8	*Devario aequipinnatus*	Giant danio	LC	EN-IS
9	*Rasbora daniconius*	Slender barb	LC	Not known
10	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not known
11	*Mystus armatus*	Kerala mystus	LC	EN-IS
12	*Mystus oculatus*	Malabar mystus	LC	EN-WG
13	*Clarias batrachus*	Magur	LC	Not known
14	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
15	*Wallago attu*	Boal	NT	Not known
16	*Xenetodon cancila*	Freshwater garfish	LC	Not known
17	*Aplocheilus lineatus*	Malabar killie	LC	EN-IS
18	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
19	*Nandus nandus*	Mottled nandus	LC	Not known
20	*Channa orientalis*	Walking snakehead	NE	Not known
21	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
22	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
23	*Anabas testudineus*	Climbing perch	DD	Not known
24	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not known

Table.2.14. List of fish species reported from Ithikkara river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not known
2	*Hyselobarbus curmuca*	Curmuca barb	EN	EN-WG
3	*Puntius dorsalis*	Long-snouted barb	LC	EN-I
4	*Puntius filamentosus*	Black-spot barb	LC	EN-I
5	*Puntius mahecola*	Wynaad barb	LC	EN-K
6	*Puntius ticto*	Ticto barb	LC	Not known
7	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not known
8	*Puntius amphibius*	Scarlet-banded barb	DD	Not known
9	*Puntius fasciatus*	Melon barb	LC	EN-I
10	*Puntius vittatus*	Kooli barb	LC	EN-IS
11	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
12	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
13	*Devario malabaricus*	Malabar danio	LC	EN-IS
14	*Devario aequipinnatus*	Giant danio	LC	EN-IS
15	*Barilius bakeri*	Malabar baril	LC	EN-WG
16	*Barilius gatensis*	River carp baril	LC	EN-WG
17	*Rasbora daniconius*	Slender barb	LC	Not known
18	*Garra mullya*	Mullya garra	LC	EN-I
19	*Wallago attu*	Boal	NT	Not known
20	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
21	*Mystus armatus*	Kerala mystus	LC	EN-IS
22	*Mystus oculatus*	Malabar mystus	LC	EN-WG
23	*Clarias batrachus*	Magur	LC	Not known
24	*Heteropneustes fossilis*	Stining catfish	LC	Not known
25	*Xenetodon cancila*	Freshwater garfish	LC	Not known
26	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
27	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
28	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
29	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
30	*Anabas testudineus*	Climbing perch	DD	Not known
31	*Glossogobius giuris*	Tank goby	LC	Not known
32	*Channa striata*	Banded snake head	LC	Not known
33	*Channa marulius*	Giant snake head	LC	Not known

Table 2.15. List of fish species reported from Kabbini river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Notopterus notopterus*	Grey featherback	LC	Not Known
2	*Dayella malabarica*	Day's Round Herring	LC	EN-K
3	*Cirrhinus reba*	Reba Carp	LC	EN-IS
4	*Cirrhinus mrigala*	Mrigal	LC	EN-IS
5	*Labeo kontius*	Pigmouth carp	LC	EN-I
6	*Labeo potail*	Deccan labeo	EN	EN-WG
7	*Labeo rohita*	Rohu	LC	EN-IS
8	*Labeo ariza*	Reba	LC	EN-IS
9	*Cyprinus carpio*	Common carp	VU	EX
10	*Hypselobarbus micropogon*	Korhi barb	EN	EN-WG
11	*Hypselobarbus dubius*	Niligiris barb	EN	EN-WG
12	*Osteochilus brevidorsalis*	Kantaka barb	LC	EN-WG
13	*Osteochilus nashii*	Nash's barb	LC	EN-WG
14	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
15	*Puntius arulius*	Longfin barb	EN	EN-WG
16	*Puntius bimaculatus*	Red side barb	LC	Not Known
17	*Puntius conchonius*	Rosy barb	LC	Not Known
18	*Puntius chola*	Chola barb	LC	Not Known
19	*Puntius vittatus*	Kooli barb	LC	Nor Known
20	*Puntius fasciatus*	Melon barb	LC	EN-I
21	*Puntius filamentosus*	Black-spot barb	LC	EN-I
22	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
23	*Puntius ticto*	Ticto barb	LC	Not Known
24	*Puntius mahecola*	Wynaad barb	DD	EN-K
25	*Puntius nigripinnis*	Not known	NE	Not Known
26	*Barbodes wynaadensis*	South Indian barb	CR	EN-WG
27	*Barbodes carnaticus*	Carnatic barb	LC	EN-WG
28	*Tor khudree*	Deccan mahseer	EN	Not Known
29	*Tor putitora*	Putitor mahseer	EN	Not known
30	*Amblypharyngodon mola*	Mola carplet	LC	EN-IS
31	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
32	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS

33	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
34	*Barilius bakeri*	Malabar baril	LC	EN-WG
35	*Barilius gatensis*	River carp baril	LC	EN-WG
36	*Barilius canarensis*	Jerdon's baril	EN	EN-WG
37	*Danio rerio*	Zebra danio	LC	EN-IS
38	*Devario malabaricus*	Malabar danio	LC	EN-IS
39	*Devario aequipinnatus*	Giant danio	LC	EN-IS
40	*Esomus danrica*	Flying barb	LC	EN-IS
41	*Laubuca laubuca*	Indian glass barb	LC	Not Known
42	*Rasbora daniconius*	Slender barb	LC	Not Known
43	*Garra stenorhynchus*	Nilgris garra	LC	EN-WG
44	*Garra mullya*	Mullya garra	LC	EN-I
45	*Bhavania australis*	Western Ghat loach	LC	EN-WG
46	*Nemacheilus monilis*	Spotted Loach	LC	EN-WG
47	*Nemacheilus nilgiriensis*	Not known	LC	EN-WG
48	*Nemacheilus semiarmatus*	Dotted Loach	LC	EN-WG
49	*Nemacheilus mooreh*	Not known	LC	EN-I
50	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
51	*Nemacheilus petrubanarescui*	Not known	EN	EN-WG
52	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
53	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
54	*Acanthocobitis botia*	Mottled loach	LC	Not Known
55	*Longischistura striatus*	Not known	EN	EN-WG
56	*Glyptothorax madraspatanus*	Travancore sucker catfish	LC	EN-WG
57	*Glyptothorax annandalei*	Annandale's sucker catfish	LC	EN-IS
58	*Glyptothorax anamalaiensis*	Anamalai Sucker Catfish	EN	EN-WG
59	*Bailtora mysorensis*	Slender stone loach	VU	EN-WG
60	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
61	*Mystus cavasius*	Gangetic mystus	LC	Not Known
62	*Mystus armatus*	Kerala mystus	LC	EN-IS
63	*Mystus montanus*	Wynaad mystus	LC	EN-I
64	*Mystus gulio*	Long-whiskered catfish	LC	Nor Known
65	*Mystus oculatus*	Malabar mystus	LC	EN-WG
66	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG

67	*Hemibagrus punctatus*	Nilgiri mystus	CR	EN-WG
68	*Pterocryptis wynaadensis*	Malabar Silurus	EN	EN-WG
69	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
70	*Wallago attu*	Boal	NT	Nor Known
71	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
72	*Clarias batrachus*	Magur	LC	Not Known
73	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
74	*Xenentodon cancila*	Freshwater garfish	LC	Nor Known
75	*Aplochelius lineatus*	Malabar killie	LC	EN-I
76	*Poecilia reticulata*	Guppy	NE	EX
77	*Mastacembelus armatus*	Spiny eel	LC	Nor Known
78	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
79	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
80	*Parambassis ranga*	Indian glassy fish	LC	Not Known
81	*Chanda nama*	Elongate glass-perchlet	LC	EN-IS
82	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
83	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
84	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
85	*Oreochromis mossambicus*	Tilapia	NT	EX
86	*Glossogobius giuris*	Tank goby	LC	Not Known
87	*Nandus nandus*	Mottled nandus	LC	Not Known
88	*Channa striata*	Banded snake head	LC	Not Known
89	*Channa marulius*	Giant snake head	LC	Not Known
90	*Channa orientalis*	Walking snakehead	NE	Not Known

Table 2.16. List of fish species reported from Kadalundi river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Notopterus notopterus*	Grey featherback	LC	Not Known
2	*Dayella malabarica*	Day's Round Herring	LC	EN-K
3	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
4	*Osteochilichthys thomassi*	Konti barb	LC	EN-I
5	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
6	*Puntius vittatus*	Kooli barb	LC	Not Known
7	*Puntius fasciatus*	Melon barb	LC	EN-I
8	*Puntius filamentosus*	Black-spot barb	LC	EN-I
9	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
10	*Puntius parrah*	Parrah barb	LC	EN-WG
11	*Puntius ticto*	Ticto barb	LC	Not Known
12	*Salmphasia acinaces*	Silver razorbelly minnow	LC	Not Known
13	*Salmphasia boopis*	Boopis razorbelly minnow	LC	EN-WG
14	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
15	*Barilius gatensis*	River carp baril	LC	EN-WG
16	*Devario malabaricus*	Malabar danio	LC	EN-IS
17	*Devario aequipinattus*	Giant danio	LC	EN-IS
18	*Rasbora daniconius*	Slender barb	LC	Not Known
19	*Garra mullya*	Mullya garra	LC	EN-I
20	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
21	*Nemachelius guentheri*	Gunther's Loach	LC	EN-WG
22	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
23	*Mystus armatus*	Kerala mystus	LC	EN-IS
24	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
25	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
26	*Wallago attu*	Boal	NT	Not Known
27	*Clarias batrachus*	Magur	LC	Not Known
28	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
29	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
30	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
31	*Mastacembelus armatus*	Spiny eel	LC	Not Known
32	*Mastacembelus guentheri*	Malabar spiny eel	LC	EN-K
33	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
34	*Chanda nama*	Elongate glass-perchlet	LC	EN-IS
35	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
36	*Nandus nandus*	Mottled nandus	LC	Not Known
37	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
38	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
39	*Oreochromis mossambicus*	Tilapia	NT	EX
40	*Glossogobius giuris*	Tank goby	NE	Not Known
41	*Anabas testudineus*	Climbing perch	DD	Not Known
42	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not Known
43	*Channa striata*	Banded snake head	LC	Not Known
44	*Channa marulius*	Giant snake head	LC	Not Known
45	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.17. List of fish species reported from Kallada river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not Known
2	*Megalops cyprinoides*	Indo pacific tarpon	DD	Not Known
3	*Dayella malabarica*	Day's Round Herring	LC	EN-K
4	*Chanos chanos*	Milk fish	NE	Not Known
5	*Cirrhinus mrigala*	Mrigal	LC	EN-IS
6	*Cyprinus carpio*	Common carp	VU	EX
7	*Hypselobarbus curmuca*	Curumuca barb	EN	EN-WG
8	*Hypselobarbus kurali*	Kurali	LC	EN-WG
9	*Hypselobarbus thomassi*	Red canarese barb	CR	EN-WG
10	*Hypselobarbus kolus*	Kolus	VU	EN-WG
11	*Osteobrama bakeri*	Malabar osteobrama	LC	EN-K
12	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
13	*Puntius arulius*	Longfin barb	EN	EN-WG
14	*Puntius chola*	Chola barb	LC	Not Known
15	*Puntius vittatus*	Kooli barb	LC	Not Known
16	*Puntius fasciatus*	Melon barb	LC	EN-I
17	*Puntius filamentosus*	Black-spot barb	LC	EN-I
18	*Puntius ticto*	Ticto barb	LC	Not Known
19	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
20	*Puntius dorsalis*	Long-snouted barb	LC	EN-I
21	*Puntius exclamatio*	Not known	EN	Not Known
22	*Puntius jerdoni*	Jerdon's carp	LC	EN-WG
23	*Puntius mahecola*	Wynaad barb	DD	EN-K
24	*Puntius assimilis*	Not known	VU	EN-WG
25	*Tor malabaricus*	Malabar Mahseer	EN	EN-WG
26	*Tor khudree*	Deccan mahseer	EN	Not Known
27	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
28	*Amblypharyngodon microlepis*	Indian carplet	LC	EN-IS
29	*Barilius bakeri*	Malabar baril	LC	EN-WG
30	*Barilius gatensis*	River carp baril	LC	EN-WG
31	*Devario malabaricus*	Malabar danio	LC	EN-IS
32	*Devario aequipinnatus*	Giant danio	LC	EN-IS
33	*Rasbora daniconius*	Slender barb	LC	Not Known
34	*Garra mullya*	Mullya garra	LC	EN-I
35	*Garra mcclellandi*	Cauvery garra	LC	EN-WG
36	*Bhavania australis*	Western Ghat loach	LC	EN-WG

37	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
38	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
39	*Travancoria jonesi*	Travancore loach	EN	EN-K
40	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
41	*Mystus cavasius*	Gangetic mystus	LC	Not Known
42	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
43	*Mystus armatus*	Kerala mystus	LC	EN-IS
44	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
45	*Mystus montanus*	Wynaad mystus	LC	EN-I
46	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
47	*Ompok malabaricus*	Goan catfish	NT	EN-I
48	*Glyptothorx annandalei*	Annandale's sucker catfish	EN	EN-IS
49	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
50	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
51	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
52	*Hyporhamphus limbatus*	Congaturi halfbeak	LC	EN-IS
53	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
54	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
55	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
56	*Pseudambassis ranga*	Indian glassy fish	LC	Not Known
57	*Chanda nama*	Elongate glass-perchlet	LC	EN-IS
58	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
59	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
60	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
61	*Oreochromis mossambicus*	Tilapia	NT	EX
62	*Glossogobius giuris*	Tank goby	LC	Not Known
63	*Channa striata*	Banded snake head	LC	Not Known
64	*Channa marulius*	Giant snake head	LC	Not Known
65	*Channa diplogramma*	Malabar snake head	VU	EN-WG
66	*Mugil cephalus*	Flat head mullet	LC	Not Known
67	*Mastacembelus armatus*	Spiny eel	LC	Not Known

Table 2.18. List of fish species reported from Kallai river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Dayella malabarica*	Day's Round Herring	LC	EN-K
2	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not known
3	*Puntius filamentosus*	Black-spot barb	LC	Not known
4	*Puntius sophore*	Spotfin swamp barb	LC	Not known
5	*Puntius ticto*	Ticto barb	LC	Not known
6	*Puntius vittatus*	Kooli barb	LC	Not known
7	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
8	*Devario aequipinnatus*	Giant danio	LC	EN-IS
9	*Devario malabaricus*	Malabar danio	LC	EN-IS
10	*Rasbora daniconius*	Slender barb	LC	Not known
11	*Garra mullya*	Mullya garra	LC	EN-I
12	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
13	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not known
14	*Mystus gulio*	Long-whiskered catfish	LC	Not known
15	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
16	*Mystus oculatus*	Malabar mystus	LC	EN-WG
17	*Wallago attu*	Boal	NT	Not known
18	*Clarias batrachus*	Magur	LC	Not known
19	*Xenetodon cancila*	Freshwater garfish	LC	Not known
20	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
21	*Mastacembelus armatus*	Spiny eel	LC	Not known
22	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
23	*Parambassis thomassi*	Day's glassy perchlet	LC	EN-WG
24	*Pseudambassis ranga*	Indian glassy fish	LC	Not known
25	*Nandus nandus*	Mottled nandus	LC	Not known
26	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
27	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
28	*Glossogobius giuris*	Tank goby	LC	Not known
29	*Anabas testudineus*	Climbing perch	DD	Not known
30	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not known
31	*Channa marulius*	Giant snake head	LC	Not known
32	*Channa striata*	Banded snake head	LC	Not known
33	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.19. List of fish species reported from Karamana river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not known
2	*Hypselobarbus curmuca*	Curumuca barb	EN	EN-WG
3	*Hypselobarbus kolus*	Kolus	VU	EN-WG
4	*Puntius fasciatus*	Melon barb	LC	EN-I
5	*Puntius filamentosus*	Black-spot barb	LC	EN-I
6	*Puntius parrah*	Parrah barb	LC	EN-WG
7	*Puntius mahecola*	Wynaad barb	DD	EN-K
8	*Puntius ticto*	Ticto barb	LC	Not known
9	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not known
10	*Puntius arulius*	Longfin barb	EN	EN-WG
11	*Puntius chola*	Chola barb	LC	Not known
12	*Puntius vittatus*	Kooli barb	LC	Not known
13	*Tor khudree*	Deccan mahseer	EN	Not known
14	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
15	*Barilius bakeri*	Malabar baril	LC	EN-WG
16	*Barilius gatensis*	River carp baril	LC	EN-WG
17	*Devario malabaricus*	Malabar danio	LC	EN-IS
18	*Devario aequipinnatus*	Giant danio	LC	EN-IS
19	*Rasbora daniconius*	Slender barb	LC	Not known
20	*Garra mullya*	Mullya garra	LC	EN-I
21	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
22	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
23	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
24	*Mystus oculatus*	Malabar mystus	LC	EN-WG
25	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
26	*Heteropneustes fossilis*	Stinging catfish	LC	Not known
27	*Xenetodon cancila*	Freshwater garfish	LC	Not known
28	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
29	*Mastacembelus armatus*	Spiny eel	LC	Not known
30	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
31	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
32	*Pseudambassis ranga*	Indian glassy fish	LC	Not known
33	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
34	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
35	*Oreochromis mossambicus*	Tilapia	NT	EX
36	*Sicyopterus griseus*	Clown Goby	LC	EN-IS
37	*Glossogobius giuris*	Tank goby	LC	Not known
38	*Nandus nandus*	Mottled nandus	LC	Not known
39	*Channa marulius*	Giant snake head	LC	Not known
40	*Channa striata*	Banded snake head	LC	Not known

Table 2.20. List of fish species reported from Karuvannur river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Notopterus notopterus*	Grey featherback	LC	Not Known
2	*Gibelion catla*	Catla	LC	EN-IS
3	*Cirrhinus mrigala*	Mrigal	LC	EN-IS
4	*Ctenopharyngodon idella*	Grass carp	NE	EX
5	*Osteobrama bakeri*	Malabar osteobrama	LC	EN-K
6	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
7	*Puntius fasciatus*	Melon barb	LC	EN-I
8	*Puntius filamentosus*	Black-spot barb	LC	EN-I
9	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
10	*Puntius ticto*	Ticto barb	LC	Not Known
11	*Puntius arulius*	Longfin barb	EN	EN-WG
12	*Puntius chola*	Chola barb	LC	Not Known
13	*Puntius parrah*	Parrah barb	LC	EN-WG
14	*Puntius sophore*	Spotfin swamp barb	LC	Not Known
15	*Puntius vittatus*	Kooli barb	LC	Not Known
16	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
17	*Devario malabaricus*	Malabar danio	LC	EN-IS
18	*Devario aequipinnatus*	Giant danio	LC	EN-IS
19	*Esomus danrica*	Flying barb	LC	EN-IS
20	*Barilius gatensis*	River carp baril	LC	EN-WG
21	*Rasbora daniconius*	Slender barb	LC	Not Known
22	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
23	*Nemacheilus triagularis*	Zodiac Loach	LC	EN-WG
24	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
25	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
26	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
27	*Mystus armatus*	Kerala mystus	LC	EN-IS
28	*Mystus cavasius*	Gangetic mystus	LC	Not Known
29	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
30	*Hemibagrus punctatus*	Nilgiri mystus	CR	EN-WG
31	*Ompok malabaricus*	Goan catfish	LC	EN-I
32	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
33	*Wallago attu*	Boal	NT	Not Known
34	*Clarias batrachus*	Magur	LC	Not Known
35	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
36	*Xenentodon cancila*	Freshwater garfish	LC	Not Known

37	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
38	*Mastacembelus armatus*	Spiny eel	LC	Not Known
39	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
40	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
41	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
42	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
43	*Nandus nandus*	Mottled nandus	LC	Not Known
44	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
45	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
46	*Glossogobius giuris*	Tank goby	LC	Not Known
47	*Anabas testudineus*	Climbing perch	DD	Not Known
48	*Chaana marulius*	Giant snake head	LC	Not Known
49	*Channa orientalis*	Walking snakehead	NE	Not Known
50	*Channa punctatus*	Spotted snake head	LC	Not Known
51	*Channa striata*	Banded snake head	LC	Not Known
52	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.21. List of fish species reported from Kariangode river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not Known
2	*Dayella malabarica*	Day's Round Herring	LC	EN-K
3	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
4	*Osteobrama bakeri*	Malabar osteobrama	LC	EN-K
5	*Osteochilus nashi*	Nash's barb	LC	EN-WG
6	*Puntius denisonii*	Red Line Torpedo Barb	EN	EN-K
7	*Puntius fasciatus*	Melon barb	LC	EN-I
8	*Puntius filamentosus*	Black-spot barb	LC	EN-I
9	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
10	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
11	*Puntius arulius*	Longfin barb	EN	EN-WG
12	*Puntius chola*	Chola barb	LC	Not Known
13	*Puntius conchonius*	Rosy barb	LC	Not Known
14	*Puntius sophore*	Spotfin swamp barb	LC	Not Known
15	*Puntius ticto*	Ticto barb	LC	Not Known
16	*Puntius vittatus*	Kooli barb	LC	EN-IS
17	*Tor khudree*	Deccan mahseer	EN	Not Known
18	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
19	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
20	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
21	*Barilius bakeri*	Malabar baril	LC	EN-WG
22	*Barilius gatensis*	River carp baril	LC	EN-WG
23	*Barilius canarensis*	Jerdon's baril	EN	EN-WG
24	*Devario malabaricus*	Malabar danio	LC	EN-IS
25	*Devario aequipinnatus*	Giant danio	LC	EN-IS
26	*Rasbora daniconius*	Slender barb	LC	Not Known
27	*Garra mullya*	Mullya garra	LC	EN-I
28	*Garra hughi*	Cardamon garra	EN	EN-WG
29	*Bhavania australis*	Western Ghat loach	LC	EN-WG
30	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
31	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
32	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
33	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
34	*Ompok malabaricus*	Goan catfish	LC	EN-I
35	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
36	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG

37	*Mystus armatus*	Kerala mystus	LC	EN-IS
38	*Mystus oculatus*	Malabar mystus	LC	EN-I
39	*Wallago attu*	Boal	NT	Not Known
40	*Pterocryptis wynaadensis*	Malabar Silurus	EN	EN-WG
41	*Glyptothorax annandalei*	Annandale's sucker catfish	LC	EN-IS
42	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
43	*Clarias batrachus*	Magur	LC	Not Known
44	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
45	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
46	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
47	*Microphis cuncalus*	Crocodile-tooth pipefish	LC	EN-IS
48	*Mastacembelus armatus*	Spiny eel	LC	Not Known
49	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
50	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
51	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
52	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
53	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
54	*Oreochromis mossambicus*	Tilapia	NT	EX
55	*Nandus nandus*	Mottled nandus	LC	Not Known
56	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
57	*Anabas testudineus*	Climbing perch	DD	Not Known
58	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not Known
59	*Glossogobius giuris*	Tank goby	LC	Not Known
60	*Channa striata*	Banded snake head	LC	Not Known
61	*Channa marulius*	Giant snake head	LC	Not Known
62	*Channa orientalis*	Walking snakehead	NE	Not Known
63	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.22. List of fish species reported from Keecheri river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Cirrhinus mrigala*	Mrigal	LC	EN-IS
2	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
3	*Puntius filamentosus*	Black-spot barb	LC	EN-I
4	*Puntius chola*	Chola barb	LC	Not Known
5	*Puntius fasciatus*	Melon barb	LC	EN-I
6	*Puntius sophore*	Spotfin swamp barb	LC	Not Known
7	*Puntius ticto*	Ticto barb	LC	Not Known
8	*Puntius vittatus*	Kooli barb	LC	EN-IS
9	*Barilius gatensis*	River carp baril	LC	EN-WG
10	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
11	*Devario malabaricus*	Malabar danio	LC	EN-IS
12	*Devario aequipinnatus*	Giant danio	LC	EN-IS
13	*Garra mullya*	Mullya garra	LC	EN-I
14	*Rasbora daniconius*	Slender barb	LC	Not Known
15	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
16	*Mystus armatus*	Kerala mystus	LC	EN-IS
17	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
18	*Mystus oculatus*	Malabar mystus	LC	EN-WG
19	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
20	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
21	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
22	*Clarias batrachus*	Magur	LC	Not Known
23	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
24	*Mastacembelus armatus*	Spiny eel	LC	Not Known
25	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
26	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
27	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
28	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
29	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
30	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
31	*Oreochromis mossambicus*	Tilapia	NT	EX
32	*Nandus nandus*	Mottled nandus	LC	Not Known
33	*Glossogobius giuris*	Tank goby	LC	Not Known
34	*Anabas testudineus*	Climbing perch	DD	Not Known
35	*Channa marulius*	Giant snake head	LC	Not Known
36	*Channa orientalis*	Walking snakehead	NE	Not Known
37	*Channa punctatus*	Dwarf snakehead	LC	Not Known
38	*Channa striata*	Banded snake head	LC	Not Known
39	*Carinotetradon trvancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.23. List of fish species reported from Kuppam river system

Sl. No.	Species	Common name	IUCN status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not Known
2	*Dayella malabarica*	Day's Round Herring	LC	EN-K
3	*Hypselobarbus curmuca*	Curumuca barb	EN	EN-WG
4	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
5	*Puntius vittatus*	Kooli barb	LC	EN-IS
6	*Puntius fasciatus*	Melon barb	LC	EN-I
7	*Puntius filamentosus*	Black-spot barb	LC	EN-I
8	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
9	*Puntius arulius*	Longfin barb	EN	EN-WG
10	*Puntius chola*	Chola barb	LC	Not Known
11	*Puntius parrah*	Parrah barb	LC	EN-WG
12	*Puntius ticto*	Ticto barb	LC	Not Known
13	*Tor khudree*	Deccan mahseer	EN	Not Known
14	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
15	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
16	*Barilius bakeri*	Malabar baril	LC	EN-WG
17	*Barilius gatensis*	River carp baril	LC	EN-WG
18	*Devario malabaricus*	Malabar danio	LC	EN-IS
19	*Devario aequipinnatus*	Giant danio	LC	EN-IS
20	*Esomus danrica*	Flying barb	LC	EN-IS
21	*Rasbora daniconius*	Slender barb	LC	Not Known
22	*Garra mullya*	Mullya garra	LC	EN-I
23	*Garra hughi*	Cardamon garra	EN	EN-WG
24	*Bhavania australis*	Western Ghat loach	LC	EN-WG
25	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
26	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
27	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
28	*Batasio travancoria*	Malabar batasio	VU	EN-WG
29	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
30	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
31	*Mystus armatus*	Striped dwarf catfish	LC	EN-IS
32	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
33	*Mystus oculatus*	Malabar mystus	LC	EN-WG
34	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
35	*Glyptothorax annandalei*	Annandale's sucker catfish	LC	EN-IS
36	*Clarias batrachus*	Magur	LC	Not Known
37	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
38	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
39	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
40	*Poecilia reticulata*	Guppy	NE	EX
41	*Xenentodon cancila*	Freshwater garfish	LC	Not Known

42	*Oryzias setnal*	Malabar ricefish	LC	EN-I
43	*Mastacembelus armatus*	Spiny eel	LC	Not Known
44	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
45	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
46	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
47	*Nandus nandus*	Mottled nandus	LC	Not Known
48	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
49	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
50	*Oreochromis mossambicus*	Tilapia	NT	EX
51	*Sicyopterus grises*	Clown Goby	LC	EN-I
52	*Glossogobius giuris*	Tank goby	LC	Not Known
53	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not Known
54	*Channa striata*	Banded snake head	LC	Not Known
55	*Channa marulius*	Giant snake head	LC	Not Known
56	*Channa orientalis*	Walking snakehead	NE	Not Known

Table 2.24. List of fish species reported from Kuttiadi river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not known
2	*Dayella malabarica*	Day's Round Herring	LC	EN-K
3	*Gibelion catla*	Catla	LC	EN-IS
4	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not known
5	*Puntius arulius*	Longfin barb	EN	EN-WG
6	*Puntius chola*	Chola barb	LC	Not known
7	*Puntius filamentosus*	Black-spot barb	LC	EN-I
8	*Puntius fasciatus*	Melon barb	LC	EN-I
9	*Puntius ticto*	Ticto barb	LC	Not known
10	*Puntius vittatus*	Kooli barb	LC	EN-IS
11	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
12	*Devario aequipinnatus*	Giant danio	LC	EN-IS
13	*Devario malabaricus*	Malabar danio	LC	EN-IS
14	*Barilius gatensis*	River carp baril	LC	EN-WG
15	*Rasbora daniconius*	Slender rasbora	LC	Not known
16	*Garra mullya*	Mullya garra	LC	EN-I
17	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
18	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
19	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not known
20	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
21	*Wallago attu*	Boal	NT	Not known
22	*Mystus armatus*	Kerala mystus	LC	EN-IS
23	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
24	*Mystus oculatus*	Malabar mystus	LC	EN-WG
25	*Pterocryptis wyannadensis*	Malabar Silurus	EN	EN-WG
26	*Clarias batrachus*	Magur	LC	Not known
27	*Heteropneustes fossilis*	Stinging catfish	LC	Not known
28	*Xenetodon cancila*	Freshwater garfish	LC	Not known
29	*Poecilia reticulata*	Guppy	NE	EX
30	*Microphis cuncalus*	Crocodile-tooth pipefish	LC	EN-IS
31	*Matacembelus armatus*	Spiny eel	LC	Not known
32	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
33	*Pseudambassis ranga*	Indian glassy fish	LC	Not known
34	*Nandus nandus*	Mottled nandus	LC	Not known
35	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
36	*Sicyopterus griseus*	Clown goby	LC	Not known
37	*Oreochromis mossambicus*	Tilapia	NT	EX
38	*Glossogobius giuris*	Tank goby	LC	Not known
39	*Anabas testudineus*	Climbing perch	DD	Not known
40	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not known
41	*Channa marulius*	Giant snake head	LC	Not known

Table 2.25. List of fish species reported from Mahe river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Dayella malabarica*	Day's Round Herring	LC	EN-K
2	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not known
3	*Puntius arulius*	Longfin barb	EN	EN-WG
4	*Puntius chola*	Chola barb	LC	Not known
5	*Puntius filamentosus*	Black-spot barb	LC	EN-I
6	*Puntius fasciatus*	Melon barb	LC	EN-I
7	*Puntius ticto*	Ticto barb	LC	Not known
8	*Puntius vittatus*	Kooli barb	LC	EN-IS
9	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
10	*Devario aequipinnatus*	Giant danio	LC	EN-IS
11	*Devario malabaricus*	Malabar danio	LC	EN-IS
12	*Barilius gatensis*	River carp baril	LC	EN-WG
13	*Rasbora daniconius*	Slender barb	LC	Not known
14	*Garra mullya*	Mullya garra	LC	EN-I
15	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
16	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not known
17	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
18	*Mystus armatus*	Kerala mystus	LC	EN-IS
19	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
20	*Clarias batrachus*	Magur	LC	Not known
21	*Xenetodon cancila*	Freshwater garfish	LC	Not known
22	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
23	*Microphis cuncalus*	Crocodile-tooth pipefish	LC	EN-IS
24	*Mastacembelus armatus*	Spiny eel	LC	Not known
25	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
26	*Nandus nandus*	Mottled nandus	LC	Not known
27	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
28	*Oreochromis mossambicus*	Tilapia	NT	EX
29	*Glossogobius giuris*	Tank goby	LC	Not known
30	*Sicyopterus griseus*	Clown Goby	LC	EN-IS
31	*Anabas testudineus*	Climbing perch	DD	Not known
32	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not known

Table 2.26. List of fish species reported from Mamom river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
2	*Puntius chola*	Chola barb	LC	Not known
3	*Puntius amphibius*	Scarlet-banded barb	DD	Not known
4	*Puntius filamentosus*	Black-spot barb	LC	EN-I
5	*Puntius fasciatus*	Melon barb	LC	EN-I
6	*Puntius ticto*	Ticto barb	LC	EN-IS
7	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
8	*Devario malabaricus*	Malabar danio	LC	EN-IS
9	*Rasbora daniconius*	Slender barb	LC	Not known
10	*Garra mullya*	Mullya garra	LC	EN-I
11	*Mystus oculatus*	Malabar mystus	LC	EN-WG
12	*Heteropneustes fossilis*	Stinging catfish	LC	Not known
13	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
14	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
15	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
16	*Anabas testudineus*	Climbing perch	DD	Not known

Table 2.27. List of fish species reported from Manimala river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Labeo dussumieri*	Malabar labeo	LC	Not Known
2	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
3	*Osteobrama bakeri*	Malabar osteobrama	LC	EN-K
4	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
5	*Puntius vittatus*	Kooli barb	LC	EN-IS
6	*Puntius fasciatus*	Melon barb	LC	EN-I
7	*Puntius filamentosus*	Black-spot barb	LC	EN-I
8	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
9	*Puntius ticto*	Ticto barb	LC	Not Known
10	*Puntius chola*	Chola barb	LC	Not Known
11	*Puntius arulius*	Longfin barb	EN	EN-WG
12	*Puntius conchonius*	Rosy barb	LC	Not Known
13	*Puntius fasciatus*	Melon barb	LC	EN-I
14	*Puntius denisonii*	Red Line Torpedo Barb	EN	EN-K
15	*Puntius madusoodani*	Not known	NE	Not Known
16	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
17	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS

18	*Amblypharyngodon microlepis*	Indian carplet	LC	EN-IS
19	*Amblypharyngondon melettinus*	Silver carplet	LC	Not Known
20	*Devario aequipinnatus*	Giant danio	LC	EN-IS
21	*Devario malabaricus*	Malabar danio	LC	EN-IS
22	*Barilius bakeri*	Malabar baril	LC	EN-WG
23	*Barilius gatensis*	River carp baril	LC	EN-WG
24	*Barilius canarensis*	Jerdon's baril	EN	EN-WG
25	*Rasbora daniconius*	Slender barb	LC	Not Known
26	*Garra mullya*	Mullya garra	LC	EN-I
27	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
28	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
29	*Nemacheilus denisoni*	Not known	LC	EN-I
30	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
31	*Pangio goaensis*	Indian coolie -loach	LC	EN-WG
32	*Batasio travancorica*	Malabar batasio	VU	EN-WG
33	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
34	*Mystus armatus*	Kerala mystus	LC	EN-IS
35	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
36	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
37	*Mystus oculatus*	Malabar mystus	LC	EN-WG
38	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
39	*Wallago attu*	Boal	NT	Not Known
40	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
41	*Clarias batrachus*	Magur	LC	Not Known
42	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
43	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
44	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
45	*Mastacembelus armatus*	Spiny eel	LC	Not Known
46	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
47	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
48	*Nandus nandus*	Mottled nandus	LC	Not Known
49	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
50	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
51	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
52	*Oreochromis mossambicus*	Tilapia	NT	EX
53	*Glossogobius giuris*	Tank goby	LC	Not Known
54	*Anabas testudineus*	Climbing perch	DD	Not Known
55	*Channa striata*	Banded snake head	LC	Not Known
56	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.28. List of fish species reported from Manjeswar river system

Sl. No.	Species	Common name	IUCN status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not known
2	*Dayella malabarica*	Day's Round Herring	LC	EN-K
3	*Puntius amphibius*	Scarlet-banded barb	DD	Not known
4	*Puntius filamentosus*	Black-spot barb	LC	EN-I
5	*Puntius vittatus*	Kooli barb	LC	EN-IS
6	*Devario malabaricus*	Malabar danio	LC	EN-IS
7	*Devario aequipinnatus*	Giant danio	LC	EN-IS
8	*Rasbora daniconius*	Slender barb	LC	Not known
9	*Garra mullya*	Mullya garra	LC	EN-I
10	*Mystus armatus*	Kerala mystus	LC	EN-IS
11	*Mystus gulio*	Long-whiskered catfish	LC	Not known
12	*Xenetodon cancila*	Freshwater garfish	LC	Not known
13	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
14	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
15	*Nandus nandus*	Mottled nandus	LC	Not known
16	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
17	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
18	*Oreochromis mossambicus*	Tilapia	NT	EX
19	*Glossogobius giuris*	Tank goby	LC	Not known
20	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not known

Table 2.29. List of fish species reported from Meenachil river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not Known
2	*Dayella malabarica*	Day's Round Herring	LC	EN-K
3	*Labeo dussumieri*	Malabar labeo	LC	Not Known
4	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
5	*Osteobrama bakeri*	Malabar osteobrama	LC	EN-WG
6	*Puntius filamentosus*	Black-spot barb	LC	EN-I
7	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
8	*Puntius ophicephalus*	Channa barb	EN	EN-WG
9	*Puntius ticto*	Ticto barb	LC	Not Known
10	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
11	*Puntius arulius*	Longfin barb	EN	EN-WG
12	*Puntius chola*	Chola barb	LC	Not Known

13	*Puntius jerdoni*	Jerdon's carp	LC	EN-WG
14	*Puntius fasciata*	Melon barb	LC	EN-I
15	*Puntius parrah*	Parrah barb	LC	EN-WG
16	*Puntius vittatus*	Kooli barb	LC	EN-IS
17	*Puntius denisonii*	Red Line Torpedo Barb	EN	EN-K
18	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
19	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
20	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
21	*Devario aequipinnatus*	Giant danio	LC	EN-IS
22	*Devario malabaricus*	Malabar danio	LC	EN-IS
23	*Barilius bakeri*	Malabar baril	LC	EN-WG
24	*Barilius gatensis*	River carp baril	LC	EN-WG
25	*Esomus danrica*	Flying barb	LC	EN-IS
26	*Rasbora daniconius*	Slender barb	LC	Not Known
27	*Garra mullya*	Mullya garra	LC	EN-I
28	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
29	*Mesonoemacheilus keralensis*	Kerala Loach	VU	EN-K
30	*Mstus cavasius*	Gangetic mystus	LC	Not Known
31	*Mystus armatus*	Kerala mystus	LC	EN-IS
32	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
33	*Mystus oculatus*	Malabar mystus	LC	EN-WG
34	*Horabagrus branchysoma*	Gunther's catfish	VU	EN-WG
35	*Wallago attu*	Boal	NT	Not Known
36	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
37	*Clarias batrachus*	Magur	LC	Not Known
38	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
39	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
40	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
41	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
42	*Nandus nandus*	Mottled nandus	LC	Not Known
43	*Aplocheilus lineatus*	Malabar killie	LC	EN-IS
44	*Mastacembelus armatus*	Spiny eel	LC	Not Known
45	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
46	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
47	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
48	*Oreochromis mossambicus*	Tilapia	NT	EX
49	*Anabas testudineus*	Climbing perch	DD	Not Known
50	*Channa striata*	Banded snake head	LC	Not Known
51	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.30. List of fish species reported from Mogral river system

Sl.No.	Species	Common name	IUCN status	Endemism
1	*Dayella malabarica*	Day's Round Herring	LC	EN-K
2	*Puntius ticto*	Ticto barb	LC	Not known
3	*Puntius vittatus*	Kooli barb	LC	EN-IS
4	*Puntius filamentosus*	Black spot barb	LC	Not known
5	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
6	*Devario malabaricus*	Malabar danio	LC	EN-IS
7	*Devario aequipinnatus*	Giant danio	LC	EN-IS
8	*Rasbora daniconius*	Slender barb	LC	Not known
9	*Garra mullya*	Mullya garra	LC	EN-I
10	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
11	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not known
12	*Mystus oculatus*	Malabar mystus	LC	EN-WG
13	*Xenetodon cancila*	Freshwater garfish	LC	Not known
14	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
15	*Nandus nandus*	Mottled nandus	LC	Not known
16	*Mastacembelus armatus*	Spiny eel	LC	Not known
17	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
18	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
19	*Oreochromis mossambicus*	Tilapia	NT	EX
20	*Glossogobius giuris*	Tank goby	LC	Not known
21	*Anabas testudineus*	Climbing perch	DD	Not known
22	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not known

Table 2.31. List of fish species reported from Muvattupuzha river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not Known
2	*Dayella malabarica*	Day's Round Herring	LC	EN-K
3	*Gibelion catla*	Catla	LC	EN-IS
4	*Labeo dussumieri*	Malabar labeo	LC	Not Known
5	*Hypselobarbus kolus*	Kolus	VU	EN-WG
6	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
7	*Osteobrama bakeri*	Malabar osteobrama	LC	EN-K
8	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
9	*Puntius chola*	Chola barb	LC	Not Known
10	*Puntius fasciatus*	Melon barb	LC	EN-I
11	*Puntius filamentosus*	Black-spot barb	LC	EN-I
12	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
13	*Puntius ticto*	Ticto barb	LC	Not Known
14	*Puntius arulius*	Longfin barb	EN	EN-WG
15	*Puntius dorsalis*	Long-snouted barb	LC	EN-I
16	*Puntius parrah*	Parrah barb	LC	EN-WG
17	*Puntius crescents*	Not known	EN	EN-WG
18	*Puntius mahecola*	Wynaad barb	DD	EN-K
19	*Puntius muvattupuzhaensis*	Muvattupuzha Barb	DD	EN-K
20	*Puntius punctatus*	Not known	LC	EN-WG
21	*Puntius vittatus*	Kooli barb	LC	EN-IS
22	*Barbodes carnaticus*	Carnatic barb	LC	EN-WG
23	*Tor khudree*	Deccan mahseer	EN	Not Known
24	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
25	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
26	*Amblypharyngondon melettinus*	Silver carplet	LC	Not Known
27	*Barilius bakeri*	Malabar baril	LC	EN-WG
28	*Barilius gatensis*	River carp baril	LC	EN-WG
29	*Barilius canarensis*	Jerdon's baril	EN	EN-WG
30	*Devario malabaricus*	Malabar danio	LC	EN-IS
31	*Devario aequipinnatus*	Giant danio	LC	EN-IS
32	*Laubuca fasciatus*	Malabar hatchet chela	VU	EN-K
33	*Laubuca dabiburjori*	Dadio	LC	EN-WG
34	*Esomus danrica*	Flying barb	LC	EN-IS
35	*Rasbora daniconius*	Slender barb	LC	Not Known
36	*Garra mullya*	Mullya garra	LC	EN-I

37	*Garra emarginata*	Not known	NE	Not Known
38	*Garra stenorhynchus*	Nilgiris garra	LC	EN-WG
39	*Horadandia attukorali*	Green carplet	LC	EN-IS
40	*Bhavania australis*	Western Ghat loach	LC	EN-WG
41	*Nemacheilus denisoni*	Not known	LC	EN-I
42	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
43	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
44	*Nemacheilus keralensis*	Kerala Loach	VU	EN-K
45	*Horabagrus branchysoma*	Gunther's catfish	VU	EN-WG
46	*Mystus cavasius*	Gangetic mystus	LC	Not Known
47	*Mystus armatus*	Kerala mystus	LC	EN-IS
48	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
49	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
50	*Mystus oculatus*	Malabar mystus	LC	EN-WG
51	*Mystus montanus*	Wynaad mystus	LC	EN-I
52	*Mystus vittatus*	Striped dwarf catfish	LC	EN-IS
53	*Ompok malabaricus*	Goan catfish	LC	EN-I
54	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
55	*Wallago attu*	Boal	NT	Not Known
56	*Glyptothorax annandalei*	Annandale's sucker catfish	LC	EN-IS
57	*Glyptothorax madraspatanus*	Travancore sucker catfish	EN	EN-WG
58	*Glyptothorax housei*	Not known	EN	EN-WG
59	*Clarias batrachus*	Magur	LC	Not Known
60	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
61	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
62	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
63	*Aplocheilus blocki*	Dwarf panchax	LC	EN-IS
64	*Aplocheilus panchax*	Panchax minow	LC	Not Known
65	*Microphis cuncalus*	Crocodile-tooth pipefish	LC	EN-IS
66	*Mastacembelus armatus*	Spiny eel	LC	Not Known
67	*Mastacembelus guentheri*	Malabar spiny eel	LC	EN-K
68	*Ophisternon bengalense*	Bengal eel	LC	Not Known
69	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
70	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
71	*Nandus nandus*	Mottled nandus	LC	Not Known
72	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
73	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
74	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
75	*Oreochromis mossambicus*	Tilapia	NT	EX

76	*Anabas testudineus*	Climbing perch	DD	Not Known
77	*Glossogobius giuris*	Tank goby	LC	Not Known
78	*Awaous stamineus*	Not known	NE	Not Known
79	*Pseudosphromenus dayi*	Not known	VU	EN-K
80	*Channa striata*	Banded snake head	LC	Not Known
81	*Channa marulius*	Giant snake head	LC	Not Known
82	*Channa orientalis*	Walking snakehead	NE	Not Known
83	*Channa gaucha*	Dwarf snakehead	LC	Not Known
84	*Chanda nama*	Elongate glass-perchlet	LC	EN-IS
85	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.32. List of fish species reported from Neyyar river system

Sl. No.	Species	Common name	IUCN status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not known
2	*Gibelion catla*	Catla	LC	EN-IS
3	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
4	*Puntius dorsalis*	Long-snouted barb	LC	EN-I
5	*Puntius fasciatus*	Melon barb	LC	EN-I
6	*Puntius filamentosus*	Black-spot barb	LC	EN-I
7	*Puntius mahecola*	Wynaad barb	DD	EN-K
8	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not known
9	*Puntius ticto*	Ticto barb	LC	Not known
10	*Puntius amphibius*	Scarlet-banded barb	DD	Not known
11	*Puntius arulius*	Longfin barb	EN	EN-WG
12	*Puntius vittatus*	Kooli barb	LC	EN-IS
13	*Barbodes carnaticus*	Carnatic barb	LC	EN-WG
14	*Tor khudree*	Deccan mahseer	EN	Not known
15	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
16	*Salmophasia balookee*	Bloch razorbelly minnow	LC	EN-I
17	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
18	*Barilus gatensis*	River carp baril	LC	EN-WG
19	*Barilius bakeri*	Malabar baril	LC	EN-WG
20	*Devario malabaricus*	Malabar danio	LC	EN-IS
21	*Devario aequipinnatus*	Giant danio	LC	EN-IS
22	*Rasbora daniconius*	Slender barb	LC	Not known
23	*Garra mcclellandi*	Cauvery garra	LC	EN-WG
24	*Garra mullya*	Mullya garra	LC	EN-I

25	*Garra hughi*	Cardamon garra	EN	EN-WG
26	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
27	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not known
28	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
29	*Mystus bleekeri*	Day's bleekeri	LC	EN-IS
30	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
31	*Mystus oculatus*	Malabar mystus	LC	EN-WG
32	*Mystus armatus*	Kerala mystus	LC	EN-IS
33	*Mystus gulio*	Long-whiskered catfish	LC	Not known
34	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
35	*Ompok malabaricus*	Goan catfish	LC	EN-I
36	*Wallago attu*	Boal	NT	Not known
37	*Clarias batrachus*	Magur	LC	Not known
38	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
39	*Heteropneustes fossilis*	Stinging catfish	LC	Not known
40	*Xenetodon cancila*	Freshwater garfish	LC	Not known
41	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
42	*Aplocheilus blocki*	Dwarf panchax	LC	EN-IS
43	*Mastacembelus armatus*	Spiny eel	LC	Not known
44	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
45	*Pseudambassis ranga*	Indian glassy fish	LC	Not known
46	*Nandus nandus*	Mottled nandus	LC	Not known
47	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
48	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
49	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
50	*Oreochromis mossambicus*	Tilapia	NT	EX
51	*Glossogobius giuris*	Tank goby	LC	Not known
52	*Sicyopterus griseus*	Clown Goby	LC	EN-IS
53	*Anabas testudineus*	Climbing perch	DD	Not known
54	*Channa marulius*	Giant snake head	LC	Not known
55	*Channa orientalis*	Walking snakehead	NE	Not known
56	*Channa striata*	Banded snake head	LC	Not known
57	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.33. List of fish species reported from Nileswar river system

Sl.No.	Species	Common name	IUCN Status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not Known
2	*Dayella malabarica*	Day's Round Herring	LC	EN-K
3	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
4	*Puntius arulius*	Longfin barb	EN	EN-WG
5	*Puntius chola*	Chola barb	LC	Not Known
6	*Puntius ticto*	Ticto barb	LC	Not Known
7	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
8	*Puntius vittatus*	Kooli barb	LC	EN-IS
9	*Puntius fasciatus*	Melon barb	LC	EN-I
10	*Puntius filamentosus*	Black-spot barb	LC	EN-I
11	*Tor khudree*	Deccan mahseer	EN	Not Known
12	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
13	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
14	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
15	*Devario malabaricus*	Malabar danio	LC	EN-IS
16	*Devario aequpinnatus*	Giant danio	LC	EN-IS
17	*Barilius gatensis*	River carp baril	LC	EN-WG
18	*Rasbora daniconius*	Slender barb	LC	Not Known
19	*Garra mullya*	Mullya garra	LC	EN-I
20	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
21	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
22	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
23	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
24	*Mystus armatus*	Kerala mystus	LC	EN-IS
25	*Mystus oculatus*	Malabar mystus	LC	EN-WG
26	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
27	*Clarias batrachus*	Magur	LC	Not Known
28	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
29	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
30	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
31	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
32	*Mastacembelus armatus*	Tire-track eel	LC	Not Known
33	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
34	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
35	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
36	*Nandus nandus*	Mottled nandus	LC	Not Known
37	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
38	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
39	*Oreochromis mossambicus*	Tilapia	NT	EX
40	*Glossogobius giuris*	Tank goby	LC	Not Known
41	*Anabas testudineus*	Climbing perch	DD	Not Known
42	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not Known
43	*Channa striata*	Banded snake head	LC	Not Known
44	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.34. List of fish species reported from Pallikkal river system

Sl. No.	Species	Common name	IUCN status	Endemism
1	*Puntius amphibius*	Scarlet-banded barb	DD	Not known
2	*Puntius arulius*	Longfin barb	EN	EN-WG
3	*Puntius filamentosus*	Black-spot barb	LC	EN-I
4	*Puntius fasciatus*	Melon barb	LC	EN-I
5	*Puntius ticto*	Ticto barb	LC	Not known
6	*Puntius vittatus*	Kooli barb	LC	EN-IS
7	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
8	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
9	*Devario malabaricus*	Malabar danio	LC	EN-IS
10	*Devario aequipinnatus*	Giant danio	LC	EN-IS
11	*Barilius gatensis*	River carp baril	LC	EN-WG
12	*Rasbora daniconius*	Slender barb	LC	Not known
13	*Garra mullya*	Mullya garra	LC	EN-I
14	*Mystus armatus*	Kerala mystus	LC	EN-IS
15	*Mystus oculatus*	Malabar mystus	LC	EN-WG
16	*Clarias batrachus*	Magur	LC	Not known
17	*Heteropneustes fosilis*	Stinging catfish	LC	Not known
18	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
19	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
20	*Nandus nandus*	Mottled nandus	LC	Not known
21	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
22	*Glossogobius giuris*	Tank goby	LC	Not known

Table 2.35. List of fish species reported from Pamba river system

Sl. No	Species	Common name	IUCN status	Endemism
1	*Dayella malabaricia*	Day's Round Herring	LC	EN-K
2	*Anguilla bengalensis*	Indian long fin eel	LC	Not Known
3	*Cyprinus carpio*	Common carp	VU	EX
4	*Cirrhinus mrigala*	Mrigal	LC	EN-IS
5	*Gibelion catla*	Catla	LC	EN-IS
6	*Labeo dussumieri*	Malabar labeo	LC	Not Known
7	*Labeo fimbriatus*	Fringed-lipped penisula carp	LC	EN-IS
8	*Labeo calbasu*	Kalbasu	LC	Not Known
9	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
10	*Osteobrama bakeri*	Malabar osteobrama	LC	EN-K
11	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
12	*Puntius bimaculatus*	Red side barb	LC	EN-IS
13	*Puntius chola*	Chola barb	LC	Not Known
14	*Puntius denisonii*	Red Line Torpedo Barb	EN	EN-K
15	*Puntius vittatus*	Kooli barb	LC	EN-IS
16	*Puntius fasciatus*	Melon barb	LC	EN-I
17	*Puntius filamentosus*	Black-spot barb	LC	EN-I
18	*Puntius ticto*	Ticto barb	LC	Not Known
19	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
20	*Puntius arulius*	Longfin barb	EN	EN-WG
21	*Tor khudree*	Deccan mahseer	EN	Not Known
22	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
23	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
24	*Amblypharyngondon melettinus*	Silver carplet	LC	Not Known
25	*Amblypharyngodon microlepis*	Indian carplet	LC	EN-IS
26	*Barilius bakeri*	Malabar baril	LC	EN-WG
27	*Barilius gatensis*	River carp baril	LC	EN-WG
28	*Devario malabaricus*	Malabar danio	LC	EN-IS
29	*Devario aequipinnatus*	Giant danio	LC	EN-IS
30	*Rasbora daniconius*	Slender barb	LC	Not Known
31	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
32	*Garra ceylonensis*	Stone stucker	NE	Not Known
33	*Garra mullya*	Mullya garra	LC	EN-I
34	*Garra hughi*	Cardamon garra	EN	EN-WG
35	*Garra surendranathani*	Periyar Garra	EN	EN-K
36	*Bhavania australis*	Western Ghat loach	LC	EN-WG
37	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG

38	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
39	*Nemachelius denisoni*	Not known	LC	EN-I
40	*Nemacheilus menoni*	Periyar Blotched Loach	VU	EN-K
41	*Batasio travancoria*	Malabar batasio	VU	EN-WG
42	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
43	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
44	*Mystus armatus*	Kerala mystus	LC	EN-IS
45	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
46	*Mystus oculatus*	Malabar mystus	LC	EN-WG
47	*Hemibagrus menoda*	Menoda catfish	LC	EN-IS
48	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
49	*Wallago attu*	Boal	NT	Not Known
50	*Glyptothorax madraspatans*	Travancore sucker catfish	EN	EN-WG
51	*Clarias batrachus*	Magur	LC	Not Known
52	*Clarias gariepinus*	North African catfish	NE	EX
53	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
54	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
55	*Aplochelius lineatus*	Malabar killie	LC	EN-I
56	*Microphis cuncalus*	Crocodile-tooth pipefish	LC	EN-IS
57	*Mastacembelus armatus*	Spiny eel	LC	Not Known
58	*Macrognathus aral*	One-stripe spiny eel	LC	EN-IS
59	*Mastacembelus guentheri*	Malabar spiny eel	LC	EN-K
60	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
61	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
62	*Nandus nandus*	Mottled nandus	LC	Not Known
63	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
64	*Pristolepis rubripinnis*	Not known	NE	Not Known
65	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
66	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
67	*Glossogobius giuris*	Tank goby	LC	Not Known
68	*Sicyopterus griseus*	Clown Goby	LC	EN-IS
69	*Bunaka gyrinoides*	Not known	LC	Not Known
70	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not Known
71	*Anabas testudineus*	Climbing perch	DD	Not Known
72	*Channa striata*	Banded snake head	LC	Not Known
73	*Channa orientalis*	Walking snakehead	NE	Not Known
74	*Channa marulius*	Giant snake head	LC	Not Known
75	*Channa diplogramma*	Malabar snake head	VU	EN-WG
76	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.36. List of fish species reported from Pambar river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Gibelion catla*	Catla	LC	EN-IS
2	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
3	*Oncorhynchus mykiss*	Rainbow trout	NE	EX
4	*Puntius fasciatus*	Melon barb	LC	EN-I
5	*Puntius arulius*	Longfin barb	EN	EN-WG
6	*Puntius filamentosus*	Black-spot barb	LC	EN-I
7	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
8	*Puntius ticto*	Ticto barb	LC	Not Known
9	*Barbodes carnaticus*	Carnatic barb	LC	EN-WG
10	*Tor remadevi*	Not known	NE	EN-K
11	*Tor khudree*	Deccan mahseer	EN	Not Known
12	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
13	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
14	*Barilius bakeri*	Malabar baril	LC	EN-WG
15	*Barilius bendelisis*	Hamilton's barila	LC	Not Known
16	*Barilius gatensis*	River carp baril	LC	EN-WG
17	*Devario aequipinnatus*	Giant danio	LC	EN-IS
18	*Devario malabaricus*	Malabar danio	LC	EN-IS
19	*Esomus danrica*	Flying barb	LC	EN-IS
20	*Rasbora daniconius*	Slender barb	LC	Not Known
21	*Garra stenorhynchus*	Nilgiris garra	LC	EN-WG
22	*Garra mullya*	Mullya garra	LC	EN-I
23	*Garra hughi*	Cardamon garra	EN	EN-WG
24	*Garra mcclellandi*	Cauvery garra	LC	EN-WG
25	*Garra menoni*	Silent Valley Algae Eater	VU	EN-K
26	*Horalabiosa joshuai*	Lipped Algae Eater	EN	EN-WG
27	*Nemacheilus monilis*	Spotted Loach	LC	EN-WG
28	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
29	*Nemacheilus semiarmatus*	Dotted Loach	LC	EN-WG
30	*Nemacheilus denisoni*	Not known	LC	EN-I
31	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
32	*Nemacheilus pulchellus*	Not known	EN	EN-WG
33	*Mesonoemacheilus pambarensis*	Pambar Banded Loach	VU	EN-K
34	*Indoreonectes evezardi*	Not known	LC	EN-WG
35	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
36	*Batasio travancoria*	Malabar batasio	VU	EN-WG
37	*Mystus armatus*	Kerala mystus	LC	EN-IS
38	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
39	*Mystus oculatus*	Malabar mystus	LC	EN-WG
40	*Mystus cavasius*	Gangetic mystus	LC	Not Known
41	*Wallago attu*	Boal	NT	Not Known
42	*Pseudeutropius mitchelli*	Malabar patashi	EN	EN-K
43	*Glyptothorax annandalei*	Annandale's sucker catfish	LC	EN-IS
44	*Heleropneustes fossilis*	Stinging catfish	LC	Not Known
45	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
46	*Pristolepis marginatus*	Malabar catopra	LC	EN-WG
47	*Oreochromis mossambicus*	Tilapia	NT	EX
48	*Anabas testudineus*	Climbing perch	DD	Not Known

Table 2.37. List of fish species reported from Periyar river system

Sl. No.	Species	Common name	IUCN status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not Known
2	*Anguilla bicolor*	Shortfin eel	LC	Not Known
3	*Pisodonophis boro*	Rice-paddy eel	LC	Not Known
4	*Dayella malabarica*	Day's Round Herring	LC	EN-K
5	*Oncorhynchus mykiss*	Rainbow trout	NE	EX
6	*Cyprinus carpio*	Common carp	VU	EX
7	*Gibelion catla*	Catla	LC	EN-IS
8	*Cirrhinus mrigala*	Mrigal	LC	EN-IS
9	*Ctenopharyngodon idella*	Grass carp	NE	EX
10	*Labeo calbasu*	Kalbasu	LC	Not Known
11	*Labeo rohita*	Rohu	LC	EN-IS
12	*Labeo dussumieri*	Malabar labeo	LC	Not Known
13	*Labeo nigriscens*	Not known	DD	Not Known
14	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
15	*Hypselobarbus kurali*	Kurali	LC	EN-WG
16	*Hypselobarbus thomassi*	Red canarese barb	CR	EN-WG
17	*Hypselobarbus periyarensis*	Periyar Barb	EN	EN-K
18	*Hypselobarbus kolus*	Kolus	VU	EN-WG
19	*Osteobrama cotio penisularis*	Penisular osteobrama	DD	EN-WG
20	*Osteochilus nashi*	Nash's barb	LC	EN-WG
21	*Osteochilichthys thomassi*	Konti barb	LC	EN-I
22	*Osteobrama bakeri*	Malabar osteobrama	LC	EN-K
23	*Osteochilus longidorsalis*	Long Finned Barb	EN	EN-K
24	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
25	*Puntius ophicephalus*	Channa barb	EN	EN-WG
26	*Puntius denisonii*	Red Line Torpedo Barb	EN	EN-K
27	*Puntius filamentosus*	Black-spot barb	LC	EN-I
28	*Puntius fasciatus*	Melon barb	LC	EN-I
29	*Puntius vittatus*	Kooli barb	LC	EN-IS
30	*Puntius ticto*	Ticto barb	LC	Not Known
31	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
32	*Puntius jerdoni*	Jerdon's carp	LC	EN-WG
33	*Puntius chola*	Chola barb	LC	Not Known
34	*Puntius dorsalis*	Long-snouted barb	LC	EN-I
35	*Puntius mahecola*	Wynaad barb	DD	EN-K

36	*Puntius parrah*	Parrah barb	LC	EN-WG
37	*Puntius sophore*	Spotfin swamp barb	LC	Not Known
38	*Puntius muvattupuzhaensis*	Muvattupuzha Barb	DD	EN-K
39	*Puntius punctatus*	Not known	LC	EN-WG
40	*Puntius vittatus*	Kooli barb	LC	EN-IS
41	*Barbodes carnaticus*	Carnatic barb	LC	EN-WG
42	*Tor khudree*	Deccan mahseer	EN	Not Known
43	*Crossocheilus periyarensis*	Periyar Latia	EN	EN-K
44	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
45	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
46	*Salmophasia balookee*	Bloch razor belly minow	NE	Not Known
47	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
48	*Amblypharyngodon microlepis*	Indian carplet	LC	EN-IS
49	*Barilius bakeri*	Malabar baril	LC	EN-WG
50	*Barilius gatensis*	River carp baril	LC	EN-WG
51	*Barilius canarensis*	Jerdon's baril	EN	EN-WG
52	*Devario malabaricus*	Malabar danio	LC	EN-IS
53	*Devario aequipinnatus*	Giant danio	LC	EN-IS
54	*Devario fraseri*	Fraser danio	VU	EN-WG
55	*Laubuca dadiburjori*	Dadio	LC	EN-WG
56	*Laubuca fasciata*	Malabar hatchet chela	VU	EN-K
57	*Esomus danrica*	Indian glass barb	LC	EN-IS
58	*Esomus thermoicos*	Flying barb	LC	EN-IS
59	*Rasbora daniconius*	Slender barb	LC	Not Known
60	*Lepidopygopsis typus*	Periyar trout	EN	EN-K
61	*Garra mullya*	Mullya garra	LC	EN-I
62	*Garra travancoria*	Not known	NE	Not Known
63	*Garra periyarensis*	Periyar Stone Sucker	VU	EN-K
64	*Garra surendranathani*	Periyar Garra	EN	EN-K
65	*Garra ceylonensis*	Stone stucker	NE	Not Known
66	*Garra emarginata*	Not known	NE	EN-K
67	*Garra mlapparaensis*	Not known	NE	EN-K
68	*Garra mcclellandi*	Cauvery garra	LC	EN-WG
69	*Garra stenorhynchus*	Nilgiris garra	LC	EN-WG
70	*Horadandia atukorali*	Green carplet	LC	EN-IS
71	*Horalabiosa arunachalami*	Not known	CR	EN-K
72	*Homaloptera santhamparaiensis*	Santhampara Loach	EN	EN-K
73	*Homaloptera silasi*	Not known	NE	Not Known
74	*Bhavania australis*	Western Ghat loach	LC	EN-WG

75	*Travancoria jonesi*	Travancore loach	EN	EN-K
76	*Travancoria elongata*	Periyar Loach	EN	EN-K
77	*Nemacheilus denisoni*	Not known	LC	EN-I
78	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
79	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
80	*Nemacheilus menoni*	Periyar Blotched Loach	VU	EN-K
81	*Nemacheilus periyarensis*	Periyar Reticulated Loach	VU	EN-K
82	*Nemacheilus keralensis*	Kerala Loach	VU	EN-K
83	*Nemacheilus pulchellus*	Not known	EN	EN-WG
84	*Indoreonectes evezardi*	Not known	LC	EN-WG
85	*Acanthocobitis botia*	Mottled loach	LC	Not Known
86	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
87	*Batasio travancoria*	Malabar batasio	VU	EN-WG
88	*Horabagrus nigricollaris*	White collared imperial catfish	EN	EN-K
89	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
90	*Mystus cavasius*	Gangetic mystus	LC	Not Known
91	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
92	*Mystus vittatus*	Striped dwarf catfish	LC	EN-IS
93	*Mystus armatus*	Kerala mystus	LC	EN-IS
94	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
95	*Mystus montanus*	Wynaad mystus	LC	EN-I
96	*Mystus oculatus*	Malabar mystus	LC	EN-WG
97	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
98	*Ompok malabaricus*	Goan catfish	LC	EN-I
99	*Wallago attu*	Boal	NT	Not Known
100	*Pseudeutropius mitchelli*	Malabar patashi	EN	EN-K
101	*Glyptothorax annandalei*	Annandale's sucker catfish	LC	EN-IS
102	*Glyptothorax housei*	Not known	EN	EN-WG
103	*Glyptothorax madraspatanus*	Travancore sucker catfish	EN	EN-WG
104	*Clarias gariepinus*	North African catfish	NE	EX
105	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
106	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
107	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
108	*Strongylura strongylura*	Spottail needlefish	NE	Not Known
109	*Hyporhamphus limbatus*	Congaturi halfbeak	LC	Not Known
110	*Hyporhamphus xanthopterus*	Vembanad halfbeak	VU	EN-K
111	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
112	*Aplocheilus blocki*	Dwarf panchax	LC	EN-IS
113	*Aplocheilus panchax*	Panchax minow	LC	Not Known

114	*Poecilia reticulata*	Guppy	NE	EX
115	*Microphis cuncalus*	Crocodile-tooth pipefish	LC	EN-IS
116	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
117	*Mastacembelus armatus*	Spiny eel	LC	Not Known
118	*Macrognathus aral*	One-stripe spiny eel	LC	EN-IS
119	*Ophisternon bengalense*	Bengal eel	LC	Not Known
120	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
121	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
122	*Chanda nama*	Elongate glass-perchlet	LC	EN-IS
123	*Nandus nandus*	Mottled nandus	LC	Not Known
124	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
125	*Awaous stamineus*	Not known	NE	Not Known
126	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
127	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
128	*Oreochromis mossambicus*	Tilapia	NT	EX
129	*Sicyopterus griseus*	Clown Goby	LC	EN-IS
130	*Glossogobius giuris*	Tank goby	NE	Not Known
131	*Anabas testudineus*	Climbing perch	DD	Not Known
132	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not Known
133	*Pseudosphromenus dayi*	Not known	VU	EN-K
134	*Channa striata*	Banded snake head	LC	Not Known
135	*Channa marulius*	Giant snake head	LC	Not Known
136	*Channa orientalis*	Walking snakehead	NE	Not Known
137	*Channa gachua*	Dwarf snakehead	LC	Not Known
138	*Channa punctatus*	Spotted snake head	LC	Not Known
139	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.38. List of fish species reported from Peruvamba river system

Sl. No.	Species	Common name	IUCN status	Endemism
1	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
2	*Puntius vittatus*	Kooli barb	LC	EN-IS
3	*Puntius fasciatus*	Melon barb	LC	EN-I
4	*Puntius filamentosus*	Black-spot barb	LC	EN-I
5	*Salmophasia acinaces*	Silver razorbelly minnow	LC	EN-IS
6	*Barilius gatensis*	River carp baril	LC	EN-WG
7	*Devario malabaricus*	Malabar danio	LC	EN-IS
8	*Rasbora daniconius*	Slender barb	LC	Not Known
9	*Garra mullya*	Mullya garra	LC	EN-I
10	*Garra mcclellendi*	Cauvery garra	LC	EN-WG
11	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
12	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
13	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
14	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
15	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
16	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
17	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
18	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
19	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
20	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
21	*Oreochromis mossambicus*	Tilapia	NT	EX
22	*Channa striata*	Banded snake head	LC	Not Known

Table 2.39. List of fish species reported from Puzhakkal river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not Known
2	*Dayella malabarica*	Day's Round Herring	LC	EN-K
3	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
4	*Puntius parrah*	Parrah barb	LC	EN-WG
5	*Puntius filamentosus*	Black-spot barb	LC	EN-I
6	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
7	*Puntius ticto*	Ticto barb	LC	Not Known
8	*Puntius fasciatus*	Melon barb	LC	EN-I
9	*Puntius vittatus*	Kooli barb	LC	EN-IS
10	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
11	*Devario aequipinnatus*	Giant danio	LC	EN-IS
12	*Devario malabaricus*	Malabar danio	LC	EN-IS
13	*Rasbora daniconius*	Slender barb	LC	Not Known
14	*Garra mullya*	Mullya garra	LC	Not Known
15	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
16	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
17	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
18	*Mystus oculatus*	Malabar mystus	LC	EN-WG
19	*Mystus cavasius*	Gangetic mystus	LC	Not Known
20	*Clarias batrachus*	Magur	LC	Not Known
21	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
22	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
23	*Aplochelius lineatus*	Malabar killie	LC	EN-I
24	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
25	*Mastacembelus armatus*	Spiny eel	LC	Not Known
26	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
27	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
28	*Nandus nandus*	Mottled nandus	LC	Not Known
29	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
30	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
31	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
32	*Glossogobius giuris*	Tank goby	LC	Not Known
33	*Anabas testudineus*	Climbing perch	DD	Not Known
34	*Channa marulius*	Giant snake head	LC	Not Known
35	*Channa striata*	Banded snake head	LC	Not Known
36	*Channa orientalis*	Walking snakehead	NE	Not Known
37	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.40. List of fish species reported from Shiriya river system

Sl. No.	Species	Common name	IUCN status	Endemism
1	*Dayella malabarica*	Day's Round Herring	LC	EN-K
2	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
3	*Puntius filamentosus*	Black-spot barb	LC	EN-I
4	*Puntius chola*	Chola barb	LC	Not Known
5	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
6	*Puntius ticto*	Ticto barb	LC	Not Known
7	*Puntius vittatus*	Kooli barb	LC	EN-IS
8	*Puntius fasciatus*	Melon barb	LC	EN-I
9	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
10	*Devario aequipinnatus*	Giant danio	LC	EN-IS
11	*Devario malabaricus*	Fraser danio	LC	EN-IS
12	*Rasbora daniconius*	Slender barb	LC	Not Known
13	*Garra mullya*	Mullya garra	LC	EN-I
14	*Nemacheilus triangularis*	Zodiac Loach	LC	EN-WG
15	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not Known
16	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
17	*Mystus armathus*	Kerala mystus	LC	EN-IS
18	*Mystus oculatus*	Malabar mystus	LC	EN-WG
19	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
20	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
21	*Pterocryptis wynaadensis*	Malabar Silurus	EN	EN-WG
22	*Clarias batrachus*	Magur	LC	Not Known
23	*Xenentodon cancila*	Freshwater garfish	LC	EN-I
24	*Aplocheilus lineatus*	Malabar killie	LC	EN-IS
25	*Microphis cuncalus*	Crocodile-tooth pipefish	LC	Not Known
26	*Mastacembelus armatus*	Spiny eel	LC	EN-WG
27	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
28	*Parambassis thomassi*	Westerbn Ghats glassy perchlet	LC	Not Known
29	*Nandus nandus*	Mottled nandus	LC	EN-IS
30	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
31	*Etroplus maculatus*	Orange chromidae	LC	EX
32	*Oreochromis mossambicus*	Tilapia	NT	Not Known
33	*Glossogobius giurius*	Tank goby	LC	Not Known
34	*Anabas testudineus*	Climbing perch	DD	Not Known
35	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not Known

Table 2.41. List of fish species reported from Tirur river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Dayella malabarica*	Day's Round Herring	LC	EN-K
2	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
3	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
4	*Puntius vittatus*	Kooli barb	LC	EN-IS
5	*Puntius fasciatus*	Melon barb	LC	EN-IS
6	*Puntius filamentosus*	Black-spot barb	LC	EN-IS
7	*Puntius ticto*	Ticto barb	LC	Not Known
8	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
9	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
10	*Devario malabaricus*	Malabar danio	LC	EN-I
11	*Devario aequipinnatus*	Giant danio	LC	EN-I
12	*Rasbora daniconius*	Slender barb	LC	Not Known
13	*Mystus armatus*	Kerala mystus	LC	EN-IS
14	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
15	*Mystus oculatus*	Malabar mystus	LC	EN-WG
16	*Clarias batrachus*	Magur	LC	Not Known
17	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
18	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
19	*Wallago attu*	Boal	NT	Not Known
20	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
21	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
22	*Mastacembelus armatus*	Spiny eel	LC	Not Known
23	*Aplocheilus linetatus*	Malabar killie	LC	EN-I
24	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
25	*Pseudambassis ranga*	Indian glassy fish	LC	Not Known
26	*Nandus nandus*	Mottled nandus	LC	Not Known
27	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
28	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
29	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
30	*Oreochromis mossambicus*	Tilapia	NT	EX
31	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not Known
32	*Anabas testudineus*	Climbing perch	DD	Not Known
33	*Channa striata*	Banded snake head	LC	Not Known
34	*Channa orientalis*	Walking snakehead	NE	Not Known

Table 2.42. List of fish species reported from Vamanapuram river system

Sl.No.	Species	Common name	IUCN Status	Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not known
2	*Dayella malabarica*	Day's Round Herring	LC	EN-K
3	*Hypselobarbus curmuca*	Curumuca barb	EN	EN-WG
4	*Puntius amphibius*	Scarlet-banded barb	LC	Not known
5	*Puntius arulius*	Longfin barb	EN	EN-WG
6	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not known
7	*Puntius ticto*	Ticto barb	LC	Not known
8	*Puntius vittatus*	Kooli barb	LC	EN-IS
9	*Puntius filamentosus*	Black-spot barb	LC	EN-I
10	*Puntius chola*	Chola barb	LC	Not known
11	*Puntius dorsalis*	Long-snouted barb	LC	EN-I
12	*Puntius fasciatus*	Melon barb	LC	EN-I
13	*Puntius mahecola*	Wynaad barb	DD	EN-K
14	*Tor khudree*	Deccan mahseer	*EN*	*Not known*
15	*Salmophasia boopis*	Boopis razorbelly minnow	LC	EN-WG
16	*Amblypharyngodon melettinus*	Silver carplet	LC	Not known
17	*Barilius bakeri*	Malabar baril	LC	EN-WG
18	*Barilius gatensis*	River carp baril	LC	EN-WG
19	*Devario aequipinnatus*	Giant danio	LC	EN-IS
20	*Devario malabaricus*	Malabar danio	LC	EN-IS
21	*Rasbora daniconius*	Slender rasbora	LC	Not known
22	*Garra mullya*	Mullya garra	LC	EN-I
23	*Garra hughi*	Cardamon garra	EN	EN-WG
24	*Bhavania australis*	Western Ghat loach	LC	EN-WG
25	*Travancoria jonesi*	Travancore loach	EN	EN-K
26	*Nemacheilus traingularis*	Zodiac Loach	LC	EN-WG
27	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
28	*Lepidocephalichthys thermalis*	Malabar loach	LC	Not known
29	*Botia striata*	Zebra loach	EN	EN-WG
30	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
31	*Mystus armatus*	Kerala mystus	LC	EN-IS
32	*Mystus gulio*	Long-whiskered catfish	LC	Not known
33	*Mystus oculatus*	Malabar mystus	LC	EN-WG
34	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
35	*Wallago attu*	Boal	NT	Not known
36	*Glyptothorax madraspatanus*	Travancore sucker catfish	EN	*EN-WG*

37	*Xenentodon cancila*	Freshwater garfish	LC	Not known
38	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
39	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
40	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
41	*Nandus nandus*	Mottled nandus	LC	Not known
42	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
43	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
44	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
45	*Oreochromis mossambicus*	Tilapia	NT	EX
46	*Glossogobius giuris*	Tank goby	LC	Not known
47	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not known
48	*Channa marulius*	Giant snake head	LC	Not known
49	*Channa gachua*	Dwarf snakehead	LC	Not known
50	*Channa striata*	Banded snake head	LC	Not known

Table 2.43. List of fish species reported from Valapattanam river system

Sl. No.	Species	Common name	IUCN Status	Endemism
1	*Megalops cyprinoides*	Oxeye tarpon	DD	Not Known
2	*Anguilla bengalensis*	Indian long fin eel	LC	Not Known
3	*Dayella malabarica*	Day's Round Herring	LC	EN-K
4	*Gibelion catla*	Catla	LC	EN-IS
5	*Labeo calbasu*	Kalbasu	LC	Not Known
6	*Hypselobarbus curmuca*	Curmuca barb	EN	EN-WG
7	*Osteobrama bakeri*	Malabar Osteobrama	LC	EN-K
8	*Osteochilichthys nashii*	Nash's barb	LC	EN-WG
9	*Puntius amphibius*	Scarlet-banded barb	DD	Not Known
10	*Puntius denisonii*	Red Line Torpedo Barb	EN	EN-K
11	*Puntius arulius*	Longfin barb	EN	EN-WG
12	*Puntius jerdoni*	Jerdon's carp	LC	EN-WG
13	*Puntius fasciatus*	Melon barb	LC	EN-I
14	*Puntius filamentosus*	Black-spot barb	LC	EN-I
15	*Puntius vittatus*	Kooli barb	LC	EN-IS
16	*Puntius ticto*	Ticto barb	LC	Not Known
17	*Puntius sarana subnasutus*	Penisular olive barb	LC	Not Known
18	*Puntius chola*	Chola barb	LC	Not Known
19	*Puntius sophore*	Spotfin swamp barb	LC	Not Known
20	*Tor khudree*	Deccan mahseer	EN	Not Known
21	*Salmphasia boopis*	Boopis razorbelly minnow	LC	EN-WG
22	*Amblypharyngodon melettinus*	Silver carplet	LC	Not Known
23	*Barilius bakeri*	Malabar baril	LC	EN-WG
24	*Barilius canarensis*	Jerdon's baril	EN	EN-WG
25	*Barilius gatensis*	River carp baril	LC	EN-WG
26	*Devario aequipinnatus*	Giant danio	LC	EN-IS
27	*Devario malabaricus*	Malabar danio	LC	EN-IS
28	*Dario urops*	Not known	NE	Not Known
29	*Laubuca fasciata*	Malabar hatchet chela	VU	EN-K
30	*Esomus danrica*	Flying barb	LC	EN-IS
31	*Rasbora daniconius*	Slender barb	LC	Not Known
32	*Garra mullya*	Mullya garra	LC	EN-I
33	*Bhavania australis*	Western Ghat loach	LC	EN-WG
34	*Nemacheilus guentheri*	Gunther's Loach	LC	EN-WG
35	*Mesonoemacheilus triangularis*	Zodiac Loach	LC	EN-WG
36	*Lepidocephalichthys thermalis*	Common spiny loach	LC	Not Known

37	*Horabagrus brachysoma*	Gunther's catfish	VU	EN-WG
38	*Mystus cavasius*	Gangetic mystus	LC	Not Known
39	*Mystus gulio*	Long-whiskered catfish	LC	Not Known
40	*Mystus armatus*	Kerala mystus	LC	EN-IS
41	*Mystus malabaricus*	Jerdon's mystus	NT	EN-WG
42	*Mystus oculatus*	Malabar mystus	LC	EN-WG
43	*Ompok bimaculatus*	Indian butter catfish	NT	EN-IS
44	*Ompok malabaricus*	Goan catfish	NT	EN-I
45	*Wallago attu*	Boal	NT	Not Known
46	*Glyptothorax malabarensis*	Not known	DD	EN-K
47	*Clarias batrachus*	Magur	LC	Not Known
48	*Clarias dussumieri*	Valenciennes clariid	NT	EN-WG
49	*Heteropneustes fossilis*	Stinging catfish	LC	Not Known
50	*Xenentodon cancila*	Freshwater garfish	LC	Not Known
51	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
52	*Aplocheilus blocki*	Green Panchax	LC	EN-IS
53	*Poecilia reticulata*	Guppy	NE	EX
54	*Microphis cuncalus*	Crocodile-tooth pipefish	LC	EN-IS
55	*Mastacembelus armatus*	Spiny eel	LC	Not Known
56	*Macrognathus guentheri*	Malabar spiny eel	LC	EN-K
57	*Parambassis dayi*	Day's glassy perchlet	LC	EN-WG
58	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
59	*Pseudambassis baculis*	Himalayan glassy perchlet	LC	Not Known
60	*Pseudambassis ranga*	Indian glassy fish	LC	Not Known
61	*Nandus nandus*	Mottled nandus	LC	Not Known
62	*Pristolepis marginata*	Malabar catopra	LC	EN-WG
63	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
64	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
65	*Oreochromis mossambicus*	Tilapia	NT	EX
66	*Sicyopterus griseus*	Clown Goby	LC	EN-IS
67	*Glossogobius giuris*	Tank goby	LC	Not Known
68	*Anabas testudineus*	Climbing perch	DD	Not Known
69	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	EN-IS
70	*Channa marulius*	Giant snake head	LC	Not Known
71	*Channa orientalis*	Walking snakehead	LC	Not Known
72	*Channa striata*	Banded snake head	LC	Not Known
73	*Carinotetradon travancoricus*	Malabar puffer fish	VU	EN-WG

Table 2.44. List of fish species reported from Uppala river system

Sl.No.	Species	Local name		Endemism
1	*Anguilla bengalensis*	Indian long fin eel	LC	Not known
2	*Dayella malabarica*	Day's Round Herring	LC	EN-K
3	*Puntius amphibius*	Scarlet-banded barb	DD	Not known
4	*Puntius filamentosus*	Black-spot barb	LC	EN-I
5	*Puntius fasciatus*	Melon barb	LC	EN-I
6	*Puntius vittatus*	Kooli barb	LC	EN-IS
7	*Devario aequipinnatus*	Giant danio	LC	EN-IS
8	*Devario malabaricus*	Malabar danio	LC	EN-IS
9	*Rasbora daniconius*	Slender barb	LC	Not known
10	*Garra mullya*	Mullya garra	LC	EN-I
11	*Mystus gulio*	Long-whiskered catfish	LC	Not known
12	*Mystus armatus*	Kerala mystus	LC	EN-IS
13	*Mystus oculatus*	Malabar mystus	LC	EN-WG
14	*Xenetodon cancila*	Freshwater garfish	LC	Not known
15	*Aplocheilus lineatus*	Malabar killie	LC	EN-I
16	*Microphis cuncalus*	Crocodile-tooth pipefish	LC	EN-IS
17	*Parambassis thomassi*	Western Ghat glassy perchlet	LC	EN-WG
18	*Gerres limbatus*	Saddleback silver-biddy	NE	Not known
19	*Ambassis miops*	Flag-tailed glass perchlet	LC	Not known
20	*Nandus nandus*	Mottled nandus	LC	Not known
21	*Etroplus maculatus*	Orange chromidae	LC	EN-IS
22	*Etroplus suratensis*	Banded pearl spot	LC	EN-IS
23	*Oreochromis mossambicus*	Tilapia	NT	EX
24	*Glosogobius giuris*	Tank goby	LC	Not known
25	*Pseudosphromenus cupanus*	Spiketailed paradisefish	LC	Not known
26	*Terapon jarbuca*	Jarbua terapon	LC	Not known
27	*Mugil cephalus*	Flat head mullet	LC	Not known

Table.2.45 Comparison between river systems of Kerala based on the nature of species diversity

Species characterestics	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Total species	86	29	19	120	46	128	83	60	24	33	90	45	67	33	40	63	52	39	56	41
Ornamental fishes	38	16	14	60	29	65	47	35	13	18	47	23	31	18	21	37	23	24	31	22
Food fishes	18	4.5	2.5	22.5	4.5	23	13	9	4	5.5	13	8.5	12	5.5	6.5	9	10.5	4.5	8.5	6.5
Cultivable fishes	12	4	0	15	8	18	10	6	3	4	16	5	12	4	6	8	8	6	8	6
Critically End. species	0	0	0	10	0	5	10	0	0	0	5	0	5	0	0	0	0	0	0	0
Endangered species	27	0	0	30	15	42	21	15	0	3	33	3	21	0	9	21	3	0	12	6
Vulnerable species	16	2	0	16	4	16	8	2	0	0	6	2	10	2	4	4	8	4	4	0
Near Threatened species	4	2	0	5	4	5	5	4	2	2	5	3	5	2	3	6	4	3	4	4
Endemic fishes of Kerala	60	10	10	100	20	140	60	30	10	10	30	20	40	20	20	40	20	10	10	20
Endemic species to the particular river system	0	0	0	60	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0
River index	261	67.5	45.5	439	131	442	277	161	56	75.5	245	110	203	84.5	110	188	128.5	91	134	106
Catchment area	1484	412	66	4400	562	1404	2535	570	145	642	1920	1122	1699	96	702	429	1054	401	469	583
Index value per Km2	0.175	0.16	0.68	0.1	0.23	0.31	0.11	0.28	0.39	0.12	0.13	0.1	0.12	0.88	0.2	0.44	0.122	0.2	0.28	0.18
Status of river system as hot spot	G	P	P	E	M	E	G	M	P	P	G	M	G	P	M	M	M	P	M	M

Species characterestics	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Total species	32	20	16	56	51	22	85	57	44	22	48	76	139	22	37	35	34	50	73	27
Ornamental fishes	21	12	12	33	28	14	48	30	24	17	29	46	72	15	18	18	16	31	42	14
Food fishes	4.5	2.5	2	8	8	3.5	13	8	12	2	6	10.5	20.5	2	7.5	7	7	6.5	10.5	5
Cultivable fishes	2	3	0	6	7	1	11	11	6	1	7	15	24	3	4	3	4	6	10	3
Critically End. species	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0
Endangered species	3	0	3	12	12	0	21	12	6	3	21	21	54	0	0	0	0	21	15	0
Vulnerable species	0	0	0	6	6	0	12	4	2	0	6	12	26	0	2	0	0	0	6	0
Near Threatened species	3	1	0	5	3	1	4	5	3	0	3	3	5	3	0	2	4	4	6	1
Endemic fishes of Kerala	10	10	0	20	30	20	80	10	20	0	40	60	270	0	20	10	20	30	60	10
Endemic species to the particular river system	0	0	0	0	0	0	0	0	0	0	40	0	220	0	0	0	0	0	0	0
River index	75.5	48.5	33	146	145	61.5	274	137	117	45	200	244	841	45	88.5	75	85	148.5	222.5	60
Catchment area	394	90	114	847	1272	132	1554	497	190	220	384	2235	5284	300	234	290	117	687	1321	76
Index value per Km2	0.19	0.54	0.3	0.17	0.11	0.47	0.176	0.28	0.62	0.2	0.52	0.11	0.16	0.15	0.378	0.26	0.73	0.216	0.168	0.789
Status of river system as hot spot	P	P	P	M	M	P	G	M	M	P	G	G	E	P	P	P	P	M	G	P

1 Achenkovil
2 Anjarakandy
3 Ayoor
4 Bharathapuzha
5 Bhavani
6 Chalakudy
7 Chaliyar
8 Chandragiri
9 Chittari
10 Ithikkara
11 Kabbini
12 Kadalundi
13 Kallada
14 Kallai
15 Karamana
16 Kariangode
17 Karuvannur
18 Keecheri
19 Kuppam
20 Kuttiadi
21 Mahe
22 Manjeswar
23 Mamom
24 Manimala
25 Meenachil
26 Mogral
27 Muvattupuzha
28 Neyyar
29 Nileswar
30 Pallikkal
31 Pambar
32 Pamba
33 Periyar
34 Peruvamba
35 Puzhakkal
36 Shiriya
37 Tirur
38 Vamanapuram
39 Valapattanam
40 Uppala

Table 2. 46. Comparison of species inventory between river systems of Kerala based on regional distribution

Sl.No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Total
1	*Notopterus notopterus*				*			*				*	*				*																									5
2	*Megalops cyprinoides*	*			*		*							*																										*		5
3	*Elops machnata*						*																																			1
4	*Anguilla bicolor*				*		*																											*					*			4
5	*Anguilla bengalensis*	*			*		*	*			*			*		*		*		*	*				*	*		*	*	*		*		*		*				*	*	20
6	*Pisodonophis boro*	*											*																					*								3
7	*Dayella malabarica*	*	*		*		*	*	*	*		*		*	*			*		*	*	*			*	*	*	*		*		*		*		*	*	*	*	*	*	27
8	*Stolephorus commersonii*						*																																			1
9	*Chanos chanos*				*									*																												2
10	*Cirrhinus reba*											*																														1
11	*Cirrhinus mrigala*				*		*					*		*			*		*													*		*								8
12	*Gibelion catla*	*			*		*										*				*							*	*			*	*	*						*		11
13	*Cyprinus carpio*	*					*					*		*																		*		*								6
14	*Ctenopharyngodon idella*																*																	*								2
15	*Labeo calbasu*																															*		*						*		3
16	*Labeo rohita*	*			*		*					*																						*								5
17	*Labeo dussumieri*	*					*																	*		*		*				*		*								7
18	*Labeo fimbriatus*				*																											*										2
19	*Labeo ariza*					*																																				1
20	*Labeo potail*					*						*																														2
21	*Labeo kontius*											*																														1
22	*Labeo nigriscens*								*																									*								2
23	*Hypselobarbus curmuca*	*			*		*	*	*		*		*	*		*		*		*			*	*		*		*	*			*	*	*					*	*		21
24	*Hypselobarbus kurali*	*												*																				*								3
25	*Hypselobarbus thomassi*						*							*																				*								3
26	*Hypselobarbus periyarensis*																																	*								1
27	*Hypselobarbus kolus*				*		*							*		*												*						*								6
28	*Hypselobarbus dubius*	*				*						*																														3
29	*Hypselobarbus micropogon*											*																														1
30	*Osteobrama cotio penisularis*																																	*								1
31	*Osteobrama bakeri*	*			*		*	*	*					*			*	*						*		*		*				*		*						*		14
32	*Osteochilus nashi*				*	*		*	*			*						*																*						*		8
33	*Osteochilichthys thomassi*												*																					*								2

34	*Osteochilus longidorsalis*						*																											*								2
35	*Osteochilichthys brevidorsalis*				*			*				*																														3
36	*Puntius amphibius*	*	*	*	*		*	*	*	*	*	*	*	*			*	*	*	*			*	*	*	*		*	*	*	*	*		*	*	*	*	*	*	*	*	33
37	*Puntius ophicephalus*																									*								*								2
38	*Puntius denisonii*	*			*		*	*	*									*						*		*						*		*						*		11
39	*Puntius arulius*				*	*		*	*			*		*		*	*	*		*	*	*		*		*		*	*	*	*	*	*						*	*		22
40	*Puntius conchonius*				*			*	*			*						*						*																		6
41	*Puntius filamentosus*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	38
42	*Puntius fasciatus*	*		*	*	*	*	*	*		*	*	*	*		*	*	*	*	*	*	*	*	*		*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	34
43	*Puntius vittatus*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	37
44	*Puntius ticto*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*		*	*	*	*	*		37
45	*Puntius sarana subnasutus*	*	*		*		*	*	*	*	*	*	*	*	*	*	*	*		*	*	*		*		*		*	*	*		*	*	*		*	*	*	*	*		31
46	*Puntius jerdoni*	*			*		*		*					*												*								*						*		8
47	*Puntius chola*	*			*	*	*	*	*			*		*		*	*	*	*	*	*	*	*	*		*		*		*		*		*			*		*	*		25
48	*Puntius dorsalis*				*	*	*				*			*														*	*					*					*			9
49	*Puntius mahecola*						*				*	*		*		*												*	*					*					*			9
50	*Puntius parrah*				*		*						*			*	*			*						*		*						*		*						10
51	*Puntius sophore*				*	*		*	*						*		*	*	*															*						*		10
52	*Puntius bimaculatus*	*					*					*																				*										4
53	*Puntius muvattupuzhaensis*																											*						*								2
54	*Puntius chalakkudiensis*	*					*																																			2
55	*Puntius punctatus*						*																					*						*								3
56	*Puntius assimilis*						*							*																												2
57	*Puntius crescents*						*																					*														2
58	*Puntius exclamatio*													*																												1
59	*Puntius madusoodani*																							*																		1
60	*Puntius nigripinnis*											*																														1
61	*Barbodes carnaticus*	*			*	*	*	*				*																*	*				*	*								10
62	*Barbodes bovanicus*				*																																					1
63	*Barbodes wynaadensis*							*				*																														2
64	*Tor khudree*	*			*	*	*	*	*			*		*		*		*		*								*	*	*		*	*	*					*	*		19
65	*Tot tor*								*																																	1
66	*Tor putitora*											*																														1
67	*Tor malabaricus*													*																												1
68	*Tor remadevi*																																*									1
69	*Crossocheilus periyarensis*																																	*								1

70	*Salmophasia acinaces*	*			*	*	*	*	*			*	*					*		*				*		*		*		*		*	*	*	*							18
71	*Salmophasia boopis*	*	*	*	*	*	*	*	*	*	*	*	*	*			*	*						*		*		*	*	*	*	*	*	*				*	*	*		27
72	*Salmophasia balookee*																												*													1
73	*Amblypharyngodon melettinus*	*	*	*	*		*	*	*	*	*	*	*		*	*		*	*	*	*	*	*	*		*	*	*	*	*	*	*		*		*	*	*	*	*		33
74	*Amblypharyngodon microlepis*	*			*		*	*						*										*								*		*								8
75	*Amblypharyngodon mola*											*																														1
76	*Barilius bakeri*	*	*		*	*	*	*	*		*	*		*		*		*		*				*		*		*	*			*	*	*					*	*		22
77	*Barilius gatensis*	*			*	*	*	*	*		*	*	*	*		*	*	*	*	*	*	*		*		*		*	*	*	*	*	*	*	*				*	*		29
78	*Barilus bendelisis*				*	*	*																										*									4
79	*Barilius canarensis*				*	*	*	*				*						*						*				*						*						*		10
80	*Devario malabaricus*	*		*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	38
81	*Devario aequipinnatus*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	37
82	*Devario fraseri*																																	*								1
83	*Dario urops*																																							*		1
84	*Laubuca dadiburjori*				*		*																					*						*								4
85	*Laubuca fasciata*	*			*		*	*																				*						*						*		7
86	*Laubuca laubuca*											*																														1
87	*Esomus danrica*				*		*	*									*			*						*		*					*	*						*		10
88	*Esomus thermoicos*				*		*					*																						*								4
89	*Danio rerio*								*			*																														2
90	*Rasbora daniconius*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	40
91	*Lepidopygopsis typus*																																	*								1
92	*Garra mullya*	*	*	*	*	*	*	*	*		*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	37
93	*Garra hughi*	*																*		*									*			*	*						*			7
94	*Garra menoni*				*	*																											*									3
95	*Garra travancoria*																																	*								1
96	*Garra periyarensis*																																	*								1
97	*Garra surendranathanii*	*			*		*																									*		*								5
98	*Garra ceylonensis*	*																														*		*								3
99	*Garra emarginata*																											*						*								2
100	*Garra mlapparaensis*																																	*								1
101	*Garra mcclellandi*				*			*						*															*				*	*	*							7
102	*Garra stenorhynchus*																											*					*	*								3
103	*Garra annandalei*				*																																					1
104	*Garra nilamburensis*							*																																		1
105	*Horalabiosa joshuai*				*																												*									2

106	*Horalabiosa arunachalami*																																	*								1
107	*Horadandia attukorali*						*																					*						*								3
108	*Homaloptera santhamparaiensis*																																	*								1
109	*Homaloptera silasi*																																	*								1
110	*Homaloptera pillaii*				*																																					1
111	*Homaloptera montana*				*		*																																			2
112	*Homaloptera menoni*					*																																				1
113	*Baltora mysorensis*	*			*	*		*				*																														5
114	*Bhavania australis*	*			*	*	*	*	*			*		*				*		*								*				*		*					*	*		15
115	*Travancoria jonesi*						*							*																				*					*			4
116	*Travancoria elongata*						*																											*								2
117	*Nemachelius denisoni*				*	*			*															*				*				*	*	*								8
118	*Nemacheilus guentheri*	*			*	*	*	*	*			*	*		*		*	*		*	*			*		*		*		*		*	*	*					*	*		21
119	*Nemacheilus triangularis*	*			*	*	*	*	*			*	*	*		*	*	*	*	*	*	*		*			*	*	*	*		*	*	*		*	*		*	*		28
120	*Nemacheilus menoni*																															*		*								2
121	*Nemacheilus periyarensis*																																	*								1
122	*Nemacheilus keralensis*																									*		*						*								3
123	*Nemacheilus pulchellus*						*	*																									*	*								4
124	*Nemachelius semiarmatus*					*						*																					*									3
125	*Nemacheilus monilis*					*						*																					*									3
126	*Nemacheilus nigiriensis*											*																														1
127	*Nemacheilus mooreh*											*																														1
128	*Nemacheilus petrubanarescui*											*																														1
129	*Mesonoemacheilus remadevii*				*																																					1
130	*Mesonoemacheilus pambarensis*																																*									1
131	*Indoreonectes evezardi*				*				*																								*	*								4
132	*Longischistura striata*											*																														1
133	*Acanthocobitis botia*											*																						*								2
134	*Lepidocephalichthys thermalis*	*	*		*	*	*	*	*	*		*	*	*	*		*	*	*		*	*		*			*		*	*		*	*	*	*	*	*		*	*		29
135	*Lepidocephalichthys guntea*				*																																					1
136	*Botia striata*																																						*			1
137	*Pangio bashai*							*																																		1
138	*Pangio goaensis*							*																*																		2
139	*Batasio travancoria*	*			*		*	*	*											*				*								*	*	*								10
140	*Horabagrus nigricollaris*	*					*																											*								3
141	*Horabagrus brachysoma*				*		*	*				*		*		*	*	*	*	*				*		*		*	*			*		*						*		17

142	*Mystus cavasius*	*			*		*	*				*		*			*									*		*					*	*		*				*		13
143	*Mystus gulio*	*			*		*	*	*			*	*	*	*		*		*	*				*	*	*		*	*	*		*		*	*	*	*		*	*	*	26
144	*Mystus vittatus*				*		*																					*						*								4
145	*Mystus armatus*	*	*		*	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*		*	*	*		*	*	*	*	*	*	*			*	*	*	*	*	33
146	*Mystus malabaricus*	*	*		*	*	*	*	*		*	*		*	*	*	*	*	*	*	*	*		*				*	*			*	*	*			*	*	*	*		28
147	*Mystus montanus*	*			*		*					*		*		*												*						*								8
148	*Mystus oculatus*	*	*	*	*		*	*	*	*	*	*			*			*	*	*	*		*	*		*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	32
149	*Mystus keletius*	*					*																																			2
150	*Mystus bleekeri*																											*													1
151	*Hemibagrus menoda*	*																													*										2
152	*Hemibagrus punctatus*				*			*				*					*																									4
153	*Ompok bimaculatus*	*			*	*	*	*	*	*		*	*	*		*	*	*	*	*	*	*		*		*		*	*	*		*		*	*		*	*	*	*		29
154	*Ompok malabaricus*	*			*		*		*					*			*	*										*	*					*						*		11
155	*Wallago attu*	*	*		*	*	*	*	*	*	*	*	*		*		*	*			*			*		*		*	*			*	*	*				*	*	*		25
156	*Pterocryptis wynaadensis*							*			*						*			*																*					5
157	*Pseudeutropius mitchelli*					*																										*	*								3
158	*Glyptothorax annandalei*	*					*	*	*			*		*				*		*								*					*	*								11
159	*Glyptothorax anamalaiensis*							*				*																														2
160	*Glyptothorax housei*	*			*																							*						*								4
161	*Glyptothorax madraspatanus*	*			*							*																*				*		*					*			7
162	*Glyptothorax lonah*					*																																			1
163	*Glyptothorax davissinghi*						*																																		1
164	*Glyptothorax malabarensis*																																						*		1
165	*Clarias batrachus*	*	*		*	*	*	*	*	*	*	*	*		*		*	*	*	*	*	*		*		*		*	*	*	*	*				*	*	*		*		29
166	*Clarias gariepinus*																														*		*								2
167	*Clarias dussumieri*				*		*	*				*		*				*		*				*					*	*				*	*					*		13
168	*Heteropneustes fossilis*	*			*	*	*	*			*	*	*	*		*	*	*	*	*	*		*	*		*		*	*	*	*	*	*	*	*	*		*		*		29
169	*Nemapteryx caelata*					*																																			1
170	*Pseudolaguvia austrina*				*																																				1
171	*Xenentodon cancila*	*	*		*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*		*		*	*	*	*	*	*	*	*	35
172	*Strongylura strongylura*						*																										*								2
173	*Oryzias setnai*																		*																						1
174	*Hyporhamphus limbatus*	*			*		*							*																			*								5
175	*Hyporhamphus xanthopterus*	*			*		*																										*								4
176	*Aplocheilus lineatus*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*		*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	37
177	*Aplocheilus blocki*					*																						*	*					*						*		5

178	*Aplocheilus panchax*					*																					*						*								3
179	*Poecilia reticulata*				*		*	*				*								*	*													*						*		8
180	*Gambusia affinis*						*																																			1
181	*Xiphophorus maculatus*						*																																			1
182	*Microphis cuncalus*				*		*	*										*			*	*						*				*		*			*			*	*	12
183	*Macrognathus guentheri*			*	*		*	*				*	*		*	*	*	*	*		*							*		*		*		*		*		*		*		19
184	*Mastacembelus armatus*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*	*	*	*		*		*	*	*	*	*		*		*		*	*	*		*		31
185	*Macrognathus aral*																										*					*		*								3
186	*Ophisternon bengalense*						*																					*						*								3
187	*Parambassis dayi*	*			*		*		*				*	*			*	*	*	*				*		*		*		*		*		*	*	*	*	*	*	*		22
188	*Parambassis thomassi*	*		*	*		*	*		*	*	*		*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*		*	*		*	*	*	33
189	*Pseudambassis ranga*				*							*		*	*	*					*								*									*		*		9
190	*Pseudambassis baculis*	*																																						*		2
191	*Ambassis gymnocephalus*				*		*																																			2
192	*Ambassis ambassis*				*																																					1
193	*Chanda nama*	*			*		*	*				*	*	*														*						*								9
194	*Gerres filamentosus*	*			*		*																																			3
195	*Ambassis miops*																																								*	1
196	*Gerres limbatus*																																								*	1
197	*Nandus nandus*	*	*		*	*	*		*	*		*	*		*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*		*		*	*	*	*	*	*	33
198	*Pristolepis marginata*	*			*		*	*				*	*	*			*	*		*				*		*		*	*			*	*	*		*		*	*	*		21
199	*Pristolepis rubripinnis*						*																									*										2
200	*Etroplus suratensis*	*			*		*	*	*	*	*	*	*	*	*	*	*	*	*	*				*	*	*		*	*	*		*		*	*	*	*	*	*	*	*	31
201	*Etroplus maculatus*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	38
202	*Oreochromis mossambicus*	*	*		*	*	*	*				*	*	*		*		*	*	*	*	*		*	*	*	*	*	*	*			*	*	*		*	*	*	*	*	30
203	*Oreochromis niloticus*				*																																					1
204	*Entomacrodus vermiculatus*						*																																			1
205	*Osphronemus goramy*						*																																			1
206	*Eleotris fusca*				*		*																																			2
207	*Bunaka gyrinoides*																															*										1
208	*Sicyopterus griseus*				*		*	*	*							*				*	*	*							*			*		*						*		12
209	*Awaous stamineus*																											*						*								2
210	*Awaous guamensis*						*																																			1
211	*Glossogobius giuris*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		*	*		*	*	*	*	*	*		*		*	*		*	*	*	34
212	*Schismatogobius deraniyagalai*							*																																		1
213	*Anabas testudineus*	*	*	*	*		*	*	*	*	*		*		*		*	*	*		*	*	*	*		*	*	*	*	*		*	*	*		*	*	*		*		30

214	*Pseudosphromenus cupanus*	*	*		*		*	*	*	*			*		*			*		*	*	*			*		*			*		*		*			*	*	*	*	*	23
215	*Pseudosphromenus dayi*						*																					*						*								3
216	*Channa striata*	*			*		*	*	*		*	*	*	*	*	*	*	*	*	*				*		*		*	*	*		*		*	*	*		*	*	*		27
217	*Channa marulius*	*	*		*	*	*	*			*	*	*	*	*	*	*	*	*	*	*							*	*			*		*		*			*	*		24
218	*Channa orientalis*	*					*	*	*	*		*					*	*	*	*								*	*			*		*		*		*		*		17
219	*Channa gachua*	*					*																					*						*					*			5
220	*Channa punctatus*	*															*		*															*								4
221	*Channa diplogramma*	*												*																		*										3
222	*Nuchequula blochii*				*																																					1
223	*Lutjanus argentimaculatus*				*		*																																			2
224	*Terapon jarbuca*				*		*																																		*	3
225	*Caranx hippos*						*																																			1
226	*Sillago vincenti*				*																																					1
227	*Macrospinosa cuja*						*																																			1
228	*Scatophagus argus*				*		*																																			2
229	*Mugil cephalus*						*							*																											*	3
230	*Chelon planiceps*				*																																					1
231	*Cynoglossus macrostomus*				*																																					1
232	*Brachirus orientalis*				*		*	*																																		3
233	*Carinotetraodon travancoricus*	*	*		*		*	*					*		*		*	*	*					*		*		*	*	*		*		*		*				*		19
234	*Oncorhynchus mykiss*						*																										*	*								3

1	Achenkovil	5	Bhavani	9	Chittari	13	Kallada	17	Karuvannur	21	Mahe	25	Meenachil	29	Nileswar	33	Periyar	37	Tirur
2	Anjarakandy	6	Chalakudy	10	Ithikkara	14	Kallai	18	Keecheri	22	Manjeswar	26	Mogral	30	Pallikkal	34	Peruvamba	38	Vamanapuram
3	Ayoor	7	Chaliyar	11	Kabbini	15	Karamana	19	Kuppam	23	Mamom	27	Muvattupuzha	31	Pambar	35	Puzhakkal	39	Valapattanam
4	Bharathapuzha	8	Chandragiri	12	Kadalundi	16	Kariangode	20	Kuttiadi	24	Manimala	28	Neyyar	32	Pamba	36	Shiriya	40	Uppala

.....ജൽ.....

