SYSTEMATICS, GERMPLASM EVALUATION AND PATTERN OF DISTRIBUTION AND ABUNDANCE OF FRESHWATER FISHES OF KERALA (INDIA)

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2006

Dedicated to my family

DECLARATION

I, **Radhakrishnan K.V.**, do hereby declare that the thesis entitled **"Systematics, Germplasm evaluation and pattern of distribution and abundance of freshwater fishes of Kerala (India)"** is a genuine record of research work carried out by me under the guidance of **Dr. B. Madhusoodana Kurup**, Professor, School of Industrial Fisheries, Cochin University of Science and Technology, Kochi-16 and no part of the work has previously formed the basis for the award of any Degree, Associateship and Fellowship or any other similar title or recognition of any University or institution.

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CERTIFICATE

This is to certify that the thesis entitled "**Systematics, Germplasm evaluation and pattern of distribution and abundance of freshwater fishes of Kerala (India)**" to be submitted by **Sri. Radhakrishnan. K.V.**, is an authentic record of research work carried out by him under my guidance and supervision in partial fulfillment of the requirement for the degree of Doctor of Philosophy of Cochin University of Science and Technology, under the faculty of Marine Sciences.

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Chapter 1

GENERAL INTRODUCTION

1.1. Introduction

Biodiversity is the measure of variety of Life. The convention on Biological diversity held at Janeva during 1992 proclaimed sovereign right and responsibility for the member countries to conserve and utilize the diverse resources for meeting the primary needs of growing populations. In conjunction with this, in 2000, "Ecosystem approach" has been identified as the primary framework for the implementation of conservation plans and recommended the application of its principles (Narain, 2000). At the heart of this approach is the awareness that, without the effective management of ecosystems, there can be no economic development that generates sustainable human and social welfare and on the other hand, without the full engagement of diverse sectors of society, there can be no effective biodiversity conservation (Daniels, 2001). The alarming deterioration of ecosystems and habitats as a result of industrialization and population expansion are the most serious threats facing which can even wipe out the unique biodiversity of the earth (Matthews, 1998). Awareness of this fact is of course, the reason for the materialization of the Convention on Biological Diversity itself (Kottelat and Whitten, 1996).

Aquatic ecosystems and management are among the most discussed topics today. The loss in biodiversity is much faster in aquatic systems than the terrestrial environment (Moyle and Williams, 1990) and this problem is particularly acute in streams and rivers (Allan and Fecker, 1993; Allan, 1995). Nelson (1994) opined that the loss of aquatic biodiversity is severe in freshwaters, which represent only a meager 0.1% of earth's water wealth, yet they harbour 40 % of the fish species so far recorded. Fishes are the key stone species, which determine the distribution and abundance of other organisms in the ecosystem they represent and are good indicators of the water quality and health of the ecosystem. However, nearly 20% of the world's freshwater fish fauna is already extinct or in the verge of extinction (Moyle and Leidy, 1992).

Knowledge of species and communities can reveal crucial facts necessary for the management of ecosystems and habitats (Menon,1999). Identification, listing and prioritization of species are one of the important tasks in ecosystem conservation. It is well known that species information itself has many gaps in various taxon. In many cases, the species has not been collected since its description and some species itself are still remain buried in the synonymy due to constant misidentification (Menon, 1999). Further, the paucity of specimens for taxonomic studies make it difficult to ascertain the specific differences existing between different specimens. Conservation of biodiversity also requires a thorough knowledge of the community ecology and natural characteristics and processes that create, support, or limit communities (Rathert *et al.*, 1999). The identification of pattern in community structure, influence of biotic and abiotic factors and inter and intra relationships over spatial and (or) temporal scales is a common problem with which community ecologists and bio-geographers struggle (Jackson *et al.* 1992).

Briggs (1974) gives an account of the faunal strength of various zoogeographic regions. The greatest number of fish species in the world inhabits the south East Asian region. A noteworthy difference between the freshwater fish fauna of south-east Asia and those of other tropical areas is the number of families involved. South America has only some 60 families and Africa, some 74, whereas south-east Asia has some 105 (Kottelat, 2001). Matthews (1998) reported that there are many species per family in temperate river assemblages. On the other hand, in tropical river assemblages there are few species per family, but the number of families are many. It is also obvious that tropical and subtropical belt of the world is rich in biodiversity because it has remained unaffected by glaciation which has decimated biodiversity in temperate and polar belts (Jayaram, 1999). Matthews (1998) also stresses that the success of a family in a tropical river is due to the availability of food, habitats and general resources.

With its great diversity of ecological conditions, and its position at the confluence of three bio-geographic realms, viz., Paleartic, Afro-tropical and Indo-Malayan, the Indian subcontinent has a tremendous diversity of plant and animal species (Gadgil & Meher Homji, 1990). With so much diversity it is but natural that in the Indian subcontinent, the variety and quantum of the catch is typical of the tropics (Jayaram, 1999). India is one of the mega diversity countries with respect to freshwater fish species (Molur and Walker, 1998). In freshwater fish diversity, India occupies eighth position in the world and third in Asia (Dahanukar *et al.*, 2004). Of the total 8411 freshwater fishes known to exist world over, in the Indian region alone there are 930 freshwater inhabitants. 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 along with the north-east India are considered as the hotspots of freshwater fish biodiversity in the world (Kottelat and Whitten, 1996). It is no wonder that interest in study of fish is as old as vedic times in India. Fishes have been a part of the Indian culture and have appeared in Mythology. The ancient Indians classified fish, based on shape and structure and their knowledge from keen observations are remarkable as seen from Kautilya's Arthashasthra (300 B.C), King Someswara's Manasallosa (1127 A.D.), etc. However, studies with a more scientific, more accurate and fulfilling the needs of modern taxonomy on the Indian freshwater fish fauna started only from the 19th century. Much of the early study on the freshwater systems of the Indian subcontinent were initiated by the British officers working for the East India Company, who took great interest in the natural history of the region. The real exploration of the Indian fish fauna sprouted with the beginning of 20th century when stalwarts like Hora, Mukerji, Day, Misra, Menon, Talwar, Jhingan, Jayaram and Das etc. made very monumental studies on the taxonomy of freshwater fishes of India.

The aquatic resources of Peninsular India comprising of five southern states viz. Kerala, Tamilnadu, Karnataka, Andhra Pradesh, Pondicherry, Goa and parts of Maharashtra and Orissa cover about 20% river and canal resources, as much as 38.6% (8.07 lakh ha.) swamp and derelict waters of the country (Ayyappan, 1996). The majestic presence of hill ranges of Western Ghats distinguish Peninsular India as one of the unique biological regions of the world (Subhash Chandran, 1997). World Bank in its technical paper on freshwater fish biodiversity of Asia identified Western Ghats of India as one of the 21 globally recognized biodiversity hotspots with high degree of endemism as well as rich and varied species biodiversity including freshwater teleosts (Kottelat and Whitten, 1996). Of the 617 and odd species of freshwater fishes of India, the distribution of several species are confined to

South Indian waters, espicially concentrated in Western Ghats (Gopalakrishnan and Ponniah, 2000). The Ghats extend about 1600 km northwards from the southern tip of Peninsula (8^0 N) up to the mouth of Tapti (21^0N) and is the source of origin of 38 east flowing and 27 west flowing major river systems. The west flowing rivers drain in to the Arabian sea while the east flowing rivers confluent to of the three major river systems viz. Cauveri, Krishna and Godavari. The richest expression in diversity, abundance and endemism of freshwater fish fauna is met in these drainages in India, in addition to the north-eastern region (Anon, 1998). The levels of endemism were found to be very high over all the vertebrate taxa in the Western Ghats. Fishes in this region are also found to have high endemicity. Of the 218 species recorded, 114 (52%) are endemic to the WG and Sri Lanka (Daniels, 2001). The Ghats offer substantial fish materials for taxonomic and ecological studies and many workers have contributed to the knowledge on the ichthyofaunal diversity of this region (Menon, 1999; Jayaram, 1999).

The state of Kerala is a narrow strip of land located at the southern extremity of the Indian sub continent, along the shores of Arabian sea covering a coastal length of 580 km. with Karnataka state on the north and north east and Tamil Nadu on the east and south. Lying between 8^0 17'30" and 12 ° 47'40" north latitude and 74 ^{0} 51' and 77^0 24' east longitude, the state is spread over a land area of 38855 sq. km. The width of the state varies from 15-120 km. The freshwater resources of Kerala included 44 rivers with a total length of 3100 km and catchment area 37884 km^2, 30 reservoirs having a total area of 30000 hectares and irrigation tanks, channels and ponds of

4000 ha with a total water spread area of 85000 ha. Out of the 44 river systems of Kerala, 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. Almost the entire districts of Kerala are drained by these river systems. The river systems showed great contrast in their physical dimensions. The longest river is Periyar with a total length of 244 km while the smallest one is Manjeswar with only 16 km. The catchment area of Periyar is largest with 5398 km^2 while it is smallest for Ramapuram river system (52 km^2). In general, river length, basin area and gradient are measures that can normally correlate with fish species richness following the species-area theory (MacArthur & Wilson, 1967; Wright, 1983, Eadie *et al.*, 1986; Oberdorff *et al.*, 1995). 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. The backwaters are interconnected by a network of artificial canals for navigation. The low lands are often subjected to salinity intrusion. The midland lies between the low land and high land. The majestic presence of the Western Ghats has remarkable significance to the state from Zoogeographers and naturalist points of view. These hill ranges influence the physiographic and agro-climatic features and intricately balances the whole life supporting system of the region. Of the total 1600 km of the Western Ghats, 500 km fall in Kerala with a break or gap of 32 km at Palakkad. Most of the reserve forests of the state are at the peaks and slopes of Western

Ghats and are mainly constituted by evergreen and semi evergreen (4750 km 2 area) and moist deciduous (3140 km 2) forests. The Ghat region within Kerala covers nearly 21856 km^2 or 56% of the total geographical area of the state and 42.7% of the entire Western Ghats. Hills are generally at an elevation between 600 and 1000 meters and there are also higher hills of 1000-2000 m. About 60% of the annual rainfall is received during south-west monsoon (June-Sept.) and 20% during north-east monsoon (October-January) which cause occasional but short durational flooding of the rivers. However, this rainy season is often prolonged due to pre-monsoon and winter showers. The average annual rainfall is estimated to be of 2615 mm, which showed variation with the maximum at the high lands and minimum at the low lands. The morphology of the Ghats is attributed to one of the major factors deciding the rainfall pattern. Mean temperature of the geographical area range between 20 and 24°C. However, it frequently shoots beyond 30°C during shorter summer months (April-May) and some times falls to 0°C during winter in the higher hills (Anon, 1991).

The most well recognized pattern in the global distribution of biological diversity reveals that the tropics at lower latitudes harbour relatively more species per unit area (Gaston, 2000). In Western Ghats, the diversity and species richness of Fishes, Amphibian and Angiosperms are more at the southern Peninsula when compared to north. (Dahanukar *et al.*, 2004). In the World Bank technical report, streams of Kerala have been identified as one of the few sites in the world showing exceptional fish diversity and great degree of endemism with respect to freshwater fishes (Kottelat and Whitten, 1996). Gopalakrishnan and Ponniah (2000) reaffirmed this statement by establishing the fact that within Western Ghats, Kerala part is richest in aquatic resources with highest number of endemic and rare teleost fishes. The distribution and endemism of the fishes of the state have great correlation with its zoogeography (Silas, 1951). As the rivers of the state are mostly west flowing and are not ultimately connected with any other major river systems such as Godavari, Krishna and Cauveri of the north, the dispersal of the species became highly restricted and hence the endemism of the rivers are high. The uniqueness of freshwater fish germplasm of the state can be further illustrated by Hora's (1949) "Satpura hypothesis". During the Miocene epoch freshwater fishes from Malayan Peninsula spread through the Satpura hills and reached Western Ghats. Eventually, when Sri Lanka got separated from India, though this dispersal of the species continued, the Palaghat gap was instrumental in isolating the fishes of southern region from the northern region of Western Ghats leading to the evolution of a high endemic fish fauna at south of Palaghat. Furthermore, Palaghat gap also created a barrier for free movement of fish species and hence the uniqueness of this region became more distinct. Bhimachar (1945) and Silas (1951) have also discussed the importance of Palaghat gap as a barrier for the distribution of hill stream fishes in the Western Ghats. The seasonal rain pattern in the Western Ghats shows a longer dry period as we go from 8 to 21 ^{0} N latitude. The southern region including Kerala has high annual precipitation and a shorter dry period and so the streams and rivers persist for longer duration, which have a keen influence on the sustenance and natural recruitment especially the very ecosensitive hill stream fishes. Unlike the dry deciduous forests at the northern region, the southern region of the Western Ghats are mainly consist of moist ever green trees which form a good in stream cover and shade and support a rich primary and secondary production, abundant alochthonous food particles and ambient air and water temperature which ultimately resulted in rich fish species diversity and abundance in streams of Kerala.

The ever-increasing anthropogenic pressures have resulted in deterioration of quality and shrinkage of many aquatic ecosystems of Western Ghats and drastic decline of fish biodiversity (Menon, 1999). The threat status of fishes in the Western Ghats suggests that nearly 41% of the fish fauna are threatened, either vulnerable (VU), Endangered (EN) or Critically endangered (CR) (Dahanukar *et al.*, 2004). The freshwater fish biodiversity of Kerala is alarmingly declining due to a variety of man-made stresses (Kurup, 2000). Extensive deforestation and disappearance of riparian vegetation, increasing soil erosion in the streams, intensive agriculture in catchment areas, Industrial, agriculture and domestic pollution in the rivers, extensive sand mining, 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 are the major causes for declining freshwater fish wealth of the state (Kurup, 1994., Gopi, 2000., Ajithkumar *et al.*, 2000). Severe over fishing has resulted in reduction in the average size constituting the fishery (size over fishing), wanton killing of spawner population and predominance of forage and weed fishes replacing the commercial species. Large-scale abstraction of water from freshwater bodies, sand mining and agriculture activities in catchment areas resulted excessive siltation, habitat destruction, shrinkage and drying up of rivers during summer. Massive fish mortality due to effluent discharges from industries is a regular affair in some of the rivers such as Periyar and Chaliyar (Kurup, 1994 & 2000). 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. Similar observations were also reported by Kurup and Ranjeet (2002) in Periyar Lake of Periyar Tiger reserve, one of the biological hot spot in Kerala where ripe specimens of exotic fishes such as *Oreochromis mossambicus* (Tilapia) and *Cyprinus carpio* are available. This reserve encompasses 8 endemic fishes coming under critically endangered category. This study also registered that the indigenous species such as *Tor khudree* and *Gonoproktopterus 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 (2000) also 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. Unless and until strict management measures are not taken up, most of these unique germplasm resources will be disappearing from this state in the 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 exotic and alien fish species in the natural waters.

1.2. Review of literature

A complete review of the previous studies carried out on the freshwater fishes of India in general and Western Ghats and Kerala in particular is attempted. More than 400 relevant scientific papers were collected and screened which include the pioneer works of Hamilton-Buchanan (1822) and Day (1865-1889) and subsequent studies carried out till date. The literature on taxonomy, germplasm inventory, pattern of fish distribution, abundance and assemblages were thoroughly reviewed. Desktop inventory of 237 freshwater fishes of Kerala together with their distribution and biodiversity status as per IUCN criteria was prepared with a view to consolidate information hitherto available.

The Indian ichthyology has a very lengthy history. The ancient Hindus knew greatly about the external features and habits of a variety of fishes of the country. The great pioneers of ever time in Indian ichthyology, Lacepede (1800) followed by Bloch and Schneider (1801) paved the way for the ichthyological studies in India. However, efforts targeting and fulfilling the needs of modern taxonomy on the Indian freshwater fish fauna started only from the 19th century. Beginning with Hamilton-Buchanan's (1822) pioneer work on the fishes of Ganges which was followed by McClelland (1839), an array of dedicated and eminent scientists contributed much to shaping of modern ichthyology of the country, among them Sykes (1839), Jerdon (1849), Blyth (1858,1860), Day (1865, 1878 &1889) Cuvier and Valenciennes (1828-1849), Bleeker (1853), Beavan (1877) and Gunther (1864 & 1868) deserve special attention. Hamilton-Buchanan (1822) described 271 species of freshwater and estuarine fishes, McClelland (1839) published a detailed account of 138 species of Indian Cyprinids while Bleeker (1853) described 162 fish species. An account of the fishes of Southern India was published by Jerdon (1849) in two parts, the former part describes 22 fish species while the latter accommodates 150 species. Another important contribution is that of Beavan (1877) who brought out 'Handbook on freshwater fishes of India' described 392 fish species. The most outstanding personality in the history of Indian ichthyology is undoubtedly Day (1865-1889) who described 1340 species of freshwater and marine fishes in his monumental work *'The fishes of India, being a natural history of the seas and freshwaters of India, Burma and Ceylon'*. Numerical strength of the primary freshwater fishes described in the book is 365. Even today this remains to be the most widely referred and monumental book, known as the Bible of Indian fishes. The indomitable researches of Hora (1921-1949) placed Indian Ichthyology on a universal pedestal in the 20^{th} century. The contributions of Misra (1947,1952,1953), Menon (1987,1992), Talwar and Jhingran (1991) and Jayaram and Das (1999) can never be under estimated. In recent years many scientists from abroad has shown interest in India's ichthyodiversity. Roberts's (1989) "The freshwater fishes of Borneo" provides many new concepts in Taxa limitations. Eschmeyer's (1990) magnum opus "The genera of fishes" is a beautiful contribution for any type of ichthyological studies. Kottelat (1990) revised the Indo Chinese Nemacheilines; Rainboth (1991) and Howes (1991) provided a new classificaion in the book Cyprinids of Asia, while Banarescu and Nalbant (1995) revised the Nemachelines. Pethiyagoda's (1991) lovely book on the fresh water fishes of Sri Lanka is one of the monumental publications related to the Ichthyology of India. The fauna of Western Ghats have been a subject of study for many researchers owing to its great species diversity, endemism and zoogeographical significance. Data on the fish fauna of the Western Ghats, however are quite scattered in the literature. Studies of Ajitkumar *et al.* (2000), Annandale (1919), Easa & Shaji (1996, 1997), Frazer (1942), Ghate & Wagh (1991, 1995, 2003), Hora (1921, 1937, 1942), Hora & Misra (1937, 1938, 1942), Indra & Remadevi (1981), Jayaram (1981), John (1936), Johnsingh (2001), Kalawar & Kelkar (1956), Kharat *et al.* (2000, 2003), Menon & Rema devi (1992), Mukerjee (1931), Pethiyagoda & Kottelat (1994), Rajan (1955), Rao & Shachar (1927), Remadevi & Indra (1984, 1986), Samant (1990), Sarkar & Yadav (1996), Shaji & Easa (1995a,b,c, 1996 and 1997), Shaji *et al.* (1996), Silas (1950, 1951, 1952, 1953), Singh & Yazdani (1988, 1991), Spence & Prater (1932), Suter (1944), Tonapi & Mulherkar (1963), Wagh (1999), Tilak (1987), Tilak & Tiwari (1976), Yadav (1996, 1997, 2000 a), Yazdani & Mahabal (1978), Yazdani & Singh (1990) and Yazdani & Yadav (1995) and Talwar & Jhingran (1991) are notable among them which are invaluable for any further ichthyological research in this area. Recently, Gopalakrishnan and Ponniah (2000) and Shaji *et al.* (2000) brought out the status, threats and endemic nature of Western Gnat fishes besides unraveling their commercial utility as potential ornamental, sport and food fishes. Though most of these contributions deals with taxonomy, however, a few of them concentrated on the biogeographic distributions of fishes in the region (Jayaram 1974). A series of papers published by Hora in the 1930s to 1950s addressed the problem of the anomalous distribution of hill stream fishes in peninsular India. Notable other earlier works in this line are those of Silas (1951) on the fishes of the Anamalai and the Nelliampathi Hill ranges of southern WG, and those by Rajan (1963) on the ecology of the fishes of the rivers Moyar and Pykara. Bhimachar (1945) and Bhimachar and Rao (1941) also studied extensively on the Western Ghats fauna in these lines. Recently, there are a few studies on some parts of the WG with respect to fish assemblage structure and the association of microhabitat variables to species diversity (Arunachalam 2000). Bhat (2002 & 2003) gave an account of fish fauna and their habitat associations and assemblages in 4 river systems of central Western Ghats. Dahanukar *et al.* (2004) reported the faunal similarities and dissimilarities of different zones and illustrated the species distribution pattern which support Hora's "Satpura hypothesis". These studies seem to indicate that the high habitat diversity is instrumental for a high species diversity and abundance in the streams of Western Ghats.

Ichthyofaunal investigations in Kerala had drawn attention with the outstanding works of Jerdon (1849). *'The fishes of Malabar'* published by Day (1865) is perhaps the only book on the fishes of Kerala during the 19th century. Following Day's (1878, 1889) classical work, several other eminent researchers such as Pillay (1929), John (1936), Hora and Law (1941), Raj (1941a, b), Herre (1942) and Chacko (1948) made concerted attempts in the taxonomy of freshwater fishes of Kerala. Other notable works during the period from 1945-1980 include those of Hora and Nair (1941), Mackay (1945), Silas (1951, 1952, 1954), Menon (1951, 1952), Eapen (1965), Thobias (1973) and Antony (1977). In the 80's, Remadevi and Indra described a number of fishes new to science besides reporting some new distributional ranges (Remadevi,1981., Remadevi and Indra,1986).

The 90's witnessed a deluge of small and large ichthyological works from Kerala, which were mostly related to taxonomy and distribution. Several young and enthusiastic researchers came to the arena by reporting several new descriptions and distributional records of fish species, the most notable among them are Kurup (1990, 1994, 2000, 2002), Inasu (1991), Kurup and Kuriakose (1991), Remadevi and Menon (1992), Raghunathan (1993), Pethiyagoda and Kottelat (1994), Remadevi and Indra (1994), Easa and Shaji (1995, 1996, 1997), Easa and Basha (1995), Gopinathan (1995), Menon and Remadevi (1995), Shaji and Easa (1995a,b,c), Shaji *et al.* (1995), Arun *et al.* (1996), Gopi (1996), Menon and Jacob (1996), Remadevi *et al.* (1996), Remadevi *et al.* (1996), Shaji and Easa (1996), Shaji *et al.* (1996), Zacharias *et al.* (1996), Arun (1997), Menon (1977,1999), Bailey and Grans (1998), Gopi and Radhakrishnan (1998), Manimekalan and Das (1998), Raju Thomas *et al.* (1998, 1999), Vairavel *et al.* (1998), Ajithkumar *et al.* (1999), Biju *et al.* (1999a,b), Thomas and Abdul Aziz (1999), Zacharias & Minimol (1999), Ajithkumar *et al.*, 2000), Gopi (2000), Shaji and Easa (2000), Kurup (2001), Kurup and Ranjeet (2002) and Kurup *et al.* (2004). Kurup and Radhakrishnan (2001, 2002, 2003 & 2004 in press; 2005) described 8 new fish species and Radhakrishnan and Kurup (2004 in press) reported a new distribution records of a Sri Lanakan fish from India and 4 new distributional records of fishes from Peninsular Indian region besides reporting 14 new distributional ranges within the river systems of Kerala. The fish faunal status of Kerala waters were strengthened during this period with the description of a number of new species and many distributional records. The fish germplasm surveys recently conducted by this team were instrumental in revalidating the knowledge of the fish genetic resources of Kerala.