Chapter 3

EXPLOITED FISHERIES OF MAJOR RIVERS OF KERALA

Contents

3.1. Introduction

Fisheries is the human's utilization of fish and other aquatic organisms having certain values to human beings. It contributes more than any other animal production activity to protein intake in most of the developing countries of the world. Man has been exploiting aquatic resources ever since his presence on this planet for various activities. Sustainable exploitation of fish stock and other aquatic organism is a deep concern among fishery scientists all over the world. Inland fisheries engage more than 56 million people in the world (BNP, 2009) and majority of these inland fishers are involved in the 'small scale sector' (Welcomme *et al*., 2011), which makes it important in the economies of some of the world's poorest countries (Andrew *et al.,* 2007). Of the various ecosystems where small-scale fisheries operate, freshwaters (including rivers, lakes and reservoirs) tend to be least studied (Raghavan *et al.,* 2011). Small-scale freshwater fisheries are seldom the focus of attention because they are located in tropical developing countries where landing are made in dispersed sites (DFID, 2002). Tropical freshwater small-scale commercial fisheries provide cash income and animal protein for many people in the developing countries (Bayley and Petrere, 1989).

Fish is an important element in the diet of the people in India, where religious beliefs otherwise restrict the availability of animal protein. The fisheries sector has playing an important role in the Indian economy by its contribution to employment generation, income argumentation, foreign exchange earnings and in providing food and nutritional security. Fish production of the country has been growing steadily with improvement in production, productivity and utilization of untapped resources and the present production of fish and shell fish from capture fisheries and aquaculture being 8 million tonnes (Ayyapan *et al.*, 2011). The country also has an important role in global fisheries as the second largest producer of fish world wide and a higher enhancement levels as compared to world fish production levels. The fish production in the country increased from 0.75 million tonnes in 1950-51 to 8 million tonnes during 2009-10, over 11 times growth in the past decades, is a testimony to the contributions of the sector (Ayyapan *et al.*, 2011). India is blessed with rich water resources in the form of rivers, lakes, reservoirs, floodplain wetlands, estuaries, backwaters and numerous other water bodies. The vast and varied inland waters constitute important capture fishery resources of the country. In fact, initially, the inland fishery was neglected because of its negligible contribution to the national economy but during recent years the production from the inland fisheries has increased faster than marine fisheries.

Riverine fisheries comprise artisanal, subsistence and traditional fishing activities. They are highly dispersed and the collection of data on fishing and fish landings are difficult (Sinha, 1999). The riverine capture fishery resources of India comprises of five river systems, viz., the Ganges, Brahmaputra and the Indus river systems in the North and the Peninsular East coast and the West coast river systems in the south. Ganga -Brahmaputra Meghana system is the largest with a catchment area of about 110 million ha. (Ghosh and Ponniah, 2001). The potential of riverine systems as fishery resource varies from stretch to stretch between the rivers and also within the river. Based on the studies made by CIFRI in some selected stretches of the Ganga, Brahmaputra, Godavari and Krishna; the yield varies from 0.64 to 1.6 tonnes/km (Sinha,1999). The riverine fishes contribute siginificantly to the total inland fish production in the country and provide a means of livehood to thousands of poor fishermen. Reservoirs can emerge as one of the most vital components of inland fishery resources of India. Data on reservoirs fisheries of India are rare due to the common property nature of these resources, the diverse mode of exploitation adopted by the State Governments, the scattered nature of the fish landing centers and the remoteness of many reservoirs (Ghosh and Ponniah, 2001). India has 19,370 reservoirs spread over 15 states which contribute 93,650 tonnes of fishery annually (Sugunan, 1995). But the utilization of the potential available is only 38.2%. The fishery potential of reservoirs was not evaluated until 1970s, when fishery yields were as low as 5 to 8 kg/ha/yr (Sugunan, 1995). Stocking is used as a management option to correct species imbalance and fill vacant niches. The management strategy has yielded good results as reflected from the per hectare yield of large (11.43 kg), medium (12.30 kg) and small reservoirs (49.9 kg) in the post development scenario (Ghosh and Ponniah, 2001).

The fishery resources of many riverine waters of India are still exploited by traditional fishing methods and gears. A large number of fishing gears are employed in riverine habitat depending upon the targeted species, area of fishing, season of fishing and fish availability. The main types of fishing nets used for fishing in rivers of India were gillnets, cast nets, seine nets, hook and lines, traps, bag nets,drag net, scoop nets etc. Hook and line is the main gear in the upper stretches where no organized fishery exists. The major fishing gear used in middle stretches are drag nets, gill nets, cast nets, traps and hook and lines (Ghosh and Ponniah, 2001). In the lower regions they include gill nets, seine nets, cast nets, drag nets, scoop nets, hook and lines and traps (Sinha *et al.*, 1998). Fishing by dynamiting, poison and electric equipments are banned in many parts of the world as well as in India. Information available on the gears and methods available in the rivers of the country is incomplete, as many of them have only a brief description about their character. In the exploitation of fishery wealth of rivers, standardization of gears is a factor of great importance because it helps in assessing properly the catch per unit effort. Review of available literature showed that the first work on freshwater fish and fisheries in India is from Eastern Bengal and Assam was by De (1910). An account of fishing gears operated in Nilgiris region was given by Wilson (1920). Inland fishing gears of some parts of Punjab were reported by Hora (1926;1935b), Mysore (Bhimachar, 1942), Uttar Pradesh (Famqui and Sahai, 1943), Ganga river (Saxena 1964, 1993), Brahmaputra river (Joseph and Narayanan, 1965), Himachal Pradesh (Sehgal, 1973, Tandon and Sharma, 1984), Rajasthan (Kulshreshtha, 1986) and Karnataka (Sathyanarayanappa *et al.*,1987). Fishing methods employed in the fishery of Indian shad in Narmada river was given by Kulkarni (1951) and Jones (1959 a,b). Different types of seine net prevalent in Brahmaputra river are given by Joseph and Narayanan (1965). Fishing methods in reservoirs of India was described by Kurian (1971) and Khan *et al.* (1991). Seine nets in reservoir fishing was detailed by Jones (1959 a,b), Kurian (1971), Brandt (1972), George (1983 a, b), Varghese *et al*. (1982), Khan *et al.* (1991) and Ninan and Swamikumar (2003). Fishing methods of flood plain lakes in North Eastern region, North Bihar, West Bengal and Eastern Uttar Pradesh were reported by Yadava *et al.* (1981), Bhagavati and Kalita (1987) and Choudhury (1992). Sharma *et al.* (1993), Nath and Dey (1989), Bhattacharya *et al.* (2004) and Gurumayum and Choudhury (2009) reported the fishing methods of North Eastern India. Mohan (1993) studied the fish trapping devices and methods in Southern India. Karr *et al*. (2000) gave an account of fishing implements used in Assam. George (2002) gave a note on the present status of fishing techniques of riverine and reservoir systems. Fishing method employed in lentic and lotic environment of Jammu province of Jammu and Kashmir state is described by Dutta *et al.* (2000). Srivastava *et al.* (2002) reported the fishing methods employed in the streams of Kumanon Himalayan region of India. Different types of gill nets operated in inland waters of India have been described by several workers. Hornell (1924), Saxena (1964) and Seth and Katiha (2003) described the Gangetic gill nets. Kulkarni (1951) reported the operation of sunken drift nets for *Hilsa ilisha* in Narmada river. Jones (1959 a, b) while reporting the fishing methods for the *Hilsa ilisha*, described gill nets for fishing in the Indian region while gill nets of River Brahmaputra have been given by Joseph and Narayanan (1965). *Phasla jal*, a gill net for catching *Hilsa* in the Ganga and Yamuna was reported by Saxena and Chandra (1968). Tandon and Sharma (1984) mentioned about gill nets operated in the Kangra and Hamirpur districts in Himachal Pradesh. Different types of gill nets operated in Indian rivers was reported by Sreekrishna and Shenoy (1987) and Saxena (1988). Description of cast net for inland waters in the country have been given by several workers like Hornell (1938), Jones (1946), Hickling (1961), Joseph and Narayanan(1965), George (1971) and Saxena (1988). An account of destructive fishing methods in Nilgiri district was reported by Wilson (1920) and fishing in rivers of hill ranges of Travancore was reported by Jones (1946). Indigenous plant piscicides used in north eastern India was reported by Sharma *et al.* (2005).

The state of Kerala was located in the southern region of Indian subcontinent, along the shore of the Arabian Sea. The total inland water spread area in Kerala was about 3,55,037 ha. There are 44 rivers in Kerala with a total catchment area of 37,884 km^2 (Anon, 1995). In addition to these; there exist a much larger number of smaller rivulets and streams. Periyar, Bharathapuzha, Chalakudy, Pamba, Chaliyar, Kallada, Valapatanam and Muvattupuzha are the major river systems of Kerala. These rivers were originating from Western Ghats which is one of the global biodiversity hotspots of the world (Mittermeier *et al.*

1998; Myers *et al.* 2000). The rivers of Kerala harbour rich fish diversity with numerous endangered and threatened fishes. Malampuzha, Sholayar, Neyyar, Kallada, Idukki, Periyar, Porigalkuthu are some of the major reservoirs of the state. These rivers and reservoirs support many varieties of fishes like common carp, Indian major carps, tilapia, catfishes, snake heads, prawns etc. The fish and fisheries play a crucial role in the well being of Kerala's economy. No attempts have been made till to quantify the exploited fishery resources of the rivers and reservoirs. More than half of the reservoirs in Kerala remains unutilized or under utilized as far as fisheries are concerned. lndo - German Reservoir Fisheries Development Project has estimated an annual potential fish production of 1700 tonnes from all reservoirs in Kerala (Sugunan, 1995). The percentage compostion of various fish species landed in the different inland landing centres of Kerala showed that freshwater fish species such us *Gibelion catla* (9%),*Cyprinus carpio* (9%) and *Cirrhinus mrigala* (6%) were the dominant species in the landing (Kurup and Radhakrishnan, 2006). Most of the earlier works on fish, fisheries and fishing methods in Kerala inland waters are scattered as part of various studies. The fishing methods prevailed in the erstwhile princely state of Travancore during the 1940s encompasses three distinct categories, viz., explosives, poisons and traps (Shaji and Laladhas, 2013). Destructive methods of fishing in the rivers of the hill ranges of Travancore were given by John (1936). Some interesting methods of fishing in the backwaters of Travancore were given by Gopinath (1953). Fishing methods of *Macrobrachium rosenbergii* were reported by Raman (1975), Kurup *et al.* (1993) and Harikrishnan and Kurup (1998). Fishing gears and fishing methods in Vembanad Lake was reported by Kurup and Samuel (1985). Fishing gears operated in 18 rivers of Kerala and Vembanad lake was given by Kurup *et al.* (1993). Baiju and Hridayanathan (2002) gave an account of the fishing gears operated in Muvattupuzha River. Jose (2002) gave an account on the inland fishermen and inland fishing at Neelamperoor village (Kottayam district). An account of inland fishing method in North Kerala was reported by Remesan (2006). Riverine fishing gears of central Kerala was studied by Baiju (2005). Gill nets of inland waters in North Kerala was reported by Remesan and Ramachandran (2005). Fish and fisheries in Periyar Lake was studied by Kurup *et al.* (2006). Renjithkumar *et al.* (2011) quantified the exploited fishery resources in Pamba river, Kerala.

Compared to marine waters, studies on the fisheries and fishing methods in freshwaters are relatively less. The literature available on inland capture fisheries of Kerala is scattered in estuarine waters. No effort has been made in the past to quantify the exploited fish and fisheries of rivers of Kerala and method of exploitation. In this context, it found essential to conduct a detailed study on the exploited fisheries of major rivers of Kerala and various fishing methods used in Kerala rivers. In the present study an attempt was made to quantify the exploited fisheries resources of major river systems of Kerala. A compressive account of operation of various gears used to exploit fish diversity of Kerala, species composition in the gear and catch per unit hour were also calculated and presented.

3.2. Materials and Methods

The study was carried out during January 2007- March 2010 as part of investigation carried out in KSCSTE project "Development of a database on fish germplasm, capture fisheries and biodiversity threats of rivers of Kerala". The exploited fishery of the rivers were estimated based on the data generated from major landing centres, where regular systematic surveys and sampling were conducted during pre monsoon, monsoon and post monsoon seasons. Pamba, Chalakudy, Periyar, Meenachil, Muvattupuzha, Kallada, Bharathapuzha and Achenkovil rivers were selected for the study (Fig.3.1). The details of the river systems surveyed such as month and year are given in Table 3.1. 39 major fish landing sites located in eight rivers were surveyed from 2007-2010. The number of landing centre selected for various rivers were as follows; Pamba-5 (Fig.3.4), Periyar-10 (Fig.3.12), Chalakudy-4 (Fig.3.19), Bharathapuzha-7 (Fig.3.27), Achenkovil-2 (Fig.3.35), Kallada-3(Fig.3.43), Muvattupuzha-6 (Fig.3.49) and Meenachil -2 (Fig.3.57). These landing centres are the principal locations where fishermen bring their catches for disposal. Details of landings were collected from more than 30% of the gears landed, giving emphasis to type of gear, mesh size, species composition and weight, size groups represented in the catch, actual fishing hours and man power engaged. Selection of fishing units for detailed observation was done following Alagaraja (1984) and Kurup *et al*. (1992). Fishermen were interviewed in the morning (4-8 am) before they could sell their fish and once on the shore the catches were recorded by species with corresponding weights. Fishermen were interviewed to determine what type of gear was used to catch each species and how many fishermen had participated in the operation. Each fisherman typically exploits a river segment not more than 10 km up stream or downstream from the landing site. Based on the interview, it was computed that the number of fishermen on a given day at a given landing centres varied from 2-15 individuals per site per day. The catch from the fisherman who arrived at a given landing site on a given time was examined. The fishing practise and effort are influenced by the availability of fish stocks in the river stretch. Fishermen do not target fishes that are rare and virtually all species and size classes, including the smallest were found valuable in the landing centres. The same group of fishermen could assess in the same landing centres throught out the 4-year study interval and this is because landing centres were proximated to their villages. The fishing methods of rivers surveyed were classified under gill net, cast net, seine net, drag net and hook and line. All the primary and secondary fresh water fish species that had collected from the landing centre within the limits of freshwater area of different river systems were brought under study. Fish specimen were preserved in 8% formalin and brought to the laboratory for species level identification following Day (1878), Talwar and Jhingaran (1991) and Jayaram (1999, 2009). Specimens were weighed with a spring balance or kitchen balance. Voucher speciemens were archived at the School of Industrial fisheries Museum, Cochin University of Science & Technology. Catch per Unit effort (CPUE) of each gear was calculated following Scaria *et al.* (1997). Daily landings from each type of gears and fishing methods were computed following Kurup *et al.* (1992).

$$W = (w/n) \times N$$

Where W = total weight of fish, w = total weight of fish from gear sampled

n = number of gear sampled, N = total number of similar gears operated.

Monthly catch was estimated by multiplying daily catch with total number of fishing days in a month. Season wise landing was estimated by multiplying monthly catch to number of months in the season. The annual exploited quantity was calculated by summarizing the landings of three seasons.

Table 3.1. Details of survey and sampling carried out in major rivers systems of Kerala

Sl. No	River systems	Month of survey
1	Pamba	June 2008,November 2008 and March 2009
2	Periyar	January 2008,May 2008,August 2008 and June 2008
3	Chalakudy	July 2008, October 2008 and January 2009
4	Bharathapuzha	March 2009,June 2009,November 2009 and December2009
5	Achenkovil	July 2009, November 2009, and March 2010
6	Kallada	February 2009, July 2009 and December 2009
7	Muvattupuzha	July 2008, December 2008 and March 2008
8	Meenachil	January 2007, April 2007 and August 2007

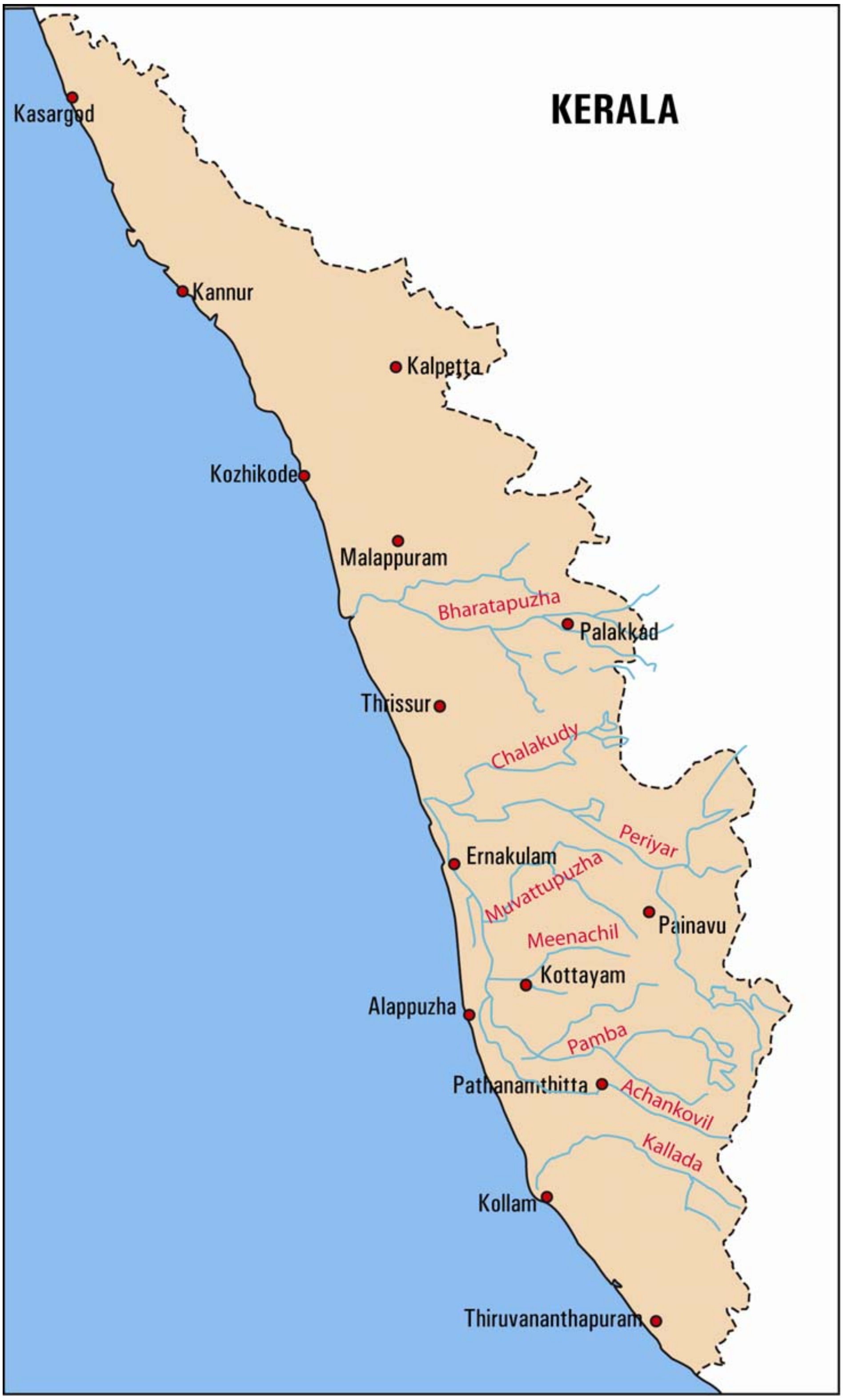


Fig.3.1. Map of Kerala showing river systems surveyed

3.3. Results

3.3.1. Exploited fish diversity of major rivers

54 fish species belonging to 9 orders, 21 families and 37 genera were recorded in the exploited fishery of eight major river systems during the study. The commercially important species and their biodiversity status are depicted in Table 3.2. Cypriniformes, Siluriformes and Perciformes were the dominant orders represented in the exploited fishery. Percentage contribution of various fish families to the total riverine fishery is depicted in Fig.3.2. Among the 54 fish species recorded in the landing centres, family Cyprinidae was the most dominant group with 20 species followed by Bagridae (5 species). *Gibelion catla, Labeo rohita, Cirrhinus mrigala, Cyprinus carpio, Oreochromis mossambicus* and *Clarias gariepinus* were the non-native species observed in the landings while freshwater prawns, *Macrobrachium rosenbergii* and *M. idella* were the invertebrate species in the exploited fishery. The landings were represented by one critically endangered (*Hypselobarbus thomassi*), two endangered (*Hypselobarbus curmuca* and *Tor khudree*), 5 vulnerable fish species (*Wallago attu, Ompok bimaculatus, Cyprinus carpio, Hypselobarbus kolus* and *Horabagrus brachysoma*) (Fig.3.3). Plate 1 - 8 depicts the pictures from fish landings centres from major rivers of Kerala.

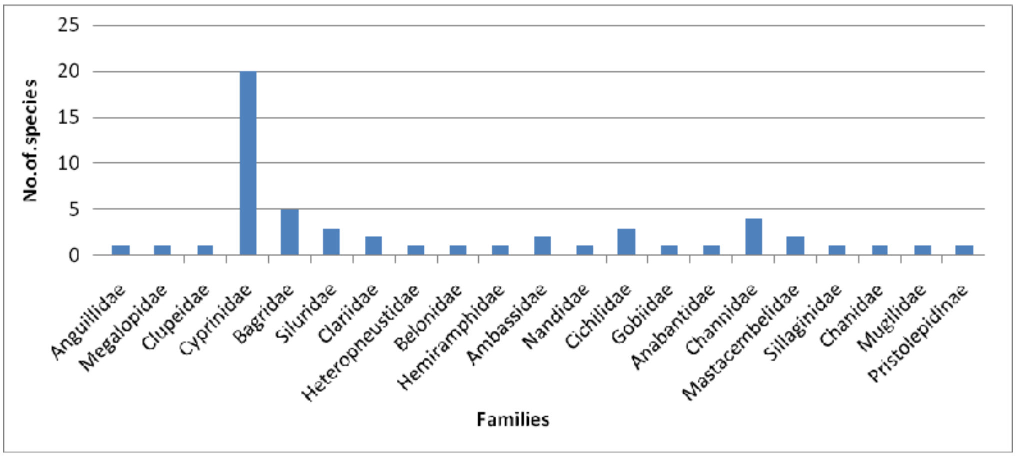


Fig.3.2. Numerical strength of various fish families contributed to the exploited fishery in rivers

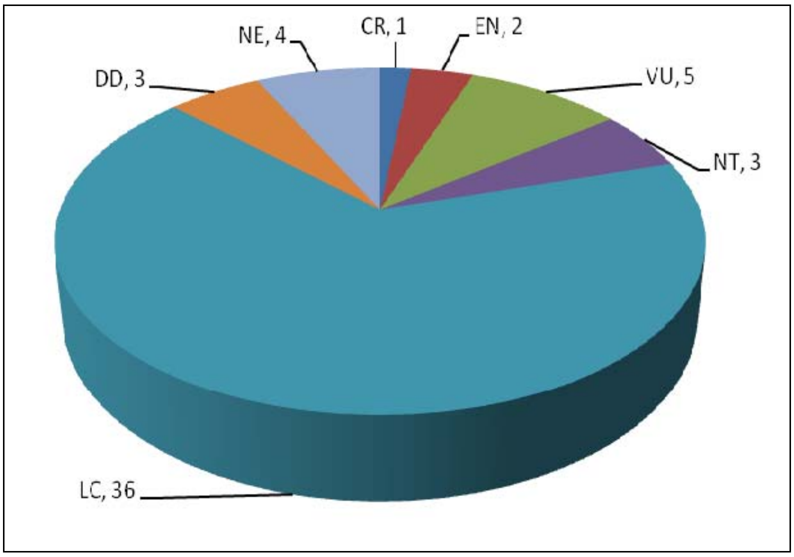


Fig.3.3. Biodiversity status of exploited fish species in major rivers of Kerala

3.3.2. Pamba river system

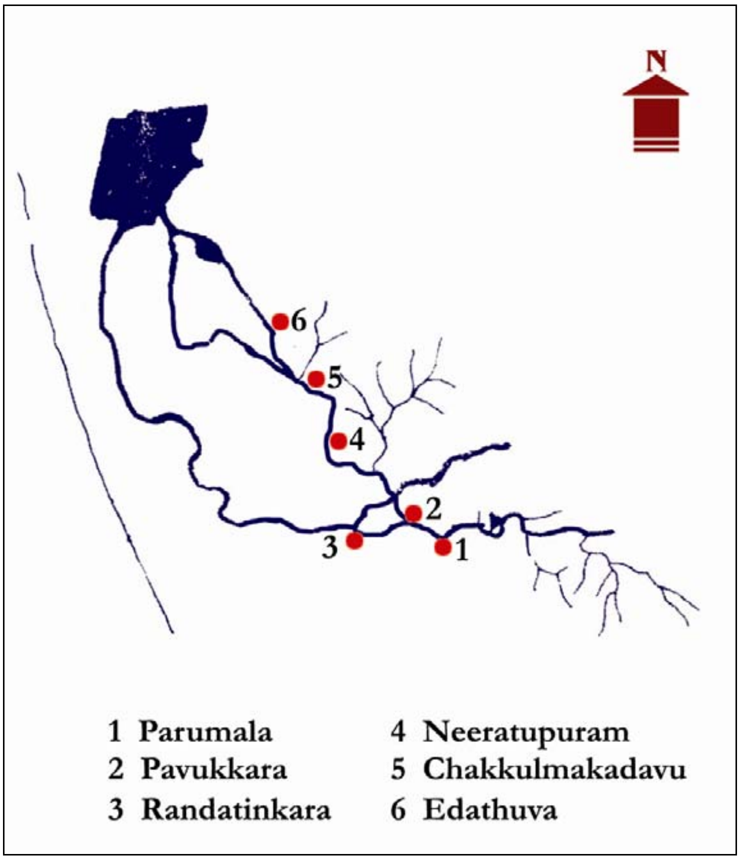


Fig.3.4. Map of Pamba river basin showing landing centre surveyed

3.3.2.1. Exploited fishery

26 fish species belonging to 5 orders, 13 families and 21 genera were recorded in the exploited fishery of Pamba river during the study period. Cypriniformes, Siluriformes and Perciformes were the dominant orders represented in the exploited fishery. Numerical strength of various fish families contributed to the exploited fishery is depicted in Fig.3.5. Among the 26 fish species recorded in the landing centres, family Cyprinidae was the most dominant group with 8 species (31%) followed by Channidae (11%). *Gibelion catla* and *Clarias gariepinus* were the non-native species observed in the landings while the giant freshwater prawn, *Macrobrachium rosenbergii* formed the only invertebrate species in the exploited fishery. The landings were represented by one endangered (*Hypselobarbus curumca*), two each vulnerable (*Horabagrus branchysoma* and *Channa diplogramma*) and near threatened (NT) fish species (*Wallago attu* and *Ompok bimaculatus*) (Fig.3.6).

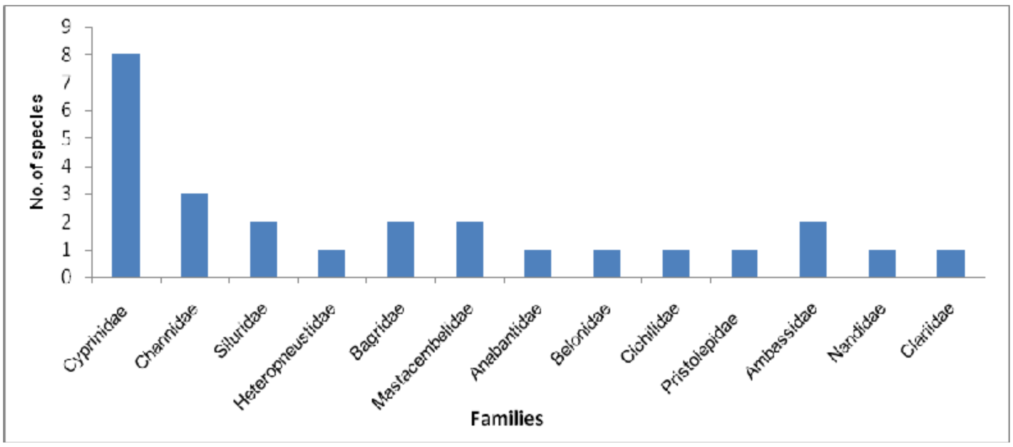


Fig.3.5. Numerical strength of various fish families contributed to the exploited fishery in River Pamba

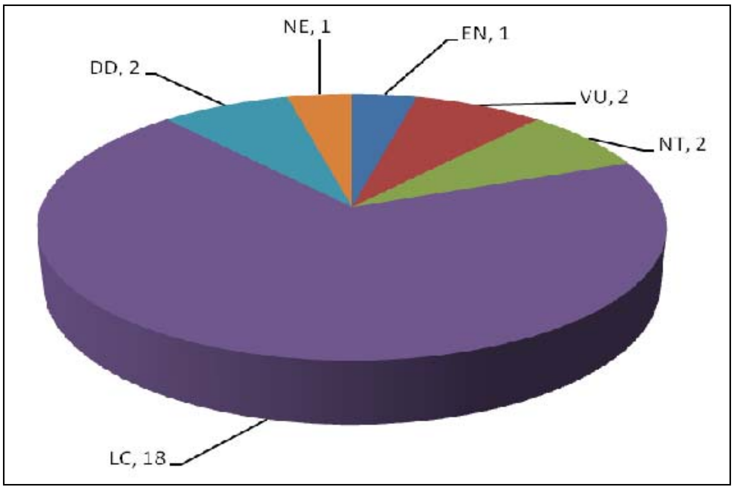


Fig.3.6. Biodiversity status of exploited fish species in River Pamba

3.3.2.2. Quantification of exploited fishery resources

The average annual exploited fishery of the Pamba river was estimated at 394.22 tonnes. The dominant fish species in the catch at Pamba river were *Labeo dussumieri, Wallago attu, Channa striata, Channa marulius, Horabagrus brachysoma, Puntius sarana subnasutus, Amblypharyngodon microlepis* and *Etroplus suratensis.* The commercially important species, their common names and quantity of landings are presented in Table.3.3. Highest landings were recorded during pre monsoon season (194.48 t) whereas it was lowest during monsoon (38.97 t). *Labeo dussumieri*, commonly known as 'Thooli' showed highest landings (19.27%) in the river. This species supported a lucrative fishery year around and sustained as the major source of livelihood source to the fishermen. The dominant size group reported in the landing was 160- 287 mm. *Wallago attu* formed 9.55% of total landing and the dominant size group was 300-990 mm. *Channa striata* (36.34 t), *C. marulius* (30.06 t) and *C.diplogramma* (0.79 t) formed other major groups in the fishery constituting 17% of total landings. Genus *Puntius* represented by three species viz., *Puntius sarana subnasutus* (39.51 t), *P. filamentosus* (20.64 t) and *P. amphibius* (0.07 t) constituted 15 % of total landings. The annual landings of *Macrobranchium rosenbergii* in the river was estimated at 27.05 t. The small-sized fish, *Amblypharyngodon microlepis,* commonly known as 'Vayambu' formed a major fishery in the river accounting 34.32 t in the landings. *Parambassis thomassi* and *P. dayi*, the two species of glassy perchlets were represented by the size ranges 60-170 mm. *P. dayi* was more abundant during post monsoon season.

In monsoon season, *Labeo dussumieri* contributed 33% of the fishery in the river. But during pre monsoon and post monsoon seasons the fishery of *L. dussumieri* was low when compared to monsoon (18% each). The fishery of freshwater prawn *Macrobranchium rosebergii* was very low in monsoon season when compared to pre monsoon and post monsoon (7.8 and 6.5% each). During monsoon season, lower reaches of Pamba river gets flooded which helped for better catch of *Wallago attu.* So fishery of *W. attu* was high in monsoon season (21%). In post monsoon season, *Amblypharyngodon microlepis* contributed to maximum share in the fishery having 19.5%.

Among the six landing centres, Parumala contributed to 65.3% to the total fish landing, followed by Edathuva (14.5%) (Fig.3.7). The fishery was insignificant in other landing centres such as Neeretupuram (7.2%), Chakkulamkadavu (6.9%) and Pavukkara (3.8%). The fishery was poor in Randatinkara (2.3%).

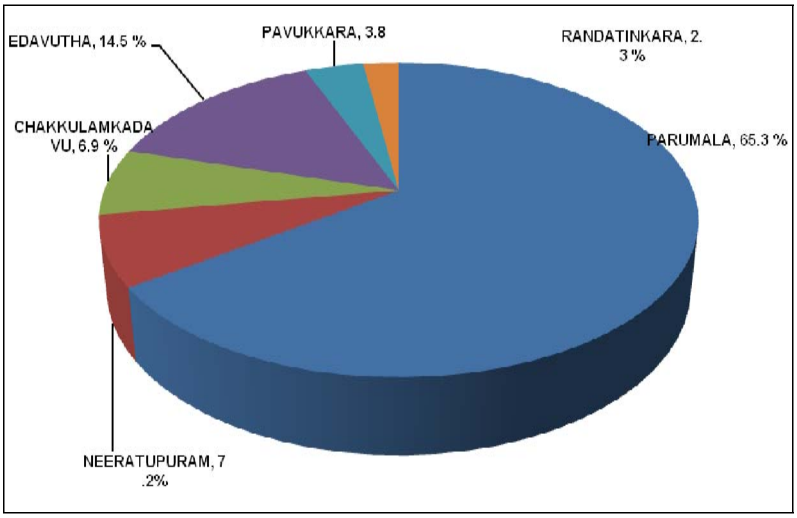


Fig.3.7. Percentage contribution of fish landing centres supporting fishery in Pamba river system

Fish landings were invariably high in all the landing centres during pre monsoon season except in Neeretupuram and in Pavukkara, where post monsoon was the major season. Among the fishes landed, *Etroplus suratensis* and *Wallago attu* were found as the highly priced species.

3.3.2.3 Craft and Gear

The percentage contribution by weight of various gears in the exploited fishery from Pamba river is given in Fig.3.8. Gill net locally known as 'Odakkuvala' was the predominant fishing gear operating all along the river and they accounted for 77% of catch. Seines (19%), cast nets (3%) and hook and lines (1%) were also operated in this river. Gill net size varied from 30-150 meters and was operated at a depth of 2-6 meters. Mesh size was in the range 22-150 mm in different designs. The main catches of this net consist of *Labeo dussumieri* (17%), *Wallago attu* (11%) and *Etroplus suratensis* (5%). The catch per unit effort of gill nets with respect to the major commercially important fish species in Pamba river is depicted in Fig.3.9. Highest catch per unit was recorded for *Amblypharyngodon microlepis* (1.88 kg/hr) in gill net followed by *Gibelion catla* (1.50 kg/hr), *Puntius sarana subnasutus* (1.33 kg/hr), *Wallago attu* (0.93 kg/hr), *Labeo dussumieri* (0.87 kg/hr) and *Channa marulius* (0.77kg/ hr). *Macrobranchium rosenbergii* was mostly caught by gillnets (0.37kg/hr). Seine net was commonly operated in pre monsoon season because of low water level in the river. The main species caught in this gear consist of *Channa marulius (*19%*), Labeo dussumieri* (18%), *Amblypharyngodon microlepis* (15%) and *Puntius filamentosus* (14%). The catch per unit hour of seine net for various fish species in Pamba river is depicted in Fig.3.10. *Amblypharyngodon microlepis* recorded the highest catch per unit hour in seines (2.40 kg/hr) while *Labeo dussumieri* and *Channa marulius* showed 1.22 kg/hr and 1 kg/hr respectively. Cast net contributed only a minor fishery in Pampa river. Cast nets of size 2 to 4 m were commonly operated with a wide range of mesh sizes (10 to 45 mm). *Labeo dussumieri* and *Amblypharyngodon* *microlepis* constituted the main catches in cast nets (2.50 kg/hr and 0.63 kg/hr respectively). The catch per unit hour of cast net for various fish species in Pamba river is depicted in Fig.3.11. Cast nets were operated throughout the year, including June to August when the river get flooded with monsoonal runoff. Hook and line was commonly used in post monsoon season for catching mainly *Wallago attu* with a catch per unit of 1.22 kg/hr.

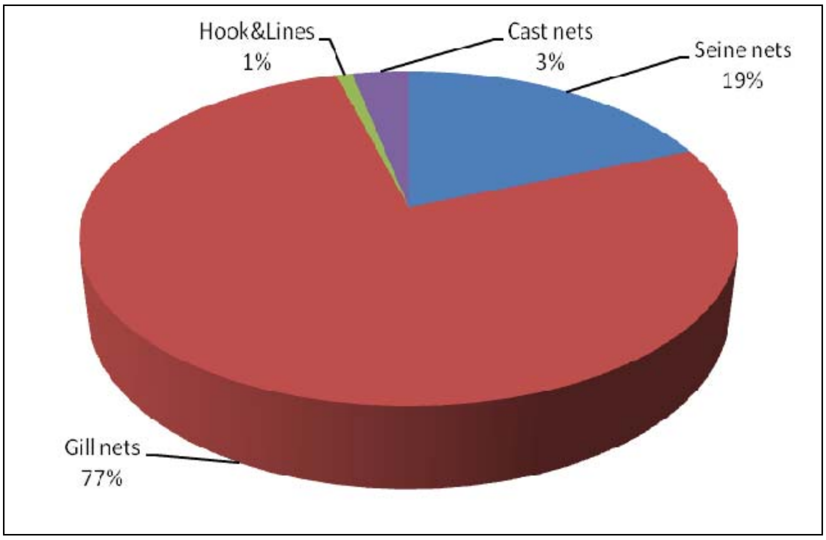


Fig.3.8. Percentage contribution of various gears in the exploited fishery from River Pamba

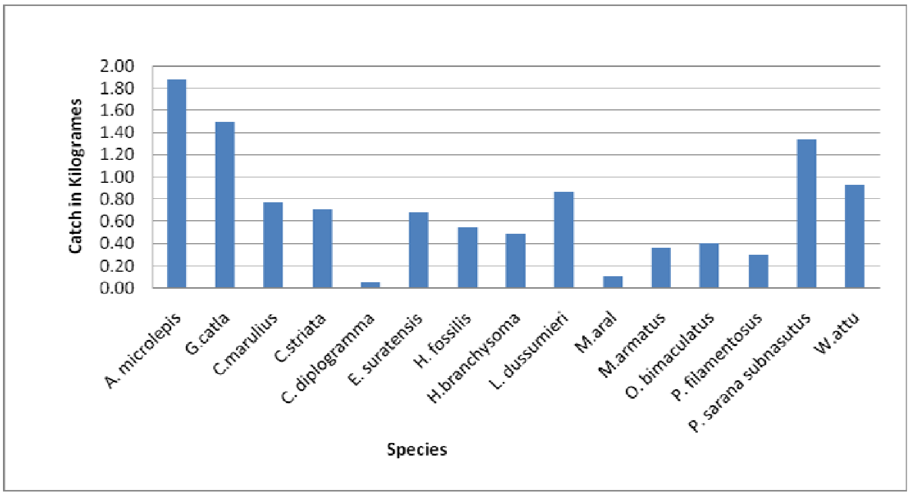


Fig.3.9. Catch per unit hour of major fish species exploited by Gill nets in River Pamba

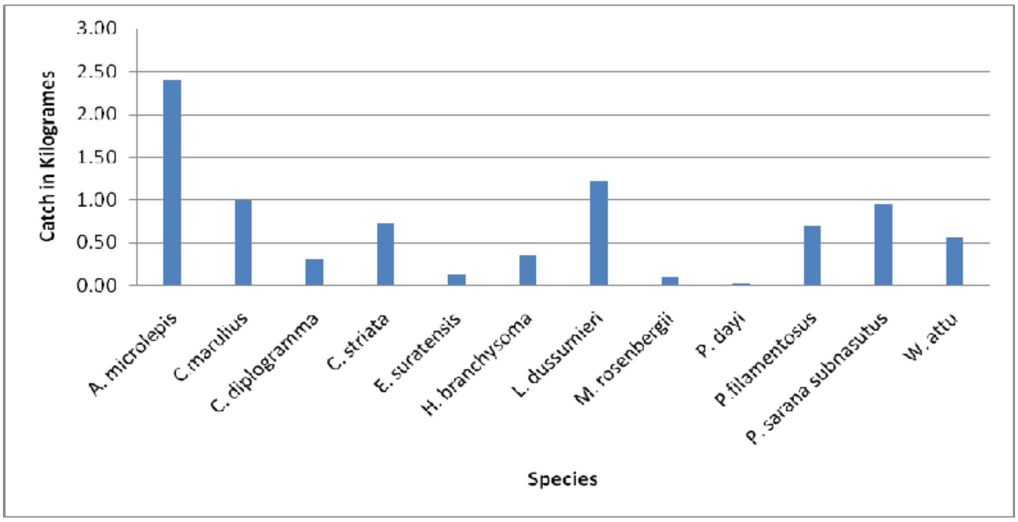


Fig.3.10. Catch per unit hour of major fish species exploited by Seine nets in River Pamba

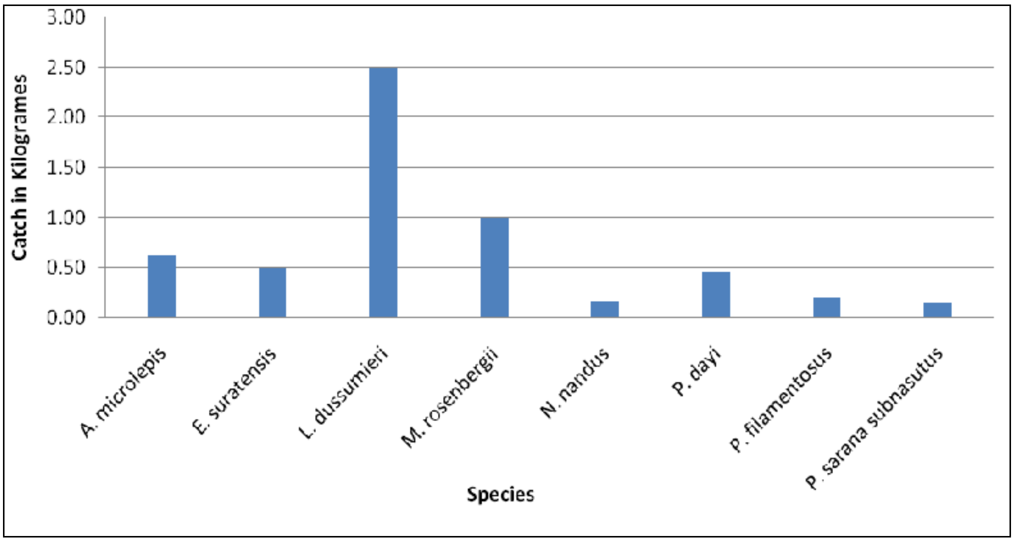


Fig.3.11. Catch per unit hour of major fish species exploited by Cast nets in River Pamba

3.3.3. Periyar river system

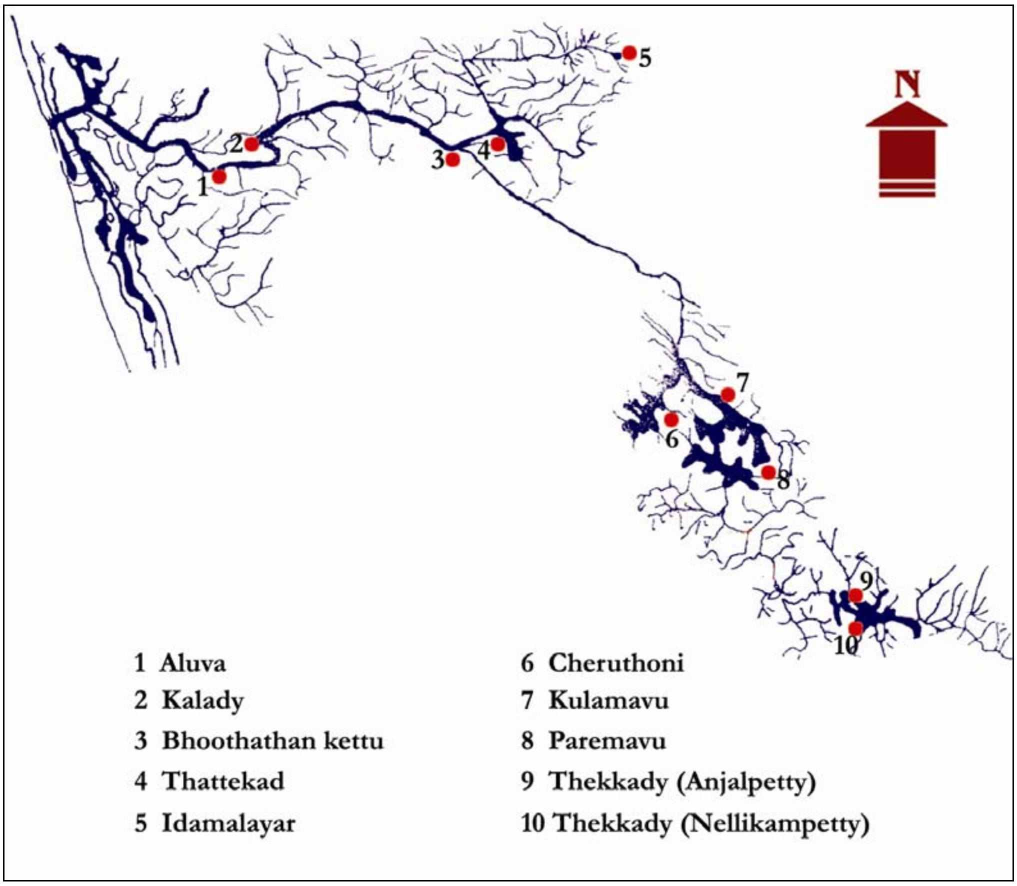


Fig 3.12. Map of Periyar river basin showing landing centres surveyed

3.3.3.1. Exploited fishery

21 fish species belonging to four orders, 11 families' and 17 genera were identified in the exploited fishery of Periyar River. Among the orders, Siluriformes and Perciformes were the dominant group with 33% in the species composition followed by Cypriniformes (29%). Numerical strength of various fish families contributed to the exploited fishery in River Periyar is depicted in Fig. 3.13. Among the 21 species reported in the landing centre, family Cyprinidae was the dominant group with 6 species (29%) followed by Siluridae (14%). The landing were represented by two endangered (*Hypselobarbus curmuca* and *Tor khudree*), three each vulnerable (*Horabagrus branchysoma*, *Cyprinus*

carpio and *Hypselobarbus kolus*) and near threatened (*Ompok bimaculatus, Oreochromis mossambicus* and *Wallago attu*) fish species (Fig.3.14). *C. carpio, O. mossambicus* and *Clarias gariepinus* were the non-native species observed in the landing.

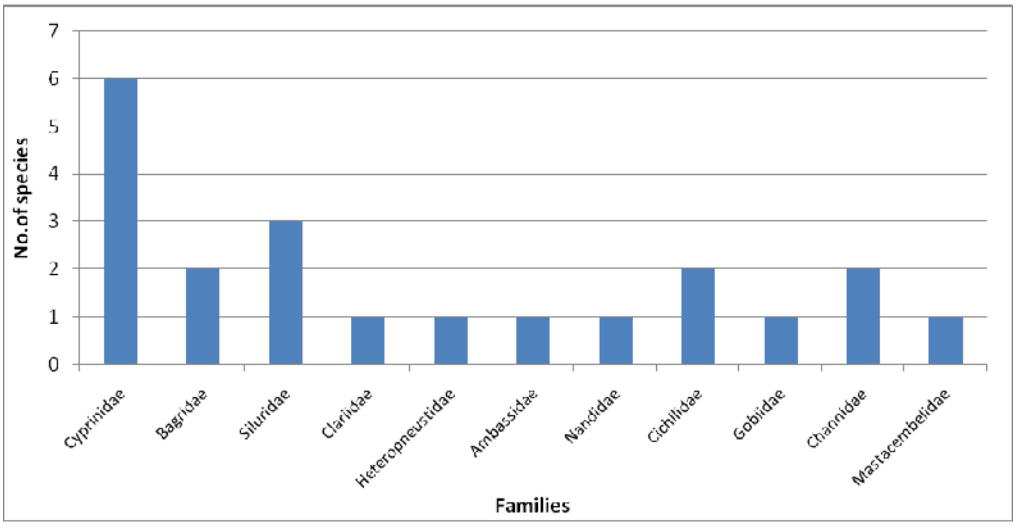


Fig.3.13. Numerical strength of various fish families contributed to the exploited fishery in River Periyar

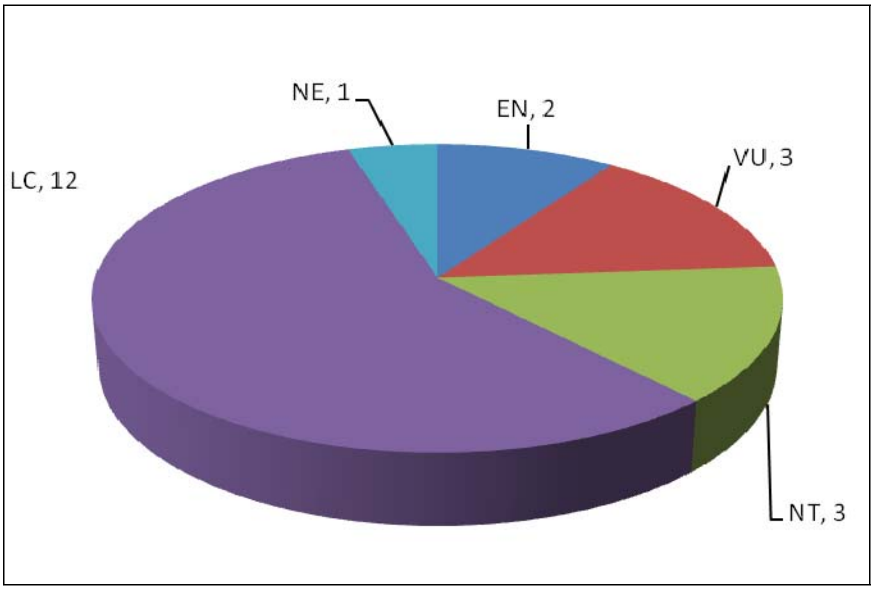


Fig.3.14. Biodiversity status of exploited fish species in River Periyar

3.3.3.2.Quantification of exploited fishery resources

The total exploited fishery of the Periyar river was estimated at 70.11 tonnes. The commercially important species, their common names and quantity of landings are presented in Table.3.4. The major species in the landing were represented by *Cyprinus carpio*, *Oreochromis mossambicus, Tor khudree, Hypselobarbus curmuca*, *Channa striata* and *Puntius sarana subnasutus.* Highest landings were recorded during post monsoon season (27.03 t) whereas it was lowest during monsoon (21.32 t). *Cyprinus carpio* commonly known as ‘Common carp’ showed the highest landings (26.53%) in the river. The size group 200-499 mm of this species was dominated in the landing. *Oreochromis mossambicus* locally known as ‘Tilapia’ formed 10.31% of the total landings and the dominant size group was 110-229 mm. *Tor khudree* commonly known as ‘Deccan Mahseer’ contributed to 9.76% of the fishery. *Channa striata (*5.83 t) and *C. marulius* (3.55 t) formed other major groups in the fishery constituting 13.37% of total landings. Genus *Puntius* constituted 8.56 % of total landings; represented by two species viz., *Puntius sarana subnasutus* (5.39 tonnes*)* and *P. filamentosus* (0.62 t). The annual landings of *Macrobranchium rosenbergii* in the river was estimated at 0.15 t. *Hypselobarbus curmuca* and *H. kurali* formed 13.24% of total landings. *Wallago attu* contributed to 2.18 t in the fishery.

The fishery of *Cyprinus carpio* was high during the monsoon and post monsoon seasons (32.7% and 26.6% each). In monsoon season the fishery was low with 20%. Fishery of *Orechromis mossambicus* was high during post monsoon season (16.15%). Among the nine landing centres, Thekkady (Anjalpetty and Nellikampetty) contributed 48.7 % to the total fish landing, followed by Aluva (11.69 %) (Fig.3.15). Only a marginal fishery was recorded in other landing centres such as Paremavu (10.02%), Bhoothathan kettu (9.15%), Thattekad (8.7%) and Cheruthoni (8.09%). The fishery was poor in Kalady (1.86%), Idamalayar (1.30%) and Kulamavu (0.44%). Fish landings were invariably high in all the landing centres during post monsoon season.

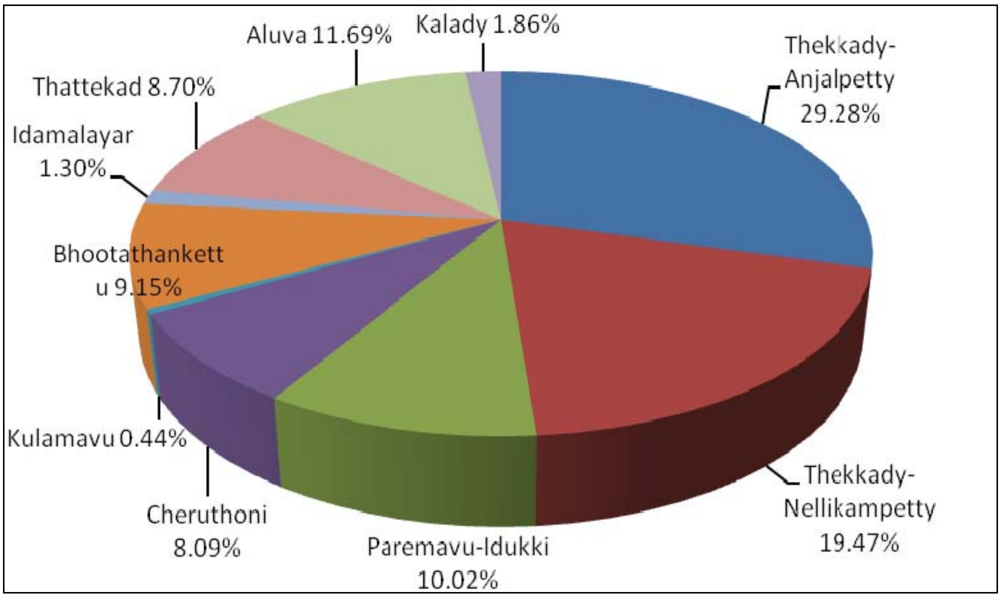


Fig.3.15. Percentage contribution of fish landing centres supporting fishery in Periyar river system

3.3.3.3. Craft and Gear

The exploited fishery in River Periyar was contributed by gill net, hook and line, cast net and seine. Gill net locally known as 'Odakkuvala' was the predominant fishing gear operated all along the entire stretches of the river and it accounted for 89% of catch. The contribution of hook and line (6%), seines (4%) and cast nets (1%) was very low in the fishery of this river. Fig.3.16. depicts the percentage contribution by weight of various gears in the exploited fishery from River Periyar. The major species appearing in the catches of this net consisted of *Cyprinus carpio* (25.58%), *Oreochromis mossambicus* (10.79%) and *Channa striata* (9.01%). The catch per unit effort (CPUE) of gill nets in respect of the major commercially important fish species in Periyar river is depicted in Fig.3.17. Highest catch per unit was recorded for *C. carpio* (0.23kg/hr) in gill net followed by *Hypselobarbus curmuca* (0.12 kg/hr), *Wallago attu* (0.12 kg/hr) and *Tor khudree* (0.11 kg/hr) respectively. Hook and line contributed insiginificantly to the fishery in river Periyar. The main species caught from this gear consist of *Cyprinus carpio* (38.07%) *Horabagrus branchysoma*

(23.2%) and *T. khudree* (21.65%). The CPUE of hook and line in respect of the major commercially important fish species in Periyar river is depicted in Fig.3.18. Highest catch per unit was recorded for *Horabagrus brachysoma* (0.35 kg/hr) in gill net followed by *C. carpio* (0.25 kg/hr) and *Mastacembelus armatus* (0.25 Kg/hr). Gears like tripods (Muppalli) were also operated along the river banks for catching murrels and prawns.

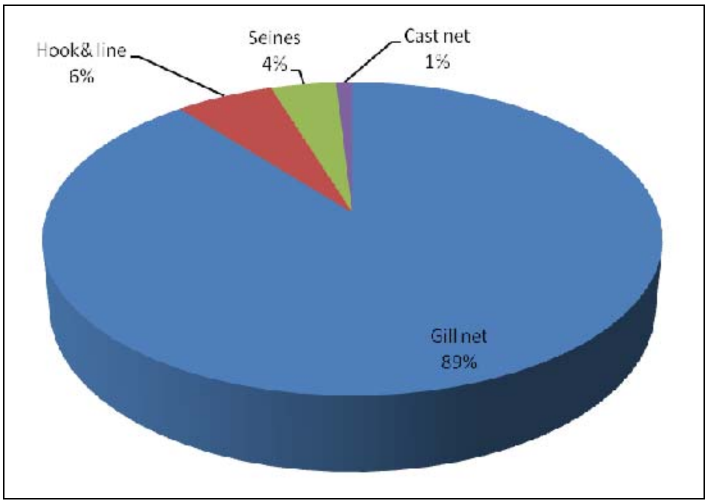


Fig.3.16. Percentage contribution of various gears in the exploited fishery from River Periyar

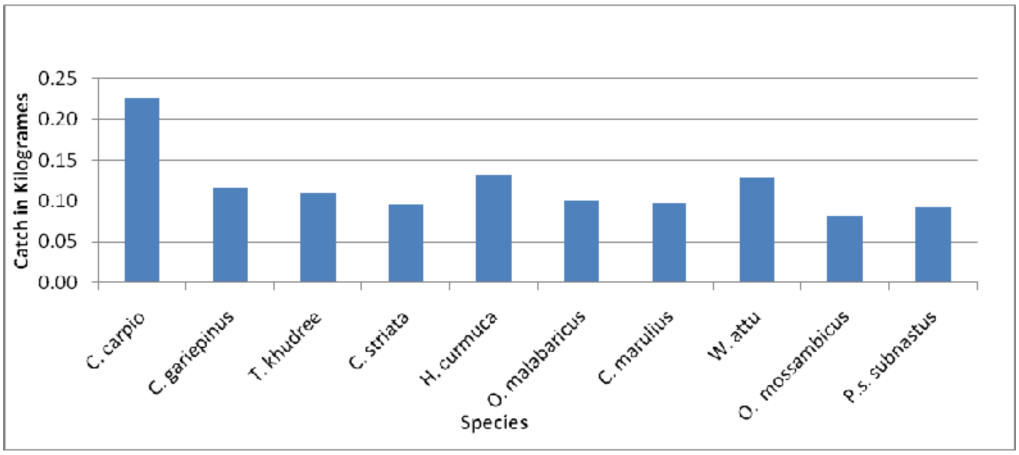


Fig.3.17. Catch per unit hour of major fish species exploited by Gill nets in River Periyar

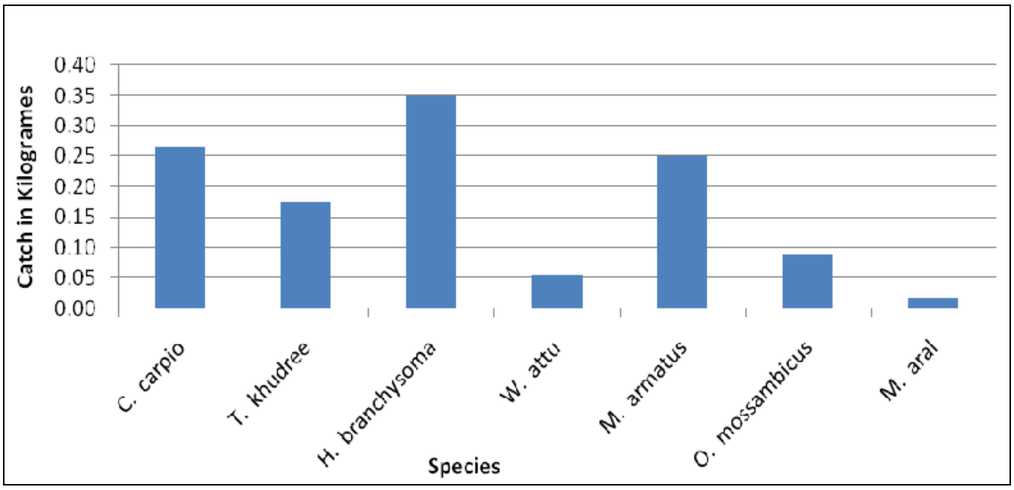


Fig.3.18. Catch per unit hour of major fish species exploited by Hook and lines in River Periyar

3.3.4. Chalakudy river system

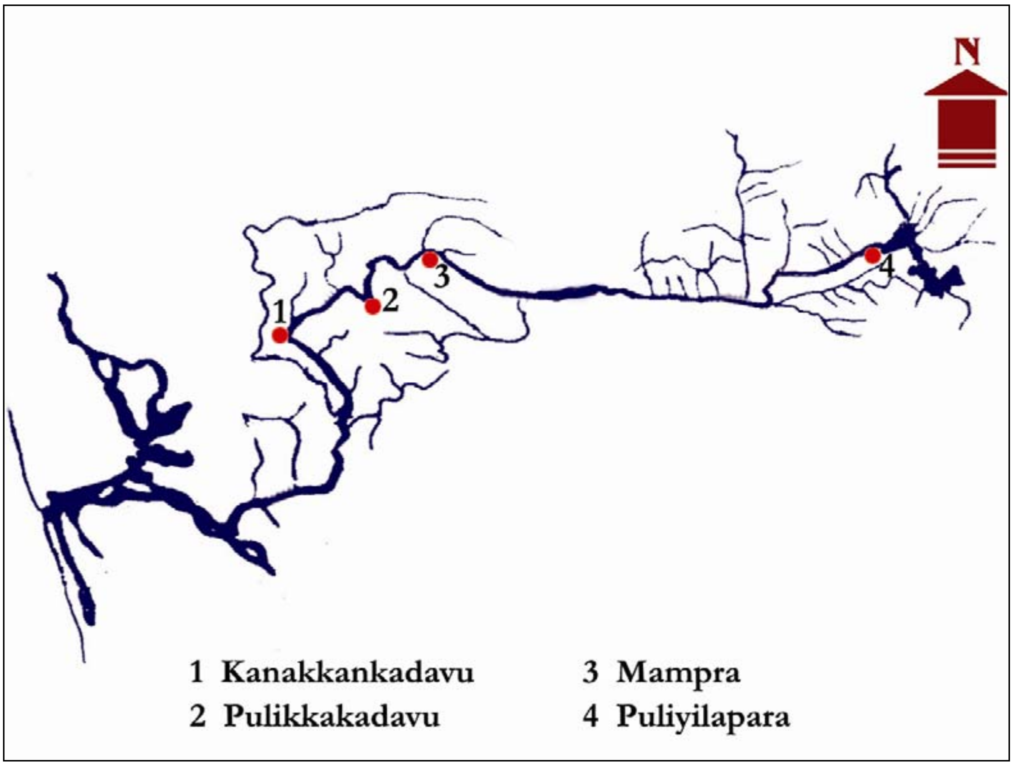


Fig.3.19. Map of Chalakudy river basin showing landing centres surveyed

3.3.4.1. Exploited fishery

31 fish species belonging to 7 orders and 22 genera were identified in the exploited fishery of Chalakudy River. Cypriniformes and Perciformes were the most abundant orders represented in the catch. Family Cyprinidae ranked first among different fish groups with a numerical strength of 12 species (39%) followed by Bagridae with four species (13%). Fig.3.20 represents the numerical strength of various fish families contributed to the exploited fishery in River Chalakudy. It is worth mentioning that two endangered (*Hypselobarbus curmuca* and *Tor khudree*) and 3 vulnerable (*H. kolus* and *Horabagrus brachysoma*) category, Two belonged to near threatened and 22 in the least concern category (Fig.3.21) appeared in the catches from the river. *Gibelion catla, Cyprinus carpio, Labeo rohita* and *Oreochromis mossambicus* were the non-native species which were contributing to the exploited fishery.

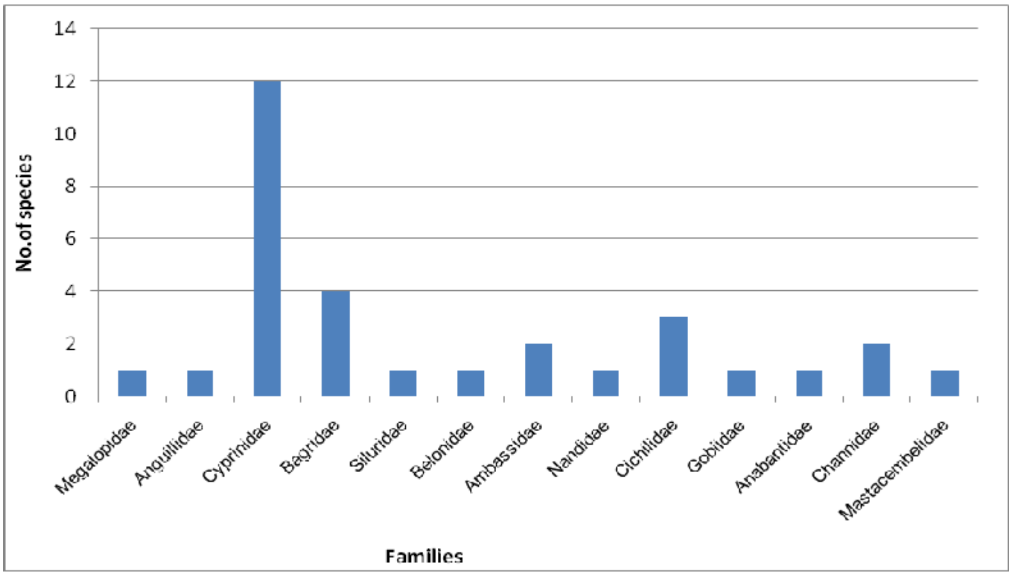


Fig.3.20. Numerical strength of various fish families contributed to the exploited fishery in River Chalakudy

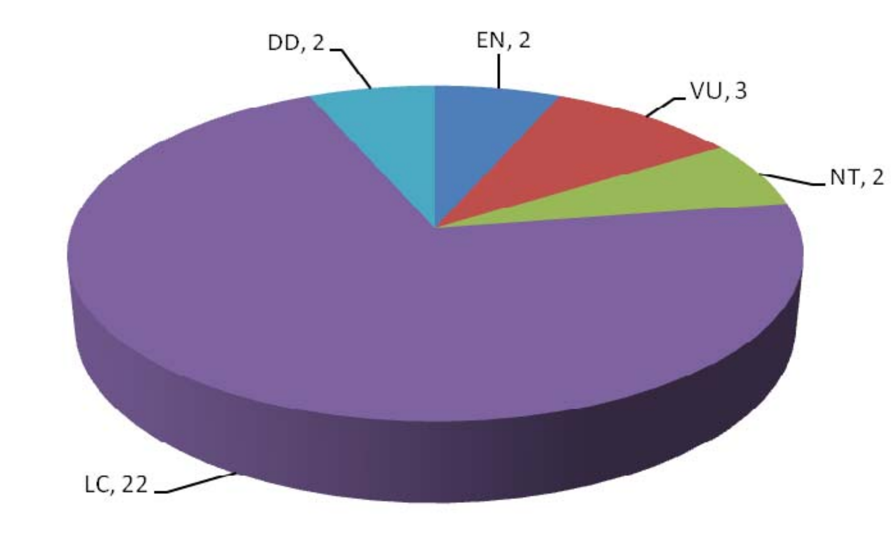


Fig.3.21. Biodiversity status of exploited fish species in River Chalakudy

3.3.4.2 Quantification of exploited fishery resources

Annual exploited fishery of the Chalakudy river was estimated at 37.85 t. Highest landings were recorded during pre monsoon season (27.03 t) whereas it was lowest in post monsoon (21.32 t). The commercially important species, their common names and quantity of landings are presented in Table.3.5. *Etroplus suratensis* commonly known as 'Karimeen' showed highest landings (19.5%) in the river. *Macrobranchium rosenbergii* was the only invertebrate species which formed 13.18% of total landings. *Wallago attu*, locally known as 'Vala' formed 8.88% of total landings and the dominant size group was 300-650 mm. *Barbodes carnaticus* called 'Carnatic carp' contributed to 8.79% in the total landing. Four non-native species (*Gibelion catla, Cyprinus carpio, Labeo rohita, Oreochromis mossambicus*) contributed 15.5% of the total landing. *G. catla* (2.52 t) was the dominant species in the introduced group.

Fishery of *Etroplus suratensis* was high during the pre monsoon season (26.75%). Reciprocally, the fishery of *Barbodes carnaticus* was very low during this season contributing only 2.4% in the exploited fishery. *Macrobranchium* *rosenbergii* was abundant during monsoon season and reported 2.2 t in the fishery. On the other hand, the fishery of *Oreochromis mossambicus* was high during post monsoon season. Among the four landing centres, Kanakkankadavu contributed to 38.86% to the total fish landing, followed by Puliyilapara (31.77%). Only a marginal fishery was recorded in other landing centres such as Pulikkakadavu (18.57%) and Mampra (10.80%) (Fig. 3.22).

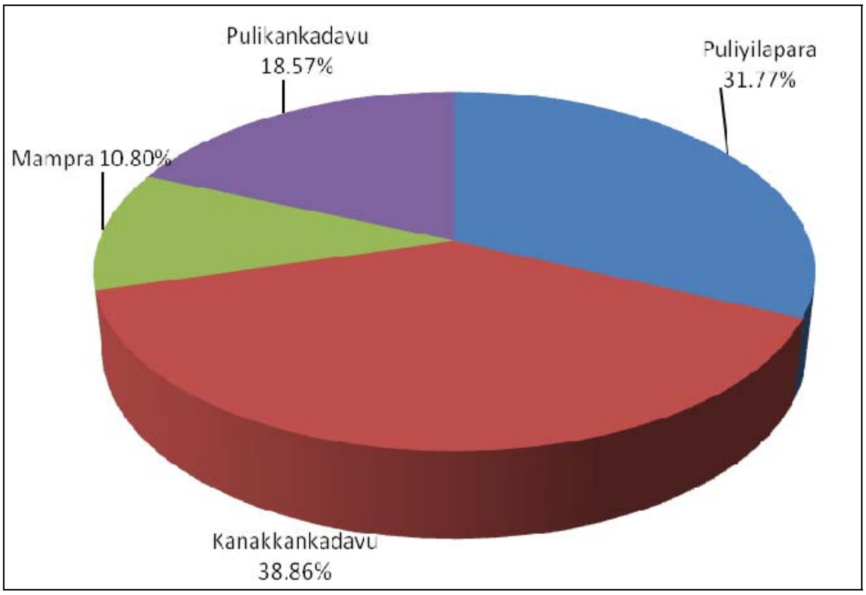


Fig.3.22. Percentage contribution of fish landing centres supporting fishery in Chalakudy river system

3.3.4.2. Craft and Gear

Fig.3.23 depicts the percentage contribution by weight of various gears in the exploited fishery from Chalakudy river. Gill net was the predominant fishing gear operating all along the river and it accounted for 77.32% of catch. Mupalli (14.36%), seine net (6.26%) and cast net (2.06%) were also operated in this river. The main catches from gill net consisted of *Etroplus suratensis* (15.07%), *Wallago attu* (11.48 %) and *Barbodes carnaticus* (11.37%). The catch per unit effort of gill nets with respect to the major commercially important fish species is depicted in Fig.3.24. Highest catch per unit was recorded for *Wallago attu* (0.21 kg/hr) in gill net followed by *Gibelion catla* (0.19kg/hr), *Barbodes carnaticus* (0.13 kg/hr) and *Labeo rohitha* (0.12 kg/hr). Muppalli was an important fishing gear very commonly used during monsoon and post monsoon seasons because of high water level in the adjacent floodplain areas. The main species caught in this gear consisted of *Macrobranchium rosenbergii* (64.24%) and *E. suratensis* (35.76%). The catch per unit effort of seine nets with respect to the major commercially important fish species is depicted in Fig.3.25. Highest catch per unit effort was recorded for *E. suratensis* (0.24 kg/hr). Cast net contributed only insiginifant fishery in Chalakudy river. The main fishes caught in cast net were *E. suratensis*, *Puntius sarana subnasutus*, *Channa striata* and *C. marulius.*

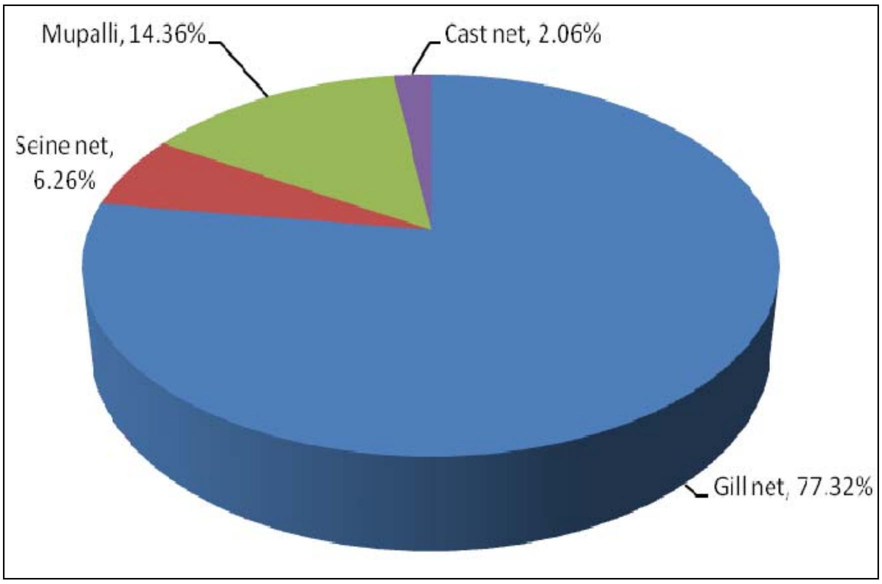


Fig.3.23. Percentage contribution of various gears in the exploited fishery from River Chalakudy

The catch per unit effort of cast net for various fish species in Chalakudy river is depicted in Fig.3.26. *E. suratensis* register the highest catch per unit hour in cast nets (0.26 kg/hr) while *Puntius sarana subnasutus* and *Mystus cavasius* recorded low catch of 0.7 kg/hr.

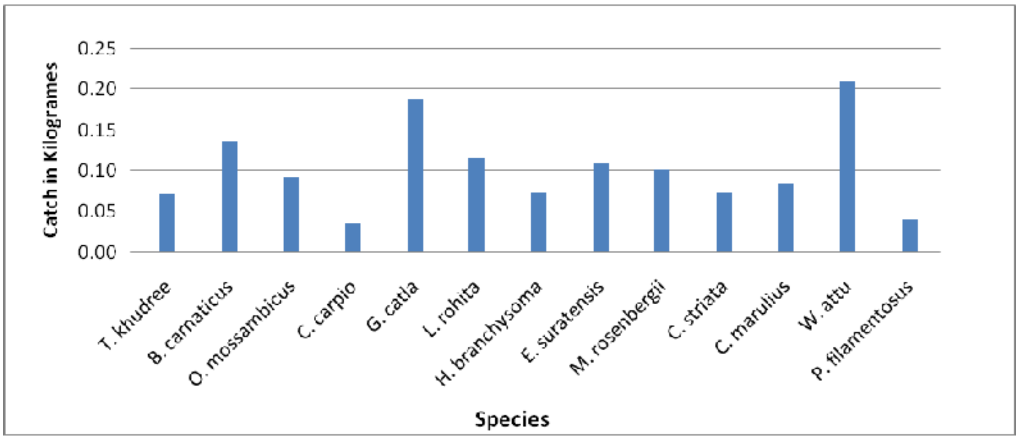


Fig.3.24. Catch per unit hour of major fish species exploited by Gill nets in Chalakudy river

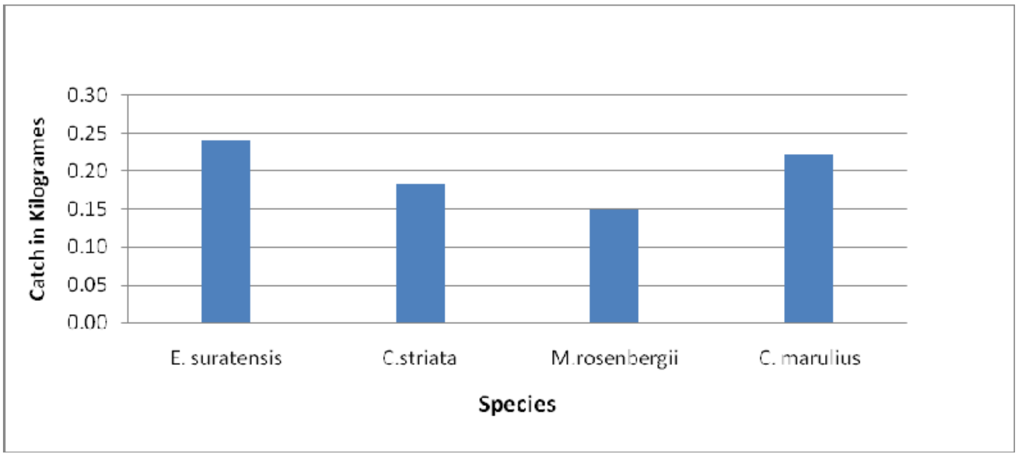


Fig.3.25. Catch per unit hour of major fish species exploited by Seine nets in Chalakudy river

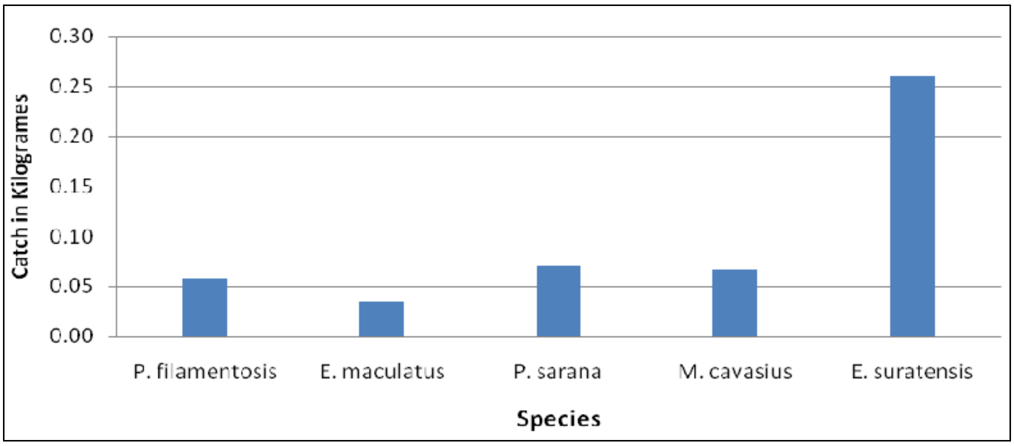


Fig.3.26. Catch per unit hour of major fish species exploited by Cast nets in Chalakudy river

3.3.5. Bharathapuzha river system

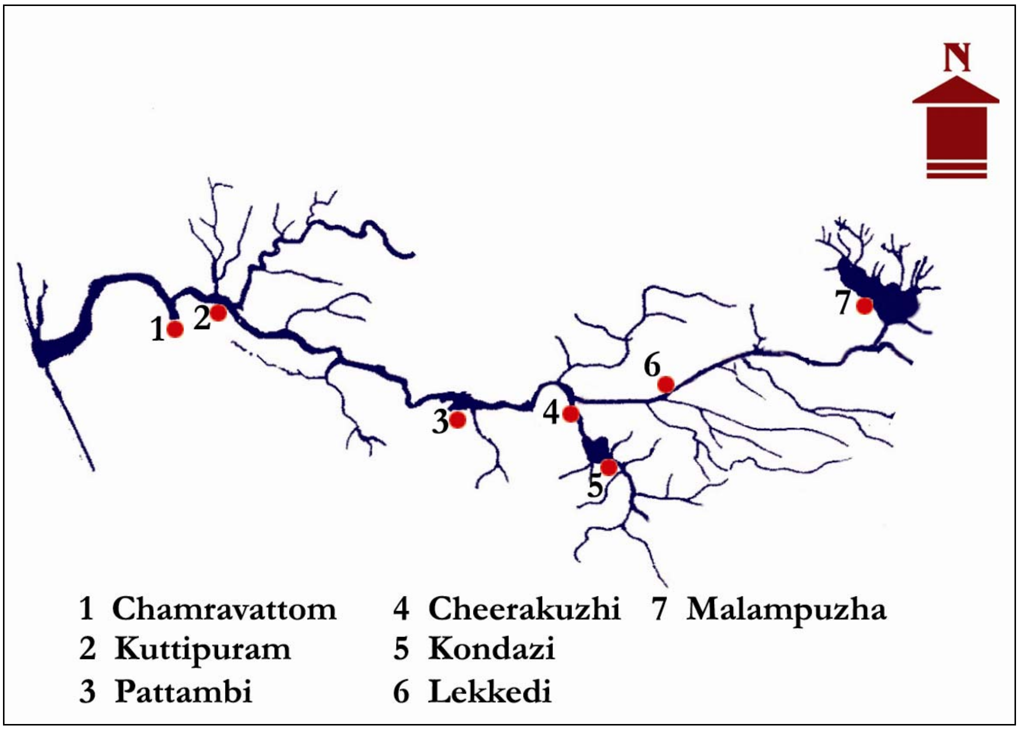


Fig.3.27. Map of Bharathapuzha river basin showing landing centres surveyed

3.3.5.1. Exploited fishery

31 fish species belonging to 7 orders and 25 genera were identified in the exploited fishery of Bharathapuzha River. Numerical strength of various fish families contributed to the exploited fishery in River Bharathapuzha is depicted in Fig. 3.28. Among the 31 species recorded in the landing centre, family Cyprinidae was the dominant group with 11 species (35%) followed Cichilidae (10%). *Gibelion catla, Cirrhinus mrigala, Labeo rohita* and *Oreochromis mossambicus* were the non-native species observed in the landing. The landings were represented by one each endangerd (*Hypselobarbus curmuca*) and vulnerable (*Hyporhampus xanthopterus*) category and three near threatened fish species (*Ompok bimaculatus, Oreochromis mossambicus* and *Wallago attu*) (Fig.3.29).

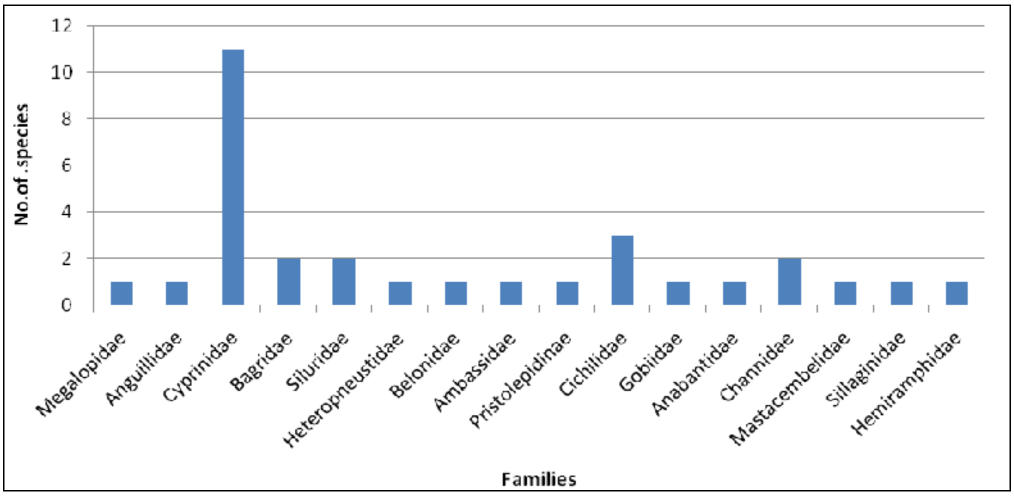


Fig.3.28. Numerical strength of various fish families contributed to the exploited fishery in River Bharathapuzha

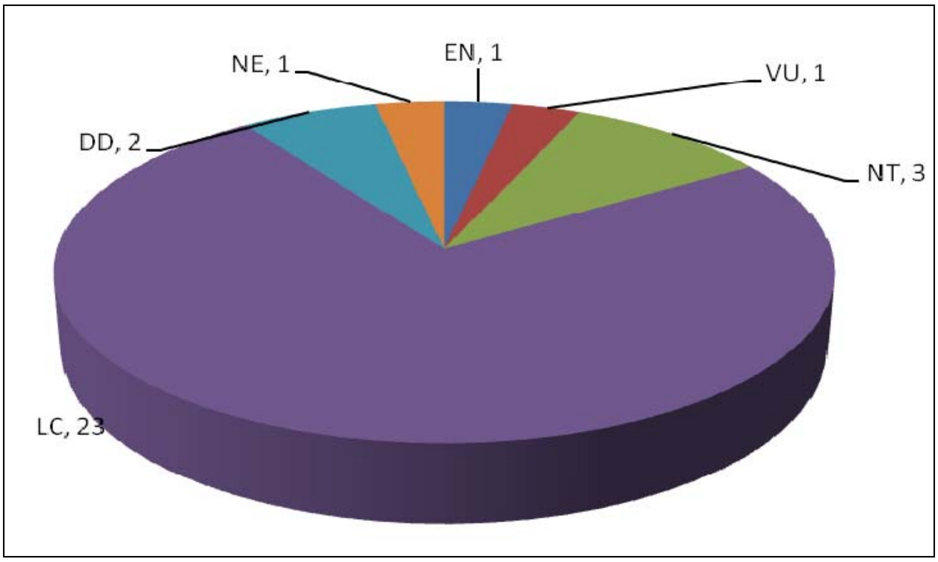


Fig.3.29. Biodiversity status of exploited fish species in River Bharathapuzha

3.3.4.1. Quantification of exploited fishery resources

The average annual exploited fishery of the Bharathapuzha River was estimated at 112.56 t. Highest landings were recorded during post monsoon season (80.58 t) whereas it was lowest during monsoon (12.81 t). *Puntius filamentosus* (17.34 t) and *P. sarana subnasutus* (12.06 t) together contributed to 26.12% in the landing. The commercially important species, their common names and quantity of landings are presented in Table.3.6. *Macrobranchium rosenbergii* locally known as 'Freshwater prawn' formed 8.49% of total landings. *Hypselobarbus curmuca* contributed to 8.78% in the landing. Indian Major carps. *Gibelion catla* (3.98 t), *Labeo rohitha* (5.14 t) and *Cirrhinus mrigala* (3.74 t) contributed to 11.43% in the landing. Secondary freshwater fish species such as *Hyporhamphus xanthopterus* (2.77 t), *Megalops cyprinoides* (0.74 t) and *Sillago vincentil* (0.60 t) contributed to 3.56 % in the fishery. Among the seven landing centres, Malampuzha contributed to 54.41% to the total fish landing, followed by Lekkedi (19.25%) and Kuttipuram (17.96%). Only a marginal fishery was recorded in other landing centres such as Cheerakuzhi (3.30%), Pattambi (3.09%), Chamravattom (1.22%) and Kondazi (0.77%) (Fig.3.30).

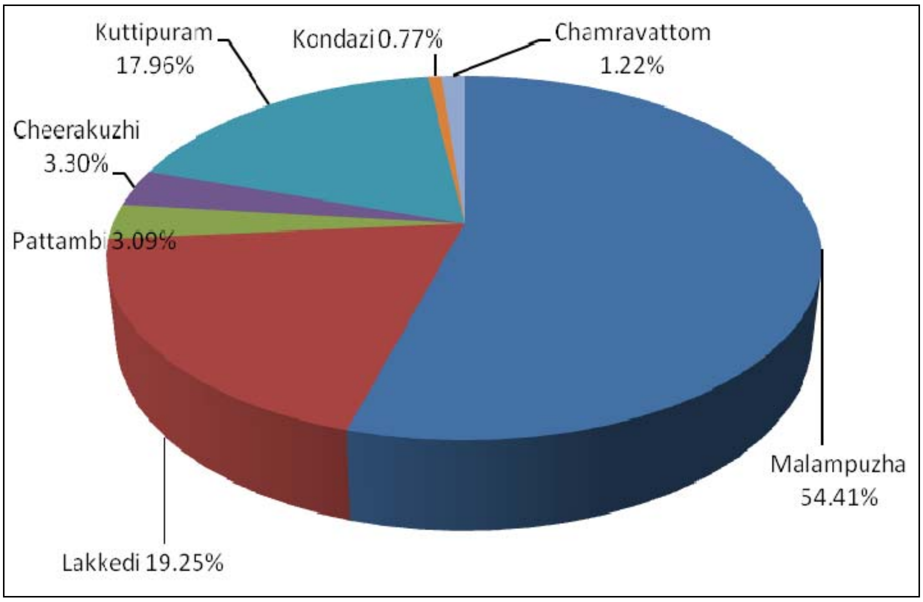


Fig.3.30. Percentage contribution of fish landing centres supporting fishery in Bharathapuzha river system

3.3.5.2. Craft and Gear

Fig.3.31 depicts the percentage contribution by weight of various gears in the exploited fishery from Bharathapuzha river. Gill net was the predominant fishing gear operating all along the river and they accounted for 87% of catch. Cast net (11%), hook and line and seine net (1% each) were also operated in this river. The main catches of the gill nets consist of *Puntius filamentosus* (15.48%), *P. sarana subnasutus* (11%), *Macrobranchium rosenbergii* (9.43%) and *Hypselobarbus curmuca* (8.9 %). The catch per unit effort of gill nets with respect to the major commercially important fish species in Bharathapuzha river is depicted in Fig.3.32. Highest catch per unit was recorded for *Etroplus maculatus* (0.75 kg/hr) in gill net followed by *Devario aequipinnatus* (0.5 kg/hr), *Labeo rohita* (0.38 kg/hr), *Puntius filamentosus* (0.20 kg/hr) and *P. sarana subnasutu*s (0.18 kg/hr). The major species of the Cast nets consist of *P. filamentosus* (16.82%), *Wallago attu* (14.29 %) and *Hypselobarbus curmuca* (12.38 %). The catch per unit effort of cast nets in respect of the major commercially important fish species in Bharathapuzha river is depicted in Fig.3.33. Highest catch per unit was recorded for *H. curmuca* (0.51kg/hr) in cast net followed by *Hyporhamphus xanthopterus* (0.50 kg/hr), *Mystus vittatus* (0.38 kg/hr), *Wallago attu* (0.29 kg/hr) and *Macrobranchium rosenbergii* (0.25 kg/hr) respectively. Drag net is a fine meshed net operated in the lower stream of the river. The main species caught in the drag nets were *Etroplus suratensis* (32.35 %), *Labeo rohita* (21.13%) and *Channa striata* (17.49%). In drag net High catch per effort was recorded in *C. striata* (0.17 kg/hr), *Labeo rohita* (0.16 kg/hr) and *Etroplus suratensis* (0.13 kg/hr). The catch per unit effort of drag nets in respect of the major commercially important fish species in Bharathapuzha river is depicted in Fig.3.34. Hook and line accounted for only a small fraction of the landing in the fishery. The main catches of the hook consist of *Channa striata, C. marulius* and *Mastacembelus armatus.*

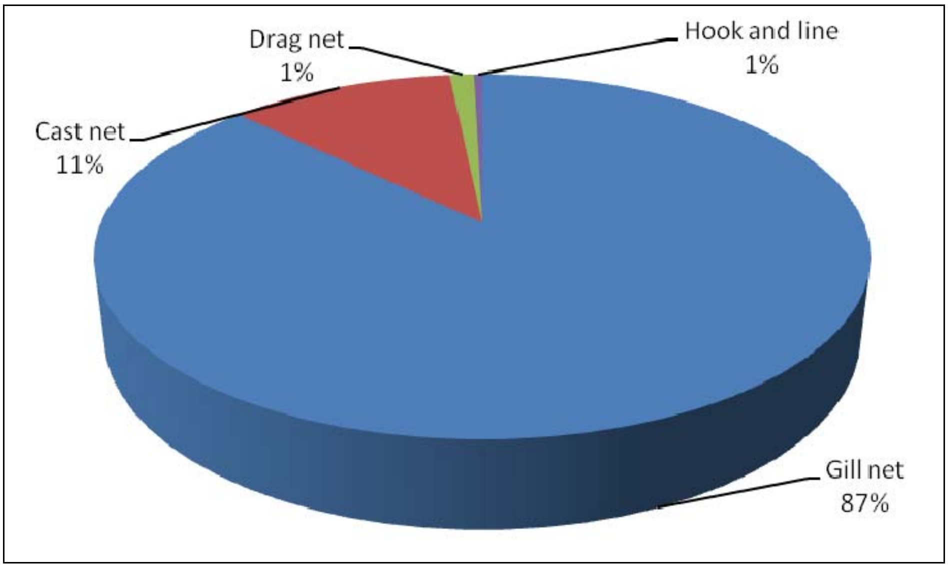


Fig.3.31. Percentage contribution of various gears in the exploited fishery from River Bharathapuzha

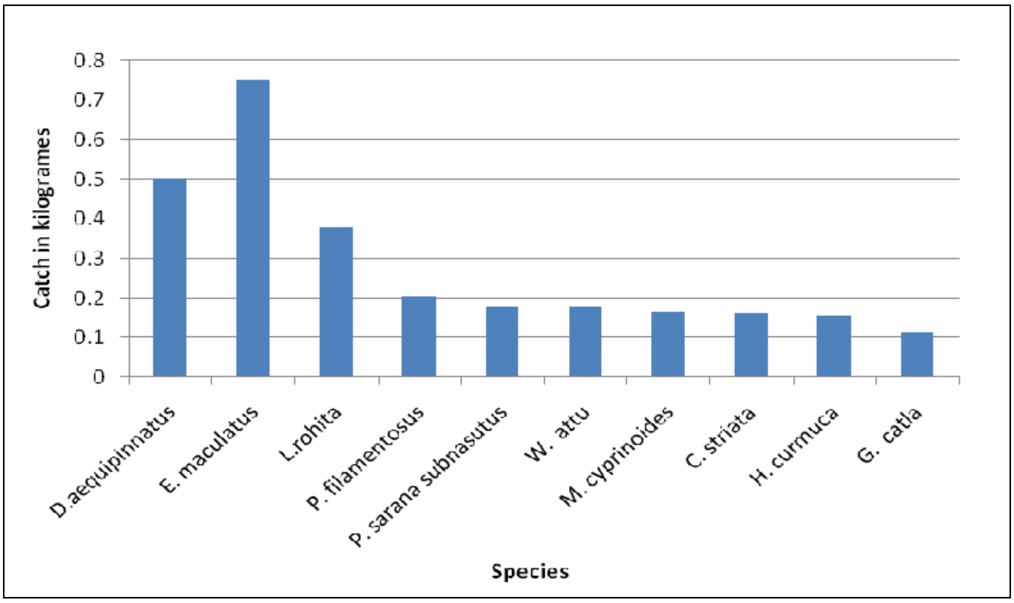


Fig.3.32 Catch per unit hour of major fish species exploited by Gill nets in Bharathapuzha

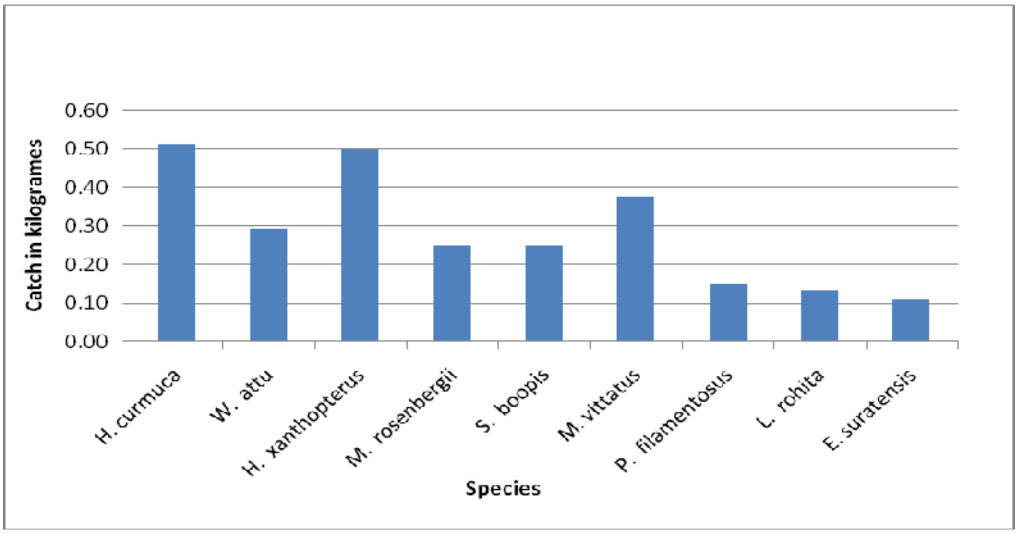


Fig.3.33. Catch per unit hour of major fish species exploited by Cast nets in Bharathapuzha

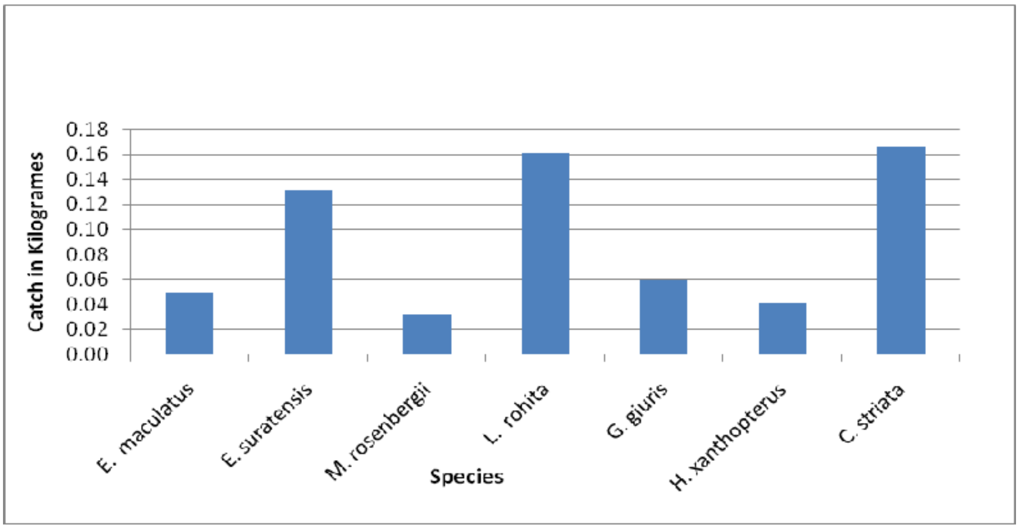


Fig.3.34. Catch per unit hour of major fish species exploited by Drag nets in Bharathapuzha

3.3.6. Achenkovil river system

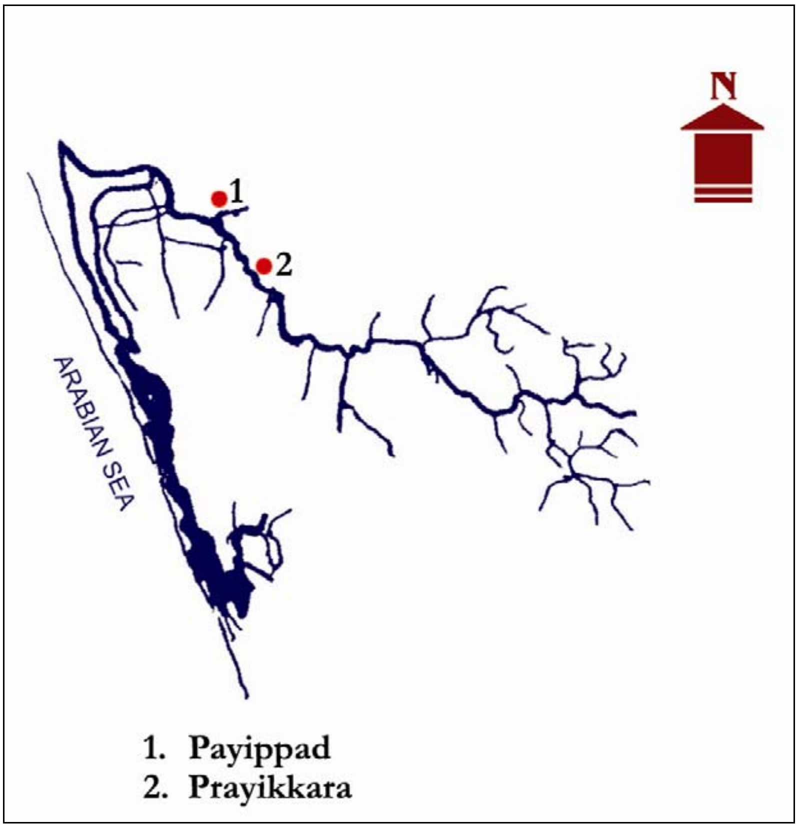


Fig.3.35.Map of Achenkovil river basin showing landing centres surveyed

3.3.6.1. Exploited fishery

24 species belonging to 7 orders and 19 genera were recorded in the exploited fishery of Achenkovil River. Numerical strength of various fish families contributed to the exploited fishery in River Achenkovil is depicted in Fig. 3.36. Family Cyprinidae ranked first among the different fish groups with 4 species followed by Channidae (4 species). The landing were represented by three vulnerable (*Horabagrus branchysoma, Channa diplogramma* and *Hyporhamphus xanthopterus*) and two near threatened fish species (*Ompok bimaculatus* and *Wallago attu*) (Fig 3.37).

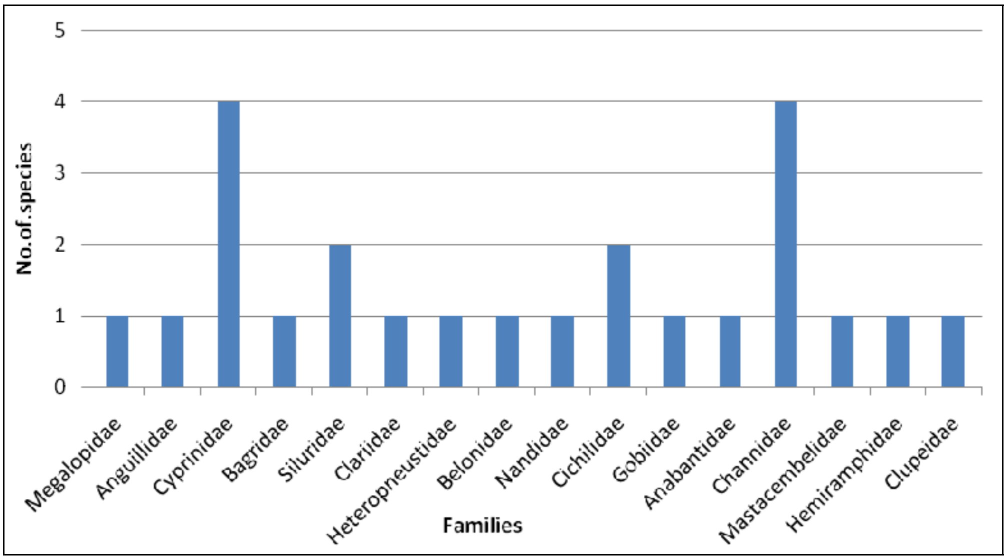


Fig.3.36. Numerical strength of various fish families contributed to the exploited fishery in River Achenkovil

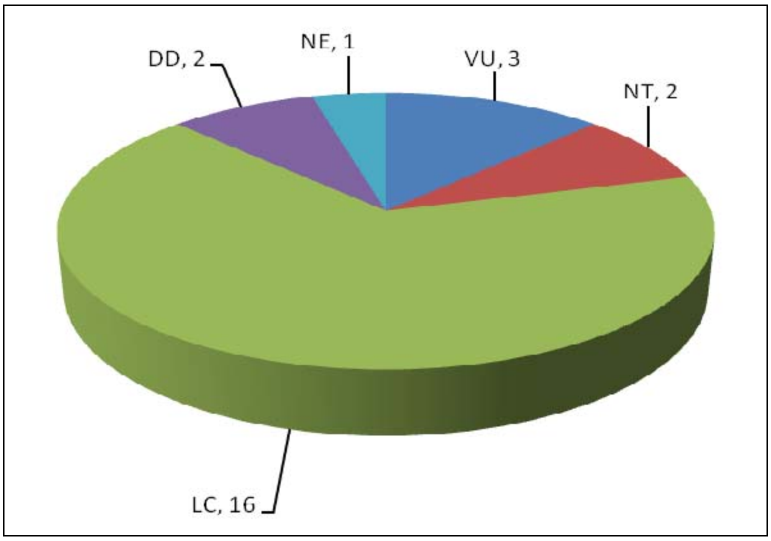


Fig.3.37. Biodiversity status of exploited fish species in River Achenkovil

3.3.6.2. Quantification of exploited fishery resources

The total exploited fishery of Achenkovil river was 162.74 t. Highest landings were recorded during post monsoon season (64.58 t) whereas; the lowest landing in monsoon (48.31 t). *Labeo dussumieri*, commonly known as 'Thooli' showed highest landings (29.09%) in the river. This species supported a lucrative fishery round the year. *Channa striatus* (10.87 t), *C.marulius* (9.14 t), *C. diplogramma* (3.60 t) and *C. orientalis* (3.12 t) formed other major groups in the exploited fishery, constituting 16.43% of total landings. The small-sized fish *Amblypharyngodon microlepis,* commonly known as 'Vayambu', formed a major fishery in the river accounting for 18.24 t in the landings.Genus *Puntius* represented by two species ie., *Puntius sarana subnasutus* (7.46 t) and *P. filamentosus* (12.91 t) constituted 12.52 % of the total landings. *Horabagrus brachysoma* locally known as 'Majnakoori' contributed to 10.28% in the landing. The annual landings of *Macrobranchium rosenbergii* in the river was estimated at 2.16 t. Among the two landing centers, Prayikkara accounted for 60.50% to the total fish landing followed by Payippad (Fig.3.38).

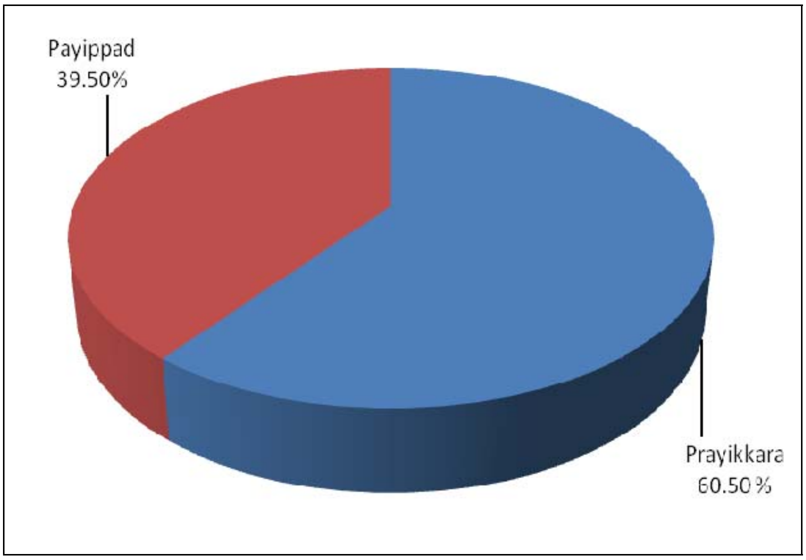


Fig.3.38. Percentage contribution of fish landing centres supporting fishery in Achenkovil river system

3.3.6.3. Craft and Gear

Fig.3.39 depicts the percentage contribution by weight of various gears in the exploited fishery from Achenkovil river. Gill net was the predominant fishing gear operating all along the river and they accounted for 84% of the catch. Seine net (13%), hook and line (2%) and cast net (1%) were also operated in this river. The main catches of the gill nets consisted of *Labeo dussumieri* (34.63%), *Horabagrus brachyosoma* (11.89%), *Channa striata* (7.95%) and *Puntius filamentosus* (7.69%). The catch per unit effort of gill nets in respect of the major commercially important fish species in Achenkovil river is depicted in Fig.3.40. Highest catch per unit was recorded for *Labeo dussumieri* (0.87 kg/hr) in gill net followed by *Puntius filamentosus* (0.38 kg/hr). Bulk of the catches in seine net consist of *Amblypharyngodon microlepis* (81.56%) followed by *Puntius filamentosus* (9.83%). Highest catch per unit was recorded *Amblypharyngodon microlepis* (2.6 kg/hr) followed by *Puntius filamentosus* (1.20 kg/hr). The catch per unit effort of seine nets with respect to the major commercially important fish species in Achenkovil river is depicted in Fig.3.41.The main species caught in the hook and line was *Wallago attu* (80%) and catch per unit hour was 1 kg/hr. The main catch in the cast net was represented by *Macrobranchium idella* (46.15%) and *Hyporhamphus xanthopterus* (23%). *M. idella* (1.2 kg/hr) and *H. xanthopterus* (0.6 kg/hr) showed high CPUE. The catch per unit effort of cast nets in respect of the major commercially important fish species in Achenkovil river is depicted in Fig.3.42.

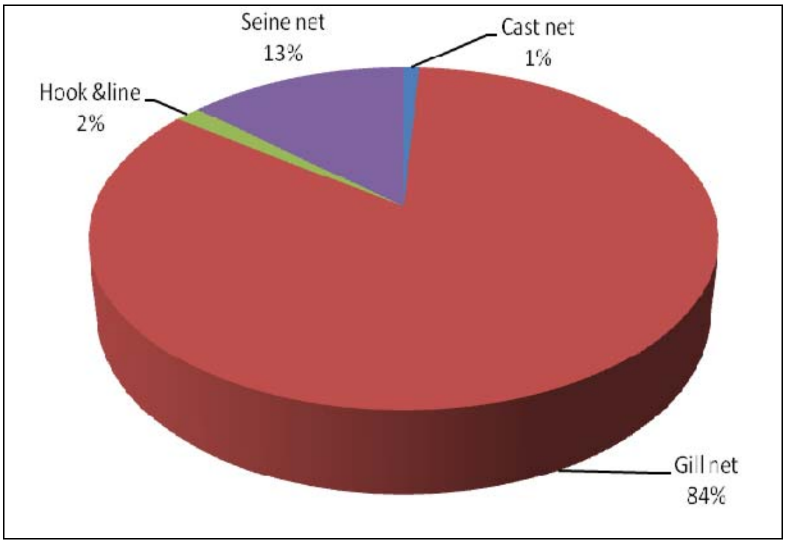


Fig.3.39. Percentage contribution of various gears in the exploited fishery from Achenkovil river

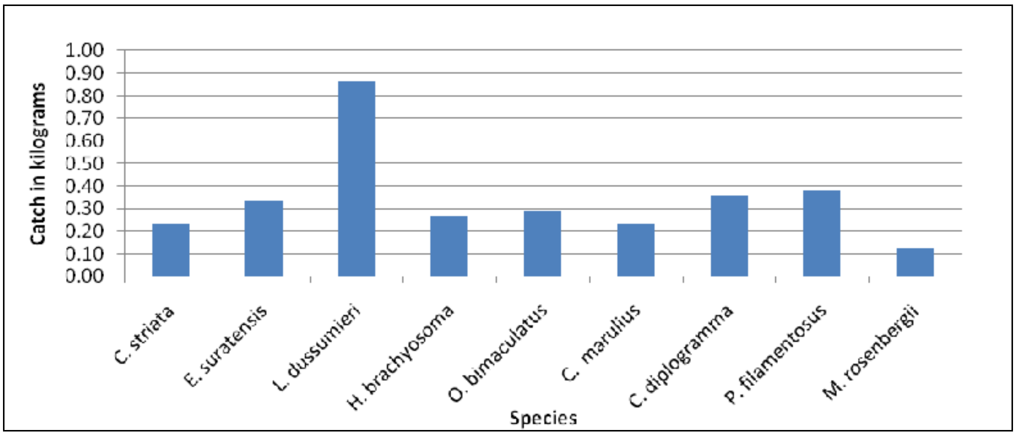


Fig.3.40. Catch per unit hour of major fish species exploited by Gill nets in Achenkovil river

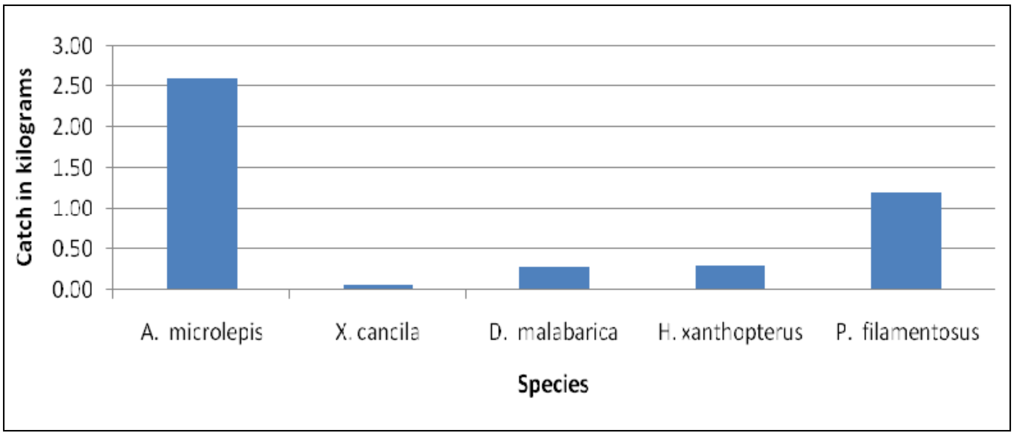


Fig.3.41. Catch per unit hour of major fish species exploited by Seine nets in Achenkovil river

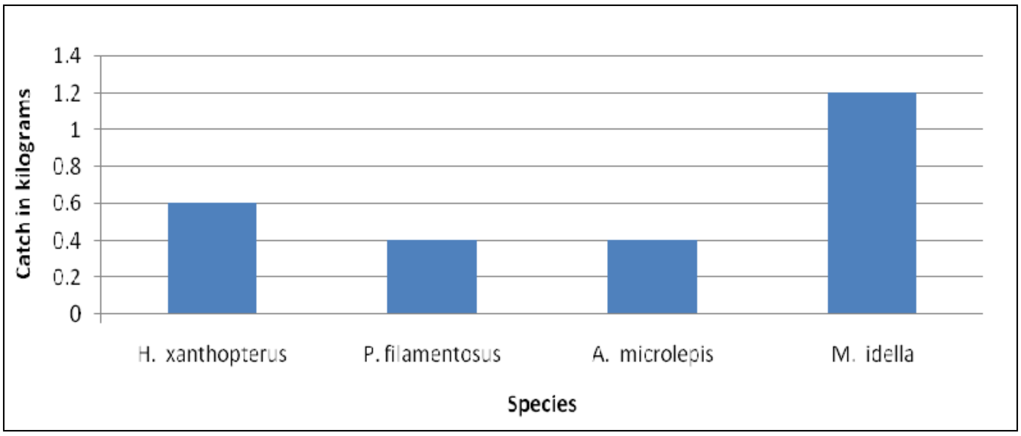


Fig.3.42. Catch per unit hour of major fish species exploited by Cast nets in Achenkovil river

3.3.7. Kallada river system

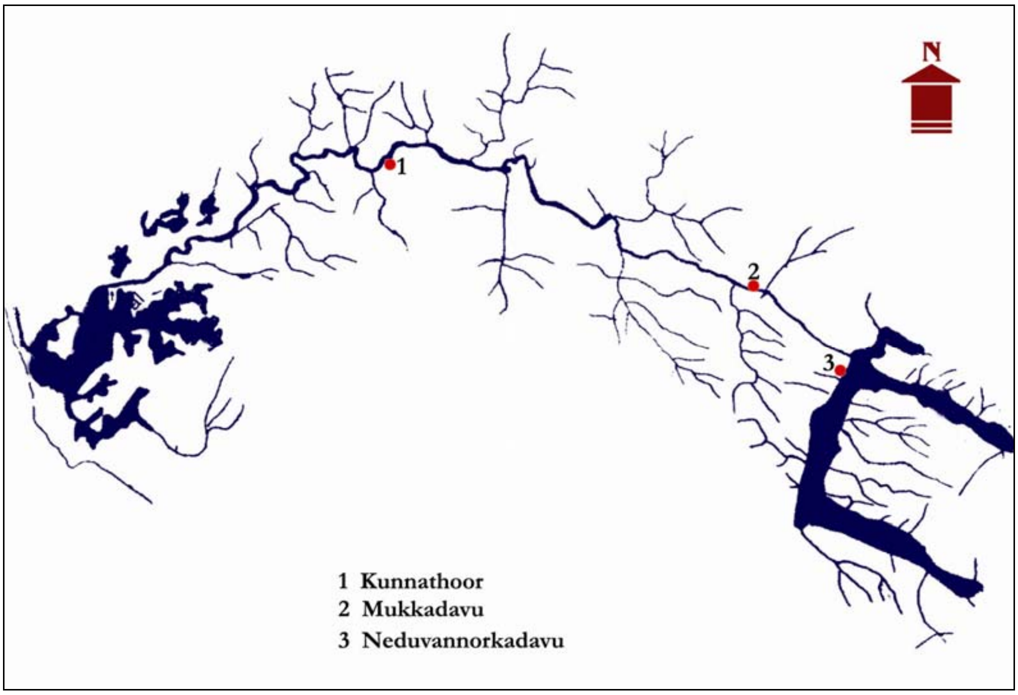


Fig 3.43.Map of Kallada river basin showing landing centres surveyed

3.3.7.1. Exploited fishery

21 fish species belonging to 6 orders and 15 genera were identified in the exploited fishery of Kallada River. Numerical strength of various fish families contributed to the exploited fishery in River Kallada is depicted in Fig.3.44. Among 21 fish species recorded in the landing centres, family Cyprinidae was the most dominant group with 6 species (28%) followed by Cichilidae and Channidae (14%). The landings were represented by one critically endangered (*Hypselobarbus thomassi*), two each of endangered (*Hypselobarbus curmuca* and *Tor khudree*), vulnerable (*Horabagrus branchysoma* and *Channa diplogramma*) and near threatened (*Oreochromis mossambicus* and *Ompok bimaculatus*) and 12 least concern (LC) category (Fig.3.45).

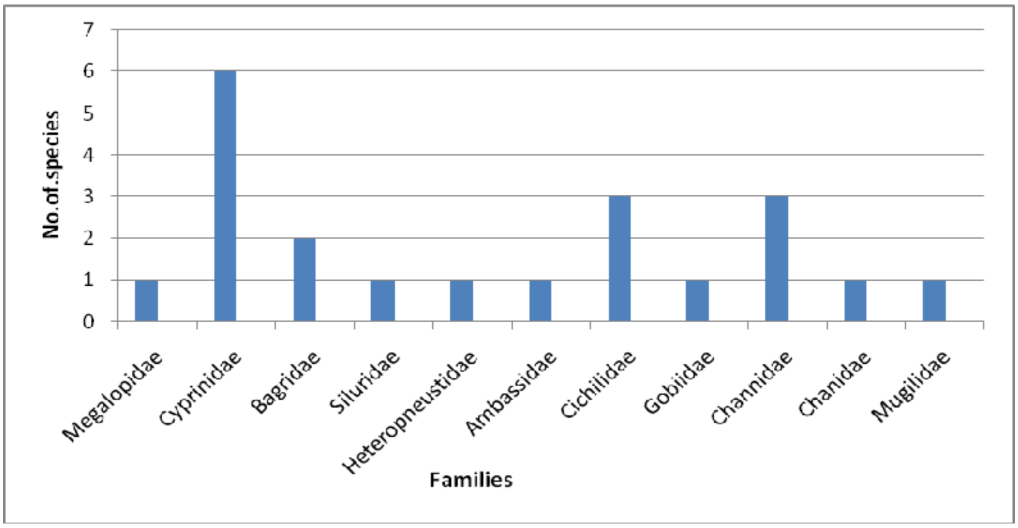


Fig.3.44. Numerical strength of various fish families contributed to the exploited fishery in River Kallada

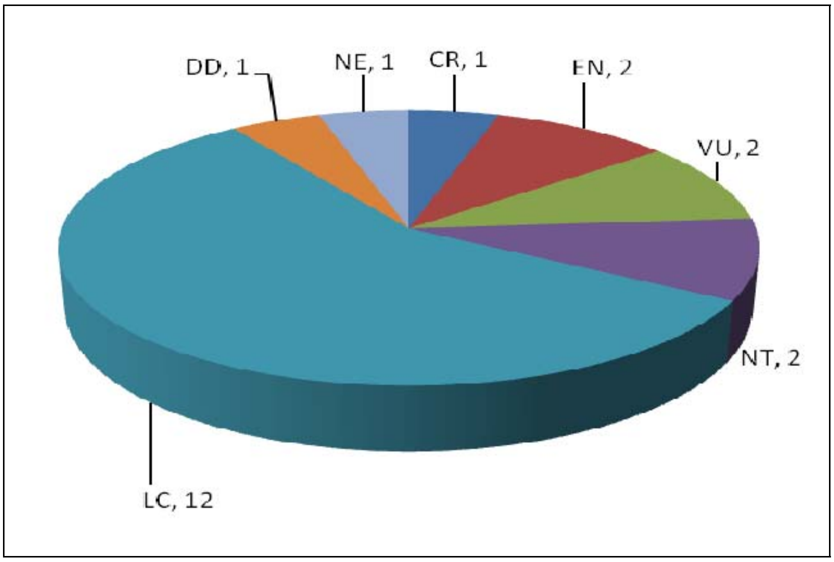


Fig.3.45. Biodiversity status of exploited fish species in River Kallada

3.3.7.2 Quantification of exploited fishery resources

The exploited fishery of Kallada river was estimated as 16.58 t. The main species in the exploited fishery of this river were *Hypselobarbus curmuca, H. thomassi, Chanos chanos, Megalops cyprinoides, Channa striata* and *Etroplus suratensis.* Genus *Hypselobarbus* was the main group in the landing and they contributed to 37.9 % of fishery in the river. *Hypselobarbus curmuca* (4.75 t), *H. kurali* (0.42 t) and *H. thomassi* (1.12 t) were the species reported in this group. Among them, *H. curmuca* formed 28.63 % of total landings. Murrels such us *Channa striata* (1.61 t), C. *marulius* (0.19 t) and *C. diplogramma* (0.87 t) contributed to 16.12% in the landing. Secondary freshwater fishes viz., *Chanos chanos* (2.09 t), *Mughil cephalus* (0.94 t) and *Megalops cyprinoides* (1.01 t) accounted for 24.32 % in the landing. Puntius species (*Puntus filamentosus* and *P. sarana subnasutus*) contributed to 4.4% in the landing. Highest landings were recorded during pre monsoon season (9.3 t) whereas; it was lowest in monsoon (1.88 t). Among the three landing centres, Kunnathoor contributed to 52.36% to the total fish landing followed by Neduvannorkadavu (46.84%). Whereas only marginal fishery was recorded at Mukkadavu (0.8%) (Fig.3.46).

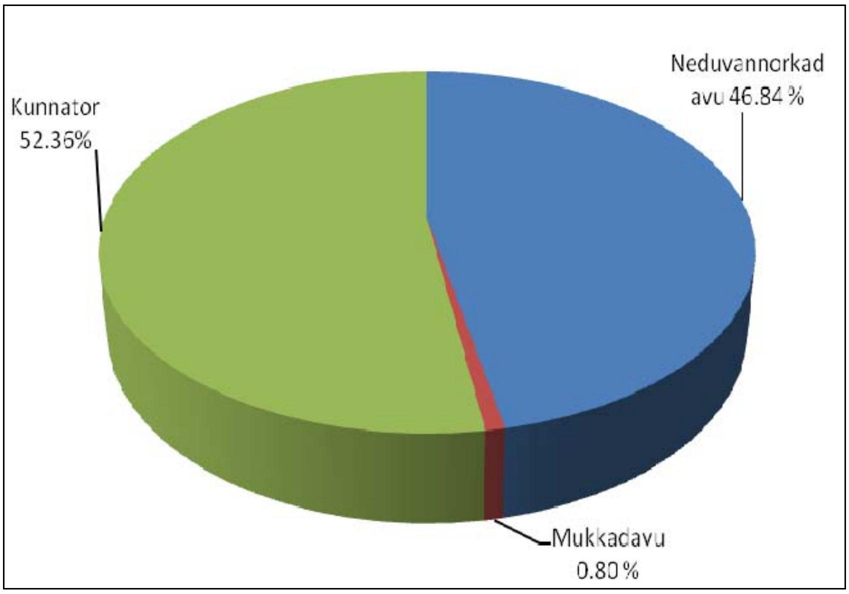


Fig.3.46. Percentage contribution of fish landing centres supporting fishery in Kallada river system

3.3.7.3. Craft and Gear

Fig.3.47. depicts the percentage contribution by weight of various gears in the exploited fishery from Kallada river. Gill net was the predominant fishing gear operating all along the river and it accounted for 99% of catch. Cast net contributed only an insiginificant share in the fishery (1%). The main catches of gill net consisted of *Hypselobarbus curmuca* (28.86%), *Chanos chanos* (12.17%), *Channa striata* (9.81%), *Etroplus suratensis* (7.77%) and *Hypselobarbus thomassi* (6.79%). Highest catch per unit was recorded for *H. curmuca* (0.28 kg/hr) in gill nets followed by *Chanos chanos* (0.10 kg/hr), *H. thomassi* (0.07 kg/hr) and *Tor khudree* (0.06 kg/hr). The catch per unit effort of gill nets in respect of the major commercially important fish species in Kallada river is depicted in Fig.3.48. The main catches of the cast net consisted of *Puntius filamentosus* (47.74%) and *Puntius sarana subnasutus* (27%). Highest catch per unit was recorded in respect of *P. s.subnasutus* (0.15 kg/hr).

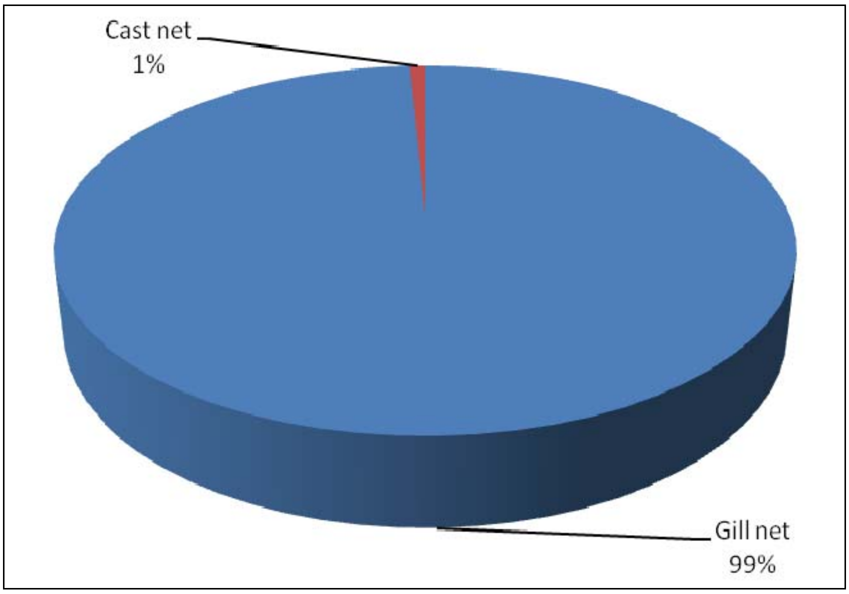


Fig.3.47. Percentage contribution of various gears in the exploited fishery from River Kallada

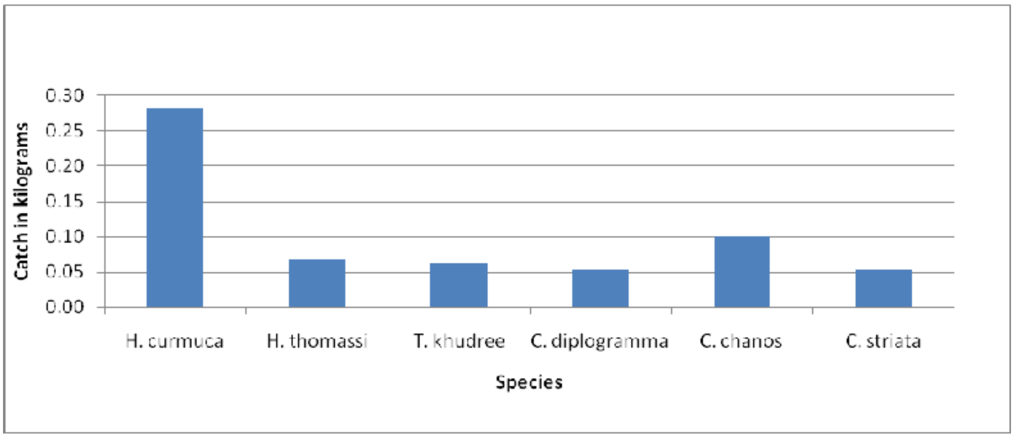


Fig.3.48. Catch per unit hour of major fish species exploited by gill nets in river Kallada

3.3.8. Muvatupuzha river system

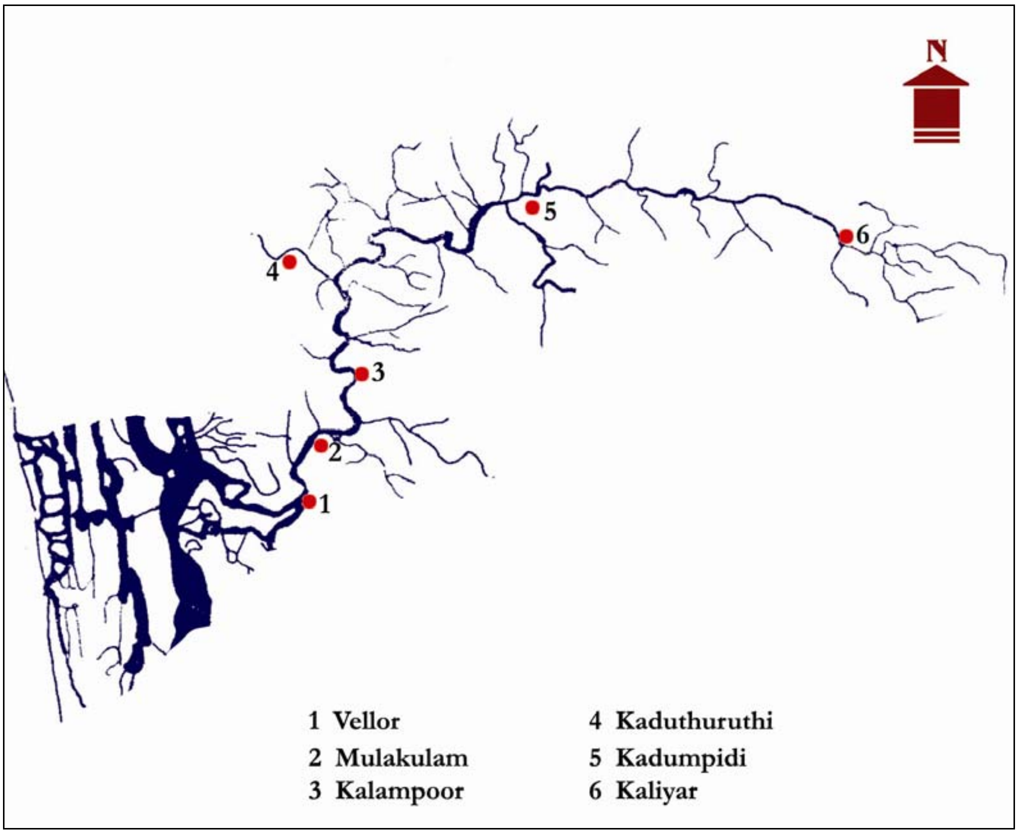


Fig.3.49. Map of Muvatupuzha river basin showing landing centres surveyed

3.3.8.1. Exploited fishery

23 fish species belonging to 6 orders and 19 genera were identified in the exploited fishery of Muvatupuzha River. The dominant fish species in the catch were *Wallago attu*, *Labeo dussumieri*, *Hypselobarbus curmuca*, *Channa striata* and *Puntius sarana subnasutus.* Family Cyprinidae ranked first among different fish groups with a numerical strength of 6 species (26%). Numerical strength of various fish families contributed to the exploited fishery in River Muvatupuzha is depicted in Fig. 3.50. It was evaluated that two species belonged to endangered, while one under vulnerable and two near threatened category (Fig.3.51).

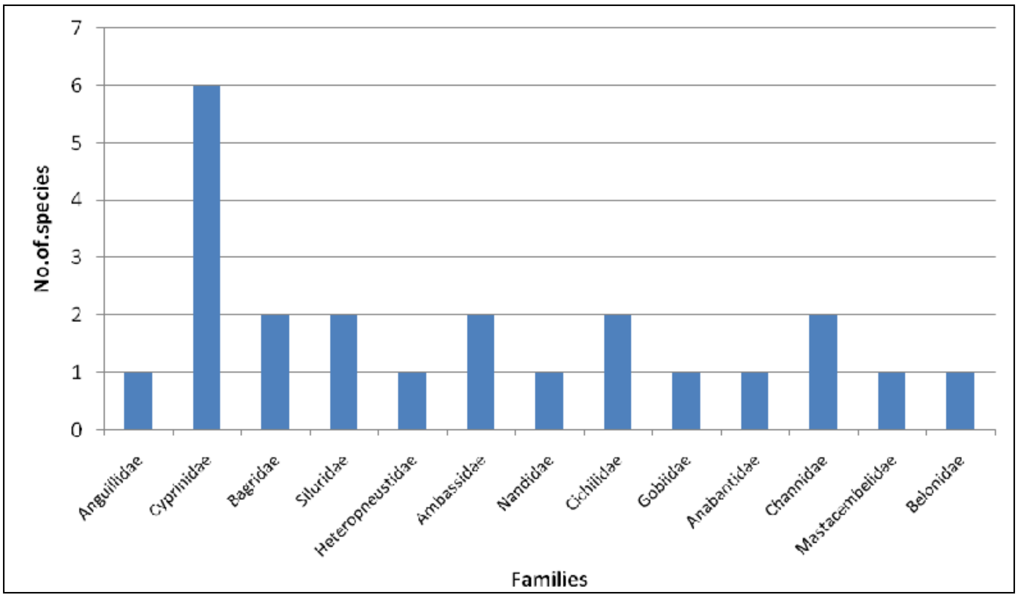


Fig.3.50. Numerical strength of various fish families contributed to the exploited fishery in River Muvatupuzha

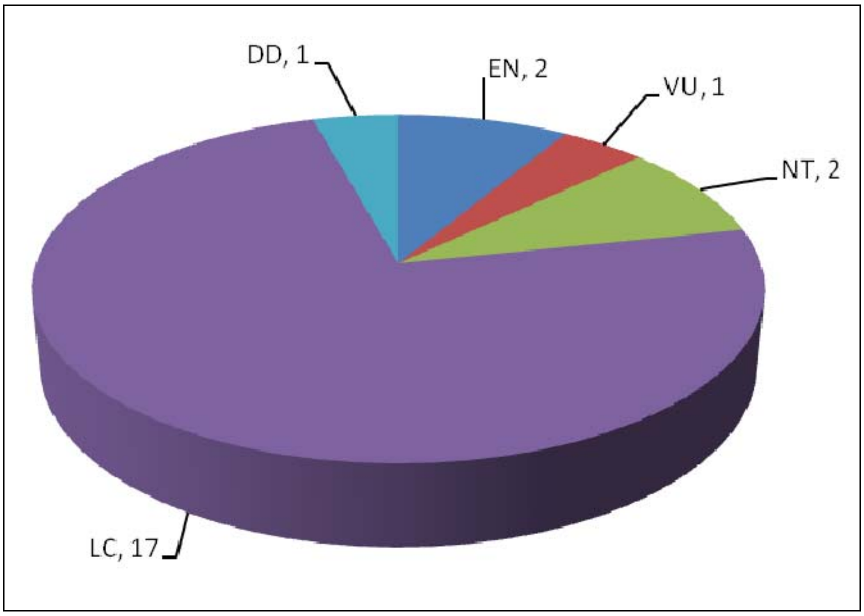


Fig.3.51. Biodiversity statusof exploited fish species in River Muvatupuzha

3.3.8.2. Quantification of exploited fishery resources

The total exploited fishery of this river was estimated as 45.01 t. The species wise landings are shown in Table.3.9. *Wallago attu,* one of the most important catfish in flood plain fisheries in india and commonly known as 'Freshwater shark' showed highest landings (16.93%) in this river. This species supported a lucrative fishery round the year and sustained as the major source of livelihood source to the fishermen. *Labeo dussumieri* was formed 16.01% of total landings. *Channa striata* (4.60 t) and *C. marulius* (2.24 t) formed other major species in the fishery, constituting 15.19% of total landings. Genus *Puntius* represented by two species viz., *Puntius sarana subnasutus* (4.45 t) and *P. filamentosus* (2.51 t) constituted 15.44 % of total landings. *Hypselobarbus curmuca,* commonly known as 'Kooral' formed a major fishery in the river accounting 4.9 t in the landings. Highest landings were recorded during post monsoon season (21.87 t) whereas, it was lowest during monsoon (7.38 t).

Among the six landing centres; Mulakulam accounted for 31.62 % to the total fish landing, followed by Kalampoor (26.88%). Kaliyar (2.87%) and

Kadumpidi (8%) contributed only an insiginificant portion to the total landing (Fig.3.52). Among the fishes landed, *Wallago attu* and *Channa* species were the highly priced species.

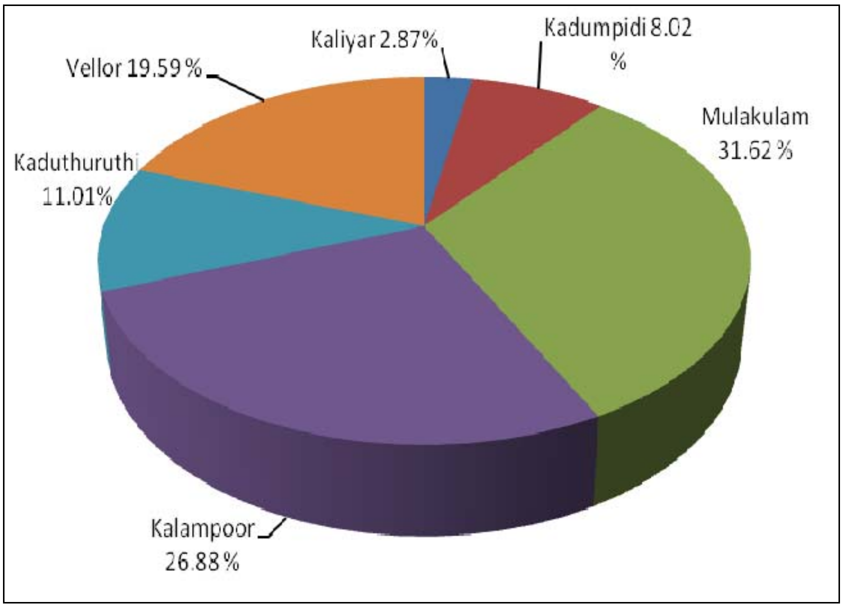


Fig.3.52. Percentage contribution of three fish landing centres supporting fishery in Muvatupuzha river system

3.3.8.3. Craft and Gear

Fig.3.53 depicts the percentage contribution by weight of various gears in the exploited fishery from Muvatupuzha river. Gill net was the predominant fishing gear operating all along the river and they accounted for 88% of catch. Seine net (11%), Cast net (1%) and Hook and line (0.3%) were also found in this river. The landing from the gill nets comprised of *Wallago attu* (19.22%), *Labeo dussumieri* (18.18%), *Hypselobarbus curmuca* (12.06%) and *Horabagrus branchysoma* (8.90%). Highest catch per unit was recorded in gill net for *W.attu* (0.11 kg/hr), *Channa striata* (0.08 kg/hr), *Tor khudree* (0.08 kg/hr), *Gibelion catla* (0.08 kg/hr) and *C. marulius* (0.07 kg/hr). The catch per unit effort of gill nets with respect to the major commercially important fish species in Muvatupuzha river is depicted in Fig.3.54. The main catches in the seine net consisted of *Channa striata*

(39.95%), *C. marulius* (30.68%), *Heteropneusteus fossilis* (11.62%) and *Anabas testudineus* (7.94%). Highest catch per unit effort was recorded in the case of *Channa striata* (0.28 kg/hr), *C. marulius* (0.20kg/hr) and *Horabagrus branchysoma* (0.08kg/hr). The catch per unit effort of seine nets in respect of the major commercially important fish species in Muvatupuzha river is depicted in Fig.3.56.

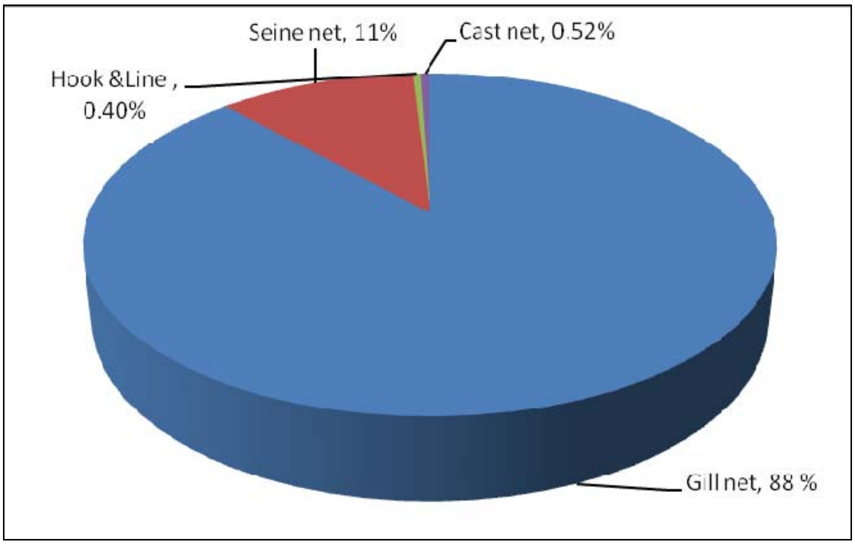


Fig.3.53. Percentage contribution of various gears in the exploited fishery from Muvatupuzha river

The main catches in the cast net consisted of *Hypselobarbus curmuca* (51%) and *Puntius filamentosus* (25.51%). Highest catch per unit was recorded *H. curmuca* (0.5 kg/hr) and *P. filamentosus* (0.25 kg/hr). The catch per unit effort of cast nets with respect to the major commercially important fish species in Muvatupuzha river is depicted in Fig.3.55. *Mastacembelus armatus* and *Anguilla bengalensis* were mainly obtained in the hook and line fishery.

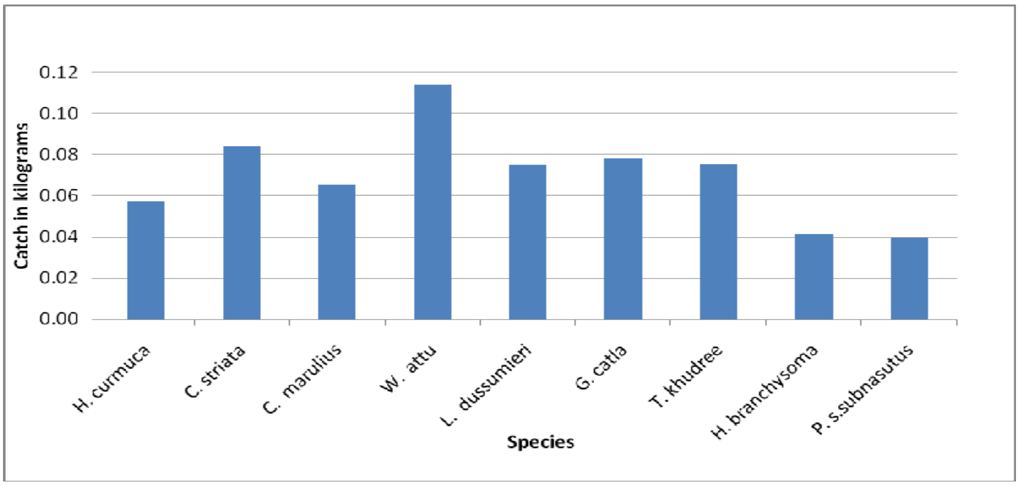


Fig.3.54. Catch per unit hour of major fish species exploited by gill nets in Muvatupuzha

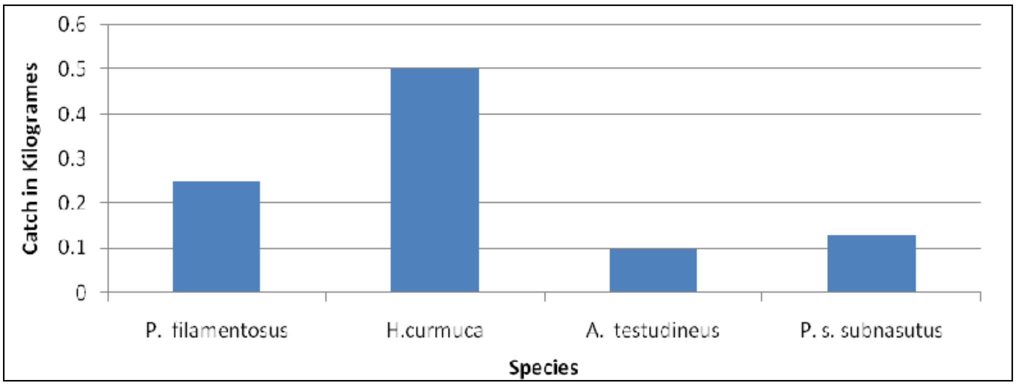


Fig.3.55. Catch per unit hour of major fish species exploited by cast nets in Muvatupuzha river

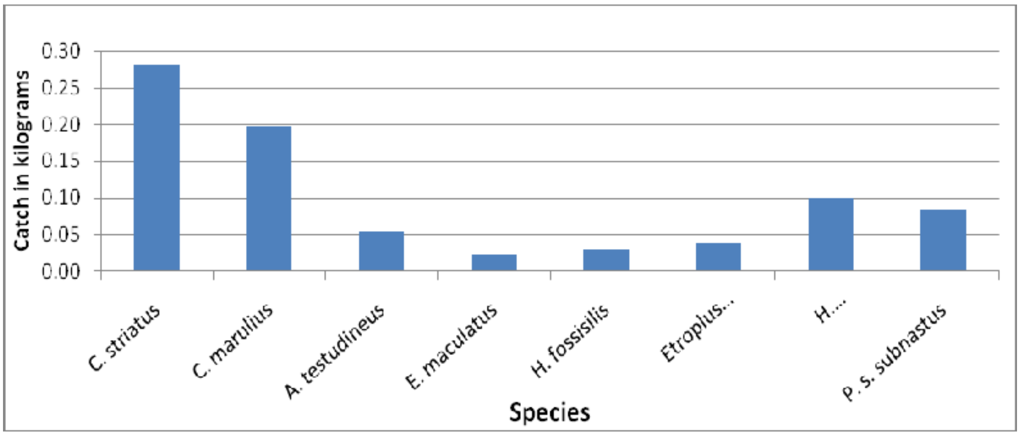


Fig.3.56. Catch per unit hour of major fish species exploited by seine nets in Muvatupuzha river

3.3.9. Meenachil river system

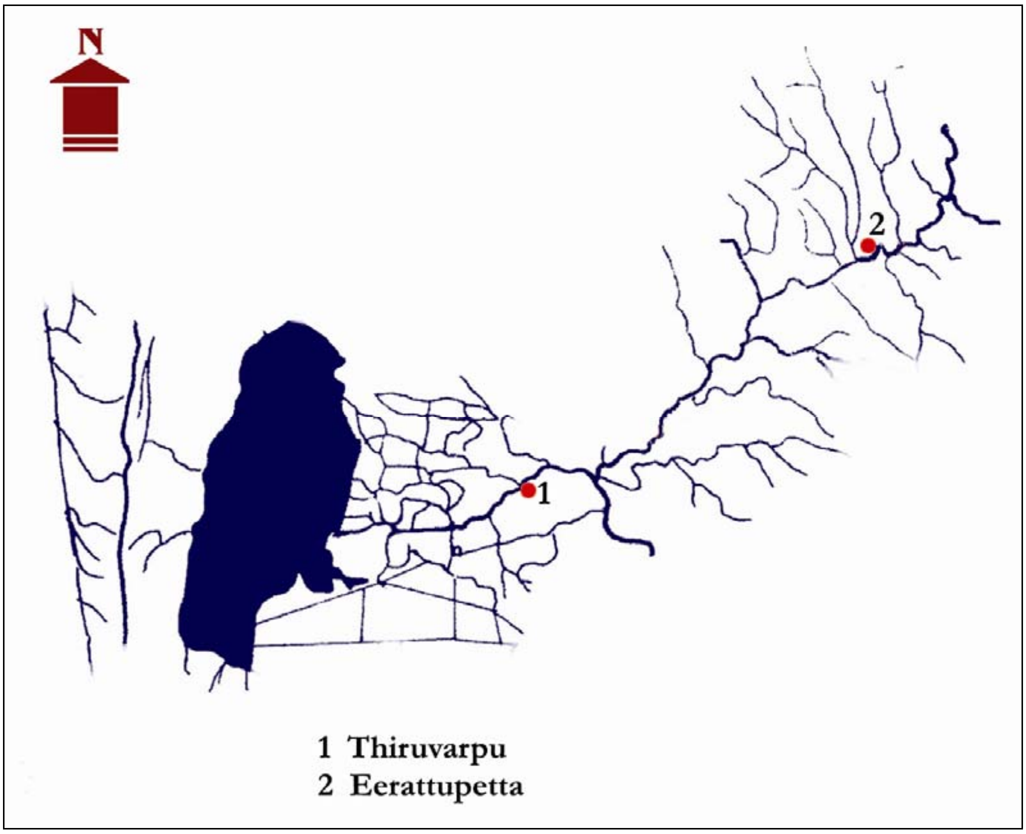


Fig.3.57. Map of Meenachil river basin showing landing centres surveyed

3.3.9.1.Exploited fishery

13 species belonging to 4 orders, 8 families and 10 genera were contributed to the exploited fishery of Meenachil river. Numerical strength of various fish families contributed to the exploited fishery in River Meenachil is depicted in Fig.3.58. The landings were represented by one each vulnerable and near threatened fish species (Fig. 3.59).

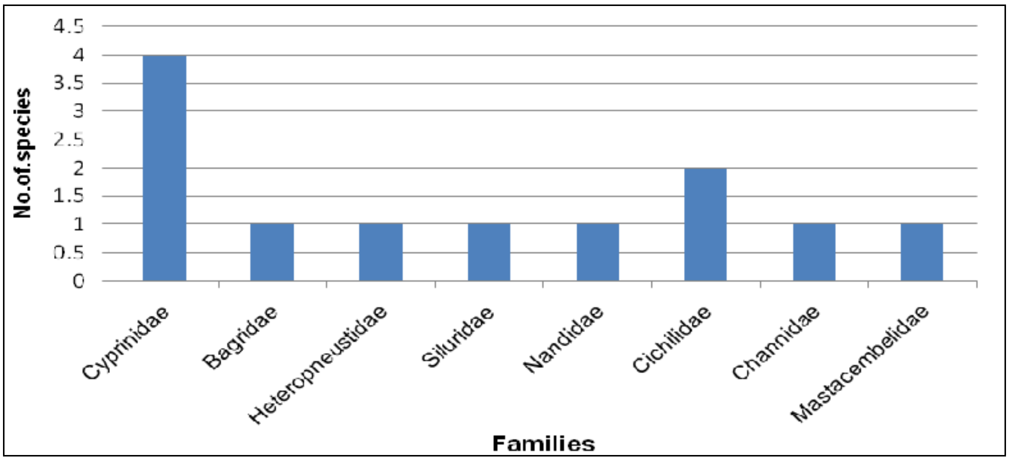


Fig.3.58. Numerical strength of various fish families contributed to the exploited fishery in River Meenachil

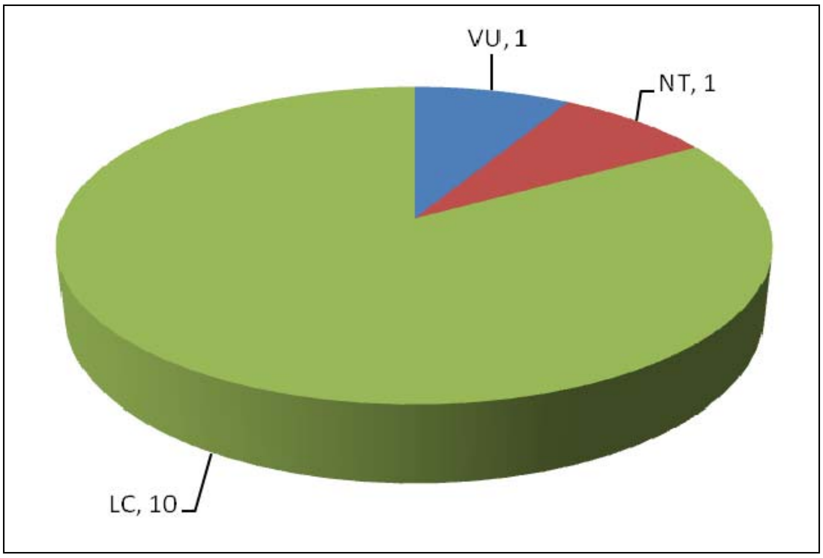


Fig.3.59. Biodiversity status of exploited fish species in River Meenachil

3.3.8.2. Quantification of exploited fishery resources

The annual exploited fishery of the Meenachil river was 15.67 t. Highest landings were recorded during post monsoon season (8.53 t) whereas the landing was lowest in pre monsoon (3.49 t). *Etroplus suratensis* was the main species in the exploited fishery with a landing of 3.26 t followed by *Wallago attu* (2.32 t) and *Labeo dussumieri* (2.07 t). Freshwater prawn, *Macrobranchium rosenbergii* accounted for 20.71% in the fishery. Among the two landing centres, Thiruvarpu accounted 78.4% to the fish landing followed by Eerattupetta (21.6%) (Fig.3.60).

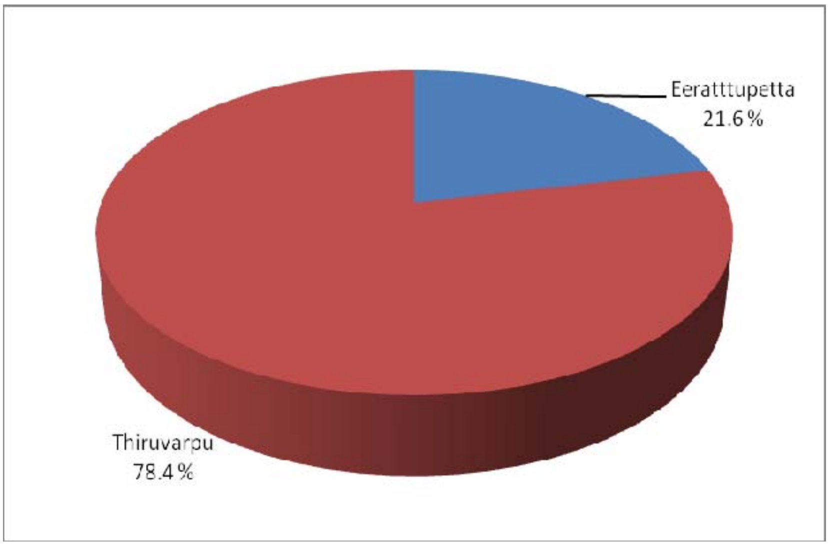


Fig.3.60.Percentage contribution of fish landing centres supporting fishery in Meenachil river system

3.3.8.3. Craft and gear

Fig.3.61 depicts the percentage contribution by weight of various gears in the exploited fishery from Meenachil river. Gill net was the predominat gear operating all along and they accounted 94% of the catch followed by seine net (3.3%). The main catches of gill net consist of *Labeo dussumieri, Wallago attu, E.suratensis*, *Channa striatas* and *Heteropneustes fossilis.* The catch per unit effort of gill nets with respect to the major commercially important fish species in Meenachil river is depicted in Fig.3.62. Highest catch per unit effort was recorded in the case of *E.suratenis* (0.14 kg/hr), *L.dussumieri* (0.13kg/hr) and *Macrobranchium rosenbergii* (0.13kg/hr).

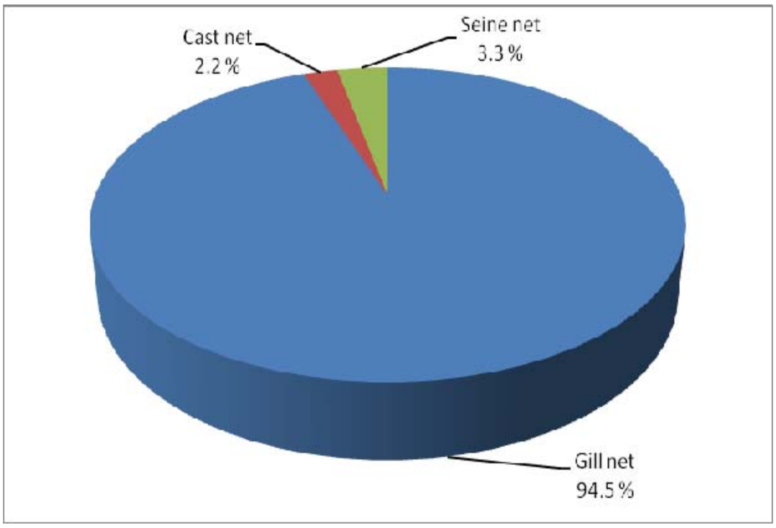


Fig.3.61. Percentage contribution of various gears in the exploited fishery from Meenachil river

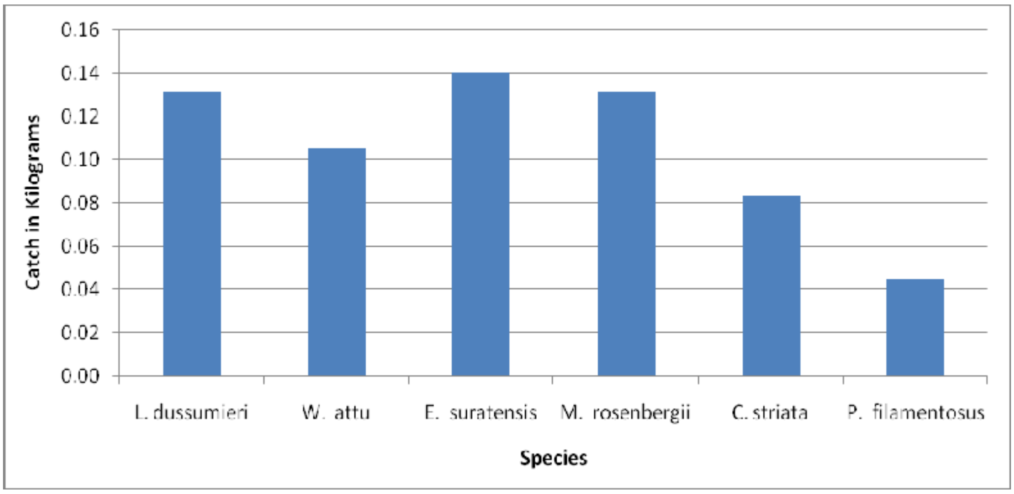


Fig.3.62. Catch per unit hour of major fish species exploited by gill nets in Meenachil river

3.4. Discussion

Riverine fisheries are highly dispersed and unorganized. Collection of data on fishing and fish yields were utmost difficult in riverine environment (Sinha, 1999). Information regarding estimates of fish production from river stretches in India is scarce (Jhingran, 1991; Kurup,1993a; Sinha, 2002), though many estimates on estuarine, lacustrine or reservoir fisheries are available (Ramakrishnah, 1987; Rani and Manoharan, 2010). The data collection from rivers is very difficult in contrast to estuarine and marine habitats, mainly because of lack of organized landing centres and patterns. The collection of data of fish production from inland water bodies is difficult due to various constraints such us (1) highly dispersed and isolated nature of fishing and landing centres (2) diversity of fishing gears employed 3) innumerable landing centres (4) migration of fisherman from one area to the other for fishing (5) multispecies composition of catches and the landing of catches in unsorted conditions and (6) isolated nature of fishing areas where transportation facility are very limited (Pillay,1960). The Central Inland Fisheries Research Institute (CIFRI) has collected data on fishery from selected stretches of the rivers Ganga, Brahmaputra, Narmada, Tapti, Godavari and Krishna. These rivers harbour a rich and varied fish fauna, among them, the Gangetic system alone has 265 species, followed by the Brahmaputra system with 126 species and the peninsular rivers harbouring 76 species (Sinha, 1999). Seasonal floodplains pulses greatly influences ecosystem and fishery production in tropical rivers (Arthington *et al.*, 2003). Flood plains aquatic habitats provide shelter in the form of submerged macrophytes and abundant food resources (Welcomme, 1985; Neiff *et al.*, 2009). Year with more extensive flooding increases the primary and secondary productivity cause higher fish growth rate and greater fish recruitment (Junk, 2007; Bayley, 1988; Halls *et al.*, 1998; Agostinho *et al.*, 2003; Bailly *et al.*, 2008).

In the present study, the total exploited fishery of major rivers of Kerala were estimated at 854.75 t. Pamba, Periyar, Bharathapuzha and Achenkovil rivers accounted for 86% of the total fish production in the rivers. The contribution from the remaining rivers was only 14% in the fishery. Periyar river is the largest river system in Kerala and this river contributed to the tune of 70.11 t in the exploited fishery of Kerala rivers. The upstream region of Periyar river consist of Periyar Lake, which is one of the biodiversity rich areas in Southern Western Ghats, supports many endemic and threatened species of fishes (Silas 1950,1952; Zacharias *et al.,* 1996; Kurup *et al.,* 2006; Radhakrishnan and Kurup, 2010). The present study revealed that the Periyar lake harbored a very rich diverse fish fauna. A total 10 fish species were reported in the exploited fishery of Periyar Lake. Earlier Kurup *et al.* (2006) reported 36 species of fishes belonging to 10 families and 21 genera from this Lake. The authors also reported two exotic fishes from the exploited fishery of the lake viz., *Cyprinus carpio* and *Oreochromis mossambicus.* But in the present study, one more invasive fish species was also recorded in Periyar Lake viz, *Clarias gariepinus*. This exotic fish was recently introduced in to the lake from nearby culture pond and propagated to a breeding population. *C.carpio, O.mossambicus* and *C. gariepinus* were the exotic fishes which were contributed to 38% of the fishery in Periyar river. These exotic fish species can impact ecosystems through competition and predation with other native fishes and by altering habitats, nutrient cycles, and energy budgets (Mack *et al.,* 2000). Kurup *et al.* (2006) had quantified the exploited fishery from Periyar Lake and therefore the present results on fishery were compared with the previous situation. The average fish production from Periyar Lake was estimated to be merely of 2.32 t (Kurup *et al.*, 2006). However in the present study, the fish production was on a higher side (34.17 t).

Labeo dussumieri commonly known as *Thooli* in vernacular were contributed a good amount of fishery (132.87 t) in Pamba, Chalalakudy, Meenachil, Muvatupuzha and Achenkovil rivers of Kerala. This species was the only indigenous fish under the genus *Labeo* to the rivers of central of Kerala. It attains about 50 cm in length and more than 2 kg in weight (Kurup,1988). In India this species is one of the highly esteemed food fishes and commands a good price as compared to the Indian major carps, especially in Kerala State (Padmakumar *et al.,* 2004). The distribution of this species is confined to Sri Lanka and Peninsular India especially Travancore region of Kerala (Hora and Law, 1941; John, 1936). John (1936) also reported that

L.dussumieri as one of the most common species of the rivers of Travancore where it was frequently encountered in gillnets. Kurup and Kuriakose (1991) reported that this species occur only in four rivers of Travancore (Pamba, Manimala, Meenachil and Achenkoil) and in Vembanad Lake. In the present study another two river systems namely River Muvatupuzha and Chalakudy were found to be contributing to the population diversity of *L. dussumieri*. Pamba River contributed to the maximum quantity of *Thooli* in Kerala rivers (75.98 t). The landing of this species is high in Parumala landing center. (Kurup and Kuriakose, 1991) reported that the occurrence of this species encountered in the downstream region of Pamba river between Pallaturuthy and Mannar in almost round the year and in Achenkovil river its distribution appeared to be extended up to Mavelikkara. River Chalakudy and Periyar also sustained the fishery of this rare species before a decade, after that the fishery of this species got disappeared from these two rivers (Kurup and Kuriakose, 1991). But in the present study it was observed that this species got replenished in Chalakudy river and contributed to 0.27 t to the fishery of this river. This species supported annual landings of 5.14 to 7.08 t in Pamba River during 1987-1990 (Kurup, 1993). According to Kurup (1993a), the landing from Pavukkara and Parumala landing centres varied from 2.4 to 3.2 t and 2.02 to 2.64 t respectively. On the contrary, in the present study, the landing was estimated at 6.38 t and 37.56 t respectively in the above two landing centres. The size ranges of *L. dussumieri* observed was (110-359 mm) found to be lower when compared to 90 – 454 mm as reported by Kurup (1993a). The author reported that the catch per unit effort of this species varied from 0 to 2.63 kg/hr/man. In the present study, the average CPUE of various gear varied from 0.87 to 2.50 kg/hr. In 1990’s, there was an alarming depletion of population of this species due to water abstraction, fishing during *Oothayilakkom*, fishing by explosives and poisons, exploitation of gravid females, etc (Kurup, 1993a). Gravid females of *L. dussumieri* of Pamba were subjected to indiscriminate killing during the outbreak of monsoon, which was commonly known as

"Thooli chakara in Pamba" (Kurup 1994a). Pethiyagoda (1994) recorded a decline of this species in Sri Lanka because of competition with the exotic tilapia. The workshop on Conservation Assessment Management Plan (CAMP) to evaluate the status of this species as 'endangered' based on IUCN criteria due to restricted distribution, loss of habitat, over-exploitation, destructive fishing practices and trade (CAMP, 1998; Ponniah and Gopalakrishnan, 2000). Kurup and Kuriakose (1991) developed the captive breeding technology of *L. dussumieri* and had undertaken ranching of this fish species in the Pamba river. The stock revival in the Pamba river is attributed due to the ranching of this species. The stocking of fishes in rivers has proven one of the most successful fishery measures undertaken to enhance yield and it supplements the natural recruitment (Jenkinsins, 1961). In recent IUCN assessment this species was assessed as Least Concern (LC) category.

Wallago attu commonly known as 'freshwater shark' was distributed in floodplains rivers of South Asia, Indo China and Western Indonesia (Giri *et al*., 2002). This species was contributed to a mere of 62.78 t in the fishery of major rivers of Kerala. Kurup (1994a) collected *W. attu* from landing centres of Pamba, Periyar, Bharathapuzha, Achenkovil, Chalakudy, Meenachil and Muvattupuzha rivers. In addition to these rivers *W. attu* was collected also from the landing centres of Muvatupuzha river. High landing of this species was observed from River Pamba with 37.65 t while the lowest catch was reported in Achenkovil river system (2.04 t). Rao *et al*. (1991) reported that *Wallago attu* constituted a fishery to the tune of 7.4 to 8.2% in the Narmada River. The average annual yield of 353.9 kg was reported from River Ganga (Montana *et al.,* 2011. The size range occur in the fishery of *Wallago* was reported to be in the range of 100-120cm (Day, 1865) and 40-70 cm (Kurup, 1994a). Due to the population declines, this species assessed as near threatened (NT) in the recent IUCN assessment.

Mahseer is one of the important game fishes of India, inhabiting fast flowing streams and rivers of hilly regions in India. Species of the *Tor* are the biggest freshwater fishes of the world (Lakra, 1996). Commonly occurring species of mahseer inhabiting Indian waters are *Tor khudree, T. tor, T. putitora, T. musallah,, T. mosal* and *T. progenies* (Jhingran, 1991). *Tor khudree* (Deccan mahseer) was one of the important food fishes and they landed to the tune 9.48 t in the fishery of rivers.of Kerala. *T. khudree* is a long lived and slow growing (Froese and Pauly, 2010) species of Mahseer, which occur in various river systems of east and west peninsular India especially Karnataka, Kerala and Maharashtra hill streams and was known to attain 120-150 cm total length and 40-50 kg weight (Shanmukha, 1996). This species was also reported from the South Canara, Thenmalai region of Kallada river and hill ranges of Western Ghats (Day, 1878; Pillay, 1929; Hora and Law, 1941; Silas, 1951). In the present study, *T. khudree* was represented in the exploited fishery of Periyar, Chalakudy, Muvatupuzha and Kallada rivers. Among them, the landing from Periyar river was 6.85 t. Cast nets and gill nets were used to catch Mahseer by local fishers in Periyar and Chalakudy rivers and in some areas indiscriminate fishing using dynamite to catch this fish was also encountered (Raghavan *et al.*, 2011). Daniels (2002) reported that *T. khudree* grows to maximum size of 1000 mm. In Periyar and Chalakudy river, the average size of this species was >460 mm (Raghavan *et al.*, 2011). *T. khudree* has a low resilience and a longer population doubling time of 4.5 to 14 years (Froese and Pauly, 2007). Large scale exploitation of this species as food is of critical concern as population of such species will take long time to recover (Raghavan *et al.*, 2008b). The catches of *T. khudree* have declined drastically in past few years in Periyar lake and Chalakudy rivers (Minimol, 2000; Solomon, 2009). Non-native species such as *Cyprinus carpio* and *Oreochromis mossambicus* were known to be a major threat to *T. khudree* in Periyar Lake, one of the major habitats of this species in Southern Western Ghats (Kurup *et al.*, 2006). The fishing mortality rate of *T. khudree* in Poringalkuthu reservoir of Chalakudy river was one of the highest of any other species of Mahseer in India and this is due to the indiscriminate exploitation by local fishermen (Raghavan *et al.,* 2011). The IUCN has listed *T. khudree* as an endangered species based on current criteria (IUCN, 2011). Severe overfishing and population decline have been observed in many part of India for Deccan Mahseer (Bhatt *et al.,* 2000,2004; Nautiyal *et al.,* 2008). This species had faced a drastic decline in the northern Western Ghats and has almost disappeared from its type locality in Mula-Mutha river of Pune (Kharat *et al.,* 2003; Wagh and Ghate, 2003). National Commission on Agriculture (1979) reported that there is a general decline in the fishery of Mahseer due to indiscriminate fishing of brood and juvenile fish and adverse effects of dams. The percentage contribution in the total fish landings in Periyar lake during 2001- 02 and 2002-03 had showed that *Cyprinus carpio* dominated in the landings, forming 48% in the former and 58% in the later years whereas, *T. khudree* formed 29% during 2001-02 and 26% during 2002-03 (Kurup *et al.*, 2006). *Oreochromis mossambicus* posed severe threat to the existence of *T. khudree* in Periyar lake as 78% of their food was found overlapped while *C. carpio* showed 57% of diet overlap with that of *T. khudree* in its food preference (Kurup *et al.,* 2006). *T. khudree* may face severe competition for food and was resulted in their phased displacement from the lake over a period of time. There no restriction on catch size or limit in the fishery of Mahseer in protected areas of Kerala (Rajeev *et al.,* 2011). Mahseer fishing site are under the control of Department of Forest and Wildlife and in some areas under Department of Electricity (Rajeev *et al.,* 2011). Regulation of fishing effort on of this species is an important management strategy to the adoption for the conservation of this species. There is also need for a ban on *T. khudree* fishing from October to December because this species is known to breed during this season in the rivers of Kerala (Arun *et al.,* 2001). Selective harvesting of other exotic and transplanted fishes from rivers and reservoirs of Kerala will also be helpful in protecting the mahseer fish species diversity and also useful in the reduction of invasive species. The periodic stock enhancement through ranching of captive bred fry and fingerlings, similar to those carried out in Central and Northern Western Ghats (Basavaraja, 2007; Ogale, 2002) can also be adopted in Kerala rivers and reservoirs.

Horabagrus brachysoma (Yellow Catfish), commonly known as Golden Catfish, belongs to the family Bagridae, formed the mainstay in the exploited fisheries of the rivers of Kerala (Sunil et al, 1999). The landing of *H. brachysoma* in Kerala rivers was low (45.67 t) when compared to that of Vemband Lake (67.44 t) (Kurup *et al.*, 1995). It is an excellent table fish with high market demand and consumer preference. *H. brachysoma* is distributed in the rivers and occasionally lakes and backwaters in the southern region of the Indian subcontinent. In Kerala, this species occurs in Chalakudy, Periyar, Meenachil, Manimala, Pamba, Muvattupuzha, Achenkovil rivers and Vembanad Lake (Ali *et al*., 2007). It is one of the important food fish species which is targeted frequently by fishermen of Periyar River using gill nets, hooks and lines (Prasad *et al.,* 2012). *H.brachysoma* is known to grow to a maximum size of 450 mm (Talwar and Jhingaran, 1991). Sreeraj *et al*. (2007) reported a size range of 160 - 330 mm in its population from Vembanad Lake. On the contrary, the present study revealed that this species has been subjected to size overfishing in the river Pamba as evident from its lower size range represented in fishery (90 - 230 mm). The juvenile fishery of this species is mainly due to the use of fine mesh nets having a mesh size of 10-30 mm. In Karuvannor and Vemband, the catches were predominantly represented by 30-40 cm and 20-30 cm respectively (Kurup, 1992). The exploited population of *H.brachysoma* in Periyar during 2005 was constituted by individuals ranging from 112 to 340 mm (Prasad *et al*., 2012). Fishery of the yellow catfish in Vembanad Lake showed fluctuating trend from 1995 until 2004, evinceing show oscillation with in a very time frame (Kurup *et al.* 1995; Bindu 2006; Sreeraj *et al.* 2007). Due to heavy decline of landing, this fish species is getting listed as vulnerable(VU) in the IUCN Red List of Threatened Species (IUCN, 2011).

The populations of this species have declined drastically and the fish has became very rare and restricted to tributaries of Chalakudy, Meenachil, Manimala and Pamba rivers opening to the Vembanad wetlands (Padmakumar *et al.,* 2011). Overexploitation, habitat degradation and pollution has resulted in the population decline of *H. brachysoma* in its habitat (Ali *et al.,* 2007; Prasad, 2008; Sreeraj *et al.,* 2007). Kurup *et al.* (1993) reported that this species had shown an alarming decline in its population. A survey conducted during 2000–2001 along with the riverine sector of Vembanad Lake, revealed that *H. brachysoma*, once abundant in this lake, constituted only 1.52% of the total riverine fishes in the lake (Padmakumar *et al.,* 2002). The peculiar life history traits of the species, including a medium resilience to overfishing and a minimum population doubling time of 1.4 to 4.4 years (Froese and Pauly, 2009) also makes this species vulnerable to the overfishing. In spite of its threatened status, declining numbers and specific life history traits, exploitation of *H. brachysoma* for both the food and ornamental markets continues to be unabated (Ali *et al.,* 2007).

Fishes of the genus *Puntius* are prolific and known to occupy a broad variety of freshwater niches in tropical Asia (Jayaram, 1999) and 127.46 t of this group of fishes were exploited from rivers of Kerala in the present study. *Puntius filamentosus* is widely distributed throughout Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Goa (Jayaram, 2009). It is normally seen all rivers of Kerala and are landed to the tune of 56.91 t from eight rivers of Kerala. Among them, Pamba river contributed highest production of 20.64 t. This fish normally occurs in lowland rivers and also in estuaries, reservoirs and marshes (Kortmulder *et al.,*1990; Pethiyagoda and Kottelat, 2005). It is often found very close to the sea in brackish water and is a species commonly seen in Kerala fish markets. *Puntius sarana subnasutus* commonly known as "*olive barb*" (*Kuruva* in vernacular) is an important food fish of Kerala and 70.19 t were exploited annually from rivers as per the present study. Pamba river contributed to 55% of *Kuruva* fish catch. It is a tasty, the most popular and favorite table fish among barb species having high nutritional and market value in Asian countries (Chakraborty *et al*., 2007). The populations of this species were declining due to a combination of overexploitation, environmental degradation, natural disasters, pesticide and aquatic pollution, spread of disease, uncontrolled introduction of exotic fishes, destruction of breeding grounds, excessive water abstraction, siltation, various ecological changes in its natural habit and lack of proper management (Mijkherjee *et al*., 2002; Chakraborty *et al*., 2007, Md *et al.*, 2009). *Puntius sarana subnastusus* and *Puntius filamentosus* were assessed as Least concern category (LC) as per assessment following IUCN (2011).

The four air breathing fishes (*Channa striatus, C. marulius, C. orientalis* and *C. diplogramma*) were contributed a significant fishery in the rivers of Kerala (122.46 t). Air breathing fishes form about 13% of the total marketable freshwater fishes in India and among them murrels belonging to the genus *Channa* are highly priced all over India (Chakrabarty, 2006; Aliyu- Piaki *et al*., 2009). *Channa marulis* was the most common murrel species of Kerala rivers (John, 1936), where as *Channa diplogramma* is very rare (Hora and Law, 1941). *C. marulius* (Great snake head) is considered as an important food fish in India and it is a significant component of the freshwater fishery in Andhra Pradesh (Talwar and Jhingran, 1991). Total exploited fishery of *C. marulius* from rivers of Kerala was estimated to be 46.68 t and River Pamba were contributed 60% of the total landing. *C. striatus* is commonly known as '*Cherumeen*' in vernacular is an obligate air breather native to Asia and Africa (Ng and Lim, 1990; Banerjee, 2007). The landing of *C. striatus* from Kerala rivers was estimated to be 67.37 t. *C. striatus* is one of three species of snakeheads commercially fished in Lake Jaisamand, the oldest reservoir in India (Rao and Durve, 1989). This species was reported to be the largest of the family Channidae, attaing a length of 120-122 cm (Bardach *et al.*, 1972; Talwar and Jhingran, 1991). The results of present study revealed that *C. diplogramma* contributed to the tune of 5.3 t in the exploited fishery of the rivers of Kerala. The fishery of this species was found significant in Pamba, Achenkovil and Kallada rivers. Among them, Achenkovil river accounted for the highest landings (3.6 t). Talwar and Jhingran (1991) remarked that this species is only having minor interest to fisheries in Kerala State. This species was subjected to alarming decline in its population due to destructive type fishing activities including dynamiting and poisoning, Epizootic Ulcerative Syndrome (EUS), habitat alteration and pollution (Kurup, 2000). This species is listed as vulnerable category (VU) in the IUCN assessment of freshwater fishes of Western Ghats (IUCN, 2011). The native air breathing fish species found in the rivers of Kerala are under threat and are slowly getting eliminated owing to various reasons, notably due to diseases like Epizootic Ulcerative Syndrome (EUS). Introduction of exotic species is also responsible for their extermination.

In the rivers of Kerala genus *Hypselobarbus* accomadating four species viz., *Hypselobarbus curmuca, H. kolus, H. kurali* and *H. thomassi*, were contributed to the tune of 30.88 t in the exploited fisheries of major rivers of Kerala. *Hypselobarbus curmuca* (Red tailed barb) is endemic to the rivers of Southern part of the Western Ghats in Peninsular India (Gopalakrishnan and Ponniah, 2000). This species contributed to 85% of the landing in *Hypselobarbus* genus. This species is distributed in Bhavani, Tamiraparani, Manimuthar, Krishna, Godavary, Cauvery and in all major rivers of Kerala such us Chaliyar, Achenkovil, Pamba etc (Radhakrishnan, 2006; Jayaram, 2009). In the present study this species appeared in the exploited stock from six rivers of Kerala and, among them River Periyar accounted for highest landing of 5.71 t. The sharp decline in abundance of *H.curmuca* and it is endangered status are of serious concern (Gopalakrishnan and Ponniah, 2000; IUCN, 2011). *H. kolus* is an endemic fish to Western Ghats (Ponniah and Gopalakrishnan, 2000; Dahanukar *et al.*, 2004). This species has been recorded from the states of Kerala, Karnataka, Tamil Nadu and Maharashtra. This species is distributed in Chalakudy, Periyar, Muvattupuzha and Karamana of Kerala (Chhapgar and Mankadan, 2000; Raghavan *et al.*, 2008b; Kurup *et al.*, 2004) and the exploited quantity was quantified as 3.87 t. *H. kurali* is endemic to the southern Western Ghats and reported from Periyar river (Ajithkumar *et al.*, 2001), Periyar Tiger Reserve, Central Kerala, Achankovil and Kulathupuzha (Johnson and Arunachalam, 2009) rivers in Southern Kerala (Jayaram, 2009). Annual landing of this species is quantified as 0.42 t in Kallada river. It is also recorded from the west flowing Chittar river in Kanyakumari, Tamil Nadu (Arunachalam, 2004). *H. thomassi,* commonly known as '*Red canarese barb*' is an endemic fish to the Western Ghats (Dahanukar *et al.,* 2004). *H. thomassi* has been recorded from Periyar, Kabbini and Kallada rivers in Kerala (Thomas, 2004; Shaji and Easa, 2003; Kurup *et al.,* 2004). This species contributed to the exploited fishery in Kallada river at Kulatupuzha region to the tune of 1.12 t. Due to the rapid decline of population of this species in Kerala, it is listed as Critically Endangerd species (CR) as per IUCN assessment of fishes of Kerala (IUCN, 2011).

Ompok is an important genus of this family that accomodating four freshwater fish species in India namely *Ompok bimaculatus O. malabaricus*, *O. pabda* and *O. pabo* (Verma *et al.*, 2011). *Ompok bimaculatus,* commonly known as the '*Indian butter cat fish'* contributes to 4.26 t in the fishery of Kerala rivers. It is a highly priced freshwater teleost, native to South–east Asia. Periyar river contributed to the maximum level of exploitation of this species (1.85 t). This species contributes to the exploited fishery of five rivers of Kerala. Over the past 10 years, its wild population had undergone a steady decline (> 50%) mainly due to over exploitation, loss of habitat, disease, pollution, siltation, poisoning, dynamite and other destructive fishing. it listed one among the 91 endangered fish species of India as per the IUCN status (CAMP, 1998). Overexploitation of this species for food is a major threat and has resulted in the drastic population decline (Mishra *et al.*, 2009).

Gibelion catla, *Labeo rohita* and *Cirrhinus mrigala*, commonly known as 'Indian major carps' (IMC) were constituted an important fishery in the rivers of Kerala, with 35.72 t. These species are transplanted from Northeastern states of India to the Western Ghats for augmenting production (Sugunan, 2000). Indian major carps have been stocked in the peninsular reservoirs for many decades and in some of the reservoirs of Southern India, they have established the breeding populations (Sugunan, 2000). *Gibelion catla* commonly known a 'Catla' belongs to the family Cyprinidae and constitutes an important commercial species for freshwater aquaculture and capture fisheries in India (Deepak *et al.*, 2008). This is the fastest growing riverine carp of India. *G. catla* appeared in the exploited fishery of four rivers of Kerala viz, Pamba (17.28 t), Chalakudy (2.52 t), Bharathapuzha (3.98 t) and Muvatupuzha (2.56 t) rivers. This species was introduced in to Kerala for the first time in Periyar Lake from Godavari River (Chacko, 1948). Rao et al. (1991) reported that *G. catla* supported a lucrative fishery in River Narmada with an average annual production of 7.8 t. Sathanur reservoir in Tamil Nadu has naturalized population of catla that contributes 80-90% of the total catch. It has eclipsed all indigenous fish fauna including *Labeo fimbriatus*, which dominated the catch in mid 1960s by contributing 36% (Sugunan, 2000). *L. rohita* was an important component in the fishery of two rivers in Kerala (Chalakudy and Bharathapuzha). The production of *Labeo rohita* in Chalakudy river (0.50 t) is low when compared with Bharathapuzha (5.14 t).

Oreochromis mossambicus (Tilapia) appeared in the exploited fishery of four rivers of Kerala viz., Periyar, Chalakudy, Bharathapuzha and Kallada rivers and the annual landing was 12.21 t. Tilapia has been used worldwide for aquaculture purposes and has escaped from many ponds where they were cultured (Peterson *et al.,* 2005). In the present study, *O.mossabicus* and *Tor khudree* accounted for 14% and 18% of the total fishery in Periyar lake respectively. Kurup *et al.* (2006) reported that *O.mossambicus* and *T. khudree* were contributing 10% and 26 % respectively in the total landing of Periyar lake. So there was a gradual increase in the quantity of tilapia landing, on the contrast, *T. khudree* show a decrease in the landing in Periyar River.

The giant freshwater prawn, *Macrobrachium rosenbergii*, supported a lucrative fishery in the rivers and backwaters of Central Kerala. This prawn species landed 47.13 t in the fishery of Kerala river and a high landing in Pamba river. The exploited stock of *M. rosenbergii* from Vembanad lake and 5km stretch confluent rivers was quantified as 121.14 t annually (Kurup and Harikrishnan, 2000). Riverine regions contributed 30.23% of the total exploited stock while the share of the upstream part of lake was 33.2%, whereas 36.43% of the total catch was registered from the downstream part of the lake (Kurup and Harikrishnan, 2000). Invariably, *M.rosenbergii* show their peak abundance in India during monsoon and post monsoon seasons (Ibrahim, 1962; George, 1969; Rajyalekshmi,1980; Prakash,1989). The total yield of *M. rosenbergii* in Irrawady river in Burma was reported as 1782.2 t and the prime period of landing is in September to January (Taw,1983). In Kolleru lake, highest landing of *M. rosenbergii* was reported in winter and monsoon seasons which accounted for 62% and 28% respectively (Rao,1992). The distribution and landing of *M. rosenbergii* in the Kerala rivers was observed during the above periods which is in agreement with the above finding. The depeletion of the stock of *M. rosenbergii* was attributed mainly to the impact of man made changes in the ecosystem such as habitat alteration, reduction of natural grow-outs, recruitment over-fishing etc. (Kurup *et al.,* 1992).

Brandt (1984) reviewed fishing methods all over the world. The author found that it was impossible to review all fishing gears operated anywhere in the world, now or in earlier times. Saxena (1988) opined that due to highly diverse nature of riverine habitat, the fishing methods range from catching with hands to the operation of large and indigenously designed nets for fishing. Gill nets, cast nets, seine nets, drag nets and hook and lines were the gears employed in the exploited fishery in the rivers of Kerala. Among these gears, gill nets accounted for major share of the exploited fishery. The gill net fishery was prevalent along the entire lacustrine, rivers and reservoirs of Kerala. Kurup *et al.* (1993) identified 28 types of gill nets in the Inland waters of Kerala. In world fisheries, gill nets ranked third to trawls and purse seines in terms of total catch (Thomas, 2002). Gill nets are size selective and for a given mesh size, catch decreases sharply on either side of the length of the fish most frequently caught by it (Boopendranath, 2000). Gill nets of different colour show difference in catches and usually less visible net are more productive (Pauly, 1991). As passive gear, their catching ability relies on the movement or migration of fish through the area where nets are set and the operculum of fishes entangled in to the meshes of the nets, when the fishes try to pass through it. Odakkuvala (Neetuvala) and Thandadivala were the major types of gill nets operated in Kerala rivers. Gill net size varied from 30-150 meters while the mesh size varied from 22-150 mm in different designs. 70% of the fishermen in Northern Kerala region operated gill nets (Remeshan, 2006).

Cast nets were widely operated all over the world. The correct method of casting the net can only be learnt by experience. Fishermen employed this gear in the river channel or other areas where natural congregation of fish take place. This net is not important as it is contributed only a small percentage in the exploited fishery. The range of mesh size varied from 6-20mm. Brandt (1972) reported that cast nets were originally developed in India. The cast net can only be effectively operated in waters that have no hidden obstacles.

Seine net is a long wall of netting with or without bag, supported by floats and sinkers, which are operated by surrounding areas of water with potential catch (Hameed, 2002). They are typical gear for bulk fishery in the sea, rivers, reservoirs, estuaries and lakes where the water is not so deep. It is an active fishing gear operated in all types of water bodies. Almost all types of fishes are caughy by these nets. Kurup and Samuel (1985) and Kurup *et al.* (1993) reported the presence of seines in rivers and Vembanad Lake in central Kerala. 10 % of the inland fishermen operated seine net in North Kerala (Remeshan, 2006). This net is very effective net and should be banned by the Government because of its potential to overexploit the juvenile fishes. It is very harmful net and is responsible for the decline in fish populations in rivers and floodplains. Unfortunately this net was widely operating in many rivers of Kerala throughtout the year.

The fish landing from the rivers of Kerala is declining due to proliferation of different types of fishing gears and unscientific utilization aquatic resources. Sugunan and Sinha (2001) reported that rivers, estuaries and back waters in our country are exploited to the maximum and it is not possible to further increase the production. Adoption of conservation and management measures like closed areas and closed season are required for sustaining the present level of fish production in these water bodies.

Table 3.2 List of fish species reported from the exploited fishery of major rivers of Kerala with their biodiversity status

Sl No.	Order	Family	Species	Biodiversity status
1	Anguilliformes	Anguillidae	*Anguilla bengalensis*	LC
2	Elopiformes	Megalopidae	*Megalops cyprinoides*	DD
3	Cluepiformes	Clupeidae	*Dayella malabarica*	LC
4	Cypriniforms	Cyprinidae	*Puntius amphibius*	DD
5			*Barbodes carnaticus*	LC
6			*Puntius filamentosus*	LC
7			*Puntius sarana subnasutus*	LC
8			*Amblypharyngodon microlepis*	LC
9			*Gibelion catla*	LC
10			*Cirrhinus mrigala*	LC
11			*Cyprinus carpio*	VU
12			*Devario aequipinnatus*	LC
13			*Devario malabaricus*	LC
14			*Garrya mullya*	LC
15			*Hypselobarbus kolus*	VU
16			*Hypselobarbus curmuca*	EN
17			*Hypselobarbus kurali*	LC
18			*Hypselobarbus thomassi*	CR
19			*Labeo dussumieri*	LC
20			*Labeo rohita*	LC
21			*Osteobrama bakeri*	LC
22			*Salmophasia boopis*	LC
23			*Tor khudree*	EN
24	Siluriformes	Bagridae	*Horabagrus branchysoma*	VU
25			*Mystus vittatus*	LC
26			*Mystus gulio*	LC
27			*Mystus cavasius*	LC
28			*Mystus armatus*	LC
29		Siluridae	*Ompok bimaculatus*	NT
30			*Ompok malabaricus*	LC
31			*Wallago attu*	NT
32		Clariidae	*Clarias gariepinus*	NE
33			*Clarias batrachus*	LC
34		Heteropneustidae	*Heteropneustes fossilis*	LC
35	Beloniformes	Belonidae	*Xenentodon cancila*	LC

36		Hemiramphidae	*Hyporhamphus xanthopterus*	VU
37	Perciformes	Ambassidae	*Parambassis dayi*	LC
38			*Parambassis thomassi*	LC
39		Pristolepidinae	*Pristolepis marginata*	LC
40		Nandidae	*Nandus nandus*	LC
41		Cichilidae	*Etroplus maculatus*	LC
42			*Etroplus suratensis*	LC
43			*Oreochromis mossambicus*	NT
44		Gobiidae	*Glossogobius giuris*	LC
45		Anabantidae	*Anabas testudineus*	DD
46		Channidae	*Channa striata*	LC
47			*Channa marulius*	LC
48			*Channa orientalis*	NE
49			*Channa diplogramma*	VU
50		Mastacembelidae	*Macrognathus aral*	LC
51			*Mastacembelus armatus*	LC
52		Sillaginidae	*Sillago vincentil*	NE
53	Gonorhynchiformes	Chanidae	*Chanos chanos*	NE
54	Mugiliformes	Mugilidae	*Mugil cephalus*	LC

Table 3.3. List of commercially important species, their common names and quantity of landings in Pamba river

Sl No	Order	Family	Fish species	Common name	Quantity (Tonnes)
1	Cypriniformes	Cyprinidae	*Puntius filamentosus*	Black spot barb	20.64
2			*Puntius sarana subnastus*	Penisular olive barb	39.51
3			*Labeo dussumieri*	Malabar Labeo	75.98
4			*Amblypharyngodon microlepis*	Indian Carplet	34.32
5			*Puntius amphibius*	Scarlet banded Barb	0.07
6			*Gibelion catla*	Catla	17.28
7			*Hypselobarbus curmuca*	Curmuca Barb	0.04
8			*Osteobrama bakeri*	Malabar Osetobrama	0.01
9	Siluriformes	Bagridae	*Horabagrus branchysoma*	Yellow cat fish	17.11
10			*Mystus armatus*	Kerala mystus	0.09
11		Heteropneustidae	*Heteropneustes fossilis*	Stinging catfish	15.97
12		Clariidae	*Clarias gariepinus*	African catfish	0.15
13		Siluridae	*Wallago attu*	Boal	37.65
14			*Ompok bimaculatus*	Indian butter catfish	1.44
15	Perciformes	Anabantidae	*Anabas testudineus*	Climbing Perch	2.88
16		Ambassidae	*Parambassis dayi*	Day's glass fish	1.3
17			*Parambassis thomassi*	Western Ghats Glassy perchlet	0.07
18		Nandidae	*Nandus nandus*	Leaf fish	2.3
19		Pristolepidinae	*Pristolepis marginata*	Malabar Catopra	0.06
20		Cichilidae	*Etroplus suratensis*	Banded Pearlspot	31.88
21		Channidae	*Channa striata*	Banded Snakehead	36.34
22			*Channa marulius*	Giant Snakehead	30.06
23			*Channa diplogramma*	Malabar Snakehead	0.79
24	Synbranchiformes	Mastacembelidae	*Macrognathus aral*	One stripe spiny eel	0.42
25			*Mastacembelus armatus*	Spiny eel	0.24
26	Beloniformes	Belonidae	*Xenentodon cancila*	Freshwater gar fish	0.55
Prawn species					
1			*Macrobranchium rosenbergii*	Indian freshwater prawn	27.05
Total					**394.2**

Table 3.4. List of commercially important species, their common names and quantity of landings in Periyar river

Sl No	Order	Family	Fish species	Common name	Quantity (Tonnes)
1	Cypriniforms	Cyprinidae	*Cyprinus carpio*	Common carp	18.61
2			*Hypselobarbus curmuca*	Curmuca barb	5.71
3			*Hypselobarbus kolus*	Kolus barb	3.58
4			*Puntius filamentosus*	Black spot barb	0.62
5			*Puntius sarana subnasutus*	Penisular olive barb	5.39
6			*Tor khudree*	Deccan mahseer	6.85
7	Siluriformes	Bagridae	*Horabagrus branchysoma*	Yellow cat fish	2.52
8			*Mystus cavasius*	Gangetic mystus	0.04
9		Siluridae	*Ompok bimaculatus*	Indian butter catfish	1.85
10			*Ompok malabaricus*	Goan catfish	0.10
11			*Wallago attu*	Boal	2.18
12		Clariidae	*Clarias gariepinus*	African catfish	1.01
13		Heteropneustidae	*Heteropneustes fossilis*	Stinging catfish	0.46
14	Perciformes	Ambassidae	*Parambassis dayi*	Day's glass fish	0.38
15		Pristolepidinae	*Pristolepis marginata*	Malabar Catopra	0.07
16		Cichilidae	*Etroplus suratensis*	Banded Pearlspot	0.53
17			*Oreochromis mossambicus*	Tilapia	7.23
18		Gobiidae	*Glossogobius giuris*	Tank goby	0.13
19		Channidae	*Channa striata*	Banded Snakehead	5.83
20			*Channa marulius*	Giant Snakehead	3.55
21	Synbranchiformes	Mastacembelidae	*Mastacembelus armatus*	Spiny eel	3.39
Prawn species					
1			*Macrobrachium rosenbergii*	Indian fresh water prawn	0.15
Total					**70.17**

Table 3.5. List of commercially important species, their common names and quantity of landings in Chalakudy river

Sl No	Order	Family	Fish species	Common name	Quantity (Tonnes)
1	Elopiformes	Megalopidae	*Megalops cyprinodies*	Indo pacific tarpons	0.10
2	Anguilliformes	Anguillidae	*Anguilla bengalensis*	Indian long fin eel	0.72
3	Cypriniforms	Cyprinidae	*Gibelion catla*	Catla	2.52
4			*Cyprinus carpio*	Common carp	0.91
5			*Hypselobarbus curmuca*	Curmuca barb	0.18
6			*Hypselobarbus kolus*	Kolus barb	0.29
7			*Tor khudree*	Deccan mahseer	1.62
8			*Puntius filamentosus*	Black spot barb	1.42
9			*Puntius sarana subnasutus*	Peninsular olive barb	0.49
10			*Barbodes carnaticus*	Carnatica barb	3.33
11			*Puntius amphibius*	Scarlet banded barb	0.19
12			*Labeo rohita*	Rohu	0.50
13			*Amblypharyngodon microlepis*	Indian carplet	0.03
14			*Labeo dussumieri*	Kerala Labeo	0.27
15	Siluriformes	Bagridae	*Horabagrus branchysoma*	Yellow cat fish	1.91
16			*Mystus armatus*	Striped dwarf catfish	0.05
17			*Mystus gulio*	Long whiskered catfish	0.49
18			*Mystus cavasius*	Gangetic mystus	0.14
19		Siluridae	*Wallago attu*	Boal	3.36
20	Beloniformes	Belonidae	*Xenentodon cancila*	Freshwater garfish	0.07
21	Perciformes	Ambassidae	*Parambassis dayi*	Day's glass fish	0.53
22			*Parambassis thomassi*	Western Ghats glassy perchlet	0.03
23		Nandidae	*Pristolepis marginata*	Malabar Catopra	0.10
24		Cichilidae	*Etroplus maculatus*	Orange chromidae	0.34
25			*Etroplus suratensis*	Banded Pearlspot	7.39
26			*Oreochromis mossambicus*	Tilapia	1.96
27		Gobiidae	*Glossogobius giuris*	Bar eyed goby	0.50
28		Anabantidae	*Anabas testudineus*	Climbing Perch	0.07
29		Channidae	*Channa striata*	Banded Snakehead	1.78
30			*Channa marulius*	Giant Snakehead	1.16
31	Synbranchiformes	Mastacembelidae	*Mastacembelus armatus*	Spiny eel	0.41
			Prawn species		
1			*Macrobranchium rosenbergii*	Fresh water prawn	4.99
			Total		**37.85**

Table 3.6. List of commercially important species, their common names and quantity of landings in Bharathapuzha river

Sl No	Order	Family	Fish species	Common name	Quantity (Tonnes)
1	Elopiformes	Megalopidae	*Megalops cyprinoides*	Indo pacific tarpons	0.74
2	Anguilliformes	Anguillidae	*Anguilla bengalensis*	Indian long fin eel	2.40
3	Cypriniforms	Cyprinidae	*Gibelion catla*	Catla	3.98
4			*Cirrhinus mrigala*	Mrigal	3.74
5			*Labeo rohita*	Rohu	5.14
6			*Hypselobarbus curmuca*	Curmuca barb	9.89
7			*Puntius filamentosus*	Black spot barb	17.34
8			*Puntius sarana subnasutus*	Peninsular olive barb	12.06
9			*Puntius amphibius*	Scarlet banded barb	0.10
10			*Amblypharyngodon microlepis*	Indian carplet	2.55
11			*Devario aequipinnatus*	Giant danio	0.24
12			*Devario malabaricus*	Malabar danio	0.10
13			*Salmophasia boopis*	Boopis minow	0.12
14	Siluriformes	Bagridae	*Mystus cavasius*	Gangetic mystus	0.43
15			*Mystus vittatus*	Striped dwarf catfish	1.97
16		Siluridae	*Ompok bimaculatus*	Goan catfish	0.63
17			*Wallago attu*	Boal	7.61
18		Heteropneustidae	*Heteropneustes fossilis*	Stinging catfish	1.23
19	Beloniformes	Belonidae	*Xenentodon cancila*	Freshwater garfish	1.47
20		Hemiramphidae	*Hyporhamhpus xanthopterus*	Vembanad halfbeak	2.67
21	Perciformes	Ambassidae	*Parambassis dayi*	Day's glass fish	8.39
22		Pristolepidinae	*Pristolepis marginata*	Malabar Catopra	0.03
23		Cichilidae	*Etroplus maculatus*	Orange chromidae	0.91
24			*Etroplus suratensis*	Banded pearlspot	4.23
25			*Oreochromis mossambicus*	Tilapia	2.83
26		Gobiidae	*Glossogobius giuris*	Tank goby	0.73
27		Anabantidae	*Anabas testudineus*	Climbing Perch	0.03
28		Channidae	*Channa striata*	Banded Snakehead	5.17
29			*Channa marulius*	Giant Snakehead	0.34
30		Sillaginidae	*Sillago vincentil*	Estuarine whiting	0.60
31	Synbranchiformes	Mastacembelidae	*Mastacembelus armatus*	Spiny eel	5.31
Prawn species					
1			*Macrobranchium rosenbergii*	Indian freshwater prawn	9.55
Total					**112.56**

Table 3.7. List of commercially important species, their common names and quantity of landings in Achenkovil river

Sl No	Order	Family	Fish species	Common name	Quantity (Tonnes)
1	Elopiformes	Megalopidae	*Megalops cyprinoides*	Indo pacific tarpons	0.96
2	Anguilliformes	Anguillidae	*Anguilla bengalensis*	Indian long fin eel	2.16
3	Cluepiformes	Clupeidae	*Dayella malabarica*	Days round herring	0.96
4	Cypriniforms	Cyprinidae	*Puntius filamentosus*	Black spot barb	12.91
5			*Puntius sarana subnasutus*	Peninsular olive barb	7.46
6			*Amblypharyngodon microlepis*	Indian carplet	18.24
7			*Labeo dussumieri*	Kerala Labeo	47.34
8	Siluriformes	Bagridae	*Horabagrus branchysoma*	Yellow cat fish	16.73
9		Siluridae	*Ompok bimaculatus*	Indian butter catfish	2.88
10			*Wallago attu*	Boal	2.04
11		Clariidae	*Clarias batrachus*	Magur	0.58
12		Heteropneustidae	*Heteropneustes fossilis*	Stinging catfish	1.44
13	Beloniformes	Belonidae	*Xenentodon cancila*	Freshwater gar fish	0.12
14		Hemiramphidae	*Hyporhampus xanthopterus*	Vembanad halfbeak	1.08
15	Perciformes	Nandidae	*Nandus nandus*	Mottled nandus	3.60
16		Cichilidae	*Etroplus maculatus*	Orange chromidae	2.45
17			*Etroplus suratensis*	Banded Pearlspot	7.01
18		Gobiidae	*Glossogobius giuris*	Tank goby	0.29
19		Anabantidae	*Anabas testudineus*	Climbing Perch	1.87
20		Channidae	*Channa striata*	Banded Snakehead	10.87
21			*Channa marulius*	Giant Snakehead	9.14
22			*Channa orientalis*	Walking snake head	3.12
23			*Channa diplogramma*	Snakehead	3.60
24	Synbranchiformes	Mastacembelidae	*Macrognathus aral*	Marble spiny eel	3.00
Prawn species					
1			*Macrobracnhium rosenbergii*	Indian freshwater prwan	2.16
2			*Macrobracnhium idella*		0.72
Total					**162.736**

Table3.8. List of commercially important species, their common names and quantity of landings in Kallada river

Sl No	Order	Family	Fish species	Common name	Quantity (Tonnes)
1	Elopiformes	Megalopidae	*Megalops cyprinoides*	Indo pacific tarpons	1.01
2	Cypriniforms	Cyprinidae	*Hypselobarbus curmuca*	Curmuca barb	4.75
3			*Hypselobarbus thomassi*	Red canarese barb	1.12
4			*Hypselobarbus kurali*	Kurali	0.42
5			*Tor khudree*	Deccan mahseer	0.36
6			*Puntius filamentosus*	Black spot barb	0.61
7			*Puntius sarana subnasutus*	Peninsular olive barb	0.12
8	Siluriformes	Bagridae	*Horabagrus branchysoma*	Yellow cat fish	0.06
9			*Mystus cavasius*	Gangetic mystus	0.14
10		Siluridae	*Ompok bimaculatus*	Indian butter catfish	0.32
11		Heteropneustidae	*Heteropneustes fossilis*	Stinging catfish	0.12
12	Perciformes	Ambassidae	*Parambassis dayi*	Day's glass fish	0.18
13		Cichilidae	*Etroplus maculatus*	Orange chromidae	0.02
14			*Etroplus suratensis*	Banded Pearlspot	1.28
15			*Oreochromis mossambicus*	Tilapia	0.19
16		Gobiidae	*Glossogobius giuris*	Tank goby	0.20
17		Channidae	*Channa striata*	Banded Snakehead	1.61
18			*Channa marulius*	Giant Snakehead	0.19
19			*Channa diplogramma*	Malabar snake head	0.87
20	Gonorhynchiformes	Chanidae	*Chanos chanos*	Milk fish	2.09
21	Mugiliformes	Mugilidae	*Mugil cephalus*	Filat head mullet	0.94
Total					**16.58**

Table 3.9. List of commercially important species, their common names and quantity of landings in Muvattupuzha river

Sl No	Order	Family	Fish species	Common name	Quantity (Tonnes)
1	Anguilliformes	Anguilidae	*Anguilla bengalensis*	Indian long fin eel	0.12
2	Cypriniforms	Cyprinidae	*Hypselobarbus curmuca*	Curmuca barb	4.90
3			*Labeo dussumieri*	Kerala Labeo	7.21
4			*Tor khudree*	Deccan mahseer	0.65
5			*Gibelion catla*	Catla	2.56
6			*Puntius filamentosus*	Black spot barb	2.51
7			*Puntius sarana subnasutus*	Peninsular olive barb	4.45
8	Siluriformes	Bagridae	*Horabagrus branchysoma*	Yellow cat fish	3.67
9			*Mystus cavasius*	Gangetic mystus	0.26
10		Siluridae	*Ompok bimaculatus*	Indian butter catfish	0.02
11			*Wallago attu*	Boal	7.62
12		Heteropneustidae	*Heteropneustes fossilis*	Stinging catfish	1.27
13	Perciformes	Ambassidae	*Parambassis dayi*	Day's glass fish	0.19
14			*Parambassis thomassi*	Glassy perchlet	0.02
15		Pristolepidae	*Pristolepis marginata*	Malabar Catopra	0.09
16		Cichilidae	*Etroplus maculatus*	Orange chromid	0.75
17			*Etroplus suratensis*	Banded Pearlspot	0.71
18		Gobiidae	*Glossogobius giuris*	Tank goby	0.11
19		Anabantidae	*Anabas testudineus*	Climbing Perch	0.78
20		Channidae	*Channa striata*	Banded Snakehead	4.60
21			*Channa marulius*	Giant Snakehead	2.24
22	Synbranchiformes	Mastacembelidae	*Mastacembelus armatus*	Spiny eel	0.14
23	Beloniformes	Belonidae	*Xenentodon cancila*	Freshwater gar fish	0.14
Total					**45.01**

Table 3.10. List of commercially important species, their common names and quantity of landings in Meenachil river

Sl No	Order	Family	Fish species	Common name	Quantity (Tonnes)
1	Cypriniforms	Cyprinidae	*Puntius filamentosus*	Black spot barb	0.86
2			*Puntius sarana subnastus*	Peninsular olive barb	0.71
3			*Labeo dussumieri*	Kerala Labeo	2.07
4	Siluriformes	Bagridae	*Horabagrus branchysoma*	Yellow cat fish	0.84
5			*Garra mullya*	Mullya garra	0.04
6		Siluridae	*Wallago attu*	Boal	2.32
7		Heteropneustidae	*Heteropneustes fossilis*	Stinging catfish	0.20
8	Perciformes	Cichilidae	*Etroplus maculatus*	Orange chromid	0.36
9			*Etroplus suratensis*	Banded Pearlspot	3.26
10		Channidae	*Channa striata*	Banded Snakehead	1.16
11		Pristolepidae	*Pristolepis marginata*	Malabar Catopra	0.10
12	Synbranchiformes	Mastacembelidae	*Mastacembelus armatus*	Spiny eel	0.51
Prawn species					
1			*Macrobrachimum rosenbergii*		3.24
Total					**15.67**

.....✿✿.....