1.3. Objectives of the study

While scanning the literature, it become evident that a substantial database is now available on the freshwater fishes of India in general and Kerala in particular, commencing with the studies of Hamilton-Buchanan (1822) and quite recently by Talwar & Jhingran (1991), and Jayaram (1999). However, most of these publications were focused on the taxonomic listing and distribution status of fishes within some specific geographical area. Barring some taxonomic collections, not much work has been done on freshwater fishes in the Western Ghats itself. Also, large parts of the Western Ghats are remain unexplored and the distribution and status of many of the fish species described remains uncertain. Given the high levels of faunal diversity and endemicity observed so far, there is an urgent need to understand the fish diversity and distribution pattern of freshwater fishes of Kerala in a more comprehensive and holistic way. Fish surveys carried out in the rivers of Kerala invaluably contributed many new additions to the fish fauna of the state, however, there are possibilities for locating many species new to science, especially from the thick forest covered rapids and cascades of river uplands. As Hora (1921) rightly opined, due to its difficult terrain and extreme climatic conditions, the species inventory surveys on hill streams are very adventurous task, so only a few of them become successful in accomplishing the targets. Hectic surveys and sampling can only unearthen, classify and safeguard those rare fish germplasm resources. More over, though a number fishes have been added to faunistic list of Kerala either as new descriptions or new records, however, there is no authentic literature wholly deals with the updated version of fish fauna of Kerala. It can thus be concluded that, since Day (1865), no subsequent effort was made to revalidate the freshwater species of Kerala and their descriptions. The streams and reservoirs were the major substances of species inventory study for various fish researchers in Kerala. However, such investigations were mostly centered around five major river systems such as Periyar, Chalakkudy, Bharathapuzha, Pamba, Kabbini and Chaliyar and certain ecologically sensitive or geographically significant areas such as Periyar Tiger reserve, Anamalai-Nelliampathy hills, Aralam and Parambiculam wild life sanctuaries. The information on fish fauna of other river systems is scanty. Nevertheless, in a recent attempt, Western Ghat fishes were categorized based on their commercial utility for Ornamental, sport and food fishes and also assessed for their biodiversity status based on IUCN criteria by NBFGR, Lucknow, however, a river system wise data base on the commercially important and potential fishes and assessment of their biodiversity status either as threatened or non-threatened category are still lacking. In recent years, a shifting of the approaches for conservation and sustainable utilization of the resources from single species to community-ecosystem concept is widely practiced, and this type of an exercise which focus on individual rivers as ecological units have tremendous magnitude and relevance. The dynamics of spatio-temporal variations in species abundance and assemblages in freshwater bodies, especially of fishes, are a subject of study world over particularly in highly diversified tropical waters of South America, Australia and Africa, but is still a virgin field for India. It is laudable, to see that, of late, some research have been initiated in some parts of the Western Ghats with respect to fish diversity, abundance and assemblage structure and their association with habitat variables. These areas of research are practically unknown for the streams of Kerala. This becomes all the more pertinent especially when the unbridled human activities are plundering for the exploitation water resources for hydroelectric purposes and the idea of linking river systems even without considering their deleterious effect on aquatic biodiversity, delicate ecological balances and habitat species assemblages of rivers which abound innumerable sensitive microhabitats for its living beings. Not only are the rivers directly affected by the developmental activities, but they are also affected by other threats like introduction of exotic species, unethical and over fishing and the disposal of industrial and domestic wastes from industries and settlements. Before getting the rich species diversity of this region of the subcontinent is lost forever, authentic and comprehensive documentation of the species with their systematic position, biodiversity status and commercial importance as well as their diverse distribution and abundance patterns and assemblage structures in different river systems are crucial as these information are inevitable inputs for formulating appropriate plans for their conservation and utilization under sustainable level for mankind. Against this background, the present study was conceptualized and undertaken mostly aiming at bridging these gaps by generating an authentic data base on systematics, river wise germplasm inventory and evaluation, distribution, abundance and assemblages of freshwater fishes of Kerala.

The present investigation aims at:

1. Generate an authentic database on organic diversity (systematics) of fishes resolving ambiguities in nomenclature, taxonomic overlaps, species ambiguities, etc.

2. Discover fish species new to science, new records and extension ranges of fishes harboring rives of Kerala.
3. Generate a river system wise database on the germplasm inventory of fishes of Kerala together with their categorization based on commercial utilization, biodiversity status, endemic nature and distribution pattern.
4. Bring out the river system wise abundance and assemblage pattern of fishes in selected river systems both season wise and year wise.

1.4. Organization of chapters

The thesis is presented under five well organized chapters. The subject is adequately introduced vide chapter 1. Thenceforth, it is divided into two sections, while the former section gives a holistic account on the systematics of freshwater fishes of Kerala, the latter deals with the river wise species inventory, distribution, abundance and assemblage structure. The second section is further divided in to two chapters, the first one presents the results river wise germplasm inventory and distribution pattern of freshwater fishes of Kerala while the second one encompasses the results of the abundance and assemblage pattern of fishes and their spatio-temporal variations in six major river systems of Kerala.

In the first chapter, an Introduction to the topic has been made, the importance of the present study is emphasized, works done so far on taxonomy and distribution of freshwater fishes of Kerala have been extensively reviewed, the gap areas identified, the objectives of present study are defined and the general organization of thesis is described.

The systematics of freshwater fishes of Kerala is presented in chapter 2. The fishes are classified under different orders, families and genus. The description of individual species are based on morpho-meristic characters. Methods for taxonomic classification and abbreviation of taxonomic measurements used are also described in this chapter. User friendly Identification keys are provided for all the genera and species (except for monogeneric and monotypic species). The species are described more or less in a uniform pattern. The characters of taxonomic value of families and genera are briefly described. The systematic classification of 145 fish species under 12 orders, 28 families and 66 genera are presented besides providing information on distribution, habitat and fishing methods generally employed. The description of each species is followed by a colour photograph.

In chapter three, a holistic account of germplasm resources of Kerala is presented highlighting fishes new to science described, new records of fish species in Kerala and new extension ranges. Details regarding commercial utility, biodiversity status and endemism of fish species are also furnished. This is followed by the river wise germplasm inventory details for 25 major river systems of Kerala. Under each river system, the composition of germplasm resources, evaluation of fishes based on their commercial utilization as ornamental, cultivable and food fishes, biodiversity assessment of the fishes based on IUCN criteria, nature of endemism of the species and also pattern of distribution of the species within the river system are given. The river systems were compared for their nature and level of species diversity based on river index values and the areas which require immediate protection as aquatic sanctuaries are demarcated. The longitudinal and regional distribution pattern of the fishes in the river systems of Kerala are thoroughly illustrated. An attempt is made to correlate species diversity in river systems with their geometrical dimensions such as river length and catchment area and conclusions are drawn. The species diversity of different latitudinal zones of Kerala were compared and the results are also correlated with the total length of river systems and catchment areas of each zones.

Chapter four discusses the spatio-temporal variations in abundance and assemblage pattern of fishes in six major river systems of Kerala viz. Periyar, Chalakkudy, Kabbini, Pamba, Kallada and Bharathapuzha. The variations in species abundance and community structure in each river system over space and time are illustrated with the help of advanced statistical packages. The similarities or variations in species abundance between species, locations and river systems are discussed. The dominant and critical species that ultimately determine the particular assemblage structure of each location is brought out. Investigations are also made on whether the species abundance can be correlated with the latitude and altitude of the location and distance of the location from the sea. The geographical variation in species abundance dispersal in Kerala is established.

Chapter five embodies summary of the present study and suggestions for conservation and management of freshwater fish germplasm resources of Kerala. 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 of the rivers of Kerala are also proposed.

In general, each chapter is subdivided into brief introduction, materials and methods, results and discussion. Table, graphs and photographs are inserted at appropriate places. The list of references consulted is appended at the end of the thesis followed by the list of publications generated from the present study.

Chapter 2

SYSTEMATICS

2.1. Introduction

With the signing of the agreement on Convention of Biological Diversity, this subject has received considerable attention globally not only because the health of biosphere depends on the health of biodiversity, but also because the very future of plant and animal wealth (including human race) also depends on it. It is also clear that tropical-subtropical belt of the world is rich in biodiversity because it has remained unaffected by glaciation which has decimated biodiversity in temperate to polar belts. Keeping this in mind, of late, the taxonomic studies of India's biodiversity have gained importance (Jayaram, 1999). With so much diversity it is but natural that in the Indian subcontinent, the variety and quantum of the catch is typical of the tropics. Of the total 8411 freshwater fishes known world over. Indian region alone abound 930 species with another 1570 species as marine. The Eastern and Western Ghats cover 10% of this country's land area and are said to have about 55% of India's terrestrial and freshwater biodiversity (Menon, 1999). It is no wonder that interest in study of fish is as old as Vedic times in India. The ancient Indians classified fish, based on shape and structure and their knowledge from keen observations are remarkable as seen from Kautilya's Arthashasthra (300 B.C), King Someswara's Manasallosa (1127A.D.) etc. However, studies with a more scientific, more accurate and fulfilling the needs of modern taxonomy on the Indian freshwater fish fauna started only from the 19th century. Beginning with Hamilton-Buchanan's (1822) account of the fishes of Ganges, followed by McClelland (1839), Sykes (1839), Jerdon (1849), Blyth (1858,1860), the vast array of fish found in this region came to light. All these pioneer researchers were instrumental in lying solid foundations for Indian systematic Ichthyology. Day (1875-1878) brought out for the first time the monumental treatise "Fishes of India" embodying mostly the results of his own extensive observations. Day included in his work (including the supplement) 1418 species found within the boundaries of India, Pakistan (including Afganistan), Bengladesh, Myanmar and Sri Lanka. Though Day's work had its own limitations, however, his monograph is irreplaceable even today considering the wide coverage and compactness. Gunther's (1864, 1868) catalogue of the fishes in the British Museum is also worth mentioning. It includes a number of taxa of this region but without many illustrations or analysis as Day has done.

It is Hora (1921-1949) who placed Indian Ichthyology on a universal pedestal in the 20th century with his indomitable researches on modern ichthyology and zoogeography of fishes. For any student of Indian ichthyology the very first source of reference and further basic information, the publications of Hora are indispensable. Hora in his lifetime established 3 families, 28 genera, 139 species; many of them are still considered as valid. Hora's associate Dev Dev Mukherji within a small span of time made several noteworthy contributions to Indian Ichthyology. Misra (1947, 1952 and 1953) published a series of checklists and manuals for the identification of the fish fauna of Indian region and its adjacent countries. In 1962, Misra published "An aid to the identification of the common commercial fishes of India and Pakistan" dealing with 402 marine, brackish and freshwater fish species belonging to 205 genera under selected families. In "Fauna of India" he made an attempt to cover different families of fishes. Misra's (1969) volume on Elasmobranchii and Holocephali was first in this series on Pisces, followed by a volume on Cluepiformes, Bathycluepiformes, Galaxiformes, Scopeliformes and Atelopiformes (1976a). The third volume was on the Siluroids (1976b). This was followed by several invaluable works such as Schizothoracinae by Tilak (1987), Balitoridae by Menon (1987, 1999) and a revision of the fishes of Genus *Puntius* (Jayaram, 1981). Talwar and Jhingan (1991) published in two volumes an account of the inland fishes of Indian region. Jayaram and Das (1999) published a revision of the genus *Labeo* Cuvier. In recent years, many scientists from abroad have also took interest in the ichthyodiversity of the country. Mirza (1962) studied the fish fauna of Pakistan and adjuscent countries, while "The freshwater fishes of Borneo" by Roberts (1989) provides many new concepts in taxa limitations. Eschmeyer's (1990) magnum opus "The genera of fishes" would be an asset for any ichthyological works. Kottelat (1990) revised the Indo Chinese Nemacheilines; Rainboth (1991) and Howes (1991) provided a new classificaion in the book "Cyprinids of Asia" whereas Banarescu and Nalbant (1995) thoroughly reclassified the Nemachelines. Pethiyagoda's (1991) book on the fresh water fishes of Sri Lanka is another attraction among the works related to the Ichthyology of India.

Taking account the home scenario, there are numerous studies on the Ichthyodiversity of Kerala. Day's (1865) "Fishes of Malabar" is the pioneer attempt in this direction which provides basic information on the fish fauna of Kerala. After Day, Pillay (1929), John (1936) and Hora and Law (1941) contributed much especially on the fish fauna of Travancore region which contributed several new species. Raj (1941a, b) and Herre (1942) were also added several new species. Other notable contribution during the period from

1945-1980 are those of Hora and Nair (1941), Chacko (1948), Silas (1951, 1952, 1954), Menon (1951, 1952), Remadevi and Indra (1984).

An intensive search on the fish fauna of the river systems of Kerala were also carried out during 1990-2000, notable among them are Kurup (1990, 1994, 2000, 2002), Remadevi and Menon (1992), Pethiyagoda and Kottelat (1994), Remadevi and Indra (1994), Easa and Shaji (1995, 1996, 1997), Easa and Basha (1995), Menon and Remadevi (1995), Shaji and Easa (1995a,b, c), Shaji *et al.* (1995), Arun *et al.* (1996), Gopi (1996, 2000), Menon and Jacob (1996), Remadevi *et al.* (1996), Zacharias *et al.* (1996), Arun (1997), Menon (1977,1999), Gopi and Radhakrishnan (1998), Ajithkumar *et al.* (1999), Biju *et al.* (1999a,b), Kurup and Radhakrishnan (2001,2002,2003 and 2004 in press; 2005) etc.These efforts were culminated in unearthening either species new to science or locating species hitherto not known from India or in Kerala. Remadevi and Indra (1986) described a new Cyprinid fish, *Garra menoni* from Silent valley and another one, Nemacheilus *pambarensis* from Pambar river (Remadevi and Indra, 1994). Shaji *et al.* (1996) described *Garra surendranathani*, a new Cyprinid fish from the southern Western Ghats; Gopi (2001) described *Garra periyarensis* from Periyar Tiger Reserve, Thekkadi; Arunachalam *et al.* (2002) described *Homaloptera santhamparaiensis,* a new species from Panniyar, a tributary of rive Periyar. Further additions to the species new to science are *Crossocheilus periyarensis* (Menon and Jacob, 1996) from Periyar Lake; *Puntius chalakkudiensis* from Chalakkudy river, Trichur district (Menon *et al.*, 1999); *Monopterus digressus* (Gopi, 2002), which is the fourth Synbranchid species under genus from Kerala, *Homaloptera menoni* from Indekkuthodu, a tributary of Bhavani river at

Siruvani in the Western Ghats (Shaji and Easa, 1995c); *Osteochilichthys longidorsalis*, *Travancoria elongata* and *Horabagrus brachysoma* from Vettilappara region of Chalakkudy river (Pthiyagoda and Kottelat, 1994); *Homaloptera pillai* from Silent valley, Kunthi river (Indra and Remadevi, 1981); *Horalabiosa arunachalami* from a stream in Santhanparai hills (Johnson and Soranam, 2001); *Glyptothorax davissinghi* from Karimpuzha, Nilambur reserved forests, Chaliyar river basin (Manimekalan and Das, 1998); *Nemacheilus menoni* (Zacharias and Minimol, 1999) from Periyar Tiger Reserve and a sub species, *Horadandia attukorali brittani* (Remadevi and Menon, 1992) from Pathiramanal islands, Cherthala and Kurup and Radhakrishnan (2001, 2002, 2003 and 2004 in press; 2005) described eight new freshwater fishes by their extensive surveys and samplings in different river systems of Kerala. Among the new species, *Nemacheilus periarensis, Homaloptera silasi, Garra mlapparaensis*, *Garra travancoria* and *Garra emarginata* are described from Periyar river system, *Salarias reticulates* from Chalakkudy, *Tor remadevii* from Pambar and *Garra nilamburensis* was described from Chaliyar river system.

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 brought out on the systematics of freshwater fishes of Kerala (Zacharias *et al.*, 1996). Though we have rich and varied freshwater fish diversity, however, most of the studies were carried out either as regional basis and just resulted in to listing of fish fauna of some of the water bodies or geographical region. 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 encompassing 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, 1981and 1999). The publications of Shaji and Easa (2001) and Ajithkumar *et al.* (2000) are worth mentioning, however, these are also incomplete for want of species description and other relevant informations for systematic classification of fishes. It is therefore asserted that after Day (1865), no subsequent effort was made to conduct another comprehensive taxonomic study on the freshwater fishes of Kerala and virtually there is no publication is available which deals with the biodiversity of freshwater fishes of Kerala with user-friendly keys for easy identification, revalidation of the species and distribution pattern of the species, etc. It is against this background that the present study was conceptualized and undertaken to generate an authentic database on systematics of freshwater fishes of Kerala by fulfilling the above gaps, descriptions with user friendly taxonomic keys and revalidation of the new species and new distributional records. Description of individual species is followed by a remarks section which deals mainly with aspects of conservation and fishery, habitat and fishing method, etc.

2.2. Material and methods

The materials for the present study were collected from 25 major river systems of Kerala during the period from April 2000 to December 2004. A map of Kerala showing the river system is given in Fig.2.1. Diverse types of fishing methods were employed for the collection of specimens (Plate I) which are summarized below.

Cast nets – 16 mm, 18 mm, 22 mm and 30 mm mesh sizes

Gill nets – 32 mm, 38 mm, 64 mm, 78 mm, and 110 mm mesh sizes

Drag nets – (4mm mesh size, 15 x 3 mtrs)

Scoop nets – 1 mm and 2 mm mesh sizes

Other local contrivances such as Koodu (a kind of traditional trap), Muppalli (a kind of spear)

All the resident and migratory fish species (visiting freshwater species) which were collected within the limits of freshwater area of different river systems (the lower limit of a river system from where the salinity observed as '0'ppt.) were brought under classification. The species collected from various reservoirs, irrigation canals, channels and ponds, which are built across, along or connected to the rivers/tributaries, are also included in the present study. However, the species, which were collected either from aquaculture farms or ornamental fish farms, but not found in natural waters, were excluded. The fish samples were preserved in 10% formalin in the field itself and brought to the laboratory for further systematic studies. Details of the coloration were recorded in the fresh specimens itself.

The fishes were identified up to species level with the help of authentic keys such as Day (1878), Talwar and Jhingran (1991), Jayaram (1981, 1999) and Tekrival and Rao (1999). The characters used for identification were morphology, morphometry and meristic counts (Jayaram, 1981, 1999). Meristic counts were made on alizarin stained material. The fin ray counts such as dorsal, pectoral, pelvic, anal and caudal and scale counts such as lateral line scales, transverse rows of scales between dorsal and lateral line and those between lateral line and pelvic fin were done following Jayaram (1999) and shown in the meristic formulae of the respected species. Morphometric measurements were recorded with a dial-reading caliper with an accuracy of 0.02 mm. Data are presented as percentages, with the range followed by the mean in parentheses. The number of morpho-meristic characters studied varied from family to family and also some cases between different genera of the same family.

List of morphometric measurements observed and abbreviations used in the present study are given below:

Morphometric measurement	**Abbreviation used**
1. Total length	TL
2. Standard length	SL
3. Greatest body depth	BD
4. Head length	HL
5. Head width	HW
6. Pre dorsal length	PDL
7. Pre pectoral length	PPL
8. Pre ventral length	PVL
9. Pre anal length	PAL
10. Dorsal fin height	HD
11. Dorsal fin base	DB
12. Adipose fin base	ADB
13. Pectoral fin height	HP
14. Ventral fin height	HV
15. Anal fin height	AH
16. Anal fin base	AB
17. Caudal fin height	HC
18. Caudal peduncle length	LCPD
19. Least depth of caudal peduncle	HCPD
20. Interorbital width	INTO
21. Snout length	SNL

22. Post orbital length	POL
23. Length of sucking disc	LSD
24. Width of sucking disc	WSD
25. Vent to anal fin distance	Vt -AF
26. Ventral fin to anal fin distance	VF-AF
27. Barbell length	BL
28. Distance between pectoral and ventral	
29. Distance between ventral and anal	

The number of specimens used for various morphometric measurements and meristic counts ranged from 1-20, depending on the availability of specimens for various species. The number of specimens observed and its size ranges are shown under the taxonomic description of each species. The different sexes of a species were not treated separately for taking the measurements unless they exhibit any clear-cut sexual dimorphism.

The scheme of classification followed in this study is mainly of Jayaram (1999) with minor modifications based on the recent studies such as Menon (1999), Ajithkumar *et al.* (1999), Shaji and Easa (2001) and Talwar and Jhingran (1991). The families, subfamilies and genera were provided with concise introduction so as to provide a concept of each group. As far as possible, the keys and descriptions are made user friendly. Except for monotypic taxa, all other taxa are provided with dichotomous keys. All keys are prepared based on morphological appearance and they do not portray any phylogenic arrangement or affinity. The various species under a genus are arranged and presented based on the order they appear in the key. But the sequence of suborders, families, sub families and genera are arranged and described according to their known phylogenic and inter-generic affinities. A more or less uniform pattern of citation and description of species has been adopted. Synonyms were greatly limited to a few monumental works. Common name and local name/names are provided for each species. Among the various morhometric ratios worked out, those essential ratios required for the identification of the species are only given and so is the description. The geographical distribution of the species within Kerala are revalidated and presented. Information on habitat and the most common fishing method are also provided. A photograph of the species in live condition follows each description. A total of 145 freshwater fishes belonging to 12 orders, 28 families and 66 genera were described in this chapter.

2.3. Results

Systematic account

The scheme of classification followed here is after Jayaram (1999)

Superclass: Gnathostomata

Class: Actinopterygii

Subclass: Neopterygii

Division: Telostei

Order: Osteoglossiformes

Family: Notopteridae

Genus: *Notopterus* **Lacepede**

Notopterus notopterus **(Pallas)**

Order: Elopiformes

Family: Megalopidae

Genus: *Megalops* Lacepede

Megalops cyprinoides (Broussonet)

Order: Anguilliformes

Family: Anguillidae

Genus: *Anguilla* Schrank

Anguilla bicolor bicolor McClleland

Anguilla bengalensis bengalensis (Gray)

Order: Clupeiformes

Family: Clupeidae

Genus: *Dayella* Talwar and Whitehead

Dayella malabarica (Day)

Order: Cypriniformes

Family: Cyprinidae

Subfamily: Cyprininae

***Genus:* Cirrhinus** *Cuvier*

Cirrhinus reba (Hamilton-Buchanan)

Cirrhinus mrigala (Hamilton-Buchanan)

Genus: *Cyprinus* Linnaeus

Cyprinus carpio Linnaeus

Genus: Catla *Valenciennes*

Catla catla (Hamilton-Buchanan)

Genus: *Neolissochilus* Day

Neolissochilus wynaadensis (Day)

Genus: *Tor*

Tor khudree (Sykes)

Tor remadevii Kurup and Radhakrishnan

Genus: *Osteobrama* Heckel

Osteobrama bakeri (Day)

Genus: *Osteochilus* Gunther

Osteochilus (*Kantaka*) *brevidorsalis* (Day)

Osteochilus longidorsalis Pethiyagoda and Kottelat

Osteochilus nashii (Day)

Genus: *Gonoproktopterus* Bleeker

Gonoproktopterus kolus (Sykes)

Gonoproktopterus dubius (Day)

Gonoproktopterus micropogon periyarensis Raj

Gonoproktopterus thomassi (Day)

Gonoproktopterus curmuca (Hamilton-Buchanan)

Gonoproktopterus kurali (Menon and Remadevi)

Genus: *Labeo* Cuvier

Labeo dussumieri (Valenciennes)

Labeo fimbriatus (Bloch)

Labeo nigriscens Day

Labeo kontius (Jerdon)

Labeo calbasu (Hamilton-Buchanan)

Labeo rohita (Hamilton-Buchanan)

Genus: *Puntius* Hamilton-Buchanan

Puntius chola (Hamilton-Buchanan)

Puntius parrah (Day)

Puntius dorsalis (Jerdon)

Puntius filamentosus (Val.)

Puntius arulius (Jerdon)

Puntius bimaculates (Bleeker)

Puntius denisoni (Day)

Puntius amphibius (Val.)

Puntius sarana subnasutus (Val.)

Puntius carnaticus (Jerdon)

Puntius bovanicus (Day)

Puntius fasciatus (Jerdon)

Puntius jerdoni (Day)

Puntius ophicephalus (Raj)

Puntius vittatus Day

Puntius ticto (Hamilton-Buchanan)

Puntius conchonius (Hamilton-Buchanan)

Sub family: Cultrinae

Genus*:* *Chela* Hamilton-Buchanan

Chela dadiburjuri (Menon)

Chela fasciata Silas

Genus: *Salmostoma* Swainson

Salmostoma acinaces (Valenciennes)

Salmostoma boopis (Day)

Genus: *Esomus* Swainson

Esomus thermoicos (Valenciennes)

Genus: *Amblypharyngodon* Bleeker

Amblypharyngodon microlepis (Bleeker)

Genus: *Brachydanio* Weber and de Beufort

Brachydanio rerio (Day)

Genus*:* *Rasbora* Bleeker

Rasbora daniconius (Hamilton-Buchanan)

Genus: *Barilius* Hamilton-Buchanan

Barilus bendelisis (Hamilton-Buchanan)

Barilius gatensis (Valenciennes)

Barilius bakeri Day

Barilius canarensis (Jerdon)

Genus: *Danio* Hamilton-Buchanan

Danio malabaricus (Jerdon)

Danio aequipinnatus (McClelland)

Genus: *Lepidopygopsis* Raj

Lepidopygopsis typus Raj

Sub family: Garrinae

Genus: *Crosocheilus* van Hesselt

Crosocheilus periyarensis Menon and Jacob

Genus: *Garra* Hamilton-Buchanan

Garra gotyla stenorhynchus (Jerdon)

Garra mullya (Sykes)

Garra ceylonensis Bleeker

Garra periyarensis Gopi

Garra mcClellandii (Jerdon)

Garra menoni Remadevi and Indra

Garra hughi Silas

Garra travancoria Kurup and Radhakrishnan

Garra nilamburensis Kurup and Radhakrishnan

Garra mlapparaensis Kurup and Radhakrishnan

Garra surendranathani Shaji, Arun and Easa

Garra emarginata Kurup and Radhakrishnan

Family: Balitoridae

Subfamily: Balitorinae

Genus: *Bhavania* Hora

Bhavania auatralis (Jerdon)

Genus: *Travancoria* Hora

Travancoria elongata Pethiyagoda and Kottelat

Travancoria jonesi Hora

Genus: *Baltora* Gray

Baltora mysorensis Hora

Genus: *Homaloptera* van Hesselt

Homaloptera pillai Indra and Remadevi

Homaloptera silasi Kurup and Radhakrishnan

Subfamily: Nemachilinae

Genus: *Oreonectes* Gunther

Oreonectes keralensis Rita and Nalbant

Genus: *Acanthocobitis* Peters

Acanthocobitis botia (Hamilton-Buchanan)

Genus: *Schistura* McClelland

Schstura denisoni (Day)

Schistura semiarmatus (Day)

Schistura striatus (Day)

Schistura nilgiriensis (Menon)

Genus: *Nemacheilus* Bleeker

Nemacheilus monilis Hora

Genus: *Mesonemacheilus* Banarescu and Nalbant

Mesonemacheilus pambarensis (Remadevi and Indra)

Mesonemacheilus periyarensis Kurup and Radhakrishnan

Mesonemacheilus guntheri (Day)

Mesonemacheilus triangularis (Day)

Mesonemacheilus menoni Zacharias and Minimol

Mesonemacheilus petrubenarescui (Menon)

Mesonemacheilus remadevi Shaji and Easa

Family: Cobitidae

Genus: *Lepidocephalus* Bleeker

Lepidocephalus thermalis (Valenciennes)

Order: Siluriformes

Family: Bagridae

Genus: *Horabagrus* Jayaram

Horabagrus brachysoma (Gunther)

Horabagrus nigricollaris Pethiyagd and Kottelat

Genus: *Batasio* Blyth

Batasio travancoria Hora and Law

Genus: *Mystus* Scopoli

Mystus bleekeri (Day)

Mystus cavasius (Hamilton-Buchanan)

Mystus oculatus (Valenciennes)

Mystus armatus (Day)

Mystus gulio (Hamilton-Buchanan)

Mystus montanus (Jerdon)

Mystus vittatus (Bloch)

Mystus menoda (Hamilton-Buchanan)

Mystus malabaricus (Jerdon)

Family: Siluridae

Genus: *Wallago* Bleeker

Wallago attu (Schneider)

Genus: *Ompok* Lacepede

Ompok malabaricus (Valenciennes)

Ompok bimaculatus (Bloch)

Genus: *Silurus* Linnaeus

Silurus wynaadensis (Day)

Family: Schilbeidae

Genus: *Pseudeutropius* Bleeker

Pseudeutropius mitchelli Gunther

Family: Sisoridae

Genus: *Glyptothorax* Blyth

Glyptothorax anamalaensis Silas

Glyptothorax annandalei Hora

Glyptothorax lonah (Sykes)

Glyptothorax madraspatnam (Day)

Family: Clariidae

Genus: *Clarias*

Clarias dussumieri Valenciennes

Family: Heteropneustidae

Genus: *Heteropneuste*

Heteropneustes fossilis (Bloch)

Order: Beloniformes

Family: Belonidae

Genus: Xenentodon *Regan*

Xenentodon cancila (Hamilton-Buchanan)

Order: Cyprinidontiformes

Family: Aplocheilidae

Genus: *Aplocheilus* McClleland

Aplocheilus blocki (Arnold)

Aplocheilus lineatus (Valenciennes)

Family: Poecilidae

Genus: *Poecilia* Bloch and Schneider

Poecilia reticulata Peters

Order: Syngnathiformes

Family: Syngnathidae

Genus: *Microphis* Kaup

Microphis cuncalus (Hamilton-Buchanan)

Order: Synbranchiformes

Family: Mastacembelidae

Genus*:* *Macrognathus* Lacepede

Macrognathus aral (Bloch and Schneider)

Genus: Mastacembeles Lacepede

Mastacembelus armatus (Lacepede)

Order: Perciformes

Family: Ambassidae

Genus: *Parambassis* Bleeker

Parambassis dayi (Bleeker)

Parambassis thomassi (Day)

Genus*:* Pseudambassis Bleeker

Pseudambassis baculis (Hamilton-Buchanan)

Family: Nandidae

Genus: *Nandus* Valenciennes

Nandus nandus (Hamilton-Buchanan)

Sub Family: Pristolepidinae

Genus: ***Pristolepis*** Jerdon

Pristolepis marginatus Jerdon

Family: Cichilidae

Genus: ***Oreochromis*** Gunther

Oreochromis mossambica (Peters)

Genus: *Etroplus* Cuvier

Etroplus maculates (Bloch)

Etroplus suratensis (Bloch)

Family: Blennidae

Genus: ***Salarias*** Cuvier

Salarias reticulates Kurup and Radhakrishnan

Sub order: Gobiodei

Family: Eleotrididae

Genus: ***Eleotris*** Bloch and Schneider

Eleotris fusca (Schneider)

Family: Gobiidae

Sub family: Gobiinae

Genus: ***Glossogobius*** Gill

Glossogobius giuris (Hamilton-Buchanan)

Genus: ***Awaous*** Valenciennes

Awaous gutum (Hamilton-Buchanan)

Genus: ***Sicyopterus***

Subfamily: Sicydiaphiinae

Genus: *Sicyopterus* Gill

Sicyopterus griseus (Day)

Suborder: Anabantoidea

Family: Anabantidae

Genus: ***Anabas*** Cuvier

Anabas testudineus (Bloch)

Family: Belontidae

Genus: ***Macropodus*** Bleeker

Macropodus cupanus (Valenciennes)

Suborder: Channoidei

Family: Channidae

Genus: ***Channa*** Scopoli

Channa orientalis Bloch and Schneider

Channa micropeltes (Cuvier)
Channa marulius (Hamilton-Buchanan)
Channa striatus (Bloch)

Order: Tetradontiformes

Family: Tetradontidae

Genus: *Tetradon* Linnaeus

Tetradon travancoricus Hora and Nair

SYSTEMATIC DESCRIPTION

Superclass: Gnathostomata

Class: Actinopterygii

Sub class: Neopterygii

Division: Teleostei

Key to orders

1. a) Body eel shaped 2

   b) Body not eel shaped 3

2. a) Gill openings confluent, dorsal and anal fins vestigial ....Synbranchiformes

   b) Gill openings free, dorsal and anal fins long, continuous with caudal fin ....Anguilliformes

3. a) Body short, round and bones on jaws fused to form a beak...Tetradontiformes

   b) Body fusiform, bones on jaws not fused 4

4. a) Skin without scales, pectoral fin spine osseous, strong and serrated..Siluriformes

   b) Skin usually with scales, pectoral fin spine with no such modifications..5

5. a) abdominal edge keeled with serrations........ 6

b) Abdominal edge usually smooth and round.................................7

6. a) Abdominal edge with single serration, anal fin short and lateral line absent.................. ....Clupeiformes

b) Abdominal edge with double serrations, anal fin very long and lateral line present..Osteoglossiformes

7. a) an osseous gular plate at symphysis of lower jaw covering the intermediate area..Elopiformes

b) No such gular plate present..8

8. a) Body encased in a series of bony rings ....Syngnathiformes

b) Body not encased in bony rings..9

9. a) Body elongate, cylindrical and both upper and lower jaws extended in to long beaks and with sharp teeth............................Beloniformes

b) Body compressed, jaws not forming beaks................................10

10. a) No spines in dorsal and anal fins, snout spatulate, eyes placed much superiorly, lateral line chiefly on head....................Cyprinidontiformes

b) Dorsal and anal fins may have spines, snout not spatulate, eyes placed in the middle of the head, lateral line if present, always on body..11

11. a) Scales on head, jaws with teeth and generally with two dorsal fins..Perciformes

b) No scales on head, jaws toothless, always with a single dorsal fin ....Cypriniformes

ORDER: OSTEOGLOSSIFORMES

Family: Notopteridae

Genus *Notopterus* Lacepede

Notpterus Lacepede, *Hist. Nat. Poiss.*, 2: 183, 1800 (Type, *Gymnotus notopterus* Pallas).

Notopterus notopterus (Pallas)

(Plate II, Fig. 1)

Gymnotus notopterus Pallas, *Specil. Zool.*, Petersburg, 7:40, pl.6, fig.2, 1769 (Type locality: ponds and river of Bengal).
Notopterus kapirat Lacepede, *Hist. Nat. poiss.*, 2:190,1800
Mystus kapirat Hamilton-Buchanan, *Fish. Ganges*, pp.235,385,1822 (Ponds and rivers of Bengal)
Notopterus osmani Rahimullah and Das, *Bull. Soc. Port. Nat.*, 12(18): 136, pl.23, 1936 (Type locality: rivers of Hyderabad, Deccan)

Common name: Grey feather back **Local name:** Pulluvala, Ambattanvala

Distinguishing characters: (Based on 4 specimens, 152- 256 mm TL)

D. 8; P.14-16; V. 5; A. 93-95; C.15.

Elongate, deep and highly compressed body. Dorsal profile more convex than ventral. BD 21.02-28.37 (24.7) and HL 27.12-27.73 (27.42) in SL. Head compressed, snout blunt. Eyes moderate, 15.93-18.64 (17.28) in HL and are placed a little bit anteriorly and superiorly. Mouth moderate to large, terminal, maxillae extend to beyond middle of orbit. A pair of small rostral barbells present. Abdomen in front of pelvic fin sharp edged. Dorsal fin small, HD 48.11-48.37 (48.24) in HL, inserted more close to caudal fin than snout. Pectoral fin originates below opercula. HP 109.74-121.72 (115.73) in HD. Pelvic fins rudimentary with bases united. HV 20.20-22.21 (20.09) in HP. Anal fin very long and continuous with caudal fin. HC 8.91-9.49 (9.20) in SL. LCPD 9.87-10.21 (9.91) in SL. Scales minute, Lateral line abrupt. Grayish silvery to dull white body with fins grayish.

Geographical distribution: Pakistan, India, Nepal, Bengladesh, Burma, Thailand, Malaya and Indonesia (Talwar and Jhingran, 1991; Menon, 1999)

Distribution in Kerala: Periyar Tiger Reserve (Chacko, 1948; Zacharias *et al.*, 1996), Kerala part of Nilgiri Biosphere Reserve (Easa and Basha, 1995) Kabbini and Chalakkudy rivers (Shaji and Easa, 1996; Ajithkumar *et al.*, 1999), 4 rivers of Kerala (Ajithkumar *et al.*, 2000; Kurup, 2002; Kurup *et al.*, 2004).

Habitat : Pools of stagnant or clear waters with sandy or gravelly bottom

Fishing methods: Cast nets and gill nets.

ORDER: ELOPIFORMES

Genus ***Megalops*** Lacepede

Megalops Lacepede, *Hist. nat. Poiss.*, 5, p.289, 1803 (Type, *Megalops filamentosus* Lacepede)

Megalops cyprinoides (Broussonet)

(Plate II, Fig. 2)

Clupea cyprinoides Broussonet, *Ichth.*, pl. 9, 1782
Megalops filamentosus Bleeker, *Atlas Ichth. Ind. Neerl.*, vi, 1782, pl. 82

Common name: Oxeye tarpon **Local name:** Palan, Palankanni

Distinguishing characters: (Based on 3 specimens, 178-206 mm TL)

D. ii, 16-18; P. i,14-15; V. i,10; A. ii,22-24; C.19; Ll. 40-41, Ltr. 4.5-5/2.5-3

Elongate, moderately deep and distinctly compressed body. Abdomen rounded, head moderate and compressed. BD 27.35-29.04 (28.20) and HL 29.12-29.32 (29.26) in SL. Eyes larger, 26.47-26.99 (28.23) in HL. Mouth superior, lower jaw prominent and slightly projecting. Two supramaxillaries present on either side of mouth. A median bony gular plate present between arms of lower jaw. Cleft of mouth extending to first one by third of orbit. Barbells absent. Dorsal fin closer to caudal base than snout, last ray elongate, filamentous. HD 125.71-131.24 (128.47) in HL, upper margin concave. DB 27.54-40.75 (34.15) in HD. HP 50.15-54.69 (52.42) in HD. HV 69.47-71.31 (70.39) in HP. in LCPD 7.8-8.2 (8.00) in SL. Caudal deeply forked, HC 32.19-35.74 (33.97) in SL. Body with cycloid scales. Lateral line complete. Body brilliantly silver coloured. Fins generally red orange and pectoral fins yellowish.

Geographical distribution: Indo-West Pacific (Talwar and Jhingran, 1991)

Distribution in Kerala: Chaliyar and low land waters of Trichur (Easa and Shaji, 1997), Periyar (Kurup *et al.*, 2004).

Habitat: Pool habitats at the downstream with sand or mud as substratum.

Fishing method: Gill nets.

ORDER: ANGUILLIFORMES

Family: Anguillidae

Genus ***Anguilla*** Schrank

Anguilla Schrank, *Fauna Bioca*, 1:76, 1798 (Type, *Muraena anguilla* Linnaeus)

Body cylindrical and elongate, compressed at tail portion. Dorsal and anal fins long and continuous with caudal fin. Anterior nostrils in the form of a free tube. Gill openings in the form of vertical slits. Dorsal fin commences far behind gill openings. No spines on fins. Pelvic fins absent. Lateral line in the form of minute pores.

Key to species

1. a) Dorsal fin inserted near anus.....................*Anguilla bicolor bicolor*

   b) Dorsal fin inserted far infront of anus .... *Anguilla bengalensis bengalensis*

Anguilla bicolor bicolor McClleland

(Plate II, Fig. 3)

Anguiilla bicolor McClelland, *Culcutta J. nat. Hist*, 5(8): 178, pl.6, fig.1, 1845 (Type locality: Sandoway, Burma)
Anguilla mowa Bleeker, *Verh, Bat Gen.*, 25:16, 1856
Anguilla moa Bleeker, *Verh, Bat Gen.*, 25: 22,1853
Anguilla australis (nec Richardson) Jones and Sujansinghani, *Indian J. Fish.*, 2:270, 1954 (Chilka lake)

Common name: Short fin eel **Local name:** Mananjil

Distinguishing characters: (Based on 4 specimens, 342- 386 mm TL)

D. 220-245; P.16-18; A. 200-220

BD 5.2-6.4 (6.1) and HL 13.68-14.48 (14.23) in SL. Eyes small, 6. 98-7.62 (7.52) in HL, HD 15.86-16.94 (16.34) in HL, HP 132.85-142.92 (138.59) in HD. Angle of mouth a little behind posterior margin of eyes. Dorsal fin inserted slightly infront or after anus. Body olive green or greenish brown. Fins greenish brown. Ventral side at abdominal portion lighter or dirty white.

Geographical distribution: East Africa to Pakistan, India and Sri Lanka (Talwar and Jhingran, 1991)

Distribution in Kerala: Travancore (Hora and Law, 1941), Periyar Tiger Reserve (Chacko, 1948), Chalakkudy and Periyar rivers (Ajithkumar *et al.*, 2000), rivers of Kerala (Shaji and Easa, 2001), Chalakkudy (Kurup *et al.*, 2004)

Habitat: Riffle-pool habitats at upstream with bedrock and boulders as substratum. It is also available in pool-run habitats of low lands.

Fishing method: Gill nets.

Anguilla bengalensis bengalensis (Gray)

(Plate II, Fig. 4)

Muraena bengalensis Gray, *Ill. Ind. Zool*; pl. 95, fig. 5, 1831 (Type locality: The Ganges)
Anguilla nebulosa McClelland, *Culcutta J. Nat. Hist.*, 5:179, 1844
Anguilla marmorata Kaup, *Cat Apodal Fish., Brit. Mus.*,p. 43, fig. 32, 1856
Anguilla anguilla Kulkarni and Ranade, *Maharashtra State Gazett. Faun.* p.53, 1974

Common name: Indian longfin eel **Local name:** Mananjil

Distinguishing characters: (Based on 12 specimens, 312- 512 mm TL)

D. 250-305; P.17; A.220-250

BD 5.36-6.1 (5.9) and HL12.96-14.2 (13.17) in SL. Eyes 6.32-7.84 (7.6) in HL, HD 14.62-16.24 (15.65) in HL, HP135.24-148.63 (143.39) in HD. Angle of mouth distinctly behind posterior margin of eyes. Dorsal fin inserted far infront of anus. Body olive green or greenish brown. Fins greenish brown. Ventral side at abdominal portion lighter or dirty white.

Geographical distribution: East Africa to Pakistan, India and Sri Lanka (Talwar and Jhingran, 1991)

Distribution in Kerala: Travancore (Hora and Law, 1941), Periyar Tiger Reserve (Chacko, 1948), Kunthi river in Silent valley (Shaji and Easa, 2001), Chlakkudy, Periyar and Pamba river systems (Kurup *et al.*, 2002 and 2004)

Fishing method: Gill nets.

ORDER: CLUEPIFORMES

Family: Cluepidae

Sub family: Pellonulinae

Genus ***Dayella*** Talwar and Whitehead

Dayella Talwar and Whitehead, *Bull.Brit.Mus.nat.Hist.(Zool.)*, 22 (2), p.63 (type, *Spraelloides malabaricus* Day)

Dayella malabarica (Day)

(Plate II, Fig. 5)

Spratelloides malabaricus Day, *FAO Fish. Synop.*, (125) 7(1), pp. 173-174, 1985 (Type locality: Malabar coast)

Common name: Day's round herring

Distinguishing characters: (Based on 11 specimens, 46-72 mm TL)

D. ii, 11; P.1,10-12;V.i,8 A.iii,13;C.19; Ll.38; Ltr.3.5-4/3.5-4

Body small and slender, belly round and not keeled. Pre pelvic scutes present. BD 20.11-26.32 (22.45) and HL 21.36-32.45 (28.65) in SL. Eyes 23.58-29.65 (28.63) large, in HL. Mouth terminal, lower jaw slightly projecting. Dorsal fin placed at middle of body, HD 82.67-89.63 (87.61) in HL, HP 71.59-81.29 (79.02) in HD and HV 70.59-76.93 (73.25) in HP. Pelvic fins inserted behind dorsal fin origin. Body yellowish green, ventral side silvery white. A silvery golden stripe along flank. Upper lobe of caudal fin tipped with blue.

Geographical distribution: South Western India (Talwar and Jhingran, 1991)

Distribution in Kerala: Vembanad lake (Remadevi *et al.*, 1996); Midland areas of rivers of Kerala (Ajithkumar *et al.*, 1999), Periyar river system (Kurup *et al.*, 2004)

Habitat: Riffle-pool habitats at upstream with gravel or cobbles as substratum.

Fishing method: Cast nets.

ORDER: CYPRINIFORMES

Family: Cyprinidae

Body covered with scales, generally compressed. Abdomen rounded or cutting. Eyes never covered with skin. Mouth with or without a sucker, more or less protractile and toothless. Upper jaw usually bordered only by pre maxilla, Lower jaw may be prominent, sharp or rounded, some times provided with a symphysial knob. Lips usually thin, not with papillae and sometimes absent from one of jaws or closely adnate to both jaws. Barbells present or absent. if present, usually one or two pairs. Labial fold present, continuous or interrupted. Gill openings wide and gill membranes usually joined with isthmus. Last unbranched ray of dorsal fin spiny, osseous, smooth or articulated. No well developed adipose fin. Pharyngeal teeth one to three rows, never more than eight teeth in any one row, Lateral line complete or incomplete.