Chapter 4

STATUS OF NON - NATIVE FISH INTRODUCTION IN KERALA RIVERS

Contents

4.1. Introduction

Freshwater fisheries of the world are severely over exploited and the global fish diversity shows a rapid declining trend (Allan *et al.,* 2005; Dudgeon *et al.*, 2006). The threats affecting the freshwater biodiversity can be generally grouped into five categories; over exploitation, water pollution, flow modification, destruction of habitat and invasion of exotic species (Allan and Fleckar,1993; Naiman *et al*., 1995; Naiman and Turner, 2000; Jackson *et al.,* 2001; Malmqvist and Rundle, 2002; Rahel, 2002; Postel and Richter, 2003; Revenga *et al.,* 2005). Humans have introduced hundreds to thousands of exotic species into freshwaters around the world, dozens of which (water hyacinth, zebra mussels, Nile perch) have had intricate and long lasting ecological impacts on the aquatic ecosystems (FAO, 2008; Strayer, 2010). The introduction of invasive species is counted as the second major cause of decline of a number of indigenous and endemic species diversity around the world (Wilcove *et al.*, 1998).

Fishes are among the most introduced group of aquatic animals in the world (624 species) and also one of the most threatened, with a total number 1201 fish species (Gozlan, 2008; IUCN, 2008). A number of terms have been use to describe fish introductions. These include terms such as Exotic, Alien, Invasive, Non-indigenous, Introduced, Non-native and transferred (transplanted). The Convention on Biological Diversity (CBD) defines Alien species as (a) a species that has been transported by human activities, intentional or accidental, into a region where it does not occur OR (b) a species occurring in an area outside of its historically known natural range as a result of intentional or accidental dispersal by human activities (also known as exotic and non-indigenous species). Transplanted species (=transferred species) defined as any species intentionally or accidently transported and released within areas of established populations (ICES). The introduction of a non-native species in an ecosystem is generally likely to present an ecological risk if the species is able to integrate itself successfully into the ecosystem (Gozlan and Newton, 2009) and such introduction, upsets the balance of indigenous fishes and threatens their very existence (Johal *et al.,* 1998; Tandon, 1999). Non-native species may become invasive and are capable of spreading exotic diseases, decreasing biodiversity through competition, predation and habitat degradation, genetic deterioration of wild populations through hybridization and gene introgression in short or long course of time (Casal, 2006; Singh and Lakra, 2006; García-Berthou, 2007; Lakra *et al.,* 2008). Invasive species also can affect the socio-economic aspects of the human community that depends on the aquatic ecosystem for their livelihood (Philipp *et al.,* 1995). Worldwide exotic fish introductions have been reported to impact the fish biodiversity and have provided significant warning of the various effects on environment posing threats to the community trophic structure disrupting biological integrity (Casal, 2006: Lakra *et al.,* 2008).

In India, during the past several decades, more than 300 species of alien fishes have been introduced for aquaculture, sport fishing, ornamental purpose and mosquito control (Bijukumar, 2000; Singh and Lakra, 2011). Hundreds of alien ornamental species form part of the aquarium trade in India (Lakra *et al.,* 2008). Fish introduction inadvertently, purposefully or illegally are taking place in India. The use of introduced species in India has been practiced since the middle of 19th century for fisheries and aquaculture purposes (Singh and Lakra, 2006; Lakra *et al*., 2008). Sir Francis Day was probably the first person who tried to introduce the Brown trout, *Salmo trutto fario* in the Nilgiri water in 1863, but his attempt was unsuccessful (Jhingran, 1975). Later in 1874, Trench, *Tinca tinca* (Linnaeus) and the Gold fish, *Carassius carassius* were introduced in Ooty Lake, Nilgiris, South India (Jayaram, 1979). The Giant Gouramy, *Osphronemus goramy* was probably first introduced in Calcutta from Java was unsuccessfully established during the first half of nineteen century and the second lot brought to Tamil Nadu in 1865 had met with the same fate (Talwar and Jhingran,1991). Mozambique Tilapia, *Oreochromis mossambicus,* was first introduced into the pond ecosystem in 1952 and thereafter stocked in the reservoirs of South India for production enhancement (Sugunan, 1995). This species was abundantly found in almost all reservoirs of Tamil Nadu, Kerala and Andhra Pradesh and in some reservoirs of Karnataka (Sugunan, 1995; Lakra *et al.*, 2008). Three varieties of the Prussian (German) strain of common carp, namely the scale carp (*Cyprinus carpio communis*), the mirror carp (*Cyprinus carpio specularis*) and the leather carp (*Cyprinus carpio nudus*) were introduced from Ceylon (Sri Lanka) in 1939. They were stocked in several high altitude ponds and lakes during the 1950s (Lakra *et al.,* 2008). Later in 1957 a Bangkok strain of the common carp and the Chinese silver carp, *Hypophthalmichthys molitrix* were brought into the country with the objectives of broadening the species spectrum in aquaculture and increasing yields through better utilisation of vacant trophic niches. Both silver carp (*H. molitrix*) and grass carp (*Ctenopharyngodon idella*) were introduced in 1959 for a specific purpose and had led to the development of a high yielding technology, 'Composite Fish Culture'. Atlantic salmon, *Salmo salar* was introduced into trout hatcheries of Kashmir in 1960, but failed to establish (Singh and Lakra, 2011). Silver barb, *Puntius gonionotus* is an important species in many south-east Asian countries was introduced in to India in 1972 from Indonesia with a view to control aquatic weeds (Alam *et al.,* 2004; Das *et al.,* 1994)

The ornamental fish trade in India is dominated by introduced varieties of fishes such as angel, gold fish, platy, guppy, sword tail, gourami, oscar, piranha, pacu, koi carp, sucker mouth catfish and arowana. More than 200 alien aquarium fish species are now bred in different parts of India (Ghosh *et al.,* 2003; Lakra *et al*., 2008). The most commonly cultivated aquarium alien species in India are goldfish (*Carassius auratus* and *C. carassius*), oscar (*Astronotus ocellatus*), red-bellied pacu (*Piaractus brachypomus*), guppy (*Poecilia reticulata*), gourami (*Trichogaster* spp.), koi carp (*Cyprinus carpio*), sutchi catfish (*Pangasianodon hypophthalmus*), piranha (*Pygocentrus nattereri*) and sucker mouth catfish (*Pterygoplichthys* spp.) (Singh and Lakra, 2011). The most common larvicidal fishes in India are *Poecilia reticulata* and *Gambusia affinis* which were introduced in 1908 and 1928 respectively, to control mosquito larvae in confined waters (Singh and Lakra, 2011). These species have now entered in several natural aquatic environments in India and the impacts in case of escapee were not yet properly assessed.

In recent years, many alien species such as the Big head carp (*Aristichthys nobilis*), African catfish (*Clarias gariepinus*), Nile tilapia *(Oreochromis niloticus*) and Pacu (*Piaractus brachypomus*) and Sutchi catfish (*Pangasianodon hypophthalmus*) have been smuggled into India and are being cultivated (Singh and Lakra, 2011; Singh and Lakra, 2006). However, many of this fish species were introduced for aquaculture purpose without considering their ecological consequences. Big head carp (*Aristichthys nobilis*) a popular aquaculture species in India was possibly introduced in 1987 from Bangladesh and this species was spread quickly in most areas of freshwater aquaculture. African catfish (*Clarias gariepinus*) was clandestinely introduced in to West Bengal possibly during 1994 and quickly spread throughout the country. Hybrid catfish

(*Clarias gariepinus* X *C. macrocephalus*) is a hybrid seed produced in hatcheries in Bangladesh (Baruah *et al.,* 1999; Khan *et al.,* 2000) and then smuggled into the bordering Northeastern states, Assam and West Bengal and as far as Bihar, forming the basis of a flourishing trade in India. Sutchi catfish, *Pangasiandon hypophthalmus*, has introduced in to in West Bengal possibly during 1997 for aquaculture purposes (Singh and Lakra, 2011). Nile tilapia (*Oreochromis niloticus*) was first introduced into West Bengal possibly during 1987 from Thailand and became a popular species in Tamil Nadu, West Bengal and Rajasthan (Singh and Lakra, 2011). The introduction of *Tilapia zilli* was for aquatic weed control in the Indira Gandhi Canal in Rajasthan. Red-bellied pacu (*Piaractus brachypomus*) was introduced in the state of West Bengal in 2001 from Bangladesh for culture and breeding and has become popular particularly in the states of Andhra Pradesh, Kerala, Maharashtra and Orissa, and in some areas of the Northern India(Lakra *et al.,* 2008; Chatterjee and Mazumdar, 2009).

The Western Ghats region in Southern India, which forms a mountain range of 1490 km, is one of the 34 biodiversity hotspots of the world (Bossuyt *et al.,* 2004) exhibiting a high species diversity and a great degree of endemism (Gunawardene *et al.,* 2007). Among 290 fish species recorded from this region, 189 (65%) species were endemic to this region (Dahanukar *et al*., 2011). However, many of these species had already threatened (37%) due to various anthropogenic influences (Kurup *et al.,* 2004; Dahanukar *et al.,* 2011). Introduction of invasive species is one of the major threats to the fish diversity of the Western Ghats and 13 exotic fish species were reported from Western Ghats region (Dahanukar *et al.,* 2011). The exotic fishes so far recorded from Western Ghats are *Cyprinus carpio, Oreochromis niloticus, Oreochromis mossambicus, Clarias gariepinus, Oncorhyncus mykiss, Pangasianodon hypophthalmus, Piaractus brachypomus, Osphronemus goramy. Pterygoplichthys multiradiatus, Trichogaster trichopterus, Poecilia reticulata, Xiphophorus* *maculatus* and *Gambusia affinis* (Dahanukar *et al*., 2011). Several species of these exotic fishes have been introduced in many reservoirs of Kerala and are colonized in those habitats (Dahanukar *et al*., 2011).

Several non-native fish species are now established in the natural waters of Kerala. 31 species of exotic fishes were identified as being alien to the Kerala part of Western Ghats (Radhakrishnan *et al.,* 2012), posing a severe threat to indigenous fish fauna of Kerala. Tilapia, *Oreochromis mossambicus* was recorded in Periyar Lake (Arun *et al.,* 1996; Zacharias *et al*., 1996), Chalakudy River (Ajith kumar *et al.,* 1999; Raghavan *et al.,* 2008a), Southern Kerala River systems (Thomas *et al.* 2002; Kurup *et al*. 2004), Rivers of Northern Kerala (Biju, 2003) and Reservoirs of Western Ghats (Sugunan, 2002). Radhakrishnan (2006) also recorded this species from 15 rivers of Kerala state. *Oreochromis niloticus* was reported from Bharathapuzha River system (Bijukumar, 2008). Common carp, *Cyprinus caripo* was recorded from Periyar Lake (Arun *et al.,* 1996; Zacharias *et al*., 1996), Chalakudy River (Ajithkumar *et al.,* 1999), Achenkovil River (Kurup *et al*., 2004), Nilgiri Biosphere Reserve (Yazdani *et al*., 2001), Southern Kerala River systems (Thomas *et al.,* 2002) and Western Ghats river systems (Dahanukar *et al.,* 2011). *Clarias gariepinus* was reported from Manulur (Gopi and Radhakrishnan, 2001), Periyar Lake (Radhakrishnan and Kurup, 2010; Periyar foundation, 2006) and Vembanad Lake (Krishnakumar *et al.,* 2011). Species like Grass carp (*Hypophthalmichthys molthrix*) and silver carp (*Ctenopharyngodon molitrix)* were recorded in pond and lakes of Nilgiris (Pandit, 1998; Sunder, 1998). Indian major carps; *Gibelion catla, Labeo rohita and Cirrhinus mrigala* have been reported from Bharathapuzha River system (Bijukumar and Sushama, 2001), Chalakudy River system (Ajithkumar *et al*., 1999), Achenkovil River (Kurup *et al*., 2004), Parambikulam Wild Life Sanctuary (Biju *et al.,* 1999), Idukki and Neyyar Wilde Life Sanctuary (Thomas *et al*., 2000), Peechi-Vazhani Wild Life Sanctuary and Southern Kerala river systems

(Thomas *et al*., 2002). *Pterygoplichthys multiradiatus,* an armoured catfish have been reported from Kunnamkulam in Thrissur District (Ajithkumar *et al.*, 1998) and Akkulam Lake in Thiruvanathapuram District (Baiju, 2009). *Poecilia reticulata* was found from Chalakudy River (Raghavan *et al*., 2008a), Periyar River (Kurup *et al.,* 2004) and Southern Kerala River systems (Thomas *et al*., 2002). *Gambusia affinis, Osphronemus goramy* and *Xiphophorus maculatus* were reported from Chalakudy River (Raghavan *et al.*, 2008a). *Trichogaster trichopterus,* commonly called the three-spot Gourami has encountered from Vembanad Lake (Krishnakumar *et al.*, 2009).

With the rapid increase in the human population and increasing dependency on aquatic resources, many non-native fish species are introduced in to Kerala. The lack of definite information on the various threats by the native fish fauna due to non-native fish introductions in Kerala rivers is a major drawback for the appropriate conservation and management practices. Not many studies have been carried out on the impacts of non-native species in India especially in Kerala. For effective management and conservation of the native and indigenous fish biodiversity of rivers, an assessment of the fishery of these non-native species are needed in urgent. In this context, the present investigation was carried out based on the magnitude of fishery, exploitation level and Catch per unit effort (CPUE) of the non-native fishes dwelling in major rivers of Kerala. This study also focuses on the potential threats of non-native especially on the indigenous fish fauna inhabiting various river of Kerala and the data generated in this direction would be invaluable in the conservation of endemic and indigenous fish fauna of Kerala.

4.2. Materials and Methods

Six rivers were selected for the present study viz., Chalakudy, Periyar, Muvatupuzha, Kallada, Bharathapuzha and Pamba. The study was carried out for a span of four years (2007-2010). Season wise sampling was done (pre monsoon, monsoon and post monsoon seasons) from major landing centres of the selected rivers. Quantity of exploited fishes and non-native fishes (Alien and transplanted species) in the rivers were estimated based on the data collected from landing centres. Details of landings of fishes were collected from more than 30% of the gears giving emphasis to quantity, the total fish exploited, non-native species composition and percentage, weight, size groups represented in the catch and actual fishing hours spent for fishing. Catch per unit effort (CPUE) was computed following Scaria *et al.* (1997). Samples were collected and fixed in 8% formaldehyde in plastic bottle and transferred to the laboratory, where they were identified using standard literature (Talwar and Jhingaran, 1991 and Jayaram, 1999, 2009). From the catch, the non-native fish species was separately counted. Daily landings of catch of non-native species were computed following Kurup *et al.* (1992).

$$W = (w/n) \times N$$

Where W = total weight of non-native species w = total weight of fish from gear sampled

n = number of gear sampled, N = total number of similar gears operated.

Monthly catch was estimated by multiplying daily catch with total number of fishing days in a month. Season wise landing was estimated by multiplying monthly catch to number of months in the season. The annual exploited quantity was calculated by summarizing the landings of three seasons. Information about the various biodiversity threats prevailing in the rivers of Kerala was collected by interviewing the experienced local fisherman and people engaged fishing in activities using pretested questionnaire.

4.3. Results

4.3.1. Exploited non-native fish diversity

Based on extensive exploration, a total of 6 non-native species, viz, *Gibelion catla, Labeo rohita, Cirrhinus mrigala, Cyprinus carpio, Oreochromis mossambicus* and *Clarias gariepinus* representing three families, six genera and three orders were recorded from various landing centres of the six rivers of Kerala surveyed. Among them, *C. carpio, O. mossambicus* and *C. gariepinus* were the alien and *G. catla, L. rohita, C. mrigala* were the transplanted species. *Oreochromis mossambicus* and *Gibelion catla* were emerged as the most widely distributed introduced species, recorded in the exploited fishery of 4 rivers, followed by *Cyprinus carpio, Clarias gariepinus* and *Labeo rohita* (2 rivers each). River Chalakudy and Bharathapuzha harbour highest number of non-native fish species in the exploited stock (4 species each) followed by Periyar and Pamba (2 species each). Table 4.1 shows the list freshwater non-native species recorded from the exploited fishery of major rivers of Kerala.

Table 4.1 List of the freshwater non-native species recorded from the exploited fishery of major rivers of Kerala

Species	Pamba	Periyar	Bharathapuzha	Chalakudy	Muvatupuzha	Kallada
Labeo rohita			+	+		
Giblion catla	+		+	+	+	
Cirrhinus mrigala			+			
Cyprinus carpio		+		+		
Clarias gariepinus	+	+				
Oreochromis mossambicus		+	+	+		+

Table 4.2 shows the comparison of exploited fishery of non-native fishes. The total exploited fishery of the non-native fishes in rivers of Kerala was estimated at 68.61 t. Indian major carps, viz, *Gibelion catla, Labeo rohita, Cirrhinus mrigala* contributed to 52% of the total introduced fishery of rivers of Kerala. Among them, *G. catla* commonly known as 'Catla' was contributed

26.34 t in the exploited fishery of introduced fishes. This species supported a lucrative fishery in major rivers of the state and sustained as the major source of livelihood source to the fishermen. *C. carpio* commonly known as 'Common carp' occupied second position in the non-native species landing of the state and contributed to the tune of 19.52 t. *O. mossambicus* contributed to 12.21 t in the non-native species fishery. The landing of non-native fishes was highest in Periyar river (26.85 t) followed by Pamba (17.43 t) and Bharathapuzha (15.69 t) rivers.

Table 4.2. Comparison of annual exploited fishery of non-native fishes in six rivers of Kerala during 2007-2010

	Pamba	**Periyar**	**Bharathapuzha**	**Chalakudy**	**Muvattupuzha**	**Kallada**	**Total(tonnes)**
Total exploited quantity (tonnes)	394.2	70.71	112.56	37.85	45.01	16.58	**676.93**
Fish species							
Gibelion catla	17.28		3.98	2.52	2.56		26.34
Labeo rohita			5.14	0.5			5.64
Cirrhinus mrigala			3.74				3.74
Cyprinus carpio		18.61		0.91			19.52
Oreochromis mossambicus		7.23	2.83	1.96		0.19	12.21
Clarias gariepinus	0.15	1.01					1.16
Non-native species quantity (tonnes)	**17.43**	**26.85**	**15.69**	**5.89**	**2.56**	**0.19**	**68.61**

4.3.2. Pamba river

26 fish species were recorded from the exploited fishery of Pamba River. Among them, 2 are non-native in nature. Native fish species contributed to 95.5% in the fishery in this river. The major native fishes are *Labeo dussumieri, Puntius sarana subnastus, Wallago attu* and *Channa striata. Gibelion catla* (Indian major carp) and *Clarias gariepinus* (African catfish) were the non-native species observed in the landings with a share of 4.42% in the fishery. *G. catla* landed 17.28 t while the landing of *C. gariepinus* was 0.15 t. *G. catla* was introduced by ranching of fish seed in various places in the river. But *C. gariepinus* was introduced from nearby aquaculture ponds, where monsoon rain water destructs the bunds of ponds during high floods. *G. catla* was the predominant introduced species whose share was 99% of the total introduced fish production and it is mainly caught from the downstream part of the river. The size range and weight of *Catla* reported from this river was 166-456 mm and 0.45- 8.5 kg respectively. Catch per unit effort of *G. catla* in gill net was 1.5 kg/hr. Percentage contribution of non-native and native fishes in the exploited stock of River Pamba is depicted Fig.4.1.

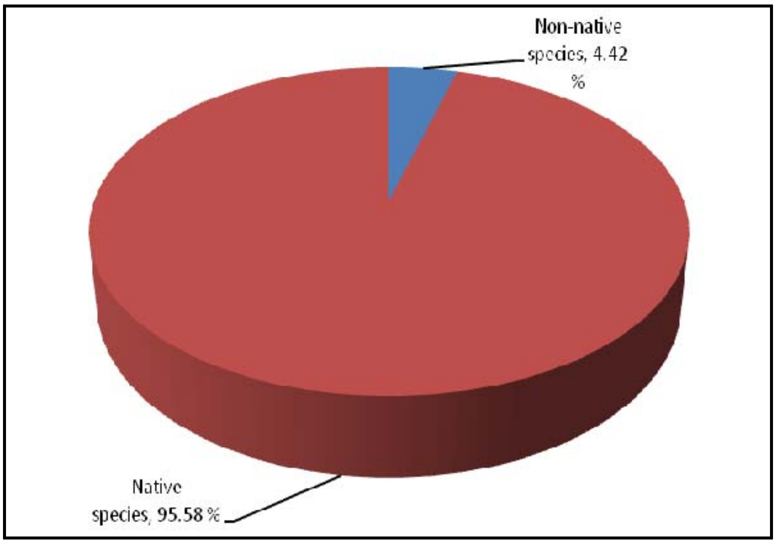


Fig.4.1. Percentage contribution of non-native and native fish species in the exploited fishery of Pamba river (2007-2010)

4.3.2. Periyar river

21 species of fishes were identified from the exploited fishery of Periyar river, among them, 3 were non-native species. *Cyprinus carpio* (Common carp), *Oreochromis mossambicus* (Tilapia) and *Clarias gariepinus* (African catfish) were the non-native fish species recorded in the fishery from Periyar river. The quantity of non-native fish species landed from this river is estimated to be 26.85 t which forms 38.2 % of the total exploited fishery of this river. *C. carpio* accounted for highest landings (26.53%) in the river with a dominance of 200-499 mm size group in the landing. In Periyar lake, *C. carpio* dominated in the landing with an annual landing of 16.46 t. The catch per unit of this species was 0.23 kg/hr in gill net. During monsoon season, the fishery of the common carp was high (6.68 t) while it was very low during pre monsoon (3.38 t). *O. mossambicus* formed 10.31% of the total landing and the dominant size group was 110-229 mm. The catch per unit hour of *O. mossambicus* in gill net and hook and line were 0.08 and 0.09 kg/hr respectively. *C. gariepinus* contributed to 1.44% in total landing of Periyar river and the CPUE was 0.12 kg/hr. *C. gariepinus* has been recently encountered into this lake which account for 3% of the fishery of this lake. This species was accidently entered in to the lake from the aquaculture ponds located in the vicinity of lake. Non-native species accounted for 65% of fishery of this lake. *C. carpio* and *O. mossambicus* formed 48% and 14.4% respectively in the fishery of this lake. Percentage contribution of native and non-native fishes in exploited fishery of River Periyar is depicted Fig.4.2.

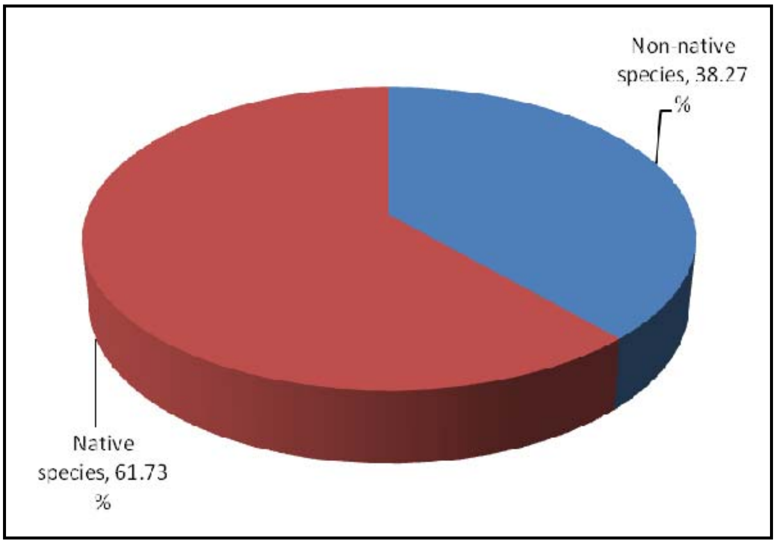


Fig.4.2. Percentage contribution of non-native and native fish fauna in the exploited fishery of Periyar river (2007-2010)

4.3.3. Chalakudy

31 species of fishes were identified from the exploited fishery of Chalakudy river, among them 4 were non-native fish species. Non native species such as *Gibelion catla, Cyprinus carpio, Labeo rohita* and *Oreochromis mossambicus ac*counted for 15.5% of the total landing with a landing of 5.89 t. *G. catla* was the dominant species in the landing (2.52 t) of introduced groups with a size range of 282-832 mm. The catch per hour of the *G. catla* was 0.19 kg/hr in gill net. During the monsoon season the fishery of *Catla* was very high (1.8 t). The landing of *O. mossambicus* was 1.96 t with an average size in the range 125-256 mm. The catch per unit effort (CPUE) of this species was 0.09 kg/hr. *C. carpio* and *L. rohita* contributed to 2.40% and 1.32% respectively in the fishery of this river. Porigalkuttu dam was the most important water body for the non-native fishes. These fishes are introduced in to the dam for enhancing the fish production from the reservoir. Percentage contribution of non-native and native fish species in the exploited fishery of River Chalakudy is depicted in Fig.4.3.

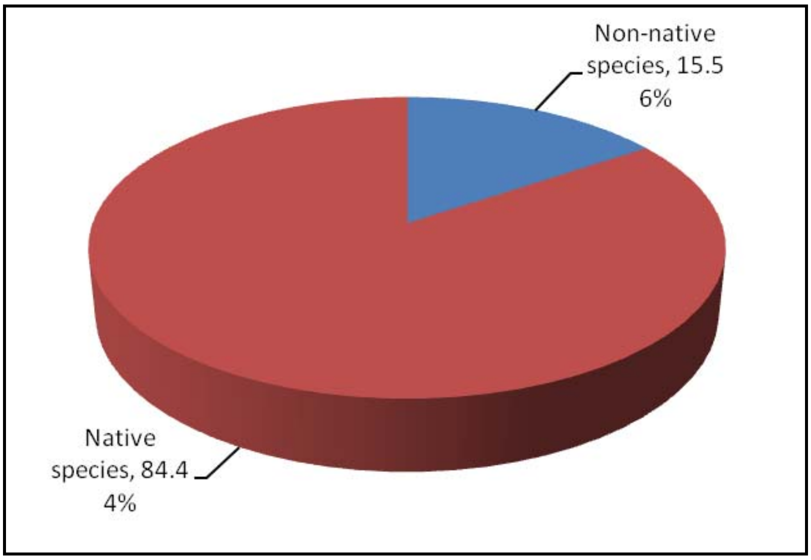


Fig.4.3. Percentage contribution of non-native and native fish fauna in the exploited fishery of Chalakudy River (2007-2010)

4.3.4. Bharathapuzha

31 fish species belonging 7 orders and 16 families were identified from Bharathapuzha river of Kerala, among them 4 were found introduced which constituted 14% in the fishery of this river. *Gibelion catla, Labeo rohita* and *Cirrhinus mrigala* and *Oreochromis mossambicus* were the non-native species represented in the exploited fishery. *G. catla* (3.98 t), *L. rohitha* (5.14 t) and *C. mrigala* (3.74 t) were the transplanted species, which together formed 11.43% in the total landing of the river. The size range of Catla, Rohu, Mrigal in the catch is in between 240-720 mm, 290-560 mm, 190-360 mm respectively. *O. mossambicus* was accounted for 2.5% of the fishery of this river. Percentage contribution of non-native and native fishes in the exploited fishery of river Bharathapuzha is depicted Fig.4.4.

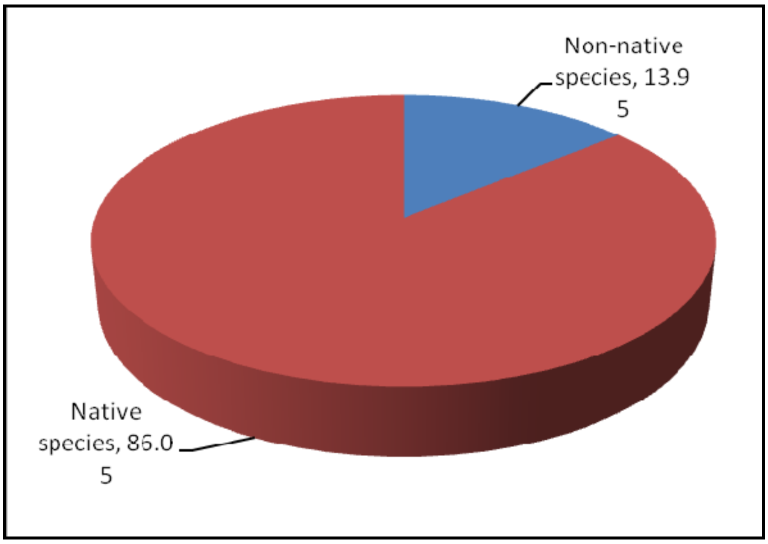


Fig.4.4. Percentage contribution of non-native and native species in the exploited fishery of Bharathapuzha river (2007-2010)

4.3.5. Kallada river

Out of 21 species reported in the exploited fishery of Kallada river, only *Oreochromis mossambicus* was recorded as introduced species with its share of 1.13% in the fishery. Percentage contribution of non-native and native fish species in the exploited fishery of river Kallada is depicted in Fig.4.5.

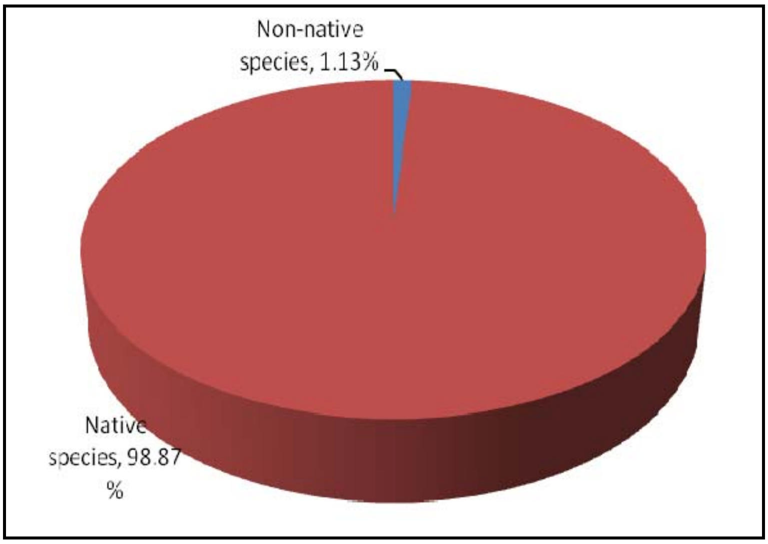


Fig.4.5. Percentage contribution of non-native and native fish species in the exploited fishery of Kallada river (2007-2010)

4.3.6. Muvatupuzha

23 species of fishes were identified from Muvatupuzha river of Kerala, among them, only one non-native species was recorded. The annual exploited fishery of the Muvatupuzha river was estimated to be 45.01 t while the non-native species contributed to 2.56 t in the fishery. *Gibelion catla* formed 5.67% in the fishery. Percentage contribution of native and non-native fish species in the exploited fishery of river Muvatupuzha is depicted in Fig.4.6.

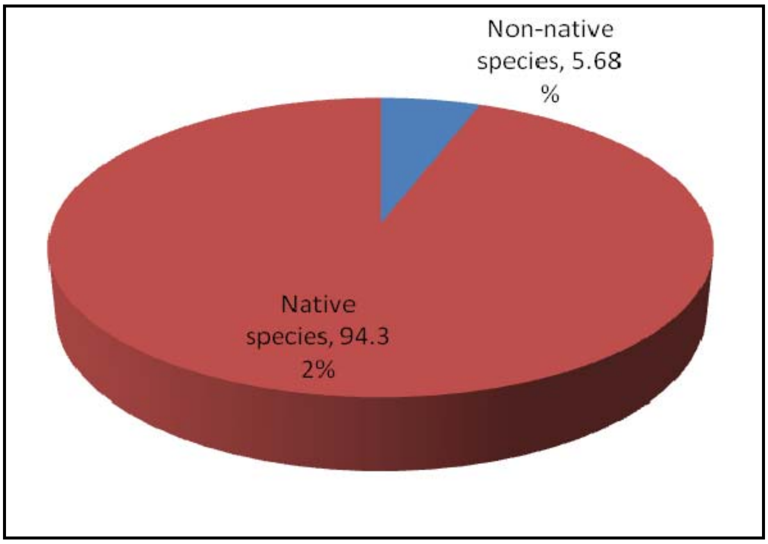


Fig 4.6. Percentage contribution of non-native and native fish species in the exploited fishery of Muvattupuzha river (2007-2010)

4.3. Discussion

The result of the present study revealed that, non-native fish species are important in sustaining the fishery wealth of Kerala with a share of 8% in the major rivers of Kerala. Six species of non-native (alien and transplanted species) fishes were recorded from the rivers of Kerala. *Cyprinus carpio, Oreochromis mossambicus*, *Clarias gariepinus*, *Gibelion catla*, *Labeo rohita* and *Cirrhinus mrigala* were the non-native fish species recorded in the landing, among them *Gibelion catla* share was very high with 38% in the landing of non-native fishes. In the present study, highest number of non-native species was recorded in Bharathapuzha and Chalakudy rivers (4 species each). Alien and transplanted fishes are contributing a significant fishery in many reservoirs of Kerala. About 50 major dams have been constructed in the Western Ghats (Sugunan, 2000). Periyar Lake, Idduki dam (Periyar River), Poringalkuttu reservoir (Chalakudy river) and Malamupzha dam (Bharathapuzha river) were identified as the major spot of alien and transplanted fish species invasion. A higher number of landing of introduced fishes in the reservoirs might also be due to the fact that majority of the Western Ghats reservoirs are stocked with such invasive fishes to augment fish production (Sugunan, 2000). Aquaculture in reservoirs and aquarium fish industries in this region was exacerbate the invasion of alien and transplanted fish species (Radhakrishnan *et al*., 2012).

To augment fish production, a number of alien fishes have been introduced for aquaculture purposes throughout the world and they have accounted for over 12.2% of total cultured finfish production (De Silva *et al.*, 2006, 2009). These introductions have been impacted the fish biodiversity and have caused various effects on environment posing threats to the community trophic structure disrupting biological integrity (Casal, 2006; De Silva *et al.*, 2006; García-Berthou, 2007; Rowe, 2007; Lakra *et al.*, 2008). Alien fish species have been brought into India intentionally or otherwise for the purposes of aquaculture, ornamental values, research and biological control (Singh and Lakra 2006; Lakra *et al.*, 2008). Such unauthorized activities are causing indiscriminate spreading of alien species, with potentially adverse ecological consequences. The unregulated introduction of aquatic species into India has invited serious attention from scientists and policy makers (Singh and Lakra, 2006; Lakra *et al.*, 2008).

The fast-growing Gangetic carps viz., Catla *(Gibelion catla*), Rohu (*Labeo rohita*) and Mrigal (*Cirrhinus mrigala*), popularly known as Indian major carps, were introduced in the rivers and reservoirs of Kerala for increasing the inland production in the state (Sugunan, 2000; Santha, 2007; Nandakumar, 2010) and they accounted for 52% of the non-native species landing in the present study. *Gibelion catla* belongs to natural habitat of the freshwater bodies of the rivers of northern India, in contrast, they contributed 38% of the non-native species fishery in Kerala rivers. *Gibelion catla* were first introduced in to Kerala in Periyar Lake from Godavari River (Chacko, 1948) and this attempt was unsuccessful. This species contributed the fish landing of four rivers of Kerala viz, Pamba, Chalakudy, Bharathapuzha and Muvatupuzha rivers, among them, River Pamba supported a moderately good fishery (17.28 t/year) of this fish species. This species has eclipsed all indigenous fish fauna including *Labeo fimbriatus*, which dominated in the scene by contributing 36% of the catch during the mid 1960s in Santhanur reservoir in Tamil Nadu and catla contributes 80-90% of the total catch at present (Sugunan, 2000). *Labeo rohita* was recorded in the landing of two rivers in Kerala (Chalakudy and Bharathapuzha). The landing of *L. rohita* in Chalakudy river (0.50 t) was relatively low when compared to that of Bharathapuzha (5.14 t). Rohu and Mrigal were first introduced to Kerala in 1951, in reservoirs to enhance the fish production and neither the State government nor private farmers are aware of the consequences of ranching of these non-native and hatchery reared species (Gopalakrishnan and Basheer, 2000). Sreenivasan (1995) reported that introduction of non-native Chinese and Indian major Carps as the major factor leading to the decline of endemic Peninsular carps such as *Cirrhinus cirrhosa*, *Labeo kontius*, *Puntius carnaticus, P. dubius* and *P. pulchellus* in South Indian reservoirs. Gopalakrishnan and Basheer (2000) reported the introduction of Indian major carps in Pamba, Manimala and Meenachil rivers of Kerala and Rohu and Mrigal contributed less than 0.1% in landing of these rivers. The authors also reported four ripe Rohu females from Pamba river which pointer towards their chances of breeding population and slow establishment. The present report on the higher landings of Indian Major Carps in rivers of Kerala is definitely a pointer towards its chance of establishment of natural propagation in the rivers and reservoirs of Kerala. The ranching of Indian Major Carps may pose potential threats to indigenous species in future. The cultured stock which genetically differs from its wild relatives, may sometimes escape from ponds or cages into natural waters, creating an opportunity for interbreeding between non-native/cultured stock and native/wild stock and no studies was so far conducted on the impact of hatchery stocks or wild relatives, especially the impact of hatchery reared Indian Major Carps (Silas, 2010). State Fisheries Department is of the view that these species probably don't breed under the ecological conditions of the local rivers in Kerala, however local fishers fear that in long run, these exotic varieties could endanger the indigenous fish species by establishing breeding population (Santha, 2007).

The introduction of *Oreochromis mossambicus*, in India had been claimed as a success story by fisheries officials and this species caused negative impact of both freshwater and brackish water fisheries (Bijukumar, 2000). The result of the present study showed that this species contributed to 12.21 t in the total exploited fishery of four rivers of Kerala (Periyar, Chalakudy, Kallada and Bharathapuzha rivers). Among them Periyar river showed 59 % of Tilapia landing. Introduced Tilapias as a result of anthropogenic activities tend to establish in waters that have deteriorated or in quasi-natural water bodies such as reservoirs, rivers and irrigation systems (Singh and Lakra, 2011). The ecological consequences of establishment tilapias in such water bodies could be serious (Canonico *et al.*, 2005; Lakra *et al.*, 2008). Its prolific breeding habit and parental care help it to multiply every 3 weeks, causing space overlap with local species and Tilapia form their establishment as part of the fish fauna in the Godavari, Krishna, Cauvery, Yamuna, Sharavathi, Ganga, Bharathapuzha and Chalakudy rivers of India (Lakra *et al.*, 2008; Raghavan *et al.*, 2008; Bijukumar, 2000; Sarkar *et al.*, 2010; Bhat, 2003). Several reports are available on fish species decline from various water bodies in India including many reservoirs and rivers due to the proliferation and establishment of tilapia (Jhingran, 1984). Introduction of tilapia has brought down the population of *Labeo kontius* in Vaigai reservoir and *Puntius dubius* in Amaravathy reservoir (Natarajan and Menon, 1989). The growth of *Chanos chanos* was restricted to less than 100g/year compared with the usual 500g/year in many water bodies in Tamil Nadu where tilapia was introduced (Singh and Lakra, 2011). The introduction of *O. mossambicus* in the Vaigai reservoir of South India replaced all fish species including major carps and has contributed 99% of the total catch (Sreenivasan and Sundarajan, 1967). In Jaisalmund Lake (Rajasthan) Tilapia out-competed many local species and resulted in a phenomenal reduction in the average weight of Indian major carps (Lakra *et al.,* 2008). Sreenivasan (1996) found that in Ayakulam pond the growth rates of *Gibelion catla, Labeo fimbriatus* and *Cirrhinus mrigala* were adversely affected by Tilapia population. In Kabini reservoir Tilapia has adversely affected the indigenous *Cirrhinus reba* and Tilapia has caused decrease of catch of *C. reba* to 70% to 20% (Murthy *et al*., 1986).

O. mossambicus contributed to 1.96 t in the landing of Chalakudy River. Biju *et al*. (2000) reported that this species was well established in all region of this river. The presence of well established population of Tilapia in the Chalakudy River will cause negative effects of native fish fauna especially to Orange Chromide, *Etroplus maculatus* because tilapia shares more or less the same resources as that of orange chromidae (Raghavan *et al.,* 2008a). Tilapia can make up a substantial part (up to 25%) of the catch in many reservoirs of Kerala, resulting in stunted and poor growth and total elimination of indigenous species (Lakra *et al.,* 2008). *O. mossambicus* posed severe threat to the existence of *Tor khudree* in Periyar Lake as 78% of their food were common (Kurup *et al.,* 2006) and Tilapia contributed 15% of fish landing in Periyar lake. Mahanta *et al.* (2003) observed that Tilapia was stocked Malampuzha reservoir in Kerala in early sixties and presently this species contributed 70% of the catch. It has also found that Tilapia was displacing local prized species *Etroplus suratensis* in Kayakulam Lake, Kerala (Lakra *et al.*, 2008).

Cyprinus carpio was contributed to the tune of 19.52 t in the exploited fishery of Kerala rivers. This fish is native to eastern Europe and central Asia and reported to be posing severe threat to other native fish community in rivers (Vilizzi and Walker, 1999), basins (Godinho and Fereira, 1998) and Lakes (Das and Pandey,1998). Common carp was introduced into India during 1939 and 1957 (Froese and Pauly, 2004; Singh and Lakra, 2006) for aquaculture purpose and it contributed more than 7.17% in total inland fish production of the country (Dey *et al.*, 2005).This fish has escaped in rivers and presently flooding in the entire stretch of river Yamuna and also in Gomthi, Godavari, Cauvery, Krishna, Tapti and Mahanadi (Singh and Lakra, 2006). This fish grow rapidly, achieves sexual maturation in the 2^{nd} year of life, produced < 2 million eggs per female (Balon, 1975). The combination of these features allows rapid spread and increased biomass of the species contributing to their invasiveness potential (Troca and Vieira, 2012). *C. carpio* showed 26.53% of total fishery in Periyar river and in Periyar lake it accounted 48% in the landing. *C. carpio* posed severe threat to the existence of *Tor khudree* in Periyar Lake as 57% of their food was common (Kurup *et al.*, 2006). Kurup *et al.* (2006) reported that this species forming 54% in the total landing of Periyar lake. The ecological consequences of its presence in a natural ecosystem are serious and introduced common carp has been reported to implicate environmental changes principally eutrophication through an increase in turbidity and mobilization of nutrients to the water column from the benthos through its habit of rooting or digging in the bottom (Britton *et al.*, 2007; Khanna *et al.*, 2007; Rowe, 2007). This fish has not only the potential to hybridize with Rohu (*Labeo rohita*), Catla (*Catla catla*) and Mrigal (*Cirrhinus mrigala*) but can easily breed with gold fish as well (Mishra *et al.*, 2000; Singh and Lakra, 2006). Hybrid of common carp and gold fish (*Carassius carassius*) were available in wild and abundant on farms (Shetty *et al.,* 1989).Adverse impacts of *C. carpio* have been reported across the world, including North America (Britton *et al*., 2007), Japan (Mabuchi *et al*., 2008), New Zealand (Rowe, 2007) and Australia (Koehn, 2004) The invasion of common carp in Australia has already been reported to quickly spread and dominate fish communities (Koehn, 2004). Significant negative effects of common carp on the piscine diversity have been reported in India. Common carp cause sharp decline in the catches of endemic Schizothoracids (Singh and Lakra, 2006; Lakra *et al.*, 2008) in the lakes of Kumaon and the production of common carp increased since 1985 (Shyam,1998). In Manipur the exotic common carp displaced endemic *Osteobrama belangeri* from Loktak Lake (Singh and Lakra, 2006). The introduction of common carp has significantly destabilised the native fish community balance of the Dal Lake in Kashmir (Natarajan and Menon, 1989) and has altered the energy flow system much to the disadvantage of indigenous snow trout species (*Schizothorax niger, S.* esocinus and S. *curvifrons*). The declining trend in the Indian major carps and increasing appearance of common carp in the fishery of Ganga River is a big concern (Sarkar *et al.*, 2012a). Sehgal (1989) reported that common carp catches from Govindsagar and Pong reservoirs (Himachal Pradesh) were gaining predominance over the mighty mahseer (*Tor putitora*) and shizothoracids.

African cat fish, *Clarias gariepinus* is widely distributed in the world and it has been introduced in more than 16 countries including India, Bangladesh and Nepal (Krishnakumar *et al.*, 2011). This exotic catfish species was illegally introduced into India from Bangladesh, first in to West Bengal, then later spreads to the other parts of the country for aquaculture (Singh and Lakra, 2011) and has been farmed in Kerala since 1993 (Krishnakumar *et al.*, 2011). Because of its prolific predatory nature (Lal *et al.*, 2003; Amin *et al*., 2009), competition for food and ability to alter food web structure (Khan and

Panikkar, 2009) and introgression with wild population (Na-Nakorn *et al.*, 1998; Peh, 2010), the fish became a potential threat to many of the native freshwater fishes. The fish is also reported to be exacerbating habitat degradation and the spread of disease and parasites (Booth *et al.,* 2010). There was a loss to the carps in the range of 78–86 % when *C. gariepinus* was cultured under polyculture with carps (Baruah *et al.*, 1999; Lakra *et al.,* 2008). African catfish exists in fish ponds, lakes, streams and other natural water bodies and this species got entry in some reservoirs and rivers like Ganga, Yamuna, Sutlej and Godavari river (Mishra *et al.,* 2000, Sugunan, 2002). In the present study, *C. gariepinus* was reported from Periyar and Pamba rivers and this species accounted for 1.5% of the exploited fishery in Periyar river. African catfish had also formed an important species in the landing of Periyar Lake in Kerala, a hot spot harbouring many endemic and endangered native fishes (*Lepidopygopsis typus, Crossocheilus periyarensis, Garra periyarensis, Nemacheilus periyarensis, N. menoni* and *Hypselobarbus periyarensis*) (Kurup *et al.,* 2004; Radhakrishnan and Kurup, 2010). Invasiveness nature of African catfish attributed by various character such as survival in different agro-climatic conditions, superior growth over local species, carnivorous and aggressive behaviour, acceptability of a wide range of feed, including live fish and other aquatic animals, and attaining maturity in different water bodies (Singh and Lakra, 2011). Depletion of 56 native species in Bangladesh has been reported due to the introduction of *C. gariepinus* (Barua *et al.,* 2000). *C. gariepinus* was reported causing threats to native fishes in reservoirs of south India due to its voracious and predatory feeding habits and high growth rate (Singh and Lakara, 2006). In Western Ghats, a global biodiversity hotspot, farmers culture *C. gariepinus* over the endemic yellow catfish (*Horabagrus brachysoma*), which has now critically declined (Lakra *et al.,* 2008). *C. gariepinus* has the potential to hybridize with local *Clarias batrachus* (Rahman *et al.,* 1995; Sahoo *et al.,* 2003), suggesting the possibility of genetic pollution. Its spread in different aquatic ecosystems has negatively impacted on the existence of local Magur, *Clarias batrachus*, in addition to other native species. Gopi and Radhakrishnan (2001) reported the negative impacts of introduction and culture of *C. gariepinus* on the native fish fauna of Manalur Gramapachayath in Kerala. Moorhen (*Gallinula chloropus*) a critically declining bird was found in the gut of a 67-cm-long fish caught from the Bharatpur bird sanctuary in Rajasthan (Anoop *et al.*, 2009).

The river of Kerala have received non-native fishes accidentally or purposely causing ecological damage and eliminating indigenous fish fauna. Alien species have been found to be establishing in the wild and cause ecological damage in several natural aquatic systems. Natarajan and Menon (1989) has warned the fisheries people that the introduction of non-native species is one of the greatest ever ecological threats to the native fishes. Once alien species successfully establishes itself and starts spreading, efforts to eradicate them become increasingly less successful and costly. In recent years, there has been an alarming increase of alien species in the rivers, ponds, lakes and reservoirs of India (Raghavan *et al.*, 2008a; Lakra *et al.*, 2008). Most of these introductions were from unauthorized culture of species which are moved into natural waters by accidental ways. Due to the various adverse impacts of these introductions there is an urgent need to prevent or control the unauthorized entry of alien fishes in to the country. Some countries have developed and implemented biosecurity rules and policies to reduce the threats of alien species. Public and private institutions could play an important role in introduction and management of alien fish species for the benefit to fisher communities without adversely affecting the ecological balance. Studies on impact of introduction (Long term and short term effects) on carrying capacity of habitat, alteration of ecological communities, influence on the function and overall health of ecosystem, assessment of negative impacts of biological invasions affecting the fishery production are needed urgently. There is an imperative need from the Department of fisheries has to take speedy actions for banning the culture of alien fishes in order to eliminate it from the state water. To create awareness and educate the fish farmers, aquarists and the general public people about the harm full effects of the alien fishes, the dep. is carrying out educative campaigns via various media like newspaper, TV channels, Radio, mobile phones etc and also at grama pachayath and municipality levels. In order to ensure strict enforcement of the ban, introduction of a bill soon in the state level to control the impact of alien fishes.

.....ନଔ.....

Section II

BIONOMICS OF *HYPSELOBARBUS THOMASSI* (DAY 1874)

Chapter 5

SYSTEMATICS

Contents

5.1. Introduction

The state of Kerala is located at the South west coast of the Indian Subcontinent. Due to the varied climatic and geographical features, the state harbors a rich and diversified fish fauna characterized by many endemic and threatened species. The state abounds with an extensive inland water resources which are suitable for fish culture including 30 reservoirs, tanks, ponds and irrigation channels and 44 rivers. Kurup *et al.* (2004) recorded 175 fish species from rivers and streams of Kerala including 106 ornamental and 67 food fishes. In spite of having immense scope and potential for the development of freshwater fish culture as well as capture fisheries in the state, the yield from these water bodies are far below optimum. However, with the increasing demand for fish as a source to cater to the ever increasing demand for protein requirements of the human beings, development of captive breeding techniques of suitable candidate species and their introduction in aquaculture activities are needed for conservation and utilization of indigenous fish germplasm resources of Kerala.

Early life stages and intra specific variation in life history traits of Indian fishes have received little attention (Ponniah and Gopalakrishnan, 2001). A thorough understanding of the life history traits is of great significance in conservation point as it provides not only the natural history of a particular fish but also its ecology, reproductive biology, age and growth and population status. The studies on life history traits become indispensable for understanding the basic biology and facilitating captive breeding and mass production of seeds. This will also be helpful for conservation and management. The details of life history data with reference to habitat ecology in different geographical population are vital to formulate species and location specific strategies for conservation (Sarkar *et al.,* 2005). In this context, many of endemic species in Kerala rivers are of value either as food or ornamental species. There is a need to standardize the technology of mass production of seeds to replenish and restore them in natural habitats through ranching programme. Mass production of seeds of endemic and rare species by captive breeding will also facilitate their sustainable utilization on commercial trials.

The fish species selected for the present study, *Hypselobarbus thomassi* (Day, 1874) is an endemic fish of rivers of the Western Ghats of India, which has been listed as 'Critically Endangered' in the IUCN Red list of threatened species (Remadevi and Ali, 2011; Dahanukar and Raghavan, 2013). It is locally used as a food fish and is a candidate species for aquaculture. So an effort in this direction was attempted by investigating the life history traits of *H. thomassi* from Kallada river.

5.2. Description of the species

Hypselobarbus thomassi (Day 1874) is a cyprinid, which is commonly known as 'Red Canarese barb' and is locally known as *'Chakkali'* (Fig.5.1).

Fig.5.1. *Hypselobarbus thomassi* (Day, 1874) from Kallada River

Systematic position

Kingdom: Animalia
Phylum: Chordata
Sub Phylum: Vertebrata
Super-class: Gnathostomata
Grade: Pisces
Class: Osteichthyes
Sub-class: Actinopterygii
Sub-Division: Teleostei
Order: Cypriniformes
Sub-order: Cyprinioidei
Family: Cyprinidae
Sub-Family: Cyprinidae
Genus: *Hypselobarbus* (Bleeker, 1860)
Species: *Hypselobarbus thomassi* (Day, 1874)

Synonyms of *Hypselobarbus thomasi* (Day, 1874) are as follows

Barbus thomassi (Day,1874)

Puntius thomassi (Jayaram, 1981)

Gonoproktopterus thomassi (Jayaram, 2009)

Hypselobarbus thomassi (Arunachalam *et al*., 2012; Ali *et al*., 2013)

Hypselobarbus thomassi exhibits the following diagnostic characteristics

Body elongate, laterally compressed, dorsal profile convex with the pre dorsal contour ascending up to dorsal fin origin, then descending gently towards caudal peduncle. Ventral profile also convex anteriorly up to pelvic fin origin, almost flat up to anal fin base, then slanting sharply to the caudal base.

Head laterally compressed, eyes positioned somewhat superiorly, visible from dorsal and ventral profiles. Nares placed very close to the antero-superior rim of the orbit. An elevated flap is present at the middle of the nares. Mouth sub-terminal, reaching to vertical at middle of nostrils, U shaped in ventral aspect with interrupted labial fold. Two pairs of thin barbels; the rostral pair shorter than the maxillary one. Rostral barbels reach the base of maxillary barbels and a point in vertical from the posterior extremity of the nostrils.

Dorsal fin takes origin above 10th scale of the lateral line and is slightly in advance of pelvic fin origin; sharply pointed at apex with a concave distal margin. Posterior margins of pectoral and pelvic fins convex, curved and not reaching to vertical from insertion of pelvic fin and anal fin respectively. Anal fin with a concave distal margin; caudal fin deeply forked; both the lobes with pointed tips, upper lobe slightly longer than the lower one.

Dorsal fin with four simple and nine branched rays, the last being branched to the base. Last unbranched dorsal fin ray longest followed by the first branched ray. Pectoral fin with one simple and 15 branched rays. Pelvic fin with one simple and nine branched rays. Anal fin with three simple and five branched rays, last one branched to the base. Caudal fin with 9+8 branched rays and 3-4 procumbent rays above and below the principal fin rays of each lobe.

Lateral line complete with 33–34 pored scales, plus one unperforated scale at the base of the caudal fin. Eleven pre dorsal scales (excluding the notched one at fin origin) and 14 circumpeduncular scales (½-3-1-2-½ scale in transverse line). Transverse scale count between dorsal fin origin and pelvic fin origin ½+5+1+3 and 3½ scales between lateral line and anal fin. There exist 21 pre ventral scales and 30 pre anal scales. Dorsal base sheathed with 9–10 scales where as the anal fin with 5–6 scales. One scale row between the urogenital opening and anal fin origin. The two axillary scales present at the pelvic fin base exceed a bit beyond the posterior insertion of the fin.

Dorsal side of the body and the flanks above the lateral line are greenish grey in colour and the flanks below lateral line and the ventral side are bright silvery in colouration. Body devoid of any distinct markings. All the fins orange-red in colour at their proximal ends and with a greyish tinge at the distal ends.

H. thomassi inhabits pool-riffle, run and glide habitats in fast to moderately flowing streams shaded with fine amount of riparian vegetation (Ali *et al.,* 2013). The adults of the species always dwell in moderately deep pools, while the juveniles are seen in shallow areas associated with pool-riffle habitats.

5.3. Distribution

Day (1874, p707) described *Barbus* (*Hypselobarbus*) *thomassi* from South Canara as a large barb growing to more than 450 mm in length. Subsequently, Day (1878, p 567; 1889, p 311) provided additional notes on this species. The first record of *H. thomassi* outside its type locality was most likely made by Jayaram *et al.* (1976) from the rivers of the Cardamom Hills. Subsequent compilations and checklists (Talwar and Jhingran,1991; Menon,1999; Easa and Shaji, 2003; Remadevi *et al*., 2005) provided the distribution range for *H. thomassi* as South Canara and Cardamom Hills. Later, many researchers added new records of this species from various rivers in Kerala (Table 5.1).

Table 5.1. Previous records of *Hypseobarbus thomassi* from the Western Ghats

Locations	References
South Canara	Day (1874,1878,1889)
Cardamom Hills	Jayaram *et al*. (1976)
Kabbini river	Easa and Shaji (2003)
Periyar River	Thomas *et al*.(2002); Thomas (2004); Beevi and Ramachandran (2009)
Chalakudy River	Thobias (1973); Kurup *et al.* (2004); Beevi and Ramachandran (2009)
Kallada River	Gopi (2000); Kurup *et al.* (2004); Ali *et al*. (2013)
Tunga River	Ahmad and Venkateshwarlu (2012); Ahmad *et al.(*2011)
Kempu Hole River	Knight *et al*.(2013)
Mula-Mutha River	Wagh and Ghate (2003)

The genus *Hypselobarbus* (Bleeker, 1860) is endemic to rivers of peninsular India, with most species occurring in rivers, streams and reservoirs of Western Ghats or lower reaches of rivers in the range. Currently, the genus includes 11 species namely, *H. curmuca* (Hamilton,1807), *H. dobsoni* (Day,1876), *H. dubius* (Day,1867), *H. micropogon* (Valenciennes,1842), *H. jerodoni* (Day,1870), *H. kolus* (Sykes,1839), *H. kurali* (Menon & Remadevi,1995) *H. lithopidos* (Day, 1874) *H. periyarensis* (Raj,1941), *H. pulchellus* (Day,1870*)* and *H. thomassi* (Day,1874). There is hardly any freshwater body where one can fail to encounter any of these species. Generally, most of them grows to only small size, in contrast, *H. thomassi* attains a maximum length of 100 cm (Menon,1999). Gopi (2000) attributed 'very rare' status to *H. thomassi*. Menon (1997) reported that *H. thomassi* is distributed in large streams and rivers of the Western Ghats. It was reported that this species prefer running water of highland areas (Biju *et al.*, 2000). In Kerala, *H. thomassi* is available in Chalakudy, Kabbini, Periyar and Kallada rivers. However, the catch of this species have significantly declined in recent years. Local knowledge of fishers in the Chalakudy and Periyar Rivers reveal that the fish is not common and is rarely caught (Ali *et al.*, 2013), though it contributed to a significant landings in the fishery of Kallada river**.**

Ever since the description of *B. thomassi* by Day (1874), virtually nothing has been added to the knowledge on this species. This dearth of information on this valuable rare food fish has prompted to undertake the present study on its life history traits and resource characteristics. During the study from April 2009 to March 2011, the following aspects were dealt with-

1) Food and feeding habits to provide the information on the basic components of diet and seasonal variability in feeding behavior
2) Reproductive biology to unravel spawning season, sex ratio, fecundity, size at first maturity and other related aspects.
3) Length-weight relationships and condition factor to ascertain the nature of growth in this fish and its general well being.
4) Age and growth study to understand the age composition of exploited stock, age of maturation and life span of species, growth rate etc.
5) Population dynamics to estimate mortality rates, exploitation ratio, exploitation rate, relative yield per recruit, etc. so as to bring out the present level of exploitation of its stock and also examine whether the current exploitation rate maintains a judicious level or not.

.....ꙮ.....

Chapter 6

FOOD AND FEEDING HABITS

Contents

6.1. Introduction

Every organism on earth requires energy for growth, reproduction and other metabolic activities. These life sustainable processes take place utilizing food energy. Hence, food is considered as the most essential component for the growth of all living organisms. Fishes like any other organisms depends on the energy received from its food to perform its biological processes. Food consumption is the major factor controlling fish production. Information on the natural food of fish is important in understanding its nutritional requirements, its interaction with other organisms and its potential use for aquaculture (Royce, 1987). Food web analysis is one of the most important areas in community structure research. Quantitative assessment of food items and feeding habits in fishes is an important aspect of fisheries management and the study of food and feeding habits of fishes can shed light on the behaviour, habitat use and energy intake of various fish species and inter / intra specific interactions that occur in aquatic ecosystems (Walters *et al.*, 1997). Once the food preference of a species is ascertained, an evaluation of its trophic relationship such as overlapping of food spectrum with other co-existing species, competition from other species, selectivity or flexibility in feeding on the food items etc, can be made. Different feeding habits and food preferences would be the likely outcomes of potential use of artificial diets and their compositional adjustment aimed at achieving improved results (Sabapathy and Teo, 1993; Hidalgo *et al.,* 1999; Moraes and Bidinotto, 2000; Deguara *et al*., 2003).

The food and feeding habits of fish also vary with time, space as well as stages of growth (Hardy, 1924) and this would, in turn, pinpoint the importance of detailed study of this aspect. Same species occupying in different habitats may feed on different types of food (Hyndes *et al*., 1997) or even in the same habitat, the diet may vary at different times. The diets of most fish species vary with age and growth. The variation of fish diet with extrinsic (biotope, region) or intrinsic (species, size, behaviour) factors provide information on basic functioning of fish assemblages too, which are important for developing Ecosystem Based Fisheries Management models (Hanson and Chouinard, 2002; Kublicki *et al.,* 2005). Feeding habit is an important factor to be considered while introducing species to a new ecosystem so as to leave the native fauna with least disturbance in their natural habitat. Information on feeding habits at different age groups is essential for hatchery operation. In the aquaculture sector, brood stock nutrition plays very important role in the reproductive performance of many fish species (Bromage and Roberts, 1995; Brooks *et al.,* 1997; Izquierdo *et al.,* 2001). Basic knowledge on the food preference and feeding habits of a species are primary requirements for ascertaining its suitability for aquaculture and for determining desirable species combinations in culture systems with minimum interspecies competition for the natural food.

The dietary habits of freshwater fishes have been extensively studied world over. Some of the outstanding works in these fields are those of Al-Hussaini (1949), Hynes (1950), Grossman *et al*. (1980), Hyslop (1980), Asif (1988), Jellyman (1989), Padma *et al*. (1995), Amezaga *et al*. (1998), Guruge

(2002), De Melo *et al.* (2004), Mamun *et al.* (2004), Beltrano *et al.* (2006), Bhuiyan *et al.* (2006), Shahidul *et al.* (2006), Bascinar and Sagalam (2009) and Shaloof and Khalifa (2009).

Food and feeding habits of freshwater fishes belong to different parts of India had been studied by a serious of scientists, notable among them are those of Mookherjee (1944), Chacko and Kuriyan (1949), Das and Moitra (1955,1956a,b,1958,1963), Menon and Chacko (1957,1958), Natarajan and Jhingran (1961), Bhatnagar (1963), Qayyum and Quasim (1964 a,b,c), Rajan (1965), Pandian (1966), Chakrabarthy and Singh(1967), Sinha (1972), David and Rajagopal (1975), Pathak (1975), Badola and Singh (1980), Gupta (1981), Vinci and Sugunan (1981), Nautiyal and Lal (1984), Biswas (1985.1986), Dasgupta (1988,1990,1991a). Ravishanker *et al.* (1991) Sharma *et al. (*1992), Nath (1994a), Mahinder *et al.* (1996), Kohli and Goswami (1996), Das and Goswami (1997), Kishor *et al.* (1998), Rao *et al.* (1998), Basudha and Vishwanath (1999), Singh and Subbaraj (2000), Serajuddin and Ali (2005), Suresh *et al.* (2007), Dinesh and Roy (2009), Ashraf (2010), Saikia *et al.* (2012). Chacko and Kuriyan (1949) studied the food habits of nine species of *Barbus*. Hynes (1950) has worked on the food and feeding habits of freshwater sticklebacks, *Gastrosteus aculeatus* and *Pyrosteus pungitius*. Kapoor (1953) had reported on the feeding habits of *Wallago attu*. Das and Moitra (1963) have described food and feeding habits of the twenty four freshwater fishes of Utter Pradesh (India). Khanna and Pant (1964) have described feeding habits of some teleostean fishes. Kamal (1967) has described food and feeding habits of *Gibelion catla*, *Labeo rohita* (juvenile), *L. bata* and *Cirrhinus mrigala.* George (1965) described the food of some major carps in some fish ponds of Delhi. Thomas (1966) studied the food and feeding habits of *Clarias senegalensis*. Malhotra (1967) discussed the feeding habits of *Tor, Puntius* and *Botia birdi.* Food and feeding habits of *Tor*, *Puntius* and *Barilius* were studied by Badola and Singh (1980), while Johar and Singh (1981) studied same in

Sicamugil cascasia. Studies on the dietary habits of certain cyprinid fishes including *Cirrhinus mrigala* (Kamal, 1967) have suggested that generalizations on food and feeding habits of freshwater fishes living in isolated pockets will have to be made with great caution unlike in marine species. Kumar (2007) had studied food and feeding habits of fishes of Kharagpur (Munger).

Nevertheless, information on the feeding habits of freshwater fishes in Kerala waters are very few. Antony (1977) reported the feeding habits of hill stream fishes of Trichur district. The diets of loaches (*Lepidocephalus thermalis* and *Nemacheilus triangularis*) was studied by Ritakumari (1977). Nair and Shobana (1980) analyzed the food preferences and seasonal variations in food composition and feeding activity of *Puntius sarana*. The diet of *Aplocheilus lineatus* and *Macropodus cupanus* was revealed by Sheila (1981). Premkumar *et al.* (1985) investigated the food and feeding habits of two cyprinid forage fishes, *Puntius filamentosus* and *P. amphibius* collected from South Kerala. The morphological adaptations of digestive system along with food and feeding habits of *Puntius vittatus* was studied by Geetha *et al.* (1990). Kurup (1993b) studied the food and feeding habits of *Labeo dussumieri* of Pampa river along with the feeding habits of fry, fingerlings and juveniles which helped in identifying this species as cultivable fish. Mercy *et al.* (2002) described the food and feeding habits of *Puntius melanampyx*, an endemic fish from Western Ghats. Manojkumar and Kurup (2002 a,b) studied the food and feeding habits of threatened fishes, *Tor khudree* and *Neolissocheilus wynadensis* from Kerala rivers. Euphrasia (2004) reported the food and feeding habits of *Osteobrama bakeri* and Manojkumar (2006) studied the feeding habits of *Puntius carnaticus.* Food and feeding behavior of Golden catfish, *Horabagrus brachysoma* was described by Padmakumar *et al.* (2009) and Sreeraj *et al.* (2006). Prasad and Ali (2008) also analyzed the gut contents of *H. brachysoma* in their juveniles and adult stages of life.

Hypselobarbus thomassi attains more than 100 cm (Menon, 1999) and its larger size is suitable for aquaculture purposes. Food and feeding habits of this species is hitherto unknown. Knowledge of the food and feeding is a prerequisite for taking decisions in respect of its candidature for captive breeding and farming purpose. The present study was undertaken to examine the food preferences, feeding intensity and seasonal variations in diet of *H. thomassi* inhabiting Kallada River.

6.2. Materials and Methods

Specimens for the study were collected from the Kulathupuzha river, a tributary of Kallada river using gill net during the period from April 2009 to March 2011. 537 specimens comprising of 244 males, 140 females and 153 indeterminates were examined. The samples were persevered in 8% formalin after making a few perforation in the vent region for better preservation of the internal organs. After recording the total length (mm), standard length (mm) and total weight (gm), the fishes were dissected out to determine the sex and fullness of stomach. The length, fullness and weight of the gut were examined.

The extent of feeding was judged by the degree of fullness of stomach or from the amount of food contained in it. Depending on the extent of distension of the stomach and the amount of food in it, the stomachs were described as,

1) *Gorged*- A stomach with transparent wall, the gut contents were full occupying the entire stomach.
2) *Full stomach*- A stomach in which the food items occupied the entire cavity of the stomach.
3) 3/4 *full stomach*- A stomach in which the food items occupied ¾ of the stomach.
4) *1/2 full stomach*- A stomach in which the food items occupied ½ of the stomach.

5) *1/4 full stomach*- A stomach in which the food items occupied ¼ of the stomach.

6) *Trace stomach*- Very little or few organisms were present in the stomach.

7) *Empty stomach*- No food items were found in the stomach.

The degree of distension of gut was expressed as gorged (50 points), full (40 points), ¾ full (30 points), ½ full (20 points), ¼ full (10 points), trace (5 points) and empty (0 points), following Kurup and Samuel (1988).

The feeding intensity or the degree of feeding is related with season, maturity, spawning and availability of food materials. It was determined by calculating the Gastro-somatic index (GSI). The GSI was calculated to investigate monthly as well as size wise variations in feeding intensity, using the method adopted by Desai (1970).

GSI = (Weight of the gut / Total weight of the fish) x 100

The length of the gut was measured and the relative length of the gut was estimated (RLG) for the different length groups by the method of Al-Hussaini (1949).

RLG = Length of the alimentary canal / Total length of the body

The percentage occurrence of diet was determined following the occurrence method as described by Hynes (1950). The relative index of food items was calculated by the 'Index of Preponderance' (Natarajan and Jhingran, 1961), which combines both volumetric and frequency of occurrence methods giving rise to accuracy in grading various food elements. This index was employed to evaluate the food preferences of males, females and indeterminates. The Index of Preponderance was calculated by the formula;

$$I = (Vi\ Oi / \sum Vi\ Oi) \times 100$$

Where I = Index of preponderance of the food items

Vi = Percentage of volume index the food items

Oi = Percentage of occurrence index of the food items

The point method (Volumetric) described by Pillay (1952) was used for estimating the volume index of the food items. The fullness of stomach was also taken in to account in the allotment of the points (Frost, 1943). The points gained by each food item altered proportionally to the total points allocated for the stomach. The food elements were identified as far as possible up to the species or genus or family depending on the state of digestion.

6.3. Results

Alimentary canal system of *H. thomassi* comprises of mouth, buccal cavity, oesophagus, stomach, intestine and rectum. Mouth is sub terminal in position. The alimentary canal is very long, thin, coiled and poorly differentiated. The intestine is very long and highly coiled. The ratio between gut length and length of the fish gave some indications about the nature of fish diet.

The length of alimentary canal of this species was found to be comparatively large with the relative gut length varying between 0.7 to 2.5. It ranged from 0.7 to 1.5 in indeterminates, 0.9 to 2.08 in males and 1.1 to 2.5 in females. RLG values was found to be highest in the size range of 380-399 mm (2.08) in males and 420-439 mm (2.5) in females respectively (Fig.6.1). It was observed that the RLG values increased with the increase in length of the fish. This species appears to be a voracious feeder as in most of the occasions the gut was found completely gorged or full.

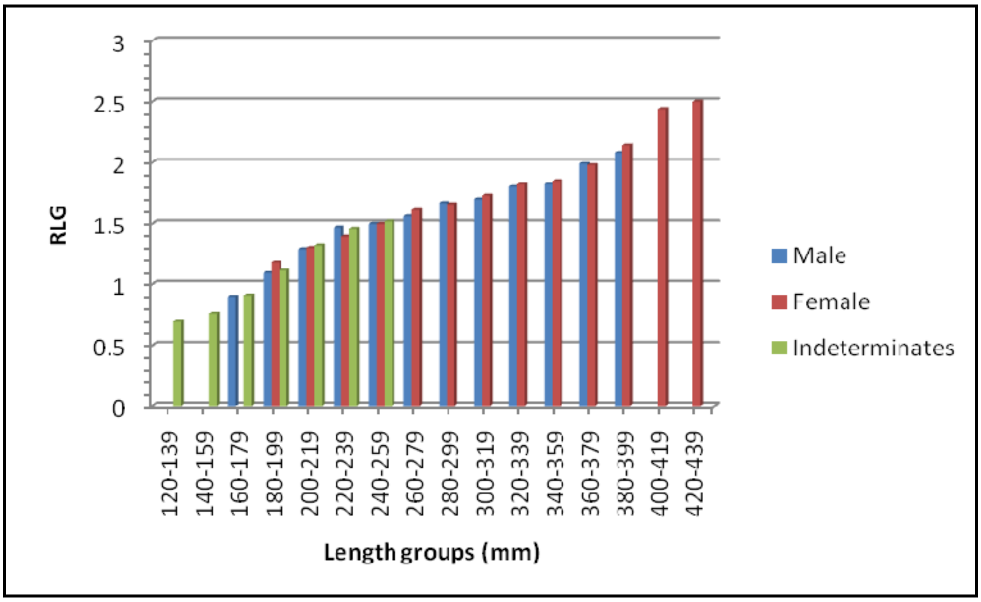


Fig.6.1. Variation in relative gut length in different length groups of *H. thomassi*

6.3.1. General diet composition

The various food items recorded from the stomach of *Hypselobarbus thomassi* during the study period are presented in Table.6.1. Examination of the stomach content revealed that the food items could be assorted in to eight categories namely Semi digested plant matter, Chlorophyceae, Bacillariophyceae, Cyanophyceae, Semi digested animal matter, Seeds, Mud and Miscellaneous matter.

Semi digested plant matter was the most predominant dietary item recorded round the year. It was represented by leaves, roots, flower and parts of plant stems.

Chlorophyceae (Green algae) were regularly encountered in the gut of the fish species. Filamentous algae viz, *Spirogyra*, *Ulothrix*, *Oedogonium* and desmids like *Cosmarium*, *Closterium* and *Staurastrum* were regularly present in the gut.

Table.6.1. Index of preponderance value of different food items in the gut of *Hypselobarbus thomassi*

Sl .No.	Food items	2009-10	2010-11	pooled
1	Semi digested plant matter	66.61	67.16	66.88
2	Chlorophyceae	8.26	7.87	8.06
3	Bacillariophyceae	8.01	7.81	7.91
4	Cyanophyceae	0.84	0.75	0.79
5	Semi digested animal matter	4.91	5.22	5.06
6	Seeds	3.84	3.23	3.53
7	Mud/soil	6.38	6.90	6.64
8	Miscellaneous	1.15	1.07	1.11

Bacillariophyceae was also present as another important food item represented by, *Navicula, Nitzchia, Clostrium, Calothrix, Pinnularia, Fragillaria, Dinophysis, Nitzchia, Synedra,Cymbella, Rhizosolenia. Gyrosigma, Rhopalodia* and *Stauroneis.*

Cyanophycea (Blue green algae) was present in small amounts represented by *Oscillatoria, Spirulina and Microcystis.*

Semi digested animal matter was comprised mainly of insects (70-80%). They were represented by Diptera, Hemiptera, Ephemeroptera, Coleoptera and Odonata. Gastropods and worms were also found in gut occasionally. Parts of small fishes such us scales and gills were also encountered in the gut contents.

Seeds of plants and trees along the riparian zone were observed in the gut contents of *H. thomassi*. Presence of soil and mud was also encountered in most of samples.

6.3.2. Variation in the diet composition of males, females and indeterminates

The food of males, females and indeterminates were analyzed separately to find out the differences, if any. The percentage composition of different food items of males and females and indeterminates are given in Fig.6.2a, 6.2b and 6.2c respectively. The food preferences of males, females and indeterminates were similar with variations in the magnitude of different food items consumed.

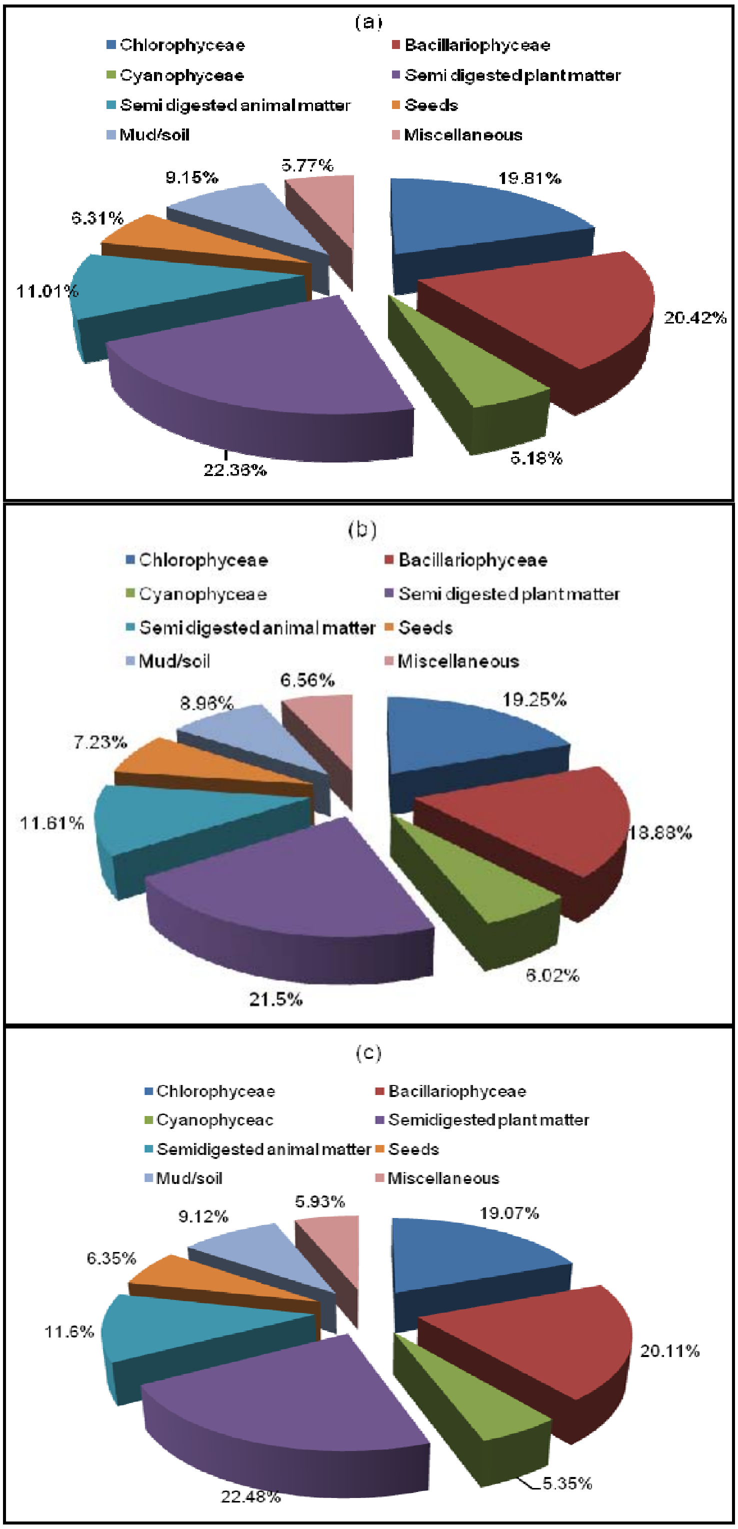


Fig.6.2. Diet composition of (a) males (b) females and (c) indeterminates of *H. thomassi* (Pooled for 2009-10 and 2010-11)

Semi digested plant matter, green algae, diatoms, mud, semi digested animal matter and seeds were the order of preference in all groups. Semi digested plant matter contributed to 22.36 % in males, 21.5% in females and 22.48 % in indeterminates, while green algae formed 19.81% in the diet of males, 19.25% in females and 19.07% in indeterminates. The preference for diatoms was found to be higher in males (20.42%) than to indeterminates (20.11%) and females (18.88%). Semi digested animal matter formed 11.61% in females followed by 11.6 % in indeterminates and 11.01% in males. The occurrence of plant seeds was noticed in certain season which contributed to 6.31% in males, 7.23% in females and 6.35 % in indeterminates.

The preference of blue green algae was found to be higher in females (6.02%) followed by indeterminates (5.35%) and males (5.18%). Mud was higher in males (9.15%) followed by indeterminates (9.12%) and females (8.96%). Miscellaneous matter including the plastic materials formed 5.93% of the diet in indeterminates, 5.77% in males and 6.56% in females.

6.3.3. Seasonal variations in the diet of males and females

Monthly fluctuations in index of preponderance of males and females, for the year 2009-10 and 2010-11 are given in Tables 6.2, 6.3, 6.4 and 6.5. It could be noticed that the percentage composition of different food items varied in different months according to their availability and to the food preference of fish. Semi digested plant matter was present in the stomach throughout the year.

Table 6.2. Monthly Index of Preponderance values of different food items in males of *H. thomassi* during 2009-10

Months	April	May	June	July	August	September	October	November	December	January	February	March	Average
Food items	Index of preponderance												
Chlorophyceae	8.47	6.71	12.03	9.81	8.42	7.35	6.45	6.51	6.9	8.06	7.89	8.86	8.12
Bacillariophyceae	6.48	5.37	6.22	6.58	7.36	10.59	9.61	8.03	9.46	8.68	9.96	11.22	8.3
Cyanophyceae	0.53	0.34	1.29	2.49	1.12	1.18	0.34	0.32	0.56	0.21	0.49	0.55	0.78
Semi digested plant matter	69.05	67.11	66.84	68.29	69.26	67.65	68.34	69.88	65.88	62.5	61.86	66.07	66.89
Semi digested animal matter	8.6	9.23	6.94	9.34	7.36	4.71	3.05	2.89	2.12	3.25	3.89	2.22	5.3
Seeds	0.13	1.26	3.34	0.93	1.2	4.71	9.92	4.82	4.2	0.93	6.29	4.43	3.51
Mud/soil	5.56	9.23	2.06	1.4	3.46	3.53	0.92	7.23	9.9	15.55	9.13	6.09	6.17
Miscellaneous	1.19	0.76	1.29	1.17	1.82	0.29	1.37	0.32	0.98	0.83	0.49	0.55	0.92

Table 6.3. Monthly Index of Preponderance values of different food items in males of *H. thomassi* during 2010-11

Months	April	May	June	July	August	September	October	November	December	January	February	March	Average
Food items	Index of preponderance												
Chlorophyceae	7.88	8.05	10.57	8.82	7.42	8.56	4.96	5.2	7.81	6.78	9.45	7.48	7.75
Bacillariophyceae	6.01	6.71	7.32	7.2	7.72	8.56	9.38	9.16	10.4	9.04	10.84	9.25	8.47
Cyanophyceae	0.6	0.22	0.81	1.56	0.76	0.34	0.31	0.68	0.42	0.73	0.43	0.87	0.64
Semi digested plant matter	68.4	68.9	66.09	69.1	66.47	68.49	68.84	67.56	66.54	63.89	64.19	68.24	67.23
Semi digested animal matter	8.23	8.05	6.1	8.88	8.65	5.14	2.71	3.42	1.62	2.89	1.93	4.48	5.17
Seeds	0.57	0	2.54	0.78	2.9	5.14	7.75	5.16	3.23	1.06	1.73	3.26	2.84
Mud/soil	6.62	7.16	5.8	1.49	4.26	3.42	5.12	8.46	9.24	14.67	11.13	5.66	6.92
Miscellaneous	1.69	0.89	0.76	2.17	1.82	0.34	0.93	0.36	0.74	0.94	0.29	0.76	0.97

Table 6.4. Monthly Index of Preponderance values of different food items in females of *H. thomassi* during 2009-10

Months	April	May	June	July	August	September	October	November	December	January	February	March	Average
Food particles	Index of preponderance												
Chlorophyceae	9.23	7.3	12.32	11.02	9.45	6.92	5.6	6.48	7.2	6.87	9.56	8.74	8.39
Bacillariophyceae	5.9	4.69	7.39	6.43	8.53	6.92	8.23	9.33	8.42	9.35	8.82	8.74	7.73
Cyanophyceae	0.37	0.52	0.82	3.28	0.79	0.77	0.91	1.04	0.8	0.76	0.25	0.35	0.89
Semi digested plant matter	70.85	65.71	68.99	67.19	68.5	67.69	64	68.39	66.1	61.83	60.29	66.43	66.33
Semi digested animal matter	8.86	8.47	4.11	6.3	5.47	4.62	2.74	2.33	2.98	1.15	5.15	2.1	4.52
Seeds	0	1.04	2.46	0.26	1.48	9.23	12.57	5.18	3.22	2.29	5.88	6.29	4.16
Mud/soil	4.43	11.08	2.05	1.57	4.26	3.08	4.11	6.22	10.22	16.03	9.07	6.99	6.59
Miscellaneous	0.37	1.17	1.85	3.94	1.52	0.77	1.83	1.04	1.06	1.72	0.98	0.35	1.38

Table 6.5. Monthly Index of Preponderance values of different food items in females of *H. thomassi* during 2010-11

Months	April	May	June	July	August	September	October	November	December	January	February	March	Average
Food particles	Index of preponderance												
Chlorophyceae	8.76	6.58	10.88	9.88	8.46	9.43	4.77	7.12	6.9	7.46	8.74	6.9	7.99
Bacillariophyceae	6.21	3.7	7.4	7.02	5.89	6.04	9.35	8.22	9.01	8.59	6.9	7.56	7.16
Cyanophyceae	0.46	0.41	1.36	2.44	1.26	0.75	0.76	0.85	0.56	0.41	0.43	0.55	0.85
Semi digested plant matter	68.88	65.84	67.67	68.22	70.21	67.92	66.79	66.67	67.61	62.83	64.72	67.67	67.09
Semi digested animal matter	8.44	9.88	4.83	6.86	6.55	6.79	4.58	2.12	4.51	1.8	3.02	3.68	5.26
Seeds	0.12	0	3.63	0.22	2.78	5.66	10.69	6.48	1.69	2.93	3.88	5.2	3.61
Mud/soil	5.6	13.17	3.63	2.12	2.68	3.02	2.29	7.68	9.15	13.78	11.87	7.57	6.88
Miscellaneous	1.53	0.41	0.6	3.24	2.17	0.38	0.76	0.86	0.56	2.2	0.43	0.87	1.17

6.3.3.1 Seasonal diet variations in males

During 2009-10, semi digested plant matter formed the dominant food item throughout the year in males with its highest occurrence in November (Index value of 69.88) in contract to a minimum in February (61.86) (Table .6.2). Green algae and diatoms formed the second and third dominant food items respectively. The index value of semi digested animal matter ranged between 2.12 in December and 9.34 in July. Seeds of plants growing in the riparian zone formed a minor portion of the diet during all months and its contribution varied from 0.13 in April to 9.92 in October. The index value of mud was high in January (15.55) and low in October (0.92). Miscellaneous matter varied from 0.29 in September to 1.82 in August. The pattern of variation was more or less on a similar during 2010-11 with very slight difference (Table.6.3). The quantity of semi digested plant matter, filamentous algae, diatoms and semi digested animal matter followed similar trend during both the years. It could be noticed that the index value of semi digested plant matter was high during pre monsoon and monsoon months while low values was recorded in December to February. Plant seeds recorded high index value in October (7.75) and present in the gut in all months except in May, 2010-11.

6.3.3.2 Seasonal diet variation in females

Semi digested plant matter was the dominant food item of females throughout in 2009-10 (Table.6.4) with a highest occurrence in April (70.85) and June (68.99). Green algae which formed the second dominant food item, varied between 5.6 in October to 12.32 in June. Diatoms showed their peak occurrence in January (9.35), however declined to 4.69 in May. Semi digested animal matter showed its highest occurrence in April (8.86) and it was lowest with 1.15 in January. Plant seeds contributed to substantial quantity during September to March while its index was low during April to August. The index values of mud varied from 1.57 in July to 16.03 in January. Presence of miscellaneous matter varied from 0.35 in March to 3.94 in July. Similar trend was observed during 2010-11 with only slight variations (Table.6.5). The highest contribution of semi digested plant matter was in August (70.21) followed by April (68.88). Green algae showed similar pattern of variation as seen in the previous year and varied its contribution from 4.77 in October to 10.88 in June. The index value of semi digested animal particles varied from 1.8 in January to 9.88 in May. Mud and seeds of plants also showed a similar trends of variation as observed during the previous years.

Index of preponderance values of indeterminates of *H. thomassi* from April 2009 - March 2011 are given in Table 6.6. Among the different food items, semi digested plant matter (68.45%) was the dominant food item followed by green algae (9.01%), bacilllariophyceae (6.9%), semi digested animal matter (5.07%), seeds (4.51%) and mud (4.23%) in the order of their dominance. Miscellaneous items formed 1.27% of the diet.

Table 6.6. Index of Preponderance values for different food items in indeterminates of *H. thomassi* from April 2009 to March 2011

Food items	% Volume	% Occurrence	Vi Oi	Vi Oi/£ViOi
Chlorphyceae	21.05	7.34	154.51	9.01
Bacillariophyceae	18.42	6.42	118.30	6.90
Cyanophyceae	5.26	1.83	9.66	0.56
Semi digested plant matter	23.68	49.54	1173.35	68.45
Semi digested animal matter	10.53	8.26	86.91	5.07
Seeds	5.26	14.68	77.26	4.51
Mud/soil	7.89	9.17	72.43	4.23
Miscellaneous	7.89	2.75	21.73	1.27
Total	**100**	**100**	**1714.15**	**100**

6.3.4. Feeding intensity

6.3.4.1 Guts in different degrees of fullness

Monthly variations in the percentage occurrence of guts with different degrees of fullness in males and females of *H. thomassi* during the years 2009-10 and 2010-11 are depicted in Figs 6.3, 6.4, 6.5 and 6.6 respectively.

Males with gorged guts were present during all months of 2009-10 and showed highest occurrence in June (33.33%) while the lowest representation was observed in October (4.45%). Similarly, the incidence of full guts was also noticed in all months with a high percentage in October (52.1%) and January (45.45%). Individuals with 3/4 full guts showed maximum occurrence during November (44.44%) followed by January (36.36%) and March (33.3%). Predominance of ½ full guts was seen in April (23.08%) but such guts were absent in September and November. 1/4 full guts showed their higher occurrence during September (10%). Individuals with only trace amount of food materials were observed during March (5.56%). While empty guts were observed only during August (27.78%) and February (2.44%). During 2010-11, full guts could be seen in most of the months. Dominance of gorged guts was seen in April (25%) whereas full guts recorded their highest percentage in July (56.25%). The occurrence of ¾ full guts were recorded throughout year with highest percentage in March (50%). Highest number of fishes with ½ full guts were noticed in December (27.27%). ¼ guts were recorded in October, February and March with highest of preponderance in February (11.43%). Trace guts were observed during May and February. The highest percentage of empty guts was recorded in August (18.18%) followed by June and October.

During 2009-10, females with gorged guts showed its highest frequency (36.84%) in September. Dominance of full guts was seen in May and December (53.33% each) and ¾ full in November (50%). Fishes with ½ full guts were encountered during all months except in September and November whereas ¼ full guts were absent during March to June and November to January. ½ full guts were abundant in April (21.43 %) and least in January (5.26%). Highest percentage of occurrence of ¼ full guts was noticed in September (10.53%) while it was very low in February (2.94%). Fishes with trace guts were encountered in October and February while empty guts were observed during August and September with highest percentage in September (21.05%). During 2010-11 gorged guts were recorded in March (45.45%) while fishes with full guts showed highest percentage in May (53.33%) and minimum in March (27.27%). Frequency of ¾ guts were evident in all months with peak percentage in August (46.15%) and lowest in March (9.09%). ½ guts were recorded from October-December, April and July with peak percentage in December (23.53%) and lowest in July (4.76%). Incidence of ¼ full guts were only reported from October and February with a peak percentage in February (13.33%). Fishes with guts having trace quantity were observed only in May, while empty guts were observed during June, August and October with a high percentage in August and October (7.69%).

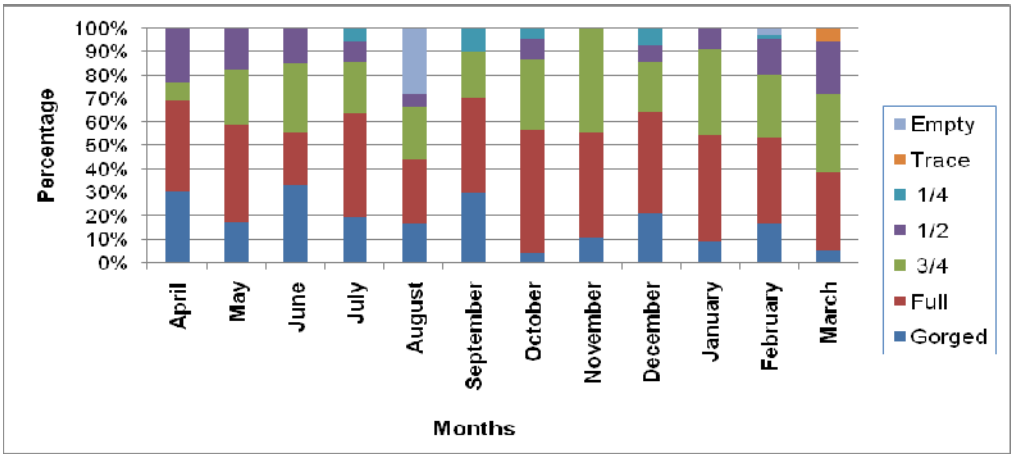


Fig.6.3. Percentage occurrence of guts in different degrees of fullness in males of *H. thomassi* during April 2009-March 2010

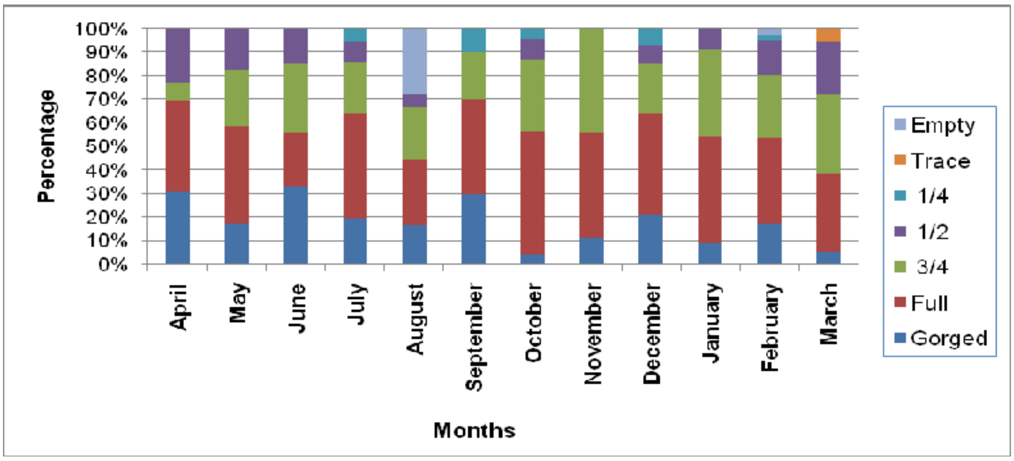


Fig.6.4. Percentage occurrence of guts in different degrees of fullness in females of *H. thomassi* during April 2009-March 2010

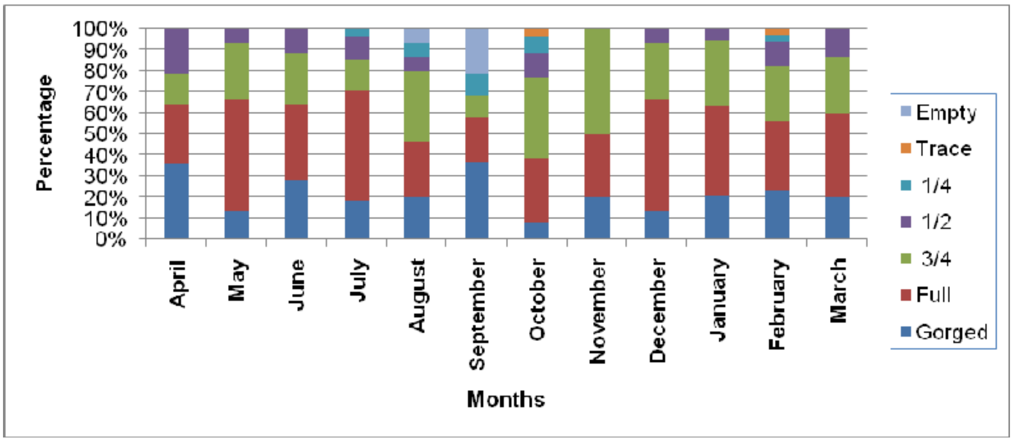


Fig.6.5. Percentage occurrence of guts in different degrees of fullness in males of *H. thomassi* during April 2010-March 2011

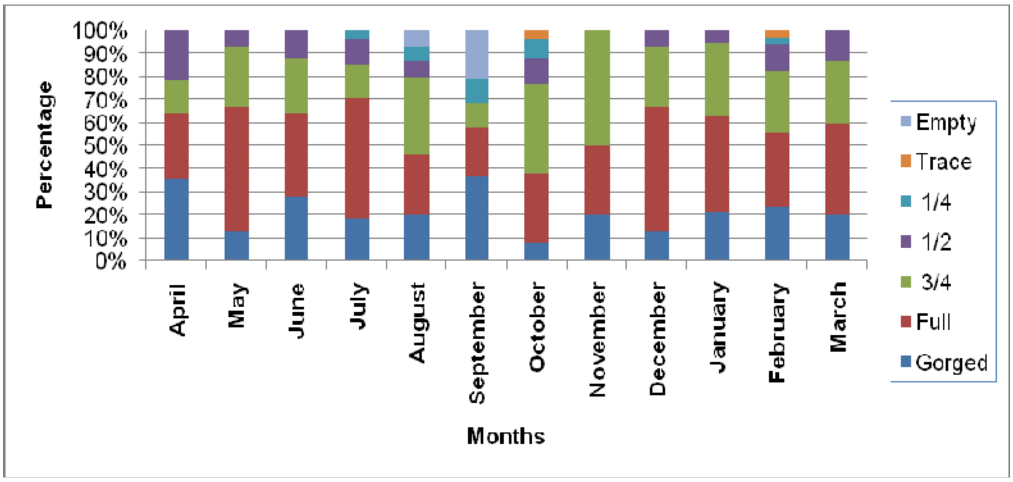


Fig.6.6. Percentage occurrence of guts in different degrees of fullness in females of *H. thomassi* during April 2010-March 2011

6.3.5. Gastrosomatic index

Monthly variations in Gastrosomatic index of male and female *Hypselobarbus thomassi* during 2009-10 and 2010-11 are shown in Figs 6.7 and 6.8 respectively.

In males during 2009-10, a sharp increase in GSI could be noted from July onwards and registered a peak value of 6.4 in September. Thereafter, the GSI showed a decreasing trend in the succeeding months and reached the lowest value of 3.18 in June. During 2010-11 also the GSI showed the similar trend with the highest GSI of 6.6 registered in September. In females, during 2009-10, the GSI gradually increased from 4.1 in July and peaked to 7.2 in September. From October onwards, the GSI declined and reached 3.6 in June. During 2010-11 also the GSI showed a similar trend with a peak in September (7.46).

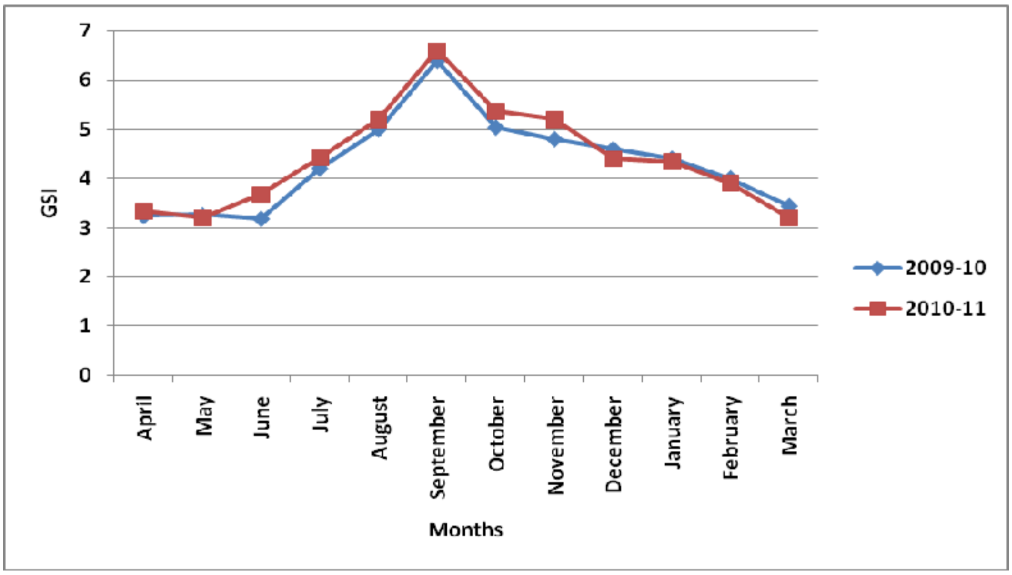


Fig.6.7. Monthly variation in gastrosomatic index of males of *H. thomassi*

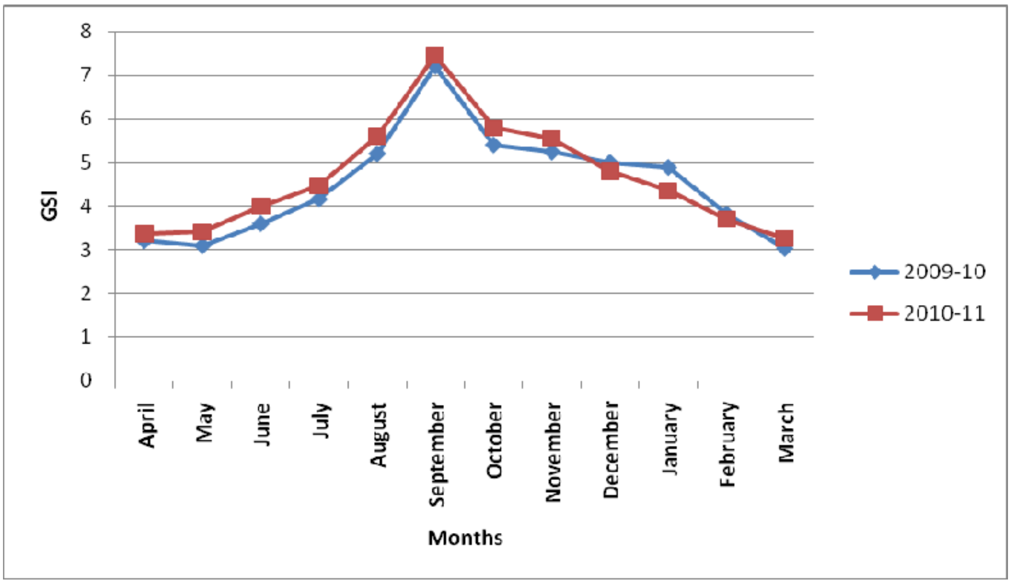


Fig.6.8. Monthly variation in gastrosomatic index of females of *H. thomassi*

Lengthwise variation in GSI of males, females and indeterminates is depicted in Fig.6.9. In males, from a higher value of 4.8 in 160-179 mm size group, the GSI gradually declined to 3.29 in 360-379 mm size group. GSI recorded a similar trend in females. From a higher value of 4.59 in 220-239 mm size group, the GSI gradually declined to 2.98 in 400-419 mm size group. In indeterminates, the highest value of 4.10 was recorded in 240- 259 mm size group. Generally, GSI values of females were found higher than their male counterparts and among the three groups studied, females registered the highest GSI values.

It can also be observed that males, gemales and indeterminates followed almost similar trends in feeding intensity as manifested by gastro-somatic index during both the years with only minor variations (Fig.6.10 and 6.11).