Key to subfamilies

1. a) Upper lip not separated from snout.................................*Garrinae*

   b) Upper lip separated from snout...2

2. a) Scales irregularly scattered over the body and some portion scale less, row of tile-like scales between vent and anal fin...*Schizothoracinae*

   b) Scales regular, complete, no such scale pattern between vent and anal fin..3

3. a) Abdominal edge keel like, dorsal fin inserted more towards caudal base than snout tip...*Cultrinae*

   b) Abdominal edge round, not keel like...4

4. a) Lower jaw with a symphysial process............................*Rasborinae*

   b) Symphysial process absent...*Cyprininae*

Sub family: Cyprininae

Fishes with laterally compressed, elongate or ovate body. Head without scales. Abdomen usually round. Mouth mostly protractile and always toothless. Jaws smooth or with a horny covering. Barbells rostral and maxillary, both pairs may absent sometimes. Dorsal fin inserted before or opposite to (rarely slightly behind) base of pelvic fins, of varying heights, with or without a spine which may be smooth or serrated, weak or osseous and with 7-30 branched rays. Anal fin short with 5-9 branched rays, pectoral and pelvic fins laterally inserted. Scales small to large. Lateral line complete or incomplete, generally running in middle of body.

Key to Genera

1. a) Anal fin with anterior rays osseous, third spine serrated........*Cyprinus*

   b) Anal fin with anterior rays not serrated..2

2. a) Dorsal fin inserted posterior to pelvic fin........................*Osteobrama*

   b) Dorsal fin inserted above pelvic fins or slightly anterior to it.............3

3. a) Lower jaw with a small post symphysial knob.....................*Cirrhinus*

   b) Lower jaw without a post symphysial knob..................................4

4. a) Upper lip absent, Head comparatively large............................*Catla*

   b) Upper lip present, Head normal..5

5. a) Snout with median and lateral projections, lips with dense and tiny papillae, scales with extensive radii.........................*Gonoproktopterus*

   b) Snout without any lateral projections, lips plain...............................6

6. a) Lower lip develops in to a fleshy lobe below mandibular symphysis 7

b) Lower lip does not develop in to fleshy lobe..........8

7. a) Gill rakers on lower arm 6-9..........*Tor*

b) Gill rakers on lower arm 10-14..........*Neolissochilus*

8. a) No horny covering on inner side of lips..........*Puntius*

b) Horny covering on inner side of one or both lips..........9

9. a) Horny covering inside lower jaw is covered with fringed lips ....*Labeo*

b) Horny covering inside lower jaw not covered by lips..........10

10. a) Last unbranched dorsal ray osseous..........*Kantaka*

b) Last unbranched dorsal ray week..........*Osteochilus*

Genus ***Cirrhinus*** Cuvier

Cirrhinus (Oken), Cuvier, *Regne Animale*, 2: 193, 1817 (Type, *Cyprinus cirrhosa* Bloch)

Body elongate, abdomen rounded. Head moderate to small. Mouth sub terminal, Lower jaw rather sharp, Upper lip not continuous with lower lip. Lower lip thin and closely adnate to lower jaw. Barbells one pair. Eyes moderate to large, Dorsal with last unbranched ray non-osseous and non-serrated. Lateral line complete, scales hexagonal, having grayish to dark edges which apparently give appearance of several continuous lines along flanks. Caudal forked. The members of this genus closely resemble *Labeo*, but differences are seen in the lower lip closely adnate to lower jaw and in the absence of the inner transverse labial folds.

Key to species

1.a) Dorsal fin with eight branched rays, body depth much more than head length, lateral line scales 40..*Cirrhinus reba*

b) Dorsal fin with 12-13 branched rays, body depth about equal to head length, lateral line scales 40-42..............................*Cirrhinus mrigala*

Cirrhinus reba (Hamilton-Buchanan)

(Plate II, Fig. 6)

Cyprinus reba Hamilton-Buchanan, *Fish. Ganges*, pp.280, 386, 1822 (Type locality: rivers and ponds of Bengal and Bihar)
Cirrhina dussumeiri Valenciennes, *Hist. Nat. Poiss.*, 16:291, pl. 480, 1842 (Mysore)
Cirrhina rewah Steindachner, *Sitz. Akad. Wiss. Wein.*, p.56, 1867
Crossocheilus reba Gunther, *Cat. Fish. Brit. Mus.*, 7:74, 1868 (India)

Common name: Reba carp **Local name:** Kavori meen

Distinguishing characters: (Based on 3 specimens, 181-205 mmTL)

D. ii, 8; P.i,14; V.i,8; A.ii,5; C.19; Ll. 40, Ltr. 6.5-7/4.5-5

Elongate, BD 24.23-25.32 (24.942) and HL 14.36-16.19 (15.27) in SL. BD much more than HL, 168.72-162.35 (164.3) in latter. Snout slightly projecting. Eyes 39.10-40.38 (39.74) in HL. Barbells one pair of rostrals only. Dorsal fin closer to snout than caudal, HD 156.05-162.56 (159.31) in HL, upper margin concave. DB 69.33-74.77(72.05) in HD. HP 70.03-75.69 (72.86) in HD. HV 96-99.16 (97.58) in HP. LCPD 17.20-18.44 (17.82) in SL. Caudal forked, HC 27.45-29.18 (28.32) in SL. Body with hexagonal scales. PDS 12-13. Grayish dorsally and flanks silvery. Scales with darker edges, forming grayish blue longitudinal bands especially above lateral line. Fins generally red orange.

Geographical distribution: India, Nepal, Pakisthan and Bengladesh (Talwar and Jhingran, 1991)

Distribution in Kerala: Kabbini river, Kerala (Easa and Basha, 1995; Kurup *et al.*, 2004)

Habitat: Found in the shallow riffle-pool and deep pool habitats with cobbles and sandy bottom.

Fishing method: cast nets and gillnets.

Cirrhinus mrigala (Hamilton-Buchanan)

(Plate II, Fig. 7)

Cyprinus migala Hamilton-Buchanan, *Fish. Ganges*, pp.297, 389, pl.6, fig.79, 1822 (Type locality: Ponds and freshwater rivers of Gangetic provinces)
Cirrhina plumbea Valenciennes, *Hist. Nat. poiss.*, 16:289, 1842 (Type locality: River Irrawady)
Cirrhina macrops Steindachner, *Sitz. Akad.Wiss Wein.*, 61: 636, 1870 (Type locality: Madrass)
Cirrhinus mrigala mrigala : Talwar and Jhingran, *Inland fish.*, 1:172,1991(Type locality: Northern India and Bengladesh)

Common name: Mrigal **Local name:** Mrigal

Distinguishing characters: (Based on 4 specimens, 202-362 mm TL)

D. iii, 12; P.i,14; V.i,8; A.ii,5; C.19; Ll. 40-42, Ltr. 6.5/5

Elongate, BD 26.28-22.52 (24.35) and HL 26.52-20.26 (23.48) in SL. BD about equal to HL, 99.28-108.21 (103.73) in latter. Snout blunt, eyes 20.42-26.58 (24.55) in HL. Barbells one pair of rostrals only. Dorsal fin closer to snout than caudal, HD 102-116 (111.15) in HL and less than body depth, upper margin concave. DB 76-84 (82.00) in HD. HP 82.32-92.31 (88.45) in HL. HV 79.21-88.21 (85.73) in HP. LCPD 10.24-16.2 (13.06) in SL. Caudal forked, HC 22.31-26.41 (24.30) in SL. Body with hexagonal scales. PDS 13. Grayish dorsally and flanks silvery. Scales with darker edges, forming grayish blue longitudinal bands above lateral line. Fins generally yellowish orange.

Geographical distribution: India; Pakistan and Bengladesh (Talwar and Jhingran, 1991)

Distribution in Kerala: Peppara Reservoir (Thomas and Aziz, 1999); Chalakkudy, Periyar, Bharathapuzha, Karuvannur and Keecheri rivers (Ajithkumar *et al.*, 2000), Bharathapuzha and Kabbini river systems (Kurup *et al.*, 2004)

Habitat: Pools with sandy or muddy bottom

Fishing method: Gill nets

Genus ***Cyprinus*** Linnaeus

Cyprinus Linnaeus, *Systema Naturae*, Ed. 10, 1, p.320, 1758 (type, *Cyprinus carpio* Linnaeus)

Cyprinus carpio Linnaeus

(Plate II, Fig. 8)

Cyprinus carpio Linnaeus, *Syst. Nat.*, ed. 10, 1758, p.320
Cyprinus carpio var. specularis Jones and Sarojini, *Jour. Bombay Nat. Hist. Soc.*, 1, 1952, fig. 4

Common name: Chinese carp **Local name:** gold, goldfish

Distinguishing characters: (Based on 12 specimens, 256-361 mm TL)

D. iii, 18; P. i,15; V.i,9; A.i,5; C.19; Ll. 39-40, Ltr. 5.5/4.5

Body stout and deep. BD 40.65 and HL 35.50 in SL. Head triangular, Snout conical and tip blunt. Eyes moderate, 18.46 in HL. INTO 38.87 in HL. Barbells two pairs, rostral and maxillary, latter more in length than former. Dorsal fin equally placed between snout and caudal fin, long, HD small, 58.46 in HL and 20.75 in SL. DB 179.31 in HD. Pectorals longer, HP 68.72 in HL and 117.56 in HD. HV 93.22 in HP. LCPD 15.22 in SL. Caudal forked, HC 32.20 in SL. Scales on body are broader, PDS 10. Usually olivaceous with silvery or golden sides. Fins yellowish, reddish or golden.

Geographical distribution: Central Asia (Talwar and Jhingran, 1991)

Distribution in Kerala: Periyar, Malampuzha, Idukki, Peringalkuthu reservoirs and Kabbini and Chalakkudy rivers (Shaji and Easa, 2001; Periyar

Tiger Reserve (Zacharias *et al.,*1996., Kurup and Ranjeet, 2002) Kerala part of NBR(Easa and Basha,1995), Chalakkudy river system (Kurup *et al.*, 2004)

Habitat: Pools at upper, middle and lower streches of river systems

Fishing method: Gill nets

Genus ***Catla*** Valenciennes

Catla Valenciennes In: Cuvier & Valenciennes, *Hist. Nat. Poiss.*, 18,410, 1844 (Type, *Catla buchanani* Valenciennes)

Catla catla (Hamilton-Buchanan)
(Plate II, Fig. 9)

Cyprinus catla Hamilton-Buchanan, *Fish. Ganges.*, pp.287, 318, 387, pl.13, fig. 81, 1822 (Type locality: rivers and tanks of Bengal)
Cyprinus abramioides Sykes, *Trans, zool. Soc.*, 2:353, pl. 61, fig. 2, 1841
Leuciscus catla Valenciennes, *Balang. Voy, Ind. Orient.*, p. 379, pl. 3, fig. 2, 1844
Hypselobarbus abramioides Bleeker, *Consp. Syst. Cypr.*, p. 430,1860

Common name: Catla **Local name:** Catla

Distinguishing characters: (Based on 4 specimens, 202-452 mm TL)

D. iii, 14-16; P.i,20; V.i,8; A.ii,5; C.19; Ll. 40-43, Ltr. 6.5/6

Body deep, BD 39.28-38.49 (38.46) in SL. Head enormously large and mouth uptuned. HL 41.23-43.29 (43.22) in SL. Lower jaw prominent. Snout blunt, mouth wide and terminal. Upper lip absent, lower lip thick. Eyes more anteriorly placed and 15.26-14.89 (14.29) in HL. INTO wide, 44.28-43.25 (42.66) in HL. Barbells absent. Dorsal fin equidistant between snout and caudal, Upper margin concave. PDS 15-16. Grayish on back and flanks, silvery white below. Fins dusky.

Geographical distribution: India and Pakisthan (The species is transplanted to many other countries including Srilnka and China) (Talwar and Jhingran, 1991)

Distribution in Kerala: Chalakkudy, Periyar, Neyyar; Karuvannur, Moovattupuzha, Pambar, Valapatnam, Kuttiyadi, Chaliyar and

Bharathapuzha rivers and connected reservoirs (Ajithkumar *et al.*, 2000; Shaji and Easa, 2001), Malampuzha, Thenmala and Walayar reservoirs (Kurup *et al.*, 2004).

Habitat: Pools with sandy or muddy bottom

Fishing method: Gill nets

Genus ***Neolissochilus*** Rainboth

Neolissochilus Rainboth, *Beufortia*, 35, No. (3): 26 1985 (Type, *Barbus stracheyi* Day)

Neolissochilus wynaadensis (Day)

(Plate II, Fig. 10)

Barbus wynaadensis: Day, *J. Linn. Soc.*, 11: 528, 1873 (Vithiry, Wynaad, Kerala)
Puntius wynaadensis Jayaram, *HBFW Fish. India*. 103,1981(Type locality: Vythiri, Wynaad, Kerala)
Barbus wynaadensis Rainboth, *Beaufortia*, 35(3): 29, 1985

Common name: South Indian Barb **Local name:** Kadanna

Distinguishing characters: (Based on 4 specimens, 202- 452 mm TL)

D. iii-iv, 9-10; P.i,13-15; V.i,8; A.ii,5; C.19; Ll.28-30, Ltr.3.5-4

Body tapered from a rather broad head, moderately deep trunk to a compressed peduncle. BD 23.30-27.77(19.88) in SL and 78.06-95.12(67.05) in HL. HL 28.86-32.47(30.23) in SL. Labial folds interrupted in middle. Mouth terminal. Eyes anteriorly placed, visible from lower side of head, 18.43-23.45 (21.38) in HL. INTO 30.75-32.82 (30.72) in HL. Barbells two prominent rostral and maxillary pairs, latter more than eyes and longer than former. Dorsal fin equidistant between snout and caudal, upper margin concave, HD 55.07-73.03 (66.65) in HL. DB 65.13-79.58 (73.29) in HD. HP 86.9-104.85 (93.35) HV 82.16-107.88 (92.59) in HP. LCPD 13.74-15.47 (14.56) in SL. Caudal forked, HC 25.97-30.93 (27.19) in SL. PDS 11-13. Back olivaceous, golden yellowish on flanks, a dark band running from behind eye to middle of caudal base where it often ends in a black blotch. Fins yellowish orange.

Geographical distribution: India (Talwar and Jhingran, 1991)

Distribution in Kerala: Wynaad (Kerala) and headwaters of Cauveri river (Talwar and Jhingran, 1991); Kabbini river, Wynaad (Shaji and Easa, 2001; Kurup, 2002 and Kurup *et al.*, 2004).

Habitat: shallow to deep pool-run habitats with thick instream cover and a substratum preferably with sand, cobbles.

Fishing method: cast nets and gillnets.

Genus ***Tor*** Gray

Tor Gray, *Ill Indian Zool*, 2: 196, 1834 (Type, *Tor Hamilton-Buchananii* Gray)

Elongate and moderately compressed fishes. Head broadly pointed, Mouth terminal or subterminal in position, eyes at anterior part of head, not visible from ventral surface. Lips continuous, fleshy, often hypertrophied. Lower lip with a medium lobe (mentum) and post-labial groove continuous. A pair of rostral and maxillary barbells. Dorsal fin inserted above ventral fin with strong or weak but smooth spine. Caudal fin deeply forked. Lateral line complete.

Key to species

1. a) Length of head shorter or more or less equal to body depth, dorsal spine weakly osseous, its length shorter than body depth........... *Tor khudree*

b) Length of head considerably greater than body depth, dorsal spine strong, osseous, its length equal to body depth.................................... 2

2. a) A characteristic hump over occiput, head and snout straight, mouth slightly upturned, Body bluish dark with fins red orange........... *Tor remadevii*

b) No hump over occipit, Head and snout normal, mouth slightly subterminal, body silvery with fins yellowish............................*Tor putitora*

Tor khudree (Sykes)

(Plate III, Fig. 11)

Barbus khudree Sykes, *Proc. Zool. Soc. Lond.*, p 159, 1838 (Mota-Mola River, 8 miles east of Poona)
Barbus malabaicus Jerdon, *Madras J. Lit. Soc.*, 15:312, 1849 (Mountain streams of Malabar)
Barbus longispinus Gunther, *Cat. Fish. Brit. Mus.*, 7: 132, 1868 (Ceylon)
Barbus (Tor) khudree malabaricus MacDonal, *J. Bombay Nat. Hist. Soc.*, 44(3): 52, 1944 (South Canara, Western Gnats, Travancore hills)

Common name: Deccan Mahseer **Local name:** Kuyil, Katti

Distinguishing characters: (Based on 16 specimens, 118-284 mm TL)

D. iii, 9; P. i, 14-15; V.i,8; A.i-ii,5; C.19; Ll. 22-23, Ltr. 3.5-4.5/2.5

Body elongate, dorsal profile more convex than ventral profie anteriorly. BD 26.23-27.73 (26.65) in SL and about equal to HL, 95.91-100.28 (98.10) of it. HL 26.15-28.22 (27.19) in SL. SNL 31.12-31.75 (31.44) in HL. Mouth slightly subterminal. Eyes anteriorly placed, 21.95-22.31 (22.13) in HL. Barbells rostral and maxillary pairs, latter longer and more than eyes. Dorsal fin equidistant between snout and caudal, upper margin concave, HD 91.52-94.64 (93.08) in HL.DB 54.86-57.55 (56.21) in HD. HP 82.89-84.10 (83.50) in HD. HV 86.58-90.60 (88.59) in HP. Caudal forked, HC 30.18-31.81 (30.49) in SL. HCPD 72.99-80.55(76.77) in LCPD. PDS 8. Metallic Silvery body with back more dark and ventral side creamy white. Fins generally red orange with bluish sheen. Head darkly olivaceous. The colour found varying based on habitat.

Geographical distribution: India and Srilanka (Talwar and Jhingran, 1991; Menon, 1999; Jayaram, 1999)

Distribution in Kerala: 10 rivers of Kerala (Shaji and Easa, 2001); Travancore ((Hora and Law, 1941), High ranges, Ponnani drainage, Anamalai hills (Silas, 1951), Chaliyar river, NBR (Easa and Basha, 1995), 16 rivers of Kerala (Ajithkumar *et al.*, 2000), 12 river systems of Kerala (Kurup *et al.*, 2004)

Habitat: cascades, rapids, riffle-pool habitats with bedrock, cobbles and gravels as substratum.

Fishing method: Cast nets and gill nets.

Tor remadevii Kurup and Radhakrishnan

(Plate III, Fig. 12)

Tor remadevii Kurup and Radhakrishnan, *J.Bombay Nat. Hist. Soc.* (in press)

Holotype: Deposited in ZSI (WGRS) CLT.No. V/F 13119a, 331.82 mm TL, Chambakkad, Pambar river, Chinnar Wild Life sanctuary, 18-5-2004

Para type: 2ex. Deposited in ZSI (WGRS) CLT.No. V/F 13119b, 160.84 mm and 113.64 mm TL, Chambakkad, Pambar river, Chinnar Wild Life sanctuary, 18-5-2004

Diagnosis: An elongated species with dorsal fin equal to depth of body and with a strong osseous spine, head straight, shout pointed and with a terminal or slightly upturned mouth, head length more than body depth, a deep hump at occipit, lateral line scales 27-29. Body color greenish to metallic silvery along back and fins reddish with blackish patches.

Distinguishing characters: (Based on 19 specimens, 113.64-331.82 mm TL)

D IV, 10; P i, 15; V I 8; A i, 5; C.19 Ll. 27-29, Ltr. 4.5/2.5-3

Body elongate, HL 31.48-33.68 (32.45) in SL. BD 84.43-90.10 (83.55) in head length and 25.60-28.37 (27.09) in SL. HW 39.19-44.89 (41.02) in HL. Snout elongated and SNL form 30.45-48.17(34.33) in HL and 9.29-16.09(11.15) in SL. Eyes lie at posterior half and superiorly and its diameter form 13.21-23.55 (18.49) in HL. Dorsal profile has a moderate to prominent hump after head region, before insertion of dorsal fin. Maxillary barbells more elongated than rostral barbells. Origin of dorsal lies opposite to that of pelvics and midway between tip of snout and base of caudal fin. Dorsal spine forming 96.28-101.24 (99.02) in latter, 27.91-30.87(29.60) in SL and 88.12-96.04 (91.22) in HL. HP form 60.13-74.73 (67.10) in HD, HV 91.18-99.34 (92.51) in HP. Caudal fin is sharply divided. HC 25.87-29.49 (27.54) in SL. LCPD 14.42-17.23 (15.60) in HL. HCPD 68.29-88.67 (74.46) in its length. PDS 9-11, pre ventral scales 8 and pre anal scales 17-18. Scales between pectoral and ventral fins 8, pelvic and anal fins 9-10. circumpeduncular scales 11-16. Dorsal side of body greenish to metallic black with sides silvery and on ventral side white. Head silvery white while eyes are dark bluish. Fins are eventually reddish with blackish patches. Body uniformly silvery in colour in younger specimens, belly white and fins red orange.

Geographical distribution: India (Talwar and Jhingran, 1991, Jayaram, 1999; Menon, 1999)

Etymology: Named after the renowned freshwater fish taxonomist, Dr.K. Remadevi, Scientist, Zoological Survey of India, Chennai.

Other materials examined: *Tor putitora:* NBFGR, 1 ex. 186 mm TL

Habitat: Cascade and rapids at upstream of river Pambar and Chinnar.

Fishing method: Cast nets and Gill nets.

***Tor putitora* (Hamilton-Buchanan)**

(Plate III, Fig. 13)

Cyprinus putitora Hamilton-Buchanan, *Fish Ganges*, pp.303, 388, 1822 (Type locality: Eastern part of Bengal)
Cyprinus mosal Hamilton-Buchanan, *Fish Ganges*, pp.306,308, 1822 (River Kosi)
Barbus putitora Hora, *J. Bombay Nat. Hist. Soc.*,41(2): 272, 2 pls. and 2 figs., 1939
Tor putitora Menon, *Rec. Indian Mus.*, 52 : 22, 1954 (Nepal)

Common name: Yellow finned mahseer **Local name**: Kuyil

Distinguishing characters: (Based on two specimens, 278.4 and 138.58 mm TL.)

D Iii, 9; P i, 15; V I 8; A ii, 5; C.19 Ll. 26-27, Ltr. 3.5/2.5

Body elongate, HL 30.3-35.2 (33.82) 3.03 and BD 37.2-43.16 (38.53) in SL. Eyes lie on posterior half of head, 55.9-66.21 (59.23) in HL. Lips fleshy and continuous at corners of mouth. Both lips are hypertrophied in small specimen. Dorsal and ventral profiles are equally convex. Maxillary barbells more elongated than rostral barbells. Origin of dorsal lies opposite to that of pelvics and midway between tip of snout and base of caudal fin. Caudal fin sharply divided. Pelvic fin bears a well-developed scaly appendage. Pre dorsal scales 9-10. Dorsal side of body greenish black while ventral profile silvery. Head slightly yellowish white while eyes are dark bluish. Fins are eventually golden yellowish and paired fins are characterized with fringed red colouration. Caudal fin mottled black.