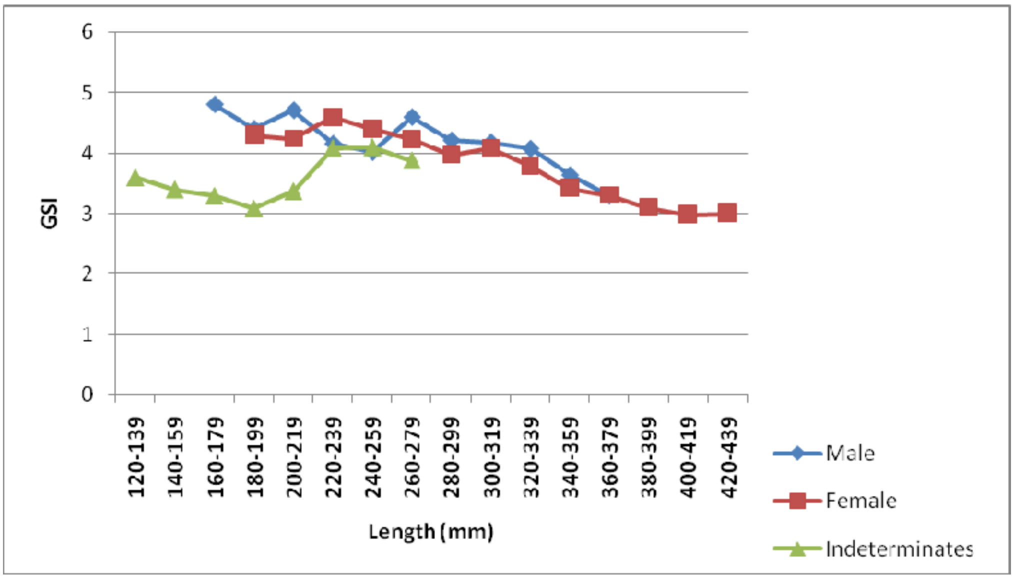


Fig.6.9. Lengthwise variation in gastrosomatic index of *H. thomassi*

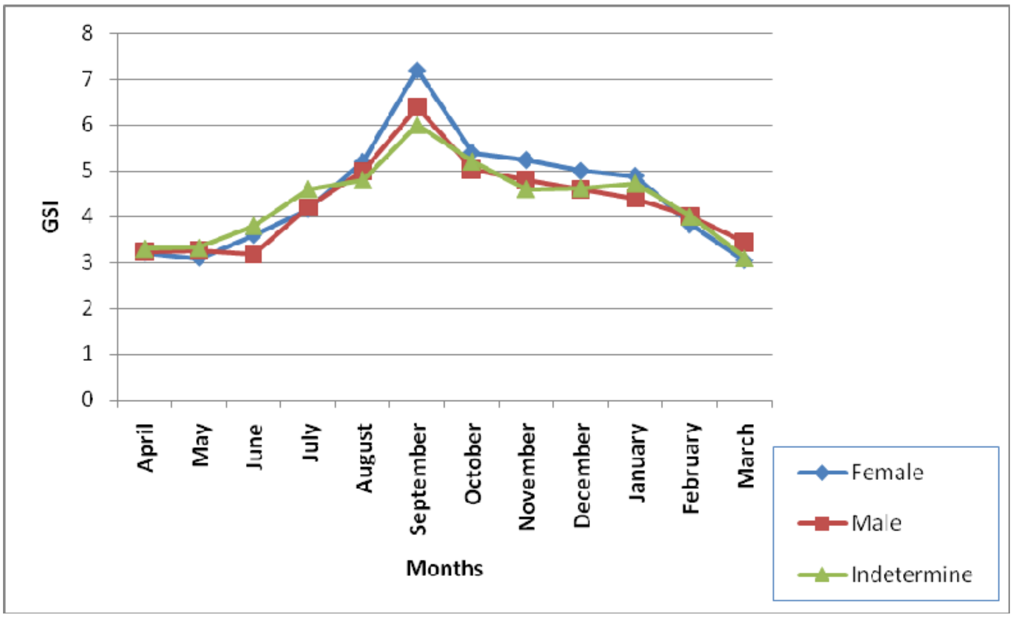


Fig.6.10. Monthly variation in gastrosomatic index of *H. thomassi* during April 2009-March 2010

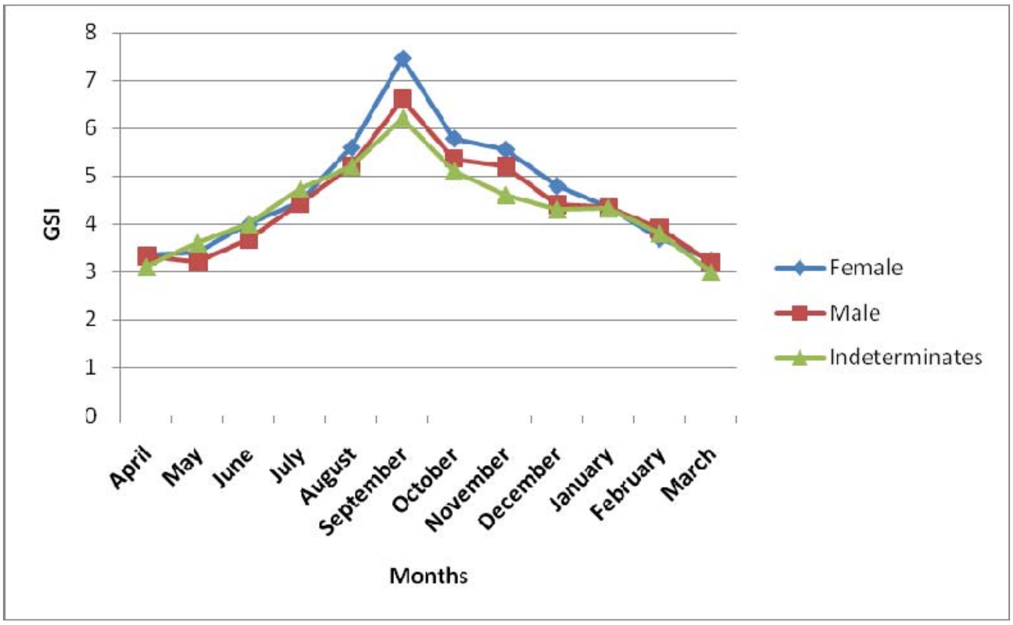


Fig.6.11. Monthly variation in gastrosomatic index of *H. thomassi during* April 2010-March 2011

6.4. Discussion

Knowledge of feeding regimes of fish species is of great importance in understanding their ecological interaction (Alberto *et al.,* 2003). The feeding behavior is a species characteristic formed during its life history (Nilkolsky, 1963). The alimentary canal of fishes is well adapted and modified in accordance with their nature of diet and mode of feeding habits. The structure of alimentary canal and external morphology are influenced greatly by ecology of the food and feeding regimes (Thomas, 1962; Sinha, 1968). The variation in position, shape and size of mouth can be correlated to the dietary habits of fishes.

The length of intestine in fish depends up on its feeding habits. Modification of the intestine (short, moderate, long or coiled) is an indication of its feeding habit- carnivores, omnivores or herbivores (Fukusho, 1969). According to Fryer and Iles (1972), the length of fish intestine is clearly related to the trophic status of the species, being in the order, carnivores < omnivores < herbivores < detritivores. Junger *et al.* (1989) stated that short intestine indicates a tendency towards carnviory. Carnivore fishes normally have short and more or less straight intestine because the meat gets digested more easily, whereas in herbivore fishes, the intestine is long and coiled as the vegetable food items take more time for digestion (Pandey and Shukla, 2005; Serajuddin and Ali, 2005). An intermediate condition is found in omnivores. Jacobshagen (1913) found a direct correlation between nature of food and length of intestine. According to him carnivores fishes have short intestine and plant and mud feeders have long intestine. Longer gut lengths (larger rations) are typical of herbivores that ingest fibrous plant foods that resist digestion, whereas carnivores have shorter length (smaller rations) adapted to processing mostly high quality food (Wootton,1990). According to Nikolsky (1963), gut length less than 100% of body length indicates carnivory while more than

100% indicates herbivory. Low relative gut length (RLG) is indicative of carnivory while greater RLG of herbivory.

The coiling of intestine is regarded as a specific feature of herbivores and omnivores. *H. thomassi* has elongated intestine, which represents the omnivores habit with more affinity towards plant matter. An intermediate value indicates omnivorous mode of feeding (Das and Moitra, 1956a; Das and Nath, 1965; Gupta *et al*., 1999). According to Jobling (1995), the ratio of the intestinal length to body length is usually less than unity in carnivores species. In omnivores, the ratio may increase to around 2-3, and the ratio is even higher in herbivores and those fish species which consumes diet with a high roughage content. Relative gut lengths summarized by Al-Hussaini (1949) and Kapoor *et al.* (1975) ranged from 0.5 to 2.4 for carnivores, 0.8 to 4 for omnivores and 2 to 21 for herbivores. In all dietary categories, both maximal and minimal values for relative gut length tended to increase with body size, but absolute increases was much greater for the herbivores than the omnivores and greater for the omnivores than the carnivores (Kramer and Bryant, 1995).

Junger *et al*. (1989) studied the gut morphology of cyprinid fishes and observed that fishes with RLG ranging between 0.776 and 0.869 showed carnivorous habits while those with values from 0.913 to 1.254 were omnivores, whereas RLG value of 2.053 was recorded in herbivorous species. In the present analysis, RLG values of 0.9 to 2.08 in males, 1.1 to 2.5 in females and 0.7 to 1.5 in indeterminates indicate the tendency towards omnivores. In *H. thomassi,* the RLG values of both sexes increased with increase in total length of the body. The result of the present study is in agreement with that of earlier workers. Das and Moitra (1956 a, b, c, 1958, 1963) observed that in herbivorous fishes *Labeo rohita* and *L. gonius,* the RLG values were about 12.0 and 9.5 respectively and in omnivorous fishes (Das and Nath, 1965), the RLG values were lower, e.g. *Puntius conconius* (3.3) and *Barbus hexastichus* (2.3). In carnivorous fishes RLG values were always the lowest, e.g. *Bagarius bagarius* (0.8) and *Notopterus chitala* (0.4) (Das and Moitra, 1956 a). Dasgupta (2004) observed an average RLG values of 0.70 for carnivorous fishes, 1.37 for omnivorous, 3.70 for planktivorous and 4.77 for herbivorous fishes and the RLG value increased with the increase of plant matter and decreased with increase of animal matter in the gut content.

The analysis of gut contents of *H. thomassi* collected from Kallada river revealed that there exists a strong preference towards plant materials in males, females and indeterminates. Plant matter formed the most preferred category of food consumed regularly by all fishes irrespective of sex and size, followed by blue green algae. Diatoms and mud constituted 3rd and 4th preferential food groups of *H. thomassi* respectively. On the basis of relationship between fishes and their food (feeding preference), Nikolsky (1963) divided fish food in to four categories. (A) basic food-normally eaten by fish and comprise of major part of the gut contents. (B) secondary food-frequently found in the gut, but in small quantities. (C) incidental food-found rarely in the gut. (D) obligatory food- found in the absence of basic food. In accordance with the above categorization, semi digested plant matter, green algae and diatoms could be discerned as the basic food in all groups of *H. thomassi,* while semi digested animal matter coming under the category of secondary food item whereas plant seeds, mud/soil and cyanophyceae can be adjudged as an incidental food item.

According to the diversity of food types consumed, Nikolsky (1963) classified fishes as (A) Euryphagic – feeding on a variety of food (B) Stenophagic-feeding on a few selected type of foods (C) Monophagic- feeding on only single type of foods. Based on this classification, all size and sexes of *H. thomassi,* including indeterminates can be categorized as stenophagic feeders. *H. thomassi,* being selective in its feeding habits. Its food comprises of a narrow spectrum, including plant materials as its main food items and considerably low consumption of green algae, diatoms and animal matter and therefore could be categorized as stenophagic in nature. It is widely accepted that stream fishes are mostly opportunistic in their feeding habits because of the highly variable nature of habitat and resources (Lowe- McConnell, 1987; Degerman *et al.,* 2000). Moreover, stream ecosystems are poor in primary production and the fish species present often depend heavily on allochthonous food resources (insects, leaves, seeds and fruits dropping into the water) (Kortmulder 1987; Allan, 1995).

On the basis of the nature of food consumed and the percentage of ingested food stuff, Das and Moitra (1956a and 1963) applied an improved classification of freshwater teleosts from Utter Pradesh as (A) Herbivorous- more than 75% of food comprise plant material (B) Omnivorous- approximately 50% of both plant and animal food, usually with variation in their percentage neither is less than10-15% (C) Carnivorous-more than 75% of animal matter. Later, two more categories were added: (A) Herbi-omnivorous –fishes in the greater amount of plant foods 2) Carni-omnivorous-greater amount of animal matter. While evaluating *H. thomassi* in the light of above categorization, it appears that this species belonged to herbi-omnivore group because 87% of the food spectrum was comprised of materials from plant origin.

Based on the trophic niches, Das and Moitra (1955) divided fishes in to 3 categories: (A) Plankton eating surface feeder- fishes living in surface water and feeding zoo and phytoplankton while have developed efficient filter mechanism for obtaining food (B) Column or mid feeders-fishes that feed on the mid water organism (C) bottom feeders- They scrap on the surface of bottom stones, rocks to collect detritus. Most of the bottom feeders are benthophagous and detritophagous. The column feeders feeds both surface and bottom food organisms like algae, insects, adult crustaceans, aquatic plants, mud, sand etc. Surface feeders are mainly omnivorous or carnivorous while mid and bottom feeders can be herbivore, omnivore or carnivore (Das and

Moitra,1955). Gupta *et al*. (1999) observed that, the column feeders are characterized by sub-terminal mouth. According to Johnson and Arunachalam (2012), the position of mouth is superior in terrestrial insect feeders like *Barbodes sarana, Devario aequipinnatus* and *Rasbora daniconius,* terminal in vegetal matter feeder *Hypselobarbus dobsoni* and inferior in species that feed in stream bottom (*H. curmuca, H. dubius* and *Puntius* spp.). The sub terminal mouth seen in *Hypselobarbus thomassi* is well adapted to suit its column feeding habit.

A comparison on the food and feeding habits of *H. thomassi* with that of other related species revealed similarities as well as differences in its diet. Johnson and Arunachalam (2012) studied the feeding habits of three species of fishes under genus *Hypselobarbus* i.*e., H. curmuca, H. dubius* and *H. dobsoni* from Thalayani stream of Western Ghats. *H. curmuca* and *H. dubius* mostly ingested macro invertebrates such as molluscs, small crabs and shrimps. Vegetative matter (55.5- 82%) was the dominant food component of *H. dobson*i in wet season which comprised leaves, flowers, fruits and seeds, whereas in dry season, this species consumed a greater portion of detritus. The results of the present study also revealed a similar feeding habitats in *H. thomassi.*

From the present finding, it is understood that the food preferences of *H. thomassi* were more or less same in indeterminates and in both the sexes but there was conspicuous variation in the percentage of occurrence of different food items. Indeterminates showed more affinity towards seeds than both the sexes. While in both male and female the affinity towards the plant matter was almost same. Monthly variation in the gut contents confirmed that indeterminates and both the sexes have identical feeding habits, more or less consuming the same food items, but slight variation in magnitude. As from the results, it could be inferred that the greater portion of the diet comprised of plant matter during throughout the period of investigation. It appeared that among the three major groups of food items such as semi digested plant matter, Blue green algae and diatoms; a decrease in any of the category was duly compensated by another group. During both the years, in males and females, semi digested plant matter showed more or less minor variation. Slight variation also observed in the minor component of the diet of males and females during both years. There is no variation in the diet of *H. thomassi* in relation to sex, size and season.

Fishes with heavily fed (gorged, full and 3/4 full), moderately fed (1/2 full and ¼ full) and poorly fed (Trace and empty) stomachs were observed. The feeding intensity of the fish was found to be very high. During both the years studied, gorged and full gut was found as the dominant category in both sexes, which indicated the voracious feeding nature of this species. The emptiness percentage and stomach fullness indices are very important to assess feeding intensity (Prabha and Manjulatha,2008). Feeding intensity is negatively related to the percentage of empty stomachs (Bowman and Bowman, 1980).

Gastrosomatic index showed an inverse relationship with the occurrence of empty guts. Feeding intensity of fish was related to maturity, spawning and the availability of food items (Malhotra, 1967; Khan *et al.*, 1988;Gowda *et al.*,1988; Keshava *et al.*,1988;Geetha *et al.*,1990; Das and Goswami,1997; Rao *et al.*,1998; Kiran and Waghray,1998; Pandian and Rahman,1999). It appears that in *H. thomassi,* the rate of feeding was very much influenced by the reproductive cycle. Higher feeding activity pointed to the extra requirement of energy and low feeding to the exhaustion caused by spawning. Feeding intensity was found to be less during the pre-spawning and spawning periods in females as indicated by the low gastro-somatic index and low degrees of gut fullness. Higher feeding intensity observed during the periods of June-July and September, might be attributed to the occurrence of (a) spent fishes which tried to make good the loss caused by the reduced rate of pre-spawning feeding and (b) presence of immature individuals which require a rigorous feeding for the ensuing vitellogenesis for the subsequent breeding season. When compared to females, the feeding intensity of males didn't show much variation during pre-spawning and spawning periods. The low pre-spawning feeding intensity seen in females might be due to the pressure exerted on the alimentary canal by the voluminous ovary whereas in males, the testes do not grow much in size. But, it appears that there exists a feeding rhythm in both males and females. A period of high feeding activity was found to alternate with a period of low feeding. Malhotra (1967) reported the fasting in *Botia birdi* during pre-spawning period might be due to the pressure exerted by the voluminous ovary against alimentary canal. The occurrence of poor feeding coincident with peak breeding in other fishes has been reported by Karekar and Bal (1958), Thomas (1969), Desai (1970), Pisolkar and Karamchandani (1981), Khan *et al.* (1988), Kurup (1993 b) and Bhuiyan *et al.*(2006). According to Kiran and Puttaiah (2004), other reason for empty stomachs are regurgitation (Pillay,1952), periodicities in feeding, availability of food, digestibility, physiological reason, health factor and low metabolic activity. Lagler (1952) had suggested that feeding pattern of fishes is influenced by a number of factors such as light intensity, time of day, season, temperature, salinity, pH and any internal rhythm that may exist.

Gastro-somatic index indicated higher percentage of feeding among females than males and indeterminates. Generally females consumed more food than their male counterparts. Higher feeding intensity in females, when compared to males, had been reported by Pandian and Rahman (1999) in *Etroplus suratensis*. Influence of feeding intensity on condition factor was clearly evident during some of the months in both the sexes of *H. thomassi*. This aspect has been dealt with in detail in Chapter 8 on Length-weight relationship and condition factor. Gastro-somatic index indicated high feeding intensity in immature and juvenile fish than the mature ones. This may be due to the very high food requirement in the young and fast growing fish

(Kuthalingam, 1967; Pati, 1980; Armstrong, *et al.,* 1992; Sivakami,1996). Small sized fish actively and more frequently feed than larger ones. This phenomenon has been reported in majority of fish species (Nikolsky, 1963).

The present study indicated that *H. thomassi* showed stenophagism by selecting few organisms in their diet despite the presence of large number of organisms in the habitat. The result revealed that the fish is an "Omnivorous-stenophagic-column feeder", This fish is showing more preference towards plant materials as food. Presence of mud and soil in the gut content indicates the bottom feeding habit of the species. It is obvious that composition and preferences of food are the same in both sexes. But the observation on average quantity of food consumed by both sexes shows that females exhibit a higher feeding intensity than males.

Based on the results of the present study it can be concluded that it would be possible to develop a natural diet of *H. thomassi* which is a very useful approach towards a more sustainable management of their stocks and developing conservation measures. It would also be possible to develop this fish as a substitute for grass carp in composite culture since this species is having voracious feeding habits on plant matters, leaves, stem, roots, fruits and seeds mostly seen in the fringes of the rivers. Since, this species is categorized under critically endangered category, its germplasm needs to be protected and conserved by its rehabilitation in streams through aqua ranching and utilizing of this species in the aquaculture basket of Kerala. Development of captive breeding technique was found to be an immediate prerequisite for the implementation of the above programmes.

.....ഇൻ.....

Chapter 7

REPRODUCTIVE BIOLOGY

Contents

7.1. Introduction

The ability to produce new individuals is one of the fundamental characteristics of living organisms. All multi cellular animals, including fishes have a limited life span and survival of the species therefore depends on the ability of reproduction, a mechanism for the production of its new generation. Reproduction is a very complex process that involves synchronized gametogenesis, development of accessory reproductive organs and secondary sexual characters, migration of fishes to breeding grounds, courtship behaviour, breeding etc. It is the most conservative and the most adaptive function in the propagation and evolution of a species. The success of any fish species is ultimately determined by the ability of its members to reproduce successfully in a fluctuating environment and thereby to maintain a viable population (Moyle and Cech, 1988). Therefore, the reproductive strategy, as reflected in anatomical, behavioral, physiological and energetic adaptation is an essential commitment to future generations. In nature, reproduction is closely correlated with the environmental conditions, particularly the temperature, day length and food supply (Sundararaj and Vasal, 1976; Davies *et al.*, 1999). These environmental factors have great influence on gonadal development and fecundity of a species. During recent years, the natural and anthropogenic factors and stresses have been bringing about drastic reduction in the population abundance of many fish species, even leading to the endangerment of some of them. If any fish species is to be managed, conserved and exploited scientifically, a thorough knowledge on the various intricacies of reproduction is of paramount importance.

Qasim (1973 a), while studying the importance of maturation and spawning of fishes, has stated that the main purpose of such studies is to understand and predict the biological changes undergone by the population. Information on the related aspects such as ecological conditions leading to synchronization of maturity and breeding activity in males and females, size at first maturity, breeding migration, sex ratio, sexual dimorphism, fecundity, etc, are having immense application in conservation and management of fish stocks, in developing captive breeding techniques and in undertaking aquaculture programmes. Size at first maturity is important in determining the size at first capture of a natural population. Fecundity studies have been considered useful in tracing the different stocks or populations of the same fish species in different areas (Gupta, 1968). A study on fecundity is essential from the viewpoints of regeneration, stock recruitment relationships and stock assessment in any water body (Nautiyal and Lal, 1985). The knowledge on maturing time, breeding migration, breeding grounds and aggregation assume importance in various fishery regulation and conservation programmes. Information on breeding habitats and breeding migration helps in identifying habitats that require conservation and declaring them as aquatic sanctuaries.

Information on the reproductive biology of a species is very much essential for the development of aquaculture industry. In order to proceed with the artificial method of reproduction and to produce good quality seeds, it is necessary to have basic information on reproductive biology of fishes. An aquaculturist may require both proximate and ultimate environmental cues that sustain the reproductive cycle. Studies on reproduction including the assessment of maturation cycle, sex ratio, size at first maturity, breeding season, fecundity etc, of a fish species are an essential prerequisite for sustainable management of fisheries. These studies are essentially meant for elucidating both short term and long term variation in the production of broods which are finally recruited in the population as exploitation stocks. Studies on the reproductive biology of freshwater fishes from Indian rivers have been successfully carried out by many authors. Among them notable contributions are Khan (1945), Mookherjee (1945), Ahmad (1948), Ganapati and Alikunhi (1950), Alikunhi (1956), Prabhu (1956), Khanna (1958), David (1959), Sathyanesan (1959), Qasim and Qayyum (1961), Belsare (1962), Das (1964), Saigal (1967), Malhotra (1966,1967), Saxena (1972), Selvaraj *et al.* (1972), Desai (1973), Murthy (1975), Sinha (1975), Chaturvedi (1976), Siddiqui *et al.* (1976 a,b), Chondar(1977), Raina (1977), Joshi and Khanna (1980), Pathani (1980,1981a), Somavanshi (1980,1985), Singh *et al.*(1982), Badola and Singh (1984), Nautiyal (1984), Nautiyal and Lal (1985), Rao and Karamchandani (1986), Shrestha (1986), Sunder (1986), Joshi (1987), Kaushal and Rao (1990), Guha and Mukherjee (1991), Reddy and Rao (1991), Jyoti and Abrol (1992), Kaul (1994), Nath (1994b), Badapanda (1996), Gaur and Pathani (1996), Kiran and Puttaih (2003,2009), Kumar *et al.* (2003), Singh *et al.* (2005), Abdus *et al.* (2006), Kharat *et al.*(2008), Gaikwad *et al.* (2009), Joshi and Pathani (2009), Alam and Pathak (2010), Santhoshkumar and Biswas (2011), Serajuddin and Pathak (2012) and Arthi *et al.* (2013).

Studies on the reproductive behavior and fecundity indices of freshwater fishes in Kerala rivers are very few. Notable among them are Ritakumari and Nair (1978), Kurup (1994b), Kurup and Kuriakose (1994), Euphrasia and Kurup (2008), Radhakrishnan and Kurup (2008), Lekshmi *et al.* (2010), Simmy *et al.* (2011), Bindhu *et al.* (2012) and Seena *et al.* (2012). A thorough review of available literature showed that hitherto no information is available on the reproductive biology of *Hypselobarbus thomassi*. Therefore, a detailed investigation on various aspects of reproduction such as maturity stages, gonadosomatic index, size at first maturity, breeding season, sex ratio and fecundity of *H. thomassi* from Kallada river was carried out in the present study.

7.2. Materials & Methods

The study was based on 384 specimens of *H. thomassi*, with 244 males and 140 females having a size range of 118 mm to 439 mm and 107 to 418 mm in total length respectively. Samples of *H. thomassi* were collected at monthly intervals from April 2009 to March 2011 from Kallada river system (Kerala, South India). The specimens were preserved in 8% formalin after making some perforations in the vent region and brought to the laboratory for further investigation. After removing the excess water by blotting, total length (mm), standard length (mm), total weight (g) and colour of the fishes were recorded. Fishes were dissected out to record the sex (presence of ovaries and testis) and the condition of the gonad. Gonads were taken out and their length and weight were recorded following Kurup and Kuriakose (1994). After assessing the stage of maturation, the ovaries were preserved in 4% formalin for ova diameter and fecundity studies. The spawning season was delineated on the basis of: (1) quantification of maturity stages, (2) the monthly percentage occurrence of fish with gonads in different stages of maturity, (3) pattern of progression of ova during different months and (4) variation in gonadosomatic index.

Based on the method developed by Qayyum and Qasim (1964 a,b,c) and Qasim (1973 a), the testis and ovary were grouped under five maturity stages. Quantification of maturity stages was done following microscopic and morphological characteristics of the gonad such as appearance, colour, degree of distension, relative space occupied in the body cavity and ova diameter measurement. To trace the development of ova, ova diameter was measured from ovaries belonging to all the five stages of maturity, following the method of Clark (1934). A total of 75 ovaries in different stages of maturation were examined. Ova from the anterior, middle and posterior region of each ovary were taken for ova diameter study. Measurements of ova diameter were taken by an ocular micrometer, which was calibrated using stage micrometer. Each ocular micrometer division was equal to 0.014 mm. Ova measurements were classified into groups of 0.2 mm intervals and the monthly percentage frequency of each size group was calculated.

Gonadosomatic index (GSI) was calculated month-wise for males and females applying the formula of June (1953) and Yuen (1955)

$$\text{GSI} = \frac{\text{Weight of gonad}}{\text{Weight of fish}} \times 100$$

The length at first maturity defined as the length at which 50% of all individuals within a population are sexually mature (Lm_{50}) (Kagwade, 1968; Geevarghese and John, 983; Kurup, 1994) where the mature individuals are characterized by the presence of spermatophores or ova in gonads. This can be well described by a logistic function. A logistic curve was fitted for the proportion of sexually mature males and females (P) by total length (L) adapting to the equation of Rickey (1995), P=1/ (1+exp $^{(a+b)\ L}$), where a and b are parameters. The parameters of this equation was made by correlation analysis of variables P and L after linearization. Size at first maturity was calculated from the ratio between the constants a and b (Lm_{50}) = - (a/b).

Sex-ratio was analyzed month wise and size-wise. Chi-square formula (Snedecor and Cochran, 1967) was employed to test whether the observed ratio between males and females deviated from the expected 1:1 ratio for the two sexes using the formula:

$$X^2 = \frac{(O-E)^2}{E}$$

Where, O = observed number of males and females in each month/ length group

E = expected number of males and females in each month/ length group

Fecundity was estimated on the basis of 20 ripe ovaries of *H. thomassi* in the length range of 234mm to 418 mm. Sub samples from the anterior, middle and posterior regions of the ovary were weighed and the number of ova in each sub-sample was counted manually. Fecundity was estimated by the gravimetric method, applying the formula:

F = nG/g

where F = Fecundity

n = number of eggs in the sub-sample

G = Total weight of the ovary

g = weight of the subsample

Relative fecundity indices such as the number of ova produced per gram weight of the body (Bagenal, 1963), the number of ova produced per gram ovarian weight were calculated. Similarly, coefficient of maturity was calculated as the ovarian weight as percentage of total fish weight (Bagenal and Braum, 1968). The gonadosomtic index was calculated as the ovarian weight in relation to the fish weight excluding the ovary weight (Somavanshi, 1985). Regression analysis was employed to find out the correlation between fecundity and various body parameters such as total body length, total body weight, ovary length and ovary weight and also between ovary weight and parameters such as total body length and total body weight.

7.3. Results

As in most teleosts, the gonads in male and female *H. thomassi* are paired, elongated structures lying on the side of air bladder ventral to kidneys. The ovary is attached to the dorsal wall of body cavity by mesovarium and the testes by means of mesoarchium. Posteriorly, the two lobes of ovary unite to form a short oviduct, which opens to exterior by the genital aperture. The testes communicate to the exterior through the genital aperture and sperm duct.

7.3.1. Stages of maturation

The following stages of maturation were identified in males and females of *H. thomassi*

Degree of Maturation	Description
Immature virgins	**Ovaries**: Slender, elongated jelly-like, flesh coloured, occupy a little more than ¼ of the body cavity. Ova invisible to the naked eye.
	Testes: Extremely thin, thread-like, translucent, occupy nearly 1/5 of the body cavity.
Maturing virgins	**Ovaries**: Somewhat flattened pale yellow, occupy ½ of the body cavity.
	Testes: Opaque, firm, white, occupy nearly 1/3 of the body cavity.
Ripening	**Ovaries**: Slightly cylindrical, yellow. Opaque, occupy ¾ of the body cavity, the inner side slightly depressed to accommodate the gut. Usually asymmetry observed between the two lobes of ovary.
	Testes: Creamy white, lobulated with irregular outer margin, occupy ½ of the body cavity

Ripe **Ovaries**: Considerably enlarged, occupy nearly the entire length of the body cavity, golden yellow in colour, distended outer membrane, loosely arranged and clearly visible mature and ripe ova having a diameter ranging from 1.9-3 mm. The ovary is highly vasculated with rich blood supply.

Testes: Very soft, cream coloured, occupy more than ¾ of the body cavity.

Spent **Ovaries**: Shrunken, flaccid, blood shot, translucent, occupy a little more than ½ of the body cavity. Few residual eggs, which are in different stages of maturity were observed.

Testes: Shrunken, flabby, partly opaque and partly semitransparent occupy less than ½ of the body cavity.

7.3.2. Monthly percentage occurrence of fish with gonads in different stages of maturity

The monthly percentage occurrence of males and females in different stages of maturity during 2009-10 and 2010-11 are shown in Fig. 7.1 and 7.2 respectively. In males, the immature individuals (Stage I) appeared from October onwards and reached the maximum in December and were contributed to 83.3% in 2009-10 and 62.5% during 2010-11. After January, Stage I individuals showed a sharp decline and after March their presence in the catch was not observed. Recovering spent (Stage II) fishes started to appear in the catch from November onwards and reached a peak during February in 2009-10 with a contribution of 68.75 % and during March (66.67%) in 2010-11. From April onwards the Stage II individuals showed a sharp decline. Fishes with gonads of stage III or ripening individuals appeared in the catch from December onwards and reached the peak in April in 2009-10 and April and May in 2010-11 contributed 77.88% and 71.43% respectively. Ripe (stage IV) individuals were available in the catch from May onwards and reached the peak during July and were contributed 62.5% in 2009-10 and 71.43% in 2010-11. Spent (stage V) fishes were present from July onwards and reached the peak during October and showed their presence in the catch up to November.

In females the immature (stage I) individuals appeared in the catch from September to March and reached the peak in December in 2009-10 and January in 2010-11, contributed of 80% and 75% respectively. Maturing virgins of fishes with gonads in Stage II appeared in the catch from December onwards and reached the peak during February with a contribution of 66.66% during 2009-10 and March (71.43 %) in 2010-11. After May, maturing virgins were not observed in the catch. Ripening (Stage III) fishes appeared in the catch from December onwards and reached the peak during April with a contribution of 75% during 2009-10 and April and May (75% each) in 2010-11. Fishes with gonads in stage III condition showed their presence in the catch till August in 2009-10 and July in 2010-11. Ripe (Stage IV) fishes appeared in the catch from May to October and reached its peak during June and September with a contribution of 66.67% during 2009-10 and June (75%) in 2010-11. Spent (stage V) fishes appeared in the catch from July to November and reached the peak during October with a contribution of 62.5% during 2009-10 and 71.42% in 2010-11.

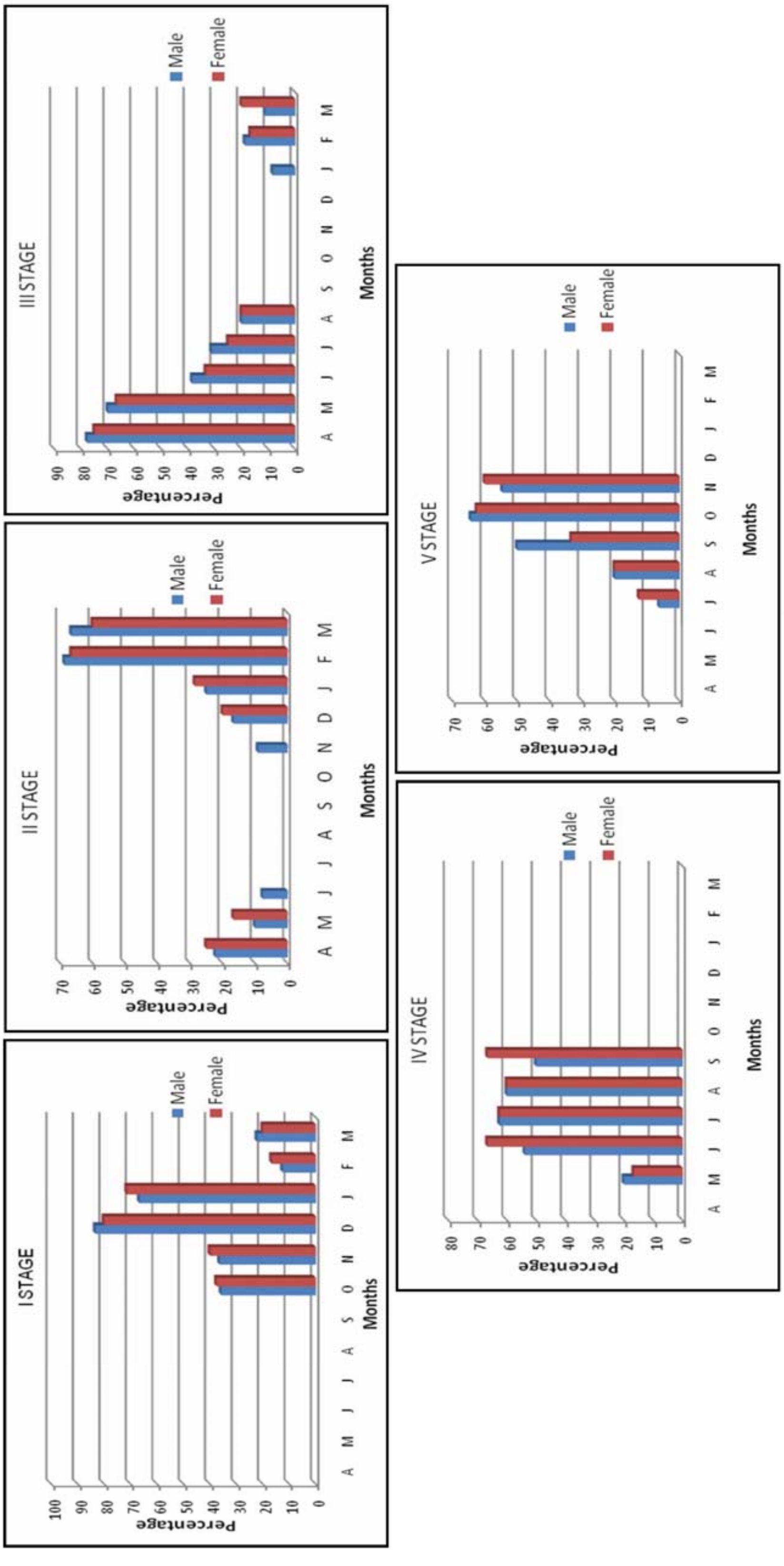


Fig.7.1. Monthly percentage occurrence in gonads in different stages of maturity of *H. thomassi* during 2009-10

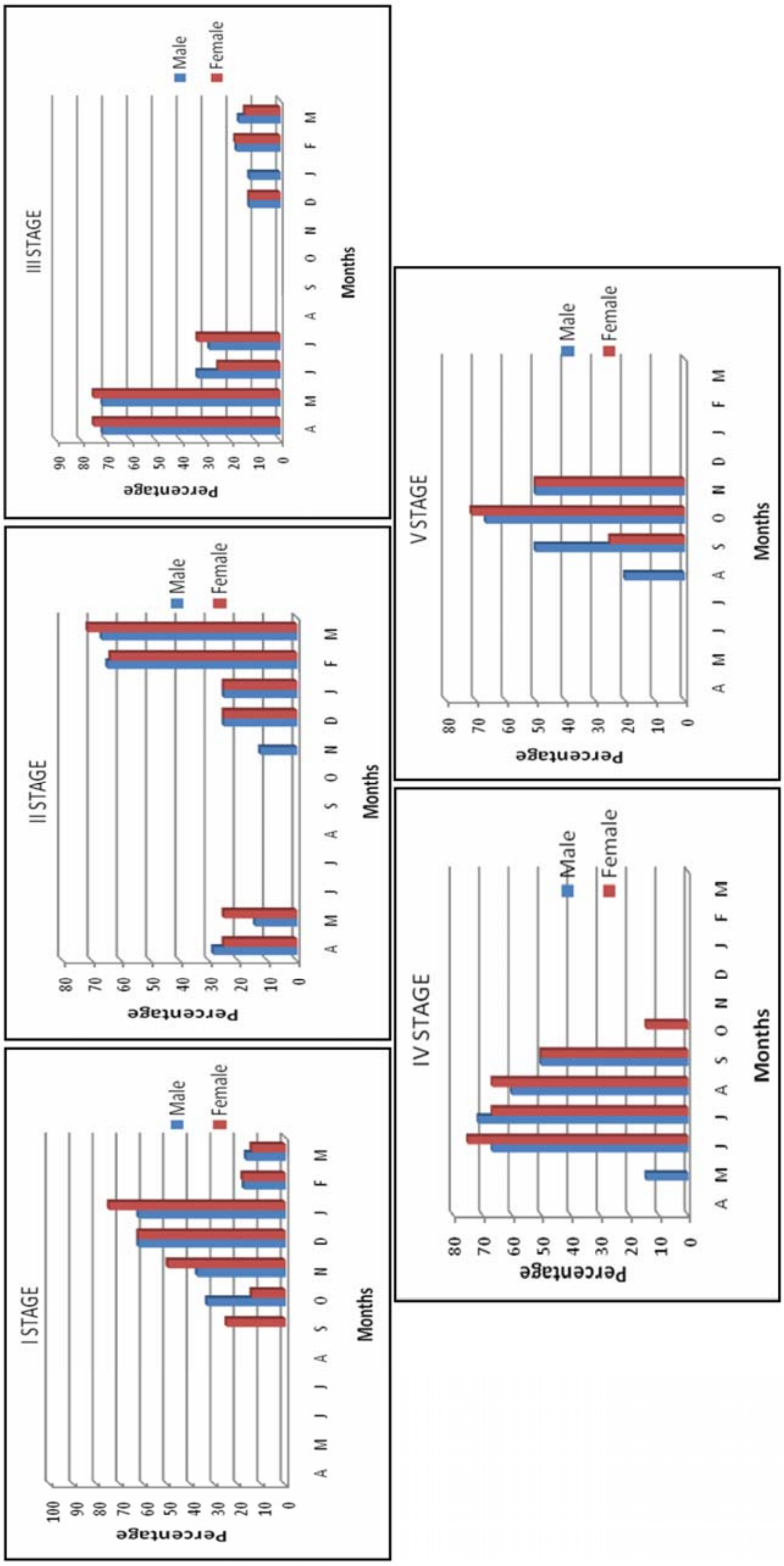


Fig.7.2. Monthly percentage occurrence in gonads in different stages of maturity of *H. thomassi* during 2010-11

7.3.3. Pattern of progression of ova during different months

The pattern of progression of ova during January to October is depicted in Fig. 7.3. All the ova less than 1.2 mm diameter were immature. The next group of ova between 1.2-1.4 mm was identified as maturing ones. The ova in the range between 1.4-1.8 mm were belonged to the ripening eggs. Ova measuring 1.8 mm and above were in fully ripe condition. The development of ova during different months showed the preponderance of immature and maturing ova during January and February. Oocytes up to 1.8 mm were appeared in March. The ripening oocytes were very prominent in April. In May the ova diameter ranged between 1.2 to 2.2. During June and July the ova diameter ranged between 1.4-2.6 mm size class and the ripe ova contributed to 73% and 78% respectively during both the months. During June, July, August only ripening and ripe eggs having diameter ranged between 1.4 mm to 2.6 mm were observed in the ovary.

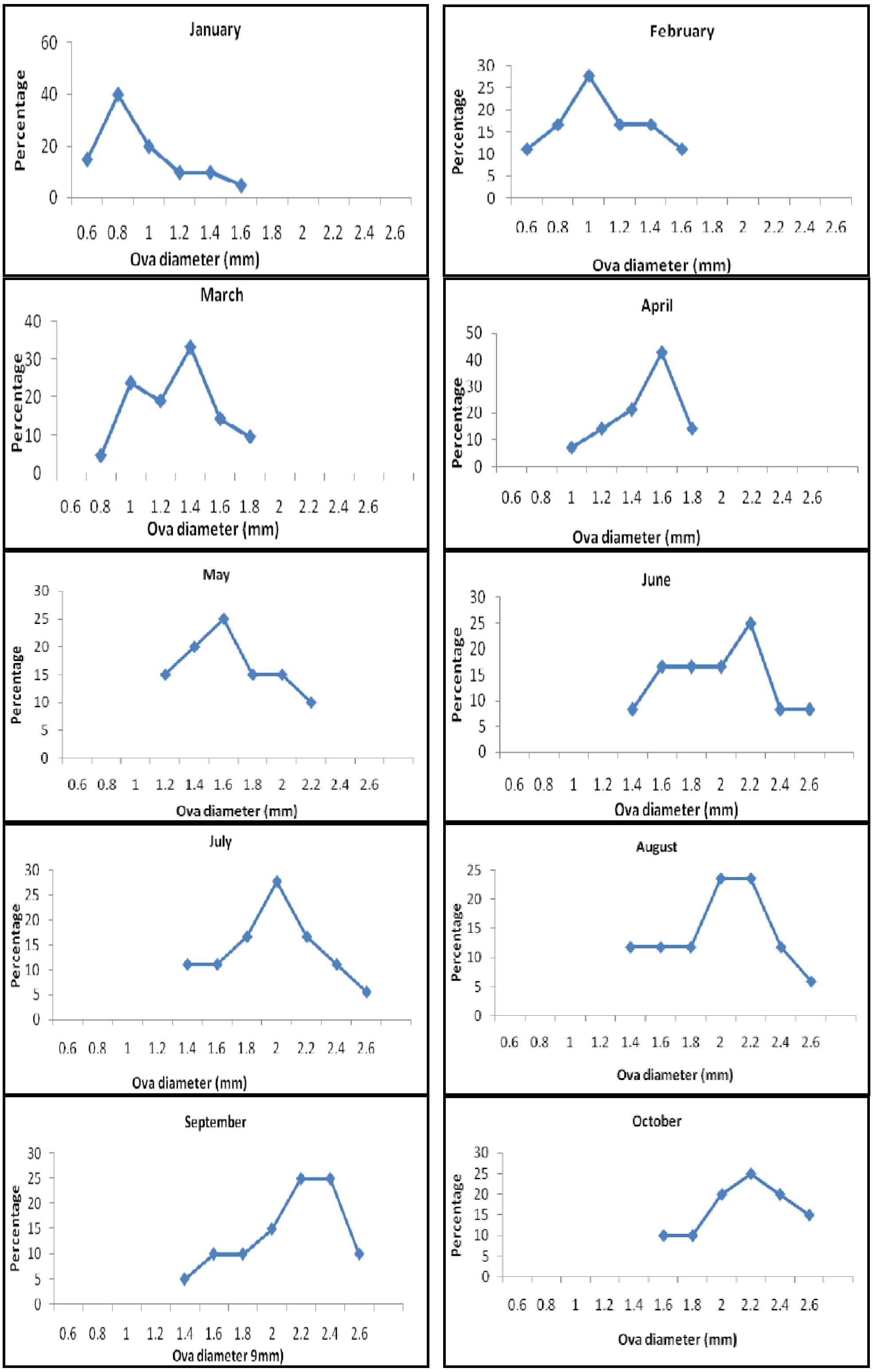


Fig.7.3. Monthly variation in ova diameter percentage frequency of *H. thomassi*

7.3.4. Gonadosomatic index

The mean monthly variation of gonadosomatic index (GSI) values of males and females during April 2009 to March 2010 and April 2010 to March 2011 are depicted in Fig.7.4 and 7.5 respectively. During 2009-10, the testicular weight started increasing from November (0.12) and attained the peak in July and September (1.4 each). After September, the GSI showed a drastically declining trend. The trend was more or less the same during 2010-11 except for the variation in the values. Females showed distinct seasonality in GSI values similar to those of males. Index values were lowest in November (0.32) and steadily increased to a peak in August (3.42) during 2009-10. The GSI value showed a declining trend from October onwards and reached the lowest level during November. A similar trend could also be describe in female GSI in 2010-11.

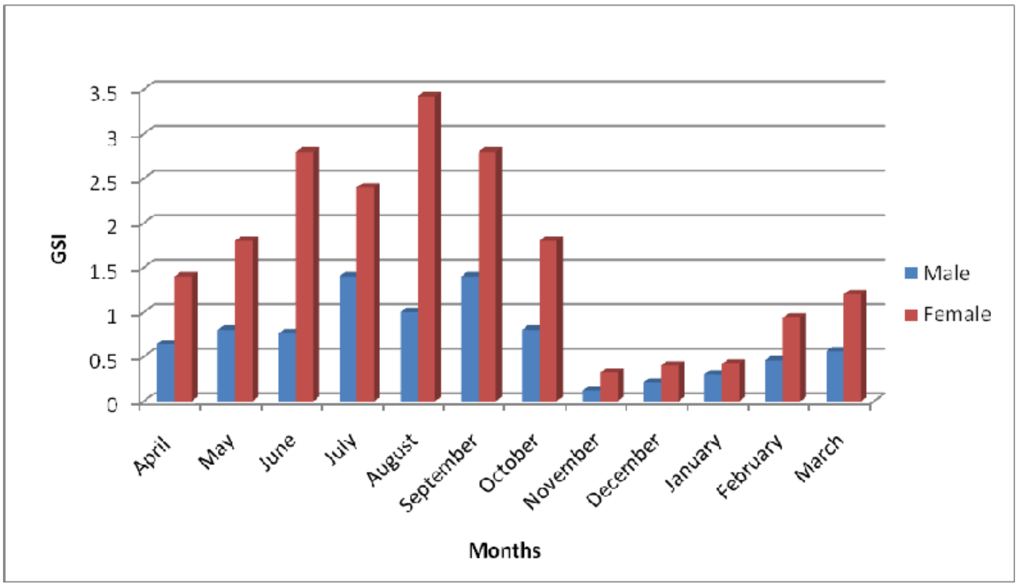


Fig.7.4. Monthly variation of gonadosomatic index in *H.thomassi* during 2009-2010

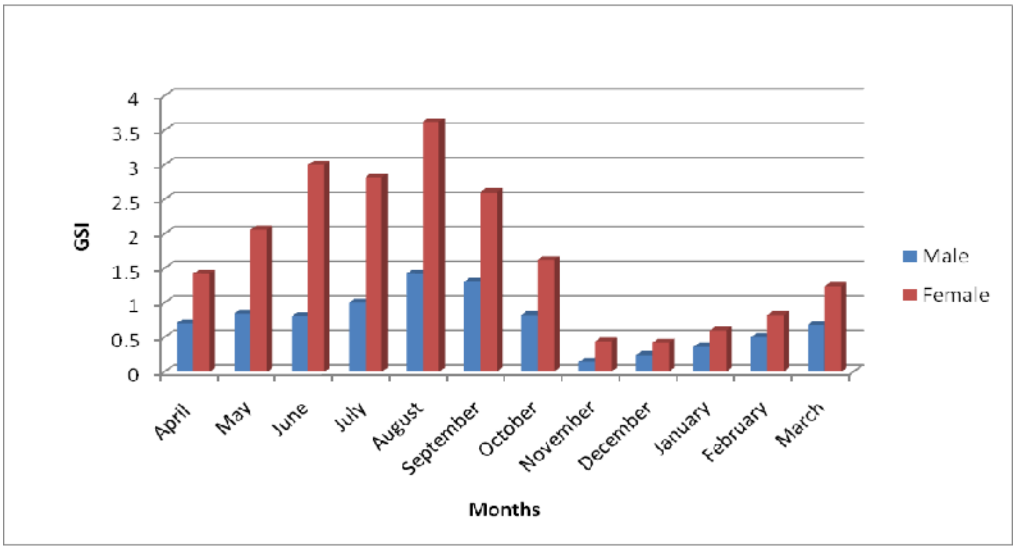


Fig.7.5. Monthly variation of gonadosomatic index in *H.thomassi* during 2010-11

7.3.5. Length at first maturity

Occurrence of males and females at different stages of maturity in various size groups are shown in Table 7.1 and 7.2 respectively. Stage I and II of both testes and ovary were arbitrarily considered immature and the subsequent stages mature. It appeared that in females, specimens up to 300 mm total length and in male specimens up to 280 mm were belonged to immature and maturing fishes. The percentage of ripening fishes increased rapidly up to 260 mm TL in both males and females beyond which there was a sudden increase in the occurrence of fishes with ripe gonads. The smallest ripe male and female belonged to 220-239 mm size group.

The sexual maturity phases corresponding to the length groups for male and female individuals is depicted in Fig.7.6 and 7.7. The obtained finding displayed that male *H. thomassi* reached their first maturity at the length of 290.2 mm whereas the first maturity of the female ones were observed to be 330 mm. Thus, males were found to mature at a lower size than their female counterpart.

Table 7.1. Maturity stages (in %) in different length groups of male *H. thomassi*

Length group (mm)	Maturity Stages				
	1	2	3	4	5
160-179	100				
180-199	33.33	33.33	33.33		
200-219	56.52	34.78	8.70		
220-239	44.19	23.26	13.95	13.95	4.65
240-259	28.85	19.23	13.46	21.15	17.31
260-279		36.36	24.24	15.15	24.24
280-299	3.45	34.48	27.59	17.24	17.24
300-319	5	5	25	40	25
320-339			43.75	43.75	12.50
340-359		16.67	33.33	33.33	16.67
360-379				50	50
380-399				100	
400-419					
420-439					100

Table 7.2. Maturity stages (in %) in different length groups of female *H. thomassi*

Length group (mm)	Maturity Stages				
	1	2	3	4	5
140-159	100				
160-179					
180-199	75		25		
200-219	66.67	33.33			
220-239	52.38	28.57	9.52	4.76	4.76
240-259	35.29	29.41	17.65	11.76	5.88
260-279	8.33	20.83	29.17	25	16.66667
280-299		15.79	15.79	52.63	15.79
300-319		22.73	31.82	18.18	27.27
320-339		10	30	50	10
340-359			50	50	
360-379				50	50
380-399				100	
400-419					100
420-439					

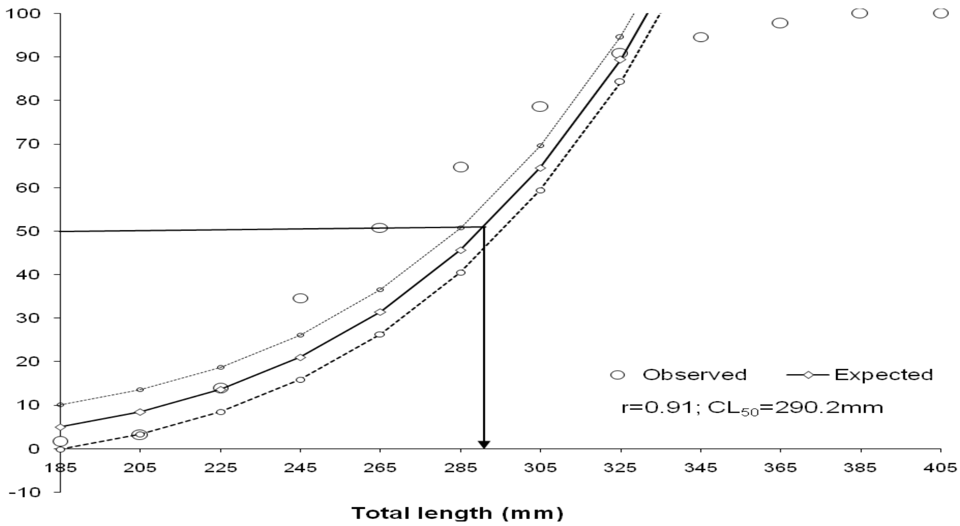


Fig.7.6. Logistic function fitting proportion of matures males of *H. thomassi* as function of size class

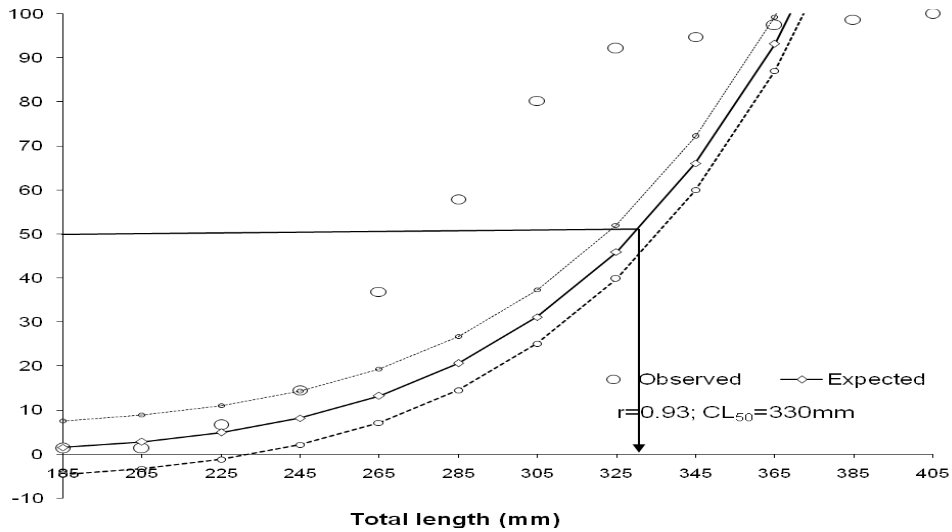


Fig.7.7. Logistic function fitting proportion of matures females of *H. thomassi* as function of size class

7.3.6. Sex ratio

Due to the absence of sexual dimorphism in *H. thomassi* the fishes were sexed by gonadal examinations. Out of 384 specimens examined, 244 males and 140 females could be identified. The month wise distribution of the two sexes (Table.7.3) revealed that the sexes were disproportionate in the population. Males outnumbered the females in most of months during 2009-10 except in August, December, January and March. Chi-square test confirmed the significant dominance of males during 2009-10 (Table 7.3). During 2010-11, the preponderance of males in all months except August and November were glaringly evident from the chi-square values. During August and November the females showed significant dominance in the population. Though there was considerable variation in the distribution of the sexes in some of the months of both the years, the overall sex ratio showed significant dominance of males. The ratio of males to females was 1:0.58 for the year 2009-10 and 1:0.56 for 2010-11 and the respective chi-square values of 13.98 and 14.21 lend to support to the above observation that the sex ratio significantly skewed from the expected 1:1 ratio ($P<0.01$).

Table 7.4.shows the variation in sex ratio among the various size groups. Chi-square values indicated that there was significant variation from 1:1 ratio in the size groups between 180 and 399 mm TL. The chi-square value of 28.17 for the overall sex ratio showed that the variation was highly significant ($p<0.01$).

Table 7.3 Sex ratio of *H. thomassi* during different months of 2009-10 and 2010-11

Months	Total	Male	Female	M:F	Chi square	Probability
2009-2010						
April	16	12	4	0.33	4.00	P<.05
May	22	16	6	0.38	4.55	P<.05
June	19	14	5	0.36	4.26	P<.05
July	27	19	8	0.42	4.48	P<.05
August	13	5	8	1.60	0.69	P>0.5
September	9	6	3	0.50	1.00	P>0.5
October	21	15	6	0.40	3.86	P<.05
November	14	9	5	0.56	1.14	P>.05
December	11	4	7	1.75	0.82	P>.05
January	11	4	7	1.75	0.82	P>.05
February	29	20	9	0.45	4.17	P<.05
March	9	3	6	2.00	1.00	P>.05
Total	**201**	**127**	**74**	**0.58**	**13.98**	**P<.01**
2010-2011						
April	16	12	4	0.33	4.00	P<.05
May	8	5	3	0.60	0.50	P>.05
June	26	18	8	0.44	3.85	P<.05
July	14	11	3	0.27	4.57	P<.05
August	10	3	7	2.33	1.60	P>.05
September	6	4	2	0.50	0.67	P>.05
October	15	10	5	0.50	1.67	P>.05
November	14	5	9	1.80	1.14	P>.05
December	26	18	8	0.44	3.85	P<.05
January	9	5	4	0.80	0.11	P>.05
February	25	18	7	0.39	4.84	P<.05
March	14	8	6	0.75	0.29	P>.05
Total	**183**	**117**	**66**	**0.56**	**14.21**	**P<.01**

Table 7.4 Sex ratio in *H. thomassi* at various length groups

Length group (mm)	Total	Male	Female	M:F	Chi square	Probability
140-159	1	0	1		1.00	P>.05
160-179	3	3	0	0	3.00	P>.05
180-199	10	6	4	0.67	0.40	P>.05
200-219	37	22	15	0.68	1.32	P>.05
220-239	64	43	21	0.49	7.56	P<.05
240-259	63	46	17	0.37	13.35	P<0.1
260-279	64	40	24	0.60	4.00	P<.05
280-299	53	34	19	0.56	4.25	P<.05
300-319	37	15	22	1.46	1.32	P>.05
320-339	31	21	10	0.48	3.90	P<.05
340-359	9	6	3	0.50	1.00	P>.05
360-379	6	4	2	0.50	0.67	P>.05
380-399	4	3	1	0.33	1.00	P>.05
400-419	1	0	1		1.00	P>.05
420-439	1	1	0	0.00	1.00	P>.05
Total	**384**	**244**	**140**	**0.57**	**28.17**	**P<.01**

7.3.7. Fecundity

Fecundity is determined as the total number of ova shed by the mature fish in a spawning season. The average values of fecundity indices of *H. thomassi* are given in Table 7.5. Relationship of fecundity with total body length, body weight, ovary length and ovary weight were worked out by regression analysis and the results are depicted in Figs 7.8 – 7.11. Fig.7.12 and 7.13 represents the regression of ovary weight on total body length and body weight.

7.3.7.1. Fecundity indices

The absolute fecundity varied from 305-1089 eggs in specimens ranging from 234–418 mm in total length and the average was worked out to be 720 ova. The number of ova per gram ovarian weight varied between 77.33 (311mm TL) and 220.69 (256mm TL), with the average 124.53. Gonosomatic values varied between 1.17 (220—239 mm size group) and 2.57 (300-319mm size group) and registered an increasing trend up to 300-319 mm length group, followed by a diminishing trend.

Table 7.5. Average values of fecundity indices in the spawners of *H. thomassi*

Length group (mm)	Average fish length (mm)	Average fish weight (g)	Average ovarian weight (g)	No of specimen examined	No of ova/g fish weight	No of ova/g of ovarian weight	GSI	Absolute fecundity
220-239	234	138	1.62	1	2.21	188.5	1.17	305
240-259	256	160	2.6	1	3.59	220.7	1.63	574
260-279	269.8	191.2	3.34	5	2.69	164.9	1.65	479
280-299	286.67	240.67	5	3	2.65	126.7	2.10	635
300-319	306.6	309.4	7.96	5	2.52	103.7	2.57	778
320-339	320	388	9	1	2.55	110.0	2.32	990
360-379	364.5	571	10	2	1.66	92.5	1.78	928
400-419	414	840	11.5	2	1.27	92.7	1.37	1063

The no ova per gram of fish weight was estimated to be vary between 1.15(418 mm TL) and 3.59 (256 mm TL) with an average of 2.34

7.3.7.2. Relationship between fecundity and body parameters

Fecundity and total length (TL) showed a straight line relationship when expressed logarithmically (Fig.7.8). The regression equation thus arrived at is:

$$\text{Log } F = -2.04194 + 1.9628 \text{ Log } TL$$

The degree of correlation indicates that the number of ova produced have a direct relationship with the length of the fish.

The fecundity and body weight also showed a linear relationship. The regression equation between fecundity and fish weight (Fig.7.9) was found to be

$$\text{Log } F = 1.4351 + 0.5644 \text{ Log } W$$

Fecundity was related to the measurements of ovary, the ovary length (OL) (Fig.7.10) and ovary weight (OW) (Fig.7.11) which can be expressed as follows

Log F =3.4456-0.3085 log OL

Log F = 2.4168+0.5518 log OW

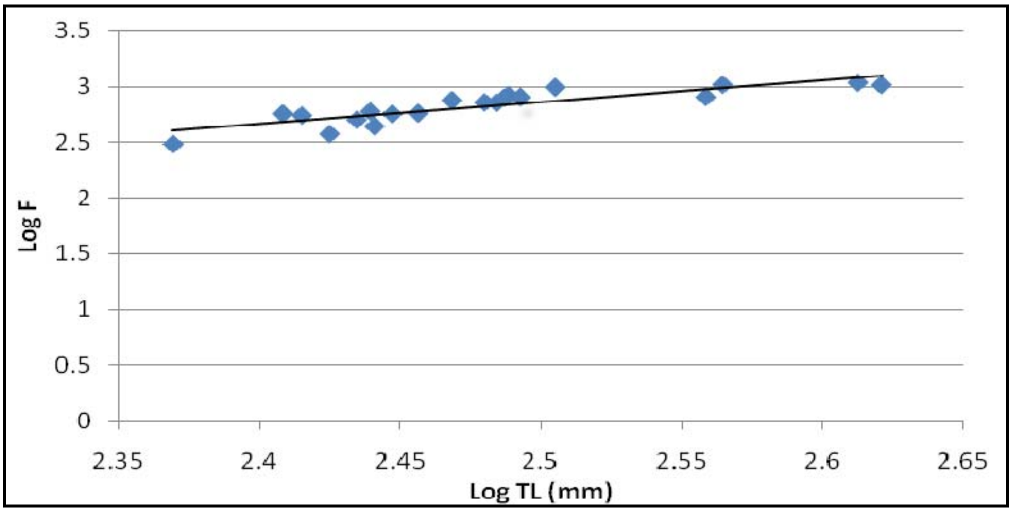
The results indicated a direct proportional increase in fecundity with increase weight of the ovary. On the contrary, fecundity was not directly proportional to ovary length.

The regression equation of ovarian weight (OW) on body weight (TL) (Fig.7.12) and body length (W) (Fig.7.13) are given below

Log OW = -1.6631+0.9758 log W

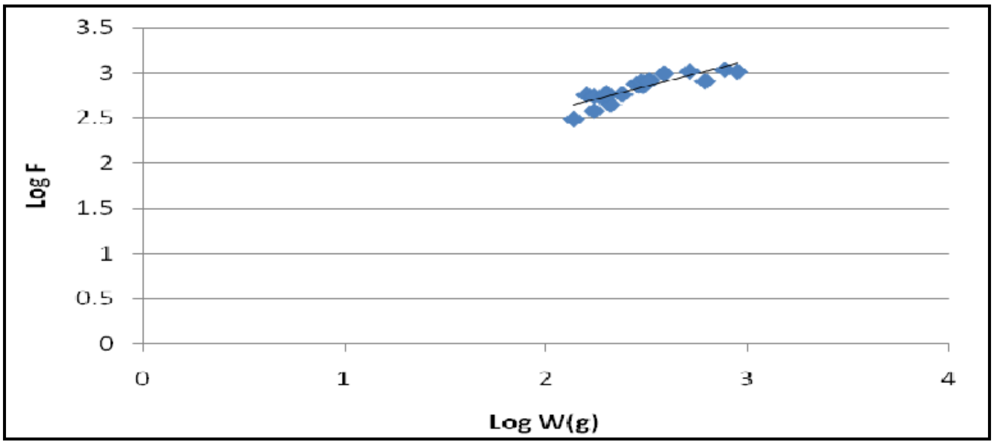
Log OW = -7.6860+3.3980 log TL

The results indicated a direct proportional increase in ovary weight with increase in total length and weight.



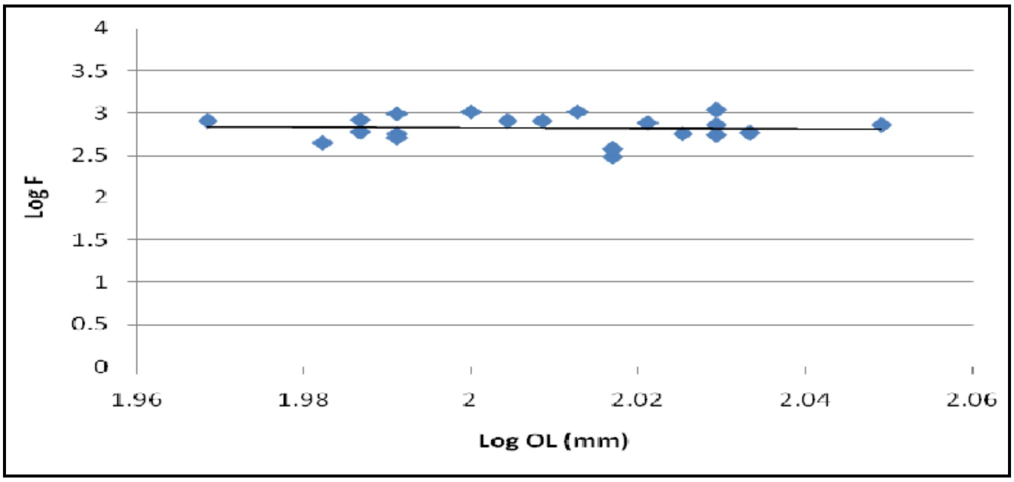
Log F=-2.04194 + 1.9628 Log TL

Fig.7.8. Relationship between fecundity and total length of *H. thomassi*



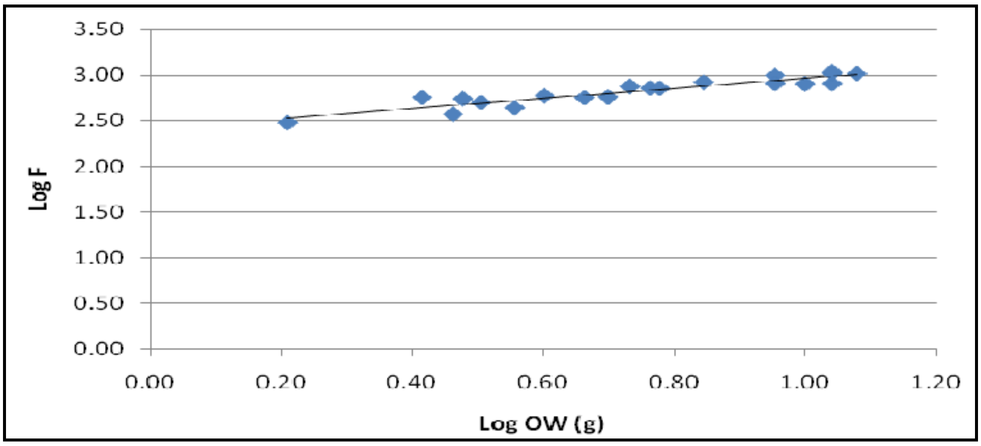
Log F = 1.4351+ 0.5644 Log W

Fig.7.9. Relationship between fecundity and total weight of *H. thomassi*



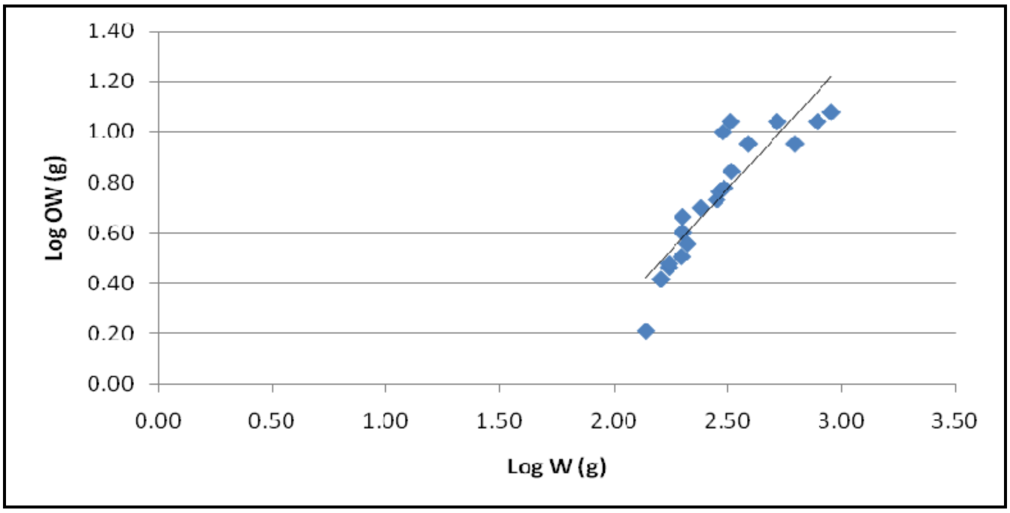
Log F =3.4456-0.3085 log OL

Fig.7.10. Relationship between fecundity and ovary length of *H. thomassi*



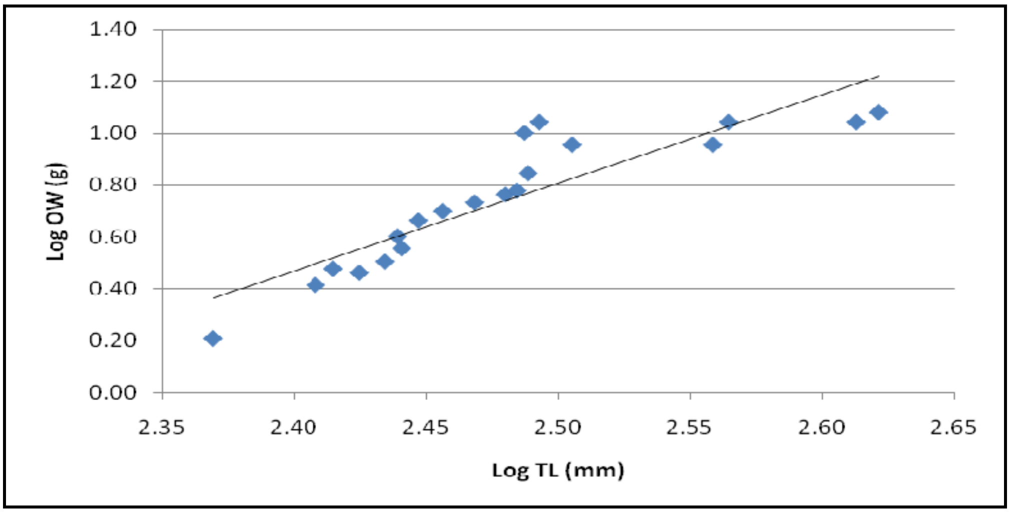
Log F = 2.4168+0.5518 log OW

Fig.7.11. Relationship between fecundity and ovary weight of *H. thomassi*



Log OW = -1.6631+0.9758 log W

Fig.7.12. Relationship between body weight and ovary weight of *H. thomassi*



Log OW = -7.6860+3.3980 log TL

Fig.7.13. Relationship between total length and ovary weight of *H. thomassi*

7.4. Discussion

The male and female reproductive organs of *Hypselobarbus thomassi* are built on the general teleostean pattern. The paired testes in teleost fishes are either fused along the entire length or completely separate or fused posteriorly. In *H. thomassi*, the testes are united at the posterior region to form a spermatic duct as reported in *Channa gachua* (Sanwal and Khanna, 1972), *Barbus tor* (Rai,1965), *Schizothorax richardsonii* (Bisht, 1974) and *S. plagiostomus* (Agarwal, 1996).

Breeding season was ascertained by applying indirect methods such as quantification of maturity stages, monthly occurrence of gonads in different stages of maturity, monthly progression of ova towards maturity and seasonal variations in the gonado-somatic index. Results of the two years data have shown that as far as occurrence of gonads in different stages of maturity is concerned, both the males and females followed almost similar trend. During December, all fishes collected belonged to immature and maturing stages Thenceforth, majority of the fishes underwent ripening rapidly and by the end of February, majority of the males and females were in the virgin maturing stage. At the end of April, most of males and females reached the ripening stage. From the end of May onwards ripe males appeared in the population. While maximum number of ripe males appeared in the population during July. In the case of females, ripe fishes were observed in the population from May to September with a peak during June. Females showed strong variation in their occurrence from June to September.

Though ripe individuals appeared in insignificant numbers during May, the presence of spent fishes was observed only by July in females, which would suggest that actual spawning might have commenced in June. The fish might have completed its spawning by the end of October, as manifested by the total absence of spent fishes during December and January. Based on the results of the present study, it can well be concluded that *H. thomassi* inhabiting Kallada river has a prolonged spawning period extending from June to October with a distinct peak during June –August.

It is well known that ova diameter measurements can give reliable evidence about the time of spawning and spawning periodicity of fishes. Clark (1934) made the first attempt to study the maturity of California sardine

(*Sardina caerulea*) based on the size frequency of ova in the ripe ovary. This method has been successfully applied for delineating the spawning period of many Indian fishes by several authors (Prabhu, 1956; Qasim and Qayyum, 1961; Sathyanesan, 1962; Annigeri, 1963; Bhatnagar, 1967; Desai and Karamchandani, 1967; Qasim, 1973a; Murty, 1975; James and Baragi, 1980; Jayaprakas and Nair, 1981; Thakre and Bapat, 1981; Geevarghese and John, 1983; Kurup, 1994b; Santhoshkumar and Biswas, 2011; Bindhu *et al.,* 2012, Seena *et al.*, 2012; Serajuddin and Pathak, 2012; Arthi *et al.*, 2013 and Mercy *et al.*, 2013).

In *H. thomassi*, all the ova measuring 1.8 mm and above were fully ripe while the group having diameter between 1.4-1.8mm were the ripening ones. Those falling below 1.4 mm were adjusted as maturing and immature groups. From the appearance of largest oocytes of 2.59 in fully ripe conditions in June and 2.55 in October, it can be concluded that this species starts spawning during June and this is in close agreement with the spawning season delineated for *H. thomassi* in the present study. From the pattern of ova diameter frequencies arrived at different months, a distinct mode of 1.4 -1.6 mm size class were observed during March, April and May, while during June- October, 1.8-2.2 mm size class dominated in the ovary. During January and February the immature oocytes of 0.8-1mm size class showed their dominance in the ovary. While in March and April the preponderance of 1.4-1.6 size class showed their dominance. The result revealed that *H. thomassi* has a prolonged spawning season extending from June-October.

Marza (1938) described three categories of rhythm in the maturation of oocytes. (1) Total synchronism- all oocytes in the ovary develop synchronously as in *Onchorhyncus masou* (Yamamoto *et al.*, 1959). (2) Group or partial synchronism- two groups of oocytes are distinguished indicating spawning once a year within a short and definite period as in *Clarias batrachus* (Lehri, 1968). (3) Asynchronism - oocytes in different stages of development are present indicating a long spawning season with several spawning within the season as in *Schizothorax richardsonii* (Bisht and Joshi, 1975). In *H. thomassi*, different batches of oocytes continuously passing from one stage to other were observed and hence the fish exhibited asynchronism in oocyte maturation. As far as the duration of breeding season is concerned, Kramer (1978) suggested that it ranges from extremely brief (1-2 days) through moderately long (2-4 months) to continuous spawning. Prabhu (1956) treated the duration of 2-3 months as prolonged breeding season. Qasim and Qayyum (1961) stated that the breeding season is short when it lasts for about 2-4 months, relatively longer when it lasts for 4-5 months and non-seasonal occurring over a greater part of the year. In *H. thomassi*, the breeding season lasts for 4-5 months and therefore, this species can be categorised under 'Relatively long" following Quasim and Qayyum (1961).

The timing of annual spawning for each species inhabiting a particular niche has evolved to ensure that the young hatch commence feeding in a season which is most conducive to their survival (Bye, 1984). Stancey(1984) reported that ovulation in most teleosts occurs rapidly in response to specific exogenous factors relevant to reproductive success. These factors include photoperiod, temperature, spawning substrate, visual and chemical stimuli, pH, turbidity of water and availability of food items. In Indian subcontinent, most of the freshwater fishes are reported to be monsoon breeders (Jhingran, 1982). The earlier reports of Khan (1945), Kulkarni (1950,1971), Khanna, (1958), David (1959), Karamchandani (1961), Belsare (1962), Bhatnagar (1967), Parameswaran *et al.* (1972), Rao and Rao (1972), Khan and Jhingran (1975), Murty (1975), Siddiqui *et al.* (1976 b), Pathak and Jhingran (1977), Somavanshi, (1980), Vinci and Sugunan (1981), Badola and Singh (1984), Shreshtha (1986) and Kurup (1994b) tend to support the above observation. Most of the factors triggering spawning in tropical fishes are supposed to be associated with onset of monsoon and flooding. Fishes are thought to be sensitive to the rising water levels (Alikunhi and Rao, 1951; Khanna, 1958; Kulkarni, 1971; Shreshtha, 1986). Habitat expansion in the rainy season leads to decreased crowding and predation pressure (Alkins-koo, 2000). Improved productivity and food availability (Hails and Abdullah, 1982) and optimum temperature (Qasim and Qayyum, 1961) during rainy season are the other reported factors influencing the spawning of freshwater fishes. Qasim and Qayyum (1961) stated that the breeding seasons in freshwater fishes are adapted to provide optimum conditions of temperature and shelter for the newly hatched fishes. The results of the present study indicate that the beginning of spawning in *H. thomassi* coincided with the pre-monsoon showers; however, the young ones would be present in the population at the time of peak flooding.

The maturation of germ cells in fish gonads is associated with an increase in the weight of gonad and this increase is expressed by the gonadosomatic index (GSI). However, the process of maturation is not exactly identical in males and females. In ovary, as the oocytes grow, they accumulate metabolites leading to an increase in their weight (Nagahama, 1983). GSI is indicative of fish spawning in temperate and tropical regions (Bouain and Sian, 1983; Biswas *et al.,* 1984; Phukon and Biswas, 2002). In the present study, GSI values of both males and females followed more or less the same trend. Low GSI values in November and December are concomitant with a period of early development of gonads and occurrence of spent fishes. The slightly high values observed from January to March reflected a diversity of gonad stages including a large number of maturing (II stage) and ripening (III stage) gonads. Comparatively high GSI values were encountered from April to September in both the sexes. The peak GSI values encountered during June and September in females while in males the peak GSI was registered during July and September. During spawning season, the GSI shows a plummeting due to the release of gonadal products. Hence, breeding season ensues with the months with maximal GSI. Reduced GSI in females is a consequence of release of ova from the ovary while in males, it may result from the combined effect of elimination of residual body followed by initiation of spermiation (Stoumboudi *et al.*, 1993). In *H. thomassi*, the sudden drop in the values in November is an indicative of the end of spawning season. The conclusion drawn earlier that *H. thomassi* has a prolonged spawning period by extending from June to October be further be substantiated with a distinct peak during June –August.

Based on the occurrence of large number of ripe fishes and ripening individuals with advanced stages of oocytes in the ovary, the appearance of spent individuals, the presence of ripe ova and the high GSI values, it can reasonably be inferred that this species is reproductively active for 4-5 months (June-October) during the entire monsoon season to the onset of northeast monsoon. Nath (1994 a, b) studied the spawning ecology of fishes in Jammu Province and observed that the cyprinids, *Labeo rohitha*, *L.calbasu* and *Cirrhinus mrigala* became ripe in May, however, spawning commenced only from the beginning of July with the onset of monsoon. Similarly, other related fishes such as *Chela, Salmostoma, Barilius, Danio, Chanda* and *Puntius* were reported to breed during the early part of the monsoon on the margins of ponds, lakes and rivers.

Prabhu (1956) classified fishes into 4 distinct groups on the basis of the spawning pattern.

Type A: Spawning taking place only once in a year during a definite short period. 2 batches of ova, mature and immature, are found in mature ovaries.

Type B: Spawning taking place only once in a year but with a longer duration. The range in size of the mature ova will be nearly half of the total ranges in the size of the whole intra-ovarian eggs.

Type C: Spawning twice a year. Ovaries contain distinct ripe as well as maturing ova.

Type D: Spawning throughout the year but intermittently. Ovaries contain different batches of eggs which are not sharply differentiated from one another.

Qasim and Qayyum (1961), on the basis of ova diameter frequencies, classified fishes into 3 categories.

Category I: Fishes with a well-marked single batch of maturing eggs in their ovaries. Breeding occurs only once a year.

Category II: Fishes with more than one group of maturing oocytes. The breeding season is long.

Category III: Fishes with oocytes of all sizes ranging from the smallest to the largest without well-marked batches. They have non-seasonal breeding

It appears that *H. thomassi* fits into Type 'B' of Prabhu (1956) and category I of Qasim and Qayyum (1961). *H. thomassi* was found to breed once in a year in the Kallada river with ovaries containing one group of maturing oocytes. The breeding season was observed to be moderately long.

Usually, fishes attain maturity at a particular length of the individuals. The onset of maturity differs considerably inter-specifically as well as intraspecifically (Nikolskii, 1963). Information on the size of maturation is essential for avoiding over exploitation of immature juveniles and ensuring the spawning of the individual fishes at least once in life. The minimum size of maturity has been estimated earlier by several workers (Qayyum and Qasim, 1964a; Parameswaran *et al.*, 1972; Selvaraj *et al.*, 1972; Sobhana and Nair, 1974; Somavanshi, 1980: Nautiyal, 1984; Sunder, 1986; Kurup, 1994b;

Agarwal, 1996; Santhoshkumar and Biswas, 2011; Simmy *et al.*, 2011; Bindhu *et al.*, 2012 and Seena *et al.*, 2012). In *H. thomassi*, the males and females were found to be mature at 290 and 330 mm respectively. Thus, males attain sexual maturity at a smaller length than the females. Similar observations had been reported in many freshwater fishes such as *Cyprinus carpio* (Parameswaran *et al*.,1972), *Labeo boggut* (Selvaraj *et al*.,1972) *Barbus sarana* (Murthy,1975), *Tor tor* (Chaturvedi,1976), *Labeo gonius* (Siddiqui *et al*.,1976a), *Labeo bata* (Siddiqui *et al*., 1976b), *Nemacheilus triangularis* (Ritakumari and Nair,1978), *Schizothorax longipinnis* (Sunder,1986), *Labeo dussumieri* (Kurup,1994b), *Macrognathus aral* (Santhoshkumar and Biswas, 2011), *Horabagrus brachysoma* (Bindu *et al.,* 2012) and *Puntus pookodensis* (Seena *et al*., 2012). The first appearance of ripe and spent individuals in 220-239 mm size group in males and females of *H. thomassi* suggest that this roughly corresponds to the minimum size group at which the females and males attain ripeness and start spawning. The maximum size of the males and females encountered during the present investigation is 432 mm and 419 mm respectively.

A proper knowledge of sex ratio is important in the management of fishery. It indicates features such as the movement of sexes in relation to season, strength of spawning stock, catch composition, etc. Considerable variation was observed in the ratio of males and females of *H. thomassi* in some of the months of two years. Murthy (1975) reported similar condition in *Barbus sarana* and opined that the contradictory values of the two years could be due to sampling variation or may reflect actual situation of sex ratio, which shows variation from year to year. However there, was a preponderance of males during almost all the months. This observation closely agreed with the findings of David (1954), Qayyum and Qasim (1964a) and Singh (1997) in *Hilsa ilisha, Channa punctatus* and *Schizothorax plagiostomus* respectively.

The ideal sex-ratio in natural population is close to 1:1 (Nikolskiy, 1980). A definite ratio of males and females during the spawning season is a prerequisite for most effective fertilization of eggs deposited by spawning females. The deviation in sex ratio from the ideal one during the spawning season encountered during both the years with a distinct predominance of males may be a contributing factor to the endangerment of *H. thomassi*. Nautiyal (1994) and Singh (1997) reported that spawning migration of fishes can lead to alterations in sex ratio drastically. The changing sex ratios may be associated with the shoaling habits of fishes, which might be a contributing factor for the dominance of either of the sex in the catch composition of different days. Differential mortality may be another cause of skewness in sex ratio (Bhatnagar, 1972).

The higher occurrence of males in lower size groups as observed in *H. thomassi* are corroborating with the findings in a number of fish species (Bennet, 1962; Bailey, 1963; Bhatnagar, 1972; Chaturvedi, 1976; Siddiqui *et al.*, 1976a; Somavanshi, 1980; Vinci and Sugunan, 1981; Kurup, 1994b). According to Makeeva and Nikolskii (1965), variation in sex ratio at different sizes and age groups exists even in species with an overall 1:1 ratio. Nikolsky (1980) assigned the dominance of males in smaller size groups to the tendency of males to mature earlier. Siddiqui *et al.* (1976b) stated that the increase in contribution of females in higher groups might be due to heavy mortality of males in smaller size groups either due to natural death or fishing pressure as they were more active and caught more easily or more exposed to predation. According to Qasim(1966), the disparity in growth rate between sexes led to the preponderance of one sex and the preponderant sex attains a bigger size. This is at variance with the present observation in *H. thomassi* in which the males were dominant in the sample population and the minimum size at maturity first appear in males earlier than females and the maximum size of the individual was found to be higher in males.

Lowe-McConnell (1975) defined the fecundity as the number of eggs produced by an individual fish in its lifetime. Bagenal (1978) considered it as the number of ripening eggs found in female prior to spawning and termed it as individual or absolute fecundity. Fecundity is generally regarded as the number of ova in an organism, which has the potential to give rise to the off springs. Thus, the reproductive potential is a function of the fecundity of fishes. Fecundity varies both within and between fish populations and numerous factors such as nutritional state (Scott, 1962; McFadden *et al*., 1965; Stauffer, 1976), time of sampling and maturity stage (Healey, 1971), racial characteristics (Bagenal, 1966) and environmental conditions such as rainfall and salinity (Joshi and Khanna, 1980). Fecundity in teleosts range from a few hundred to several lakhs.

The fecundity estimates of important freshwater cyprinids have been reported by several authors. Fishes such as *Labeo calbasu* (Khan,1934;Rao and Rao,1972;Vinci and Sugunan,1981), *Labeo rohita* (Khan,1934; Varghese,1973), *Cirrhinus mrigala* (Khan,1934; Chakrabarty and Singh,1967), *Labeo dero* (Bhatnagar,1967), *Cyprinus carpio* (Parameswaran *et al*.,1972), *Labeo fimbriatus* (Bhatnagar,1972), *Labeo gonius* (Joshi and Khanna,1980) and *Labeo dussumieri* (Kurup,1994b) are highly fecund fishes with several lakhs of eggs. *Puntius vittatus* (Ibrahim,1957) with 26 to 302 ova, *Barilius bendelisis* (Desai and Karamchandani,1967) with 305-1168 ova, *Glyptothorax kashmirensis* (Kaul,1994) with 692-1392 ova, *Nemacheilus triangularis* (Ritakumari and Nair,1978) with 800-2126 ova, *Puntius denisonii* (Simmy *et al*., 2011) with 376 to 1098 ova and *Puntius pookodensis* (Seena *et al.*, 2012) with 426-823 ova are some freshwater fish species with less number of ova in their mature ovaries. The fecundity of other cyprinids are 2368-8590 ova in *Puntius ticto* (Ibrahim,1957), 1700-6259 ova in *Garra mullya* (Somvanshi,1985), 3340-6160 in *Crossocheilus latius diplocheilus* (Kaul,1994), 3416-53139 in *Puntius stigma* (Ibrahim,1957), 14245-58330 ova in *Puntius dorsalis* (Sivakami,1982) and 58327-139934 ova in

Puntius sarana (Sinha,1975). In *H. thomassi* the fecundity ranged from 305-1061. Comparatively bigger sizes of the eggs may be identified as one of the reasons for the low fecundity of *H. thomassi*. Bulkley (1976) discussed the influence of egg size on fecundity in steel head trout, *Salmo gairdneri* and stated that it is possible that a fish producing fewer eggs could produce larger eggs within limits than if it were producing numerous eggs. Fecundity is higher in those fishes in which eggs are smaller in size than those in which the eggs are larger (Kaul, 1994).

The reproductive potential of fishes of different size groups had been expressed as the number of ova produced per gram body weight called relative fecundity (Bagenal, 1963;De Silva, 1973) or comparative fecundity (Das, 1964). Relative fecundity provides a better comparison of fecundities and eliminates the alteration in absolute fecundity with fish age and size (Sheila and Nair, 1983). The present study revealed that the average relative fecundity of *H. thomassi* was 2.34. This value is very low when compared to a relative fecundity of 252 in *Labeo calbasu* (Pathak and Jhingran,1977), 256 in *L. rohita* (Varghese,1973), 285 in *L. bata* (Alikunhi,1956), 275 in *Barilus bendelisis* (Dobriyal and Singh,1987), 271 in *Labeo gonius* (Joshi and Khanna,1980), 228 in *Puntius vittatus* (Ibrahim,1957), 227 in *Puntius sarana sunasutus* (Sobhana and Nair,1974), 201 in *Labeo calbasu* (Vinci and Sugunan,1981) and 180 eggs in *Labeo dussumieri* (Kurup,1994b).It can therefore be concluded that the very low relative fecundity of *H. thomassi* when compared to other species is a major reason for the endangerment of this species in the natural waters. The number of ova per gram ovarian weight was ranged from 77 to 220. Sivakami (1982) estimated the average number of ova per gram of ovarian weight in *Puntius dorsalis* as 3319, which is comparatively very high when compared to that of *H. thomassi*.

Fecundity is often correlated with length, weight and age of fish and also with the length, weight and volume of ovary. The relationship between total length and fecundity differ in different species of fishes. Clark (1934) opined that the fecundity of a fish increased in proportion to the square of its length. Simpson (1951) established that the fecundity of plaice was related to the cube of its length and was thus directly proportional to fish weight. Many authors have supported Simpson's view of fecundity being related to fish length by a factor closer to the cube (Bagenal, 1957; Sarojini, 1957; Pillay, 1958; Pantalu, 1963; Varghese, 1973, 1976; Kurup, 1994b). After surveying 62 fish species, Wooton (1979) concluded that the exponent value varied from 1 to 5 with most of the values lying between 3.25 and 3.75 and invariably higher values were reported in marine species than in freshwater forms. Jhingran (1961) and Qasim and Qayyum (1963) have reported the exponential value to range around 3.

In the present study, the exponential value of *H. thomassi* was observed to be 1.9628 which showed significant difference from the value of '3' and this finding is in total agreement with the above reports. The value of exponent in the length – weight relationship of female was found to be 3.0207 (Chapter 8). Since the exponential value in the length – fecundity relation (1.9628) was observed to be lower than that in length-weight relationship (3.0207), it appears that the fecundity in the species increased at a rate lesser than the rate of increase of body weight in relation to length.

Fecundity was found to have a linear relationship to body weight. The 'b' values of 0.5644 showed that body weight has very low influence on fecundity. The coefficient of determination (r^2) indicated that 74% of the variation in fecundity was associated with body length. The correlation of fecundity on body weight indicated that 74% of the variation in egg production was explained by the changes in weight. Linear relationship between fecundity and body weight has been reported in *Labeo fimbriatus* (Bhatnagar,1972), *Puntius sarana* (Sinha,1975), *Labeo rohita* (Khan and Jhingran, 1975),*L. bata* (Siddiqui *et al*.,1976b), *L. dero* (Raina and Bali, 1982) and *L. dussumieri* (Kurup,1994b). The observations of some early workers

(Bagenal, 1957; Sarojini, 1957; Gupta, 1968; Varghese, 1973) also lend support to the linear relationship between fecundity and body weight.

The coefficient of correlation of the various statistical relationships derived between fecundity, body length, body weight, ovary length and ovary weight revealed significant relation between fecundity and the body parameters except in ovary length. The highest degree of correlation was seen between fecundity and ovary weight. This is in agreement with the observations of Chathurvedi (1976) in *Tor tor*, Joshi and Khanna (1980) in *Labeo gonius*, Qadri *et al*. (1983) in *Schizothorax richardsonii*, Sunder (1986) in *S. longipinnis* and Kurup(1994b) in *Labeo dussumieri*. It is well known that the weight of ovaries of a fish is mainly influenced by the ova contained in them. Bagenal (1957) has stated that fish length, being easier to measure in the field, is more suitable to make prediction of fecundity when large samples are to be dealt with within limited time. Fecundity in *H. thomassi* was found to be almost close to the cube of length and directly proportional to the fish weight and these results would be invaluable in enumerating the fecundity without sacrificing the specimens.

.....ഇൽ.....

Chapter 8

LENGTH - WEIGHT RELATIONSHIP AND CONDITION FACTOR

Contents

8.1. Introduction

Growth is a process of increase or progressive development of an organism. Typically growth can be defined as the change in size (length and weight) over time. Increment in size is due to conversation of food matter in to building mass of body by the process of nutrition. Many factors influence the growth of fish. Among these common determinants are the amount and size of available food, the number of fish utilizing same food source, temperature, oxygen and other water quality factor, the size, age and sexual maturity of the fish. Growth of fish can be considered as no more than the individual production of mass. The growth process is specific for each species of fish. However, it can differ in same species inhabiting different geographical locations and is easily influenced by several biotic and abiotic factor. Growth is a specific adaptive property, ensured by the unity of the species and its environment (Nikolsky,1963).

Every animal in its life exhibit growth both in length and increase in weight, the relationship between these two has both applied and basic importance. The length-weight relationship is one of the standard methods yielding authentic biological information with two objectives; firstly it establishes the mathematical relationship between the two variables, length and weight, so that unknown variable can be readily computed from the known variable. Secondly, to know the variation from the expected weight, for the known length groups, this in turn reflects its fatness, general well being, gonad development and suitability of the environment of the fish (Le cren, 1951).

Length-weight (L-W) relationships can be used 1) To estimate weight from length of individual fish and for length class of fish, 2) to estimate standing crop biomass when the length frequency distribution is known (Martin-Smith,1996; Petrakis and Stergiou,1995), 3) to convert growth in length equations to growth in weight for prediction of weight at age and used in stock assessment models (Pauly, 1993), 4) to calculate condition indices (Safaran,1992; Petrakis and Stergiou,1995) and 5) for comparison of life history and morphology among populations from different regions (Petrakis and Stergiou,1995).

Length-weight relationship is determined by collecting data on both length and weight of fish in different phases of life and calculating the relationship existing between the two by formula

$$W= a L^b$$

'W' is the weight of the fish, 'L' is the length of the fish and 'a' and 'b' are constants to be determined empirically from the data.

In fishes weight is an exponential function of length; under conditions of isomeric growth, the regression follows cube law (Rousefell and Everhart,1953; Lagler,1956; Ricker,1958). But in reality the actual relationship between variables, length and weight may depart from this either due to environmental conditions or condition of fish (Le Cren,1951). In nature the body proportions change continually with ageing. The form and specific gravity do not remain constant throughout the life history of the fish which often cause regression coefficient of weight on of length departing from 3. In such cases the value of the exponent ‘b’ in the parabolic equation may lie between 2.5 to 4 (Hile, 1936; Martin, 1949).

The exact relationship between length and weight differs among species of fish according to their inherited body shape and within a species according to the condition of individual group. But this condition is variable and dynamic. Individual fish within same sample vary considerably and the average condition of each population varies seasonally and yearly. Sex and gonadal development are other important variables in some species. The condition factor is an index of reflecting interaction between biotic and abiotc factors in the physiological condition of fishes. It shows the population’s welfare during the various stages of the life cycle (Angelescu *et al.*, 1958).

Condition of fish in general is an expression of relative fatness of fish. The relative robustness or degree of well being of a fish is expressed by “coefficient of condition” denoted by ‘K’ (also known as Fulton’s condition factor or length-weight factor or Ponderal Index). Variation in a fish coefficient of condition primarily reflect state of sexual maturity and degree of nourishment. Condition values may also vary with fish age, season and in some species with sex. K- factor varies with species and size but larger values generally are indicative of better condition. If the fish don’t undergo the cube law, the ‘K’ value is directly affected by length, age, maturity, feeding intensity and other factors. In order to eliminate the effect of these factors on the ‘K’ value, Le Cren (1951) suggested the calculation of relative condition factor ‘Kn’ which does so only if the exponent value is equal to 3. Thus K factor measures the variations from an ideal fish which holds the cube law while Kn measures the individual deviation from the expected weight derived from the length-weight relationship. The relative condition factor has an expectation of one and the deviation from one yields information such as differences in the nutritive level and the effect of physic-chemical factors on the life cycle of organism. So the study of the condition factor (‘K’) and relative condition factor (‘Kn’) is thus important for understanding the life cycle of fish species and contributes to adequate management of these species and therefore, to the maintenance of equilibrium in the ecosystem. The importance of length-weight relationship and condition factor of fishes has inspired a large number of works in different parts of world to analyze this relationship in both marine and freshwater fishes.

The length-weight relationship of cyprinids from India has been subjected to detailed studies, notably by Jhingran (1952), Bhatnagar (1963), Natrajan and Jhingran (1963), Sinha (1972), Pathak (1975), Chatterji (1980), Chatterji *et al.*(1980), Vinci and Sugunan (1981), Sivakami(1982), Choudhary *et al.* (1982), Malhotra (1982, 1985), Mohan and Sankaran (1988), Gairola *et al.* (1990), Kartha and Rao (1990), Dasgupta (1991b), Reddy and Rao (1992), Biswas (1993), Pandey and Sharma (1998), Sarkar *et al.*(1999), Patiyal *et al.* (2010), Guptha *et al.* (2011), Singh *et al.* (2011), Shaheena and Yousuf (2012) and Ujjania *et al.* (2012). In Kerala, there are some studies on the length- weight relationship of Cyprinids family fishes ie., Kurup (1990), Sunil (2000), Mercy *et al. (*2002), Kurup *et al.* (2002b), Prasad and Ali (2007), Manojkumar and Kurup (2010 a) and Fibin *et al.* (2011b).

The determination of exact nature of the relationship that exists between length-weight and condition factor of fishes has been recognized as an important part of fish biological studies. However, no information is available on the length-weight relationship and condition factor of *Hypselobarbus thomassi* and therefore, the present study was undertaken to establish the pattern of growth and general well-being of this fish species.

8.2. Materials and Methods

537 specimens of *H. thomassi* comprising 244 males, 140 females and 153 indeterminates were collected from Kulathupuzha tributary of Kallada River during April 2009 to March 2011. The specimens were preserved in 8% formalin. After blotting the specimens to remove excess water, the total length to the nearest millimeter and weight to the nearest 0.01 gram were recorded. Total length was measured from the tip of the snout to tip of the longest ray in the caudal fin (Jayaram, 1999).

The data so generated was subjected to statistical analysis by fitting length-weight relationship following Le Cren (1951). Accordingly, Length-weight relationship can be expressed as:

$$W=a\,L^b$$

Where 'W' is the weight of the fish (g), 'L' is the length of the fish (mm) and 'a' and 'b' are constants to be determined empirically from the data (Initial growth index and regression constants respectively).

When expressed logarithmically the above equation becomes a straight line of the formula:

$$\text{Log } W= \log a + b \log L,$$

Constant 'a' represents the point at which the regression line intercepts the y-axis and 'b' the slope of the regression line was estimated by the method of least square (Snedecor and Cochran, 1967). The regression of log weight on log length was first calculated independently for males, females and indeterminates and then for species. The data was processed in EXCEL software. The significance of regression was tested by ANOVA. The regression coefficients of the sexes and indeterminates were compared by analysis of covariance's (ANACOVA) (Snedecor and Cochran, 1967) to establish the variations in the 'b' values, if any, between them. The significance of differences in the estimate of 'b' in males, females and indeterminates from the expected value of 3 (isometric growth) was tested by Bailey's t-test (Snedecor and Cochran, 1967) as given by the formula:

$$t = (b-3)/Sb$$

Where b= regression coefficient of log transformed data

Sb = Standard error of 'b'.

The t-test (Snedecor and Cochran, 1967) on 'r' values reveals whether significant correlation exists between length and weight.

Condition factor (K) Ponderal index is a measure of the well being or plumpness of a fish was calculated according to the equation presented in Carlander (1970)

$$K = W \times 10^5 / (L)^3$$

Where W= Weight of fish in grams

L= Total length of the fish in millimeters. The number 10^5 is a scaling factor when metric units are used (ie, grams and milligrams) and is used to bring the value of K near unity.

Relative condition factor (Kn) introduced by Le Cren(1951) is expressed as follows:

$$Kn = W/\hat{W}$$

Where W = observed weight

W = calculated weight derived from length-weight relationship

K and Kn was calculated for different month and size wisely for both the sexes. The average value of each month irrespective of the size was considered.

8.3. Results

The mathematical relationship between total length and weight of males, females and indeterminates of *H. thomassi* obtained by logarithmic regression equations are as follows:

Logarithmic equations

Male:	log W = -5.4424 + 3.2048 Log L
Female	log W = -4.9908 + 3.0207 Log L
Indeterminates	log W = -4.1161 + 2.63 Log L

The logarithmic relationship between length and weight of males, females and indeterminates of *H. thomassi* together with correlation coefficient is depicted in Fig 8.1, 8.2 and 8.3 respectively. The correlation coefficient 'r' between log length and log weight was found to be 0.933 in males, 0.926 in females and 0.8508 in indeterminates. The 't' test on 'r' values (Table.8.1) showed the existence of very good relationship between length and weight ($P<0.01$) of males and indeterminates. The results of ANOVA on regression of males, females and indeterminates are presented in Tables 8.2, 8.3 and 8.4 respectively. The length-weight regressions were found to be highly significant in both the sexes as well as indeterminates ($P<0.001$). Based on the coefficient of determination (r2) (Croxton,1953), 85 % of the variation in weight in males, 85 % in females and 72 % in indeterminates were found to be associated with the change in the length of the fish.

The results of the analysis of covariance (ANACOVA) (Table 8.5) revealed there is no significant difference in the regression coefficient of males, females and indeterminates (F value = 8, df: 2,542) thereby indicating homogeneity of the samples. Pair wise comparison between males and females, males and indeterminates, females and indeterminates (Table.8.6) were carried out using students 't' test (Zar, 1974). The results show that 'b' values are significantly different (P<0.01) only in males and indeterminates. The comparison of elevations disclosed significant difference among the three groups (P<0.01). Hence, pooling of data to provide a single equation expressing the length-weight relationship of *H. thomassi* will not be justifiable, thus necessitating fitting up of separate equations for males, females and indeterminates.

The value of the regression coefficient in males was 3.20 while in females it was 3.02 whereas in indeterminates, the same was 2.63.