Geographical distribution: India (Talwar and Jhingran, 1991; Jayaram, 1999)

Distribution in Kerala: Kabbini river system (First report)

Habitat: Riffles and pools at upstream of river Kabbini.

Fishing methods: Cast nets and Gill nets.

Genus ***Osteobrama*** Heckel

Osteobrama Heckel, *Ichth.* In *Russegger's Reisen in Europe, Asian and Africa*, 1: 1033, 1842 (type, *Cyprinus cotio* Hamilton)

Osteobrama bakeri (Day)

(Plate III, Fig. 14)

Rohtee bakeri Day, *Proc. Zool. Soc.*, 240, 1873 (Type locality: Kottayam in Travancore)
Osteobrama bakeri Jayaram, *HBFW Fish. India*, p. 113, 1981 (Kottayam, Kerala)

Common name: Malabar Osteobrama **Local name:** Mullan paval

Distinguishing characters: (Based on 10 specimens, 112-138 mm TL)

D. ii, 8; P. i, 15; V.i,8; A.iii,11; C.19; Ll. 52-53, Ltr. 10/ 7.5

Body trapezoid and compressed. Abdominal edge sharp between bases of ventral and anal fins, but rounded in front of pelvic fins. BD 29.32-34.21 (31.96) in SL, 106-117.24 (110.74) in HL, HL small, 27.28-29.64(28.86) in SL. Snot broadly pointing, SNL 25.64-27.32 (26.94) in HL. Mouth small, subinferior. Eyes large, 34.52-37.59 (34.92) in HL. Barbells small rostral and maxillary pairs. Dorsal fin inserted ahead of pelvic fins, dorsal spine weakly osseous and serrated. HD 101.2-107.26 (101.38) in HL.DB 41.65-43.98 (43.22) in HD. HP 66.32-68.95 (68.66) in HD. Caudal forked with anterior rays elongated. HC 37.65-39.42 (38.03) in SL. HCPD 93.28-98.21 (94.58) in LCPD. Scales small and deciduous. PDS 22. Body silvery with fins generally reddish.

Geographical distribution: India (Talwar and Jhingran, 1991; Jayaram, 1999)

Distribution in Kerala: Periyar, Chalakudy, Karuvannur, Moovattupuzha, Meenachil, Manimala, Chandragiri, Chaliayr and Bharathapuzha (Ajithkumar *et al.*, 2000); Travancore (Hora and Law, 1941), Chaliayr river, NBR (Easa and Basha 1995), Periyar and Chalakkudy river systems (Kurup *et al.*, 2004).

Habitat: Pools and pool-riffle habitats with sandy and muddy substratum.

Fishing methods: cast nets and gill nets.

Genus *Osteochilus* Gunther

Osteochilus Gunther, Cat. Fishes Brit. Mus., 7, p.40, 1868 (Type , *Rohita melanopleura* Bleeker, by subsequent designation)

Elongate and compressed fishes, head small to moderate, snout conical, tip obtusely round, covered with tubercles. Eyes moderate to large, mouth sub inferior. Lower lip broadly confluent with isthmus, Labial fold absent. Lower jaw forms a sharp projecting bony edge not covered by lower lip. Barbells absent. Dorsal fin elongated, dorsal spine weak or strongly osseous (sub genus *Kantaka*), caudal fin forked, lateral line complete. 23 species, 7 species in India and 3 species in Kerala

Key to species

1. a) Last unbranched dorsal ray osseous and strong..*Osteochilus (Kantaka) brevidorsalis*

   b) Last unbranched dorsal ray weak, non-osseous............................2

2. a)Last unbranched ray elongated, body without any colour bands...*Osteochilus longidorsalis*

   b) Last unbranched ray not elongated, A dark lateral band on body and dorsal fin dark, tips, hyaline...................................*Osteochilus nashii*

***Osteochilus* (*Kantaka*) *brevidorsalis* (Day)**

(Plate III, Fig. 15)

Semiplotus brevidorsalis Day, *Proc. Zool. Soc. Lond.*, p. 239, 1873 (Type locality: rivers below Nilgherry hills
Scaphiodon brevidorsalis Day, *Fish. India*, p. 552, pl. 133, fig.2, 1878 (rivers below the Nilghirri hills in the Madras presidency)
Osteochilus (*Kantaka*) *brevidorsalis* Hora, *Rec. Indian Mus*, 44(1):10, 1942

Common name: Kantaka barb **Local name:** Kadanna

Distinguishing characters: (Based on a single specimen, 236 mm TL)

D. iv, 11; P. i, 14; V.i,8; A.iii,5; C.19; Ll.40, Ltr. 7.5/4

Body oblong, compressed and deep, pre dorsal region distinctly elevated. BD 29.58-42.91(38.23) in SL, 111.26-128.32 (124.23) in HL, Head small, HL 23.68-29.64 (28.62) in SL. Snout swollen, overhanging jaws, three or more rows of large pores across and SNL 31.29-38.26 (36.24) in HL. Mouth small, sub inferior. Lips thin, upper lip crenulated. Eyes large, 22.36-28.53 (26.89) in HL. Barbells absent. Dorsal fin inserted close to snout, dorsal spine osseous and strong. HD 102.34-109.26 (108.23) in HL. DB 89.16-94.23 (92.32) in HD. HP 91.26-106.23 (98.23) in HD. Caudal forked. HC 24.62-31.29 (28.48) in SL. HCPD 69.32-76.33 (72.54) in LCPD. Scales small and deciduous. PDS 15. Silvery body, darker on back, Fins grayish.

Geographical distribution: India (Talwar and Jhingran, 1991; Jayaram, 1999)

Distribution in Kerala: Kabbini (Shaji and Easa, 2001; Kurup *et al.*, 2004).

Habitat: Prefers pool-run habitat with bedrock, cobbles and gravelly substratum. **Fishing methods:** Cast nets and gill nets.

Osteochilus longidorsalis Pethiyagoda & Kottelat

(Plate III, Fig. 16)

Osteochilus longidorsalis Pethiyagoda & Kottelat, *J. South Asian. Nat. Hist.*, 1, no. 1: 99, 1994 (Type locality: Upstream of Chalakkudy river)

Common name: Long finned barb **Local name:** Aameen

Distinguishing characters: (Based on 6 specimens, 112- 226 mm TL)

D. iii, 10; P. i, 13; V.i,8; A.ii-iii,5; C.19; Ll.39-41, Ltr.7.5/4

Body oblong, compressed, BD 29.59-45.62 (35.63) in SL, 119.52-129.52 (119.20) in HL, head small, HL 24.45-24.76 (24.54) in SL. Snout obtusely round and covered with tubercles at tip and sides. SNL 37.23-37.64 (37.48) in HL. Mouth small, sub-inferior, lips thin. Eyes large, 24.46-27.91 (26.29) in HL. Barbells absent. Dorsal fin inserted close to snout and anterior rays are elongated (anterior rays of other fins also shown slight elongation as fish matures), dorsal spine non-osseous and weak. HD 103.44-116.76 (114.65) in HL. DB 57.69-61.21 (59.26) in HD. HP 84 62-86.32 (85.48) in HD. HV 91.30-92.55 (91.98), Caudal forked. HC 25.87-30.87 (27.64) in SL. HCPD 82.08-87.33 (84.59) in LCPD. PDS 12-14. Silvery golden body, darker on back, Fins red orange with a yellowish tinge.

Geographical distribution: India (Talwar and Jhingran, 1991; Jayaram, 1999)

Distribution in Kerala: Chalakkudy river (Shaji and Easa, 2001, Ajithkumar *et al.*, 2000), Chalakkudy and Periyar river systems (Kurup *et al.*, 2004).

Habitat: Riffle-pool habitats with bedrock, cobbles and gravel as substratum.

Fishing methods: Cast nets and gill nets.

Osteochilus nashii (Day)

(Plate III, Fig. 17)

Barbus nashii Day, *Proc. Zoo. Soc. Lond.*, p. 584, 1868 (Type locality : Fraserpett river, Coorg, Karnatka)
Osteochilus malabaricus Day, *J. Linn. Soc.*, 11: 527,1873 (Vithiri, Wynaad)
Scaphiodon nashii: Day, *Fish. India*, p.552, pl.133, fig.3, 1878 (Coorg hill streams of South Canara and Wynaad)

Common name: Nash's barb **Local name:** Kadanna

Distinguishing characters: (Based on 7 specimens, 142-186 mm TL)

D. iv, 11; P. i, 13-14; V.i,8; A.ii,5; C.19; Ll. 42-43, Ltr. 7.5-8.5/5-5.5

Body oblong, compressed, moderately high, BD 24.95-33.53 (29.5) in SL, 95.54-112.43 (107.53) in HL, Head small, HL 25.92-29.83 (27.39) in SL. Snout obtusely round and covered with tubercles. Mouth small, subinferior. Lips thin. Eyes large, 21.64-26.05 (23.83) in HL. Barbells absent. Dorsal fin inserted slightly close to snout. Dorsal spine non-osseous and weak. HD 69.5-88.44(80.75) in HL. DB 85.63-113 (97.33) HD. HP 87.71-104.79 (94.26) in HD. HV 91.52-98.83 (95.36) in HP. Caudal forked. HC 26.52-31.3 (28.72) in SL. HCPD 63.81-80.89 (73.26) in LCPD. PDS 13-15. Body light to dark bluish on back and flanks, a black lateral band from eye to caudal fin. Dorsal fin with a wide dark band, edge, hyaline. A light dark band also seen on anal fin. Other fins reddish with yellowish tinge.

Geographical distribution: India (Talwar and Jhingran, 1991; Jayaram, 1999)

Distribution in Kerala: Cheenkannipuzha, Kabbini and Chaliyar (Easa and Basha, 1995; Shaji *et al.*, 1995), Kabbini (Kurup *et al.*, 2004).

Habitat: Riffle- pool habitats with bedrock, cobbles and gravel as substratum.

Fishing methods: Cast nets and gill nets.

Genus *Gonoproktopterus* Bleeker

Hypselobarbus Bleeker, *Nat. Tijd. Ned. Ind.*, 20: 430, 1859 (Type, *Barbus mussullah*, Sykes)

Fishes with an elongate and moderate to deep body. Dorsal profile more arched than ventral. Head anteriorly tapering. Snout have a median conical pointing and two lateral projections in front of eyes and eyes appear to be slight pushed laterally which gives the head to have a distinguishable shape. Mouth sub terminal, Lower jaw never sharp but keratinized inside. Eyes large and superior. Lips fleshy. Post labial groove interrupted. Barbells one or two pairs. Dorsal fin inserted anterior to pelvic fins. Lateral line complete.

Key to species

1. a) Barbells one pair..*Gonoproktopterus kolus*

   b) Barbells two pairs...2

2. a) Last unbranched ray osseous, strong...3

   b) Last unbranched ray weak..4

3. a) Lateral line scales 38-40............. ....*Gonoproktopterus dubius*

   b)Lateral line scales 42-43...*Gonoproktopterus micropogon periyarensis*

4. a) Lateral line scales 32-34......................*Gonoproktopterus thomassi*

   b) Lateral line scales more than 35..5

5. a) Head and snout normal, caudal tips tipped with red orange and black marks...*Gonoproktopterus curmuca*

   b) Head and snout comparatively larger, caudal tips without any colour marks..*Gonoproktopterus kurali*

Gonoproktopterus kolus (Sykes)

(Plate III, Fig. 18)

Barbus kolus Sykes, *Trans. Zool. Soc.*, 2: 357, pl. 62, fig. 1, 1841 (Tpe locality: Mutha-Mola river, Poona)
Hypselobarbus kolus Bleeker, Nat. Tijd. Dierk., 20:275, 1860
Puntius kolus Silas, J. Bombay nat. Hist. Soc., 51: 581, 1953 (Krishna, river at Wai, Maharashtra
Capoeta kolus : Bleeker, *Verh. Bat. Gen.*, 25:62, 1853

Common name: Kolus **Local name:** Kooral

Distinguishing characters: (Based on 8 specimens, 142-164 mm TL)

D. iii, 9; P. i, 15; V.i,8; A.ii,5; C.19; Ll. 42, Ltr. 9.5/4.5-5.5

Body oblong, compressed, BD 21.85-27.41(24.54) in SL, in 76.76-134.32 (107.6) HL, HL 17.84-28.25 (23.25) in SL. Mouth small, sub inferior, lips thin. Eyes large, 28.26-46.98 (41.94) in HL. Barbells a single pair. Dorsal fin inserted slightly close to snout, dorsal spine non-osseous and weak, 86.17-144.16(111.0) in HL. DB 56.22-75.33 (64.55) in HD. HP 78.86-99.35(83.37) in HD. HV 80.73-100.90 (84.61) in HP. Caudal forked. HC 27.79-34.59 (30.27) in SL. HCPD 56.73-71.84 (57.34) in LCPD. Scales smaller, PDS 13-14. Body silvery with a blackish tinge. Fins generally red orange, dorsal rays dusky.

Geographical distribution: India (Talwar and Jhingran, 1991; Jayaram, 1999)

Distribution in Kerala: Chalakkudy river (Kader, 1989; Vairavel *et al.*, 1998), Chalakkudy river system(Kurup *et al.*, 2004).

Habitat: Riffle-pool habitats with bedrock, cobbles and gravel or even muddy (pools) as substratum.

Fishing method: Cast nets and gill nets.

Gonoproktopterus dubius (Day)

(Plate III, Fig. 19)

Puntius dubius Day, *Proc. Zool., Soc. Lond.* P.291, 1867 (Type locality: Bhavani river at base of Nilghirri Hills)
Barbus dubius, Gunther, *Cat. Fish. Brit. Mus.*, 7: 127, 1868
Puntius dubius Rajan, *J. Bombay nat. Hist. Soc.*, 53 (1) : 45, 1955
Gonoproktopterus dubius Talwar and Jhingran, *Inland Fish.*, 1: 188,1991(Cauvery river system)

Common name: Nilgiri barb **Local name:** Kadanna

Distinguishing characters: (Based on 8 specimens, 142-222 mm TL)

D. iv, 9; P. i, 16; V.i,8-9; A.iii,5; C.19; Ll.38-40, Ltr.7/4-4.5

Body oblong, compressed, BD 27.54-29.42 (27.42) in SL, 97.21-100.26 (99.84) in HL, HL 26.12-29.47 (27.47) in SL. SNL 34.21-38.21(36.03) in HL. Dorsal profile rises rather as a hump from occipt to dorsal fin. Mouth sub inferior. Lips thin. Eyes large, 25.13-27.41 (26.7) in HL. Barbells maxillary and rostral pairs, both are more in length than eyes. Dorsal fin inserted slightly close to snout, dorsal spine osseous, strong and elongated, upper margin deeply concave. HD 93.42-100.25 (98.65) in HL. DB 59.21-61.28 (60.58) in HD. HP 74.13-77.56 (76.11) in HD. HV 91.25-93.24 (92.31) in HP. Caudal forked. HC 21.36-24.87 (23.07) in SL. HCPD 56.21-64.21 (58.22) in LCPD. Scales normal, PDS 12. Silvery golden body with fins red orange.

Geographical distribution: India (Talwar and Jhingran, 1991, Jayaram, 1999)

Distribution in Kerala: Cauveri river system (Shaji and Easa, 2001), Kabbini (Kurup *et al.*, 2004).

Habitat: Riffle-pool habitats with bedrock, cobbles and gravel or even muddy (pools) as substratum.

Fishing methods: Cast nets and gill nets.

Gonoproktopterus micropogon periyarensis Raj

(Plate III, Fig. 20)

Barbus (Puntius) micropogon periyarensis Raj, *Rec. Indian Mus.*, 43: 379, fig. 3 and 4 (Type locality: Periyar lake)
Barbus micropogon: Chacko, *J. Bombay nat. Hist.Soc.*, 48(1),1948 (Periyar lake)
Puntius micropogon periyarensis, Jayaram, *Rec. Zool. Surv. India. Occ. Pap.*, No. 135: 96, 1991(Bhavani at Nilghiri, Wynaad and Kerala)

Common name: Periyar barb **Local name:** Kariyan

Distinguishing characters: (Based on 8 specimens, 124-292 mm TL)

D. iii, 9; P. i, 14; V.i,8; A.ii-iii,5; C.19; Ll. 42-43, Ltr. 7.5/4.5

Body oblong, compressed, BD 26.86-30.35 (29.65) in SL, 109.97-130.94 (121.25) in HL, HL 23.26-25.49 (24.47) in SL. Rising of dorsal profile from occipit to dorsal fin is smooth gentle. SNL 32.31-34.8 (33.17) in HL Mouth sub inferior. Eyes large, 24.35-27.01 (25.73) in HL. Barbells maxillary and rostral pairs, both equal or more in length than eyes. Dorsal fin inserted almost equal or slightly towards snout. Dorsal spine osseous, strong and elongated, upper margin deeply concave. HD 107.99-114.98 (112.90) in HL. DB 59.41-78.61 (65.08) in HD. HP 70.69-93.23 (79.95) in HD. HV 83.53-95.85 (90.10) in HP. Caudal forked. HC 28.21-33.29 (30.17) in SL. HCPD 59.67-74.33 (67.56) in LCPD. Scales normal, PDS 18-19. Young ones are golden silvery but as fish grow, colour become slaty and even fins become dark bluish. On preservation, specimens become darker.

Geographical distribution: India., Western Ghats of Kerala (Jayaram, 1999)

Distribution in Kerala: Periyar upstream (Arun *et al.,* 1996; Kurup *et al.*, 2004)

Habitat: Riffle-pool habitats with bedrock, cobbles and gravel or even muddy (pools) as substratum.

Fishing methods: Cast nets and gill nets.

Gonoproktopterus thomassi (Day)
(Plate IV, Fig. 21)

Barbus (Barbodes) thomassi Day, *Proc. zool. Soc. London*, p. 107, 1873 (Type locality: South Canara)
Barbus thomassi Day, *Proc. Zool. Soc.* London, p. 107, 1878 (Type locality: South Canara)
Puntius thomssi Jayaram *et al.*, *Madras, J. Fish.*, 7: 5,1976 (Cardamom hills)

Common name: Red canarese barb **Local name:** Chekkali, Kadimeen

Distinguishing characters: (Based on 22 specimens, 191-286 mm TL)

D. iv, 9; P. ii, 16; V.i,8-9; A.iii,5; C.19; Ll. 32-34, Ltr. 7/4-4.5

Body elongate, compressed, BD 24.65-29.65 (26.54) in SL, 99.21-101.26 (100.84) in HL, HL 26.12-29.47 (27.47) in SL. SNL 33.21-36.21 (33.03) in HL. Both dorsal and ventral profiles equally convex. Mouth sub inferior. Lips thin. Eyes moderate, 22.13-24.41 (23.7) in HL. Dorsal fin inserted equidistant between snout and caudal fin, dorsal spine weak. HD 93.42-97.25 (94.68) in HL. DB 62.21-64.28 (63.41) in HD. HP 71.13-74.36 (72.19) in HD. HV 91.25-93.24 (92.31) in HP. Caudal forked. HC 27.39-29.87 (27.97) in SL. HCPD 56.21-64.21 (58.22) in LCPD. Scales normal, PDS 11-12. Golden reddish body with fins red or red orange.

Geographical distribution: India (Talwar and Jhingran, 1991)

Distribution in Kerala: Chalakkudy river (Thobias, 1973), Periyar river (Ajith kumar *et al.* (2000) Kabbini river (Shaji and Easa, 2001), Periyar and Kallada river systems(Kurup *et al.*, 2004)

Habitat: Rapids and also found in deep pools.

Fishing methods: Cast nets and gill nets.

Gonoproktopterus curmuca (Hamilton-Buchanan)
(Plate IV, Fig. 22)

Cyprinus curmuca Hamilton-Buchanan, *Journ. Mysore*, 3: 344, pl. 30, 1807 (Type locality: Vedavathi river, Thungabadhra drainage)
Barbus curmuca Day, *Proc. Zool. Soc. Lond.*, p. 707, 1873
Gobio curmuca Valenciennes, *Hist. nat. Poiss.*, 16: 317, 1842

Puntius curmuca: Rajan, *J. Bombay nat. Hist Soc.*, 53(1):45, 1955 (Bhavani river)

Common name: Curmuca barb **Local name:** Kooral

Distinguishing characters: (Based on 18 specimens, 112-284 mm TL)

D. iii, 9; P. i, 15; V.i,9; A.iii,6; C.19; Ll. 40-41, Ltr. 8.5/3.5-4.5

Body compressed, profiles are more or less equally convex, BD lesser, 19.28-28.39 (24.44) in SL, 76.11-100 (83.13) in HL, head larger, HL 27.15-46.1 (29.78) in SL. SNL31.35-46.29 (37.33) in HL. Mouth sub inferior, Eyes large, 19.18-30 (24.73) in HL. Rostral barbells smaller, maxillaries equal to eyes. Dorsal fin inserted close to snout. Dorsal spine weak, HD 71.09-100 (76.59) in HL. DB 57.15-67.61 (63.88) in HD. HP 87.13-94.83 (89.53) in HD. HV 76.16-93.45 (81.81) in HP. Caudal forked. HC 25.53-29.58 (28.23) in SL. HCPD 49.89-76.0 (53.44) in LCPD. Scales moderate small, PDS 13. Body silvery golden with caudal fin tipped with red orange and black marks (This helps in distinguishing this species from others).

Geographical distribution: India: Western Ghats (Talwar and Jhingran, 1991, Jayaram, 1999)

Distribution in Kerala: All rivers of Kerala except Chinnar and Kabbini (Shaji and Easa, 2001), Chaliayr river, NBR (Easa and Basha, 1995), Bharathapuzha, Chalakkudy, Valapatnam and Bhaani rivers (Ajithkumar *et al.*, 2000). 14 river systems in Kerala (Kurup *et al.*, 2004).

Habitat: Riffle- pool habitats.

Fishing methods: Cast nets and gill nets

Gonoproktopterus kurali (Menon and Remadevi)
(Plate IV, Fig. 23)

Hypselobarbus kurali Menon & Remadevi *J. Bombay.nat.Hist.Soc.*, 1995 (3): 389-393
Barbus curmuca Day (nec Hamilton-Buchanan). *Fish.India*, p. 566 pl.141, fig.1, 1878 (Type locality: South Malabar)
Puntius curmuca: Misra, *Rec. Indian Mus.*, 57:153, 1959 (Travancore)

Local name: Kooral

Distinguishing characters: (Based on 12 specimens, 196-275 mm TL)

D. iv, 9; P. i, 15; V.i, 9; A.ii,6; C.19; Ll.4-42, Ltr. 8.5/3.5-4.5

Body compressed, profiles more or less equally arched, BD 22.96-25.48 (24.65) in SL, 71.39 (80.28) in HL, head larger, HL31.15-35.14 (32.89) in SL. SNL39.95-53.81(44.33) in HL. Mouth sub inferior, Eyes large, 19.77-24.62 (22.81) in HL. Rostral barbells smaller, maxillaries equal to eyes. Dorsal fin inserted close to snout. Dorsal spine weak, HD 66.11-76.3 (72.16) in HL. DB 61.28-63.26(62.12) in HD. HP 82.94-94.95 (91.15) in HD. HV 82.55-81.85 (79.55) in HP. Caudal forked. HC 23.49-29.0 (27.61) in SL. HCPD 52.72-65.51(60.08) in LCPD. Scales moderate to small, PDS 13. Body silvery with fins generally grayish and tips slightly dusky.