Table 8.1. Statistical details showing number of fish studied (n), intercept (log a), regression coefficients (b), standard error of b (sb) and results of Bailey's t test on b

	n	log a	b	sb	t	P	r
Indeterminates	163	-4.11616	2.63	0.1281	2.87	p = <0.01	0.85
Males	244	-5.4424	3.20	0.0791	2.59	p = <0.01	0.93
Females	140	-4.99088	3.02	0.1042	0.20		0.93

Table 8.2. Analysis on variance on the regression of the length weight relationship in males of *H. thomassi*

	df	*SS*	*MS*	*F*	*Significance F*	p
Regression	1	13.02060449	13.0206045	1643.42697	7.1818E-110	<0.001
Residual	242	1.917326626	0.00792284			
Total	243	14.93793111				

Table 8.3. Analysis on variance on the regression of the length weight relationship in females of *H. thomassi*

	df	*SS*	*MS*	*F*	*Significance F*	P
Regression	1	6.73903398	6.739034	839.6765	1.56E-60	<0.001
Residual	138	1.10755361	0.008026			
Total	139	7.84658759				

Table 8.4. Analysis on variance on the regression of the length weight relationship in indeterminates of *H. thomassi*

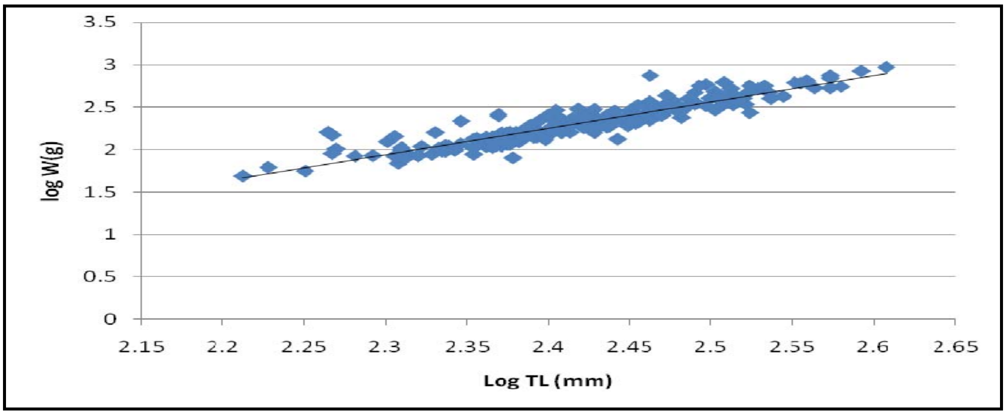
	df	*SS*	*MS*	*F*	*Significance F*	P
Regression	1	4.507422221	4.507422	422.2354558	7.34573E-47	<0.001
Residual	161	1.718697394	0.010675			
Total	162	6.226119615				

Table 8.5. Comparison of regression lines of length and weight data of male, female and indeterminates of *H. thomassi*

	f	RC	df	SS {d y.x2	MS		
Indeterminates	161	2.631923	160	1.7187	0.0107		
Males	242	3.204839	241	1.9173	0.0079		
Females	138	3.020728	137	1.1076	0.008		
WITH IN			538	4.7436	0.0088		
Reg. Coeff.			2	0.1412	0.0706		
COMMON	541	3.013352	540	4.8848	0.009	8.0068	* p=<0.01
Adj. Means			2	0.1468	0.0734	8.1157	* p=<0.01
TOTAL	547		542	5.0316			
Comparison of slopes F = 0.0706 (2,542) = 8.0068 *					=Significant at 1% level		
Comparison of elevation F = 0.0090 (2,542)= 8.12 *					(Table value 6.67 p= <0.01)		

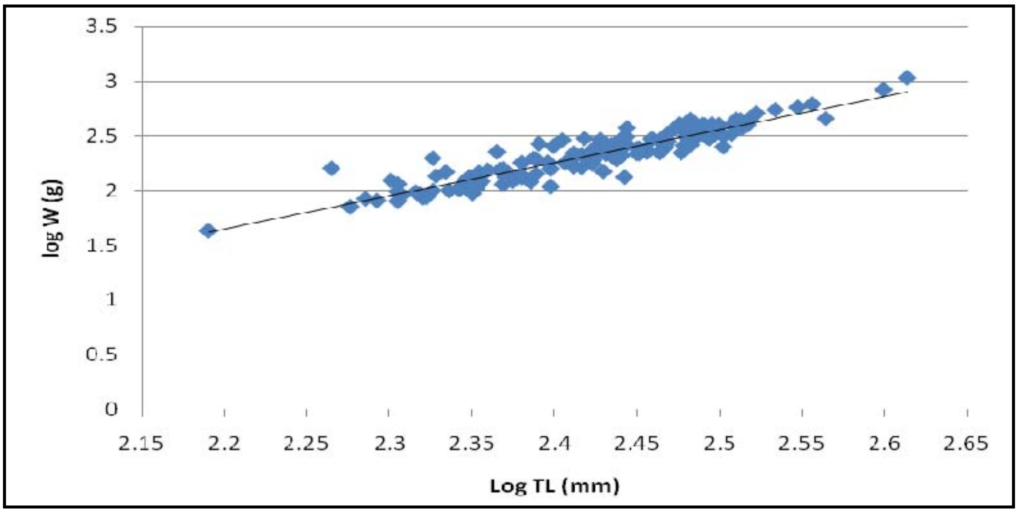
Table 8.6. Result of pair wise comparison of regression coefficients of male, female and indeterminates of *H. thomassi* using t- test

Between		t	df	Probability
Indeterminates	Males	3.95	401	p = <0.01
Indeterminates	Females	2.34	297	p = <0.05
Males	Females	1.41	378	not significant



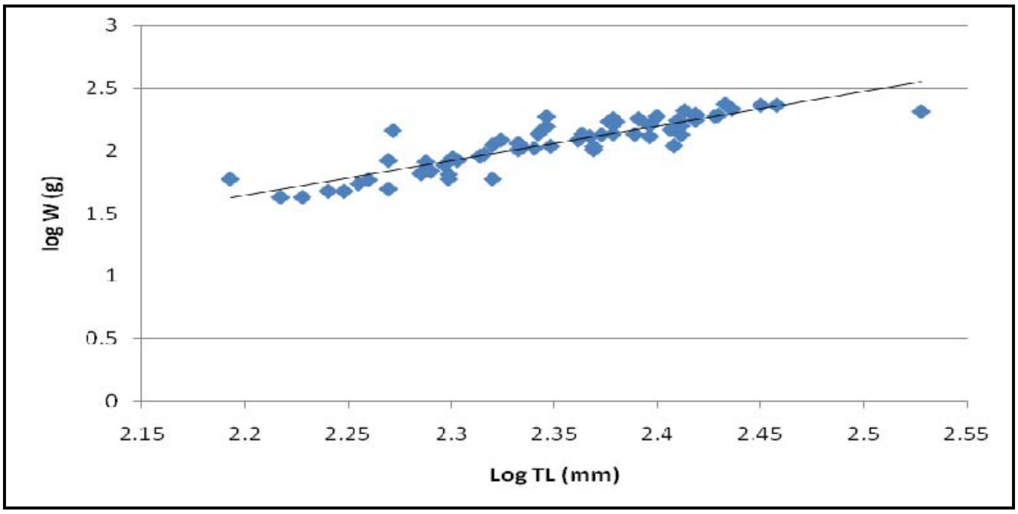
Log W = -5.4424 + 3.2048 Log L r = 0.93

Fig.8.1. Length weight relationship in males of *H. thomassi*



Log W = -4.9908 + 3.0207 Log L   r = 0.93

Fig.8.2. Length weight relationship in females of *H. thomassi*



Log W = -4.1161 + 2.63 Log L   r = 0.85

Fig.8.3. Length weight relationship in indeterminates of *H. thomassi*

The fluctuations noticed in Kn values of males and females during 2009-11 and 2009-11 are represented in Figs.8.4 and 8.5 respectively. In 2009-10, the Kn values of males showed 2 peaks (April, September) and 2 troughs (June, November-December) where as 4 peaks (January, April and August, December) and 3 troughs (March, October and December) were discerned in 2010-11. In 2009-10, males showed an increase in the Kn values in July and reached maximum in September (1.48). But a sharp inflexion in October, November and December, thus recording a lowest value of 0.88 in December. There was not much fluctuation in condition during January, February and March. In contrast, in 2010-11, the maximum Kn value was registered in January (1.33) and lowest in October (0.85). Incidentally the value of ponderal index (K) was found in the conformity to the Kn values during both the years.

During 2009-10, female registered maximum Kn value of 1.28 in April followed by 1.16 in August. Thereafter a sharp inflexion in December, recording the lowest value of 0.86. There was not much fluctuation in January, February and March and a gradual increase in April showing to maximum. In 2010-11, female showed maximum Kn value of 1.34 in April and showed a declining pattern in May and June and then reached peak in August with a value of 1.33. In October, the lowest Kn value of 0.85 was registered. A gradual increase of Kn values in December was followed by a decrease in the value in January. Kn values did not fluctuate during February and March. The seasonal variation in the condition factor (K) or ponderal index showed exactly the same trend as that of relative condition factor (Kn).

The average values of relative condition factor in respect of indeterminates and sexes belonging to different size groups are plotted in Figs. 8.6 and 8.7 respectively. In males high Kn value of 1.50 was found in 170-190mm length group, followed by a decreasing trend in 190-210, 210-230 and 230-250mm size groups and thenceforth, the values gradually increased to culminate in a peak value of 1.03 in 250-270 mm group. Lowest Kn (0.93) values were recorded in 270-290 mm length group. Beyond 290 mm, the Kn values showed not much variations and at last showed an increasing trend in 390-410. The pattern of K (ponderal index) showed the same trend as that of Kn values. In females, high Kn values were recorded in smaller fishes and larger fishes. High Kn value was found in 170-190 mm length group (1.59) followed by a decline in the next size group 190-210 mm TL. Thereafter, the values remained almost static around 1 in 190-330 mm length groups. Beyond 330mm, the values of Kn showed an increasing trend (>1). An almost similar pattern of variation was noticed in K values too (Fig. 8.9). Indeterminates showed a lowest Kn values (0.99) in 230-250mm whereas the highest value (1.08) was recorded in larger fishes (290-310mm TL). The condition factor showed exactly the same trend as that of relative condition factor (Fig.8.11).

The seasonal variations in K values of males and females were more or less similar during 2009-10, attaining lowest K value in December in both the sexes. On the other hand, highest K value were registered in September and April in males and females respectively. During 2010-11, the lowest value was observed in October in both males and females. In males the highest K value was recorded in January, whereas the same was recorded in April in females. A scrutiny of the lengthwise variation in relative condition factor exhibited high K values in smaller fishes in both the sexes. In larger fishes the K values showed high variations. In males, higher K values were observed in the length groups of 150-190, 310-330 and 390-410mm.

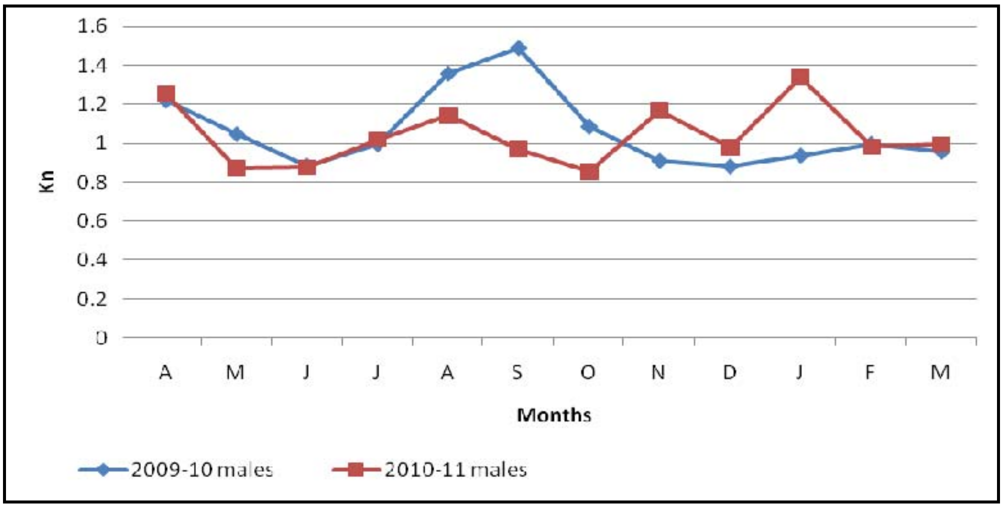


Fig.8.4. Seasonal variation in relative condition factor (Kn) in males of *H. thomassi*

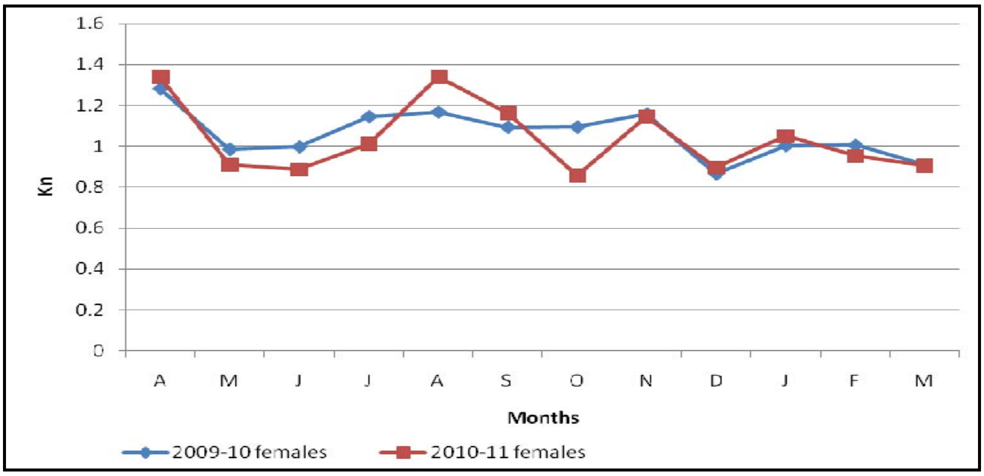


Fig.8.5. Seasonal variation in relative condition factor (Kn) in females of *H. thomassi*

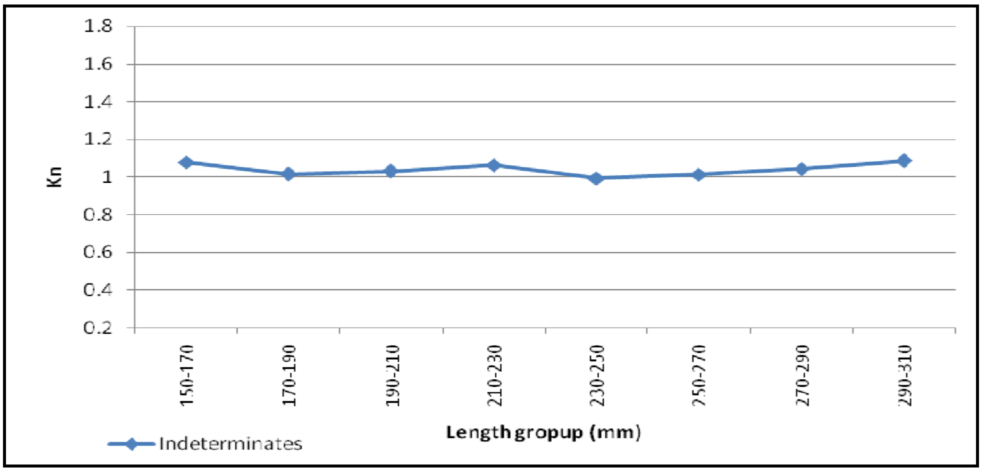


Fig.8.6. Lengthwise variation in relative condition factor(Kn) in indeterminates of *H. thomassi*

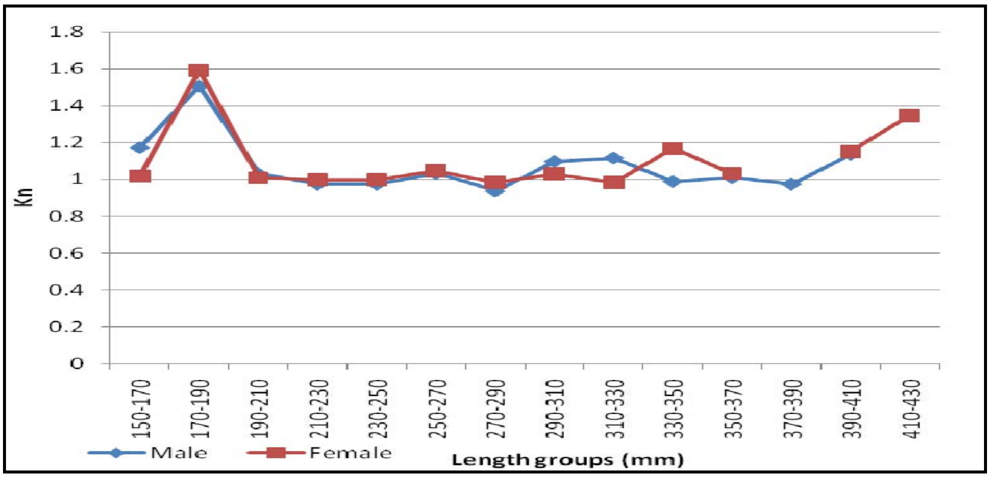


Fig.8.7. Lengthwise variation in relative condition factor in males and females (Kn) of *H. thomassi*

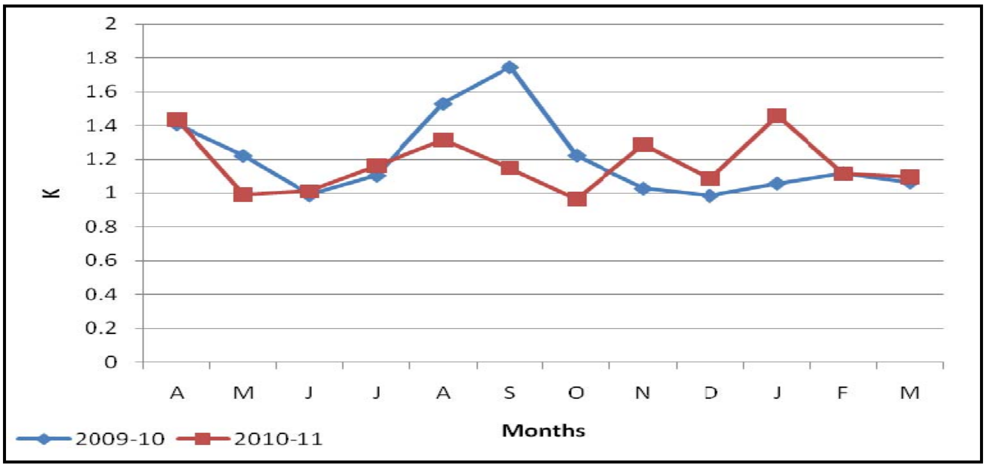


Fig.8.8. Seasonal variation in Ponderal index in males of *H. thomassi*

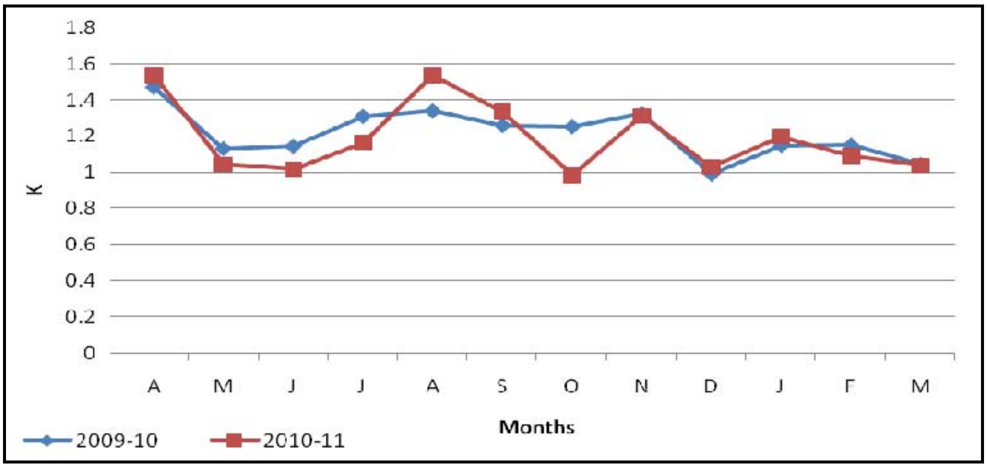


Fig.8.9. Seasonal variation in Ponderal index in females of *H. thomassi*

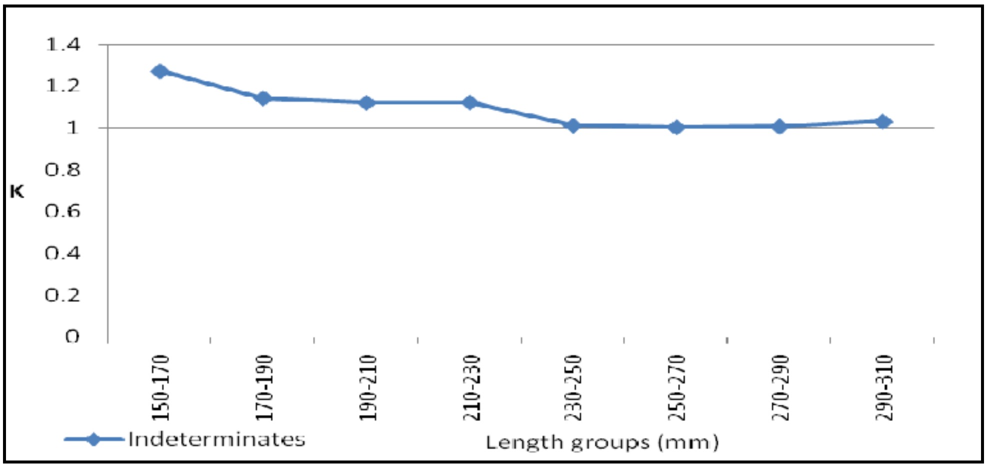


Fig.8.10. Lengthwise variation in Ponderal index (K) in indeterminates of *H. thomassi*

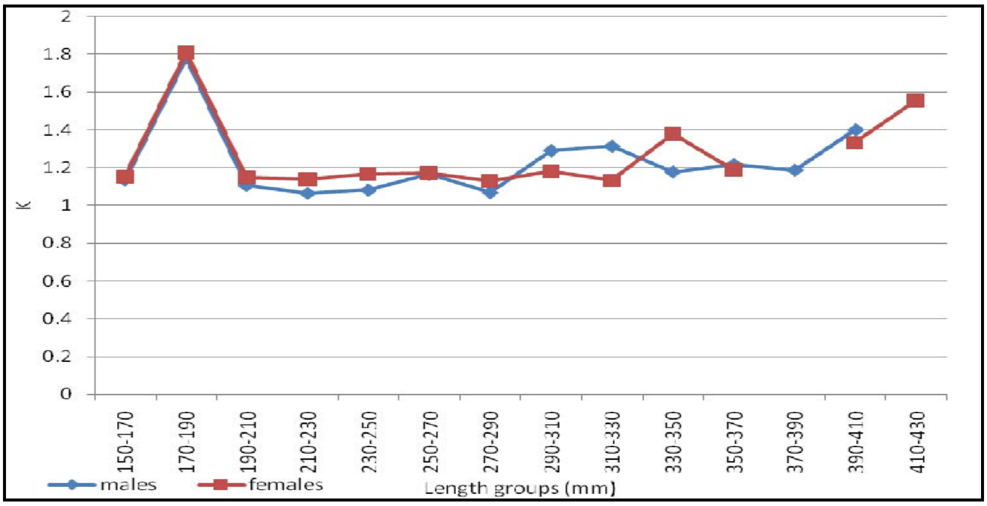


Fig.8.11. Lengthwise variation in Ponderal index (K) in male and females of *H. thomassi*

8.4. Discussion

Length-weight relationship was expressed by the cube formula $W=aL^3$ by the earlier workers (Brody, 1945; Lagler, 1952; Brown, 1957). Allen (1938) supported this law and declared that for an ideal fish, which exhibits isomeric growth, the value of regression coefficient should not be different from 3. The cube law confers a constancy of form and specific gravity to an ideal fish. However, adverting the inadequacy of the cubic law in explaining the length-weight relationships in fishes, many researchers adopted the general formula in the form $W=aL^b$. Le Cren (1951) suggested that the deviations from the cube law might be contributed to the condition of the fish, reproductive activities, taxonomic differences or environmental factors. Ricker (1958) explained that due to changes in body proportions during the various life stages of fishes, their body form and specific gravity can vary and hence cube law does not hold true for them. According to Rousefell and Everhart (1953), the value of 'b' is 3 in fishes however, the cube law need not always hold good.

In the present study, the highest 'b' value was arrived at in males of *H. thomassi* followed by females and indeterminates. The exponential value of

3.20 in males implies that the males gain weight at a faster rate in relation to its length whereas the low exponential value of 2.63 observed in indeterminates indicates their low growth rate. On the other hand, the ‘b’ value of 3.02 in females did not deviate significantly from the isometric value of ‘3’ suggesting that the juvenile fishes are neither heavier nor lighter in relation to its length. It may be concluded that during early stages of life, the fish grow allometrically and after attains sexual maturity the females grow isometrically more or less obeying cube law, while the high b value of males indicated positive allometry.

Reports on the length-weight relationship of cyprinid fishes showed that many of them strictly follow cube law while there are many in which the weights of fishes either tend to increase or decrease in proportion to the cube of length. Isometric growth pattern has been reported in *Cirrhinus mrigala* and *Labeo rohita* (Jhingran,1952), *L. calbasu* (Pathak,1975), *Puntius sarana* (Sultan and Shamsi,1981), *Puntius dorsalis* (Sivakami,1982), *Gibelion catla* (Choudhury *et al.*,1982; Kartha and Rao, 1990) and *Schizothorax plagiostomus* (Bhagath and Sunder, 1983). All these earlier reports are in compliance with the present finding on the length-weight relationship in females of *H. thomassi* in which the b values were very close to the isometric value of 3.

Deviations from cube law has been observed in Indian major carps by many authors (Jhingran, 1952; Natarajan and Jhingran, 1963; Shrivastava and Pandey, 1981; Choudhary *et al.*, 1982; Mohan and Sankaran, 1988; Pandey and Sharma, 1998; Sarkar *et al.*, 1999).The slope value of less than ‘3’ has been reported in *Tor tor* (Malhotra,1982), *L. dero* (Malhotra and Chauhan,1984), *L. dyocheilus* (Malhotra,1985), *P. ticto* and *Barilius bendelesis* (Gairola *et al.*,1990), *Cyprinus carpio communis* and *Ctenopharyngodon idella* (Dhanze and Dhanze,1997) and *Rasbora daniconius* (Sunil, 2000). The value of the slope was found to be higher than 3 in *P. sarana* (Sinha,1972), *L. bata* (Chatterji *et al.*, 1977; Azadi and Nazer, 1996), *L. dussumieri* (Kurup, 1990) and

P. sophore (Reddy and Rao, 1992). *L. calbasu* of river Kali (Chatterji *et al.*, 1980) and Nagarjuna Sagar (Vinci and Sugunan, 1981) showed higher regression coefficients contrary to those from Brahmaputra river (Choudhary *et al.*, 1982) and Rana Pratap Sagar reservoir (Choudhary *et al.*, 1991) which registered exponential values below '3'. Thakre and Bapat (1984) estimated an exponential value of 3.1524 for *Rasbora daniconius* from Maharashtra whereas, Sunil (2000) recorded the value to be less than 3 (2.641) for the same species collected from Kerala waters. All these earlier reports corroborate the present findings on the length-weight relationship in *H. thomassi* in which significant departure of 'b' value from the isometric value of 3 was noticed in respect of males.

Males of *H. thomassi* were found to surpass females in weight in relation to length as evidenced from the disparity in 'b' values. Similar trend has been observed in other cyprinids too. The values of regression coefficients of *H. thomassi* are in the range between 2 to 4 as reported by Tesch (1968). Hile (1936) and Martin (1949) stated that the values of 'b' usually fluctuate between 2.5 and 4. The exponential value in males, females and indeterminates comply with the range proposed by the above authors.

Fluctuations in the condition of fish is related to reproductive cycle (Le Cren, 1951; Sarojini, 1957; Pantalu 1963; Qayyum and Qasim, 1964 a, b, c; Chatterji, 1980; Neelakantan and Pai,1985; Gairola *et al.*, 1990; Narejo *et al.*, 2002), feeding rhythms (Hile, 1948; Qasim, 1957; Bal and Jones 1960; Blackburn, 1960; Bhatt, 1970, 1977; Shrivastava and Pandey, 1981; Dasgupta, b 1991; Pandey and Sharma, 1997) or physico-chemical factors of environment, age, physiological state of fish or some other unknown factors (Brown, 1957; Kumar *et al.*, 1979; Kurup and Samuel, 1987; Kurup, 1990; Kalita and Jayabalan, 1997). In *H. thomassi* the higher K_n values recorded in September in males and April and August in females almost coincided with the occurrence of high gonadosomatic index (GSI) in both males and females.

The values in males inclined to decrease from August due to the increased spawning strain in them, while in females the relative condition factor decreased during May-July and August to October. This may be attributed to the increased spawning strain in them as opined by Menon (1950). Thus, it appears that reproductive cycle in *H. thomassi* is related to the variations in the condition factor.

Sex-wise analysis of Kn values revealed that the mean Kn value of males (1.05) was higher than that of females (1.04). In indeterminates, the mean value was 1.08. According to Le Cren (1951), Kn values greater than 1 indicated good general condition of the fish whereas values less than 1 denotes reverse condition. Pandey and Sharma (1997) studied the condition of four exotic carps and the common carp, *Cyprinus carpio communis* was only found to have value above 1(1.0109). Similarly, high Kn values were also recorded in *Labeo rohita* (1.0129) and *Gibelion catla* (1.0007) in contrast to low value in *Cirrhinus mrigala* (0.9967) by Pandey and Sharma (1998). In the present study, it could be discussed that all the groups, males, females and indeterminates maintain good gained body condition.

.....ꙮꙮ.....

Chapter 9

AGE AND GROWTH

Contents

9.1. Introduction

Age is the lifespan of fish and growth is the addition of material to that which is already organized into a living pattern. Precise and accurate age information enables quality estimates of growth and other vital rates such as natural mortality and longevity and provides fundamental tools in fisheries biology and management. The age-determined parameters like mortality and growth forms the basics of population dynamics models used in fishery analyses. Age studies can give basic data such as natural and fishing mortality, age composition of exploited population, age at first maturity, stock age structure, recruitment success etc. Age and growth data also help in determining of population changes due to fishing activities which provide essential tools for scientific interpretation of the fluctuations in fish populations over space and time and also in formulating scientific and economic management policies for fishery in question (Seshappa, 1999). The purpose of study of growth is to determine the amount of fish that can be produced in terms of quantity in a body of water in relation to time (Qasim, 1973 a). A comparison of rate of growth from different localities may help in identifying suitable environmental conditions for the sustenance of a stock. The growth process is species specific, however can differ in the same fish inhabiting different geographical locations and is easily influenced by several biotic and abiotic factors.

The effect of inaccurate age determinations on population dynamics studies can lead to serious errors in stock assessment resulting in overexploitation (Ludwig and Reynolds, 1988: Hoenig and Gruber, 1990; Hoff and Musick, 1990). While age and growth are always used together in phraseology, it is important to remember that each term has its own distinct meaning, which was eloquently stated (DeVries and Frie, 1996). According to DeVries and Frie (1996), age refers to some quantitative description of the length of time that an organism has lived, whereas growth is the change in body or body part size between two points in time and growth rate is a measure of change in some metric of fish size as a function of time.

One of the significant aspects for getting accurate data on fish biology and population dynamics is to determine the age with lowest error (Chalanchuk,1984). The age and growth of fishes are determined by direct and indirect methods. The direct method is accomplished through direct measurement of growth rate of specific specimens extrapolated to the stock as a whole. It includes rearing fishes in captivity under controlled conditions and observing their growth and also by using mark recapture method (tagging programmes). Age data estimated by this method is definite and reliable. Furthermore, it generally establishes a basis for validation studies (Beamish and Mcfarlane, 1983). This method has limited scope due to practical difficulties of being costly and time consuming. The indirect method comprise two ways of age determination, Peterson or the length-frequency analysis is considered a reliable method when the samples are representative of a fish population that has a short life, fast growth and reproduces once in a year (Cassselman, 1987; Baker and Timmons,1991). The other method is by observing annual rings laid down on scales, otoliths, vertebral centra or other hard parts of the body. This method has been widely employed for growth and ageing studies of temperate fishes and yields good results. These techniques are not employed for tropical fish studies. The tropical fish are assumed to lack seasonal growth pattern, which is reflected by poorly developed growth marks in the hard parts (Brothers, 1980). It has been reported that tropical fishes don't show clear zonations on hard parts, it is difficult to conclude that they are formed annually only (Quasim, 1973 b),

The length frequency analysis method of Petersen (1895, 1903) is well known, in which peaks of length distribution are assumed to represent the different age groups. The method is very good for younger fish (2-4 years life). However, in older fishes, there are possibilities of over lapping of length frequencies in individuals of different age groups, as the growth rates slow down. Furthermore, age determination by length frequency analysis does not hold good to fishes with prolonged breeding season also. Length-frequency method is widely used by fishery biologists in fishes inhabiting tropical waters. A computer based method for the analysis of length frequency data, ELEFAN (Electronic Length Frequency Analysis) (Gayanilo *et al.*, 1988), has been effectively used to separate the composite length frequency into peaks and troughs and the best growth curve passing through maximum number of peaks is selected using a goodness of fit Rn ratio of ESP (Explained sum of peaks) /ASP (Accumulated sum of peaks) (Pauly and David,1981;Gayalino *et al.*,1988). The peaks are believed to represent individual cohorts. The module is incorporated into the FISAT (FAO-ICLARM Fish stock assessment tools) Software (Gayanilo and Pauly, 1997).

The age and growth of Indian freshwater fishes have been extensively studied. (Jhingran,1959; Bhatt 1959; Qasim and Bhatt,1964; Bhatt,1969,1970; Kamal,1969; Khan and Siddiqui,1973, Rao,1974; Bhatnagar,1979; Chatterji *et al.*,1979; Pathani,1981b; Reddy, 1981; Johal, and Tandon, 1981, 1987, 1989, 1992; Mathew and Zacharia,1982; Tandom and Johal, 1983; Shree and Gupta,1986; Tandon *et al.,* 1989; Desai and Shrivastava,1990; Devi *et al.*, 1990; Anil,1992; Deepak and Sharma, 1995; Singh *et al.,* 1998; Kiran and Puttaiah, 2005; Anish and Kumar, 2006 and Senguttuvan and Sivakumar, 2010). However studies related to age and growth of freshwater fishes of Kerala are very few. Kurup (1997) studied the age and growth studies of *Labeo dussumieri* from Pamap river. Manojkumar and Kurup (2010 b) worked the age structure of *Puntius carnaticus.* No attempt was made to study the age and growth of *Hypselobarbus thomassi* and hence a pioneer study was attempted in this direction.

9.2. Materials and Methods

537 specimens of *H. thomassi* comprising of 244 males and 140 females and 153 indeterminates were collected from Kallada river between April 2009 to March 2011. Total length (TL), standard length (SL) and total weight (W) of each individual fish were measured. Length frequency data were grouped into 10 mm class interval. Growth was estimated for male, female and pooled population. The von Bertalanffy growth formula (VBGF) (Bertalanffy, 1938) was used to describe the growth. The equation in growth in length is given by:

$$L_t = L_\infty \; [1 - \exp^{-k\,(t-t_0)}]$$

Where L_t = length at age t

L_∞ = asymptotic length or the maximum attainable length, if the organism is allowed to grow

e = base of neparian or natural logarithm

K = Growth coefficient

t = age of fish

t_0 = age at which length equals 0, i.e. the theoretical age at zero length

The growth parameters were estimated using the ELEFAN 1 programme in the FISAT software (Gayanilo and Pauly, 1997). Powell- Wetherall Method was used to estimate asymptotic length and the ratio of the coefficients of growth (Z/K) using length-frequency data based on Beverton and Holt (1956).

$$Z = K [(L_\infty – L)/ \bar{L} - L')]$$

It estimates the total instantaneous mortality coefficient (Z) in a steady state population with constant exponential mortality and von- Bertalanffy growth, from mean length (L) of a random sample of fish above cut off length (L'). The mean length of the selected fish (L) is a linear function of the knife edge selection length L' given by

$$L = L_\infty \{1/ \{1+(Z+K)]\} + L'\{1/\{1+(Z+K)]\}$$

For a series of arbitrary cut off lengths, we can construct a corresponding series of partially overlapping sub samples. If the mean lengths for sub samples are plotted against the cut off lengths, it results in a positive linear relationship as given by the above equation. If the intercept of the straight line is considered as a and slope as b,

$$a = L_\infty [1+ (Z+K)]\}$$

$$b = (Z/K)/ [1+ (Z+K)]$$

From this, L_∞ and Z/K can be computed as

$$L_\infty = a/(1-b)$$

$$Z/K= b/ (1-b)$$

In FiSAT, a modified form of Wetherall method as proposed by Pauly (1986) is incorporated.

$$Lt'= a + bLt$$

Where $L_\infty = a + b\,Lt$ and $Z/K= (1+b)/ -b$

Estimation of t_0

Age length key at 3 months interval was prepared from ELEFAN 1. Estimate of t_0 was done using von Bertalanffy (1934) plot in which the results of the regression of $-\ln(1- Lt/L_\infty)$ against t was used to calculate t_0.

$$t_0 = -a/b$$

Since ELEFAN curves showed the existence of only one brood in *H. thomassi*, estimation of growth parameters was restricted on one cohort only. Growth performance of this single cohort in both male and female was compared by Munro's PHI prime index, ϕ (Munro and Pauly, 1983) which was computed from the equation:

$$\phi = \log_{10} K + 2 \log_{10} L_\infty$$

where K and L_∞ are Von Bertalanffy's growth parameters.

According to Pauly (1982 b), the structure of a set of length frequency data is dependent on the recruitment pattern into a population and hence it is possible to derive some information on the seasonality of recruitment from the length frequency data. FISAT applies this inverse approach, thereby identifying the number of recruitment pulses per year and evaluating the relative importance of these pulses when compared to each other. The recruitment patterns of both male and female *H. thomassi* were obtained from FISAT programme.

9.3. Results

9.3.1. Estimation of growth parameters

9.3.1.1. Males

In males, L_∞ computed following Powell-Wetherall plot was 436 mm and Z/K = 3.401 (Fig.9.1). ELEFAN 1 growth curve (Fig.9.4) showed that the male population of *H. thomassi* was composed of a single cohort annually, generated by only one recruitment during July-August. The L_∞ estimated from ELEFAN I with highest Rn value (2.62) was 435.62 and K =0.31 yr^{-1} . Based on the values so obtained through ELEFAN I and Bertalanffy plot (1934), the von Bertalanffy growth equation (VBGF) of males of *H. thomassi* can be expressed as:

Males: $Lt = 435.62\ (1\text{-}exp^{-0.31(t-0.0051)})$

Based on the growth equation, the average annual length of males was calculated as 116,201,264,310,343,368 mm at the end of I, II, III, IVth , Vth and VIth years respectively (Fig.9.7 and Table.9.2)

9.3.1.2. Females

In females, L_∞ derived using Powell-Wetherall method was 449.66 mm and Z/K was 4.388 (Fig.9.2). ELEFAN 1 growth curves (Fig.9.5.) showed that the female population of *H. thomassi* was composed of a single cohort annually generated during June- July. The L_∞ computed from ELEFAN I with highest Rn value (3.23) was 450 and K =0.29 yr^{-1}. Based on the values obtained from ELEFAN I and Bertalanffy plot (1934), the von Bertalanffy growth equation (VBGF) of females of *H. thomassi* can be expressed as:

Females: $Lt = 449.66\ (1\text{-}exp^{-0.29(t-0.0032)})$

When compared to males, females also attained a similar length during different years with 113,198,261,308,344,371mm at the end of I, II, III, IVth, Vth and VIth years respectively (Fig.9.8 and Table 9.2)

Table.9.1. Growth parameters estimated by ELEFAN I for male, female and pooled *H. thomasssi*

Sex	Cohort	L_∞	K	t_0	Rn	Φ
Males	July-August	436	0.31	-0.0051	2.62	2.77
Females	June-July	449.66	0.29	-0.0032	3.23	2.77
Pooled	July-August	446.5	0.5	0.495	3	3

Table.9.2. Length arrived at various ages in males, females and pooled of *H. thomassi*

Age (years)	Male	Female	Pooled
1	116	113	159
2	201	198	272
3	264	261	341
4	310	308	383
5	343	344	408
6	368	371	423

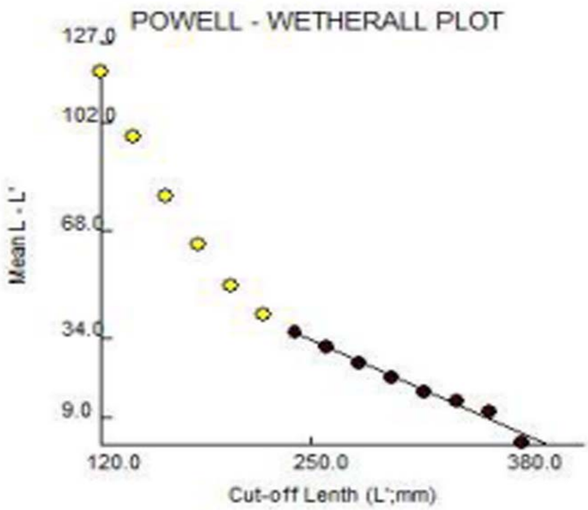


Fig.9.1. Powell- Wetherall plot of male *H. thomassi*

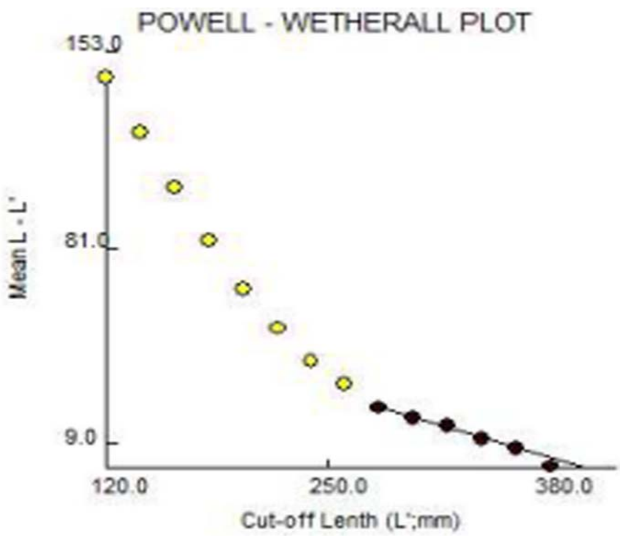


Fig.9.2. Powell- Wetherall plot of female *H. thomassi*

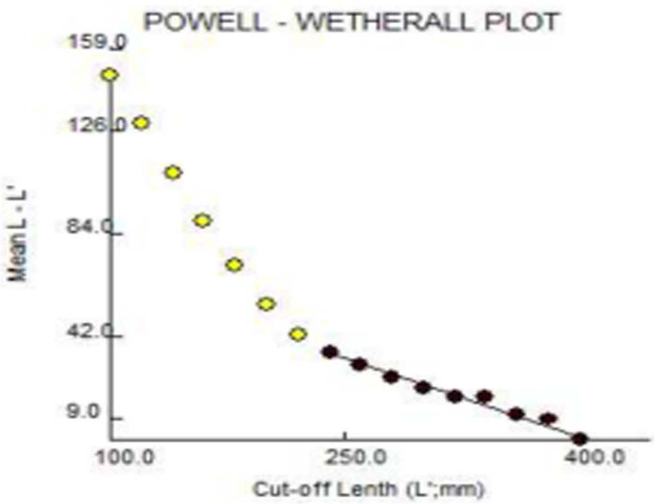


Fig.9.3. Powell- Wetherall plot of pooled *H. thomassi*

9.3.1.3. Estimation of growth parameters of pooled category

In the pooled category which includes male, female and indeterminates the L_∞ and 2/K values derived using Powell-Wetherall method was 446.5 and 3.633 respectively (Fig.9.3). ELEFAN I growth curves (Fig.9.6) showed that the whole population of *H. thomassi* comprised of a single cohort originated during July- August. The L_∞ obtained from ElEFAN I with highest Rn value (3) was 446.05 and K =0.5 yr^{-1}. Based on the values arrived at through ELEFAN I and Bertalanffy plot (1934) the von Bertalanffy growth equation (VBGF) of females of *H. thomassi* can be express as:

Pooled (male + female) : $Lt = 446.5 [1- exp^{-0.5 (t + 0.495)})$

Based on the growth equation, the average annual length of pooled population was calculated as 159,272,341,383,408,423 mm at the end of I, II, III, IVth , Vth and VIth years respectively (Fig.9.9 and Table.9.2).

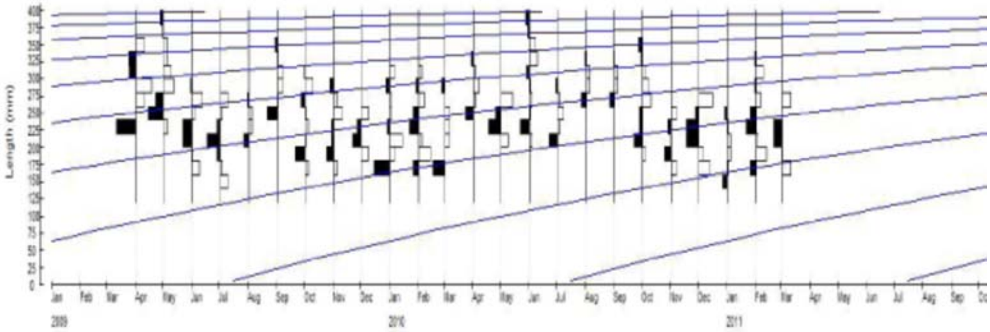


Fig.9.4.ELEFAN 1 growth curve of male population of *H. thomassi*

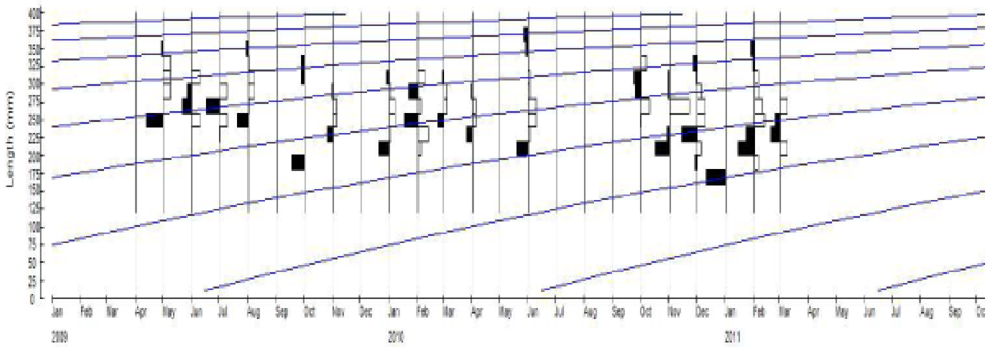


Fig.9.5.ELEFAN 1 growth curve of female population of *H. thomassi*

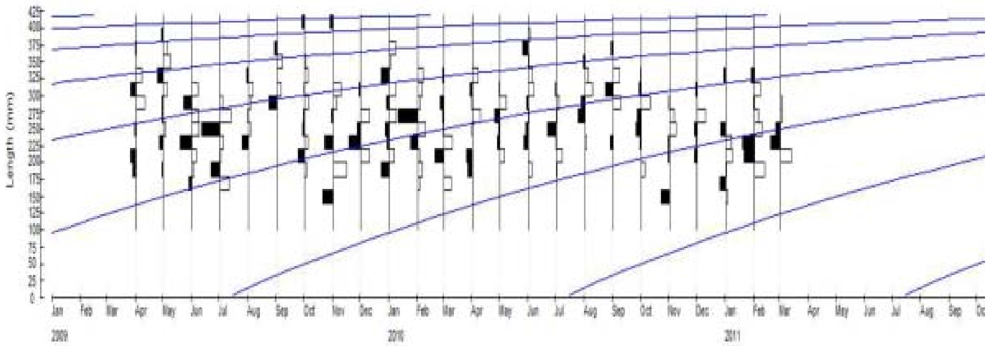


Fig.9.6.ELEFAN 1 growth curve of pooled population of *H. thomassi*

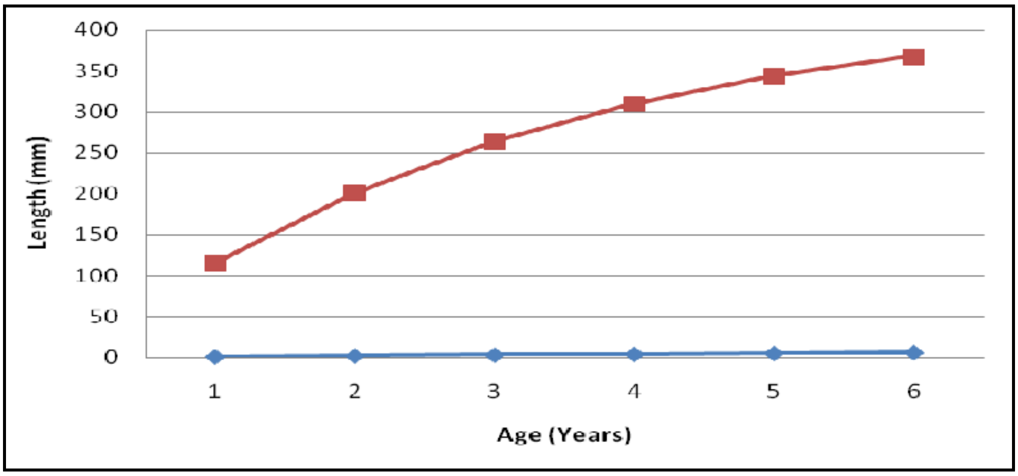


Fig.9.7.VBGA of male population of *H.thomassi*

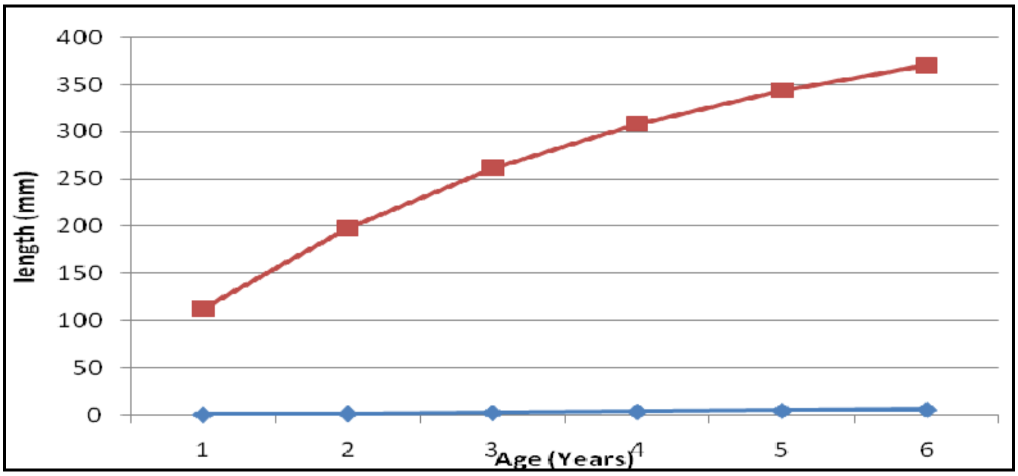


Fig.9.8.VBGA of female population of *H.thomassi*

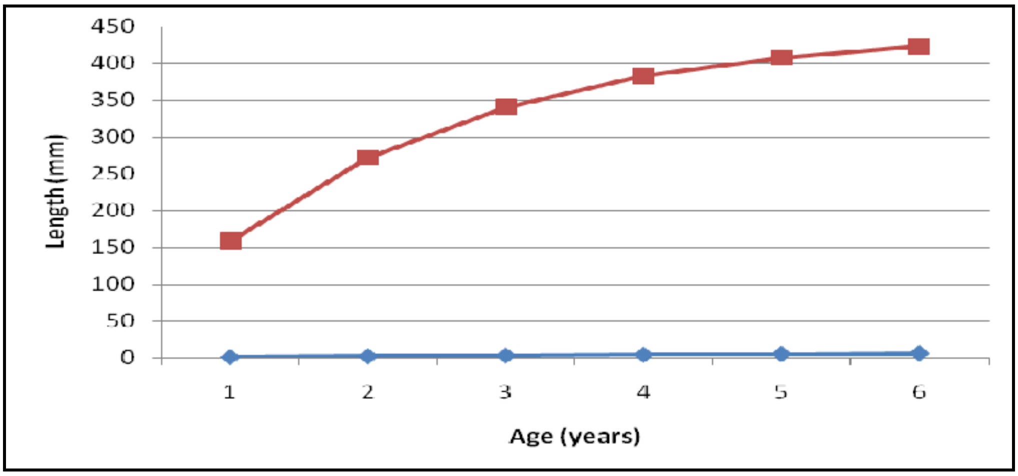


Fig.9.9 VBGA of pooled population of *H.thomassi*

9.3.2. Analysis of recruitment pattern

The recruitment pattern obtained for males and females through FISAT is given in Figs.9.10 and 9.11 respectively. In male *H. thomassi*, the recruitment period extended from April to June and October-November. The major recruit was identified from April to June with a peak of 15.32% in June. The minor mode was appeared in October-November with a peak of 11.93% in November. In the case of females, the recruitment season extended from March to September. The major peak extended from May to September with a peak in August (13.84%). Thereafter, it gradually declined and continued till February. The minor peak is in March (10.35%).

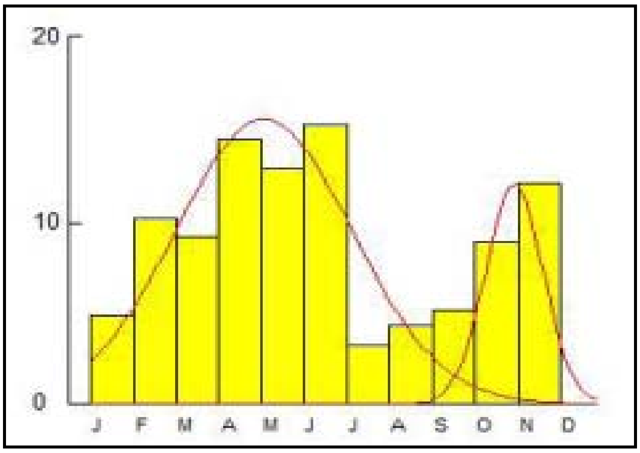


Fig.9.10.Recruitment pattern of males of *H. thomassi*

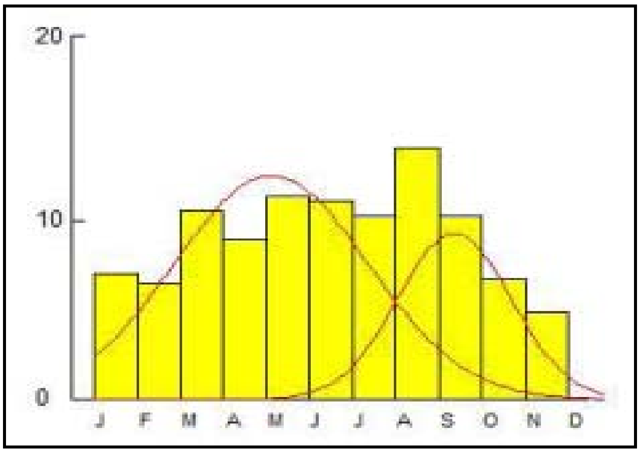


Fig.9.11.Recruitment pattern of females of *H. thomassi*

9.4. Discussion

Information on the age composition and growth of commercially important species are of vital importance in evolving polices for the management and conservation of resources. In the present study, L_∞ computed by ELEFAN I and Powell-Wetherall method were almost comparable in males, females and pooled population. Among the three groups, females showed the highest L_∞ of 450, followed by pooled category (446.5) and males (436). The 'K' value and growth performance index (Φ) were 0.31 and 2.77 in males,0.29 and 2.77 in females and 0.5 and 3 in pooled category. The higher values of growth co-efficient in females indicated that females attained asymptotic length at a faster rate than the males. While the much higher ϕ and K values in the pooled category indicated that the growth rate was very high before attaining the sexual maturity. The short lived species has small L_∞ and a high K value and long lived species have higher L_∞ and low K value (Pauly, 1985). Present study shows that *H. thomassi* having high L_∞ and smaller K values indicating that these species are long lived like *L. rohita*, *Tor tor* and *L. calbasu* (Dwivedi and Nautiyal 2012), *Gibelion catla* (Ahmed *et al.*,2003) and *L. gonius* (Haroon *et al.,* 2001)

The studies on length-weight relationship studies (Chapter 8) revealed that the 'b' values of males (3.2048) and females were (3.0207) comparatively higher in *H. thomassi* when compared to other cyprinids like *Tor tor* (Malhotra,1982), *Labeo dero* (Malhotra and Chauhan,1984) and *L dycheilus* (Malhotra,1985). Furthermore, the growth co-efficient (K) of *Gibelion catla* (0.1044), *Labeo rohita* (0.2551) and *Cirrhinus mrigala* (0.275) reported by Mathew and Zacharia (1982) are relatively less than that of *H. thomassi* in the present study, in contrast Haroon, *et al*. (2002) recorded higher values of 0.8 in *L. rohita*, 0.73 in *G. catla*, 0.7 in *C. mrigala* and 0.76 in *L. calbasu* collected from Bheels. The growth co-efficient of *Labeo dussumieri* was estimated as

0.64 for males and 0.81 in females by Kurup (1997). Pauly(1984 a) reported that species having shorter life span have higher 'K' value and therefore can reach their L_∞ within one or two years. Conversely, those having flat growth rates are characterized by a lower 'K' values and takes more years to reach their $L\alpha$. In *H. thomassi,* the low 'K' value in both the sexes support a long life span of more than 6 years, which shows a strong corroboration with the established relations between is in general agreement with the relationship between 'K' values and L_∞ as reported (Pauly,1984 a).

Based on the result of the present study, it can reasonably be inferred that the longevity of *H. thomassi* is more than 6 years. The length of males at the end of first, second, third, fourth and fifth years of life were estimated to be 116,201,264,310,343,368 mm respectively. Females attained a length of 113 at the end of I year, 198 at the end of II year, 261 at the end of third year and 308 at the end of IV year. It can be postulated that the exploited stock of males and females invariably belonged to third year age group. Accordingly representation of male and female individuals belonging to age groups above 3 and above was sparse and sporadic in the exploited stock.

H. thomassi has been listed under critically endangered category of fishes based on its biodiversity status following IUCN (Ali *et al.*,2013). The basic principle of fishery resource conservation and sustenance of the fish stock is by allowing a fish to breed at least once in its life time for ensuring the natural recruitment and regeneration. In *H. thomassi,* the length at first maturity has been estimated to be 290 mm in males and 330 mm in females (Refer: Chapter 7). It would thus appear that both male and female are getting a chance to complete the maturation and spawning before completing fourth year of their life cycle. Johal and Tandon (1987) found that the Indian Major Carps attains sexual maturity only above 30 cm TL during the second or third year of their life span. Singh *et al.*(1998) reported that *Labeo rohita* attained sexual maturity at a length of 46 cm TL after the fourth year of their life span. Based on the results of the present study, it can be well be recommended that both males and females of *H. thomassi* can be exploited before attaining third year in their life.

Recruitment to the fishery was discernible during April-June and October-November in males with two major pulses. Mustafa (1994) and Mustafa and Khan (1998) also recorded two pluses of recruitment of some fishes. In females, the recruitment period extended from March to September with the major pulse from May to September and minor in March. This finding is very much in agreement with the results of maturation and spawning studies (see Chapter 7), which could identify an extended spawning season in *H. thomassi* viz., June-October. The growth curves obtained using ELEFAN I also strongly corroborate the possible existence of a single brood in a year.

The present study revealed that *H. thomassi* is a slow growing fish which attains marketable size by the end of the third year of its life. The growth co-efficient of *H. thomassi* (male = 0.31; female = 0.29) was comparable with other freshwater fish species used for aquaculture. Moreover, the extended recruitment period revealed the long term availability of brooders and fingerlings in the wild. So the present findings are supportive of utilizing *H. thomassi* as a prime an effective aquaculture species.

.....ഇൽ.....

Chapter 10

POPULATION DYNAMICS

Contents

10.1. Introduction

The fish population is highly dynamic due to various types of forces acting on it such as fishing and other fishery independent factors (Banerji, 1967). Successful management of this living resource is required for maintaining the balance of the stock between additive and destructive forces acting on the population. Fish exploitation has been increasing at a very rapid rate to meet the growing demands of the rapidly multiplying human population which in turn has lead to a drastic decline in the abundance of many fish stocks. In Asia, the world's largest inland fish producing region, wild caught freshwater fishes have been exhibiting signs of overexploitation with decline in catch per unit effort, age at maturity and also the average size of the fish caught (Dudgeon, 2000). In spite of being small scale and artisanal in nature, the fishery of several important freshwater fish including mahseer and catfish in India (Bhatt *et al.*, 2000, 2004; Patra *et al.,* 2005; Raghavan *et al.,* 2011), major carps (de Graaf, 2003) in Bangladesh, large cyprinids in Mekong basin (Baird, 2006; Dudgeon, 2000) and sturgeons in China (Wei *et al.,* 1997) have shown a characteristic decline during the last decade. This situation calls for the development of suitable management strategies for conservation of fishery resources and for their rational use.

Studies on population dynamics are essential to formulate fishing strategy to obtain the maximum sustainable yield without disturbing the equilibrium of fish stock. These studies help in evaluating both natural and human forces acting upon a population and fitting them into yield models so as to moderate the dynamic forces through management practices and thereby sustain the benefits from a fish population on a long term basis (Bal and Rao, 1984). Some of the important contributions on fish stock assessment in the tropics were those of Pauly (1980 a, b; 1982 a, b; 1983 a, b; 1984 a, b; 1987), Banerji and Chakraborty (1973), Pauly and David (1981), Devaraj (1983), Sparre and Venema (1992) and Gayanilo and Pauly (1997). Miah *et al.* (1997) estimated the growth and mortality parameters of Hilsa from Bangladesh. Some of the recent works on the population dynamics of carps include those of Haroon *et al.* (1999, 2001) on major carps, Alam *et al.* (2000) on *Labeo calbasu*, Haroon *et al.* (2001) on *L. rohita*, *L .calbasu* and *L. gonius* and Nurulamin *et al.* (2001) on *L .rohita*.

Detailed information is available on the population dynamics and exploitation rate of large number of marine fishes. However, unlike marine ecosystem, datasets on the dynamics of exploited population of important fish species inhabiting rivers especially endemic species are largely unavailable. This is mainly due to the lack of personnel and financial resources in such countries to undertake research programs (Maccord *et al*., 2007). These deficiencies are also caused by the lack of attention from governments on this sector (Anonymous, 2002). Banerji (1967) highlighted the importance of fish population studies and reviewed the various methods available for such studies. The works of Sekharan (1974) on oil sardine and mackerel, Krishnamoorthi (1976) on *Nemipterus japonicus*, Yohannan (1983) on mackerel, Annigeri (1989) on *Sardinella gibbosa*, Karthikeyan *et al.* (1989) on *Leiognathus* sp., Khan (1989) on *Harpodon nehereus*, Khan and Nandakumaran (1993) on *Cynoglossus sp.*, Reuben *et al.* (1994) on *Upeneus sp.*, Philip and Mathew (1996) on *Priacanthus hamur*, Reuben *et al.* (1996) on *Ariomma* sp., Jaiswar *et al.* (2001) on *Decapterus russelli*, Rajkumar *et al*. (2004) on *Johnius carutta,* Manojkumar and Sivakami (2005) on *Saurida tumbil*, Joshi (2005) on *Nemipterus mesoprion,* Abdussmad (2006) on *Rastrelliger kanagurta*, Manojkumar (2007) on *Decapterus russelli*, Shubhadeep *et al*. (2009a) on *Harpodon nehereus*, Shubhadeep *et al*. (2009b) on *Trichirus lepturus*, Shubhadeep *et al*., (2009 c) on *Pampus argenteus,* Ramachandran and Philip (2010) on *Odonus niger,* Aness *et al*. (2010) on *Lepturacanthus savala* and Abraham *et al*. (2011) on silver bellies are worth mentioning.

Goswami and Devaraj (1993) estimated the potential yield of *Labeo rohita* from a flood plain lake in Assam. Optimum yield assessment of *L. rohita* and *Wallago attu* was carried out by Goswami and Devraj (1994). The total mortality estimates of *W. attu* was made by the above authors from Brahmaputra basin of Assam region (Goswami and Devraj, 1994). Kurup (1998) studied the growth parameters, mortality, biomass recruitment pattern and exploitation rate of an indigenous endangered carp, *Labeo dussumieri* of River Pamba of Kerala (South India). Sarkar *et al.* (2012b) assessed the population structure of *Labeo boggut* from Yamuna river basin. Stock assessment of *Labeo rohita, Tor tor* and *L. calbasu* from Damoh, Paisuni and Tons rivers were estimated by Amithab and Nautiyal (2012). Raghavan *et al.* (2011) estimated the stock assessment of Deccan Mahseer, *T. khudree* from the rivers of Western Ghats. Population dynamics of an endemic yellow catfish, *Horabagrus brachysoma* from River Periyar were estimated by Prasad *et al.* (2012).

Hypselobarbus thomassi is an endemic species of the rivers of Western Ghats which requires protection and judicious exploitation of stock. There is no targeted fishery of *H. thomassi* as a food fish anywhere in its distribution range. However, they are caught along with other species of *Hypselobarbus* as well as Mahseer (*Tor* sp.) in this river. Hitherto, no information is available on any aspect of population dynamics of this endemic species. The present study is aimed at providing information on the mortality parameters and exploitation rate of *H. thomassi* inhabiting river Kallada.

10.2. Materials and Methods

Fish samples were collected between April 2009 to March 2011 from the Kallada river. A total of 537 individuals of fishes were collected throughout the study period. Data was collected following the methodology of Gulland & Rosenberg (1992) on the length based approaches to fish stock analyses. On each sampling day, random samples of fish were obtained from well mixed catches. The total length (mm) of each individual fish was measured to the nearest mm by using measuring board. The length frequency data were pooled in to 10 mm length classes. Assuming that the growth of this species follows von Bertalanffy growth formula (VBGF), the VBGF parameters, L_∞, K and t_0 were estimated using the FiSAT (FAO – ICLARM stock Assessment Tools) computer software package (Gayanilo and Pauly, 1997) and was used for estimation of mortality parameter.

10.2.1. Data Analysis

Mortality coefficients, total mortality (Z), instantaneous natural mortality (M), fishing mortality (F) and exploitation ratio (E) were estimated using FiSAT program (Pauly, 1980 a; Gayanilo & Pauly, 1997)

Total mortality (Z) estimate was done by the methods of length converted catch curve method of Gayanilo and Pauly (1997).

The length converted catch curve was obtained using the following formula:

$$\ln (N_i / t_i) = a + b\, t_i$$

where N_i = number of specimens in length class i

t_i = relative age corresponding to length class i

Natural mortality (M) was calculated using the empirical formula Pauly's (Pauly, 1980 b)

Natural mortality is given by the following empirical formula:

$$\log_{10} M = 0.0066 - 0.279 \log_{10} L_\infty + 0.6543 \log_{10} K + 0.4634 \log_{10} T$$

Where M = Natural mortality

L_∞ and K = Growth parameters of VBGF

T = Annual mean temperature (^{0}C) of the water in which the fish lives.

In the present study, T was taken as 20^{0}C.

Instantaneous rate of fishing mortality (F) was computed by subtracting natural mortality (M) from total mortality (Z).

$$F = Z - M$$

Cohort analysis (Jones, 1984) **or Virtual Population Analysis (VPA)** is used to estimate stock sizes at various fishing mortalities. In this analysis, the number of fishes in the river that attain L1, is given by

$$N(L_1) = [N(L_2)\, S(L_1, L_2) + C(L_1, L_2)]\, S(L_1, L_2)$$

Where $S(L_1, L_2) = [(L_\infty - L_1) / (L_\infty - L_2)]^{M/2K}$

The exploitation rate is determined from the relationship

$$F/Z = C(L_1, L_2) / [N(L_1) - N(L_2)]$$

The fishing mortality was calculated using the formula, F = M/(F/Z) (1-F/Z). In the above expressions, L_α and K are growth parameters of VBGE. L_1 and L_2 are the lower and upper limits of a length group considered, N is the stock number, C is the number caught, F and M are the fishing and natural mortality coefficients respectively.

Exploitation rate (U) - The rate of exploitation is defined as the fraction of fish present at the start of a year that is caught during the year (Ricker, 1975). This is estimated by the equation given by Beverton and Holt (1957) and Ricker (1975) as:

$$U = \frac{F(1-e^{-z})}{Z}$$

Exploitation ratio (E)- It refers to the ratio between fish caught and the total mortality (Ricker, 1975) or the exploitation rate or fraction of death caused by fishing (Sparre and Venema, 1992). It is estimated by the equation:

$$E = F/Z = F/(M+F)$$

The ratio gives an indication of the state of exploitation of a stock under the assumption that the optimal value of E equals 0.5 ($E \approx 0.5$).This, in turn, is under the assumption that the sustainable yield is optimised when $F \approx M$ (Gulland, 1971).

Relative yield per recruit (Y/R) and relative biomass per recruit (B/R) - Y/R and B/R values were determined as a function of L_c/L_∞ and M/K (Pauly and Soriano, 1986). The estimates were made using the FiSAT software. The computed exploitation rate was compared with the expected values of E_{max} (the value of exploitation rate giving maximum relative yield-per-recruit), E 0.1 (the value of E at which marginal increase in Y/R is 10% of its value at E=0) and E=0.5 (the value of E at 50% of the unexploited relative biomass-per-recruit) (Sparre and Venema 1992; Gayanilo and Pauly, 1997).

Probability of capture of fishes L_{25} (length at which 25% of fishes caught), L_{50} (length at which 50% of fishes caught), L_{75} (length at which 75% of fishes caught) were estimated from the left ascending arm of length – converted catch curve. This method provides reasonable estimates of mean size at first capture (L_c) (Hoydal *et al.*, 1982; Jensen, 1982). By plotting the cumulative probability of capture against mid-length, a resultant curve was obtained. From this curve, the length at first capture L_c was taken as corresponding to cumulative probability at 50%.

10.3. Results

The growth parameters used for the stock assessment studies were estimated using ELEFAN 1 programme of FiSAT software (See Chapter 9). L_∞ and K computed in pooled of *H. thomassi* were 446.5 and 0.5 yrs^{-1}. The t_0 was estimated as –0.4958.

Total mortality coefficient (Z)

The length converted catch curve worked out in *H. thomassi* is depicted in Fig. 10.1. The total mortality (Z) of *H. thomassi*, estimated from the length was 1.75.

Natural mortality coefficient (M)

The natural mortality (M) estimated following Pauly's empirical formula was 0.46 y^{-1} for an average temperature for 20°C.

Fishing mortality coefficient, Exploitation ratio and Exploitation rate

The annual instantaneous rate of fishing mortality (F) was obtained by subtracting the natural mortality rate (M) from the total mortality rate (Z) and the value obtained was 1.29. The exploitation ratio (E) of *H. thomassi* population was 0.74. Similarly, the exploitation rate (U) was found to be 0.61.

Length based cohort analysis or VPN methods

Virtual population analysis (VPA) is a very useful tool that allows the reconstruction of the population from by age or size. The result reveal that the fishery exploitation take places in the size range of 190-330mm while the major size classes contributing to the fishery are 230 and 250 mm (Fig.10.2). The fish mortality (1.62) is maximum at a size class of 330mm.

Probability of capture

Probability of capture was estimated from the type of net used for fishing. The selection length of 25% or L_{25} was 201.6 mm, 50% or L_{50} 218.77mm and the 75% or L_{75} was 235.93 mm (Fig.10.3).

Relative yield per recruit (Y/R) and relative biomass per recruit (B/R)

The relative yield per recruit (Y/R) and biomass per recruit (B/R) were determined as a function of L_c/L_∞ and M/K, used for Y/R analysis of were 0.49 and 0.92 respectively. The yield/ recruit reached a maximum at an exploitation rate of 0.65 in pooled and as the exploitation rate increased, the Y/R decreased. It may be noted that the present exploitation ratio E (0.74) has clearly exceeded the optimal exploitation of E_{max} = 0.65. Exploitation rate (E) at different levels as $E_{0.1}$, $E_{0.5}$, E_{max} estimated by the analysis are 0.57, 0.365 and 0.65 respectively (Fig.10.4)

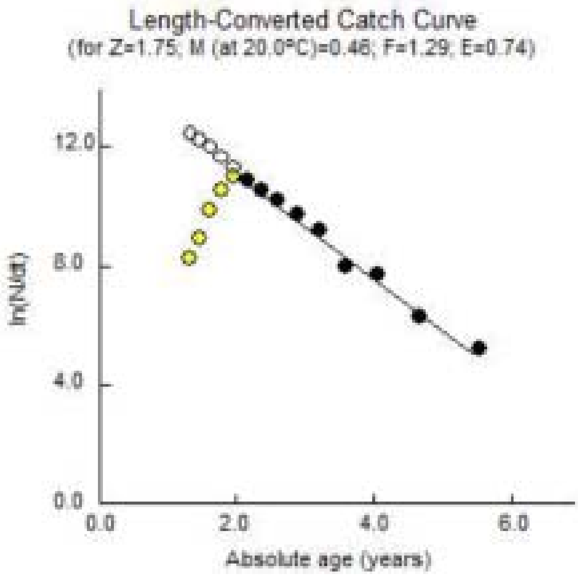


Fig.10.1.Length based cohort analysis of *H. thomassi*

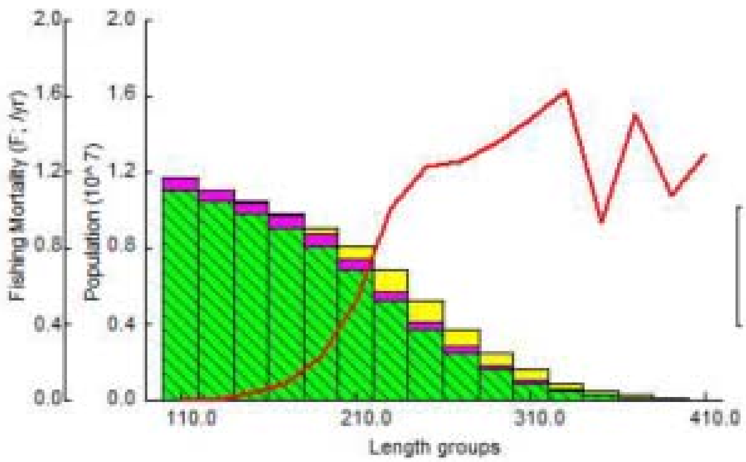


Fig.10.2. Virtual population analysis of *H. thomassi*

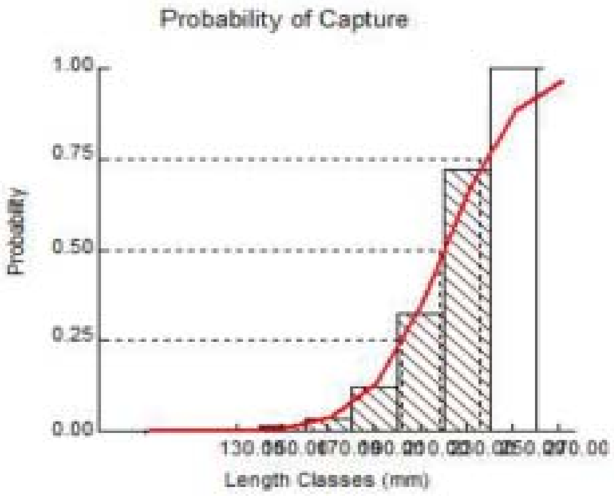


Fig.10.3.Probability of capture of *H. thomassi*

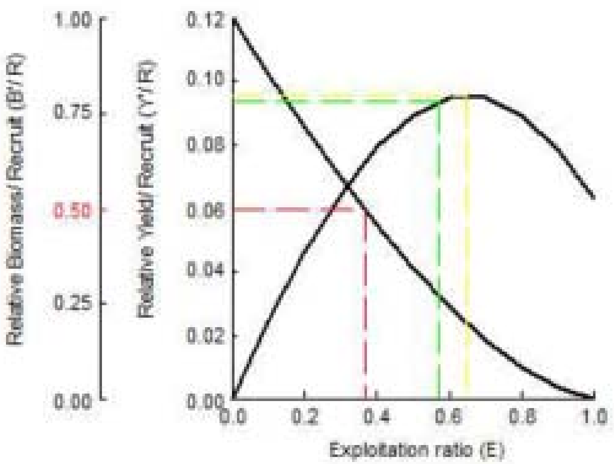


Fig.10.4.Relative yield per recruit (Y/R) of *H. thomassi*

10.4. Discussion

Growth characteristics of fishes are important part of population dynamics and essential parameters to take serious decision on the management issues of any fishery (Devries and Frie, 1996). Fisheries management requires an understanding of the biological characteristics of harvested fish stocks and also an assessment of their status. Therefore, the information on the stock structure of this resource is of paramount importance for adopting proper management measures. The use of length-based methods was also facilitated by the development of computer programs for this purpose by using the series of ELEFAN programs and WorldFish stock assessment tools, namely FiSAT software which was regarded as inexpensive and rapid, yet providing reliable results (Ilona and Len, 2003). Studies on population dynamics of fishes from tropical waters became popular after the formulation of length based methods and models and the introduction of suitable computer software's like FiSAT. In India, most of these studies pertain to marine fishes. Non-availability of required number of specimens belonging to different size classes has been the major factor hindering the progress of such studies in freshwater fishes in general and threatened fishes in particular. *H. thomassi* is a threatened and endemic species of Kerala. Virtually no information is available on the population dynamics of this species and therefore the present results gain importance.

Mortality rates are important for understanding the rate of population decay (Sparre and Venema, 1992). Mortality is caused by natural factors like diseases, predation, environmental changes, salinity etc. In an unexploited stock while in exploited stocks, in addition to natural causes, fishing is the major contributing factor to mortality. Total mortality includes both natural and fishing mortalities. For estimating total mortality (Z) and natural mortality (M) of fish population, length converted catch curve method (Gayanilo and Pauly, 1997) and empirical formula of Pauly's (Pauly, 1980 b) were used respectively. Natural mortality is influenced by several biological and environmental factors and hence an accurate estimation of it is often difficult. (Pauly, 1980 b; Cushing, 1981; Liu and Cheng, 1999). Total mortality (Z), Natural mortality (M), Fishing mortality (F) and Exploitation rate (E) of *H. thomassi* in the Kallada river were computed as 1.75 $yr^{-}1$,0.46 yr^{-1}, 1.29 yr^{-1} and 0.74 yr^{-1} respectively. Since there are no previous studies on the mortality rates and exploitation of *H. thomassi,* the present study are compared with other cyprinids species occurring in India. Rajeev *et* al. (2011) calculated a low total mortality, natural mortality, fishing mortality and exploitation rate of *Tor khudree* from Western Ghats rivers of Kerala (0.67, 0.22, 0.45 and 0.62 yr^{-1} respectively), when compared to present result of *H. thomassi*. Gupta and Tyagi (1992) reported relatively low values of total mortality, natural mortality, fishing mortality and exploitation rate for *Labeo rohita* (0.74, 0.30, 0.44 and 0.59 yr^{-1} respectively) in the Ganga river system at Allahabad. Alam *et al.* (2000) estimated a high mortality rate in *L. calbasu*, 1.11 yr^{-1} as natural mortality, 3.48 yr^{-1} as fishing mortality and 4.59 yr^{-1} as total mortality. Faster growing fish have higher natural mortality rate (Spaarre and Venema, 1992).

In the present study, the fishing mortality recorded was higher than the natural mortality for all the species which indicates that all these species are harvested at maximum levels. Palaniswamy *et al.* (2011) reported that fishing mortality is higher than natural mortality in carps (*Gibelion catla, Cyprinus carpio* and *Cirrhinus mrigala*) of Thirumoorthy Reservoir.

The natural mortality of fish is closely related to age and size as the larger fishes are less prone to predation. Therefore, M can be correlated to longevity of the fish and the latter to growth coefficient K. M/K ratio can be used as an index for checking the validity of M and K values. The relative yield per recruit (Y/R) and biomass per recruit (B/R) were determined as a function of Lc / L_∞ and M/K in the present study and the values worked out were 0. 49 and 0.92 respectively. According to Sparre and Venema (1992) the fishes with moderate K values are characteristic with moderate natural mortality, and it is related to age and size of the fish. M values in the present study is 0.46 and the corresponding K value is 0.5. Thus, M/K ratio worked out in the present study was 0.92 and was lower when compared to other cyprinids, *Labeo dussumieri* (Kurup,1998), *L. calbasu* (Alam *et al.,*2000) and *Labeo rohita* (Nurulamin *et al*., 2001). M/K ratio is found to be constant among closely related species and sometimes within the similar taxonomic groups (Beverton and Holt, 1959; Banerji, 1973).

The exploitation ratio (E) is an index used to assess if a stock is overfished, on the assumption that optimal value of E is equal to 0.50. Haroon *et al.,* (2001) reported very low exploitation rate for *L. rohita* in two successive years ie. 0.52 and 0.55 in the Sylet basin. According to Gulland (1971) the Exploitation ratio (E) will be more than 0.5 for the stocks supposed to be over fished. Ahmeds *et al.* (2004) stated that the exploitation rate close to the maximum allowable limits (E_{max}) of the yield/ recruit, which indicates that the stock is more or less under optimal fishing level. Therefore, the fishing mortality doesn't seem to be great concern. The current exploitation ratio was computed at 0.74 which is far higher than the optimum exploitation rate E_{max} (0.65) indicating that *H. thomassi* populations in Kallada River are being overexploited. Overfishing is now considered to be a contributing factor to the decline of freshwater biodiversity (Allan *et al*., 2005).

The present results of VPA revealed that the size classes subjected for fishery exploitation range between 110-350 mm, of which major size classes were 230-250 mm. The results of age and growth studies show that these size range classes belong to age group 2^{nd} and 3^{rd} year (Please refer Chapter 9). It can also be noted that the males and females attains the sexual maturity at 290 in males and 330 in females. It can be reasonably inferred that the major size classes becoming for fishing mortality before 4^{th} year, when they attains sexual maturity. *H. thomassi* in Kallada is therefore, caught before they grow large enough to contribute substantially to the stock biomass, thus demonstrating growth over fishing. Even small changes in the growth parameters used could seriously affect the computed mortality rates (Tserpes and Tsimenidis, 2001). Currently, the fishery for *H. thomassi* in Kallada River appears to be unsustainable as is evident from the high rates of exploitation and the occurrence of growth and recruitment fishing. Being an open access fishery devoid of any management plan, the fishery for the threatened carp in Kallada is vulnerable to collapse if proper management interventions are not planned and put into practice in the immediate future.

Chapter 11

SUMMARY AND RECOMMENDATIONS

11.1. Summary

Fishes form more than half of the total number of vertebrate species present on in planet and is an indicator of water bodies' health status. India has a rich heritage of biodiversity at all three levels, viz., genus, species, and ecosystem. India is endowed with large network of rivers, lakes, and freshwater bodies, as well as a huge coastline, that are home to diverse fish fauna. In India, there are 2,500 species of fishes, of which 930 live in freshwaters and 1,570 are marine. Overall, India occupies the ninth position in terms of freshwater mega biodiversity. The Western Ghats of India has been identified as a hotspot of biodiversity by the World Conservation Monitoring Centre (WCMC). It lies almost parallel to the west coast and forms a continuous hill range that traverses the states of Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala. It forms a natural wall on the eastern side of the state of Kerala and is the watershed of the 44 rivers flowing through Kerala and most of these rivers abound very rich, diversified, rare and endemic fish fauna. 290 species of freshwater fishes belonging to 11 orders, 33 families and 106 genera were reported from the Western Ghats and among them 189 species are endemic to this region. In the World Bank technical paper, special mention has been given to the streams and river systems originating from the Kerala part of Western Ghats for their rich and varied freshwater fish diversity with high degree of endemism. However, many of these fish species have already been threatened or endangered due to a variety of anthropogenic influences.

A river system wise database on the commercially important and potential ornamental and cultivable fishes together with an assessment of their biodiversity status either as threatened or non-threatened are also still lacking. Not much work has been done in Kerala on river wise fish germplasm resources and quantification of exploited fish production from rivers. The endemism and biodiversity of river wise fresh water fishes of Kerala is also not properly evaluated which is very essential for the preservation of the unique fish germplasm resources. The present study was conceptualized and undertaken mostly aiming at bridging these gaps by generating an authentic data base on systematics of freshwater fishes of Kerala, assessing river wise germplasm, quantification of exploited fisheries of major rivers, Estimation of catch per unit effort (CPUE) and status of non-native fish introduction.

The river wise fish species inventory of Kerala Rivers was prepared by screening the available literature during the past 20 years. Besides these results, the research conducted as part of Kerala State Council for Science & Technology (KSCSTE) sponsored project "*Development of a database on fish germplasm, capture fisheries and biodiversity threats of rivers of Kerala*" carried out during January 2007- March 2010 at School of Industrial fisheries, Cochin University of Science & Technology was also utilized for revalidation. Around hundreds of research papers and more than twenty PhD thesis on the freshwater fish fauna of Kerala prepared during 1992-2012 were also collected for accomplishing the mission. The biodiversity status of each species was assessed based on IUCN criteria (2011). The exploited fisheries was also estimated based on the data generated from major fish landing centres of eight rivers of Kerala from where regular systematic surveys and sampling were conducted during pre-monsoon, monsoon and post-monsoon seasons.

234 fresh water fish species belonging to 16 orders, 51 families and 104 genera were reported from 40 rivers of Kerala based on screening of the literature and present study. Cypriniformes emerged as the largest order in its numerical strength of species with 129 species followed by Perciformes (42 species) and Siluriformes (32 species), Family Cyprinidae was the largest family accommodating 26 genera and 98 species while the genus *Puntius* of this family accommodated the highest number with 25 species. Periyar river showed very rich fish diversity with 139 species followed by Chalakuddy (128 species) and Bharathapuzha rivers (120 species). The revalidation on biodiversity status of the fishes assessed based on recent IUCN status is so alarming that a high percentage of fishes (59 species) belong to threatened category which included fishes of 5 critically endangered (CR), 36 endangered and 18 species vulnerable (VU) category. The fishes belonging to critically endangered category were *Hypselobarbus thomassi, Barbodes bovanicus, B. wynaadensis, Horalabiosa arunachalami* and *Hemibagrus punctatus*. While assessing the endemism, it was found that 94 species were characterized by their distribution confirm to the Western Ghats of Peninsular India (EN-WG), among them 36 were strictly endemic to Kerala waters (EN-K). 16 species were found endemic to India (EN-I) and 32 species were endemic to Indian subcontinent (EN-IS), whereas 10 species are exotic in their nature. Comparing the fish diversity of various river systems of Kerala, Periyar river system showed richest fish species diversity in terms of total number of species, number of ornamental fish species and cultivable fishes, degree of endemism, fish species endemic to the particular river system, number of endangered and threatened species and was also characterised by the highest river index value of 841. Chalakkudy river system occupied second position and recorded an index value of 442.

The exploited fishery of the rivers was estimated based on the data generated from 39 major landing centres, Pamba, Chalakudy, Periyar, Meenachil, Muvattupuzha, Kallada, Bharathapuzha and Achenkovil rivers were selected for the study. The total exploited fishery from these rivers was estimated to be 854.75 tonnes. Highest landings were recorded in River Pamba (394.22 t) followed by Achenkovil (162.74 t) and Bharathapuzha (112.56 t). Pamba, Periyar, Bharathapuzha and Achenkovil contributed to 86% of the total riverine fish production in the state. The remaining four rivers contributed to only 14% of the landing. Bharathapuzha and Chalakudy River (31 species each) showed a high exploited fish diversity. *Labeo dussumieri, Etroplus suratensis, Channa striata, Puntius filamentosus, Horabagrus brachysoma*, *Wallago attu* and *Hypselobarbus curmuca* were the major species contributed to the exploited fishery of these rivers. Gill nets, cast nets, seine nets, drag nets and hook and lines were the major gears engaged in the exploited fishery.

Six species of non-native fishes were reported from various landing centres from the rivers of which three (*Cyprinus carpio, Oreochromis mossambicus* and *Clarias gariepinus*) are exotic to the country, while remaining three are the Indian major carps (*Gibelion catla, Labeo rohita, Cirrhinus mrigala*), which were transplanted from the gangetic plains for stock enhancement and aquaculture. *O. mossambicus* and *G. catla* were emerged as the most widely distributed non-native species, recorded in 4 rivers. River Chalakudy and Bharathapuzha harbour highest number of non-native fish species in the exploited stock (4 species each). The total exploited fishery of the non-native fishes in rivers of Kerala was estimated at 68.61 tonnes and among them, Indian Major Carps (IMC) contributed to 52%. The landing of non-native fishes was highest in Periyar river (26.85 t) followed by Pamba (17.43 t).

Hypselobarbus thomassi (Day, 1865) commonly known as 'Red Canarese barb' locally known as *Chakklai,* belongs to the family Cyprinidae. It is an endemic fish of the rivers of the Western Ghats of India, which has been listed as 'Critically Endangered' in the IUCN Red list of threatened species. It is distributed in large streams and rivers below the Western Ghats. *H. thomassi* attains a total length of 100 cm. In Kerala, *H. thomassi* is reported from Chalakudy, Kabbini, Periyar and Kallada rivers. Hitherto, no information is available on the bionomics and resource characteristics of this species. Studies on detailed life history traits are indispensable for fishery management, development of captive breeding technique and implementation of various conservation programmes of this species. In the present study, a pioneer attempt was made to investigate the life history traits and resource characteristics of *H. thomassi.*

The qualitative and quantitative aspects of food composition in relation to sex, size and season, seasonal variation in feeding intensity as well as gastro somatic index was assessed. The index of preponderance was used to assess the food preferences of males, females and indeterminates. The study indicated that the basic food of *H. thomassi* was semi digested plant particles. The other major food items identified were chlorophyceae, bacillariophyceae, cyanophyceae and semi digested animal particles. This species belonged to herbi-omnivore group because in males 87.26% of the food spectrum was comprised of materials from plant origin while in females and indeterminates it was respectively 87.1% and 89.43%. The feeding intensity of the fish was found to be very high, which indicated the voracious feeding nature of this species. Feeding intensity was found to be less during the pre-spawning and spawning periods in females as indicated by the low gastro-somatic index and low degrees of gut fullness. Gastro-somatic index indicated higher percentage of feeding among females than males and indeterminates. The sub terminal mouth seen in *H. thomassi* is well adapted to suit its column feeding habit. The result revealed that the fish is an “Omnivorous-stenophagic-column feeder.

The various aspects of reproduction such as maturity stages of males and females, monthly percentage occurrence of fish with gonads in different stages of maturity, pattern of progression of ova during different months, gonadosomatic index, length at first maturity, sex ratio, fecundity and its relationship with various body parameters were studied. The spawning season was delineated based on quantification of maturity stages, monthly percentage occurrence of fish with gonads in different stages of maturity, pattern of progression of ova during different months and the monthly variation of gonadosomatic index. Month wise percentage of mature specimens and gonadosomatic index values showed that *H. thomassi* breeds during June to October. The overall sex ratio showed the predominance of the male. Size at maturity of male and female estimated were 290 mm and 330 mm respectively. The absolute fecundity estimated during the study ranged from 305-1089 eggs. The coefficient of correlation of the various statistical relationships derived between fecundity, body length, body weight, ovary length and ovary weight revealed significant relation between fecundity and the body parameters except in ovary length. The highest degree of correlation was seen between fecundity and ovary weight.

The length-weight relationship in males, females and indeterminates was establishes by the linear equation. The values of regression coefficient for males and indeterminates were 3.20 and 2.63 respectively which showed significant departure from '3' indicating that the growth followed allometric pattern. On the contrary, the exponent value of 3.02 revealed isometric pattern of growth in indeterminates. The results of the analysis of covariance (ANACOVA) revealed that there is no significant difference in the regression coefficient of males, females and indeterminates thereby indicating homogeneity of the sample. The higher K_n values recorded in September in males and April and August in females almost coincided with the occurrence of high gonadosomatic index (GSI) in both males and females. The values in males inclined to decrease from August due to the increased spawning strain in them, while in females the relative condition factor decreased during May-July and August to October.

Length frequency data was used to determine the age and growth of fish. The growth parameters were estimated separately for the two cohorts of male and female populations following ELEFAN I programme in the FISAT software. Powell- Wetherall Method is used to estimate asymptotic length and the ratio of the coefficients of growth (Z/K) using length-frequency data based on Beverton and Holt. L_∞ computed following Powell-Wetherall plot was 436, 450, 446.5 mm and K= 0.31 yr^{-1}, 0.29 yr^{-1}, K =0.5 yr^{-1} in males , females and indeterminates respectively. VBGF equation of male derived was Lt = 435.62 (1-$exp^{-0.31(t-0.0051)}$) and attaining an average length of 116, 201, 264, 310, 343,368 mm at the end of I, II, III, IV^{th} , V^{th} and VI^{th} years respectively. VBGF of females (Fig) can be expressed as Lt = 449.66 (1-$exp^{-0.29(t-0.0032)}$) and attained a average length of 113, 198, 261, 308, 344, 371mm at the end of I, II, III, IV^{th}, V^{th} and VI^{th} years respectively. VBGF of pooled population can be expressed as: Lt = 446.5 [1- $exp^{-0.5 (t + 0.495)}$). In male, the recruitment period extended from April to June and October-November but in females the recruitment season extended from March to September.

Total mortality, natural mortality, fishing mortality, exploitation rate, exploitation ratio, probabilities of capture and yield per recruitment were studied as part of resource charactrestics. Total mortality (Z) of *H. thomassi*, estimated from the Length converted catch curve was 1.75. The natural mortality (M) estimated following Pauly's empirical formula was 0.46 y^{-1} for an average temperature for 20° C. The exploitation ratio (E) of *H. thomassi* population was 0.74 and the E_{max} value was recorded as 0.65. The fishing mortality recorded was higher than the natural mortality for all the species which indicates that all these species are harvested at maximum levels. From VPN analysis, it appeared that the maximum number of fish caught between 210-310 mm and the size class which faced maximum fishing mortality (F= 1.62) was 330 mm. Probability of capture was at a selection length of 25% or L_{25} was 201.6 mm, 50% or L_{50} 218.77mm and the 75% or L_{75} was 235.93 mm..

11.2. Recommendations

Database on the river wise freshwater fish fauna and fish biodiversity of Kerala is deficient at present. It is felt that there is an urgency to intensify the systematic and extensive fish surveys and samplings in all the 44 rivers of Kerala to strengthen and revalidate the river wise database of freshwater fishes of Kerala.

There are several new fish species yet to be discovered in the streams and rivulets located in remote areas of the forests and therefore, new exclusive surveys are required to surface fish species new to science, new distributional records etc, for the river systems.

Quantify the exploited fisheries in all the rivers of Kerala, species wise details of exploitation, details of various gears used for exploitation and also to prepare a responsible fishery practices for sustainable utilization of resources.

Captive breeding and rearing techniques for the indigenous ornamental and cultivable fishes shall be attempted and standardized and the technology so developed may be transferred to the stake holders.

The bionomics studies revealed that *H. thomassi* is having the potential to develop a good aquaculture species. Effort should be made to standardize the captive breeding technology of this species and introduce this species into the culture basket of Kerala.

Endangered freshwater fishes shall be brought under the purview of the Wild life act (1972, amended 1991) at par with the marine fishes.

Establishment of hatcheries exclusively for indigenous fish species are also found imperative to assure preservation of fish germplasm resources of the country.

Assess the status of alien and transplanted fish invasion in the rivers of Kerala and quantify their exploitation level.

A comprehensive risk assessment to know the potential impacts of the alien and transplanted fishes of Kerala are very necessary to formulate appropriate management plans to control their invasions and conserve the native fishes in Kerala rivers.

Introduction of exotic species should be allowed only after studying its biology, habitat and potential threats to native fish species and environment.

The natural breeding grounds and nurseries of the threatened fishes shall be identified and regions so demarcated shall be declared as aquatic sanctuaries.

Regulation should be brought into place to stop the unmanaged collection of endemic and threatened fishes from river basins of Kerala. Strong enforcement is also required to prohibit the use of destructive fishing practices such as dynamiting and electric fishing.

The biodiversity scenario in the current state, offer many opportunities to protect our rich freshwater biodiversity. Success will depend on the extent to which conservationist, Fisheries department, Scientist, Pachayaths, municipalities and corporations work cooperatively to maintain or restore natural water habitat of freshwater resources.

There is an urgent need of educating the fishermen community, local people, governmental and non-governmental agencies, students and the general public regarding the importance of conservation of fish fauna through group discussions, seminars, training camps and publicity through mass media. Awareness campaign needs to be initiated by bringing out posters, stickers, stamps, showing clippings in electronic media, etc.

.....ഇവ.....

Abdussmad. 2006. Fishery and population characteristics of Indian mackerel, *Rastrelliger kanagurta* (Cuvier) at Kakinada. *Indian J. Fish.*, 53(1): 77-83.

Abdus, S. B., Khairul, I. and Zaman, T. 2006. Fecundity and ovarian Characteristics of *Puntius gonionotus* (Bloch/Bleeker) (Cyprinidae: Cypriniformes). *J. Biosci*., 14: 99-102.

Abell, R., Thieme, M.L., Revenga, C., Bryer, M., Kottelat, M., Bogutskaya, N., Coad, B., Mandrak, N., Balderas, S.C., Bussing, W., Stiassny, M.L.J., Skelton, P., Allen, G.R., Unmack, P., Naseka, A., Ng, R., Sindorf, N., Robertson, J., Armijo, E., Higgins, J.V., Heibel, T.J., Wikramanayake, E., Olson, D., Lopez, H.L., Reis, R.E., Lundberg, J.G., Sabaj Perez, M.H. and Petry, P. 2008. Freshwater Ecoregions of the World: A New Map of Biogeographic Units for Freshwater Biodiversity Conservation. *Bioscience,* 58(5): 403-414.

Abraham, K. J., Murty, V. S. R. and Joshi, K.K. 2011. Fishery and population dynamics of silver bellies along the Kerala coast. *Indian J. Fish.*, 58(2): 15-21.

Acharya, P. and Iftekhar, M.B. 2000. Freshwater ichthyofauna of Maharashtra State. p.136- 144. In: Ponniah, A.G. and Gopalakrishnan, A. (Eds.). *Endemic fish diversity of Western Ghats.* NBFGR-NATP Publication-NBFGR, Lucknow, U.P. India, 347 pp.

Agarwal, N. K. 1996. Fish Reproduction. APH publishing corporation, New Delhi. 157pp.

Agostinho, A.A., Gomes, L.C., Suzuki, H.I. and Julio- Junior, H.F. 2003. Migratory fishes of the Parana River Basin Brazil. In: J. Carolsfed, B, Harvey, C. Ross and A. Baer. (Eds.) Migratory Fishes of South America: Biology, Fisheries and Conservation Status, Victoria, BC: World Bank and IDRC. pp. 19-99.

Ahmad, N. 1948. On the spawning habits and early development of the copper mahseer, *Barbus (Lissochilus) hexagonolepis* McClelland. *Proc. Nat. Inst.Sci. India.,* XIV (1-5):22-28.

Ahmed, K.K.U., Amin, S.M.N., Haldar, G.C. and Dewan, S. 2003. Population dynamics and stock assessment of *Catla catla* (Hamilton) in the Kaptai reservoir, Bangladesh. *Asian Fisheries Science*, 16:121-131.

Ahmed, K.K.U., Amin, S.M.N., Haldar, G.C. and Mazid, M.A. 2004. Population dynamics of *Cirrhinus mrigal*a (Hamilton) in the Kaptai reservoir, Bangladesh. *Indian J. Fish.*,51:325-333.

Ahmad, S. and Venkateshwarlu. M. 2012. Habitat Ecology of Cyprinid Fish Community in Relation to Environmental Factors of Tunga and Bhadra Rivers, Western Ghats, Karnataka (India). *J. Res. Dev.*,12: 65-91.

Ahmad, S., Muralidharan, M., Venkateshwarlu, M. and Arunachalam, M. 2011. Distribution pattern, endemism, threat status and conservation measures of fishes in the Tunga and Bhadra rivers of Western Ghats, India. *Env. Biol. Fish.*, 96(10–11): 1245–1256.

Ajithkumar, C.R., Biju, C.R. and Thomas, R. 1998. *Plecostomus multiradiatus*, an armoured catfish from freshwater ponds near Kunnumkulam, Kerala and its possible impacts on indigenous fishes. LAK news, Limnological Association of Kerala. 1-2.

Ajithkumar, C.R., Rema Devi, K., Thomas, R. and Biju, C.R. 1999. Fish fauna, abundance and distribution in Chalakudy river system, Kerala. *J. Bombay Nat. Hist. Soc*., 96 (2): 244-251.

Ajithkumar, C.R., Biju, C.R. and Thomas, K.R. 2000. Ecology of hill streams of the Western Ghats with special reference to fish community, final report 1996-1999. Project report submitted to Bombay Natural History Society. p.312.

Ajithkumar, C. R., Bijukumar, C. R., Thomas, R. and Azeez, P. A. 2001. On the Fishes of Puyankutty River, Kerala, India. *Zoo's Print Journal*, 16(4): 467 – 469.

Alagaraja, K.1984. Simple methods for estimation of parameter for assessing exploited fish stocks. *Indian J. Fish.*, 31(2): 177-195.

Alam, M. and Pathak, J.K. 2010. Assessment of fecundity and gonadosomatic index of Commercially important fish, *Labeo rohita* from Ramganga River. *Int. J. Phar and Bio. Sci.*,1(3):1-6.

Alam, M., Amin, S. N. M. and Haroon, A. K. Y. 2000. Population dynamics of *Labeo calbasu* (Hamilton) in the Sylhet basin, Bangladesh. *Indian J. Fish.*, 47(1): 1-6.

Alam, M.L., Dewan, S., Rahman, M.R., Kunda, M., Khaleque, M.A. and Kedar, M.A. 2004. Study on culture suitability of *Amblypahryngodon mola* with *Barbodes gonionotus* and *Cyprinus carpio* in a farmers' rice field. *Pak. J.Bio. Sci.,* 7: 1242–1248.

Alberto, C., Tylor, K.D.A., Zubcov, E., Shahidi, F. and Alexis, M. 2002. Differentiation of cultured and wild sea bass (*Dicentrarchus labrax*) Total lipid content ,fatty acids and trace mineral composition. *Food. Chem*., 9(2):145-150.

Al-Hussaini, A. H. 1949. On the functional morphology of the alimentary tract of some fishes in relation to differences in their feeding habits. 1. Anatomy and Histology. *Q. J. microsc. Sci.*, 90: 109-139.

Alikunhi, K. H. 1956. Observations on the fecundity, larval development and early growth of *Labeo bata* (Hamilton). *Indian J. Fish.*, III (1): 216-230.

Alikunhi, K. H. and Rao, S. N. 1951. On the bionomics, development and growth of a Cauvery carp, *Labeo kontius* Jerdon. *Rec. Ind. Mus*., 49: 157-174.

Ali, A., Raghavan, R. and Prasad, G. 2007. Threatened Fishes of the World: *Horabagrus brachysoma* (Gunther, 1864) (Bagridae). *Env. Bio.Fish.,*78: 221.

Ali, A., Philip, S., Dahanukar, N., Renjithkumar, C.R., Bijukumar, A. and Raghavan, R. 2013. Distribution, threats and conservation status of *Hypselobarbus thomassi* (Day, 1874), a poorly known cyprinid fish of the Western Ghats freshwater ecoregion. *J. Threa. Taxa.,* 5(17):5202-5213.

Aliyu-Paiki, M., Hashim, R. and Shu-Chien, A.C. 2009. Influence of dietary lipid/protein ratio on survival, growth, body indices and digestive lipase activity in snake head (*Channa striatus*, Bloch 1793) fry reared inre-circulating water system. *Aqua. Res*.,1-12.

Alkins-koo, M. 2000. Reproductive timing of fishes in a tropical intermittent stream. *Env. Bio. Fish.,* 57: 49-66.

Allan, J.D. 1995. Stream ecology: structure and function of running waters. Chapman and Hall, London. 388p.

Allan, J.D. and Flecker, A.S.1993. Biodiversity conservation in running water. *Bioscience,* 43:32-43.

Allan, J. D., AbelL, R., Hogan, Z., Revenga, C., Taylor, B.W., Welcomme, R.L. and Winemiller, K.2005. Over fishing of inland waters. *Bioscience,* 55:1041–1051.

Allen, K. R. 1938. Some observations on the biology of the trout (*Salmo trutta*) in Windermere. *J. Anim. Ecol*., 7: 333-349.

Amezaga, H. R. 1988. Analysis of stomach contents in fish. Literature review objectives and methodology. Technical Report of the Spanish Institute of Oceanography.63:1-74.

Amithab, C.D. and Nautiyal, P. 2012. Stock assessment of fish species *Labeo rohita*, *Tor tor* and *Labeo calbasu* in the rivers of Vindhyan region, India. *J. Env. Biol.,* 33: 261-264.

Amin, M. N., Ali, M. Y. and Salequzzaman, M. 2009. Identification and impact analysis of invasive species; a case study in the Mongla sea port area of Bagerhat district of Bengladesh. *Daffodil Int. Univ. J. Sci. Technol.,* 4: 35-41.

Anees, F.R., Deshumukg, V. D. and Chakraborty, S.K. 2010. Stock assessment of *Lepturacanthus savala* (Cuvier,1829) along north-west sector of Mumbai coast in Arabian Sea. *Indian J. Fish.,* 57(2): 1-6.

Andrew, N.L., Bene, C., Hall, S.J., Allison, E.H., Heck, S.S. and Ratner, B.D. 2007. Diagnosis and management of small-scale fisheries in developing countries. *Fish. Fisheries.,* 8: 227–240.

*Angelescu, V., Gueri, F.S. and Nani, A. 1958. La merluza del mar argentine (biologia y taxonomia). *Publico Sew. Hidrog. Nav. Buenos Aires*., 1004;1-224.

Angermeier, P.L. and Karr, J.R. 1983. Fish communities along environmental gradients in a system of tropical streams. *Env. Biol. Fish.,* 9: 117-135.

Angermeier, P.L. and Schlosser, I.J. 1989. Species area relationships for stream fishes. *Ecology*, 70: 1450-1462.

Anil, C. 1992. Age and Growth of *Labeo gonius* (Cyprinidae) in Kali River, Utter Pradesh, India. *Asian Fisheries Science,* 5: 257-260.