Geographical distribution: India: Western Ghats (Menon, 1999)

Distribution in Kerala: Periyar Tiger Resrve, Kallar river (Remadevi *et al.*, 1996, Kurup *et al.*, 2004). Except high altitude streams, wide distribution in all major rivers (Ajithkumar *et al.*, 2000).

Habitat: prefers rifle pool habitats with bedrock, cobbles and gravel or even muddy (pools) as substratum.

Fishing methods: Cast nets and gill nets.

Genus ***Labeo*** Cuvier

Labeo Cuvier, *Regne Animal.*, 2 (ed.1) : 194, 1817 (Type, *Cyprinus niloticus* Forsskal)

Fishes with sub cylindrical or almost cylindrical body, Abdomen rounded. Snout rounded or obtusely pointed, overhanging mouth. Eyes placed laterally with moderately wide interorbtiat area, mouth transverse and sub terminal. Lower jaw with bony edge covered by lower lip, which is continuous at angle of mouth and usually fringed and joined with isthmus by a bridge. Barbells small, one or two pairs or sometimes absent. Dorsal fin broad, caudal fin forked and lateral lie complete.

Key to species

1. a) Lateral line scales more than 50............................*Labeo dussumeiri*

   b) Lateral line scales less than 50..2

2. a) Dorsal fin rays 19-26..*Labeo fimbriatus*

   b) Dorsal fin rays 11-18...3

3. a) Lateral line scales 36-37....................................*Labeo nigrescens*

   b) Lateral line scales 38-42...4

4. a) Dorsal fin inserted nearer tip of snout than base of caudal ....*Labeo kontius*

   b) Dorsal fin inserted midway between tip of snout and caudal fin.........5

5. a) Dorsal fin rays 15-18, anterior rays elongated, pectoral fins as long as head length..*Labeo calbasu*

   b) Dorsal fin rays 14-16, rays not elongated; pectoral fins as long as head, excluding snout...*Labeo rohita*

Labeo dussumieri (Vaenciennes)
(Plate IV, Fig. 24)

Rohita dussumeiri Valenciennes, (in C & V), *Hist. Nat. Poiss.*, 16: 258, pl.475, 1842 (Type locality: Alleppy, Kerala)
Cirrhinus rouxii Jerdon, *Madras J. Lit.Sci.*, 15: 304, 1849
Labeo rouxii Gunther, *Cat. Fish. Brit. Mus.*, 7: 59, 1868
Labeo dussumieri Gunther, *Cat. Fish. Brit. Mus.*, 7:55, 1868

Common name: Malabar labeo **Local name:** Thooli

Distinguishing characters: (Based on 4 specimens, 162-238 mm TL)

D. ii, 13; P. i, 15; V. i, 8; A.iii,5; C.19; Ll.52-54, Ltr. 8.5/6.5

Body compressed, dorsal profile more convex, BD 26.36-31.26 (29.67) in SL, 66.32-73.26(71.0) in HL, head moderate, HL 22.36-28.21 (26.0) in SL. Snout overhanging mouth, mouth sub inferior, lips fleshy and both fringed. Eyes moderate, 17.86-21.39 (19.93) in HL. Barbells small rostral and maxillary pairs, dorsal fin inserted close to snout. Dorsal spine weak, HD 8.62-10.26 (9.07) in HL. HP 98.21-100.35 (100.21) in HD. HV 92.14-97.28 (95.46) in HP. Caudal forked. HC 28.72-31.59 (30.79) in SL. HCPD 62.36-72.45 (69.09) in LCPD. Scales moderate. Body grayish, lighter on abdomen, Scales on flanks has their edges tipped with black which appear as seven or more bluish lines. Fins red orange.

Geographical distribution: India: Western Ghats (Talwar and Jhingran, 1991)

Distribution in Kerala: Pamba and tributaries (Kurup, 1992, Kurup and Kuriakose, 1991).

Habitat: prefers pool habitats at downstream of the rivers with sandy and muddy substratum with lot of leaf litters.

Fishing methods: Gill nets.

Labeo fimbriatus (Bloch)
(Plate IV, Fig. 25)

Cyprinus fimbriatus, Bloch, *Ichth. Hist. Nat. Poiss.*, 12: 50, pl. 409, 1795(Type locality: Madras)
Cirrhinus nancar McClelland, *Aisat. Res* , pp. 266, 328, 1838
Cirrhinus fimbriatus Jerdon, *Madras J. Lit. Sci.*, 15: 305, 1849
Labeo fimbriatus: Gunther, *Cat. Fish. Brit. Mus.*, 7: 53, 1868

Common name: Fringed lipped peninsular carp **Local name:** Labeo

Distinguishing characters: (Based on a single specimen, 238 mm TL)

D. iii, 17; P. i, 16; V.i, 8; A.iii,5; C.19; Ll.46, Ltr. 8.5/6.5

Body compressed, dorsal profile distinctly elevated between occipit to dorsal fin. BD 32.33 in SL, 128.92 in HL, head moderate to small, HL 25.07 in SL. Snout slightly overhanging mouth, SNL 34.68 in HL. Mouth sub inferior, lips fleshy and both fringed, labial folds distinct. Eyes moderate, 22.50 in HL. Barbells minute rostral and maxillary pairs, dorsal fin inserted close to snout. Dorsal spine weak, HD 99.74 in HL. DB 124.55 in HD. HP 91.97 in HD. HV 100.07 in HP. Caudal forked. HC 37.08 in SL. HCPD 100.88 in LCPD. Scales moderate. Body grayish. Fins yellowish orange (Specimens collected from Kallada dam has body and fins dark in color)

Geographical distribution: India, Pakisthan, Nepal and Burma (Talwar and Jhingran, 1991; Jayaram, 1999).

Distribution in Kerala: Thenmala reservoir, Kallada river system (Kurup *et al.*, 2004)

Habitat: Deep pools, reservoirs and dams.

Fishing methods: gill nets

Labeo nigrescens Day
(Plate IV, Fig. 26)

Labeo nigrescens Day, *Proc. zool. Soc. Lond.*, p. 371, 1870 (Type locality: Mangalore)
Rohita dussumeiri Valenciennes, *Hist. Nat. Poiss.*, 16: 258, pl. 475, 1842 (Malabar)

Common name: Karnataka labeo **Local name:** Chekida

Distinguishing characters: (Based on 4 specimens, 162-238 mm TL)

D. ii, 13-15; P. i, 18; V.i, 8; A.iii, 5; C.19; Ll.36-37, Ltr. 8.5/4.5

Body subcylindrical, abdomen rounded. BD 28.86-32.66 (30.76) in SL, 100.71-108.15 (104.43) in HL, head moderate to small, HL 28.66-30.19 (29.42) in SL. Snout swollen, is overhanging mouth, SNL 39.68-40.93 (40.31) in HL. Mouth sub inferior, lips fleshy and both fringed, two rows of papillae on lower lip. Labial folds distinct. Eyes moderate, 20.97-23.71 (22.31) in HL. rostral and maxillary barbells in pairs, well developed, maxillaries equal to eyes. Dorsal fin inserted slightly close to snout. Dorsal spine weak, HD 80.59-86.61 (83.6) in HL. DB 108.86-118.65 (109.76) in HD. HP101.54-108.84 (105.19) in HD. HV 91.09-94.45(92.73) in HP. Caudal forked. HC 32.9-34.49 (33.7) in SL. Fins rays generally show elongation as fish grows. HCPD 103.14-110.81 (106.98) in LCPD. Scales moderate. Body and fins grayish black in colour with eyes and lips reddish.

Geographical distribution: India (Talwar and Jhingran, 1991)

Distribution in Kerala: Pamba river, Chalakkudy river (Shaji and Easa, 2001). **Habitat:** Deep, dark, rocky pool habitats at upstream of the rivers.

Fishing methods: Gill nets.

Labeo kontius (Jerdon)
(Plate IV, Fig. 27)

Cyprinus kontius Jerdon, *Madras J.Lit. Sci.*, 15: 302, 1849 (Type locality: Cauveri and its tributaries)
Cirrhinus rubropunctatus: Jerdon, *Madras J. Lit. Sci.*, 15: 303, 1849
Labeo kontius: Day, *Proc. Zool. Soc. Lond.*, p. 289, 1867 (rivers along base of Nilghirris)

Common name: Pigmouth carp **Local name:** Kadanna

Distinguishing characters: (Based on a single specimen, 364 mm TL)

D. ii, 13; P. i, 15; V.i, 8; A.i,5; C.19; Ll.41, Ltr.6/4.5

Body subcylindrical, abdomen rounded. BD 30.54 in SL, 139.41 in HL, head moderate, HL 21.90 in SL. Snout swollen, overhanging mouth, SNL 44.85 in HL. Mouth sub inferior, lips fleshy and upper lip plain, without papillae or fimbriated, lower lip fringed. Labial folds distinct. Eyes moderate, 17.22 in HL. Barbells rostral and maxillary pairs, well developed, maxillaries longer. Dorsal fin inserted slightly close to snout. Dorsal spine weak, HD 105.41 in HL. DB in HD. HP 82.33 in HD. HV 102.56 in HP. Caudal forked. HC 28.07 in SL. Fin rays generally show elongation as fish grows. HCPD 86.96 in LCPD. Scales moderate. Bluish grey along back, each scale with a red lunule, Fins are off-white in colour.

Geographical distribution: India (Talwar and Jhingran, 1991; Jayaram, 1999)

Distribtution in Kerala: Kabbini river system (Kurup *et al.*, 2004)

Habitat: Riffle-pool habitats with sandy or gravelly substratum.

Fishing methods: Cast nets and gill nets.

Labeo calbasu (Hamilton-Buchanan)
(Plate IV, Fig. 28)

Cyprinus calbasu Hamilton-Buchanan, *Fish. Ganges*, pp. 297, 389, pl. 2, fig. 33, 1822 (Type locality: Bengal)
Cyprinus micropogon Valenciennes, in *Jacq. Voy. Ind. Or.*, p. 372, pl. 3, fig. 1, 1841
Rohita calbasu, Valenciennes, *Hist. Nat. Poiss.*, 16: 253, 1842
Cirrhinus belangeri Jerdon, *Madras J. Lit. Sci.*, 15: 303,1849

Common name: Black Rohu **Local name:** Kakkameen

Distinguishing characters: (Based on 2 specimens, 216-218 mm TL)

D. ii,13; P. i, 18; V.i, 8; A.iii,5; C.19; Ll.43-44, Ltr. 7.5/9.5

Body compressed and rather deep. BD 27.57-33.81 (30.69) in SL, 141.45-154.01(147.75) in HL, head moderate, more conical HL 19.49-21.95 (20.72) in SL. snout somewhat pointed, or tip obtusely rounded. SNL 47.43-49.64 (48.54) in HL. Mouth sub inferior, lips fleshy, two rows of papillae on lower lip. Labial folds distinct. Eyes moderate, in HL. Barbells two pairs, well developed, rostrals more elongated than maxillaries. Dorsal fin inserted more or less equidistantly between snout and caudal base, first few rays are elongated and filamentous. HD 190.49-193.13 (191.81) in HL. DB 64.36-67.47 (65.92) in HD. HP 56.52-59.34 (57.93) in HD. HV 120.42-124.42

(122.42) in HP. Caudal forked. HC 36.04-37.89 (36.96) in SL. Rays of ventral and anal fins also show elongation. HCPD 109.65-126.45 (118.05) in LCPD. Scales moderate. Body and fins deep black with eyes and lips reddish.

Geographical distribution: India, Pakisthan, Bengladesh, Nepal, Burma, Thailand, China (Talwar and Jhingran, 1991)

Distribution in Kerala: Chalakkudy and Periyar rivers (Ajithkumar *et al.*, 2000). **Habitat:** Riffle-pool habitats with sandy, muddy or gravelly substratum.

Fishing methods: Cast nets and gill nets.

Labeo rohita (Hamilton-Buchanan)
(Plate IV, Fig. 29)

Cyprinus rohita Hamilton-Buchanan, *Fish.Ganges*, pp. 301, pl. 36, fig.85, 1822(Type locality: Gangetic provinces)
Rohita buchanani Valenciennes, *Hist. Nat. Poiss.*, 16:251, 1842
Rohita duvancelli Valenciennes, *Hist. Nat. Poiss.*, 16:251, 1842
Labeo rohita, Gunther, *Cat. Fish. Brit. Mus.*, 7:55, 1868

Common name: Rohu **Local name:** Rohu

Distinguishing characters: (Based on 2 specimens, 216-218 mm TL)

D. ii, 12; P. i, 18; V.i, 7; A.iii,5; C.19; **Ll.40-42, Ltr. 6.5/9**

Body oblong, dorsal profile more convex, abdomen rounded. BD 24.86-26.92(25.83) in SL, 91.28-94.03 (93.69) in HL, head normal, broadly round, HL 26.54-28.12 (27.57) in SL, snout projecting and overhanging mouth, SNL 32.05-34.01(33.19) in HL. Mouth sub inferior, lips fleshy, both lips fringed. Labial folds distinct. Introrbital distance wide, Eyes moderate, 15.12-17.02 (16.87) in HL. Barbells minute maxillary pairs only. Dorsal fin inserted more or less equidistantly between snout and caudal base, rays normal. HD 76.23-78.05 (77.69) in HL. DB 95.21-96.58 (96.21) in HD. HP 99.21-100.68 (100.21) in HD. HV 81.24-63.21 (82.48) in HP. Caudal forked. HC 22.13-

23.69 (23.26) in SL. HCPD 98.03-100.56 (100.18) in LCPD. Scales normal. Body grayish on back, flanks silvery. Fins generally dusky. Scales have darker edges which give appearance of continuous lines on flanks.

Geographical distribution: India, Pakisthan, Bengladesh, Nepal, Burma, Bengladesh (Talwar and Jhingran, 1991, Jayaram, 1999)

Distribution in Kerala: Many reservoirs of Kerala (Ajithkumar *et al.*, 2000), Introduced in to many rivers, Kabini, Chalakkudy puzha, Karuvannur and Malampuzha (Shaji and Easa, 2001), Achenkoil river (Kurup *et al.*, 2004)

Habitat: moderate and deep pools

Fishing methods: gill nets.

Genus ***Puntius*** Hamilton-Buchanan

Puntius Hamilton-Buchanan, *Fish. Ganges*, pp. 310, 388, 1822 (Type, *Cyprinus sophore* Hamilton-Buchanan)

Body short to elongate, laterally compressed, moderate to deep and Abdomen rounded. Head moderate to normal, eyes normal, snout obtuse, conical or rounded, often tuberculated. Mouth arched, jaws protractile and more or less terminal. Labial folds interrupted, lips thin, jaws without any horny covering. Dorsal fin short usually, inserted nearly opposite or a head of pelvic fins. Barbells four, two or none. Lateral line complete or incomplete, caudal fin forked, body with vibrant colorations.

1. a) Barbells present..2

   b) Barbells absent..15

2. a) Barbells a single pair 3

   b) Barbells two pairs..10

3. a) Last unbranched dorsal fin ray some what osseous 4

   b) Last unbranched ray of dorsal fin non-osseous or feebly osseous 6

4. a) Body with two dark blotches, one at gill opening, one near caudal peduncle..*Puntius chola*

   b) Body with a single blotch at caudal fin base 5

5. a) Dorsal fin inserted midway between snout tip and caudal base, scales from lateral line to pelvic fin 2.5-3.5...................................*Puntius parrah*

   b) Dorsal fin inserted nearer to caudal base. Scales from lateral line to pelvic fin 2.5...*Puntius dorsalis*

6. a) A finger like oval blotch on 12-16th scales. Anterior few dorsal rays may be filamentous ....*Puntius filamentosus*

   b) No such oval spot on caudal base. Dorsal rays not filamentous..............7

7. a) Body with 3 vertical dark blotches ....*Puntius arulius*

   b) Body without more than two black spots 8

8. a) Scales between lateral line and dorsal fin 3.5 to 4, dorsal fin with a black spot on base of third to eight rays. ....*Puntius bimaculates*

   b) Scales between lateral line and dorsal fin 4.5 to 5, dorsal fin without any black spot on base 9

9. a) Body with a black band along lateral line, above which another scarlet stripe, caudal fin with oblique dark and orange bands....*Puntius denisoni*

   b) Body only with a dark spot, at caudal base............*Puntius amphibius*

10. a) Last unbranched dorsal ray osseous, strong..............................11

    b) Last unbranched dorsal ray non-osseous and weak.....................13

11. a) Dark finger like mark on caudal peduncle ....*Puntius sarana sabnasutus*

    b) No such a finger like mark on caudal peduncle............................12

12. a) Lateral line scales 32-33..................................*Puntius carnaticus*

b) Lateral line scales 24 to 26 ....*Puntius bovanicus*

13. a) Body with three vertical colour bands......................*Puntius fasciatus*

b) Body without any vertical colour bands.....................................14

14. a) Lateral line scales 27-32, body golden silvery with first 5-6 rays of dorsal fin marked with a deep dark band at its distal ends ....*Puntius jerdoni*

b) Lateral line scales 44-45, body with a dark band along lateral line which ends in a dark blotch at caudal peduncle.....*Puntius ophicephalus*

15. a) Lateral line scales 20-22, dorsal spine weak, non-osseous and non-serrated..*Puntius vittatus*

b) Lateral line scales more than 22, dorsal spine strong, osseous and serrated..16

16. a) Lateral line scales 22-26, body with two spots, dorsal fin with 3-5 rows of spots...*Puntius ticto*

b) Lateral line scales 24-28. Body with a single large spot near caudal peduncle, no spots on dorsal fin..........................*Puntius conchonius*

Puntius chola (Hamilton-Buchanan)
(Plate IV, Fig. 30)

Cyprinus chola Hamilton-Buchanan, *Fish. Ganges*, pp. 312, 389, 1822 (Type locality: North eastern part of Bengal)
Barbus titius Shaw and Shebbeare, *J. roy. Asiat. Soc.* Bengal, 3(1), p.44, 1937(Terai and Duars)
Capoeta chola Bleeker, *Verh. Bat. Gen.*, 25, p. 62,1853
Barbus thermalis Gunther, *Cat. Fish. Brit. Mus.*,1868

Common name: Chola barb **Local name:** Paral

Distinguishing characters: (Based on 10 specimens, 78-106 mm TL)

D. ii,8; P. i, 14; V.i, 8; A.ii,5; C.19; Ll.25-26, Ltr. 5.5/5

Body moderately deep. BD 31.13-33.95 (32.27) in SL, head moderate to small, conical, HL 26.55-27.98 (27.37) in SL, Snout tip blunt, SNL 25.90-32.22 (29.53) in HL. Eyes 24.44-30.76 (27.51) in HL. Barbells maxillary pairs only. Dorsal spine slightly osseous and smooth, HD 83.59-88.48 (85.82) in HL. DB 75.56-79.91 (78.35) in HD. HP 66-24-78.34 (73.06) in HD. Caudal forked. HC 26.3-26.46 (26.28) in SL. HCPD 72.54 - 86.09 (81.26) in LCPD. Scales normal. Reddish brown with golden reflections on back and opercula, silvery golden on flanks and white on ventral side. Two conspicuous black spots, one near gill opening and another on 21-23 scales. Anterior dorsal rays with dark bases.

Geographical distribution: India, Pakisthan, Bengladesh, Nepal, Burma, Bengladesh (Talwar and Jhingran, 1991)

Distribution in Kerala: Meenachil river (Remadevi *et al.*, 1996), Kabbini river, Kerala pert of NBR (Easa and Basha, 1995), 22 rivers of Kerala (Ajithkumar *et al.*, 2000), Kabbini river system (Kurup *et al.*, 2004).

Habitat: Pools with thick under water vegetation and muddy or clayey substratum.

Fishing methods: gill nets.

Puntius parrah (Day)
(Plate V, Fig. 31)

Puntius parrah Day, *Proc. Zool. Soc. London.*, p. 301, 1865 (Type locality: Kurriavanoor near Thrissur)
Puntius perlee: Day, 1865
Barbus parrah: Day, 1878
Puntius parrah: Jayaram, *Handbook, FW.Fish. India*, p.101, 1981

Common name: Parrah barb **Local name:** Paral, Parapparal

Distinguishing characters: (Based on 4 specimens, 90-116 mm TL)

D. ii, 7-8; P. i, 14; V.i, 7-8; A.ii,5; C.19; Ll.25-26, Ltr. 5.5/2.5-3

Body deep, dorsal profile more arched, BD 291-38.56 (33.47) in SL, head conical, HL 25.42-28.86 (26.32) in SL, Snout tip pointed, SNL 28.3-37.09 (33.09) in HL. Eyes 19.67-26.67 (25.43) in HL. Barbells maxillary pairs only. Dorsal fin inserted equidistantly, dorsal spine osseous and smooth, HD 75.65-97.34 (91.65) in HL. DB 52-73.66 (64.31) in HD. HP 73.38-86.37 (79.85) in HD. HV 78.71-91.83 (81.89) in HD. Caudal forked. HC 23.3-30.56 (26.94) in SL. HCPD 71.88-100 (85.72) in LCPD. Scales moderate to large, PDS 9. Body silvery with a faint lateral band. Ventral side white.

Geographical distribution: India (Talwar and Jhingran, 1991, Jayaram, 1999)

Distribution in Kerala: Travancore (Remadevi *et al.,* 1996) Chalakkudy, Meenachil, Karuvannur, Periyar and Moovattupuzha (Ajithkumar *et al.*, 2000).

Habitat: Pools with muddy or sandy substratum.

Fishing methods: Cast nets and gill nets.

Puntius dorsalis (Jerdon)
(Plate V, Fig. 32)

Systomus dorsalis Jerdon, *Madras J. Lit. Sci.*, 15: 314, 1849 (Type locality: Tanks and rivers in neighborhood of Madras)
Systomus tristis Jerdon, *Madras J. Lit. & Sci.*, p.316, 1849 (Type locality: river Cauveri)
Barbus tetraspilus Gunther, *Cat. Fish. Brit. Mus.*, 7, p.142,1868
Barbus dorsalis Gunther, *Cat. Fish. Brit. Mus.*, 7 p.142, 1868

Common name: Long snouted barb **Local name:** Paral

Distinguishing characters: (Based on 6 specimens, 154-192 mm TL)

D. ii, 8; P. i, 14; V.i, 7-8; A.ii,5; C.19; Ll.26, Ltr. 5.5/2.5-3

Body elongate, dorsal profile more arched, BD 25.61-34.56 (31.47) in SL, head conical, HL 26.43-32.82 (29.32) in SL, Snout tip slightly pointed, SNL 25.3-35.09 (31.09) in HL. Eyes 20.67-28.67 (24.63) in HL. Barbells maxillary pairs only. Dorsal fin inserted equidistantly, dorsal spine osseous and smooth, HD 76.75-95.34 (89.65) in HL. DB 51-73.63 (63.31) in HD. HP73.38-86.37 (79.85) in HD. HV 78.71-91.83(81.89) in HD. Caudal forked. HC 23.3-30.56 (26.94) in SL. HCPD 71.88-100 (85.72) in LCPD. Scales moderate to large, PDS 9. Body uniformly silvery with ventral side white. Specimens from Nelliampathy had golden coloured body with a diffused spot at caudal peduncle.