Anish, D. and Kumar, K. 2006. Age and growth patterns in *Channa marulius* from Harike Wetland (A Ramsar site), Punjab, India. *J. Env.Biol*., 27(2): 377-380.

Annandale, N. 1919. Bombay streams fauna: notes on fresh water fish mostly from the Satara and Poona Districts. *Rec. Indian Mus.,* 16: 125-139.

Annigeri, G. G.1963. Maturation of the intra ovarian eggs and the spawning periodicities in few fishes of Manglore area based on ova diameter measurements. *Indian J. Fish.,* 10 (1): 23-32.

Annigeri, G.G. 1989. On the age, growth and mortality of *Sardinella gibbosa* (Blkr) of Karwar waters (West coast of India). *Indian J. Fish.*, 36(3): 199-203.

Anoop, K., Gopisundar, K.S., Khan, B. A. and Lal. 2009. Common moorhen, *Gallinula chloropus* in the diet of the African catfish, *Clarias gariepinus* in Keoladeo Ghana National Park, India. *Indian Birds*, 5 (1): 22–23.

Anon, 1995. Water Atlas of Kerala. Center for Water Resource and Management, Kozhikode. 82p.

Anon, 1998. Report of the workshop on "*Conservation Assessment and Management Plan (CAMP) for freshwater fishes of India*". Zoo Outreach Organisation and NBFGR, Lucknow, 22-26 September 1997. Zoo Outreach Organisation, Coimbatore, India, 156 pp.

Anon, 2000. Part of manual on Habitat and Biological inventory under NATP germplasm inventory and gene banking of Fresh water fishes, National bureau of Fish Genetic resources, Lucknow. 27p.

Anonymous. 2002. Fisheries management for biodiversity conservation in the Brazilian Amazon. Final Report to the Darwin Initiative for the Survival of Species. Imperial College, London.

Antony, A. D. 1977. Systematics, Ecology, Bionomics and Distribution of Hillstream Fishes of Trichur District. Ph.D. Thesis submitted to University of Calicut. pp.436.

Armantrout, N.B.1990. Conservation in developing countries In: Daniel, J.C. & J.S. Serrao (eds). Problems and prospects, Proceedings of the centenary seminar on the Bombay National History Society. 656 pp.

Armstrong, M.P., Musick, J.A and Colvocoresses, J.A. 1992. Age, growth and reproduction of the goose fish, *Lophius americanus.* (Pisces: Lophiiformes). *Fish. Bull.*, 90 (2):217-230.

Arthi, T., Nagarajan, S., Sivakumar, A. A. and Vijayaraman, K. 2013. Reproductive biology of two freshwater fishes, *Ompok bimaculatus* and *O. malabaricus* (Bloch) of the River Amaravathy, Tamil Nadu, India. *Biolife,* 1(2): 45-53.

Arthington, A.H., Lorenzen, K., Pusey, B.J., Abell, R., Halls, A.S. and Winemiller, K.O. 2003. River fisheries: ecological basis for management and conservation. In: R.L Welcomme & T. Petr (eds). Proceeding of the Second International Symposium and Management of Large Rivers for Fisheries, Vol 1 Bangkok, Thailand, RAP Publications.

Arun, L. K. 1997. Patterns and processes of fish assemblage in Periyar Lake-Valley system of Southern Western Ghats. KFRI Research Report, Kerala Forest Research Institute, Peechi, Kerala, pp. 36.

Arun, L. K., Shaji, C. P. and Easa, P. S. 1996. Record of new fishes from Periyar Tiger Reserve. *J. Bombay Nat. Hist. Soc.,* 93(1): 103.

Arun, L.K., Jayasankar, B. and Abraham, K.M. 2001. Biodiversity conservation and livelihood issues of tribes folk: a case study of Periyar Tiger Reserve. Discussion Paper No 37. Kerala Research Program on Local Level Development (KRPLLD), Center for Development Studies, Thiruvananthapuram, India, 79 p.

Arunachalam, M.2000. Assemblage structure of stream fishes in the Western Ghats (India). *Hydrobiologia,* 430: 1-31.

Arunachalam, M. 2004. Germplasm inventory, evaluation and gene banking of freshwater fishes. National Agricultural Technology Project. Government of India. Project Report. 204 pp.

Arunachalam, M. 2005. Biological invasion by introduced fishes on native fishery resources of Manimuthar reservoir in Kalakad Mundanthurai Tiger Reserve, Tamil Nadu, India. *Geophys. Res. Abstr.,* 7: 00561.

Arunachalam, M., Johnson, J.A., Sornam, R. and Haniffa, M.A., 2000a. Fish habitat and diversity of Chittar River Basin, Tamil Nadu. Pp.171-173. In: Ponniah, A.G.and Gopalakrishnan, A. (Eds.) *Endemic fish diversity of Western Ghats.* NBFGR-NATP NBFGR, Lucknow, U.P., India.1-347 pp.

Arunachalam, M., Johnson, J.A. and Manimekalan, A. 2000b. Cultivable and ornamental fishes in rivers of Wyanad district, Kerala. In: Ponniah, A.G. and A. Gopalakrishnan (Eds), *Endemic Fish Diversity of Western Ghats*, pp. 240-243. NBFGR- NATP Publication. National Bureau of Fish Genetic Resources, Lucknow, U.P., India.1-347.

Arunachalam, M., Jhonson, J.A. and Remadevi, K. 2002. *Homaloptera santhamparaiensis,* a new species of Balitorid fish (Teleostei: Balitoridae) from a Western Ghat stream of Kerala, India. *Acta Zoologia Taiwanica,* 13(1): 31-37.

Arunachalam, M., Raja, M., Muralidharan, M. and Mayden, R.L.2012. Phylogenetic Relationships of Species of *Hypselobarbus* (Cypriniformes: Cyprinidae): An Enigmatic Clade Endemic to Aquatic Systems of India. *Zootaxa*, 3499: 63–73.

Asif, A.H. 1988. Food and feeding habits of a freshwater carp, *Cyprinion macrostomus* (Heckel) from Sulaimaniyah, Iraq. *Indian J. Fish.*, 35(4): 323-326.

Ashraf, A. 2010. Food and feeding habits of freshwater catfish, (Bleeker) *Eutropiichthys vacha. Indian J. Sci. Res.*, 1(2): 83-86.

Ayyappan, S.1996. Workshop on Peninsular aquaculture abstracts. Central Institute of Freshwater Aquaculture, Bangalore Centre, 21 May 1996, Bangalore, Karnataka, 35 pp.

Ayyappan. S., Usha, M., Gopalakrishnan, A., Meenakumari, B., Jena, J.K. and Pandey, A.K. 2011. Hand book of Fisheries and Aquaculture, Publishes Indian Council of Agriculture Research (ICAR), New Delhi, 532 pp.

Azadi, M. A. and Naser, A. 1996. Length-weight relationship and relative condition factor of a carp, *Labeo bata* (Ham.) from Kaptai reservoir, Bangladesh. *Chitagong Univ. Stud., Part II: Sci.*, 20 (2): 19-25.

Badola, S.P. and Singh, H.R. 1980. Food and feeding habits of fishes of the genera *Tor, Puntius* and *Barilius. Proc. Indian. natl. Sci. acad.*, B46(1):56-62.

Badola, S. P. and Singh, H. R. 1984. Spawning of some important cold water fishes of Garhwal Himalaya. *J. Bombay Nat. Hist. Soc.*, 81 (1): 54-58.

Badapanda,1996. The fishery and biology of Mahannandi mahseer *Tor mosal mahanadicus. Indian J. Fish.*, 43(4) 325-331.

Bagenal, T. B. 1957. The breeding and fecundity of long rough dab, *Hippoglossides platessoides* (Fabr.) and associated cycle in the condition. *J. Mar. Biol. Ass. U. K.*, 36: 339-375.

Bagenal, T. B. 1963. The fecundity of Witches in the Firth of Clyde. *J. Mar. Biol. Ass. U.K.*, 43: 401-407.

Bagenal, T. B. 1966. The ecological and geographical aspects of the fecundity of plaice. *J. Mar. Biol. Ass., U. K.*, 46: 161-186.

Bagenal, T. B. 1978. Aspects of fish fecundity. *In.* Ecology of freshwater fish production. (Shelby, D. Gerking, Eds.). Blackwill scientific publication Oxford. pp. 75-101.

Bagenal, T. B. and Braum, E. 1968. Eggs and early life history. *In.* Methods for the assessment of fish production in freshwaters. (Ed.) Ricker, W.E., Blackwell Scientific, Oxford, IBP Handbook No. 3, pp. 159-181.

Baiju, M. 2005. Studies on the riverine fishing gears of central Kerala. PhD thesis. Submitted to Cochin University of Science and Technology. Cochin. 215p.

Baiju, M. and Hridayanathan, C. 2002. Fishing gears of Muvattupuzha River system of Kerala. In: Boopendranath, M.R., Meenakumari, B., Joseph, J., Sankar, T.V., Pravin, P. and Edwin, L. (Eds.) Proc. Riverine and Reservoir Fisheries of India. Society of Fisheries Technologists (India), Cochin: 256-263.

Baiju, P.T. 2009. Population status of exotic catfish, *Pterygoplichthys multiradiatus* (Hancock) in the feeder canals of Akulam Lake, Thiruvanthapuram Kerala. Mphil Dissertation, University of Kerala, India. 103p.

Bailey, M. M. 1963. Age, growth and maturity of round white fish of Apostle islands Royal region, Lake Superior. *Fish. Bull. Sacramento.*, 63: 63-75.

Bailly, D., Agostinho, A. and Suzuki, H.I. 2008. Influence of the flood regime on the reproduction of fish species with different reproductive strategies in the Cubia River, Upper Pantanal, Brazil. *River Res Appl.*, 24:1218-1229.

Baird, I.G. 2006. *Probarbus jullieni* and *Probarbus labeamajor*: the management and conservation of two of the largest fish species in the Mekong River in southern Laos. *Aqu. Con: Freshwater and Marine Ecosystems.,* 16: 517–532.

Baker, T.T. and Timmons, L.S. 1991. Precision of ages estimated from five bony structures of Arctic char (*Salvelinus alpinus*) from the Wood River system, Alaska. *Can. J. Fish. Aqut. Sci.,* 48: 1007-1014.

Balasundran, C.R., Arumugam. and Murugan, P.B. 2000. Fish diversity of Kolli hills, Western Ghats, Salem District, Tamil Nadu. *Zoo's Print Journal,* 16(1): 403-406.

Bal, D.V. and Rao, K. V. 1984. Marine fisheries, Tata Mc Graw-Hill, New Delhi. 470 p.

Bal, J.N. and Jones, J.W. 1960. On the growth of brown trout of Llyn Tegid. *Proc. Zool. Soc. London.*, 134: 1-41.

Balon, E.K.1975. Reproductive guilds of fishes: a proposal and definition. *J. Fish Res. Board of Canada.,* 32: 821–864.

Banerji, S. K. 1967. Fish population studies.In Souvenir 20th Anniversary of CMFRI.

Banerji, S. K. 1973. An assessment of the exploited pelagic fisheries of the Indian seas. *Proc. Symp. Liv. Res. Seas Around India. CMFRI spl. Publ.*, pp.114-136.

Banerji, S. K. and Chakroborty, D. 1973. On the estimation of yield from exploited marine stocks with reference to southeast Asia. *Proc. Symp. Liv. Res. Seas Around India. CMFRI Spl. Publ.*, pp. 176-183.

Banerjee, T.K. 2007. Histopathology of respiratory organs of certain air breathing fishes of India. *Fish Physiol. Biochem*., 33:441-454.

Bardach, J.E., Ryther, J.H. and McLarney, W.O. 1972. Aquaculture: The farming and husbandry of freshwater and marine organisms: Wiley, New York, Interscience, 868 p.

Baruah, U. K., Bhagowati, A. K. and Goswmi, U. C. 1999. Culture of hybrid magur (*Clarias gariepinus x C. macrocephalus*) in Assam. *Indian J. Fish.,* 46 (3): 265–272.

Barua, S.P., Khan, M.M. and Ameen, M. 2000. The status of Alien Invasive Species in Bangladesh and their Impacts in the Ecosystem, IUCN Bangladesh, 7pp.

Basavaraja, N. 2007. Freshwater fish seed resources of India, pp 267–327. In: Bondad-Reantaso, M.G. (Ed.), Assessment of Freshwater Seed Resources for Sustainable Aquaculture. FAO Fisheries Technical Paper No 501, FAO, Rome, 628 p.

Bascinar, N.S. and Sagalam, H. 2009. Feeding Habits of black Scorpion fish *Scorpaena porcus*, in the South-eastern black sea. *Turkish J. Fish. Aquat. Sci.,* 9:99-103.

Basudha, and Vishwanath, W. 1999. Food and feeding habits of an endemic carp, *Osteobrama belangeri* (Val) in Manipur. *Indian J. Fish.,* 46 (1): 71-77.

Bayley, P.B. 1988. Factors affecting growth rates of young tropical fishes: Seasonality and density. *Env. Bio. Fish.,* 21: 127-142.

Bayley, P.B. and Petrere Jr, M. 1989. Amazon fisheries; assessment methods, current status and management options. *Can. Spec, Publ. Fish. Aquat. Sci.*, 106:385-398.

Beamish, R.J. and Mcfarlane, G.A. 1983. The forgotten requirement for age validation in fisheries biology. *Trans. Amer Fish. Soci*., 112 (6) 735-743.

*Beavan, R.1877. Handbook of the freshwater fishes of India. Reeve and Co., London, VIII + 247,12pls.

Beevi, K.S.J. and Ramachandran, A. 2005. A new species of *Puntius* (Cyprinidae-Cyprininae) from Kerala, India. *J. Bombay. Nat. Hist. Soc.*, 102(1): 83-84.

Beevi, K.S.J.and Ramachandran. A. 2009. Checklist of freshwater fishes collected from Ernakulam District, Kerala, India. *J. Threa. Taxa.*, 1(9): 493-494.

Beltrano, A.M., Cannizzaro, L., Vitale, S. and Milazzo, A., 2006. Preliminary study on the feeding habits of cleaver wrasse, *Xyrichthys novacula* (Pisces: libridae) in the Striat of Sicily (Mediterranean Sea). *Elec. J. of Ichth.*, 2: 50-54.

Belsare, D. K. 1962. Seasonal changes in the ovary of *Ophiocephalus punctatus* Bloch. *Indian J. Fish.*, 9(1): 140-154.

Bennet, G. W.1962. Management of Artificial lakes and ponds. Reinhold Publishing Corporation, New York. 266p.

Bertalanffy, L. V.1934. Untersuchungen über die Gesetzlichkeit des Wachstums. I. Allgemeine Grundlagen der Theorie; mathematische und physiologische Gesetzlichkeiten des Wachstums bei Wassertieren. *Arch. Entwicklungsmech.*, 131: 613-652.

Bertalanffy, L. Von. 1938. A quantitative theory of organic growth. *Hum. Biol.*, 10:181-213.

Beverton, R. J. H. and Holt, S. J. 1957. On the dynamics of exploited fish populations. *Bull. Fish. Res. Bd. Canada.*, 19: 300.

Beverton, R. J.H and Holt, S.J.1956. A review of method for estimating mortality rates in exploited fish population, with special reference to source of bias in catch sampling. Rapp.P-V. Reun.CIEM.140:67-83.

Beverton, R. J. H. and Holt, S. J. 1959. A review of the lifespan and mortality rates of fish in nature and their relation to growth and other physiological characteristics. *In*. G. E. W. Wolstenholme and M.O. Connor (Eds.), *CIBA Found. Colloq. On Ageing.*, 5: 142-180.

Bhagath, M. J. and Sunder, S. 1983. A preliminary note on length-weight relationship and condition factor of *Schizothorax plagiostomus* (Heckel) from Jammu region. *J. Inland.Fish Soc. India.*, 15(122): 73-74.

Bhat, A. 2003.Diversity and composition of freshwater fishes in streams of Central western Ghats, India. *Env. Bio. Fish.*, 68:25-38.

Bhat, A. 2004. Patterns in the distribution of freshwater fishes in rivers of Central Western Ghats, India and their associations with environmental gradients. *Hydrobiologia*, 529: 83-97.

Bhatt, J. P., Nautiyal, P. and Singh, H.R. 2000. Population structure of Himalayan Mahseer, a large cyprinid fish in the regulated foothill section of the river, Ganga. *Fish. Res.*, 44: 267–271.

Bhatt, J.P., Nautiyal, P. and Singh, H.R. 2004. Status (1993-1994) of the endangered fish Himalayan Mahseer, *Tor putitora* (Hamilton) (Cyprinidae) in the mountain reaches of the river Ganga. *J. Asian Fish.Soc.*, 17: 341–355.

Bhatt, V.S. 1959. Age determination of *Ophicephalus striatus* Bloch. *Curr.Sci.*, 28;41-43.

Bhatt, V. S. 1969. Age determination of *Ophicephalus striatus* Bloch. *Curr. Sci.*, 2: 41-43.

Bhatt, V. S. 1970. Studies on the biology of some freshwater fishes. Part 1V. *Mystus seenghala* (Sykes). *J. Bombay. Nat. Hist. Soc.*, 67 (2):194-211.

Bhatt, V. S. 1977. Studies on the biology of some freshwater fishes. Part V11. *Heteropneustes fossilis* (Bloch). *Indian J. Fish.*, 15(1&2): 99-115.

Bhagwati, A.K. and Kalita, B. 1987. Studies on traditional fishing in some beels in Kamrup, Assam. In: Proc. of workshop on dev. beel fisheries, Assam, held at Guwahati during 21-22, April 1987: 47-69.

Bhattacharjya, B. K., Manna, R. K. and Choudhury, M. 2004. Fishing crafts and gears of north eastern India, CIFRI Bulletin No. 14: 67 pp.

Bhatnagar, G. K.1963. On some aspects of the biology of *Puntius kolus* (Sykes) of the Thungabhadra reservoir. *Indian J. Fish.*, 10 (2): 505-507.

Bhatnagar, G. K.1967. Observations on the spawning frequency and fecundity of certain Bhakra reservoir fishes. *Indian J. Fish.*, 11 (1): 485-502.

Bhatnagar, G. K. 1972. Maturity, fecundity, spawning season and certain related aspects of *Labeo fimbriatus* (Bloch) of River Narmada near Hosangabad. *J. Inland Fish Soc. India.*, IV: 26-37.

Bhatnagar, G.K. 1979. Studies on the age and growth of *Labeo fimbriatus* (Bloch) from river Narmada. *J. Inland Fish. Soc. India.*, 11(12): 96-108.

Bhimachar, B. S. 1942. Report on the survey of the fisheries of Mysore state. *Bull. Dept. Agri. Mysore.*, (1): 1-39.

Bhuiyan, A.S., Afroz, S. and Zamam, T. 2006. Food and feeding habits of the juvenile and adult snakehead, *Channa punctatus* (Bloch). *J. Life. Earth. Sci.*, 1(2) 53-54.

Bijukumar, A. 2000. Exotic fishes and freshwater fish diversity. *Zoos' print.*, 15:363-367.

Bijukumar, A. 2008. First record of Nile tilapia, *Oreochromis niloticus* (Linnaeus) (Pisces; Cichlidae) from Kerala. *J. Inland Fish Soc. India.*, 40 (2): 68 – 69.

Bijukumar, A. and Sushama, S. 2001. The fish fauna of Bharathapuzha river, Kerala. *J. Bombay Nat. Hist. Soc.*, 98(3): 464-468.

Biju, C. R. 2003. Habitat and distribution of hill stream fishes of Northern Kerala (North of Palghat Gap). Thesis submitted to Mahatma Gandhi University, Kottayam. 147pp.

Biju, C.R., Raju Thomas, K. and Ajithkumar, C.R.1996. Fish fauna of Manjeswaram river. *J. Bombay Nat. Hist. Soc.*, 84(3):38-40.

Biju, C. R., Raju Thomas, K. and Ajithkumar, C. R. 1999. Fishes of Parambikulam Wildlife Sanctuary, Palakkad district, Kerala. *J. Bombay Nat. Hist. Soc.*, 96(1): 82-87.

Biju, C. R., Raju Thomas, K. and Ajithkumar, C. R. 2000. Ecology of hill streams of Western Ghats with special reference to fish community. Final report. pp. 203. *J. Bombay Nat. Hist. Soc.*, Mumbai, p. 34-48 .

Biju C.R., Raju, T. K. and George, M.J. 2004. Status of Fishes in Protected areas of Kerala, South India In: Advance in fish and wild life ecology, Vol 3. Bani L. L Daya publishing house- Delhi. p.65-76.

Bindu, L. 2006. Captive breeding proto cols of two potential cultivable fishes, *Etroplus suratensis* (Bloch) and *Horabagrus brachysoma* (Gunther) endemic to the Western Ghats region, Kerala. Thesis submitted to Mahatma Gandhi University, Kerala, 215pp.

Bindu, L., Padmakumar, P. S., Sreerekha, P.S. and Joseph, N. 2012. Reproductive biology of the golden catfish, *Horabagrus brachys*oma (Gunther, 1864), an endemic species of the Western Ghats, India. *J. Appl. Icthyol.*, 1-6.

Bisht, J. S. 1974. Seasonal histological changes in the testis of a hill stream teleost, *Schizothorax richardsonii* (Gray and Hard). *Acta. Anat.*, 88: 398-410.

Bisht, J. S. and Joshi, M. L. 1975. Seasonal changes in the ovaries of a mountain stream teleost, *Schizothorax richardsonii* (Gray and Hard). *Acta. Anat*., 93: 512-525.

Biswas, S. P. 1985. Studies on gut length in relation to feeding habits of five commercially important fishes from Assam. *J. Assam Sci. Soc*., 28(1): 10-13.

Biswas, S. P. 1986. Food and feeding habits of a minor carp *Labeo dero* (Ham.). *Proc. 73rd Indian Sci. Congr.*, 111(7): 44.

Biswas, S.P. 1993. Bionomics of *Labeo pangusia* (Ham) from the highlands of North-East India. *The fisheries forum proceedings*, 11-14th October, 1993, Pantnagar, p.135-139.

Biswas, S.P., Nasar, S.A. K. and Chatterji, K. 1984. Inter and intra specific comparisons on some aspects of the reproductive biology of the two carps, *Labeo pangusia* (Ham.) and *Labeo dero* (Ham). *Arch. Boil. (Bruxellels*)., 95:11-27.

Blackburn, M.1960. A study of condition (weight for length) of Australian baraccuda, *Thyrsites atun* (Euphrasen). *Aust. J. Mar. Freshwater Res.,* 2(1): 14-21.

*Bleeker, P. 1853. Nalezinger op de Ichtyologische fauna vana Bengalen en. Hidden Verh Batvia Genoot 25:1-164pp.

*Bleeker, P. 1860.*Conspectus systematis Cyprinorum*. Natuurkundig Tijdschrift voor Nederlandsch-Indië. 20: 421–441.

*Bloch, M.I. 1785-1795. Naturgeschichte der auslandischen fische Berlin.

*Bloch, M.I. 1797. Icthologie ou histoire generade et particuliere des poisssons. Berlin.

*Blyth, 1858. Fishes from Pegu, Calcutta and elsewhere. Proc. Asiatic Society of Bengal. p. 281-290.

*Blyth, E. 1860. Report on some fishes received chiefly from the Sittang river and its tributary streams, Tenasserim Provinces. *J.Asiat.Soc.Bengal*., 29(2):138-174.

BNP, 2009. Big number program. Intermediate report. Food and Agricultural Organization and World Fish Center, Rome/Penang. Italy/Malaysia.

Boopendranath, M.R. 2000. Gill Nets. Technology Advisory Series. Central Institute of Fisheries Technology, Cochin. 7p.

Booth, A. J., Traas, G.R.L. and Wetl, O.L.F. 2010. Adult African sharp tooth catfish *Clarias gariepinus* population dynamics in a small invaded warm-temperature impoundment. *Afr Zool.*,45: 299-308.

Bouain, A. and Sian, T. 1983. Observations on the female reproductive cycle and fecundity of three species of groupers (*Epinephelus)* from the south-east Tunisian seashore. *Mar. Biol*., 73: 211-220.

Bossuyt, F., Meegaskumbura, M., Beenaerts, N., Gover, D.J., Pethiyagoda, R., Roelants, K., Mannaert, A., Wilkinson, M., Bahir, M.M., Mamamendra-Arachchi, K., Ng, P.K.L., Schneider, J., Oommen, O.V. and Milinkovitch, M.C. 2004. Local endemism within the Western Ghats-Sri Lanka biodiversity hotspot. *Science*, 306: 479–481.

Bowman, R.E. and Bowman, E.W. 1980. Diurnal variation in the feeding intensity and catchability of silver hake (*Merluccius bilinearis*). *Can. J. Fish. Aquat. Sci*., 37:1565-1572.

Brandt, A. V. 1972. Fish Catching Methods of the World. Fishing News (Books) Ltd. London: 240p.

Brandt, A.V. 1984. Gill Netting. Fish Catching Methods of the World (3rd Edn.). Fishing News Books Ltd., London. p 355-3.

Brautigam, A. 1999. The freshwater biodiversity crisis. Freshwater. Biodiversity World conservation. pp4-5.

Britton, J.R., Boar, R.R., Grey, J., Foster, J., Lugonzo, J. and Harper, D.M. 2007. From introduction to fishery dominance: the initial impacts of the invasive carp *Cyprinus carpio* in lake Naivasha, Kenya, 1999 to 2006. *J. Fish Biol.*, 71:239–257.

Bromage, N. R. and Roberts, R.J.1995. Broodstock management and egg and larval quality. Oxford: Blackwell Science, New York. pp 353-373.

Brooks, S., Tyler, C.R. and Sumpter, J.P. 1997. Egg quality in fish: what makes a good egg?. *Rev. Fish. Biol.*, 7: 387 – 416.

Brody, S. 1945. Bioenergetics and Growth. Reinhold publishing Corporation, New-York. 1023p.

Brown, M. E. 1957. Experimental studies on growth. *In.* The Physiology of fishes. M. E. Brown (Ed.), Academic press, New York. pp. 361-400.

Brothers, E.B. 1980. Age and growth studies in tropical fishes. Stock assessment for tropical small scale-fisheries. University Rhode Island, Kingston, Rhode Island.pp119-136.

Bulkley, R. V. 1976. Fecundity of steelhead trout, *Salmo gairdneri* from Alsea River, Oregon. *J. Fish. Res. Bd. Canada*., 24(50): 917-926.

Bye, V. J. 1984. The role of environmental factors in the timing of reproductive cycles. pp.187-205. *In*. Fish reproduction: strategies and factors. (Eds.) G. W. Potts and Wootton, R. J., Academic Press Inc. (London) Ltd. pp.410.

CAMP,1998. Report of the workshop "Conservation Assessment and Management Plan (CAMP) for freshwater fishes of India 1997" organised by Zoo Outreach Organization and National Bureau of Fish Genetic Resources, Lucknow held at NBFGR in Sept. 1997. Zoo Outreach Organization, Coimbatore, India, 156p.

Canonico, G.C., Arthington, A., McCrary, J.K. and Thieme, M. L. 2005. The effects of introduced tilapias on native biodiversity. *Aqua. Con.*, 15: 463–483.

Carlander, D.K. 1970. Handbook of freshwater fishery biology. Vol. I, The Iowa state Univ. Press. Amer Iowa.

Casal, C.M.V. 2006. Global documentation food fish introductions: the growing crisis and recommendations for action. *Biol. Invasions.*, 8: 3–11.

Cassselman, J.M. 1987. Determination of age & growth In: The biology of fish growth (Weatherly, A.H and Gill, H.S., Eds.) New York: Academic press. pp 209-242.

CEPF, 2007. Ecosystem profile: Western Ghats and Sri Lanka Biodiversity Hot spot- Western Ghats Region .Critical Ecosystem Partnership fund. p 95.

Chacko, P.I. 1948. Development of fisheries of Periyar Lake. *J. Bombay Nat. Hist. Soc.*, 48(1): 191-192.

Chacko, P. I. and Kuriyan, G. K. 1949. The bionomics of the carp *Catla catla* (Cuv. and Val.) in South Indian waters. *Proc. Zool. Soc. Lond.*, 120 (1): 39-42.

Chakraborty, N.M. 1996. Need for conservation and propagation of rare food fishes of Peninsular India. *Fishing Chimes*, 16 (8): 17-18.

Chakraborty, N.M. 2006. Murrels and Murrel Culture. Narendra Publishing House, Delhi,India. p12.

Chakraborty, B.K., Mirza, Z.A., Miah, M.I., Habib, M.A.B. and Chakraborty, A. 2007. Reproductive cycle of the endangered sarpunti, *Puntius sarana* (Hamilton, 1822) in Bangladesh. *Asian Fisheries Science*, 20: 145-164.

Chakrabarty, R. D. and Singh, S. B.1967. Observations on some aspects of the fishery and biology of the mrigal, *Cirrhinus mrigala* (Hamilton) from Allahabad. *Indian J. Fish*., X (1): 209-232.

Chalanchuk, S.M.1984. Ageing a population of white sucker, *Catostomus commersoni* by the fin ray method Can. Tech. Rep.Fish.Aquat.Sci., 1321:iv+16p.

Chapgar, B.F. and Manakadan,R. 2000. *Ecology of Hill Streams of Western Ghats with Special Reference to Fish Community*. US Fish and Wildlife Service & Bombay Natural History Society, 203pp.

Chatterji, A. 1980. The relative condition factor and length-weight relationship of a freshwater carp, *Labeo gonius* (Ham.) (Cyprinidae, Teleostei). *J. Bombay Nat. Hist. Soc*., 77 (3): 435-443.

Chatterji, A., Siddique, A. Q. and Khan, A. A. 1977. Length-weight relationship of a carp *Labeo bata* (Ham.). *Proc. Indian Acad. Sci*., 86 (3): 189-194.

Chatterji, A., Siddique, A. Q. and Khan, A. A. 1979. Studies on the age and growth of the bata, *Labeo bata* (Ham.) (Cyprinidae, Teleostei) from the river Kali, India. *Hydrobiologica*, 63(2): 167-176.

Chatterji, A., Ali, M. and Mumthaz, A. 1980. A note on the length-weight relationship of kalbasu, *Labeo kalbasu* (Ham.). *Indian J. Fish*., 27 (1&2): 261-263.

Chatterjee, S.N. and Sharma, S.K. 1994. Impact of thermal discharge on the distribution and reproduction of Indian major carps in Sarni Reservoir, M.P. *Fishing Chimes*, 14(7): 29-32.

Chatterjee, N.R. and Mazumdar, B. 2009. Induced breeding of pacu (*Piaractus brachypomus*) in captivity with pituitary extract. *Aqua. Asia*., 23.

Chaturvedi, S. K. 1976. Spawning biology of tor mahseer, *Tor tor* (Ham.). *J. Bombay Nat. Hist. Soc*., 73(1): 63- 73.

Cherian, P.T., Indra. T.J., Remadevi, K., Raghunathan, M.B. and Sathish Kumar, V.M. 2001. On the ichthyofauna of Trivandrum district, Kerala, India. *Rec.zool.Surv.India*: 99(Part 1-4): 95-110.

Chondar, S.L. 1977. Fecundity and its role in racial studies of *Gudusia chapra* (Pisces, Clupeidae). *Proc. Indian Acad. Sci.,* 86(4): 245-254.

Choudhary, M. 1992. Fishing Methods in Flood Plain Lakes. In: Yadava, Y-S and Sugunan V.V. (eds.) Compendium: FAO Sponsored Training Programme on Flood Plain Fisheries Management. 2: 163-166.

Choudhary, M. Kolekar, V. and Chandra, R. 1982. Length-weight relationship and condition factor of 4 Indian major carps of river Brahmaputhra. Assam. *J. Inland Fish. Soc.India.*, 14(2): 42-47.

Choudhary, C.S., Sharma, L. L., Sharma, S. K. and Saini, V.P. 1991. Some aspects of morpho physiology of *Labeo calbasu* (Ham.) from Ranaprathap sagar reservoir, Rajasthan. *Indian J. Fish.*, 38(4): 207-211.

*Clark, F. N. 1934. Maturity of the Californian sardine (*Sardinella caerulea*), determined by ova diameter measurements. *Fish. Bull.*, 42: 1-49.

Covich,A.P.,Austen,M.C.,Barlocher,F.,Chauvet,E.,Cardinale,B.J.,Biles,C.L.,In chausti,P.,Dangles,O., Solan,M., Gessmer,M.O., Statzner, B. and Moss, B.R 2004. The role of biodiversity in the functioning of freshwater and marine benthic ecosystems. *Bioscience*, 54, 767–775.

*Cuvier, G. and Valenciennes, A. 1822-1850. Histoire Naturelle des Poissons., 22 Vols. Paris. 11030pp., 621pls.

Cushing, D.H.1981. Fisheries biology. A study in population dynamics. The University of Wisconsin press, 2nd edition, 295p.

Dahanukar, N., Raut, R. and Bhat, A. 2004. Distribution, endemism and threat status of freshwater fishes in the Western Ghats of India. *J. Biog.*, 31:123–136.

Dahanukar, N., Raghavan, R., Ali, A., Abraham, R. and Shaji, C.P. 2011. The status and distribution of freshwater fishes of the Western Ghats. In The Status and Distribution of Freshwater Biodiversity in the Western Ghats, India. S. Molur., K.G. Smith., B.A Daniel., W.R.T Darwall, IUCN, Cambridge, UK and Gland, Switzerland and Zoo Outreach Organisation Coimbatore, India. 116pp.

Dahanukar, N. and Raghavan, R. 2013. Freshwater fishes of Western Ghats: Checklist v 1.0 August 2013. MIN - Newsletter of IUCN SSC/WI Freshwater Fish Specialist Group - South Asia and the Freshwater Fish Conservation Network of South Asia (FFCNSA). 1: 6-16.

Daniels, R. J. 1992. Geographic distribution patterns of amphibians in the Western Ghats, India. *J. Biog.*, 19: 521-529.

Daniels, R.J.R. 2001. Endemic fishes of the Western Ghats and the Satpura Hypothesis. *Curr. Sci.*, 81(3): 240-244.

Daniels, R.J.R. 2002. Freshwater fishes of Peninsular India. Universities Press (India) Private Limited. 288p.

Daniels, R.J.R. 2003. Impact of tea cultivation on the anurans in the Western Ghats. *Curr Sci.,* 85:1415–1422.

Das, P. and Pandey, A.K. 1998. Current status of fish germplasm resources of India and strategies for conservation of endangered species. *Fish. Gen Bio. Cons.,* 5: 253-273.

Das, S.K., Bhatachariya, B.K. and Sarona, K.1994. Induced spawning and hatching of tawes *Puntius javanicus* (Bleeker). *Asian Fisheries Science,* 7: 191–194.

Das, S. M. 1964. A study on the fecundity of some fresh water fishes of India with a note on a concept of comparative fecundity. *Ichthyologica,* 3: 33-36.

Das, S. M. and Moitra, S. K. 1955. On the correlation between fish food and fish gut in fishes of Uttar Pradesh. *Proc. 42nd Ind. Sci. Congr.*, Part IV, 20.

Das, S. M. and Moitra, S. K. 1956 a. The surface, mid and the bottom feeding fishes of Utter Pradesh, India. *Proc. Ind. Sci*., Part III: 307.

Das, S. M. and Moitra, S. K. 1956 b. Studies on the food of some common fishes of Uttar Pradesh, India. Part II - On the types of fish food and the variations in the relative length of the alimentary canal with a description of the latter. *Proc. Nat. Acad. Sci.,* 26 B. Part IV: 213-223.

Das, S. M. and Moitra, S. K. 1958. On the feeding types of fishes and the variation in the alimentary canal in relation to food. *J. Ichth.,* 10: 29-40.

Das, S. M. and Moitra, S. K. 1963. Studies on the food and feeding habits of some freshwater fishes of India. IV. Review on the food of some fresh water fishes with general conclusion. *Ichthyologica.,* 2: 107- 115.

Das, S.M. and Nath, S. 1965. The comparative anatomy of the alimentary tract and its modification in relation to the food and feeding habits in some fishes of Jammu Province, India. *Ichthyologica,* 4 (1-2): 63-78.

Das, B. K. R. and Goswami, U. C. 1997. Food spectrum and feeding intensity of *Accrossocheilus hexagonolepis* (Mc Celland) an endemic rheophilic teleost of commercial importance of Assam Himalayas. *Indian J. Fish.,* 44 (3): 295-300.

Dasgupta, M. 1988. A study on the food and feeding habits of the copper mahseer, *Acrossocheilus hexagonolepis* (Mc Clelland). *Indian J. Fish.,* 35 (2): 92-98.

Dasgupta, M. 1990. A study on the food and feeding habits of the mahseer *Tor tor* (Hamilton). *Indian J. Fish*., 37(4): 297-304.

Dasgupta, M. 1991a. Food and feeding habits of the Mahseer, *Tor putitora* (Hamilton). *Indian J. Fish*., 38: 212-217.

Dasgupta, M. 1991b. Length-weight relationship and condition factor (K– value) of *Tor putitora* (Hamilton) from Garo hills, Meghalaya. *Indian J. Fish*., 38(1): 35-38.

Dasgupta, M. 2004. Relative length of the gut of some freshwater fishes of West Bengal in relation to food and feeding habits. *Indian J. Fish*.,51(3) : 381-384.

Datta Munshi, J.S. and Srivastava, M.P. 1988. Natural History of fishes and systematics of freshwater fishes of India. Delhi, Narendra Publishing House, p403.

David, A.1954. A preliminary survey of the fish and fisheries of a five mile stretch of the Hoogly river near Barrackpore. *Indian J. Fish*., 1: 231-255.

David, A. 1959. Observations on some spawning grounds of the Gangetic major carps with a note on carp seed resources in India. *Indian J. Fish.,* VI (2): 327-341.

David, A. and Rajagopal, K. V. 1975. Food and feeding relationships of some commercial fishes of the Thungabhadra reservoir. *Proc. Indian Nat. Sci. Acad.,* B41: 61-74.

Davies, B., Bromage, N. and Swanson, P.1999. The brain-pituitary-gonadal axis of female rainbow trout *Oncorhynchus mykiss*: effects of photoperiod manipulation. *Gen. Comp. Endocrinol.,*115:155-166

Day, F. 1865. The Fishes of Malabar. Bernard Quaritch, London. 293 pp.

Day, F. 1867. On the fishes of the Neilgherry Hills and rivers around their bases. *Proceedings of the General Meetings for Scientific Business of the Zoological Society of London,* 2: 281–302.

Day, F. 1870. Notes on some fishes from the western coast of India. *Proceedings of the General Meetings for Scientific Business of the Zoological Society of London,* 2: 369–374.

Day, F. 1874. On some new or little-known fishes of India. *Proceedings of the General Meetings for Scientific Business of the Zoological Society of London,* 1873(3): 704–710.

Day, F. 1875-78. The fishes of India being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma and Ceylon. Text and atlas in 4 parts, William Davson, XX+ 778, pp., 195 pls.

Day, F. 1876. On some of the fishes of the Deccan. *The Journal of the Linnean Society of London,* 12(64): 565–578.

Day, F. 1878. *The fishes of India being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma and Ceylon*. Text and atlas in 4 parts, William Davson, XX+ 778, pp., 195 pls.

Day, F. 1889. Fishes. In: Blanford, W.T. (ed). *The fauna of British India including Ceylon and Burma.* Taylor & Francis, London. v. 1: 1-xviii + 1-548.

Day, F. 1889. The Fauna of British India, including Ceylon and Burma Fishes.1: 548; Bernard Quaritch, London. 2: 509 pp.

*De, K.C. 1910. Report on the fisheries of Eastern Bengal and Assam, Govt-printer, Shillong, 36 p. de Graaf, S. 2003. The flood pulse and growth of flood plain fish in Bangladesh. *Fisheries Management and Ecology,* 10: 241–247.

Deepak, P.K., Sarkar, U.K. and Negi, R.S. 2008. Age and growth profile of Indian major carp *Catla catl*a from rivers of Northern India. *Acta Zool.sinica*.,54:136-143.

Deepak, S. and Sharma, R.C. 1995. Age and growth of a Himalayan teleost, *Schizothorax richardsonii* (Gray) from the Garhwal Hills (India). *Fish. Res.,* 24: 321-329.

Degerman, E., Naslund, I. and Sers, B. 2000. Stream habitat use and diet of juvenile (0+) brown trout and grayling in sympatry. *Ecol. Freshwat. Fish.,* 9:191–201.

Deguara, S., Jauncey, K. and Agius, C. 2003. Enzyme activities and pH variations in the digestive tract of Gilthead Sea bream. *J. Fish Biol.,* 62:1033–1043.

de Graaf, S. 2003. The flood pulse and growth of flood plain fish in Bangladesh. *Fish. Man. and Ecol,* 10: 241–247.

De Melo, C.E., Machado, F.D.A. and Pinto-Silva, V. 2004. Feeding habits of a fish from a stream in the Savanna of Central Brazil, Araguaia Basin. *Neotropical Ichthyology,* 2(1) 37-44.

Desai, V.R. 1970. Studies on fishery and biology of *Tor tor* (Ham.) from river Narmada.1. Food and feeding habits. *J. Inland Fish. Soc. India.,* 2:101-112.

Desai, V. R. 1973. Studies on the fishery and biology of *Tor tor* (Hamilton) from river Narmada. II. Maturity, Fecundity and Larval Development. *Proc. Indian natn. Sci. Acad.*, B39 (2): 228-248.

Desai, V. R. and Karamchandani, S. J. 1967. On the larval development and spawning seasons of two species of *Barilius* from Narmada river. *J. Zool. Soc. India.*, 19 (1& 2): 27-41.

Desai, V. R. and Shrivastava, N.P. 1990. Studies on age, growth and gear selectivity of *Cirrhinus mrigala* (Hamilton) from Rihand reservoir, Uttar Pradesh. *Indian J. Fish.*, 37(4):305-311.

De Silva, S.S. 1973. Aspects of reproductive biology of the sprat, *Sprattus sprattus* (L) in inshore waters of the west coast of Scotland. *J. Fish. Biol.*, 5 (6): 689-705.

De Silva, S.S., Nguyen, T.T.T., Abery, N.W and Amarasinghe, U.S. 2006. An evaluation of the role and impacts of alien finfish in Asian inland aquaculture. *Aquaculture Research,*37: 1–17.

De Silva, S.S., Nguyen, T.T.T., Turchini, G. M., Amarasinghe, U.S. and Abery, N.W. 2009. Alien species in aquaculture and biodiversity: a paradox in food production. *Ambio,* 38: 24–28.

DeVries, D.R. and Frie, R.V. 1996. Determination of age and growth. In: Fisheries Techniques, Murphy, B.R. and D.W. Willis (Eds.). American Fisheries Society, Maryland, Bethesda, p. 483-512.

Devi, K.R., Indra, T.J., Raghunathan, M.B. and Ravinchandran, M.S. 2005. Fish fauna of the Anamalai hill ranges, Western Ghats, India. *Zoos' print.*, 20(3):1809-1811.

Devi, T.N., Siddiqui, M.S. and Anwar, S. 1990. The age and growth of catfish *Rita rita* (Ham) from the river Yamuna in North India. *J. Indian Fish. Assoc.,* 20: 37-41.

Devaraj, M. 1983. Fish population dynamics. Course manual. *Bull. Central. Ins. of Fish. Educ.*, 3(10): 98p.

Dey, M.M., Paraguas, F.J., Bhatta, R., Alam, F., Weimin, M., Piumsombun S., Koeshandrajana, S., Dung, L.T.C. and Sang, N.V. 2005. Carp production in Asia: Past trends and present status in Asia. Pp. 6–15. *In*: Penman D.J., Gupta M. V., Dey, M.M. (eds.) Carp genetic resources for aquaculture in Asia. Working Papers. World Fish Centre No. 16345.

DFID, 2002. Inland fisheries. Fact Sheet. Department for International Development, Rural Livelihoods Department. 2p.

Dhanze, R. and Dhanze, J.R.1994. An appraisal of depleting fish genetic resources In P.V Dehadrani., Das, P. and Varma, S.R. (Eds). Threatened fishes of India. Nature Conservator, Muzaffarnagar. pp 197-204.

Dhanze, R. and Dhanze, J. R. 1997. Biology of scale carp and grass carp. 1. Length-weight relationship and growth performance under the agro climatic zone of Himachal Pradesh. *Indian J. Fish*., 44 (3): 255-263.

Dinesh, K. and Roy, S. P. 2009. Food and feeding habits of some representative fishes of different trophic guilds of kharagpur lake with a Note on their role in energy harvest. *Ecoscan,* 3 (1&2): 169-176.

Dobriyal, A. K. Singh, H. R. 1987. The reproductive biology of a hillstreanm minor carp *Barilius bendelisis* (Ham.) from Garhwal Himalaya, India, *Vestnik Ceskoslonenske. Spolecnosti Zoologicke*., 51: 1-10.

Dubey, G.P. and Ahmad, A. 1995. Problems for the conservation of freshwater fish genetic resources of India and some possible solutions. *Naga,* 18(3):21-25.

Dudgeon, D. 2000. Riverine biodiversity in Asia: a challenge to conservation biology. *Hydrobiologia,* 418: 1–13.

Dudgeon, D., Arthington, A.H., Gessner, M.O., Kawabata, Z., Knowler, D.J., Le´veˆque, C ,.Naiman, R.J., Prieur-Richard, A.H., Soto,. Stiassny, M. L. J. and Sullivan, C.A. 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. *Bio.rev.,* 81:163-182.

Dutta, S.P.S., Bali, J.P.S., Kour, H., Gupta, S.C. and Salaria, S. 2000. Fishing method employed in lentic and lotic environment of Jammu province of Jammu and Kashmir state. Fish and Food security (Abstracts). First Indian Fisheries Science Congress. Indian Society of Fisheries Professionals, Mumbai : 21-23.

Dwivedi, A.C. and Nautyal, P. 2012. Stock assessment of fish species *Labeo rohita, Tor tor* and *Labeo calbasu* in the rivers of Vindhyan region, India. *J. Environ.Biol.,*33:261-264.

Eadie, J. M., Hurley, T. A., Montgomerie, R. D. and Teather, K L. 1986. Lakes and rivers as islands: Species-area relationships in the fish faunas of Ontario. *Env. Biol.Fish.,* 1581-1589.

Easa, P. S. and Basha, S. C. 1995. An investigative survey of stream fishes, habitat and distribution in Nilgiri Biosphere Reserve area of Kerala, KFRI research report No: 104, KFRI, Peechi, Kerala, pp. 189.

Easa, P. S. and Shaji, C. P. 1995. *Puntius melanampyx* (Day), an addition to the fish fauna of Silent Valley. *J. Bombay Nat. Hist. Soc.*, 92(3): 429 pp.

Easa, P. S. and Shaji, C. P. 1996. Freshwater fishes of Pambar river, Chinnar Wildlife Sanctuary, Kerala. *J. Bombay Nat. Hist. Soc.*, 93(2): 304-306.

Easa, P. S. and Shaji, C. P. 1997. Freshwater fish diversity in Kerala part of Nilgiri Biosphere Reserve. *Curr. Sci.*, 73 (2): 180-182.

Easa, P.S. and C.P. Shaji. 2003.Biodiversity Documentation for Kerala. Part 8. Freshwater Fishes, Kerala Forest Research Institute Handbook No 17. 127p.

Ehrlich, P.R. and Wilson, E.O. 1991. Biodiversity studies science and policy. *Sci.*, 253: 758-762.

Euphrasia C.J. 2004. Bionomics, resource characteristics and distribution of the threatened freshwater fishes of Kerala, Thesis submitted to Cochin University of Science and technology, 335p.

Euphrasia, C. J. and Kurup, B.M. 2008, Maturation and spawning of *Osteobrama bakeri*- a threatened endemic ornamental fish in Kerala, India. *Indian J. Fish.*,55(3) 273-280.

Farmqui, A.J. and Sahai, R. 1943. On the methods of catching fish in United Provinces and scope of establishing inland fisheries in these provinces. *Proc. Natl. Acad. Sci. India.*, 13:198-214.

FAO,2008. Database on introduction of aquatic species (DIAS), Food and Agriculture Organization of the United Nations, Rome, Italy (Available at; http://fao.org/fishery/dias/1).

Fibin, B., Josin, T., Philip, S., Ali, A. and Raghavan, R. 2011a. Check list of the fishes of the Achenkovil forests, Kerala, India with notes on the range extension of an endemic cyprinid, *Puntius chalakkudiensis*. *J. Threa. Taxa.*, 3(7): 1936-1941.

Fibin, B., Joshin, T., Abraham, K. M., Ramprsanth, M.R., Anwar, A. and Raghavan, R. 2011b. Length-weight relationship and condition factor of an endemic stone sucker, *Garra gotyla stenorhynchus* (Jerdon, 1849) from two opposite flowing rivers in southern Western Ghats. *J. Threa. Taxa.*,3(6): 1851-1855.

Frazer, A.G.L. 1942. Fish of Poona, Part I. *J. Bombay Nat. His. Soc.*, 43: 79-91.

Frost, W. E. 1943. The natural history of the minnow *Phoxinus phoxinus. J. Anim. Ecol.,* 12: 139-162.

Froese, R. and Pauly, D. (eds.) 2004. Fish Base [Version 06/2004] Available at http://www.fishbase.org.

Froese, R. and Pauly, D. (Eds). 2007. Fish base 2007. World Wide Web electronic publication. Available at: http://www.fishbase.org.

Froese, R. and Pauly, D. 2009. Fish base 2009. World Wide Web electronic publication. Available at: http://www.fishbase.org.

Froese, R. and Pauly, D. 2010. Fish base World Wide Web electronic publication. Available at: http://www.fishbase.org.

Fryer, G. and Iles, T.D. 1972. The cichlid fishes of Great Lakes of Africa. Oliver and Boyd, Edinburg, UK. pp 656.

Fukusho, K. 1969. Note on the convolution of the fishes of Pomocentridae (Perciformes). *Jap. J. Ichthyol.*, 16 (4):135-142.

Gadgil, M. 1996. Documenting diversity: an experiment. *Cur. sci.,* 70:36-44.

Gaikwad, M.V., Shingare, S.M., Hiwarale, D.K., More, V.R. and Khillare, Y.K. 2009. Study on Ganado-Somatic and Fecundity Relationship in Air Breathing Fish *Channa gachua* (Ham. 1822) from Godavari near Aurangabad. *African J. of Basic and Applied Sci.,* 1 (3-4): 59-61.

Gairola, D., Singh, O. V., Malhothra, S. K., Nanda, S. and Ghildiyal, R. P. 1990. Parasites, ponderal index and length-weight relationship of *Barilius bendelisis* (Ham.) and *Puntius ticto* (Ham.). *Indian J. Fish.,* 37 (4): 361-365.

Ganapati, S.V. and Alikunhi, K. H. 1950. Note on the spawning of carps in the River Tungabhadra in response to off-season freshets. *J. Zool. Soc. India*., 2(2):93-95.

García-Berthou, E. 2007. The characteristics of invasive fishes: what has been learned so far?. *J. Fish Bio.*,71 (Suppl. D): 33–55.

Gaston, K.J. 2000. Global patterns in biodiversity. *Nature,*405: 220-227.

Gaur, S.K. and Pathani, S. S.1996. Fecundity of the lesser baril *Barilius vagra* (Hamilton) from Kumaun Himalaya. *Indian J. Fish.,* 43(4): 381-384.

Gayanilo, Jr. F. C., Soriano, M., and Pauly, D. 1988. A draft guide to the complete ELEFAN, ICLARM software Project 2.65p.and 10 diskettes (5-25 inches, 360K).

Gayanilo, Jr., F. C. and Pauly, D. 1997. The FAO-ICLARM stock Assessment Tools (FiSAT) Reference Manual FAO Computerised information Series (Fisheries). No. 8, Rome, FAO, 262p.

George, M.J. 1969. Genus: *Macrobranchium* Bate 1868: In: Prawn Fisheries Of India *Bull.Cen.Mar.Res.Inst*., 14:176-216.

George, V.C. 1971. An account of inland fishing gear and methods of India, Spl. bull. Central Institute of Fisheries Technology, Cochin 1:68p.

George, V.C. 1983 a. Shore seines for reservoirs. Part-l. Design and Performance. *Fish. Tech.,* 20(1): 5-8.

George, V.C. 1983, b. Shore seines for reservoirs. Part-2. *Fish. Tech.,* 20(2): 97-100.

George, V.C. 2002. Fishing techniques of riverine and reservoir systems – Present status and future challenges. In: Boopendranath, M.R., Meenakumari, B., Joseph, 1. Sankar, T.V., Pravin, P. and Edwin, L. (Eds.) Riverine and Reservoir Fisheries of India. Society of Fisheries Technologists (India), Cochin. 192-196.

George, M.G. 1965. The food of the major carps in some fish ponds in Delhi. *Indian J. Fish.,* 12: 25-59.

Geetha, S. H., Suryanarayanan, S. and Nair, N. B.1990. Food and Feeding habits of *Puntius vittatus* (Day). *Proc. Indian nat. Sci. Acad*., B 56(4):327-334.

Geevarghese, C. and John, P. A. 1983. Maturation and spawning of a gobid fish, *Oligolepis acutipennis* (Cuv. & Val) from the South-West coast of India. *J. Fish Biol.,* 23: 611-624.

Ghate, H. V. and Wagh, G. K. 1991. First record of the Bclonlld fish *Macwpodus cupanus* Valenciennes from Pune. Maharashtra. *J. Bombay Nat. Hist. S*oc., 88: 124-125.

Ghate, H. V. and Wagh, G. K. 1995. Additional Information on the grey mullet *Rhinomugil corsula* (Hamilton) (Pisces:Mugilidae) from Western Maharashtra. *J. Bombay Nat. Hist. So*c.,92: 273-274.

Ghate, H.V. and Wagh, G.K. 2003. Fresh water fish fauna of the rivers Mula and Mutha, Pune, Maharashtra. *Zoos' Print.,*18: 977-981.

Ghosh, S. K. and Ponniah, A.G. 2001. Freshwater fish habitat science and management in India. *Aqu. Eco. health and mang.,* 11(3) 272-288.

Ghosh, A., Mahapatra, B. K and Dutta, N. C. 2003. Ornamental fish farming–successful small-scale aqua business in India. *Aquaculture Asia*,8 (3): 14–16.

Gibbs J.P. 2000. Wetland loss and biodiversity conservation. *Con. Biol.*, 14(1):314–317.

Giri, S.S., Sahoo, S.K., Sabu, B.B., Mohanty, S.N., Mukhopandhyay, P.K. and Ayyappan, S. 2002. Larval survival and growth in *Wallago attu* (Bloch and Schneider); Effects of light, photoperiod and feeding regimes. *Aquaculture*, 213: 151-161.

Gleick, P. H. 1996. Water resources. In Encyclopedia of Climate and Weather (ed. S. H. Schneider), pp. 817–823. Oxford University Press, New York, USA.

Godinho, F.N. and Fereira, M.T. 1998. The relative influence of exotic species and environmental factor on an Iberian native fish community. *Env. Bio. Fish*.,51: 41-51.

Gopi, K. C. 2000. Freshwater Fishes of Kerala State. pp. 56-76.*In*. Ponniah, A. G. and Gopalakrishnan, A. (Eds.) Endemic fish diversity of Western-Ghats. NBFGR-NATP National Bureau of Fish Genetic Resources, Lucknow, U.P., India publication-1: 347pp.

Gopi, K. C. 2001. *Garra periyarensis* - a new cyprinid fish from Periyar Tiger Reserve, Kerala, India. *J. BombayNat.Hist.Soc.*, 98(1): 82-83.

Gopi, K.C. 2002. A new Synbranchid fish, *Monopterus digressus* from Kerala, Peninsular India. *Rec. zool.surv.India*.,100 (Part 1-2): 137-143.

Gopi, K.C. 2010. *Glyptothorax malabarensis*, a new catfish (Teleostei: Sisoridae) from the Western Ghats of Kerala, India. *Zootaxa*, 2528: 53-60.

Gopi, K. C. and Radhakrishnan, C. 1998. Freshwater fish diversity in Wayanad, Kerala, South India - A revised check list. *Zoos' Print*., XIII (12):31.

Gopi, K.C. and Radhakrishnan, C. 2001. Impact assessment of African catfish (Clarias gariepinus) infestation on indigenous fish diversity in Manalur gramapanchayath, Thrissur district, Kerala: A case study in : ENVIS Newsletter. *Zool. Surv. India*., p.9-12.

Gopinath, K. 1953. Some interesting methods of fishing in the backwaters of Travancore. *J. Bombay Nat. Hist. Soc.*, 51:466-471.

Gopinathan, K. 1995. Ecology and fisheries of certain inland water bodies in Kerala. Ph.D thesis, University of Kerala, Thiruvananthapuram. pp. 216.

Goplakrishnan, A. and Basheer, V.S. 2000. Occurrence of *Labeo rohita* and *Cirrhinus mrigala* in Meenachil, Manimala and Pampa rivers, Kerala. pp 167-168. *In*. Ponniah, A.G. and Gopalakrishnan, A. (Eds.) Endemic Fish Diversity of Western Ghats. NBFGR-NATP. National Bureau of Fish Genetic Resources, Lucknow, U.P. India Publication-1.347pp.

Gopalakrishnan, A. and Ponniah, A. G. 2000. An overview of “Endemic Fish diversity of Western Ghats”. pp1-12. *In*. Ponniah, A.G. and Gopalakrishnan, A. (Eds.) Endemic Fish Diversity of Western Ghats. NBFGR-NATP National Bureau of Fish Genetic Resources, Lucknow, U.P. India Publication-1: 347pp.

Gorman, O.T. and Karr, J.R.1978. Habitat structure and stream fish communities. *Ecology,* 59: 507-515.

Goswami, P. K. and Devaraj, M. 1993. Potential yield of *Labeo rohita* from a floodplain lake (Dhirbeel) in Assam, India. *J. inland. Fish. Soc. India.,* 25(2): 12-17.

Goswami, P. K. and Devaraj, M. 1994. Optimum yield assessment of *Labeo rohita* and *Wallago attu* from the ‘Dhirbeel’ ecosystem of the Brahmaputhra basin, Assam, India. In. The National seminar on Recent Advances in Life Sciences (Abstract): 10-11 February, 1994. Dibugarh University, Assam.

Goswami, P. K. and Devaraj, M. 1996. Estimated mortalities and potential yield of freshwater shark (*Wallago attu*) from the Dhir beel (riverine flood plain lake) ecosystem of the Brahmaputhra basin, Assam, India. *Indian J. Fish.*,43 (2): 127-136.

Gowda, H. H., Joseph, P. S. and Joseph, M. M. 1988. Feeding ecology of the Indian sand whiting *Sillago sihama* (Forskal) inhibiting the Nethravathi-Gurpur estuary. *In*. Mohan Joseph (Ed). *The first Indian Fisheries Forum, Proceedings. Asian Fisheries Society Indian Branch,* Mangalore. pp. 263-266.

Gozlan, R.E. 2008. Introduction of non-native freshwater fish: is it bad?. *Fish.Fisheries.,* 9,106-115.

Gozlan, R.E. and Newton, A.C. 2009. Biological invasions: benefits versus risks. *Science,* 324.1015-1016.

Groombridge, B. 1992. Global biodiversity status of earth’s living resources. Chapman and Hall, London, 585pp.

Grossman, G. D., Coffin, R. and Moyle, P. B. 1980. Feeding ecology of the Bay goby (Pisces: Gobidae). Effects of behavioural, onto-genetic and temporal variation on diet. *J. Exp. Mar. Biol. Ecol.*,44: 47-59.

Grossman, G. D., Ratajczak, R. E. Jr., Crawford, M. and Freeman, M. C., 1998. Assemblage organization in stream fishes: effects of environmental variation and interspecific interactions. *Ecological Monographs,*68: 395-420.

Guegan, J.F., Lek, S. and Oberdorff, T. 1998. Energy availability and habitat heterogeneity predict global riverine fish diversity. *Nature,* 391: 382-384.

*Gunther, A. 1864. Catalogue of Fishes in the British Museum, London. 5, 36.

*Gunther, A.1868. Catalogue of the fishes in the British Museum, VII, pp.340-343.

Guha, D. and Mukherjee, D. 1991. Seasonal cyclical changes on the gonadal activity of common carp, *Cyprinus carpio* Linn. *Indian J. Fish.,* 38(4): 218-223.

Gulland, J. A. 1971. The fish resources of the ocean, Fishing News (Books) Ltd. West By fleet, for FAO: 225p.

Gulland, J.A. and Rosenberg, A.A. 1992. A Review of Length-Based Approaches to assessing Fish stocks, FAO fisheries Technical Paper no 323. Food and Agriculture Organization, Rome, 100p.

Gunawardene, N.R., Dulip Daniel, A.E., Gunatilleke, I.A.U.N., Gunatilleke, C.V.S.P., Karunakaran, V., Geetha Nayak, K., Prasad, S., Puyravaud, P., Ramesh, B.R., Subramanian, K.A. and Vasanthy, G. 2007. A brief overview of the Western Ghats-Sri Lanka biodiversity hotspot. *Curr. Sci.,* 93:1567–1572.

Gupta, A. K., Langer, S. and Gupta, S. C. 1999. Morphological studies of the alimentary canal of fishes of Lake Mansar. *In. Advances in Fish and wild life Ecology and Biology*. Vol. II. 231P. Basi Lal Kaul, Daya Publishing house, New Delhi -110035.

Gupta, B.K., Sarkar, U.K., Bhardwaj and Pal, A. 2011, Condition factor, length-weight and length-length relationships of an endangered fish *Ompok pabda* (Hamilton 1822) (Siluriformes: Siluridae) from the River Gomti, a tributary of the River Ganga, India. *J. Appl.Icthyol.,*27:962-965.

Gupta, M.V. 1968. Observations on the fecundity of *Polynemus paradiseus* Linn. from the Hoogly estuarine system. *Proc. Nat. Inst. Sci. India.,* B34(6):330-345.

Gupta, R.A. and Tyagi, R.K. 1992. Analytical approach to analysis of fish stock of Ganga river system *J. Inland. Fish. Soc. India* 24: 20-27.

Gupta, S.B.C. 1981. Food and feeding habits and physiology of digestion in certain riverine teleosts. *Proc. Indian Natn. Sci. Acad.*, B 47: 837-844.

Gurumayum, S.D. and Choudhury, M. 2009. Fishing methods in the rivers of Northeast India. *Indian J. Tra. Knowledge.*, 8 (2): 237-241.

Guruge, W.A.H.P. 2002. A Food And Feeding Habit Of Three co-occurring Cyprinids Fishes in Shallow Lowland Reservoir in Sri Lanka: Consequences for Resource partitioning, Proceedings of the Regional Symposium on Environment and Natural Resources, 10-11th April 2002, Hotel Renaissance Kuala Lumpur, Malaysia. Vol 1: 154-160.

Hails, A. J. and Abdullah, Z. 1982. Reproductive biology of the tropical fish *Trichogaster pectoralis* (Regan). *J. Fish Biol.*, 21: 157-170.

Halls, A.S., Hoggarth, D.D. and Debnath, K. 1998. Impact of flood control schemes on river fish migrations and species assemblages in Bangladesh. *J. Fish Bio.,* 53: 358-380.

*Hamilton, F. 1807. A Journey from Madras through the Countries of Mysore, Canara, and Malabar, performed under the orders of the most noble the Marquis Wellesley, Governor General of India. T. Cadell and W. Davies, London, 3: i-iv+1–479+i-xiii.

*Hamilton, F. 1877. Journey from Madras through the countries of Mysore, Canara.pp.264.

*Hamilton-Buchanan, F. 1822. An account of the fishes found in the river Ganges and its branches. Edinburg, London. Vii+405pp+39pls.

Hameed, M.S. 2002. Classification of fishing gears. ICAR Winter School Manual on Advances in Harvest Technoiogy. Central Institute of Fisheries Technology, Cochin: 82-100.

Hanson, J. M. and Chouinard, G.A. 2002. Diet of Atlantic cod in the southern Gulf of St. Lawrence as an index of ecosystem change, 1959 – 2000. *J. Fish. Biol.*, 60: 902 – 922.

Hardy, A. C. 1924. The herring in relation to its marine environment. Part 1. The food and feeding habits of the herring with special reference to the east coast of England. *Fish. Invest. Lond. Ser.*, 2, 7: 1-53.

Haroon, A.K.Y., Nurul Amin, S. M. and Alam, M. 1999. Some population dynamics aspects of *Catla catla* (Ham.) in the Sylhet-Mymensigh basin, Bangladesh, Pakisthan. *J. Biol. Sci.,* 2 (4): 1188-1192.

Haroon, A.K.Y., Razzaque, A., Dewan, S., Amin, S.M.N. and Rahman, S.L.2001. Population dynamics and stock assessment of *Labeo rohita* (Ham), *L. calbasu* (Ham) and *L. gonius* (ham) from the Mymensingh Basin. *J. Bio. Sci.*, 1(7): 671-675.

Haroon, A. K. Y., Alam, M., Amin, S. N. M., Dewan, S. and Islam, S. 2002. Population dynamics of Gangetic major carps from the Sylhet basin, Bangladesh. *Indian J.Fish*., 49 (2): 161-168.

Harikrishnan, M. and Kurup, B. M. 1998. Fishing methods and gear wise intensity of fishing of *Macrobrachium rosenbergi* (de Man) in Vembanad lake. In: Hameed, M.S. and Kurup, B.M. (Eds.) Technological Advancements in Fisheries. Publn. No.1. School of Industrial Fisheries, Cochin University of Science and Technology, Cochin. p216-222.

Healey, M.C. 1971. Gonad development and fecundity of the sand goby, *Gobius minutus* Pallas. *Trans. Am. Fish. Soc.,* 100: 520-526.

Hickling, C.F.1961. Tropical inland fisheries. Publ. Longman, Green and Co. Ltd. London. 287p.

Hidalgo, M.C., Urea, E. and Sanz, A. 1999. Comparative study of digestive enzymes in fish with different nutritional habits: proteolytic and amylase activities. *Aquaculture*, 170: 267–283.

*Hile, R. 1936. Age and growth of the Circo, *Leucichthys artedi* (Le Sueur) in the lakes of north-eastern highlands, Wisconsin. *Bull. U. S. Bur. Fish*., 48: 211-317.

*Hile, R. 1948. Standardisation of method of expressing length and weight of fish. *Trans. Am. Fish.Soc.,* 75:157-164.

Hoenig, J. M. and Gruber, S. H. 1990. Life-history patterns in the elasmobranchs: implications for fisheries management. In Elasmobranchs as Living Resources: Advances in Biology, Ecology, Systematics, and the Status of Fisheries (Pratt, H. L., Jr, Gruber, S. H. & Taniuchi, T., eds, pp. 1–6). NOAA Technical Report NMFS90.

Hoff, T. B. and J. A. Musick. 1990. Western North Atlantic shark-fishery management problems and informational requirements. Pages 455–472 in H. L. Pratt, Jr., S. H. Gruber and T. Taniuchi, eds. Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of fisheries. NOAA Tech. Rep. NMFS 90.

Hora, S.L.1926. On a peculiar fishing implement from the Kangra valley, Punjab. *Proc. Asiat. Soc. Bengal.*, 22:81-84.

Hora, S.L. 1935a. Ancient Hindu conception of correlation between form and locomotion of fishes. *J.Asiat.Soc.Beng Science.*, 1(1) 1-7.

Hora, S.L.1935b. Crab fishing at Uttarbhag, Lower Bengal. *Cur. Sci.*, (II) 3: 543-546.

Hora, S. L. 1942. A list of fishes of the Mysore state and of the neighboring hill ranges of the Nilgiris, Wyanad and Coorg. *Rec Indian Mus*.. 44 (2): 193-200.

Hora, S.L. 1948a. Knowledge of Ancient Hindus concerning fish and fisheries of India 1. References to fish in Arthastra (ca.300 B.C). Calcutta. *J. Asiat. Soc. Beng Letters.,*14(1) 7-10.

Hora, S.L. 1948b. Sanskrit name of fish and their significance *J.Asiat.Soc. Beng Science.*, 14(1)1-6.

Hora, S.L. 1950a. Knowledge of Ancient Hindus concerning fish and fisheries of India Matsyavinoda 2. Fishery Legislation Asoka's Pillar Edict 5(246 B.C). *J.Asiat.Soc.Beng Letters.*, Calcutta 16 (1) 43-56.

*Hora, S.L.1951a. A Sanskrit work on angling of the early twelveth centuary. *Nature*, 167:778.

Hora, S.L.1951b. Knowledge of Ancient Hindus concerning fish and fisheries of India Matsyavinoda or a chapter on angling in the Manasallosa by King Somesvara (1127 A.D). *J .Asiat. Soc. Beng Letters.*, 17 (2) 145-169 4pls.

Hora, S.L. 1951c. Zoological knowledge with special references to fish and fisheries of India before 325 B.C Arch. *Internat. D'.Hist.Des.Sci .Paris.*, 15:405-412.

Hora , S.L. 1952. Fish in Ramayana. *J. Asiat. Soc. Beng. Letters.*, 18 (2) 63-69.

*Hora S.L .1953a. Ancient Hindu naturalist Birla Vidya Vihar Mag June: 1-6.

Hora, S.L. 1953b. Knowledge of Ancient Hindu's concerning fish and fisheries in India 4.Fish in Sutra and Smriti literature. *J. Asiat. Soc. Beng. Letters.*,19(2) 63-77.

Hora, S. L.and Misra, K. S. 1937. Fish of Deolall. I, *J. Bombay Nat.. Hist. Soc*., 39 (3): 502-519, 2 pis.

Hora, S. L.and Misra, K. S. 1938. Fish of Deolali. III. On two new species and notes on some other forms. *J. Bombay Nat. Hist. Soc.,* 40 (1): 20-38.

Hora, S.L. and Law, N.C. 1941. The Fresh water fish of Travancore. *Rec. Indian Mus*., 43(2): 233-256.

Hora, S. L.and Misra, K. S.1942. Fish of Pune. Part II. *J. Bombay Nat. Hist. Soc*., 43 (2): 218-225.

Hornell, J.1924. The fishing methods of the Ganges. *Mem. Asiat. Soc.*, Bengal. 8(3): 197-237.

Hornell, J.1938. The fishing methods of Madras Presidency. Part-ll. The Malabar Coast. *Madras Fish. Bull*., 27(1): 1-69.

Horwitz, R. J. 1978. Temporal variability patterns and the distributional patterns of stream fishes. *Ecological Monographs*, 48: 507-321.

Hoydal, K., Rorvik, C.J. and Sparre, P. 1982. Estimation of effective mesh size and their utilization in assessment. *Dana*, 2: 95–96.

Hugueny, B. 1989. West African rivers as biogeo-graphic islands: species richness of fish communities. *Oecologia*,79: 235-243.

Hynes, H.B.N. 1950. The food of fresh water Stickleback (*Gasterosteus aculeatus* and *Pygosteus pungitius*) with a review of the methods used in studies of food of fishes. *J. Anim. Ecol*.,19: 36-58.

Hyndes, G. A., Platell, M. E. and Potter, I. C. 1997. Relationships between Diet and Body Size, Mouth Morphology, Habitat and Movements of Six Sillaginid Species in Coastal Water: Implications for Resource Partitioning. *Mar. Biol.*, 128: 585-598.

Hyslop, E.J. 1980. Stomach content analysis: a review of methods and their applications. *J. Fish.Bio.*, 17(4) 411-429.

Ibrahim, K. H. 1957. Bionomics of forage fishes: Observations on the fecundity of three common species of minor barbels. *J. Bombay Na. Hist. Soc.*, 54: 826-834.

Ibrahim, K.H. 1962. Observation on the fishery and biology of freshwater prawn *Macrobranchium malcolmsonii* of river Godavari. *J. Bombay Nat. Hist. Soc.,* 51: 466-471.

Ilona, S.C. and Len, R.G. 2003. NAGA World Fish Centre Quarterly. 26, 2.

Inasu, N. D. 1991. Systematics and bionomics of inland fishes of Trichur district, Ph.D Thesis, Cochin University of Science and Technology, Cochin, Kerala. pp. 342.

Indra, T. J. and Remadevi, K. 1981. A new species of the genus *Homaloptera* from Silent Valley, Kerala, South India. *Bull. Zool. Surv. India.,* 4(1):67-71.

Indra, T. J. and Remadevi, K. 1990. On a small collection of fish from Thekkadi wild life reserve, Western Ghats. *Rec. zool. Surv. India.,* 87(3): 249-257.

IUCN,2007. IUCN Red List of threatened species. International Union for Conservation of Nature and Natural Resources, Cambridge, UK. (Available from: www. iucnredlist.org).

IUCN. 2008. Numbers of Threatened Species by Major Groups of Organisms (1996–2007). Available at http://www.iucnredlist.org/info (accessed 8 June 2011).

IUCN,2011.http;//www.iucnredlist.org/apps/redlist/search.

Izquierdo, M. S., Palacios, H.F and Tacon. A.G. J. 2001. Effect of broodstock nutrition on reproductive performance of fish. *Aquaculture*, 197: 25 – 42.

Jackson, R. B., Carpenter, S.R., Dahm, C.N., Mcknight, D.M., Naiman, R.J., Postel, S.L. and Running. S.W. 2001. Water in a changing world. *Eco. Appl.*,11:1027–1045.

*Jacobshagen, E. 1913. Untersuchungen uber das Darmsystem der. Fische und Dipnoer II. *Jena. Z. Naturw.*, 49: 373-810.

Jadav, B.V., Kharat, S.S., Raut, R.N., Painganker, M. and Dhahanukar, N. 2011. Freshwater fish fauna of Koyna River, Western Ghats, India. *J. Threa. Taxa.*,3(1) 1449-1455.

Jaiswar, A. K., Chakraborthy, S. K. and Swamy, R. P. 2001. Studies on the age, growth and mortality rates of Indian scad, *Decapterus russelli* (Ruppell) from Mumbai waters. *Fish. Res.*, 53: 303-308.

James, P. S. B. R. and Baragi, V.M., 1980. Ovary as an indicator of frequency of spawning in fishes. *Proc. Indian natn. Sci. Acad.*, B 46 (4): 479-489.

Jayaram, K.C. 1976. Index HORANA Occasional Paper No.1. *Zoo.Survey of India*,p191.

Jayaram, K.C. 1979. Aspects of indigenous and exotic fishes of India. *Zoologiana*,(2); 33-39.

Jayaram, K. C. 1981. Freshwater fishes of India – A handbook. Zoological survey of India, Calcutta.pp.482.

Jayaram, K.C. 1991. Systematic status of *Danio malabaricus* (Pisces: Cyprinidae) *Ichthy. Expl. Freshwater.*, 2: 109-112.

Jayaram, K. C. 1999. The freshwater fishes of the Indian region. Narendra publishing house, New-Delhi . pp.551.

Jayaram, K.C. 2009. The freshwater fishes of the Indian region, Revised 2nd Edition Narendra Publishing House 614pp.

Jayaram, K.C., Indra, T.J. and Singh, M.S. 1976. On a collection of a fish from the Cardamom hills, South India. *Madras J. Fish.,* 7: 1-7.

Jayasree, M., Sabesan, S., Krishnamoorthy, K. and Panicker, K. N. 1993. Distribution of indigenous freshwater fishes in the central coastal region of Shertallai, Kerala. *Indian J. Fish.,* 40 (3): 125-128.

Jayaprakas, V. and Nair, N. B., 1981. Maturation and spawning in pearlspot, *Etroplus suratensis* (Bloch). *Proc. Indian natn. Sci. Acad.,* B47 (6): 823-836.

Jellyman, DJ. 1989. Diet of two species of freshwater eel (Anguilla spp.) in Lake Pounui, New Zealand. *New Zealand J. Mar.Fres. Res.*,23:1-10

Jenkinsins, R.M. 1961. Reservoir fish management–Progress and Challenge. Washington D.C Sport Fishery Institute, special Publication, 22p.

Jensen, A.L. 1982. Adjusting fishery catch curves for trawl selection using the logistics distribution. *J. Cons.*,40:17–20.

*Jerdon,T.C.1849. On the fresh water fishes of South India, *Madras. J. Lit. Sci.*,15: 302-346.

Jhingran, A.G. 1984. Some consideration on introduction of Tilapia in to inland waters. *Bull Bureau of Fish Gen. Res.* CICFRI, Barrack pore, 1-34.

Jhingran, A.G. 1989. Role of exotic fishes in capture fishery waters of India. In Jhingran, A. G and Sugunan V. V (eds) Conservation and management of inland capture fisheries resources of India. Inland Fisheries Society of India. CIFRI, Barrackpore : 257 pp.

Jhingran, V. G. 1952. General length-weight relationship of three major carps of India. *Proc. Nat. Inst. Sci., Ind.* XVIII (5): 449-455.

Jhingran, V. G. 1959. Studies on the age and growth of *Cirrhina mrigala* (Ham)from the river Ganga. *Proc. Natn. Insti. Sci.India*., B25(3): 107-137.

Jhingran, V. G. 1961. Studies on the maturity and fecundity of the Gangetic anchovy, *Setipinna phasa* (Hal.). *Indian J. Fish*., 8: 291-311.

Jhingran, V.G.1975. Fish and Fisheries of India. Hindustan Publishing Corporation (India) Delhi: 954pp.

Jhingran, V. G. 1982. Fish and Fisheries of India. Hindustan Publishing corporation, Delhi, India.

Jhingran, V. G. 1991. *Fish and fisheries of India.* Hindustan Publication house, New Delhi, 727 pp .

Jobling, M. 1995. Environmental biology of fishes. London Chapman and Hall, London. pp455.

Johal. M.S., Tandon, K.K. and Esmaeili, H.R. 1998. Exotic introductions and changing fish composition of Gobindsagar. Proceeding of Indo-U.S .Workshop on conservation and development of natural resources in Western Himalayas. pp. 70-81.P>U Chandigrh. Ministry of Agriculture, Govt of India.

Johnsingh, A.J.T. 2001.The Kalakad-Mundanthurai Tiger Reserve: a global heritage of biological diversity. *Cur. Sci.,* 80: 378-388.

Johnson, J.A. and Soranam, R. 2001. A new species of *Horalabiosa* Silas from a Kerala stream of the Western Ghats. *J. Bombay Nat. Hist. Soc.*,98 (3): 392-395.

Johnson, J.A. and Arunachalam, M. 2009. Diversity, distribution and assemblage structure of fishes in streams of southern Western Ghats, India. *J. Thre. Taxa.,* 1(10): 507-513.

Johnson, J.A. and Arunachalam, M. 2012. Feeding habit and food partitioning in a stream fish community of Western Ghats, India. *Envi. Biol. Fish.,* 93:51–60.

Johnson, J. N. 1999. Diversity and ecological structure of fishes in selected streams, rivers in Western Ghats.India.551p.

John, C. C., 1936. Freshwater fish and fisheries of Travancore. *J. Bombay Nat. Hist. Soc.,* 38: 702 – 733.

Jones, R. 1984. Assessing the effects of changes in the exploitation pattern using length composition data (with notes on VPA and cohort analysis). *FAO Fish Tech. Pap,* 256, 118p.

Jones, S. 1946. Destructive methods of fishing in the rivers of the hill ranges of Travancore. *J. Bombay Nat. Hist. Soc.*, 46(3): 437-445.

Jones, S. 1959 a. Fishing Methods of Indian Shad, *Hilsa ilisha* (Hamilton) in the Indian region, Part l, *J. Bom. Nat. Hist. Soc.*, 54 (3):714-25.

Jones, S.1959 b. Fishing Methods of Indian Shad, *Hiisa ilisha* (Hamilton) in the Indian region, Part II, *J. Bombay Nat. Hist. Soc.*,54 (3): 423-445.

Johar, M.A. and Singh, N. K. 1981. The food and feeding habits of *Sicamugil cascasia* (Ham.), *Biol. Bull. India.*, 3 (30): 191-192.

Johal, M. S. and Tandon, K. K. 1981. Age, growth and Length-weight relationship of *Tor putitora* (Ham.) from Govind Sagar Reservoir Himachal Pradesh. Pb. Fish. Bull Special Cold water Fisheries. 43-48 pp.

Johal, M.S. and Tandon, K.K. 1987. Harvestable size of two Indian major carps. *Vest. Cs -Spolec Zool.,* 51: 177-182.

Johal, M.S. and Tandon, K.K. 1989. Age and growth of *Catla catla* (Ham.) from Rang Mahal (Rajasthan), India. *Fish Res.*,14:83-90.

Johal, M.S. and Tandon, K.K., 1992. Age and growth of the carp *Catla catla* (Ham.) from North India. *Fish. Res.*,14:83-90.

Jose, R.V. 2002. Inland fishermen and inland fishing: A study at Neelamperoor village, Alappuzha. Discussion Paper Series, Kerala Research Programme on Local Development. Center for Development Studies. Thiruvananthapuram, 40p.

Joseph, K.M. and Narayyanan, K.P. 1965. Fishing gear and methods of the Brahmaputra in Assam. *Fish. Tech.,* 2: 205-219.

Joshi, K.K. 2005. Biology and Population Dynamics of *Nemipterus mesoprion* (Bleeker) Off Cochin *Indian J. Fish.,* 52(3): 315-322.

Joshi, S. N. 1987. Fecundity of a snow trout *Schizothorax richardsonii* (Gray and Hard). *Proc. Nat. Acad. Sci. India.*,57 B IV: 354-360.

Joshi, S. N. and Khanna, S. S. 1980. Relative fecundity of *Labeo gonius* (Ham.) from Nanak Sagar Reservoir, *Proc. Indian Acad. Sci. (Anim. Sci.*)., 89 (5):493-503.

Joshi, S.K. and Pathani, S.S. 2009. Spawning biology of a hill stream fish, *Botia almorhae* Day of Kumaun Himalaya, Uttarakhand. *Indian J. Fish.,* 56(2) 151-155.

Junger, H., Kotrochal, R. and Goldschmid, A. 1989. Comparative morphology and ecomorphology of the gut in European cyprinids (Teleostei). *J. Fish Biol.,* 34: 315-326.

June, F.C. 1953. Spawning of yellow fin tuna in Hawaiian waters. *Fish. Bull.,* 54: 47-64.

Junk, W. B. 2007. The Central Amazon Floodplain Ecology of Pulsing System. Ecological Studies. No. 16 Berlin, Springer, 525pp.

Jyoti, M. K. and Abrol, A. 1992. A review on spawning periodicities in Indian species of *Schizothorax. J. Inland. Fish Soc. India.,* 24 (2): 79-81.

Kagwade, V. N. 1968. Maturation and spawning in the horse mackerel, *Caranx kalla* (Cuv.and Val.). *Indian J. Fish*., 15: 207-220.

Kalita, B. and Jayabalan, N. 1997. Age and growth of the carangid *Alepes para* (Class: Osteichthyes) from Mangalore coast. *Indian J. Mar. Sci.,* 26:107-108.

Kalawar, A.G. and Kelkar, C.N. 1956. Fishes of Kolhapur. *J. Bombay Nat. His. Soc.,* 53: 669-679.

Kamal, Y. M. 1967. Studies on the food and alimentary canal of Indian major carps-II: *Labeo rohita* (Ham.) and III, *Cirrhinus mrigala* (Ham.). *Indian J. Fish.,* 14:24-27.

Kamal, Y.M. 1969. Studies on the age and growth of *Cirrhina mrigala* (Hamilton) from the river Yamuna at Allahabad. *Pro. Nat. Inst. Sci. India.,* 35 B (1):72-92.

Kapoor, B. G. 1953. The anatomy and histology of the alimentary canal in relation to its feeding habits of a siluroid fish , *Wallago attu* (Bl.and Schn.). *J. Zool. Soc. India*., 5(2): 191- 210.

Kapoor, B.J., Smith, H. and Verighina, I.A. 1975. The alimentary canal and digestion in teleosts. In Advances in marine biology (F.S Russel, and M. Yonge, eds). London: Academic press, pp.109-239.

Kapoor, D., Dayal, R., Ponniah, A.G. 2000. Fish biodiversity of India. NBFGR Lucknow, UP, India, 775pp.

Karamchandani, S. J. 1961. On the location of spawning grounds of Indian shad, *Hilsa ilisha* (Ham.) in the freshwater regions of the Narbada river. *Curr. Sci*., 30: 373-375.

Karr, J.R., Fausch, K.D., Angermeier, P.L., Yant, P.R. and Schlosser, I.J.1986. Assessing biological integrity in running waters: a method and its rationale Ill. *Nat. His. Sur.*, 5: 28.

Kar, D., Dey, S.C. and Kar, C. 2000. An account of fishing implements used in bark drainage in Assam with a note on their efficiencies. Fish and Food security (Abstracts). First Indian Fisheries Science Congress. Indian Society of fisheries Professionals, Mumbai. 22 p.

Kartha, K.N. and Rao, K. S. 1990. Length-weight and length –maximum girth relationship of *Catla catla* (Ham.) in commercial landings of Gandhi Sagar Reservoir. *Fish. Technol*., 27: 155-156.

Karekar, P.S. and Bal, D. V. 1958. The food and feeding habits of *Polynemus indicus* (Shaw) *Indian J. Fish*., 5:77-94.

Karthikeyan, M., Pillai, N. G. K. and Badrudeen, M. 1989. Population dynamics of silverbelley *Leiognathus jonesi* James in the trawling grounds of Rameswaram. *Indian J. Fish*., 36(2): 103-106.

Kaul, B. L.1994. Comparative fecundity of some Kashmir teleosts. *Rec. Adv. Fish. Ecol. Limn. Eco Conserv*., III: 71-78.

Kaushal, D. K.and Rao, Y. R.1990. Observations on the breeding of major carps in Gobindsagar reservoir, Himachal Pradesh. *J. Inland Fish. Soc. India*., 22 (1&2): 96-97.

Kerala Fisheries Statistics. 2012. Kerala fisheries statistics at a glance 2011-12.Published by Government of Kerala, Directorate of Fisheries, Thiruvanathapuram. 2pp.

Keshava., Joseph, P. S. and Joseph, M. M. 1988. Feeding habits of the Pearl spot *Etroplus suratensis* (Blotch) in the Nethravathi-Gurpur estuary. *In*: M. Mohan Joseph (Eds.) The First Indian Fisheries Forum, Proceedings Asian Fisheries Society, Indian branch, Manglore pp. 203-206.

Kharat, S.S., Dahanukar, N. and Raut, R. 2000. Decline of freshwater fish of Pune urban area. *J. Ecol. Soc.*, 13/1: 46-51.

Kharat, S.S., Dahanukar, N., Raut, R. and Mahabaleshwarkar, M. 2003. Long term changes in freshwater fish species composition in North Western Ghats, Pune District. *Cur. Sci.*, 84: 816-820.

Kharat, S.S., Khillare, Y.K. and Dahanukar, N. 2008. Allometric scaling in growth and reproduction of a Freshwater loach *Nemacheilus mooreh* (sykes, 1839). *Elec. J. Ichth.*,1:8-17.

Khan, A. H. and Jhingran, V. G. 1975. Synopsis of biological data on rohu, *Labeo rohita* (Ham). *FAO Fisheries synopsis.,* No. III: 1-100.

Khan, A. A., Kartha, K.N., Dawson, P. and George, V.C. 1991. Fish Harvesting systems in lndian Reservoirs. Proc. National Workshop on Low Energy Fishing, p: 152-155. Fishery Technology (Special Issue) Society of Fisheries Technologists (India), Cochin.

Khan, H. 1934. Habits and habitats of the food fishes of the Punjab. *J. Bombay nat. Hist. Soc*., 37: 657-62.

Khan, H. 1945. Reproductive powers and breeding habits of some of the fishes of Punjab. *Punjab Fish. Manu. (Lahore*). Appendix 2. pp. 6-11.

Khan, M. F.1989. Population dynamics of the Bombay Duck, *Harpodon nehereus* (Ham.) off Saurashtra coast. *Indian J. Fish*. 36 (2): 93-101.

Khan, M. F. and Nandakumaran, K. 1993. Population dynamics of Malabar sole, *Cynoglossus macrostomus* Norman along Calicut coast. *Indian J. Fish.*, 40(4): 225-230.

Khan, M.F. and Panikkar, P.P. 2009. Assessment of impacts of invasive fishes on the food web structure and ecosystem properties of a tropical reservoir in India. *Ecol. Model.,* 220: 2281–2290.

Khan, M. S., Ambak, M.A. and Mohsin, A. K. M., 1988. Food and feeding biology of a tropical freshwater Catfish, *Mystus nemurus* Cuv. And Val. with reference to its functional morphology. *Indian J. Fish.*, 35(2): 78-84.

Khan, R.A. and Siddiqui, A.Q.1973. Studies on the age and growth of rohu, *Labeo rohita* (Ham) from a pond and rivers Ganga and Yamuna. *Proc.Indian Natn. Sci. Acad.,* 39:582-597.

Khan, R.M., Mollah, A.M.F. and Ahmad, U.G. 2000. Mass production of hybrid magur and its culture production in Bangladesh. *Aqua. Res.,* 31 (5): 467–47.

Khanna, D.V. 1958. Observations on the spawning of the major carps at a fish farm in Punjab. *Indian J. Fish*., V (2): 282-290.

Khanna, D.R., Sarkar, P., Ashutosh, G. and Bhutiani, R. 2007. Fish scales as bio-indicator of water quality of River Ganga. *Envi. Monit. Asset.,*134 (1–3):153–160.

Khanna, S. S. and Pant, M. C. 1964. On the digestive tract and the feeding habits of some teleostean fishes. *Agra Univ. Res.*,13: 15-30.

Khoshoo, T.N. 1996. 'Biodiversity in the Indian Himalayas: conservation and utilization'. In *Banking on Biodiversity,* edited by Sheggi P Kathmandu: International Centre for Integrated Mountain Development.

Kiran, B.R and Puttiah, E.T.2003. Fecundity studies on *Chela untrahi* (Day) from Bhadra reservoir, Karnataka, India. *Inland. Fish.Soc*.,35(2): 41-44.

Kiran, B.R. and Puttiah, E. T. 2004. Food and feeding habits of *Salmostoma untrahi* from Bhadra Reservoir, Karnataka. *Indian J. Fish.,* 51(3):335-344.

Kiran, B.R. and Puttiah, E.T. 2005. Age and growth of *Salmostoma untrahi* (Pisces: Cyprinidae) from Bhadra Reservoir, Karnataka *Zoos' Print.,* 20(2): 1770-1773.

Kiran, B.R. and Puttiah, E.T. 2009. Reproductive biology of *Salmostoma untrahi* from Bhadra Reservoir, Karnataka: In Aquatic ecology by V Sakhare Narendra publishing Delhi, India, 165-178.

Kiran, V. U. G. and Waghray, S. 1998. Food and feeding habits of *Notopterus notopterus* (Pallas) of Saroornagar Lake, Hyderabad (A.P.). *Indian J. Fish.,* 45(3): 355-359.

Kishor, B., Bhatt, J.P., Rawath, V. S. and Natiyal, P. 1998. Variations in food habit of the Himalayan Mahseer - *Tor putitira* (Ham.) inhabiting the Ganga river system in Garhwal region. *Indian J. Fish*., 45 (1): 113-118.

Knight, J.D.M., Rai, A. and D'souza, R.K.P. 2013. Re-description of *Hypselobarbus lithopidos* (Teleostei: Cyprinidae), based on its rediscovery from the Western Ghats, India, with notes on *H. thomassi*. *J. Threa.Taxa*., 5(13): 4734-4742.

Koehn, J.D. 2004. Carp (*Cyprinus carpio*) as powerful invaders of Australian waterways. *Freshwater Biology*,49 (7): 882–894.

Kohli, M. P. S. and Goswami, U. C. 1996. Food and feeding habits of *Heteropneustes fossilis* (Bloch) from the Brahmaputhra river system, Assam. *Indian J. Fish.,* 43(1): 97-101.

Kortmulder, K. 1987. Ecology and behaviour in tropical freshwater fish communities. Arch Hydrobiol Beik Ergebn. *Limno*., 28:503–513.

Kortmulder, K., Padmanabhan, K.G. and de Silva, S.S. 1990. Patterns of distribution and endemism in some cyprinid fishes as determined by the geomorphology of South-West Sri Lanka and South Kerala (India). *Ichth. Explo. Fresh*., 1: 97–112.

Kottelat, M. and Whitten, T. 1996. Freshwater biodiversity in Asia with special reference to fish. World Bank Technical paper No.343, The World Bank, Washington, D.C., U.S.A., 59 p.

Kowtal, G.V.1994. Endangered, vulnerable and rare food fishes of the East coast river system. In: Dehadrai, P.V., Das, P. and Verma, S.R. (Eds.) Threatened fishes of India, NATCON-NBFGR Publication (4), pp.57-61; Nature conservators, Muzaffarnagar, U.P. p. 84-112.

Kramer, D. L., 1978. Reproductive seasonality in the fishes of a tropical stream. *Ecology*, 59(5): 976-985.

Kramer, B.L. and Bryant, M.J. 1995. Intestine length in the fishes of a tropical stream : I. Ontogenetic allometry. *Environ. Biol. Fish.*, 42:115-127.

Krishnakumar, K., Raghavan, R., Prasad, G., Bijukumar, A., Sekharan, M., Pereira, B. and Ali, A. 2009. When pets become pests - exotic aquarium fishes and biological invasions in Kerala, India. *Curr. sci.*,97: 474–476.

Krishnakumar, K., Ali, A., Pereira, B. and Raghavan, R. 2011. Unregulated aquaculture and invasive alien species: a case study of the African Catfish, *Clarias gariepinus* in Vembanad Lake (Ramsar wetland), Kerala, India. *J. Threa.Taxa.*, 3: 1737-1744.

Krishnakumar, K., Benno Pereira, F.G. and Radhakrishnan, K.V. 2012. *Puntius madhusoodani* (Teleostei; Cyprininae) a new species of barb from Manimala river, Kerala, South India. *Biosystematica*, 5(2): 31-37.

Krishnamoorthi, B., 1976. A note on mortality rates and yield per recruit in *Nemipterus japonicus* (Bloch). *Indian J. Fish*., 23(3), 354-358.

Kuehne, R. A. 1962. A classification of streams, illustrated by fish distributions in an eastern Kentucky creek. *Ecology*, 43: 608-614.

Kublicki, M., Bozec, Y. M., Labrosse, P., Letourneur,Y., Mou-Tham, G. and Wantiez. L. 2005. Diet composition of carnivorous fishes from coral reef lagoons of New Caledonia. *Aquat. Living Resour*., 18: 231-250.

Kulkarni, C. V. 1950. Breeding habits, eggs and early life history of the Indian shad, *Hilsa ilisha* (Ham) in the Narbada river. *Proc. Nat. Inst. Sci. India*., 15(2):169-176.

Kulkarni, C.V. 1951. Hilsa fisheries in the Narbada River. *J. Bombay Nat. Hist. Soc*., 49(4): 614-623.

Kulkarni, C. V. 1971. Spawning habits, eggs and early development of Deccan mahseer, *Tor khudree* (Sykes). *J. Bombay Nat. Hist. Soc*., 67(3):510-521.

Kulshreshtha, S.D. 1986. Traditional inland fishing methods in Rajasthan, India. In: Maclean, J.L., Dizon, L. B. and Hosillos, L. V. (eds.) Proc: First Asian Fish. Soc., Manila, Philippines: 413-416.

Kumar, A., Singh, I.J. and Ram, R.N. 2003. Annual reproductive cycle of male rohu, *Labeo rohita* (Ham), in Tarai region of Uttaranchal. *Indian J. Fish*., 50: 231-241.

*Kumar, D.2007. Fish and Fisheries of Kharagpur Lake. Ph.D. thesis. T.M. Bhagalpur University, Bhagalpur.

Kumar, K., Sehgal, K.L. and Sunder, S. 1979. Length-weight relationship and ponderal index of brown trout, *Salmo trutta fario* (Linnaeus) catches in the stream of Kashmir. *J. Inland Fish. Soc. India.*, 11 (1): 56-61.

Kurup, B. M. 1988. Population characteristics, bionomics, and culture of *Labeo dussumieri* (Val,), Annual progress report submitted to ICAR, 26 pp.

Kurup, B. M. 1990. Population characteristics, bionomics and culture of *Labeo dussumieri* (Val). Final report submitted to ICAR, 108pp.

Kurup B. M. 1992. Endangered, vulnerable and rare fishes of river systems flowing through Kerala. Nat. Seminar on Endangered fishes of India.25-26 April 1992, National Bureau of Fish Genetics Resources, Allahabad. P 31.

Kurup,B. M.1993a. Preliminary observation on river ranching of *Labeo dussumieri* (Val.) in Pamba, Kerala. *Proceedings of the Fifth Kerala Science Congress*, January 1993, p..197-199.

Kurup, B. M. 1993b. Food and feeding habits of *Labeo dussumieri* (Val.) of the river pampa. *Indian. J. Fish*., 40(4): 234-241.

Kurup, B. M. 1994a. An account on Threatened Fishes of River system flowing through Kerala. *Threatened Fishes of India*. Natcon publication, 4: 121-126.

Kurup, B. M. 1994b. Maturation and spawning of an indigenous carp *Labeo dussumieri* (Val.) in the river Pamba. *J. Aqua. Trop*., 9:119-132

Kurup, B. M. 1997. Age and growth of *Labeo dussumieri* (Val.) (Pisces, Cyprinidae) from the river Pamba. *Indian J. Fish*., 44(2):155-163.

Kurup, B. M. 1998. Population dynamics of an indigenous carp (*Labeo dussumieri*) of the River Pampa, Kerala, (India). *Fish. Technol.,* 35(2): 114-119.

Kurup, B. M. 2000. Management plans to arrest the decline of fresh water fish diversity of Kerala. pp. 164-166. In. Ponniah, A. G. and Gopalakrishnan, A. (Eds.) Endemic fish diversity of Western Ghats. NBFGR-NATP National Bureau of Fish Genetic Resources, Lucknow, U.P., India, publication-1, 347pp.

Kurup, B. M. 2002. Rivers and streams of Kerala part of Western Ghats - Hotspots of exceptional fish diversity and endemism. In. Riverine and Reservoir Fisheries of India. (Bopendranath, M. R., Meenakumari, B., Joseph, J., Sankar, T.V., Pravin, P. and Edwin, L. (Eds.), 204 - 217.

Kurup, B.M. and Samuel, C.T.1985. Fishing gear fishing methods of Vembanad Lake. In: Balachandran, K. K., Iyer, T.S.G., Madhavan, P., Joseph, J., Perigreen, P.A., Ragunath, M.R. and Varghese, M.D. (eds). Harvest and Post-harvest Technology of Fish. Society of Fisheries Technologists (India), Cochin p: 232-237.

Kurup, B. M. and Samuel, C. T. 1987. Length-weight relationship and relative condition factor in *Daysciaena albida* (Cuv.) and *Gerres filamentosus* (Cuv.). *Fish. Technol.,* 24 (2): 88-92.

Kurup, B. M. and Samuel, C. T. 1988. Food and feeding habits of *Daysciaena albida* (Cuvier) from the Vembanad Lake. *Indian J. Fish*., 35(4); 317-322.

Kurup, B. M. and Kuriakose, B.1991. *Labeo dussumieri* (Val) an indigenous endangered carp species of Kerala., *Fishing chimes,* 14: 39-42.

Kurup, B. M. and Kuriakose, B. 1994. Fecundity indices of an endangered indigenous carp *Labeo dussumieri* (Val.) of Kerala. *Fish. Technol*., 31(1): 8 -11.

Kurup,B.M. and Harikrishnan, M. 2000. Reviving the *Macrobrachium rosenbergii* (de Man) Fishery in Vembanad Lake, India Naga, The ICLARM Quarterly (Vol. 23, No. 2).

Kurup, B.M. and Ranjeet. K. 2002. Invasion of Exotic fish population in Periyar lake, Kerala- A hotspot of fish biodiversity. In: Proc. Life History traits of freshwater fish population for its utilization in conservation, NBFGR-NATP, Lucknow, AC-15, Pp.1–4.

Kurup, B. M. and Radhakrishnan, K.V. 2005. Fishes of the genus *Nemacheilus* (Bleeker, 1863) in Kerala with description of a new species, *Nemacheilus periyarensis. J. Bombay Nat. Hist. Soc.*, 102(1):75-78.

Kurup, B.M, and Radhakrishnan, K.V. 2006. Freshwater fish biodiversity of Kerala *Fishing Chimes*, 25 (10):111-122.

Kurup, B.M. and Radhakrishnan, K.V. 2010 a. Fishes of the genus *Homaloptera (*Van Hasselt) in Kerala with Description of s new species *Homaloptera silasi. J. Bombay. Nat. Hist. Soc.*,107(3): 224-226.

Kurup, B.M. and Radhakrishnan, K.V. 2010 b. Two new Cyprind fishes under the Genus *Garra (*Hamilton) from Kerala, Southern India. *J. Bombay. Nat. Hist. Soc.*, 107(3): 220-223.

Kurup, B.M. and Radhakrishnan, K.V. 2010 c. *Tor remadevii* ,a new species of Tor (Gray) from Chinnar Wildlife Sanctuary, Pampar River, Kerala, South India *J. Bombay. Nat. Hist. Soc.*, 107(3): 227-230.

Kurup, B. M., Sebastain, M.J., Sankaran, T.M. and Rabindranath, P. 1992. Fishery and biology of *Macrobranchium spp*. of the Vembanad Lake. In; Silas, E. G.,1992 (Ed.), Freshwater Prawns, KAU, Trichur. 78-89pp.

Kurup, B.M., Sebastian, M.J., Sankar, T.M. and Ravindranath, P. 1993. An account of Inland fishing gears and fishing methods of Kerala. In: Low Energy Fishing, Fish. Technol. (Special issue), Society of Fisheries Technologists (India), Cochin : 145-151.

Kurup, B. M., Sebastian, M.J., Sankaran, T.M. and Rabindranath, P. 1995. Exploited fishery resources of the Vembanad Lake-4. Estimates of marketable surplus of production. *J. Mar. Biol. Ass. Ind.*, 37 (1&2): 1-10.

Kurup, B. M., Ranjeet, K. and Thomas, R. K. 2002a. Biodiversity threat to fish fauna of Periyar lake, Kerala. NBFGR-NATP Publication No.4. Life history traits of freshwater fish population for its utilization in conservation. AC-1:1-5.

Kurup, B. M., Radhakrishnan, K. V. and Euphrasia, C. J., 2002b. Length -weight relationship of some of the endangered and critically endangered fresh-water fishes of Kerala part of Western Ghats. NBFGR (ICAR) - NATP Publication No: 4 Life history traits of freshwater fish population for its utilization in conservation. AA – 2: 1 – 4.

Kurup, B.M., Radhakrishnan, K.V. and Manojkumar, T.G. 2004. Biodiversity Status of Fishes Inhabiting Rivers of Kerala (South India) With Special Reference to Endemism, Threats and Conservation Measures. In: Welcomme, R.L & T. Petr. (eds), *Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries* 2 (LARS2): 310p. Cambodia.

Kurup, B.M., Manoj Kumar, T.G. and Radhakrishnan, K.V. 2005. *Salarias reticulatus* (Pisces; Blennidae) a new freshwater blenny from Chalakudy river, Kerala (South India). *J. Bombay. Nat. Hist. Soc.*, 102(2): 195-197.

Kurup, B. M., Radhakrishnan, K. V. and Manojkumar, T. G. 2006 . Fish and fisheries of Periyar Lake, Kerala. *Indian J. Fish.*, 53(2): 153-166.

Kurian, G.K. 1971. Fishing methods in fresh water reservoirs of India. All India Coordinatedresearch project for ecology and fisheries of freshwater reservoirs, Calcutta.

Kuthalingam, M.D.K. 1967. Observation on the fishery and biology of the silver Pomfret *Pampus argenteus* (Euphrasen) from the Bay of Bengal. *Indian J.Fish*., 10 (A):59-74.

*Lacepede's, B.G.S (1798-1803) *Hist. Nat.Poiss.* Vol 1-5.

*Lagler, K. F. 1956. Freshwater fishery biology. W. m C. Brown Co., Dubuque, Iowa, 421pp.

*Lagler, K. F.1952. Freshwater fishery biology. Wm.C.Brown Co., Dubuque, Iowa.

Lake, P.S. 1982. The relationship between freshwater fish distribution, stream drainage area and stream length in some streams of south-east Australia. *Bull. Aust. Soc. Limn.*, 8, 31-37.