Geographical distribution: India, Srilanka (Talwar and Jhingran, 1991)

Distribution in Kerala: Ponnani drainage, Anamalai hills (Silas, 1951), Southern Travancore (Silas, 1951) and Chaliyar rivers (Easa and Basha, 1995), Bharathapuzha, Chalakkudy, Periyar and Moovattupuzha (Ajithkumar *et al.*, 2000), Chalakkudy river system(Kurup *et al.*, 2004).

Habitat: Rocky pools of upstream. The substratum may be muddy or sandy with lot of leaf litter.

Fishing methods: gill nets.

Puntius filamentosus (Val.)
(Plate V, Fig. 33)

Leuciscus fialmentosus Valenciennes, *Hist. Nat. Poiss.*, 17: 95, pl. 492, 1844 (Type locality: Alleppy)
Barbus filamentosus Day, Fish. Malabar, p. 215, 1878
Barbus mahecola Day, Fish India, p. 582, 1878
Puntius singhala: Jayaram, *Handbook, FW. Fish. India*, p.113, 1981

Common name: Indian Tiger Barb **Local name:** Valekkodiyan paral, Kalakkodiyan, Valechuttipparal

Distinguishing characters: (Based on 16 specimens, 68-133 mm TL)

D. iii, 9; P. i, 15; V. i, 8; A.iii,6; C.19; Ll.21-23, Ltr. 4.5-5.5/2.5

Body elongate, both profiles equally arched, BD 30.06-40.51(35.21) in SL, head small, HL 28.57-32.67 (29.47) in SL, snout in adult males covered with tubercles, SNL 26.09-30.77(28.27) in HL. Eyes 24.24-34.09 (28.91) in HL.

Barbells a small maxillary pairs only. Dorsal spine weak, smooth, branched rays in adult males elongated and filamentous, HD 76.05-178.26 (107.86) in HL. DB 57.16-77.77 (58.44) in HD. HP 54.55-82.44 (67.75) in HD. HV 100-122.5 (105.49) in HD. Caudal forked. HC 28.74-36.71(32.99) in SL. HCPD 66.71-100 (77.71) in LCPD. Scales large with extensive radii, PDS 7-8. Colour varying at different stages. Adults greenish golden on back and flanks silvery. A dark oval blotch on lateral line at 14-19 th scale. Caudal fin lobes tipped with orange and black, other fins red orange with dorsal fin dusky.

Geographical distribution: India, Sri Lanka, Burma, Thailand (Talwar and Jhingran, 1991, Jayaram, 1999)

Distribution in Kerala: Throughout Kerala (Silas, 1951; Easa and Basha, 1995; Ajithkumar *et al.*, 2000; Shaji and Easa, 2001; Kurup *et al.*, 2004).

Habitat: Riffle-pool and run habitats with sand, mud or gravel as substratum.

Fishing methods: Cast nets and gill nets.

Puntius arulius (Jerdon)
(Plate V, Fig. 34)

Systomus arulius Jerdon, *Madras J. Lit. Sci.*, 15: 137, 1849 (Type locality: Cauveri river at Srirangapatinam)
Systomus rubrotinctus Jerdon, 1849
Barbus arulius: Day, *Fish. India*, p. 575, pl. 142, 1878
Puntius arulius arulius: Jayaram, 1981

Common name: Aruli barb **Local name:** Paral

Distinguishing characters: (Based on 14 specimens, 74-112 mm TL)

D. iii, 8; P. i, 15-16; V.i, 8; A.ii,5; C.19; Ll.21-23, Ltr. 5-5.5/2.5

Body deeper, dorsal profile more arched, BD 32.96-35.10 (33.99) in SL, head moderate, HL 30.36-35.9 (33.25) in SL, snout plain, SNL 28.7-32.6(30.8) in HL. Eyes 21.83-29.81 (25.61) in HL. Barbells a small maxillary pairs only. Dorsal spine weak and smooth, HD 80.17-87.98 (82.87) in HL. DB 59.9-

69.04 (63.33) in HD. HP 69.02-86.63 (80.86) in HD. HV 90.67-113.97 (108.08) in HD. Caudal forked. HC 29.79-31.45(30.94) in SL. HCPD 52.21-56.94 (54.85) in LCPD. Scales large PDS 7-8. Colour silvery green on back, flanks silvery with green iridescence. Three prominent dark vertical blotches on body. Fins generally golden yellow to red orange, caudal fin with two bright red stripes.

Geographical distribution: India: Tamil Nadu, Kerala and Cauveri river system (Talwar and Jhingran, 1991)

Distribution in Kerala: Kottayam (Jayaram, 1981) 25 rivers of Kerala (Ajithkumar *et al.* 2000), Kabbini rver system (Shaji and Easa, 2001; Kurup *et al.*, 2004)

Habitat: Pools with under water vegetation and muddy or clayey substratum.

Fishing methods: Cast nets and gill nets.

Puntius bimaculates (Bleeker)
(Plate V, Fig. 35)

Gnathopogon bimaculates, Bleeker, *Verb. Nat. Holl. Maatsch. Haarlem*, 2(20): 17, pl. 4, fig.1, 1864.
Barbus bimaculates, Gunther, *Cat. Fish. Brit. Mus.*, 7, 147, 1868 (Sri Lanka)
Barbus puckelli: Day, 1878
Puntius puckelli: Jayaram, 1981

Common name: Two-spot barb **Local name:** Paral

Distinguishing characters: (Based on 13 specimens, 48- 66 mm TL)

D. ii, 7; P. i, 10; V.i, 7; A.i-ii,5; C.19; Ll. 24, Ltr. 3.5/2-2.5

Small fishes with elongated and lean body, BD 24.75-25.62 (25.18) in SL, head normal, HL 22.15-23.53 (22.84) in SL, snout plain, SNL 27.26-33.13 (30.20) in HL. Eyes 32.13-34.33(33.23) in HL. Barbells a small maxillary pairs only. Dorsal spine weak, smooth, HD 88.09-91.67(89.88) in HL. DB 66.8-77.06 (71.93) in HD. HP 88.71-88.74 (88.43) in HD. HV 84.65-91.95 (88.30) in HD. Caudal forked. HC 21.24 -25.32 (23.28) in SL. HCPD 61.24-84.69 (72.85) in LCPD. Scales large, PDS 9. Body greenish silvery on back. Flanks silvery, ventrally white. Fins red orange. A black small band at base of 3-4th rays of dorsal fin and a deep black spot at caudal peduncle.

Geographical distribution: India, Srilanka (Talwar and Jhingran, 1991)

Distribution in Kerala: Chalakkudy river system (Shaji and Easa, 2001; Kurup *et al.*, 2004)

Habitat: shallow riffles with gravel and mud as substratum.

Fishing methods: Cast nets of small mesh size.

Puntius denisoni (Day)
(Plate V, Fig. 36)

Labeo denisonii Day, *Proc. Zool. Soc. London.*, p. 299, 1865 (Type locality: Cochin, Kerala)
Puntius denisonii: Day, *Fish. Malabar.* P. 212, pl. 16, 1865
Barbus denisonii Day, *Fish. Malabar*, p. 212, 1878
Barbus (Puntius) denisonii Hora and Law, *Rec. Indian Mus.*, 43(2), p.237, 1941(Kerala)

Common name: Denison barb

Local name: Chenkaniyan, Chorakkaniyan, Chorakkombi

Distinguishing characters: (Based on 18 specimens, 68-198 mm TL)

D. ii-iii, 8; P. i, 14; V.i, 8; A.iii,5; C.19; Ll. 27-28, Ltr. 4.5/2.5

An elongated fish with both profiles not much arched and dorsal profile rather straight than convex. BD 25.52-30.97(28.97) in SL, head moderately elongate, conical, HL 27.32-35.21 (30.49) in SL, snout pointed, SNL 25.25-35.12 (30.82) in HL. Eyes large, 25.45- 35.40 (29.69) in HL. Barbells with maxillary pairs which are equal to eyes. Dorsal spine weak, smooth, HD 73.03-110.03 (90.16) in HL. DB 55.26-66.11 (62.27) in HD. HP in 74.97-95.68 (84.58) HD. HV 91.43-101.48 (99.12) in HD. Caudal forked. HC 21.36-36.54 (24.31) in SL. HCPD 54.32-71.26 (66.82) in LCPD. Scales moderately large, PDS 11. Back golden green, flanks golden silvery with a deep dark band from snout tip ending at caudal peduncle. above this, a scarlet stripe which remain at anterior third of body. Caudal fin lobes with oblique dark hands bordered with orange markings, followed by black tips.

Geographical distribution: India: Kerala (Talwar and Jhingran, 1991)

Distribution in Kerala: Travancore (Hora & Law, 1941), Chaliyar river, the NBR (Easa and Basha, 1995), Aralam WLS (Shaji *et al.*, 1995), Chalakkudy, Periyar, Valapatnam and Chandragiri rivers (Ajith kumar *et al.*, 2000), Achenkoil, Periyar and Chalakkudy river systems (Kurup *et al.*, 2004)

Habitat: Riffle-pool habitats with sand or gravel as substratum.

Fishing methods: Cast nets and gill nets.

Puntius amphibius (Val.)
(Plate V, Fig. 37)

Capoeta amphibia Vaenciennes, (in C & V), 16: 282, pl. 478, 1842 (Type locality: Bombay)
Puntius hamiltonii Day, Day, *Fish. Malabar*, p. 213,1865
Babus amphibius, Gunther, *Cat. Fish. Brit. Mus.*, p.144, 1863 (Bombay)
Puntius amphibius Hora, *J. Zool. Soc. India.*, 1(1), p.2, 1949 (Rihand river)

Common name: Scarlet banded barb **Local name:** Paral

Distinguishing characters: (Based on 16 specimens, 42- 98 mm TL)

D. ii, 8; P. i, 12; V.i, 8; A.ii,5; C.19; Ll.24-25, Ltr. 4.5-5/2.5-3.5

An elongated fish with both profiles more or less equally convex, BD 24.54-30.15 (28.12) in SL, head normal, HL 28.08-32.05 (30.22) in SL, snout blunt, eyes large, 26.08-32.09 (28.08) in HL. Barbells with a small pair of maxillaries, dorsal spine weak, smooth, HD 88.29-94.28 (91.16) in HL. DB 70.24 -73.08 (72.9)in HD. HP 76.27-80.45 (78.77) in HD. HV 91.28-96.24 (94.78) in HD. Caudal forked. HC 26.28-29.48 (29.02) in SL. HCPD 50.28-52.64 (51.89) in LCPD. Scales moderately large, PDS 7. Body with back grayish green in colour, flanks silvery, ventral side white. Fins golden yellow. Caudal peduncle with an oval shaped dark blotch.

Geographical distribution: India, Sri Lanka (Talwar and Jhingran, 1991)

Distribution in Kerala: Throughout Kerala (Ajithkumar *et al.*, 2000; Gopi, 2000; Shaji and Easa, 2001), Chalakkudy, Bharathapuzha, Kabbini, Meenachil and Kallada river systems (Kurup *et al.*, 2004).

Habitat: shallow riffle-pools with lot of vegetation and muddy or gravelly substratum.

Fishing methods: Cast nets

Puntius sarana subnasutus (Valenciennes)
(Plate V, Fig. 38)

Barbus subnasutus Valenciennes, *Hist. Nat. Poiss.*, 16, p. 154, 1842 (Type locality: Pondicherry)
Barbus gobbosus Valenciennes, Hist. Nat. Poiss., 16, p.155,1842(Type locality: Alleppy)
Barbus russelli Gunther, Cat. Fish. Brit. Mus., 7, p.121,1868
Cyclocheilichthys pinnauratus Day, Proc. Zool. Soc. Lond., p.365, 1865

Common name: Peninsular barb **Local name:** Kuruva, Kuruvapparal

Distinguishing characters: (Based on 7 specimens, 162-267 mm TL)

D. iii, 8; P. i, 14-16; V.i, 8; A.ii,5; C.19; Ll.27-29, Ltr. 6-6.5/3.5-4

Body oblong, compressed and deep. BD 30.32-32.41 (30.89) in SL, head moderate to small, HL 25.61-25.71(26.42) in SL, snout blunt, SNL 29.99-30.93 (30.51) in HL. Eyes moderate, 21.46-26.03 (23.09) in HL. Barbells rostral and maxillary pairs, maxillaries longer and more than eyes. Dorsal spine osseous, strong and serrated posteriorly. HD 87.17-100.17(94.55) in HL. DB 59.75-72.29 (64.26) in HD. HP 73.31-95.76 (85.37) in HD. HV 81.01-93.10 (88.03) in HD. Caudal forked. HC 22.77-27.33 (24.52) in SL. HCPD 59.12-74.46 (69.43) in LCPD. Scales large, PDS 9-10. Back greenish silvery, flanks silvery, scales with black bases and in young specimens it appear as several continuous lines. Scales have extensive radii. A dark blotch on lateral line near caudal peduncle on 24th scale. Fins red orange, caudal fin edges dusky.

Geographical distribution: India (Talwar and Jhingran, 1991)

Distribution in Kerala: Travancore (Hora and Law, 1941), Periyar Tiger Reserve (Chacko, 1948), Vembanad lake (Remadevi *et al.,* 1996), Throughout Kerala (Ajithkumar *et al.*, 2000), Chalakkudy, Bharathapuzha, Kallada river systems (Kurup *et al.*, 2004)

Habitat: Low lying pool-run habitats with sandy, muddy or gravelly substratum.

Fishing methods: Cast nets and gill nets.

Puntius carnaticus (Jerdon)
(Plate V, Fig. 39)

Barbus carnaticus Jerdon, *Madras J.lit. & Sci.*,15. p.311,1849 (Type locality: Bhavani river)
Barbodes carnaticus Day, *Proc. Zool. Soc.Lond.*, p. 292, 1867
Barbus (Puntius) carnaticus Hora, *Rec. Indian Mus.*, 44, p.195, 1942 (Nilghirris, Wynaad, Mysore and South Canara)
Puntius carnaticus: Rajan, *J. Bombay nat. Hist. Soc.*, 53 (1), pp. 45, 1955(Bhavani and Moyar rivers, Nilghirri hills)

Common name: Carnatica carp **Local name:** Kadanna, Pachilavetti

Distinguishing characters: (Based on 16 specimens, 184-384 mm TL)

D. iii-iv,8; P. i, 14; V.i, 8; A.i,5; C.19; Ll.32-33, Ltr. 4.5-5.5/3.5

Body elongate, both profiles equally convex up to posterior end of dorsal base, dorsal profile straight afterwards. Body moderately deep, BD 30.32-31.59 (31.25) in SL, head moderate to small, HL 24.85-28.03 (26.44) in SL, snout blunt, SNL 28.39-28.63 (28.51) in HL. Eyes moderate, 23.63-26.26 (24.94) in HL. Barbells rostral and maxillary pairs, maxillaries longer and equal to eyes. Dorsal spine osseous, strong and smooth, 94.75-98.82 (96.79) in HL. DB 61.53-67.22 (64.37) in HD. HP 78.82-87.63 (83.23) in HD. HV 83.23-95.62 (89.42) in HD. Caudal forked. HC 27.62-33.24 (30.43) in SL.

HCPD 80.51-86.04 (83.28) in LCPD. Scales moderate to large, PDS 11-12. Back greenish silvery, flanks silvery, fins golden yellow to red orange

Geographical distribution: India (Talwar and Jhingran, 1991, Menon,1999)

Distribution in Kerala: Wynaad (Jayaram, 1991), Kabini, Chinnar, Parambikulam wild life sanctuary (Biju *et al.*, 1999b), Nelliampathy hill ranges (Silas, 1951), Kabbini river, NBR (Easa and Basha, 1995), Kabbini, Bhavani, Pambar and Chalakkudy river systems (Kurup *et al.*, 2004)

Habitat: Riffle-pool habitats with boulders, cobbles and gravelly substratum and also mid channel pools with sandy bottom and good riparian cover.

Fishing methods: Cast nets and gill nets.

***Puntius bovanicus* (Day)**
(Plate V, Fig. 40)

Barbus bovanicus Day, *Fish.India*, p.566, pl.138, fig.1,1878 (Type locality: Bhavani river at base of Nilgiri hills)
Puntius bovanicus Jayaram, *Handbk. Fw. Fish. India*, p.99, 1982 (Cauveri river, South India)

Common name: Bowani barb **Local name:** Paral

Distinguishing characters: (Based on a single specimen, 158 mm TL)

D. iii , 8; P. i, 12; V. i, 8; A.ii,5; C.19; Ll.30, Ltr. 5.5/3

Body with both profiles equally arched, moderately deep, BD 31.21 in SL, head moderate to small, HL 24.95 in SL, snout blunt, covered with fine tubercles. A distinct rise over snout and interorbital region predominantly convex, eyes large, 30.14 in HL. Barbells rostral and maxillary pairs, maxillaries longer. Dorsal spine osseous, strong and smooth, 107.39 in HL. HP 81.54 in HD. HV 97.74 in HD. Caudal forked. HC 34.29 in SL. HCPD 81.90 in LCPD. Scales moderate to large, PDS 13. Back greenish silvery, flanks silvery with golden reflections, fins golden yellow to red-orange.

Geographical distribution: India (Talwar and Jhingran, 1991)

Distribution in Kerala: Wynaad and Nilgirri hills (Talwar and Jhingran, 1991, Jayaram, 1991).

Habitat: Riffle-pool habitats with sand or gravel as substratum.

Fishing methods: Cast nets and gill nets.

Puntius fasciatus (Jerdon)
(Plate VI, Fig. 41)

Cirrhinus fasciatus Jerdon, *Madras J. Lit.& Sci.*, p.305,1849 (Type locality: streams of Malabar)
Puntius fascaitus fasciatus Jerdon, 1849
Labeo melanampyx Day, *Proc. Zool. Soc. Lond.*, p. 317, 1865 (Type locality: Cochin)
Babus melanampyx Day, *Fish. India*, p. 570, pl. 139, fig.1, 1865

Common name: Melon barb **Local name:** Vazhakkavarayan

Distinguishing characters: (Based on 18 specimens, 47-63 mm TL)

D. ii,8; P. i, 12-14; V.i, 8; A.ii,5; C.19; Ll.20, Ltr. 4-4.5/2.5-3

Body small, elongate and deep. A distinct rise from occipit to dorsal fin. BD 32.37-33.38 (32.89) in SL, head conical, normal, HL 33.32-37.94 (35.03) in SL, snout blunt, covered with fine tubercles in mature males. Lips fleshy. SNL 31.15-33.7(32.15) in HL. Eyes moderate to large, 22.21-26.37(23.66) in HL. Barbells two pairs, well developed. Maxillaries more than two times in eyes. Dorsal spine weak, HD 62.01-71.51(68.34) in HL. DB 75.9-107.74 (90.12) in HD. HP 73.85-108.85 (89.02) in HD. HV 91.8-98.84 (96.52) in HD. Caudal forked but not deep. HC 23.83-30.58(26.83) in SL. HCPD 105.71-180.11(132.0) in LCPD. Scales moderate to large, PDS 6-7. Deep to dull red body with 3-4 wide black cross bands, below dorsal fin, just above anal fin or in front, just at caudal peduncle respectively. Fins pinkish with black edges. Head and snout dark.

Geographical distribution: Peninsular India (Talwar and Jhingran, 1991, Jayaram, 1999)

Distribution in Kerala: Throughout Kerala (Ajithkumar *et al.*, 2000, Shaji and Easa, 2001), Chalakkudy, Kabbini, Kallada, Meenchil river systems (Kurup *et al.*, 2004).

Habitat: Riffles and channels at middle and upstream of rivers.

Fishing methods: Cast nets and scoop nets.

Puntius jerdoni (Day)
(Plate VI, Fig. 42)

Barbus jerdoni Day, *Proc. Ool. Soc. Lond.*, p.372, 1870 (Type locality
Barbus (Barbodes) *jerdoni* Day, J.Linn.Soc., 12, p 574, 1876 (Type locality: Deccan)
Barbus pulchellus Day, *Proc. Zool.Soc.Lond.*, p.372,1870 (South Canara)
Barbus (Barbodes) dobsoni Day, *Fish India*, p. 568, pl. 139, 1876

Common name: Jerdon's carp **Local name:** Chuttipparal

Distinguishing characters: (Based on 8 specimens, 124-184 mm TL)

D. ii,9; P. i, 14-15; V.i, 8; A.ii,5; C.19; Ll.30-31, Ltr. 6.5/3.5

Body moderate to fairly deep. Both profiles equally arched, BD 23.59-52.09 (34.47) in SL, head small, HL24.73-33.72 (29.04) in SL, snout blunt, covered with fine tubercles in mature males. SNL 28.92-34.57 (32.42) in HL. Eyes moderate to large, 26.7- 33.03 (29.63) in HL. Barbells two pairs, Maxillaries equal to eyes. Dorsal spine weak, HD 80.21-119.01(103.11) in HL. DB 49.32-65.33 (56.58) in HD. HP 68.25-76.64 (71.95) in HD. HV 87.52-101.5 (100.57) in HD. Caudal forked. HC 29.10-43.25 (33.87) in SL. HCPD 84.37-118.41(110.2) in LCPD. Scales moderate, PDS 10-11. Body silvery golden with fins golden yellow to red orange. Caudal and anal fin rays tipped with black and dorsal fin with a prominent deep dark band along distal end of first 4 rays.

Geographical distribution: India (Talwar and Jhingran, 1991)

Distribution in Kerala: Chandragiri, Bharathapuzha, Chalakkudy and Meenachil (Ajithkumar *et al.*, 2000), Chalakkudy river (Shalji and Easa, 2001), Achenkoil river system (Kurup *et al.*, 2004)

Habitat: Riffle-pools with sandy or gravelly substratum.

Fishing methods: Cast nets and gill nets.