Lakra, W.S. 1996. Cytogenetic studies on endangered fish species: Karyotypes of three species of mahseer, *Tor putitora, T. tor* (Cyprinidae: Pisces). *Cytobios,* 85: 205-218

Lakra, W.S., Singh, A.K. and Ayyappan, S. 2008. Fish introductions in India: Status, potential and challenges. Narendra Publishers, New Delhi, India 303p.

Lal, K. K., Singh, R. K., Mohindra, V., Singh, B. and Ponniah. G. 2003. Genetic makeup of exotic catfish, *Clarias gariepinus* in India. *Asian Fish Sci.*, 16: 229-234.

Lalmohan, R. S. and Remadevi, K. 2000. Fish fauna of the Chaliyar river, North Kerala. pp. 155-156. *In*: Ponniah, A.G. and Gopalakrishnan, A. (Eds.). Endemic Fish Diversity of Western Ghats. NBFGR-NATP Publication-1: 347p. National Bureau of Fish Genetic Resources, Lucknow, U.P. India.

Le Cren, E. D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition of perch (*Perca fluviatilis*). *J. Anim. Ecol.,* 20(1): 201-219.

Lekshmi S., Prasad, G. and Ritakumari, S.D. 2010. Binomics of a lesser goby, *Stenogobius gymnopomus* (Bleeker,1853) from Southern Kerala, India. *J Threa.Taxa.*,2(13) 1359-1364.

Lehri, G. K., 1968. Cyclical changes in the ovary of the catfish, *Clarius batrachus. Acta. Anat*., 69: 105-124.

*Linnaeus. (1758). Systema Nature, Tomus, 1-532pp.

*Linnaeus. (1766-68). Systema Nature, Tomus, 1-823pp.

Liu, K. W.M.and Cheng, Y.L. 1999. Virtual population analysis of the big eye *Priacanthus macranthus* in the water off north eastern Taiwan. *Fish Res.,* 41: 243-254.

Lowe-McConnell, R. H. 1975. Fish communities in Tropical Freshwater communities in Tropical Freshwaters. 337pp. London and New York, Longman.

*Lowe-McConnell, R.H. 1987. Ecological studies in tropical fish communities. Cambridge University Press, Cambridge. pp400.

Livingstone, D.A., Rowland, M. and Bailey, P.E. 1982. On the size of African riverine fish fauna. *Amer. Zool*., 22: 361-369.

Ludwig, J. A. and Reynolds, J. F. 1988. Statistical Ecology: A Primer on Methods and Computing, John Wiley and Sons, USA. pp.234.

Mabuchi, H., Senou, H. and Nishida, M. 2008. Mitochondrial DNA analysis reveals cryptic large-scale invasion of non-native genotypes of common carp (*Cyprinus carpio*) in Japan. *Mol. Eco.,* 17 (3): 796–809.

*Mac-Arthur, R.H. and Wilson, E.O. 1967. The theory of island biogeography. Princeton University Press, pp. 29.

Maccord, P.F.L., Silvano, R.A.M., Ramire, M.S. and Begossi, C.M. 2007. A dynamics of artisanal fisheries in two Brazilian Amazonian reserves: Implications to co-management. *Hydrobiologia*, 583: 365–376.

Mack, R.N., Simberloff, D., Lonsdale, W.M., Evans, H., Clout, M. and Bazzaz, F.A.2000. Biotic invasions: causes, epidemiology, global consequences, and control. *Ecol. Appl.,* 10: 689–710.

Makeeva, A. P. and Nikolskii, G. V. 1965. Sex structure of spawning populations: Its adaptive significance and methods of regulation. *In.* Tro. Reticheskieosnovy rybovodtva (Theoretical basis of fish culture). Nauka, Moscow. 53,72. From 2H Biol. 1965 No. 21148.

Mahanta, P.C., Abidi, R. and Kapoor, D. 2003. Impact of introduction of exotic and genetically manipulated fishes in Indian reservoir. In workshop on Fisheries Management in the lentic water system: stocking of reservoir with fish fed, CIFRI Publication. p74-98.

Mahinder P.S., Kohli, and Goswami, U.C. 1996. Food and feeding habits of *Heteropneustes fossilis* (Bloch) from the Brahmaputra river system, Assam. *Indian J. Fish.,* 43(1): 97-101.

Maitland, P.S. 1993. Conservation of freshwater fishes of India In. B.R Singh (Ed) Advance in Fish Research, Narendra Publishing House, New Delhi pp 349-364.

Malhotra, Y.R. 1966. Breeding in some fishes of Kashmir valley. *Ichthyologica*, 5: 53-58.

Malhotra, Y. R. 1967. On the relationships between feedings and ovarian cycle in *Schizothorax niger* Heckel and *Botia birdi* Chaudhary. *Indian J. Fish.,* 14 (1&2): 313-317.

Malhotra, S. K. 1982. Bionomics of hill-stream cyprinids III Food, parasites and length- weight relationship of Garwhal mahaseer, *Tort tor* (Ham). *Proc. Indian Acad. Sci. (Anim. Sci.).*,91:479-485.

Malhotra, S. K. 1985. Bionomics of the Hill-stream Cyprinids 1. Food parasites and length- weight relationship of *Labeo dyocheilus*. *Proc. Indian Acad. Sci.,* 94B: 377-381.

Malhotra, S. K. and Chauhan, R. S. 1984. Bionomics of hill-stream Cyprinids IV. Length – weight relationship of *Labeo dero* (Ham.) from India. *Proc. Indian. Acad. Sci. (Anim Sci.),* 93(5): 411-417.

Malmqvist, B. and Rundle, S. 2002. Threats to the running water ecosystem of the southeast United States. *Cons. Bio.,* 9:800-805.

Mamun, A., Tareq, K.M.A. and Azad, M.A. 2004. Food and feeding habits of *Amblypharyngodon mola* (Hamilton) from Kaptai Reservoir. Bangladesh. *Pakistan. J. Biol. Sci.,* 7(4):584-588.

Manojkumar, T.G. and Kurup, B.M. 2002 a. Food and Feeding habits of *Neolissocheilus wynadensis*- A endemic Critically Endangered Fish in Kerala In: NBFGR- NATP Publication No.4: Life History traits of freshwater fish population for its utilization in conservation AF2, 4p.

Manojkumar, T.G. and Kurup, B.M. 2002 b Food and Feeding habits of the Deccan Mahseer *Tor khudree* In: NBFGR- NATP Publication No.4 : Life History traits of freshwater fish population for its utilization in conservation AF1, 3p.

Manojkumar, T. G. and Kurup, B. M. 2002c. Fish habitat diversity and species assemblage structure with reference to five major river systems of Kerala. p.141-150. *In.* Riverine and Reservoir fisheries of India. (Boopendranath, M.R., Meenakumari, B., Joseph, J., Sankar, T.V., Pravin, P. and Edwin, L. (Eds.), Society of Fisheries Technologists (India), Cochin.

Manojkumar, T.G. 2006. Fish habitats and species assemblage in the selected rivers of Kerala and Investigation on life history traits of *Puntius carnaticus* (Jerdon, 1849}, Thesis submitted to Cochin University of Science & Technology. 290 p.

Manojkumar, T.G. and Kurup, B.M. 2010a. Length-weight relationship and Relative Condition Factor of *Puntius carnaticus* (Jerdon, 1849). *Fish. Techno.,* 47(1): 19-26.

Manojkumar, T.G. and Kurup, B.M. 2010b. Age and growth of the carnatic carp, *Puntius carnaticus* (Jerdon,1849) from Chalakudy river, Kerala. *Indian J. Fish*., 57(1): 81-85.

Manojkumar, P.P. 2007. Stock assessment of Indian shad, *Decapterus russelli* (Ruppell,1830) off Malabar. *J. Mar. Biol. Ass. India.*, 49(1):76-80.

Manojkumar, P.P. and Sivakami, S. 2005. Fishery of lizard fishes off Veraval with stock assessment of *Saurida tumbil* (Bloch). *Indian J. Fish.*, 52(3): 323-329.

*Marza, V. D., 1938. *Histophysiologie de lovogenese*. pp81. Hermann, Paris.

*Martin, W.R. 1949. The mechanics of environmental control of body form in fishes. *Univ.Toronto Stud. Biol.,* 56:1-91.

Martin-Smith. K.H. 1996. Length-weight relationship of fishes in a diverse tropical freshwater community, Sabah, Malaysia. *J. Fish. Biol.,* 49:731-734.

Mathew, K. and Zacharia, P.U. 1982. On the age and growth of three Indian major carps from Hirakud reservoir. *Bull. Dept. Mar. Sci. Univ. Cochin.*, X111:81-95.

Mathews, W.J. 1998. Patterns in Freshwater Fish Ecology. Chapman & Hall. 752 p.

McAllister, D. E., Platania, S. P., Schueler, F. W., Baldwin, M. E. and Lee, D. S. 1986. Ichthyofaunal patterns on a geographic grid. *In* C. H. Hocutt and E. O. Wiley, editors. The Zoogeography of North American Freshwater Fishes. John Wiley, New York. p. 15-17.

McNeely, J.A. and Mainka, S.A. 2009. Conservation for a New Era. IUCN-International Conservation Union, Gland, Switzerland, 220pp.

*McClelland, J. 1839. Indian Cyprinidae. Asiatic Researches.Vol.19, Part II. Pp.167.

Mc Fadden, J. T., Cooper, E. L. and Anderson, J. K. 1965. Some effects of environment on egg production in brown trout (*Salmo trutta*). *Limnol. Oceanogr.,*10: 88-85.

MEA,2005. *Ecosystems and Human Well-Being: A Framework for Assessment.* Millennium Ecosystem Assessment. Island Press, Washington DC, USA.

Menon, A. G. K. 1950. On a remarkable blind silurid fish of the family Clariidae from Kerala (India). *Rec. Indian Mus.,* 47:59-70.

Menon, A. G. K. 1987. The fauna of India and adjacent countries. *Pisces*: *Vol.4*: Teleostei: Gobitoidea, part 1. Homalopteridae, Zoological Survey of India, Calcutta. 259 pp., 16pl.

Menon, A.G.K. 1992. The fauna of India and the adjacent countries. *Pisces, Vol. 4.* Teleostei, Part 2 cobitidae. Zoological survey of India, Madras. pp.236.

Menon, A. G. K. 1997. Rare and endangered fishes of Malabar, India. *Zoos Print*, 12(11): 6-19.

Menon, A.G.K. 1999. *Check list - fresh water fishes of India*. Records of the Zoological Survey of India. Miscellaneous Publication, Occasional Paper No. 175: i-xxviii + 1-366

Menon, A. G. K. and Remadevi, K. 1995. *Hypselobarbus kurali* (Pisces: Cyprinidae) a new large barb from the south western rivers of Peninsular India. *J. Bombay Nat. Hist. Soc.,* 92:389-393.

Menon, A. G. K. and Jacob, P. C. 1996. *Crossocheilus periyarensis*, a new cyprinid fish from Thannikudy (Thekkady),Kerala,India. *J. Bombay Nat. Hist. Soc.*, 93: 62-64.

Menon, A.G.K., Remadevi, K. and Thobias, M. P. 1999. *Puntius chalakudiensis*, a new colourful species of Puntius (Family: Cyprinidae) fish from Kerala, South India. *Rec.zool.Surv.India.*, 97(part-4): 61-63.

Menon, M. D. and Chacko, P. I. 1957. Food and feeding habits of fresh water fishes of Madras State, India. *Proc. Indo-pacific Fish. Coun. 6th Session, Tokyo*, pp. 182-186.

Menon, M. D. and Chacko, P. I. 1958. The food and feeding habits of some freshwater fishes of Madras State. *J. Bombay Nat. Hist. Soc.*, 55 (1): 117-124.

Mercy, T. V. A., Thomas, K. R. and Jacob, E. 2002. Length-weight relationship in *Puntius denisoni* (Day). *Indian J. Fish.*, 49(2): 209-210.

Mercy, T.V.A and Eapen, J. 2007. A new species of Teleostei: *Puntius pookodensis* (Cyprinidae) from Wayanad, Kerala, India. *J. Bombay Nat His Soci.*, 104(1): 76-78.

Mercy, T.V.A., Malika,V. and Sajan,S. 2013. Reproductive biology of *Puntius denisonii* (Day 1865)- an endemic ornamental cyprinid of the Western Ghats of India. *Indian J.Fish.*, 60(2):73-78

Md, Y. H., Jun, O., Zoarder, F. A. 2009. Morphometric, Meristic Characteristics and Conservation of the Threatened Fish, *Puntius sarana* (Hamilton, 1822) (Cyprinidae) in the Ganges River, Northwestern Bangladesh. *Tur. J. Fish and Aqua. Sci.*,9: 223-225.

Miah, M. S., Haldar, G. C. and Rahman, M. A. 1997. Estimation of growth and mortality parameters of hilsa *Tenualosa ilisha* (Ham.) population in the Meghna river of Bangladesh. *Indian J. Fish.*, 44(2): 133-139.

Mijkherjee, M., Praharaj, A. and Das, S. 2002. Conservation of endangered fish stocks through artificial propagation and larval rearing technique in West Bengal, India. *Aquacul. Asia.*, 7(2): 8–11.

Misra, K. S. 1947. A check-list of the fishes of India, Burma and Ceylon. 46p.

Misra, K. S. 1952. An aid to the identification of the fishes of India. Burma and Ceylon. I. Elasmobranchii and Holocephali. *Rec. Indian Mus.*, 49(I): H9-137.

Misra, K. S. 1953. An aid to the identificalion of the fishes of India, Burma and Ceylon. II. Clupeiformes. Baihyclupeiformes. Scopeliformes and Ateleopiformes. *Rec. Indian Mus.*, SO (3 & 4): 367-422.

Misra, K. S. 1962. An aid to the identification of the common commercial fishes of India and Pakistan. *Rec. Indian Mus.*, 57(1-4):1-320.

Misra, K. S. 1969. The Fauna of India and the adjacent countries, Pisces (Elasmobranchii and Holocephali : xxiv + 276, 19 pis.

Misra, K. S. 1976 a. The fauna of India and adjacent countries. Pisces (second edition).2. Teleostomi: Clupeiformes, Bathyclupeiformes, Galaxiiformes, scopeliformes and Ateleopiformes: xxvii+438, 11pts.

Misra, K. S.1976b. The fauna of India and adjacent countries. Pisces (second edition).3. Teleostomi: Cypriniformes, Siluriformes: xxi + 387, 15pts.

Mishra, A., Pandey, A.K., Singh, A.K. Das, P. 2000. Genetic threats to icthyo biodiversity including capture and culture stocks due to introduction of exotics and genetically modified fishes. *J. Natcon.*, 12, 1-7.

Mishra, S. S., Acherjee, S. K. and Chakraborty, S. K. 2009. Development of tools for assessing conservation categories of siluroid fishes of fresh water and brackish water wetlands of South West Bengal, India. *Env. Bio.Fish.*, 84(4): 395–407.

Mini, S. 2000. Conservation of fish fauna of Periyar lake, Thekkady, Kerala.p.160. *In*: Ponniah, A.G and Gopalakrishnan, A. (Eds.). Endemic Fish Diversity of Western Ghats. NBFGR-NATP Publication- 1.347p. National Bureau of Fish Genetic Resources, Lucknow, U.P. India.

Minimol, K.C. 2000. Fishery Management in Periyar Lake. P.h D Thesis, Zoology, Mahatma Gandhi University 196p.

Minckley, W.L., Hendrickson, D.A. and Bond, C.E. 1986. Geography of western North American freshwater fishes: description and relationships to intracontinental tectonism. *The zoogeography of North American freshwater fishes* (Ed. by C.H. Hocutt and E.O. Wiley), John Wiley and Sons, New York. p. 519-613.

Mittermeier, R. A., Myers, N., Thomsen, J.B., da Fonseca, G.A.B. and Olivieri.1998. Biodiversity hotspots and major tropical wilderness; approaches to setting conservation priorities. *Cons. Biol.*, 2; 516-520.

Molur, S. 2009. Habitat and status assessment of mammals with special reference to rodents and bats in Western Ghats of Karnataka. PhD Thesis submitted to the Department of Zoology, University of Mysore, Manasagangotri, Mysore, 230pp.

Molur, S. and Walker, S. 1998. Report of the workshop "Conservation Assessment and Management Plan for Freshwater Fishes of India", Zoo Outreach organization, Conservation Breeding Specialist Group, India, Comibatore, India. 156p.

Mohan, R.K.V. 1993. Fish trapping devices and methods in Southern India. *Fish. Techno*., 30 (2): 85-93.

Mohan, M. V. and Sankaran T. M.1988. Length-weight relationship of Indian major carps with improvement in expressing exponential formula. *J. Aquaculture Trop.*, 3: 43-46.

Montana, C.G.,Choudhary.,Dey, S and Winemiller, K.O 2011.Composition trends of fisheries in the River Ganges, India. *Fish.Mang and Ecol.*, 18:282-296.

Mookherjee, H. K. 1944. Food of fresh water fishes. *Sci. and Cul.*, 9: 306.

Mookherjee, H. K. 1945. Factors influencing the spawning of principal carps in India. *Proc.Nat. Inst. Sci. India*., 11: 312-315.

Moraes, G. and Bidinotto, P.M. 2000. Induced changes in the amylohrydrolytic profile of the gut of *Piaractus mesopotamicus* (Holmberg 1885) fed different levels of soluble carbohydrate: its correlation with metabolic aspects. *Rev Ictiol*., 8:47–51.

Moyle, P.B. and Cech, J.J Jr. 1988. Fishes: An introduction to Ichthyology, 2nd ed. Prentice-Hall, Inc Englewood Cliffs, N.J pp 559.

Myers, N. 1999. The next green revolution? Its environmental underpinnings. *Current science*, 76:507-513.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B. and Kent, J., 2000. Biodiversity hotspots for conservation priorities. *Nature*, 403, 853–858.

Mukerjee, D.D. 1931. On a small collection of fish from the Bhavani river (South India). *J. Bombay Nat. His. Soc.*, 35: 162-171.

Munro, J. L. and Pauly, D. 1983. A simple method for comparing the growth of fishes and invertebrates. *ICLARM Fishbyte*, 1(1):5-6.

Murthy, N.S., Gonda, S.S. and Murthy, V.A.1986. Fishes of Kabini reservoir in Karnataka. *Fishing Chimes,* 8, 36-38.

Murty, V.S. 1975. Studies on maturation, spawning, fecundity and sex ratio in *Barbus (Puntius) sarana* (Ham-Buch) from Lake Kolleru, Andhra Pradesh. *Fish. Technol.,*12 (2): 131-144.

Mustafa, M.G. 1994. Length-based estimates of vital statistics in thread fin bream (*Nemipterus japonicas*) from Bay of Bengal, Bangladesh. *Naga ICLARM Quarterly*, 17(1): 34-37.

Mustafa, M.G. and Khan, M.G. 1998. Studies on some aspects of population dynamics of Lizard fish, *Saurida tumbil* (Bloch) from the Bay of Bengal. *Ban. J. Zoo.,* 16(2):77-84.

Nagahama, Y. 1983. The functional morphology of teleost gonads. *In.* Fish physiology (Hoar, W. S., Randall, D. J. and Donaldson, M., Eds.). Vol. 1X, Part B. Academc Press, New York, pp. 223-276.

Naiman, R.J.and Turner, M.G. 2000. A future perspective on North American's freshwater ecosystem. *Ecol. Applic.,* 10: 958-970.

Naiman, R. J., Magnuson, J.J., McKnight, D.M and Stanford, J.A. 1995. The Freshwater Imperative: A research Agenda. Island press, Washington D.C., U.S.A 165p.

Nair, N. B. and Sobhana, B. 1980. Food and Feeding habits of *Puntius sarana subanasutus* (Val*.). Proc.Indian Natn. Acad.,* B46 No.1 pp. 33-40.

Nandakumar, T. 2010. Greens oppose move to release carps into reservoirs. The Hindu *Daily*. http://www.hindu. com/2010/12/13/ stories/ 2010121358080600.htm accessed on 21st august 2012.

Na-Nakorn, U., Hara, M., Taniguchi, N. and Seki, S. 1998. Isozymes variation of *Clarias macrocephalus* from four locations in Thailand. *Fish. Sci.,* 64; 526-530.

Narain, P. 2000. Genetic diversity: Conservation and assessment. *Cur. Sci.,*79: 170-175.

Narejo, N.T., Rahmatullah, S.M. and Mamnur, M. 2002. Length–weight relationship and relative condition factor (Kn) of *Monopterus cuchia* (Hamilton). *Indian J. Fish*., 49(3):329-333.

Natarajan, A. V. and Jhingran, A. G. 1961. Index of preponderance - a method of grading the food elements in the stomach analysis of fishes. *Indian J. Fish*., 8 (1): 54-59.

Natarajan, A. V. and Jhingran, A.G. 1963. On the biology of *Catla catla* (Ham) from the river Jamuna. *Proc. Nat. Inst. Sci. India.*, 29 B (3): 326-355.

Natarajan, A.V. and Menon, V.R. 1989. Introduction of exotic fishes in Tamil Nadu. Proceeding of Workshop on exotic aquatic species in India. Asian Fisheries Society, Indian branch, Mangalore, India. pp 62-65.

Nath, S. 1994a. Studies on the bio-ecology of fishes of Jammu Province (Jammu and Kashmir State) India, Part 11: Feeding Ecology. *Rec. Adv. Fish Ecol. Limn. Eco-Conserv.*III: 63-69.

Nath, S. 1994b. Studies on the bioecology of fishes of Jammu Province (Jammu and Kashmir State) India, Part 111: Spawning Ecology. *Rec. Adv. Fish Ecol. Limn. Eco-Conserv.*, III: 79-82.

Nath, P. and Dey, S.C. 1989. Fish and fisheries of Northeastern India Vol. 1 (Arunachal Pradesh), 194 pp.

Nath, P. and Dey, S.C. 2000. Fish and fisheries of North Eastern India. Arunachal Pradesh. Narendra Publishing House, Delhi, India,217pp.

Nautiyal, P. 1984. Natural history of Garhwal Himalayan mahseer, *Tor putitora* (Ham.) II. Breeding biology.*Proc. Indian acad. Sci (Anim. Sci.).*, 93 (2): 97-106.

Nautiyal, P. 1994. Riverine mahseer. *In.* 'Mahseer - The game fish'. Rachna Publishers, Srinagar, Garhwaal. pp 323.

Nautiyal, P. and Lal, M. S. 1984. Food and feeding habits of fingerlings and juveniles of mahseer (*Tor putitora* Ham) in Nayar River. *J. Bomb. Nat Hist. Soc.*, 97 (1): 155-157.

Nautiyal, P. and Lal, M. S. 1985. Fecundity of the Garhwal Himalayan Mahseer, *Tor putitora* (Ham). *J. Bombay Nat. Hist. Soc.*, 82: 253-257.

Nautiyal, P., Rizvi, A.F. and Dhasmanaa, P. 2008. Life History traits and decadal trends in the growth parameters of Golden Mahseer, *Tor putitora* (Hamilton 1822) from the Himalayan stretch of the Ganga River System. *Turk. J. Fish. Aquat. Sci.*, 8: 125–132.

NBSAP.2002. Executive summaries of National Biodiversity strategy and Action Plans (Ecoregions, States, sub states, Sites and themes and sub thematic Reviews) December 2002: 94-04.

Neelakantan, B. and Pai, M.V. 1985. Relative condition factor in a marine fish *Lactarius lactarius* (Bloch and Schneider). *Matsya*, 11:36-41.

Neiff, J.J., Poi de Neiff, A. and Canon, M. B. 2009. The role of vegetated areas on fish assemblage of the Parana River floodplain: effects of different hydrological conditions. *Neo. Icthy.*, 7: 39-48.

Nelson. 1976. Fishes of the world John Wiley and sons New York pp 416.

Nelson 1984. Fishes of the world 2nd edition, John Wiley and sons New York, pp 523.

Nelson 1994. Fishes of the world 3rd, 3rd edition Wiley, New York 600pp.

Nelson, J.S. 2006. Fishes of the world 4th edn Wiley New York. 624p.

Ng, P.K.L. and Lim, K.K.P. 1990. Snakeheads (Pisces: Channidae): Natural, history, biology and economic importance: Essays in Zoology, Papers Commemorating the 40th Anniversary of the Department of Zoology, National University of Singapore, p. 127-152.

Ninan, G. and Swamikumar, M. 2003. Types of crafts and gears are in use for exploitation of fishes in small reservoirs of India. Proc. Workshop on Fishery Management in Lentic Water System: Stocking of Reservoir with Fish Seed. CIFRI, Barrackpore, West Bengal: 92-105.

Nikolsky, G. V. 1963. The Ecology of fishes. Academic press, London and New-York. pp.352.

Nikolsky, G. V. 1980. Theory of fish population dynamics (Translated by J. E. S. Bradely) (R. Jones, ed.), Bishan Singh Mahendrapal Singh, Dehradun and Otto Koeltz, Science Publishers, Koeltz. Science publishers, Koeninstein, Germany.323p.

Nurulamin, S. M., Haroon, A. Y. K. and Alam, M. 2001. A study on the population dynamics of *Labeo rohita*(Hamilton) in the Sylhet basin, Bangladesh. *Indian J. Fish.*, 48(3): 291-296.

Oberdorff, T., Guegan, J.F. and Hugueny, B. 1995. Global scale patterns of fish species richness in rivers. *Ecography*,18, 345-352.

Oberdorff, T., Hugueny, B. and Guegan, J.F. 1997. Is there an influence of historical events on contemporary fish species richness in rivers? Comparisons between Western Europe and North America. *J. Biog.*, 24: 461-467.

Ogale, S.N. 2002. Mahseer breeding and conservation, and possibilities for com- mercial culture: the Indian experience. In: Petr, T., Swar, S.B. (Eds.), Coldwater Fisheries in the Trans Himalayan Countries. FAO Fisheries Technical Paper 431, pp. 193–212.

Padmakumar, K.G. and Krishnan, A. 2000. Conserving fish diversity of Vembanad Wetlands, Kerala. pp. 161-163. In: Ponniah, A.G. and Gopalakrishnan, A. (Eds.) Endemic fish diversity of Western Ghats. NBFGR-NATP Publication- NBFGR, Lucknow, U.P., India. 347 pp.

Padmakumar, K. G., Krishnan, A., Radhika, R., Manu, P. S. and Shiny, C. K. 2002. Openwater fishery interventions in Kuttanad, Kerala, with reference to fishery decline and ecosystem changes. In *M.R. Riverine and Reservoir Fisheries, Challenges and Strategies* (Eds. Boopendranath, B. *et al.*), Society of Fisheries Technologists (India), CIFT, Cochin, 2002, pp. 15–24.

Padmakumar, K.G., Anuradha, K., Bindu, L P., Sreerekha, S. and Nitta, J. 2004. Captive breeding for conservation of endemic fishes of the Western Ghats, India. Regional Agricultural Research Station, Kerala Agricultural University, Kumarakom, Kottayam, Kerala, India. 80 pp.

Padmakumar K. G., Bindhu, L., Sreerekha, P.S. and Joseph, N. 2009. Food and feeding behavior of the golden catfish, *Horabagrus brachysoma* (Gunther). *Indian J. Fish.,* 56(2): 139-142.

Padmakumar, K .G., Bindu, L., Sreerekha, P., Gopalakrishnan, S.A., Basheer, V.S., Nitta, J., Manu, P. S. and Anuradha, K. 2011. Breeding of endemic catfish, *Horabagrus brachysoma* in captive conditions. *Current science,* 100(8): 1232-1236.

Padma, K., Silva, D. and Damayanthi, 1995. Aspects of the food and feeding biology of The yellow mahseer, *Tor khudree* (Sykes) (Osteichthyes, Cyprinidae) in Sri Lanka. *Cey. J. Sci. (Bio. Sci.).,* 24 (2):22-30.

Palaniswamy, R., Manoharan, S. and Geethalakshmi, V. 2011. Assessment of population parameters of Indian major carps and common carp in a culture based reservoir. *Indian J. Fish.,* 58(2): 41-44.

Paller, M.H. 1994. Relationships between fish assemblage structure and stream order in South Carolina coastal plain stream. Transactions of the American Fisheries Society, 123: 150-161.

Pandian, T. J. 1966. Feeding and reproductive cycles of the fish *Mystus gulio* in the Cooum backwaters, Madras. *Ind. J. Fish.,* XIII (1&2): 322-333.

Pandian, C. and Rahman, A. A. 1999. Food and feeding habits of pearl spot – *Etroplus suratensis* (Blotch). In. The fourth Indian Fisheries forum proceedings, 24-28 November,1996, Kochi 283-286.

Pandey, A. C. and Sharma, M. K. 1997. A preliminary study on the relative condition factor of exotic carps cultivated in sodic soil pond. *Indian J. Fish.*, 44(2): 221-223.

Pandey, A. C. and Sharma, M. K. 1998. Bionomics of the Indian major carps cultivated on sodic soil pond conditions in U.P., India. *Indian J. Fish.*, 45(2): 207-210.

Pandey, K. and Shukla, J.P. 2005. Fish and fisheries. Rastogi Publications, Meerut. pp504.

Pandit. 1998. Exotic germplasm vis-à-vis fish diversity conservation in India. Fish Genetics and Biodiversity Conservation, Natcon Publication-05, 293–299.

Pantalu, V. R. 1963. Studies on the age, growth and fecundity and spawning of *Ostigeneiosus militaries* (Linn.). *J. Com. Int. Explor. Mer.*, 28: 295-315.

Parameswaran, S., Alikunhi, K. H. and Sukumaran, K.K. 1972. Observations on the Maturation, fecundity and breeding of the common carp, *Cyprinus carpio* Linnaeus. *Indian J. Fish.*, 19 (1 & 2): 110-124.

Patra, M.K., Acharjee, S.K. and Chakraborty, S.K. 2005. Conservation categories of siluroid fishes in North-East Sundarbans India. *Biodiversity and Conservation.*, 14: 1863–1876.

Pathani, S. S. 1980. Studies on spawning ecology of Kumaun mahseer, *Tor tor* (Ham.) and *Tor putitora* (Ham.). *J. Bombat Nat. Hist. Soc.*, 79 : 525-530.

Pathani, S. S. 1981a. Fecundity of Mahseer, *Tor putitora* (Ham.). *Proc. Indian Acad. Sci. (Anim. Sci.*)., 90 (2): 253-260.

Pathani, S. S. 1981b. Age and growth of the mahseer tor, *Tor putitora* (Ham.) as determined by scales and operculum. *Matsya*, 7:41-46.

Pathak, S. C. 1975. Length-weight relationship, condition factor and food study of *Labeo calbasu* (Hamilton) from Loni reservoir (M.P.). *J. Inland Fish. Soc. India.*, VII: 58-64.

Pathak, S. C. and Jhingran, A. G. 1977. Maturity and fecundity of *Labeo calbasu* (Ham.) of Loni reservoir, M. P. *J. Inland Fish. Soc.*,9: 92-93.

Pati, S. 1980. Food and feeding of silver Pomfret, *Pampus argenteus* (Euphrasen) from the Bay of Bengal. *Indian J.Fish.*, 27: 244-256.

Patiyal, R.S., Sharma, R. C., Punia, P., Goswami, M. and Lakra, W.S. 2010. Length–weight relationship of *Tor putitora* (Hamilton, 1822) from the Ladhiya River, Uttarakhand, India. *J. Appl. Ichthyol*., 26, 472–473.

Pauly, K.V. 1991. Studies on the commercially important fishing gears of Vembanad Lake. Ph.D. Thesis, Cochin University of Science and Technology, Cochin. 71p.

Pauly, D.1993. Editorial. *Fishbyte, NAGA, The ICLARM Quarterly,* 16 (2-3), 26.

Pauly, D.1980 a. A new methodology for rapidly acquiring basic information on tropical fish stocks: growth, mortality and stock recruitment relationships. P.154-172. *In*: S. Saila and Roedal, P. (Eds.) *Stock assessment for tropical small scale fisheries*. Intern. Centre Mar. Resource Development. 198p.

Pauly, D. 1980 b. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons. CIEM*, 39(3): 175-192.

Pauly, D. 1982 a. Studying single-species dynamics in a tropical multispecies context, p.33-70. *In*. D. Pauly and G.I.Murphy (eds.) Theory and management of tropical fisheries. *ICLARM Conf. Proc.*, 9.

Pauly, D.1982 b. A method to estimate the stock recruitment relationships of shrimps. *Trans. Amer. Fish. Soc*., 111: 13-20.

Pauly, D. 1983a. Some simple methods for the assessment of tropical fish stocks. *FAO Fish Tech. Pap. 234*, 52p.

Pauly, D. 1983 b. Length converted catch curves. A powerful tool for fisheries research in the tropics. (Part-I). *ICLARM Fishbyte*, 1 (2): 9-13.

Pauly, D.1984a. Fish Population Dynamics in Tropical water, a manual for use with Programmable calculators. (Part III*) ICLARM Stud. Rev*.(8), 325 pp.

Pauly, D. 1984b. Length-converted catch curves- a powerful tool for fisheries research in the tropics (Part-III). *ICLARM Fishbyte*., 2 (3): 9-10.

Pauly D. 1985.Population dynamics of short lived species with emphasis on squids. Scientific Council Studies No 9 special session on Squids, September 1984 North West Atlantic Fisheries organization pp1-177.

Pauly, D.1986. On improving operation and use of the ELEFAN programe. Part II. Improving the estimation of L_Y *Fishbyte.*, 4(1): 18-20.

Pauly, D.1987. A review of ELEFAN system for analysis of length frequency data in fish and aquatic invertebrates. *ICLARM conf. Proc.* 13: 7-34.

Pauly, D. and David, N. 1981. ELEFAN 1, a BASIC programme for the objective extraction of growth parameters from the length frequencies data. *Meeresforsch,* 28(4): 205-211.

Pauly, D. and Soriano, M. L. 1986. Some practical extensions to Beverton and Holt's relative yield per-recruit model. P. 491-495. In: J. L. Mc Lean, L. B. Dizon and L.V. Hosillos (eds.). The first Asian Fisheries Forum, Asian Fisheries Society, Manila, Philippines.

Peh, K.S.H. 2010. Invasive species in south East Asia; the knowledge so far. *Biodivers Conserv.*,19: 1083-1099.

Periyar Foundation.2006. Annual Report of Periyar Foundation 2005-2006. accessed from www.periyarfoundation.org/pdf/pf_annualreport05-06.pdf on September 18th 2009.

Peterson, D. L., Wood, A. and Gardner,J. 2005. An assessment of Fisheries and Oceans Canada Pacific Region's effectiveness in meeting its conservation mandate. Prepared for the David Suzuki Foundation, Vancouver, Canada.

Pethiyagoda, R. 1994. Threats to the indigenous freshwater fishes of Sri Lanka and remarks on their conservation. *Hydrobiologia,* 285: 189-201.

Pethiyagoda, R. and Kottelat, M. 1994. Three new species of fishes of the genera *Osteochilichthys* (Cyprinidae), *Travancoria* (Balitoridae) and *Horabagrus* (Bagridae) from the Chalakudy river, Kerala, India. *J. South Asian. Nat. Hist.*, 1(1): 97-116.

Pethiyagoda, R. and Kottelat, M. 2005. A Review of the Barbs of the *Puntius filamentosus* group (Teleostei: Cyprinidae) of Southern India and Sri Lanka. *The Raffles Bulletin of Zoology.*,Supplement No. 12: 127-144.

Petrakis, G. and Stergiou, K.I. 1995. Weight-length relationships for 33 fish species in Greek water. *Fish. Res.,* 21:465-469.

*Petersen, C.G.J. 1895. Eine Methods zur Bestimmung des Alters and Wochses des Fische. *Mitt.Dtsch.Seefischerei-Vereins.*11: 8.

*Petersen, C.G.J. 1903. Where and under what conditions can eggs of plaice be developed into young fish within the Skrei. *Rep. Danish Biol. Station,* 12.

Pillay, R.S.N. 1929. A list of fishes taken from Travancore from 1901-1915. *J. Bombay Nat. Hist. Soc.*, 33:347- 379.

Pillay, T.V.R. 1958. Biology of the hilsa, *Hilsa ilisha* (Ham.) of the river Hoogly. *Indian J. Fish.*, 5: 201-257.

Pillay, T.V.R. 1952. A critique of the methods of food of fishes. *J. Zool. Soc. India.,*4:185-200.

Pillay, T.V.R. 1960. The collection of estuarine capture fisheries. *Sci & Cult.,* 26:6-10.

Pisolkar, M.D. and Karamchandani, S.J. 1981. Fishery and biology of *Tor tor* (Hamilton) from Govindgarh Lake (Madhya Pradesh). *J. Inland. Fish. Soc. India.,* 13(1):15-24.

Philipp, D.P., Epifanio, J.M., Mardsen, J.E. and Claussen, J. E. 1995. Protection of aquatic biodiversity. Proc. World Fish Congr. Theme 3, Oxford & IBH Publication Co. New Delhi, India. 282 pp.

Philip, K. P.and Mathew, K. 1996. Growth, mortality and exploitation of *Priacanthus hamrur* (Forskal) from the north east coast of India. *J. Mar. Biol. Ass. India.,* 38(1&2): 106-113.

Phukon, J, and Biswas, S. B. 2002. On the maturity and spawning of an ornamental fish, *Eresthistes pussilus* Muller and Troschel. *Indian J. Fish.*, 49 (1): 51-57.

Ponniah, A. G. and Gopalakrishnan, A. 2000. (Eds.) Endemic Fish diversity of Western Ghats. NBFGR-NATP Publication - 1.National Bureau of Fish Genetic Resources, Lucknow, UP, India, 347 pp.

Postel, S. L. 2000. Entering an era of water scarcity: the challenges ahead. *Ecological Applications.*, 10:941–948.

Postel, S. and Richter, B. 2003. Rivers for Life: Managing water for People and Nature. Island Press, Washington D.C., U.S.A. 220p.

Prakash, S. 1989. Some aspects of distribution and biology of freshwater prawns in Gangetic ecosystem. *Indian J. Fish.* 36(2):133-140.

Prasad, G. 2008. Population Characteristics, Bionomics, and Standardization of Captive Breeding of Two Species of Endangered Bagrid Catfishes, *Horabagrus brachysoma* (Gunther, 1864) and *H. nigricollaris* (Pethiyagoda & Kottelatt, 1994). Kerala, State Council for Science, Technology and Environment, Thiruvananthapuram.161p.

Prasad, G. and Ali, A. 2007. Length-Weight relationship of a cyprinid fish *Puntius filamentosus* from Chalakudy river, Kerala. *Zoos' Print Journal.*, 22(3): 2617-2618.

Prasad, G. and Ali, A. 2008. Morphology of the diet in the gut of threatened yellow catfish, *Horabagrus brachysoma* (Gunther 1864) at two life stages. *Fish. Physiol Biochem.,* 34:385-389.

Prasad, G., Ali, A., Harikrishnan, M. and Raghavan, R. 2012. Population dynamics of an endemic and threatened Yellow Catfish, *Horabagrus brachysoma* (Günther) from Periyar River, southern Western Ghats, India. *J. Threat. Taxa.,* 4(2): 2333–2342.

Prabha, S.Y. and Manjulatha, C. 2008. Food and feeding Habits of *Upeneus vittatus* (Forsskal, 1775) from Visakhapatnam coast (A.P) of India. *Int.J.Zool.Res*., 4 (1): 59-63.

Prabhu, M.S. 1956. Maturation of intra-ovarian eggs and spawning periodicities in some fishes. *Indian J. Fish.,* III (1): 59-90.

Premkumar K., Vijayakumar, B., Padmanabhan K.G. and Kortmulder, K. 1985. Food and feeding habits of two cyprinid forage fishes, *Puntius (Barbus) filamentosus* (Val) and *P. amphibius* (*Val)* from South Kerala. India. *Neth. J. of Zoology.,* 36(4): 449-460.

Preston, F. W. 1962. The canonical distribution of commonness and rarity. *Ecology*, 43:185-215, 410-412.

Qadri, M. Y., Mir, S. and Yousf, A. R. 1983. Breeding biology of *Schizothorax richardsoni*. Grap and Hard. *J. Indian Inst. Sci.,* 64 (6): 73-81.

Qasim, S. Z., 1957. The biology of *Blennius pholis* L. (Teleostei). *Proc. Zool. Soc. London.,* 128:161-208.

Qasim, S. Z. 1966. Sex ratio in fish populations as a function of seasonal differences in growth rate. *Curr. Sci*., 35: 140-142.

Qasim, S. Z. 1973 a. An appraisal of the studies on maturation and spawning in marine teleosts from the Indian waters. *Indian J. Fish*., 20(1): 166-181.

Qasim, S. Z. 1973 b. Some implications of the problem of age and growth in marine fishes from the Indian waters. *Indian J. Fish.,* 20 (2): 351-371.

Qasim, S. Z. and Qayyum, A. 1961. Spawning frequencies and breeding seasons of some fresh water fishes with special reference to those occurring in the plains of Northern India. *Indian J. Fish.,* VIII (1): 24-43.

Qasim, S. Z. and Qayyum, A. 1963. Fecundities of some freshwater fishes. 1. *Ophiocephalus punctatus* (Bloch) 2. *Callichrous pabda* (Ham) and 3. *Mystus vittatus (*Bloch). *Proceedings of the National Instiute of Sciences of India*., 29B(4): 373-382.

Qasim, S.Z. and Bhatt, V.G., 1964. Occurrence of growth bones in the opercular bones of the freshwater murrel, *Ophicephalus punctatus* (Bloch). *Curr. Sci.*, 33:19-20.

Qayyum, A. and Quasim, S. Z. 1964 a. Studies on the biology of some freshwater fishes Part I - *Ophiocephalus punctatus* Bloch. *J. Bombay Nat. Hist. Society*., 61(1): 74-98.

Qayyum, A. and Quasim, S. Z. 1964 b. Studies on the biology of some of freshwater fishes Part II *Barbus stigma* (Cuv. & Val.) *J. Bombay Nat. Hist. Soc*., 61 : 330-347.

Qayyum, A. and Quasim, S. Z. 1964 c. Studies on the biology of some fresh water fishes Part III. *Callichrous bimaculatus* (Bloch). *J. Bombay Nat. Hist. Soc*., 61: 627-650.

Radhakrishnan, 2006. Systematics, germplasm evaluation and pattern of distribution and abundance of freshwater fishes of Kerala. Phd thesis, Cochin University of Science & Technology, 518 p.

Radhakrishnan, K.V. and Kurup, B.M. 2008. Life history traits of *Puntius denisonii* (Day) and their implications for conservation and captive breeding. In. Ornamental fish breeding, farming and trade-selected contribution of the International seminar on Ornamentals Kerala-2006,2008. Cochin, Kerala. Dep of Fisheries. Govt. of Kerala.280 pp.

Radhakrishnan, K.V. and Kurup, B.M. 2010. Ichthyodiversity of Periyar Tiger Reserve, Kerala, India. *J. Threa. Taxa*.,2: 1192-1198.

Radhakrishnan, K.V., Sureshkumar, S. and Ng, H.H. 2010. *Pseudolaguvia austrina*, a new species of sisorid catfish (Osteichthyes: Siluriformes) from Peninsular India. *Ichth. Explo. of Freshwaters*., 21(4): 377-383.

Radhakrishnan, K.V., Kurup, B.M., Murphy, B.T and Xie, S.G. 2012. Status of alien fish species in the Western Ghats (India) as revealed from 2000-2004 surveys and literature analyses. *J .Appl. Ichthyol.*, 1-7.

Raghavan, R., Prasad, G., Ali, A. and Pereira, B. 2008 a. Exotic fish species in a global biodiversity hotspot: observations from river Chalakudy, part of Western Ghats, Kerala, India. *Biol Invasions.*, 10:37–40.

Raghavan, R., Prasad, G., Ali, A and Pereira, B. 2008b. Fish fauna of Chalakudy river, part of Western Ghats biodiversity hotspot, Kerala, India: Patterns of distribution, threats and conservations needs. *Biodiversity and conservation,* 17:3119-3131.

Raghavan, R., Ali, A., Dahanukar, N. and Rosser, A. 2011. Is the fishery for the Deccan Mahseer, *Tor khudree* (Sykes, 1839) in the Western Ghats Hotspot sustainable? A participatory approach to stock assessment. *Fish. Res.,* 110: 29–38.

Raghunathan, M.B. 1995. Ichthyological investigations in the river Chaliyar, Kerala. *Fishery Tech*., (24):18-29.

Rahel, F.J. 2002. Homogenization of freshwater faunas. *Annual Review of Ecology and Systematics.,* 33: 291-315.

Rahman, M.A., Bhadra, A., Begum, N., Islam, M.S. and Hussain, M.F.1995. Production of hybrid vigour cross breeding between *Clarias batrachus* Lin. and *Clarias gariepinus Bur. Aquaculture,* 138: 125–130.

Rai. B.P 1965 Cyclic changes in the testis of the mahseer, *Barbus tor* (*Tor tor*) *Acta anat*., 62:461-475.

Raina, H. S. 1977. Observations on the fecundity and spawning behaviour of *Schizothorax esocinus* Heckel from Dal Lake, Kashmir. *Indian J. Fish*., 24 (1&2): 201-203.

Raina, H. S. and Bali, P. S. 1982. Observations of some biological aspects of *Labeo dero* (Ham.), from Dal lake, Kashmir. *Matsya,* 5: 70-73.

Raju Thomas, K.2002. Habitat and distribution of hill stream fishes of southern Kerala (South of Palghat gap) Submitted of Mahatma Gandhi University. 186pp.

Raju Thomas, K. and Biju, C.R. 2000. On the occurrence of *Nemacheilus keralensis* (Rita *et al*.) in Muvattupuzha, Kerala, India. *J. Bombay Nat. Hist. Soc.,* 97(3).442-445.

Raju Thomas, K., Biju, C. R. and Ajithkumar, C. R. 1998a. Extension of range of *Esomus thermoicos* (Pisces: Cyprinidae: Rasborinae) to Kerala. *J. Bombay Nat. Hist. Soc*., 96 (1): 163.

Raju Thomas, K., Biju, C. R. and Ajithkumar, C. R. 1998b. First report of *Barilius bendelisis* (Ham- Buch.) from a west flowing river, Chalakudy river in Kerala. *J. Bombay Nat. Hist. Soc*., 95(3): 519-520.

Raju Thomas, K., Biju, C. R. and Ajithkumar, C. R. 1998c. Additions to the fish fauna of Pambar river, Kerala. *J. Bombay Nat. Hist. S*oc., 96(2): 332-334.

Raju Thomas, K., Biju, C. R., Ajithkumar, C. R. and John George, M. 1999. Ichthyofauna of Eravikulam National Park with notes on Trout culture in Rajamalai. Munnar, Kerala. *J. Bombay Nat. Hist. Soc*., 96(2): 199-202.

Raju Thomas, K., Biju, C.R., Ajithkumar, C.R. and John George, M. 2000a. Fishes of Chimmony and Peech- Vazhani Wildlife sanctuaries, Kerala, India. *J. Bombay nat. Hist. Soc.*, 97 (2) 289 – 292.

Raju Thomas, K., Biju, C.R and Ajithkumar, C.R. 2000b. Fishes of Idukki and Neyyar Wild life sanctuaries of Kerala, S. India. *J. Bombay Nat. Hist. Soc.*, 97(3).442-445.

Raju Thomas, K., John George, M. and. Biju, C.R. 2002. Freshwater fishes of Southern Kerala with notes on the distribution of endemic endangered species. *J. Bombay Nat. Hist. Soc.*,99(1) 47-54.

Raju Thomas, K., John George, M., Ajith kumar, C.R. and Biju, C.R. 2004. Icthyofauna of Periyar river (South India) with special reference to distribution of hill stream, endemic and endangered species: In Advance in fish and wild life biology Vol 3 by Lal Kaul Daya publishing house, Delhi. 65-76.

Raj, B.S.1941. Two new Cyprinid fishes from Travancore, South India, with remarks on *Barbus* (*Puntius*) *micropogon* Cuv. and Val. *Records of the Indian Museum (Calcutta).*, 43(3): 375–386.

Rajkumar, U. K., Rao, N. and Kingsly, H.J. 2004. Sciaenid fishery off Visakhapatnam with some aspects of population dynamics of *Johnius carutta* (Bloch). *Indian J. Fish.*, 51(3): 311-318.

Rajan, S. 1955. Notes on a collection of fish from the headwaters of the Bhavani river, South India. *J.Bombay Nat. Hist. Soc*., 53: 44-48.

Rajan, S. 1965. Food of some hillstream fishes of South India. *J. Zool.Soc. India.,* 17 (1&2): 8-15.

Rajyalekshmi, T. 1961. Studies on maturation and breeding in some estuarine Palaemonid prawns. *Proc. Natn. Inst. Sci. India.,*B27 (4):179-188.

Rahel, F.J. and Hubert, W.A. 1991. Fish assemblages and habitat gradients in a Rocky Mountain-Great Plains stream: biotic zonation and additive patterns of community change. Transactions of the American Fisheries Society, 120: 319-332.

Ralf, B., Krishnakumar, K. and Fibin, B. 2012 a. *Pristolepis rubripinnis* a new species of fish from southern India (Teleostei; Percomorpha; Pristolepididae). *Zootaxa*,3345; 59-68.

Ralf, B., Ali, A. and Philip, S. 2012,b. *Dario urops*, a new species of badid fish from the Western Ghats, southern India (Teleostei: Percomorpha: Badidae). *Zootaxa*,3348: 63–68.

Ramachandran, S. and Philip, K.P. 2010. Population dynamics of red-toothed triggerfish *Odonus niger* (Ruppell, 1836) along southwest coast of India. *J.Mar.Biol.Ass.India*., 52(1) 105-108.

Ramakrishniah, M. 1987. The fishery of Nagarjunasagar, on the river Krishna during 1976-'80. *Indian J. Fish*., 34 (4): 17-22.

Raman, K. 1975. Some interesting methods of fishing for the giant freshwater prawn in Kerala. *J. Bom. Nat. Hist. Soc.*, (2): 575-579.

Rao, J. B. and Karamchandani, S. J. 1986. On the spawning biology of *Ompok bimaculatus* (Bloch) from Kulgarhi reservoir of Madhyapradesh *J. Inland Fish Soc. India* 18 (2): 40-47.

Rao, N.C.R. and Shachar, B.R. 1927. Notes on the fresh water fish of Mysore. *Half Yearly J. Mysore Univ.*,115-143.

Rao,P.S. and Durve, V.S. 1989. Fish and fisheries of Lake Jaisamand, Rajasthan. *Indian J Fish*., 36 (1)47-52.

Rao, K. J. 1992. Fresh water prawn resources of Kolleru Lake. In: Freshwater prawns, 67-71, E.G Silas (Ed), Kerala Agricultural University.

Rao, K. S., Chatterji, S. N. and Anil K. S. 1991. Studies on the pre-impoundment fishery potential of Narmada basin (Western region) in the Context of Indira Sagar, Maheshwar Omkareshwar and Sardar Sarovar Reservoir. *J. Inland Fish. Soc. India*, 23(1): 34-41.

Rao, L.M., Ramaneswari, K. and Rao, L.V.1998. Food and feeding habits of *Channa* species from east Godavari district (Andhra Pradesh). *Indian J. Fish*., 45 (3): 349-353.

Rao, G. R. and Rao, L. H. 1972. On the biology of *Labeo calbasu* (Ham. Buch.) from the River Godavari. *J. Inland Fish Soc. India.*, IV :74-86.

Rao, R. 1974. Observations on the age and growth, maturity and fecundity *of Labeo fimbriatus* .(Bloch) of the Godavari River. *Indian J. Fish*., 21(2): 427-444.

Rani, P. and Manoharan, S. 2010. Mettur Reservoir Fisheries: past and present status. *Fishing Chimes,*30(1): 132-135.

Ravishanker P., Swamy, B.R. and Devp, P.I. 1991. Food and feeding habits of freshwater cyprinid, *Amblypharyngodon mola* (Ham.). *Indian. J. Fish.,*38(2): 126-128.

Reddy, P.B. 1981. Studies on the growth checks on scales and opercles and their validity in age determination of *Channa punctata* (Bloch,1793) (Pisces, Teleostei, Channidae) from Guntur, Andhra Pradesh. *Proc.Indian Acad. Sci. (Anim. Sci.).,*90 (2): 261-280.

Reddy, Y.S. and Rao, M. B. 1991. Gonadosomatic index and fecundity of *Heteropneustes fossilis* (Bloch) (Pisces: Heteropneustidae) from Hussain Sagar, Hyderabad. *Indian. J. Fish.,* 38(2): 93-96.

Reddy, Y.S. and Rao, M. B.1992. Length-weight relationship and relative condition factor of *Puntius sophore* (Hamilton-Buchanan) from lake Hussain sagar, Hyderabad, India. *J. Inland Fish. Soc. India.,* 24(1): 22-25.

Renjithkumar, C.R, Harikrishnan, M. and Kurup, B.M. 2011. Exploited fisheries resources of the Pampa river, Kerala, India. *Indian J. Fish.,* 58(3):13-22.

Remadevi, K. 1992. Fishes of Kalakad wild life sanctuary, Tirunelveli district, Tamil Nadu, India. *Rec.Indian Mus*., 92: 193-209.

Remadevi, K. and Indra, T.J.1981. *Garra menoni*, a new cyprinid fish from Silent valley, Kerala.S.India. *Bull.Zool.Surv.India.,*5 (2&3): 121-122.

Remadevi, K. and Indra, T. J. 1984. A new species of *Garra menoni*, a new Cyprinid fish from Silent Valley, Kerala, South India. *Bull. Zool. Surv. India.,* 5(2&3): 121-122.

Remadevi, K. and Indra, T. J.1986. Fishes of Silent Valley. *Rec. Zool. Surv. India.,* 84: 243-257.

Remadevi, K. and Indra, T. J. 1994. *Noemacheilus pambarensis,* A new loach (Cyprinoidei: Balitoridae: Noemacheilinae) from Western Ghats, Idukki, Kerala, India. *Rec. Zool. Surv. India*., 94(2): 207-210.

Remadevi, K. and Indra, T. J. 1999. Some observations on *Garra hughi* Silas from Anamalai hills, Western Ghats, Tamil Nadu, India. *Rec. Zool. Surv. India.,* 97(part 4): 53-59.

Remadevi, K. and Ali.A. 2011. *Hypselobarbus thomassi*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www. iucnredlist.org>. Downloaded on 24 October 2013.

Remadevi, K., Indra, T. J. and Emiliyamma, K. G. 1996. On the fish collections from Kerala deposited in Southern regional station, Zoological Survey of India. By. Stockholm, N.R.M. *Rec. Zool. Surv. Ind*., 95(3-4): 129-146.

Remadevi, K., Indra, T.J., Raghunathan, M.B. and Ravichandran, M.S. 2005. Fish fauna of the Anamalai hill ranges, Western Ghats, India. *Zoos Print Journal.,*20(3): 1809-1811.

Remesan, M.P. 2006. Studies on inland fishing gears of North Kerala. PhD Thesis, Cochin University of Science and Technology, 171pp.

Remesan, M. P. and Ramachandran, A. 2005. Gill nets for inland fishing in North Kerala. *Fish. Technol*., 42 (2): 125-134.

Revenga, C., Campbell, I., Abell, R., Devilliers, P. and Bryer. M. 2005. Prospects for monitoring freshwater ecosystem towards the 2010 targets. *Philosophical Transactions of the Royal Society,*B 360; 397-413.

Reuben, S., Vijayalakshmi, K. and Chithbabu, K. 1994. Growth, maturity and mortality of *Upeneus sulphureus* from Andhra-Orissa cost. *Indian J. Fish.*, 41(2): 87-91.

Reuben, S., Vijayalakshmi, K. and Achayya, P. 1996. Growth, maturity, mortality and exploitation of *Ariomma indica* (Day) from north Andhra Pradesh coast. *Indian J. Fish*., 43(1): 39-44.

*Ricker, W.E.1958. Handbook of computation for biological studies of fish populations. *Bull. Fish. Res. Bd. Canada.,*19:300.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Fish Res. Board. Can.*, 191:382.

Rickey, M.H.1995. Maturity spawning and movement of arrowtooth flounder, Arthereshes stomias, off Washington, *Fish.Bull.*, 93:127-138.

Ritakumari, S. D. 1977. Studies on the loaches of Kerala. Ph.D. thesis, University of Kerala, Thiruvananthapuram.

Ritakumari, S. D. and Nair, N. B. 1978. Maturation and spawning in a tropical loach, *Lepidocephalus thermalis* (Cuv. & Val.). *Proc. Indian natn. Sci. Acad.*, 44 B: 111-121.

Robin, K., Kelker, A.N. and Bijukumar, A. 2011. Freshwater fish fauna of the Ashambu Hills landscape, southern Western Ghats, India, with notes on some range extensions. *J. Threa. Taxa.*,3(3):1585-1593.

Roberts, T.R. 1989. The freshwater fishes of Western Borneo (Kalimantan Barat, Indonesia). *Mem. Calif. Acad. Sci.*, 14:1-210.

Rochet M.J. and Trenkel V.M.2003. Which community indicators can measure the impact of fishing? A review and proposals. *Cana. J. Fish and Aqua. Scie.*, 60:86-99.

Rousefell, G. A. and Everhart, 1953. Fishery Science: Its methods and applications. John Wiley and sons Inc. New York, pp. 444.

Rowe, D.K. 2007. Exotic fish introductions and the decline of water clarity in small North Island, New Zealand lakes: a multi-species problem. *Hydrobiologia,* 583 (1): 345–358.

*Royce, W. F. 1987. Fishery development. Academic press, New York. 248pp

Russell, D.J., Ryan, T.J., McDougall, A.J., Kistle, S.E and Aland. G. 2003. Species diversity and spatial variation in fish assemblage structure of streams in connected tropical catchments in northern Australia with reference to the occurrence of translocated and exotic species. *Mar. Fres. Res.*, 54, 813-824.

Sabapathy, U. and Teo, L.H. 1993. A quantitative study of some digestive enzymes in the rabbit fish, *Siganus canaliculatus,* and the sea bass, *Lates calcarifer. J. Fish Biol.*, 42:595–602.

Safaran, P. 1992. Theoretical analysis of the weight-length relationships in the juveniles. *Mar. Biol.*, 112: 545-551.

Saigal, B. N. 1967. Studies on the fishery and biology of the commercial catfishes of the Ganga river system. II Maturity, spawning and food of *Mystus aor* (Ham.). *Indian J. Fish*., 11: 1-44.

Saikia A.K., Abujam, S. K. S. and Biswas, S. P. 2012. Food and Feeding habit of *Channa punctatus* (Bloch) from the Paddy Field of Sivsagar District, Assam. *Bulletin of Environment, Pharmacology and Life Sciences,* 5(4): 10-15.

Sala, O.E., Chapin, F.S., Armesto. J.J., Berlow, R., Bloomfield, J., Dirzo, R., Huber Sanwald,E.,Huenneke,L.F.,Jackson,R.BKinzig,A.,Leemans, R., Lodge,D.,Moony,H.A.,Oesterheld M., Poff, N.L., Sykes, M.T., Walker, B.H., Walker, M. and Wall., D.H. 2000.Global biodiversity scenarios for the year 2100. *Science*,287 : 1770-1774.

Sahoo, S.K., Giri, S.S., Sahoo, A.K. and Ayyappan, S. 2003. Experimental hybridization between catfish *Clarias batrachus* (Linn.) *Clarias gariepinus* (Bur.) and performance of the offspring in rearing operation. *Asian Fisheries Science,* 16: 157–166.

Santha, S.D. 2007. State interventions and natural resource management: a study on social interfaces in a riverine fisheries setting in Kerala, India. *Natural Resources Forum,* 31: 61-70.

Santoshkumar, S. A. and Biswas, S.P 2011. Studies on the reproductive biology of spiny eel, *Macrognathus aral* from upper Assam. *J. Environ. Biol.,* 32, 635-639.

Sanwal, R. and Khanna, S. S. 1972. Seasonal changes in the testis of a freshwater fish *Channa gachua. Acta. Anat.,* 83: 139-148.

Samant, J.S. 1990. Studies on the potential and conservation of the resources of animal origin from the Western Ghats, Report by Division of environmental biology, Department of Zoology, Shivaji University, Kolhapur. pp. 284.

Sarkar, L. and Yadav, B.E. 1996. Larvivorous fishes of Western Ghats, Maharashtra: biocontrol of malaria. *Geobios new Reports,*15: 137-138.

Sarkar, U.K., Pathak, A.K., Kapoor, D., Paul, S.K., Srivastava, S.M. and Singh. S.P. 2005. Use of geographical information systems in monitoring freshwater fish diversity for the protected area, India. In: P.C.Mahanta and A.K Singh (Eds). National symposium on Re-assessment of Fish genetic resources in India and Need to Evolve Sustainable methodology for conservation. National Bureau of Fish Genetic Resources, Lucknow, India, pp 43-45.

Sarkar, U.K., Pathak, A.K. and Lakra, W.S. 2008. Conservation of freshwater fish resources of India: new approaches, assessment and challenges. *Biodivers Conserv.,*17:2495–2511.

Sarkar, U. K., Gupta, B .K. and Lakra, W. S.2010. Biodiversity, ecohydrology, threat status and conservation priority of the freshwater fishes of river Gomti, a tributary of river Ganga (India). *Environmentalist,*30(4):306-319.

Sarkar, U.K., Dubey, V.C., Singh, A.K., Gupta, B.R., Pandey, A., Sani, R.K. and Lakra, W.S. 2012 a. The recent occurrence of exotic freshwater fishes in the tributaries of river Ganga basin: abundance, distribution, risk, and conservation issues. *Environmentalist,* 476-484.

Sarkar U.K., Kumar, R.S., Dubey V.K., Pandey, A. and Lakra, W.S. 2012b. Population structure and reproductive biology of a freshwater fish, *Labeo boggut* (Sykes,1839) from two perennial rivers of Yamuna basin. *J. Appl. Icthyol.,* 28: 107-115.

Sarkar, S. K., Medda, C., Ganguly, S. and Basu, T. K. 1999. Length-weight and relative condition of bundh and hatchery- bred *Labeo rohita* (Ham.) during the early period of development. *Asian Fisheries Science,* 12: 289-296.

Sarojini, K. K. 1957. Biology of the grey mullets of Bengal. Biology of *Mugil parsia* Ham. *Indian J. Fish*., 4: 160-207.

Sathyanarayanappa, S.N., Hanumanthappa, B., Salian. P.K. and Sheshappa, D.S. 1987. Riverine fishing crafts and gear of Karnataka. Proc. Symp. Impact of current land use pattern and water resources development on riverine fisheries. Inland Fisheries Society of India. CIFR1, Barrackpore, West Bengal, 68p.

Sathyanesan, A. G. 1959. Seasonal histological changes in the testis of the catfish, *Mystus seenghala. J. Zool. Soc. India.*,11: 52-59.

Sathyanesan, A. G., 1962. The ova-diameter measurements in relation to spawning of *Barbus stigma* (Cuv.& Val.) in the river Ganges at Banares. *Ind. J. Fish*., IX 91): 197-204.

Saunders, D.L., Meeuwig, J.J. and Vincent, A.C.J. 2002. Fresh water protected areas: strategies conservation. *Conse. Biol.,* 16(1):30–41.

Saxena, R.K. 1964. The fishing nets and traps in a section of the middle reaches of Ganga river system in India. *Indo. Pac. Fish. Coun.*, 11(l1): 250-271.

Saxena, R. K. 1972. Studies on the maturity and fecundity of *Rita rita* (Hamilton) of Ganga River system. *J. Inland Fish Soc. India*.,IV: 169-182.

Saxena, R.K. 1988. Fishing methods in river systems. In: Jhingran, A, G. and Sugunan, V.V. (eds.) Conservation and Management of Inland capture fisheries resources. Bulletin No. 5 7, CIFRI, Barrackpore, India: 161-68.

Saxena, R.K. 1993. Drift in status of Riverine fishing gear- A case study of middle reaches of Ganga river system. ln: Low Energy Fishing, Fish. Technol. (Special issue), Society of Fisheries Technologist (India), Cochin: 159-162.

Saxena, R.K. and Chandra, R. 1968. On the introduction of phasla jal, a gill net for catching Hilsa in the Ganga and Yamuna, near Allahabad. *J. Bombay Nat. Hist. Soc*., 65(2): 496.

Scaria, K.S., Devaraj, M., Joseph, A., Synudhin, M.B., Vijayalakshmi, K.V., Ammini, P.L Beena, M.B. and Sindhu K. A. 1997. *Production pattern in the marine fisheries of Kerala*. CMFRI special publication.

Schlosser, I. J. 1982. Fish community structure and function along two habitat gradients in a headwater stream. *Ecological Monographs*, 52: 395–414.

Schlosser, I. J. 1985. Flow regime, juvenile abundance, and the assemblage structure of stream fishes. *Ecology*,66: 1484-1490.

Schlosser, I.J. 1987. A conceptual framework for fish communities in small warmwater streams. In: *Community and Evolutionary Ecology of North American Stream Fishes* (Eds W.J. Matthews & D.C. Heins), pp. 17-24. University of Oklahoma Press, Norman, OK, USA.

Scott, D. E. 1962. Effects of food quality on the fecundity of rainbow trout, *Salmo gairdneri. J. Fish. Res. Board. Can.*, 19: 715-731.

Sebastian, M.K., Peters, D.M. and Feustal, C. 1999. Impact of fishing by tribal's on the fish biodiversity of Kerala sector of Nilgiri biosphere reserve. Proceedings of the Fourth Indian Fisheries Forum. Asian Fisheries Society, Indian Branch, pp 107–108.

Seena, A. P.A., Jose, T.M., Anna mercy, T.V, Eapen, J. and Nair, J.R .2012. Reproductive biology of the endemic ornamental barb, *Puntius pookodensis*, (Anna Mercy and Eapen Jacob 2007) from the western Ghats of India. *Indian J. Fish.*,59(2):49-55.

Sehgal, K.L. 1973. Fisheries survey of Himachal Pradesh and some adjacent areas with special reference to trout, mahseer and allied species. *J. Bombay Nat. Hist. Soc*.,70(3): 458-471.

Sehgal, K.L. 1989. Present status of exotic cold water fish species in India In: Exotic aquatic species in India College of Fisheries, Mangalore. 41-47 pp.

Sekharan, K. V. 1974. Estimates of stock of oil sardine and mackerel in the present fishing grounds of west coast of India. *Indian J. Fish*., 21: 177-182.

Selvaraj, C., Radhakrishnan, S. and Parameswaran, S. 1972. Notes on the breeding season, fecundity and life history of a minor carp, *Labeo boggut* (Sykes). *J. Inland Fish Soc. India*., IV: 87-97.

Senguttuvan, M. and Sivakumar, A.A. 2010. Observations on the age and growth of *Channa striatus* (Bloch) in Ukkadam Lake, Coimbatore, Tamil Nadu, India. *Indian J. Fish*., 57(3): 7-12.

Serajuddin, M. and Ali, R. 2005. Food and feeding habits of striped spiny eel *Macrognathus pancalus* (Hamilton). *Indian J. Fish.*, 52 (1): 81-86.

Serajuddin, M. and Pathak, B.C. 2012. Study of reproductive Traits of spiny eel, *Mastacembelus armatus* (Mastacembeliforms) from Kalinadi- A Tributary of the Ganges basin. *India Research Journal of Biology*,2(5): 145-150.

Seshappa, G.1999. Recent studies on age determination of Indian fishes using scales, otoliths and other hard parts. *Indian J. Fish.*, 46 (1):1-11.

Seth, R.N. and Katiha, 2003. Riverine fishing methods with special reference to catfishes *Aorichthys seengala* (Sykes) and *Aorichthys aor* (Hamilton). *Indian J. Fish*., 50(1): 125-130.

Shaji, C. P. and Easa, P. S. 1995a. Extension of range of *Danio (Brachydanio) rerio* Hamilton- Buchanan. *J. Bombay Nat. Hist. Soc*., 92(2): 274.

Shaji, C. P. and Easa, P. S. 1995b. Extension of range of *Noemacheilus (Mesonoemacheilus) petrubanarescui* (Menon). *J. Bombay Nat. Hist. Soc*., 92(3): 428.

Shaji, C. P. and Easa, P. S. 1995c. *Homaloptera menoni*- A new Homalopterid (Pisces: Homalopteridae) from Kerala. *J. Bombay Nat. Hist. Soc*., 92(3): 395-397.

Shaji, C. P. and Easa, P. S. 1996. Freshwater fish diversity in Wayanad, Kerala, South India. *J. Zool. Soc.*, Kerala, 5(1&2): 30-36.

Shaji, C.P. and Easa, P.S. 1997. Fish fauna of Chalakudy River in Kerala. *J. Zool. Soc.*, Kerala, 6 & 7: 87-91.

Shaji, C.P. and Easa, P.S., 2000. Potential endemic ornamental freshwater fishes of Kerala. pp. 230-232. In: Ponniah, A.G. and Gopalakrishnan, A. (Eds.) Endemic fish diversity of Western Ghats. NBFGR-NATP Publication- 1,347p. NBFGR, Lucknow, U.P., India.

Shaji, C. P. and Easa, P. S. 2001. Field guide-Fresh water fishes of the Western -Ghats, pp. 101, KFRI, Peechi, Kerala and NBFGR, Lucknow, U.P.

Shaji, C. P. and Easa, P. S. 2002. *Mesonemacheilus remadevi*, a new loach species from Silent valley, Kerala. *Indian J. Fish*., 2(1), pp. 42-45.

Shaji, C.P. and Easa, P.S. 2003. *Freshwater fishes of Kerala*. Kerala Forest Research Institute (KFRI), Thrissur pp. 125.

Shaji, C.P. and Laladhas, K.P. 2013. Monsoon floodplain fishery and traditional fishing methods in Thrissur District. *Indian Journal of Traditional Knowledge*, 12(1) 102-108.

Shaji, C. P., Arun, L. K. and Easa, P. S. 1996. *Garra surendranathanii*- a new Cyprinid fish from the Southern Western Ghats, India. *J. Bombay Nat. Hist. Soc.*, 93(3): 572-575.

Shaji, C. P., Easa, P. S. and Basha, S. C. 1995. Freshwater fish diversity in Aralam Wildlife Sanctuary, Kerala, South India. *J. Bombay Nat. Hist. Soc.*, 92:360-363.

Shaji, C. P., Easa, P. S. and Gopalakrishnan, A. 2000. Freshwater fish diversity of Western Ghats. pp. 35-35 In: Ponniah, A. G. and Gopalakrishnan, A. (Eds.) Endemic fish diversity of Western Ghats, NBFGR-NATP publication 1, 347p. Natural Bureau of Fish Genetic Resources, Lucknow, U.P., India.

Shahidual, I., Rahman, M.M., Halder, G.C. and Masaru, T. 2006. Fish assemblage of a traditional fishery and the seasonal variations in diet of its most abundant species *Wallago attu* (Siluriformes: Siluridae) from a tropical floodplain. *Aquatic ecology*,40: 263-272.

Shaloof, K.A.S. and Khalifa, N. 2009. Stomach contents and feeding habits of *Oreochromis nilotics* (L) from Abu-Zabal Lakes, Egypt. *World Applied Science Journal*, 6(1):01-05.

Shaheena, S. and Yousuf, A.R. 2012. Length-weight relationship and condition factor in *Puntius conchonius* (Hamilton, 1822) from Dal Lake, Kashmir. *International journal of Scientific and Research publications*,2(3):1-4.

Shahidual, I., Rahman, M.M., Halder, G.C. and Masaru, T. 2006. Fish assemblage of a traditional fishery and the seasonal variations in diet of its most abundant species *Wallago attu* (Siluriformes: Siluridae) from a tropical floodplain. *Aquatic ecology*,40: 263-272.

Shanmukha, S.N. 1996. Status of mahseer fishery in Karnataka. *Fishing Chimes*, 26-29.

Sharma, P., Kalita, K. K. and Dutta, O.K. 1993. Low energy fishing techniques of the North eastern India. In: Low Energy Fishing, Fish. Technol (Special issue), Society of Fisheries Technologist (India), Cochin: 163-167.

Sharma, K.K., Bhattacharya, B.K., Manna, R.K., Choudhury, M., Barik, N.K., Sarkar, A. and Chandra, G. 2005. Indigenous plant piscicides used in Northeastern India. National seminar on Management challenges in fisheries of rivers and associated ecosystems-issues and strategies. 16-17, April 2005. Inland Fisheries Society, India and CIFRI, Barrackpore, West Bengal.

Sharma, J. P., Guptha, V. K. and Srivastava, J. B. 1992. Studies on the food and feeding of juvenile of Mahseer *Tor tor* (Ham.) from a tributary of the river Tawi Jammu (J&K). *Indian J. Anim. Res.*, 26(1): 37-40.

Sheldon, A.L. 1968. Species diversity and longitudinal succession in stream fishes. *Ecology*, 49: 193-198.

Sheila, S. J. 1981. Certain aspects of the ecology of the larvivorus fishes *Aplocheilus lineatus* (Cuv. And Val.) and *Macropodus cupanus* (Cuv. And Val.). Ph.D. Thesis, University of Kerala, Trivandrum.

Sheila, S. J. and Nair, N. B. 1983. Reproductive biology of the larvivorus fish *Macropodus cupanus* (Cuv &Val.). *Proc. Indian Acad. Sci. (Anim. Sci).*,92(2):159-170.

Shetty, H.P., Nandeesha, M.C and Jhingran, A.G.1989. Impact of exotic aquatic species in inland waters in: Proceeding of the workshop on the introduction of exotic organisms in Asia. Pp 45-55 . Asian Fisheries Society. Spec. Publ. No 3,154p.

Shree , P.and Gupta, R.A. 1986. Studies on the comparative growth rates of three major carps in Gobindsagar lake. *Indian J. Fish.*, 33(1):45-53.

Shreshtha, T. K. 1980. Rhythm of oocyte maturation and reproductive cycling in a female stone loach, *Nemacheilus bevani*. *Int. J. Acad. Ichthyol.*, 1: 19-30.

Shreshtha, T. K., 1986. Spawning ecology and behaviour of the mahseer, *Tor putitora* (Hamilton) in the Himalayan waters of Nepal. P.689-692. *In*. Maclean, J. L., Dizon, L. B. and Hosillos, L. V. (Eds.) The First Asian Fisheries Forum, Asian fisheries Society, Manila, Philippines.

Shrivastava, S. and Pandey A. K. 1981. Length-weight relationship and condition factor of three Indian Major carps in composite fish farming. *Matsya*, 7: 70 – 74.

Shubhadeep G., Pillai, N.G.K. and Dhokia, H.K. 2009 a. Fishery and population dynamics of *Harpadon nehereus* (Ham) off the Saurashtra coast. *Indian J. Fish.*, 56(1): 13-19.

Shubhadeep G., Pillai, N.G.K. and Dhokia, H.K. 2009, b. Fishery and population dynamics of *Trichiurus lepturus* (Linnaeus) off Veraval, north-west coast of India. *Indian J. Fish.*, 56(4):241-247.

Shubhadeep, G., Mohanraj, G., Asokan, P.K., Dhokia, H.K., Zala, M.S. and Bhint, H.M. 2009 c. Fishery and stock estimates of the Silver Pomfret, *Pampus argenteus* (Euphrasen), landed by gill netters at Veraval. *Indian J. Fish.,* 56(3): 177-182.

Shuter, B. F. and J. F. Koonce. 1977. A dynamic model of the Western Lake Erie Walleye population. *J. Fish. Res. Bd. Canada.*,34: 1972-1982.

Shyam, S. 1998. Role of exotic fishes in India uplands. Pp. 301–314. *In*: Ponniah, A.G., Das, P., Verma, S.R. (eds.) Fish genetics and biodiversity conservation. Nature Conservators. Muzaffarpur, India. Publication No. 5.

Siddiqui, A. Q., Chatterjee, A. and Khan, A. A. 1976 a. Studies on the reproductive biology of a carp, *Labeo gonius* (Ham.) (Teleostei: Cyprinidae). *J. nat. Hist.*,10: 121-130.

Siddiqui, A. Q., Chatterjee, A. and Khan, A. A. 1976 b. Reproductive biology of the carp *Labeo bata* (Ham) from the River Kali, India. *Aquaculture,*7; 181-191.

Silas, E. G. 1949. On a collection of fish from Travancore. *J. Bombay Nat Hist. Soc*., 48:792-797.

Silas, E.G. 1950. On a collection fish from Travancore. *J. Bombay Nat. Hist. Soc*., 48: 792-797.

Silas, E. G. 1951. On a collection of fish from the Anamalai and Nelliampathi hill ranges (Western Ghats) with notes on its zoogeographical significances. *J. Bombay Nat. Hist. Soc.*, 49: 670-681.

Silas, E. G. 1952. Fishes from the high range of Travancore. *J. Bombay Nat. Hist. Soc*.,50: 232-330.

Silas, E. G. 1953. Classification, Zoogeography and Evolution of the fishes of the Cyprinoid families Homalopteridae and Gastromyzonidae. *Rec. Indian Mus*., 50 (2): 173-264.

Silas, E.G. 2010. Phylogeography and evolutionary aspects of Indian fishes: challenges for the future. *Indian J.Animal Sci.,*80(4): 8-15.

Singh, A.K. 2000. Impact of unauthorized exotic fish introduction on conservation and aquaculture development of north-east region. In fish biodiversity of northeast India (eds) Dr.A. G Ponniah and U.K Sarkar.NBFGR, NATP Publication pp 155-156.

Singh, A.K. and Lakra, W.S. 2006. Alien fish species in India: Impact and emerging scenario. *Journal of Ecophysiology and Occupational Health*, 6 (3–4): 165–174.

Singh, A.K. and Lakra, W.S. 2011. Risk and benefit assessment of alien fish species of the aquaculture and aquarium trade in to India. *Reviews in Aquaculture*, 3:3-18.

Singh, A.K., Kumar, A., Singh, I.J. and Ram, R.N. 2005. Seasonal ovarian cycle in freshwater teleost, *Labeo rohita* (Ham.) in Tarai region of Uttaranchal. *J. Environ. Biol.*, 26, 557-565.

Singh, N.1997. Sex ratio of hill stream snow trout, *Schizothorax plagiostomus* Heckel (Teleostei:Cyprinidae) in the upland river Mandakini of Garhwal Himalaya. *J.Bombay Nat. Hist. Soc.*, 94: 417-421.

Singh, N. and Subbaraj, R. 2000. A profile of the food and feeding of hill stream teleosts of Garhwal Himalayas. *J. Bombay nat. Hist. Soc*., 97(1):155-157.

Singh, D.F. and Yazdani, G.M. 1988. A note on the ichthyo-fauna of Sanjay Gandhi National Park, Borivli, Bombay. *J. Bombay Nat. His. Soc.,* 85: 631-633.

Singh, D.F. and Yazdani, G.M. 1991. *Osteobrama bhimensis* a new Cyprinid fish from Bhima River, Pune District, Maharashtra. *J. Bombay Nat. His. Soc., 89*: 96-99.

Singh, H. R., Naurial, B. P. and Dobriyal, A. K., 1982. Fecundity of a hill stream minor carp *Puntius chilinoides* (Mc Celland) from Garhwal Himalaya. *Proc. Indian. Acad. Sci (Anim. Sci*), 91(5): 487-491.

Singh, N.O., Sarma, D. and Singh, N.G. 2011. Length-weight relationship of *Tor putitora* (Hamilton) from Kosi River Uttarakhand considering different stages of its life span *Indian J. Fish* 58(1): 35-38.

Singh, S., Sharma, L.L. and Saini, V. P. 1998. Age, growth and harvestable size of *Labeo rohita* (Ham.) from the lake Jaisamand, Rajasthan, India. *Indian. J. Fish.*, 45 (2):165-175.

Sinha, M. 1968. Functional morphology, anatomy and histology of the digestive organ of the catfish, *Plotosus canius* (Ham). *Proc. Indian. Acad. Sci.*, 95:23-44.

Sinha, M.1972. Observation on the biology of *Puntius sarana* (Hamilton) of Loni water reservoir (M.P.) 1. Length- weight relationship, food and condition factor. *J. Inland Fish. Soc.India*., IV: 122- 131.

Sinha, M. 1975. Observations on the biology of *Puntius sarana* (Hamilton) of Loni Reservoir (Madhyapradesh) 2. Maturity and spawning. *J. Inland Fish Soc. India.*, VII: 49-57.

Sinha, M. 1999. Inland fisheries development-achievements and destinations for twenty first century. In: M.K. Mukhopadhyay and A. Hajra,(Eds) *Souvenir: the National Seminar on Eco-friendly Management of Resources for Doubling of Fish Production-Strategies for 21st Century* Publ. Inland Fisheries Society of India, CIFRI , Barrackpore, India pp. 25-35.

Sinha, M. 2002. Riverine and Reservoir Fisheries of India-Present status and Future Prospects. In Riverine and Reservoir Fisheries of India (Boopendranath, M.R., Meenakumari, B., Joseph, J., Sankar, T.V., Pravin, P.& Edwin, L., Eds) P 192-196 Society of Fisheries Technologists (India),Cochin.

Sinha M., De. and Jha. B.C. 1998. The Ganga-Environment & Fishery, CIFRI, Barrackpore, India, 142p.

*Simpson, A. C., 1951. The fecundity of the plaice. *Fish. Invest. Lond.*, 17, 1-29.

Simmy, S., Ramprasanth, M.R., Fibin, B., Benno, P., Joshin, T., Anwar, A. and Rajeev, R. 2011. Reproductive biology of *Puntius denisonii*, an endemic and threatened aquarium fish of the Western Ghats and its implications for conservation. *J. Threa. Taxa.,* 3(9): 2071-2077.

Sivakami, S.,1982. Studies on some biological aspects of *Puntius dorsalis* (Jerdone) from Bhavanisagar reservoir (Tamilnadu), *J. Inland Fish Soc. India.*,14 (2): 61-72.

Sivakami, S. 1996 .On the food habits of the fishes of the family Carangidae-A review *J. Mar. Bio. Assoc. India.*,38(1&2):118-123.

Snedecor, G. W. and Cochran, W. G. 1967. Statistical methods. Oxford and IBH publishing company, New-Delhi. 593pp.

Sobhana, B. and Nair, N. B. 1974. Observation on the maturation and spawning of *Puntius sarana subnastus* (Valenciennes). *Indian J. Fish.,* 21:357-368.

Solomon, S. 2009. Local knowledge, attitudes and perceptions of tribals on the fish and fisheries of Poringalkuthu Reservoir, Kerala, India. B Sc Dissertation submitted to the St. Albert's College, Mahatma Gandhi University, Kerala, India, 70 p.

Somavanshi, V. S. 1980. Study on some aspects of spawning biology of a hillstream fish, *Garra mullya* (Sykes*). Proc. Indian. Natn. Sci. Acad.,* B46(1): 105-113.

Somavanshi, V. S. 1985. Indices of fecundity in the hill stream fish, *Garra mullya. Indian J. Fish.,* 32(1): 33-43.

Sparre, P. and Venema, S. C. 1992. Introduction to tropical fish stock assessment, Part-I, *Manual FAO Fish. Tech. Pap.* 306, 376pp.

Sreeraj, N., Raghavan, R. and Prasad, G. 2006. The diet of *Horabagrus brachysoma* (Gunther) an endangered bagrid catfish from Lake Vembanad (South India) *Journal of Fish biology.,* 69:637-642.

Sreeraj, N., Raghavan, R. and Prasad, G. 2007. Some aspects of the fishery of the threatened yellow catfish *Horabagrus brachysoma* from Vembanad Lake with a note on their landings at Vaikom, Kerala, India. *Zoos Print Journal.,* 22(4): 2665-2666.

Sreenivasan, A. 1976. Fish production and fish population changes in some south Indian reservoirs. *Indian J. Fish.,* 23: 133–152.

Sreenivasan, A. 1995. Where have all these fish species gone?. *Fishing Chimes,*15(2): 245-257.

Sreenivasan, A. 1996. Why exotic species? *Fishing Chimes,* 16(1): 09-10.

Sreenivasan, A. and Sundarajan, D. 1967. A note on the tilapia fishery of an impoundment in Madras State. *Science & Culture,*33:145-146.

Sreekrishna, Y. and Shenoy, L. 1987. Fish catching methods of Indian rivers. Proc. Symp. impact of current land use pattern and water resources development on riverine fisheries. CIPRI, Barrackpore, West Bengal.

Sreekantha, M.D., Mesta, D.K ., Rao., Gururaja, K.V. and Ramachandra, T.V. 2007. Fish diversity in relation to landscape and vegetation in central Western Ghats, India. *Current science,* 92:1592-1603.

Srivastava, S.K. 2000. Iso-electric focusing as a tool to resolve taxonomic conflicts. pp. 188-189. In: Ponniah, A. G. and Gopalakrishnan, A. (Eds.) Endemic fish diversity of Western Ghats. NBFGR-NATP NBFGR, Lucknow, U.P., India Publication- 1,347 pp.

Srivastava S.K., Sarkar, U.K and Patiyal, R. S. 2002. Fishing methods in streams of Kumaon Himalaya region of India. *Asian fish Science,* 15 : 347-356.

Stauffer, T. M. 1976. Fecundity of Coho salmon (*Onchorhynchus kisutch*) from the Great Lakes and a comparison with oceanic Salmon. *J. Fish. Res. Bd. Canada.,* 333:1150-1155.

Stacey, N. E. 1984. Control of the timing of ovulation by exogenous and endogenous factors. P.207-222. *In.* Fish Reproduction: Strategies and tactics. (Eds.) G. W. Potts, and R. J. Wootton. Academic press. Inc. (London) Ltd. Pp.410.

Stoumboudi, M.Th., Villivock, W., Sela, J. and Abraham, M. 1993. Gonadosomatic index in *Barbus longiceps, Capoeta damscina* and their natural hybrid (Pisces, Cyprinidae) versus spermatozoan index in the parental males. *J. Fish. Biol.,* 43: 865-875

Strayer, D. L. 2006. Challenges for freshwater invertebrate conservation. *Journal of the North American Benthological Society,*25:271–287.

Strayer, D.L. 2010. Alien species in freshwater; ecological effects, interactions with other stressors, and prospects for the future *Freshwater biology,* 55:152-174.

Strahler, A. N. 1957. Quantitative analysis of watershed geo-morphology. *American Geophysical Union Transactions,* 38: 913-920.

Subhash, C.M.D. 1997. The ecological History of Western Ghats. *Curr.Sci.,*73(2): 146-155.

Suguan, V.V. 1995. Exotic fishes and their role in reservoir fisheries in India. FAO Fisheries Technical Paper No. 345.

Sugunan.V.V. 2000. Ecology and fishery management of reservoirs in India. *Hydrobiologia.,* 430:121–147.

Sugunan, V.V. 2002. *Clarias gariepinus* (African catfish) gravitates into River Yamuna, Sutlej, Godavari: Angst comes true. *Fishing Chimes,*22: 50-52.

Sugunan, V. V. and Sinha, M. 2001. Sustainable capture and culture-base fisheries in freshwaters of India. Pages 43–70 in T. J. Pandian, editor. Sustainable Indian Fisheries. National Academy of Agricultural Sciences, New Delhi, India.

Sultan, S.and Shamsi, M. J. K. 1981. Morphometric study of *Puntius sarana* (Ham) of the river Kali. *Geobios.*, 8: 17-21.

Sunder,S.1986. On the breeding biology of a snow trout, *Schizothorax longipinnis* from the River Thelum, Kashmir. *Indian J. Fish.*,33 (2): 201-210.

Sunder, S. 1998. Role of exotic fishes in Indian uplands. *Fish Gen Biodiversity Conserv.*, 378 Natcon Pub-05, pp 301–314.

Sunil, K, G., Anna Mercy, T.V. and John, K.C. 1999. Length-weight relationship in the catfish, *Horabagrus brachysoma* (Gunther). *Indian J. Fish.*, 46(2): 191-193.

Sunil, M. S. 2000. Length-weight relationship in *Rasbora daniconis* (Ham.) from Achenkoil river, Pathanamthitta, Kerala, India. *Indian J. Fish.*, 47 (3): 271-274.

Sundararaj, B.I. and Vasal, S. 1976. Photoperiod and temperature control in the regulation of reproduction in the female catfish, *Heteropneustes fossilis* (Bloch) *J. Fish Res. Board Can.*, 33:959-973.

Suresh V.R., Biswas, B.K., Vinci, G.K., Mitra, K. and Mukherjee, A. 2007. Biology of *Amblypharyugodon mola* (Hamiliton) from a floodplain wetland, West Bengal. *Indian J. Fish.*,54(2): 155-161.

Sushma, S., Radhakrishnan, T. and Bijukumar, A. 2004. Distribution of fishes in the Nila river. *Indian.J. Fish.*, 51(3) 385-387.

Suter, M.J. 1944. New records of fish from Poona. *J. Bombay Nat. His. Soc.*, 44: 408-414.

Suyehiro Y.1942. A study of the digestive system and feeding habits of fish. *Japan J. zoology.*, 10(1):1-303.

Swapna, S. 2009. Fish diversity in Achenkovil River, Kerala, India. *J. Bombay. Nat. His.Soc.*, 106(1):104-106.

Sykes, W.H.1839. On the fishes of the Deccan. *Proceedings of the Zoological Society of London*,6: 157–165.

Tandon, K.K. 1999. My encompass with the world of fishes in the Haryana and lower reaches of Himachal Pradesh. Abstract In: National workshop on Sustainable Aquaculture. P 25, Punjab Agriculture University, Ludhiana, India.

Tandon, K.K. and Johal, M.S. 1983. Study on age and growth of *Tor putitora* (Hamilton) as evidenced by scales. *Indian J. Fish.*, 30(1): 171-175.

Tandon, K.K. and Sharma, V.K. 1984. An account of fishing methods in Kangra and Hamirpur districts of Himachal Pradesh. *J. Zool. Soc. India.*, 36(1/2): 95-100.

Tandon, K. K., Johal, M. S. and Kaur, S. 1989: Remarks on the age and growth of *Labeo calbusu* (Pisces, Cyprinidae) from Rajasthan, India. *Vest. cs. Spol. Zool.*, 53: 153–160.

Taw,N. 1983. A brief account of the giant freshwater prawn (*Macrobranchium*) fishery in Burma, 55-58, In: Giant Freshwater Prawn Farming. M.B New (Ed),Elsevier Scientific Publishing Co., Amsterdam.

Talwar,1995. Fauna of India and adjacent countries Pisces Perciformes: Sciaenidae Zoological survey of India Calcutta, 1-144.

Talwar, P. K. and Jhingran, V.G. 1991. Inland fishes of India and adjacent countries. Vol. I and II. Oxford and IBH Publishing company. New Delhi Pp. 536.

Tesch, F.W.1968. Age and growth *In.* Methods for the assessment of fish production in fresh water. W. R. Ricker (Ed.), IBP Handbook No: 3: 98-130.

Tilak, R. and Tiwari, D.N. 1976. On the fish fauna of Poona District (Maharashtra). *News Letter Zoological Survey of India,* 2:193-199.

Tilak, R. 1987. The Fauna of India and adjacent countries (Pisces: Teleostomi): Subfamily Schizothoracinaceae. Calcutta. X +229pp.

Tonapi, G.T. and Mulherkar, L. 1963. Notes on the freshwater fauna of Poona, Part: I, Fishes. *Proceedings of Indian Academy of Science,* 58: 187-197.

Thakre, V. Y. and Bapat, S. S., 1981. Maturation and spawning of *Rasbora daniconius* (Ham. Buch.). *J. Bombay nat. Hist. Soc.*, 78: 38-45.

Thakre, V. Y. and Bapat, S. S. 1984. Observations on the length-weight relationship of the fish *Rasbora daniconius* (Ham-Buch.). *J. Bombay nat. Hist. Soc.,* 81(1): 105-109.

Thobias, M.P. 1973. Study on the ecology, systematics and bionomics of freshwater fishes and paddy fields and rivers of Trichur district., Kerala. Ph.D thesis, University of Calicut, Kerala.pp. 248.

Thomas, J.D. 1966. On the biology of the catfish, *Clarias senegalensis* in a man-made lake in the Gahnian Savanna with particular reference to its feeding habits. *J . Zool.*, 148:476-514.

Thomas, J. P. 1962. The food and growth of brown trout (*Salmo trutta*) and its feeding relationship with the salmon parr (*Salmo salar*) and eel (*Anguilla Anguilla*) in the river Teify, west Wales. *J. Anim. Ecol.,* 31:175-205.

Thomas, P.A.1969. Goat fishes (Fam.: Mullidae) of the Indian seas. *Mar.Bio.Assoc.India Memoir*., III(7):152-157.

Thomas, R. K. 2004. Habitat and distribution of hill-stream fishes of southern Kerala (South of Palghat Gap), PhD Thesis. Mahatma Gandhi University, Kottayam, Kerala, India.p186.

Thomas, R.K., Biju C.R. and Ajithkumar, C.R 2000. Fishes of Idukki and Neyyar Wild life sanctuaries of Kerala, S. India. *J Bombay. Nat. Hist. Soc.,* 97:442–445.

Thomas, R.K., George, M.J and Biju. C.R. 2002. Freshwater fishes of southern Kerala with notes on the distribution of endemic and endangered species. *J. Bombay Nat. His. Soc.,*99 (1): 47-53.

Thomas, S.N. 2002. Gill nets and their operation. ln: Advances in Harvest Technology. ICAR Winter School Manual, CIFT, Cochin: 371-382.

Thomas, S. and Azis, P. K. 1999. Status of reservoir Fisheries in Kerala and strategies for development with special reference to the Peppara Reservoir, Kerala. *Ecol. Env. and Cons*., 5(1): 51-54.

Troca, D.F.A. and Vieira, J.P. 2012. Potencial invasor dos peixes não nativos cultivados na região costeira do Rio Grande do Sul, Brasil. *Boletim do Instituto de Pesca.,*38 (2): 109–120.

Tserpes, G and Tsimenidis N. 2001. Age, growth and mortality of *Serranus cabrilla* (Linnaeus, 1785) on the Cretan shelf. *Fisheries Research,* 51: 27-34.

Ujjania, N.C., Kohli, M.P.S. and Sharma. L.L.2012. Length-Weight relationship and Condition factor of Indian Major Carps (*C. catla, L. rohita* and *C. mrigala*) in Mahi Bajaj Sagar, India. *Research journal of biology,* 2(1): 30-36.

*Valenciennes, 1842. In: Cuvier, G. & A. Valenciennes 1842. *Histoire naturelle des poissons. Tome seizième. Livre dix-huitième. Les Cyprinoïdes.* Histoire naturelle des poissons, 16: i–xx+1–472.

Varghese, J.G. 1994. Studies on fish assemblage in the Achenkovil river system with special references to their niche segregation and habitat usage. PhD Thesis, Mahatma Gandhi University, Kottayam, India.

Varghese, T. J. 1973. The fecundity of the rohu, *Labeo rohita* (Hamilton). *Proc. Indian Acad. Sci.,* LXXVII B (5), 214-224.

Varghese, T. J. 1976. Studies on the fecundity of *Coilia ramcarti* (Ham. Buch.). *Proc. Indian. Acad. Sci.* Vol. 83B, No.2, pp 47-54.

Varghese, M.D., George, V.C., Khan, A.A. and Krishna, I. H. 1982. Shore seines for reservoir. Part-I l, Studies on optimal mesh size. *Fish. Technol*., 20(2): 97-100.

Verma, P. U., Chandawat, D. K. and Solanki, H. A. 2011. Seasonal variation in physico-chemical and Phytoplankton analysis of Kankaria lake, Ahemadabad. *Lifesci. Leafl*., 19: 842-854.

Vilizzi, L. and Walker, K.F. 1999. Age and growth of Common carp, *Cyprinus carpio* in the river Murray, Australia: validation consistency of age interpretation and growth models. *Env. Bio. Fish.*, 54: 77-106.

Vinci, G. K. and Sugunan, V. V. 1981. Biology of *Labeo calbasu* (Hamilton) of Nagarjunsagar reservoir, A .P, India. *J. Inland Fish. Soc. India.*, 13 (2): 22.

Viswanath. W. 2000. Fishes of Manipur. Imphal Manipur Association for Sciences and Society. 143 p.

Viswanath,W.2002. Fishes of North East India, a field guide to speices identification. Manipur university NATP Publication 198p

Vorosmarty, C. and Sahagian, D. 2000. Anthropogenic disturbance of the terrestrial water cycle. *Bio Science*, 50:753–76.

*Wagh, G.K. 1999. Study of fish, macro invertebrate and aquatic angiosperm biodiversity of the river Mutha. Ph.D Thesis, submitted to Pune University.

Wagh, G.K. and Ghate, H.V. 2003. Freshwater fish fauna of the rivers Mula and Mutha, Pune, Maharashtra. *Zoos Print.*, 18(1): 977-981.

Walters, C.V., Christensen. and Pauly, D. 1997. Structuring dynamic models of exploited ecosystems from trophic mass-balance assessments. *Rev. Fish. Biol. Fish*., 7(2): 139 – 172.

Wei, Q., Ke, F., Zhang, J., Zhuang, P., luo, J. and Zhou, R. 1997. Biology, fisheries and conservation of sturgeons and paddlefish in China. *Env. Bio. Fish.*, 48: 241–255.

Welcomme, R.L. 1979. Fisheries ecology of floodplain rivers. Longman, London, 317 pp

Welcomme, R.L. 1985. River Fisheries. Rome. FAO Fisheries, Technical Paper- 262. 330pp.

Welcomme, R.L., Cowx, L.G., Coates, D., Bene, C., Funge-Smith, S., Halls, A. and Lorenzed, K. 2011. Inland capture fisheries. *Phil. Trans. R. Soc.*, B. 365: 2881-2896.

Wilcove, D. S., Rothstein, D., Dubow, J., Phillips, A. and Losos, E. 1998. Quantifying threats to imperiled species in the United States. *Bio science,* 48; 607-615.

Winter, B.D, and Hughes, R.M. 1997. Biodiversity. *Fisheries, (*Bethesda)., 22(1):22-29.

Wootton, R. J. 1979. Energy costs of egg production and environmental determinants of fecundity in teleost fishes. *Symp. Zool. Soc. London.,* 44: 133-159.

Wootton, R.J. 1990. Ecology of teleost fishes. Chapman and Hall, London. Pp404.

Wright, D.H. 1983. Species-energy theory: an extension of species-area theory. *Oikos.,* 41: 96-506.

Wilson, H.C. 1920. Report on the methods of capture and supply of fish in the rivers of the Nilgiri district. *Madras Fish. Bull.,* 12(40):135-56.

Wilson, E.O. 1992. The Diversity of Life .Harward University Press Belknap, USA.

Yadav, B.E. 1996. New record of the percoid fish, *Pristolepis marginata* Jerdon from Krishna drainage system of Western Ghats, India. *Geobios New Reports,* 15: 55-56.

Yadav, B.E. 1997. Studies on systematics and zoogeography of the fishes of Western Ghats with observations on the status of endemic species. Ph.D Thesis, submitted to Shivaji University. pp. 416.

Yadav, B.E. 2000a. A checklist of the endemic and the threatened species of the Western Ghats. *Records of Zoological Survey of India,* 98: 39-43.

Yadav, B.E. 2000b. Conservation strategies of ichthyofauna in northern part of Western Ghats. *Records of Zoological Survey of India,* 98:45–49.

Yadav, B.E. 2000c. Conservation strategies: the ichthyofauna of northern part of Western Ghats and its conservation .Endemic fish diversity of Western Ghats (ed. by A.G. Ponniah and A. Gopalakrishnan), pp. 145–147. NBFGR-NATP Publication, National Bureau of Fish Genetic Resources, Lucknow, India.

Yadava, Y.S., Choudhury, M. and Kolekar, V. 1981. Fishing methods of flood plain lakes in North Eastern region. *J. Inland Fish. Soc. India*., 13(1): 82.

Yamamoto, K., Kai, H. and Ishida, R.1959. A preliminary report on the formation of the egg of the trout *Oncorhyncus masou. Bull. Hokkaido Reg. Fish. Res.Lab.*, 20:109-116.

Yazdani, G. M. 1992. Biodiversity of freshwater fish fauna of Indian rivers with observations on threatened species. Proc. First National Symposium on Environmental Hydraulics *Central Water Power and Research Station,* pp. 134-147. Pune.

Yazdani, G.M. and Mahabal, A. 1978. Fishes of Indrayani river. *Biovigyanam (Poona).,* 2: 119- 121.

Yazdani, G.M. and Singh, D.F.1990. On the fish resources of Ujni wetland, Pune, Maharashtra. *J. Bombay Nat. His. Soc.,* 87: 157-160.

Yazdani, G.M. and Yadav, B.E. 1995. Extension of range of distribution of the Gangetic gray mullet in India. *Geobios New Reports*, 14:167-168.

Yazdani, G.M., Devi, K.R., Raghunathan, M.R. and Singh, D.F. 2001. Fauna of Nilgiri Biosphere Reserve. *Fauna of Conservation Area Series, Zoological Survey of India,* 11: 207–224.

Yohannan, T. M. 1983. Population dynamics of Indian mackerel based on data from Manglore during 1967-75. *Indian J. Fish*., 29(1&2): 50-62.

Yuen, H.S.Y. 1955. Maturity and fecundity of big eye tuna in the Pacific. *U.S. Fish and Wildlife Service, Special Scientific Report,* No.150: 1-30.

Zacharias, V. J., Bhardwaj, A. K. and Jacob, P. C. 1996. Fish fauna of Periyar Tiger Reserve. *J. Bombay Nat. Hist. Soc.*, 93: 38-43.

Zar, H. J. 1974. *Biostatistical analysis*. Eagle Wood Cliffs, Ed.) Printice Hall, Inc. pp.620.

*Not reffred to in orginal

.....ꕤ.....

PLATES

Plate 1– Fish landing from various landing centres for River Pampa

Plate 2 – Fish landing from various landing centres for River Periyar

Plate 3 – Fish landing from various landing centres for River Chalakudy

Plate 4 – Fish landing from various landing centres for River Bharathapuzha

Plate 5 – Fish landing from various landing centres for River Achankovil

Plate 6 – Fish landing from various landing centres for River Kallada

Plate 7 – Fish landing from various landing centres for River Muvattupuzha

Plate 8 – Fish landing from various landing centres for River Meenachil

.....ഇൽ.....

List of Publications

Paper published

[1] Ali, A., Philip, S., Dahanukar, N., **Renjithkumar, C.R**., Bijukumar, A. and Raghavan, R. 2013. Distribution, threats and conservation status of *Hypselobarbus thomassi* (Day, 1874), a poorly known cyprinid fish of the Western Ghats freshwater ecoregion. *Journal of Threatened Taxa*, 5(17):5202-5213.

[2] **Renjithkumar C.R**., Harikrishnan, M. and Kurup, B.M. 2011. Exploited fisheries resources of Pampa river, Kerala, *Indian Journal of Fisheries*, 58(3):13-22.

Paper presented in Seminar/Symposium

[1] **Renjithkumar C. R** and Kurup, B.M. 2014. Exploited ornamental fishery resources in Bharathapuzha River, Kerala, India. *Internati. Sem. Ornamental fish breeding, farming and trade (26th -27th January 2014), Dep. of. Fish., Govt. of kerala-Abstract:74.*

[2] Roshni, K., **Renjithkumar, C.R** and Kurup, B.M. 2014. Food and Feeding habits of an exotic fish-tilapia, *Oreochromic mossambicus* from a Western Ghats reservoir, Kerala, *26th Kerala Science Congress, 28-31, January 2014, Wayanad, Kerala- Abstract: 87.*

[3] Kurup, B.M., Harikrishnan, M and **Renjithkumar, C.R**. 2012. Breeding, Farming and Trade of Ornamental Fishes in India- Prospects and Challenges, Souvenir- *International seminar on Ornamental fish breeding, farming & Trade,*11-12 February 2012 Cochin, Kerala, India, pp.61-75.

[4] **Renjithkumar, C. R**., Harikrishnan, M. and Kurup, B.M. 2010. First record of exotic ornamental fish Red bellied Piranha from natural waters of Kerala. Poster presentation. *International seminar on Ornamental fish breeding, farming & Trade13-15 February 2010, Cochin, India.*

[5] **Renjithkumar, C.R**., Harikrishnan, M. and Kurup, B.M. 2010. Exploited ornamental fishery resources in river Pampa. *International seminar on Ornamental fish breeding, farming &* Trade(13-*15 February 2010*) Cochin, Kerala, India.

[6] Kurup, B.M. and **Renjithkumar, C.R**.2010. Ornamental fish biodiversity of India, *National Seminar on Biodiversity conservation and Management of aquatic resources*, 9-10 December 2010,Thoothukudi,Tamil Nadu, India.

…..ഇൻ…..