Puntius ophicephalus (Raj)
(Plate VI, Fig. 43)

Barbus (Puntis) ophicephalus, Raj, *Rec. Indian Mus.*, 43. p.375, 1941(Type locality: Kallar river, Pachakkanam estate, Periyar lake)

Common name: Channa barb **Local name:** Eeetilakkenda, Eechathalakkenda

Distinguishing characters: (Based on 8 specimens, 84-181 mm TL)

D. ii, 7; P. i, 13; V.i, 8; A.ii,5; C.19; Ll.44-45, Ltr. 6-6.5/3

Body elongate, both profiles equally arched, BD 19.54-22.36 (21.18) in SL, head normal, conical, HL 17.36-19.12 (18.56) in SL, snout somewhat blunt, interorbital region flat and slightly more wide. Eyes moderate, 33.62-37.25 (36.10) in HL. Barbells two pairs, Maxillaries longer than eyes. Dorsal spine slightly osseous or stiff. HD 121.43-124.18(124.1) in HL. DB 60.12-62.38 (61.44) in HD. HP 77.12-80.12 (79.03) in HD. HV 97.48-100.26 (99.08) in HD. Caudal forked. HC 16.48-18.4 (17.34) in SL. HCPD 60.24-63.48 (62.65) in LCPD. Scales small, PDS 18. Body golden brown on back, flanks silvery golden with fins red orange. A dark band from behind opercula, ending at caudal peduncle in a dark blotch is invariably seen.

Geographical distribution: India: Kerala (Jayaram, 1999)

Distribution in Kerala: Tributaries of Kallar and Periyar (Shaji and Easa, 2001), Periyar river (Kurup *et al.*, 2004)

Habitat: Riffle-pools of small channels at upstream of Periyar, joining main stream with sandy, gravelly or muddy substratum with lot of leaf litter and good canopy cover preferably of bamboo (Eeetta = Bamboo in Malayalam)

Fishing methods: Cast nets and gill nets.

Puntius vittatus Day
(Plate VI, Fig. 44)

Puntius vittatus Day, *Proc. Zool. Soc. Lond.*, p. 303,1865 (Type locality: Madras)
Puntius muzaffarpurensis Srivasthava et al., p.72, 1976
Puntius coorgensis Jayaram, p. 47, 1982
Barbus vittatus Gunther, *Cat. Fish. Brit. Mus.*, 7, p. 156, 1878

Common name: Kooli barb **Local name:** Paral

Distinguishing characters: (Based on 12 specimens, 28-42 mm TL)

D. I, 7-8; P. i, 11; V.i, 8; A.ii, 6; C.19; Ll. 20, Ltr. 2.5-3/3.5-4

Body small, elongate and deep. Dorsal profile distinctly rise from occipit to dorsal fin. BD29.82-34.78 (31.91) in SL, head moderate, HL 26.9-32.7(30.74) in SL, snout blunt, SNL 25.46-30.90(27.29) in HL. Eyes moderate to large, 23.61-30.07(26.85) in HL. Barbells absent, dorsal spine weak, HD 72.38-87.27 (79.71) in HL. DB 67.66-80.68 (71.84) in HD. HP 64.44-109.5 (87.61) in HD. HV 79.13-105.23 (88.69) in HD. Caudal forked. HC 23.60-28.79 (26.97) in SL. HCPD 80.75-85.59 (83.29) in LCPD. Scales moderate, PDS.7-8. Back greenish silvery, flanks silvery, fins golden yellow to hyaline. Dorsal fin marked with a straight or arched dark band in middle and a black spot at caudal peduncle.

Geographical distribution: India, Pakisthan, Srilanka (Talwar and Jhingran, 1991)

Distribution in Kerala: Most of all river systems (Ajith kumar *et al.*, 2000; Shaji and Easa, 2001; Kurup *et al.*, 2004)

Habitat: Slow flowing channels or small pools with sandy or muddy substratum. **Fishing methods:** Cast nets and scoop nets.

Puntius ticto (Hamilton-Buchanan)
(Plate VI, Fig. 45)

Cyprinus ticto Hamilton-Buchanan, *Fish. Ganges*, pp. 314, 398, pl. 8, figs. 87, 1822(Type locality: South-east Bengal)
Puntius punctatus Day, 1865
Barbus stoliczkanus : Day, 1878
Barbus (Puntius) ticto: Hora and Law, 1949

Common name: Ticto barb, two spot barb **Local name:** Paral

Distinguishing characters: (Based on 10 specimens, 32-52 mm TL)

D. ii, 8; P. i, 12; V.i, 7; A.i,5; C.19; Ll. 22-23, Ltr. 4.5-5/3.5

Body small, highly compressed and deep. Dorsal and ventral profiles equally arched. BD 34.82-40.04 (35.02) in SL, head conical, small, HL 29.86-38.68 (30.93) in SL, snout blunt, SNL 24.75-38.35 (30.97) in HL. Eyes large, 22.09-33.86 (29.31) in HL. Barbells absent, dorsal spine osseous, strong and serrated at its posterior end. HD 68.86-124.48 (88.25) in HL. DB 50.09-74.21(69.78) in HD. HP 55.04-88.19(74.12) in HD. HV 86.53-121.52 (107.52) in HD. Caudal forked. HC 29.77-31.38(31.30) in SL. HCPD 74.78-108.61(94.97) in LCPD. Scales moderate, PDS 9-10. Lateral line incomplete, ceases after 7th scale. Back greenish silvery, flanks silvery golden and two spots, a small one behind opercula, on fourth scale and a large one near caudal peduncle on 19-21th scales. Dorsal fin marked with 3-5 rows of spots. Other fins golden yellow.

Geographical distribution: India, Pakisthan, Srilanka, Bengladesh, Burma and Thailand (Talwar and Jhingran, 1991)

Distribution in Kerala: Almost all rivers (Shaji and Easa, 2001, Ajith kumar *et al.*, 2000), Chalakkudy, Manimala, Bharathapuzha, Meenachil river systems (Kurup *et al.*, 2004).

Habitat: slow flowing waters with sandy or muddy substratum.

Fishing methods: Cast nets and scoop nets.

Puntius conchonius (Hamilton-Buchanan)
(Plate VI, Fig. 46)

Cyprinus conchonius Hamilton-Buchanan, *Fish.Ganges*, pp. 317, 318, 389, 1822 (Type locality: Ponds of northe east Bengal)
Systomus conchonius McClelland, Asiat.Res.,19, p. 383, 1839
Barbus conchonius Gunther, Cat. Fish. Brit.Mus., 7, p.153, 1868
Puntius conchonius khagariansis Srivasthava and Munshi, *Natural History & Syst.Fw.Fishes*, p.179, 1988 (Khagaria district, Bihar)

Common name: Rosy barb **Local name:** Vattapparal

Distinguishing characters: (Based on 12 specimens, 58-69 mm TL)

D. ii-iii,8; P. i, 13; V. i, 7; A.ii,5; C.19; Ll. 26-27, Ltr. 6.5/4.5-5.5

Body small, compressed and deep, profiles equally and greatly arched. BD 37.99-46.57(43.54) in SL, head conical, small, HL24.33-28.5 (29.69) in SL, snout bluntly pointed, SNL 16.12-24.06 (22.5) in HL. Eyes large, 22.62-27.45(27.04) in HL. Barbells absent, dorsal spine osseous, strong, and serrated at its posterior end. HD 56.66-88.39 (65.16) in HL. DB 76.71-94.64 (83.06) in HD. HP 82.9-117.17 (100.04) in HD. HV 76.57-108.25 (96.32) in HD. Caudal forked. HC 17.81-26.53 (21.54) in SL. Scales moderate to large, PDS 9-10. Lateral line incomplete, ceases after 12-13 th scale. Body silvery with a bluish sheen, scales at flanks have red lunules, more conspicuous in brooders. Fin rays are dusky black. A deep, black, round spot along lateral line near caudal peduncle, on 17-20th scales.

Geographical distribution: India, Pakisthan and Bengladesh (Talwar and Jhingran, 1991)

Distribution in Kerala: abundant in streams and rivers of Wynaad (Shaji and Easa, 2001), Bharathapuzha, Manimala, Kariyangode and Chandragiri rivers (Ajith kumar *et al.*, 2000), Kabbini and Bharathapuzha (Kurup *et al.*, 2004)

Habitat: Riffle-pool habitats with sand or gravel as substratum.

Fishing methods: Cast nets and, gill nets of small mesh size

Sub family: Cultrinae

Fishes with small to moderate and highly compressed body and a knife like (cultrate) abdominal edge. Mouth oblique and in some species directed upwards. Lower jaw prominent, often with a symphysial process, barbells absent. Dorsal fin short and placed behind origin of pelvic fins, normally opposite to anal fin. Lateral line curved downwards and running along lower half of body.

Key to Genera

1. a) Body elongate, silvery, mouth terminal and jaws with a symphysial process..*Salmostoma*

   b) Body deep, with stripes or spots, mouth and jaws without a symphysial process...*Chela*

Genus ***Chela*** Hamilton-Buchanan

Chela Hamilton-Buchanan, 1822 (Type: *Cyprinus (Chela) cachius*)

Body small, elongate, highly compressed, abdomen partly keeled. Head moderate to small. Mouth oblique, upturned, jaws without any symphysial process. Eyes large, dorsal fin with last unbranched ray non-osseous and non-serrated, inserted behind origin of pelvic fin and nearly opposite or slightly behind origin of anal fin. Fins with their outer rays generally have a

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tendency for elongation, prominently in pelvic fins. Lateral line complete, running along lower half of body. Caudal deeply forked.

1. a) Lateral band with 3-4 black dots, anal fin rays 11-12 ....*Chela dadiburjori*

b) Lateral band without any spots, anal fin rays 14.........*Chela fasciata*

Chela dadiburjori (Menon)
(Plate VI, Fig. 47)

Laubuca dadiburjori Menon, *Rec. Indian Mus.*, 49: 1, 1952 (Type locality : Cochin, Kerala)
Laubuca dadyburjori Dadyburjor, *Bull. Bombay, Aquar.Soc.*, 3(2), 12,1955
Chela (Neochela) dadiburjori Silas, *J. Bombay nat. Hist. Soc.*, 55(1), 93,1958
Chela dadiburjori: Talwar and Jhingran, *Inland Fish.*, 1: 314, 1991(Nagercoil and Goa)

Common name: Dadio **Local name:** vilanjil

Distinguishing characters: (Based on 6 specimens, 32-42 mm TL)

D. ii , 7; P.i,12; V.i,6; A.ii,11-12; C.19; Ll.32-34, Ltr.5.5/2.

BD 19.48-22.31 (21.36) and HL 26.82-32.16 (32.15) in SL. Eyes 21.72-38.42(32.35) in HL. INTO 33.16-39.26 (37.48) in HL. Dorsal fin inserted slightly behind origin of anal fin, HD 66.49-78.12 (73.15) in HL. Pectorals longer than head, HP 110.26-128.34 (118.42) in HL. First ray of ventral fin elongate, HV 72.64-81.29 (78.12) in HP. HC 23.12-27.26 (26.48) in SL. PDS 18. Dorsal and flanks silvery and fins yellowish orange. A dark steel blue lateral stripe along middle of body. Three-four black spots along flanks.

Geographical distribution: India: Nagercoil (TamilNadu) and Sanguen (Goa) (Talwar and Jhingran, 1991)

Distribution in Kerala: Trivandrum (Silas, 1958), Bharathapuzha and Chalakkudy puzha (Shaji and Easa, 2001).

Habitat: Riffles and pools at lower streches, among thick vegetation

Fishing method: Scoop nets and cast nets of small mesh sizes.

Chela fasciata Silas
(Plate VI, Fig. 48)

Chela fasciatus Silas, *J. Bombay. nat. Hist. Soc.*, p. 87, 1958 (Type locality: Anamalai river)

Common name: Malabar hatchet chela **Local name:**vilanjil

Distinguishing characters: (Based on 62 specimens, 23-52 mmTL)

D. ii , 7; P.i,11; V.i,6; A.ii,14; C.19; Ll. 32-33, Ltr. 5.5/2.

BD 19.49-23.14 (21.46) and HL 27.17-32.37(28.28) in SL. Eyes 21.86-39.11(31.01) in HL. INTO 34.50-40.59 (37.50) in HL. Dorsal fin inserted slightly behind origin of anal fin, HD 68.39-88.09 (78.01) in HL. Pectorals longer than head, HP 107.65-130.63 (119.15) in HL. First ray of ventral fin elongate, HV 72.96-89.45 (81.59) in HP. HC 23.66-30.29 (26.84) in SL. Body with broad scales. PDS 18. Back and flanks silvery, fins yellowish orange. A dark, wide lateral band from behind opercula reaches up to caudal peduncle.

Geographical distribution: Peninsular India: Anamalai hills (Talwar and Jhingran, 1991)

Distribution in Kerala: Anamalai hills (Vannathura in Chittur), Chalakkdudy (Shaji and Easa, 2001), Bharathapuzha river (Ajithkumar *et al.,* 2000; Kurup *et al.*, 2004).

Habitat: Riffles and pools at lower streches, among thick vegetation

Fishing method: Scoop nets and cast nets of small mesh sizes.

Genus ***Salmostoma*** Swainson

Salmostoma Swainson, *Nat. Hist. Fish.*, 2: 284, 1839 (Type, *Cyprinus bacaila* Hamilton-Buchanan)

Body bigger than genus *Chela,* elongate, compressed and abdomen keeled. Head moderate, snout slightly upturned. Mouth oblique, Jaws with symphysial process. Eyes large, dorsal with last unbranched ray non-osseous and non-serrated, inserted behind origin of pelvic fin and nearly opposite or slightly behind origin of anal fin. Outer rays of pelvic fins not elongate. Lateral line complete, running along lower half of body. Caudal deeply forked. Body uniformly shining silver in colour, fins yellowish orange.

Key to species

1. a) Lateral line scales 42-44, dorsal fin inserted slightly behind origin of anal fin ....*Salmostoma acinaces*

b) Lateral line scales 41-43, dorsal fin inserted opposite or in advance of anal fin ....*Salmostoma boopis*

Salmostoma acinaces (Valenciennes)
(Plate VI, Fig. 49)

Leuciscus acinaces Valenciennes, *Hist. Nat.Poiss.*, 17: 347, pl. 509, 1844(Type locality: Cauveri drainage, Mysore)
Pelecus diffuses Jerdon, Madras *J. Lit. Sci.*. 15 p. 327, 1849
Chela argentea Day, *Proc. Zool. Soc. Lond.*, p. 301, 1867 (Bowani river)
Chela diffusa: gunther, *Cat. Fish. Brit. Mus.*, 7: 334, 1868 (Cauveri river)

Common name: Silver razor belly Minnow **Local name:** Mathipparal

Distinguishing characters: (Based on 58 specimens, 34-164 mm TL)

D. ii, 8; P.i,12; V.i,7; A. ii, 15; C.19; Ll. 42-44, Ltr. 6.5/2.

BD 19.21-19.22 (19.20) and HL 16.64-17.19 (16.92) in SL. Eyes 41.76-43.90 (42.83) in HL. INTO 38.48-39.62 (39.03) in HL. Mouth oblique. Dorsal fin inserted slightly behind origin of anal fin, HD 89.21-91.73 (90.47) in HL. Pectorals longer than head, HP 149.02-153.50 (151.26) in HL. HV 56.72-62.48 (59.60) in HP. HC 25.06-26.06 (25.56) in SL. Body with broad scales. PDS 17. Dorsal and flanks silvery and fins yellowish orange.

Geographical distribution: India: Cauveri river system; Bhavani river, Wynaad; Hoogly river (West Bengal) (Jayaram, 1999)

Distribution in Kerala: Kabbini,Chalakkudy puzha, Chaliyar (Shaji and Easa, 2001), Bhavani river, Wynaad (Jayaram, 1999), 7 rivers of Kerala (Ajithkumar *et al.*, 2000; Kurup *et al.*, 2004).

Habitat: pools of upper and middle streches.

Fishing method: cast nets of small mesh sizes.

Salmostoma boopis (Day)
(Plate VI, Fig. 50)

Chela boopis Day, *Proc. Zool. Soc. Lond.*, p. 708, 1873 (Type locality: South Canara)
Oxygaster boopis : David, *Proc. nat. Acad. Sci.*, 33B (2): 276,1963 (Krishna)
Salmostoma boopis : Banarescu, *Rev. Roum. Biol.*, 13 (2): 11, 1968 (Mola-Mutha, Poona)

Common name: Boopis razor belly minnow **Local name:** Mathipparal, Kokkuparal

Distinguishing characters: (Based on 112 specimens, 32-96 mmTL)

D. ii , 7; P.i,11-12; V.i,7; A.ii-iii,14; C.19; Ll. 41- 43, Ltr. 6-6.5/1.5-2

BD 16.22-20.33 (18.88) and HL 21.73-21.83 (21.79) in SL. Eyes large, 30.67-41.35(36.01) in HL. INTO small, 20.92-31.32 (26.12) in HL. Dorsal fin inserted opposite or slightly in advance of anal fin, HD 62.92-75.44 (69.18) in HL. Pectorals longer than head, HP 107.79-112.79(110.29) in HL. HV 53.09-56.02 (54.86) in HP. HC 22.04-26.15(24.10) in SL. Body with small but broad scales. PDS 26-28. Dorsal and flanks silvery and fins yellowish orange.

Geographical distribution: India: Western Ghats: South Canara and Poona (Talwar and Jhingran, 1991)

Distribution in Kerala: Kabbini, Chalakkudy, Chaliyar, Chimmoney, Bharathapuzha and Payaswini (Shaji and Easa, 2001), 28 river of Kerala (Ajithkumar *et al.*, 2000), Achenkoil, Bharathapuzha, Kabbini river systems(Kurup *et al.*, 2004)

Habitat: pools of upper and middle streches.

Fishing method: cast nets of small mesh sizes.

Sub family: Rasborinae

Small or medium sized fishes with laterally compressed, elongate and silvery body. Abdomen round, always non-keeled. Mouth usually oblique and upturned. A symphysial knob on lower jaw may be present. Barbells present or absent. Dorsal fin without any osseous spine, placed behind origin of pelvic fins and with seven rays. Anal fin usually long with 6-16 branched rays. Scales small. Lateral line complete or rarely incomplete, curved downwards and running along lower half of body, caudal forked.

This subfamily is represented by fishes having great ornamental importance owing to vibrant nature and vivid colour pattern. Most fishes are surface feeders and most of the species are abundant in upper and middle reaches of river systems.

Key to Genera

1. a) Maxillary barbells very long. No symphysial knob on lower jaw .... *Esomus*

   b) Maxillary barbells short or absent, lower jaw usually with a symphysial knob 2

2. a) Upper lip absent, lateral line incomplete .... *Amblypharyngodon*

   b) Upper lip present, lateral line complete or incomplete or some times absent 3

3. a) Lateral line complete 4

   b) Lateral line incomplete or absent .... *Brachydanio*

4. a) Body with a single broad lateral band .... *Rasbora*

   b.) Body with longitudinal bands or bluish spots 5

5. a) Dorsal fin with 7-10 branched rays, pectoral axillary scale with a fleshy border, body with bluish spots or blue vertical bars...........*Barilius*

b) Dorsal fin with 8-18 branched rays, pectoral axillary scale small and without a fleshy border, body with golden longitudinal lines...........*Danio*

Genus: ***Esomus*** Swainson

Esomus Swainson, *Nat. Hist. Fish.*, 2: 185, 285, 1839 (type, *Esomus vittatus* Swainson)

Esomus thermoicos (Valenciennes)
(Plate VII, Fig. 51)

Nuria thermoicos Valenciennes, *Hist. Nat. Poiss.* 16: 238, pl. 472, 1842 (Type locality: Hot springs at Kannya, Ceylon)
Esomus danrica thermoicos Deraniyagala, *Coloured Atlas vert. Ceylon*, 1: 46, 1952 (Ceylon)
Esomus barbatus : Bhimachar and Rau, *J. Mys. Univ.*, 1: 146, 1941 (Tank near Narasimharajapur, Mysore)
Esomus thermoicos: Kner, *Novara Fische*, 6 p.363, 1865

Common name: Sri Lnaka flying barb **Local name:** Meesapparava

Distinguishing characters: (Based on 16 specimens, 58-74 mm TL)

D. ii , 6; P.i,14; V.i,7; A.ii,5; C.19; Ll. 34-36, Ltr. 5.5-6/1.5-2

Body elongate, slender, dorsal profile more or less straight, abdomen rounded. BD 19.44- 22.54 (20.99) and HL 22.62-23.78 (23.20) in SL. Mouth oblique and upturned. Lower jaw without any symphysial knob. Barbells rostral and maxillary pairs, maxillaries elongated, reaches up to ventral fin tips. Eyes moderate to large, ventro-lateral in position, forming 21.89-25.45 (23.65) in HL. INTO 11.68-12.06 (11.87) in HL. Dorsal fin short and its position in between ventral and anal fins. HD 75.57-79.37 (77.47) in HL. HP 138.10-155.75 (146.92) in HD. HV 53.02-58.64 (55.83) in HP. HCPD 52.42-59.48 (55.95) in LCPD. Caudal forked, HC 24.58-26.67(25.62) in SL. LCPD 17.79-18.39 (18.39) in SL. PDS 12-13. Lateral line complete.

Geographical distribution: India, Sri Lanka (Talwar and Jhingran, 1991)

Distribution in Kerala: Chaliyar and Kabbini rivers, Nilghiri Bioreserve (Easa and Basha, 1995), Bharathapuaha (Ajithkumar *et al.*, 2000), Chalakkudy river system (Kurup *et al.*, 2004)

Habitat: Riffle-pool habitats with sand or gravel as substratum.

Fishing method: Cast nets.

Genus ***Amblypharyngodon*** Bleeker

Amblypharyngodon Bleeker, *Nat. Tijdschr. Ned. Ind.*, 20 : 433, 1859 (Type, *Cyprinus mola* Hamilton-Buchanan).

Amblypharyngodon microlepis (Bleeker)
(Plate VII, Fig. 52)

Leuciscus microlepis Bleeker, *Verh. Bat. Gen.*, 25: 141, 1853 (Type locality: Bengal)
Leuciscus pellucidus McCllend, *Asiat Res.*, 19:293, 408, 1839 (Ganga and Brahmaputra rivers)
Amblypharyngodon melettinus: Bimachar and Rau, *J. Mys. Univ.*, 1:55,1941(Mysore)

Common name: Indian Carplet **Local name:** Vayambu

Distinguishing characters: (Based on 86 specimens, 63-96 mmTL)

D. ii , 7; P.i,14; V.i,8; A.ii,5; C.19; Ll., Ltr.5.5-6/1.5-2

BD 22.52-30.15 (26.98) and HL 28.61-30.96 (29.68) in SL. Eyes large, 23.51-27.82(25.24) in HL. INTO 28.78-41.90 (34.18) in HL. Barbells absent. Dorsal fin short, HD 73.11-80.55 (76.48) in HL. HP 74.59-79.46 (76.96) in HD. HV 79.83-92.48 (81.44) in HP. LCPD 16.05-20.77 (17.92) in SL. HCPD 56.6-76.82 (65.31) in LCPD. Caudal forked, HC 28.8-30.48 (29.81) in SL. Scales small, deciduous. Grayish green dorsally, flanks silvery with metallic brassy colour. A faint greenish silvery band along lateral side. Fins greenish yellow.

Geographical distribution: India (Talwar and Jhingran, 1991)

Distribution in Kerala: In low land freshwater bodies (Shaji and Easa, 2001), Chalakkudy and Bharathapuzha river systems (Kurup *et al.*, 2004)

Habitat: Pool-run habitats with sand or mud as substratum.

Fishing methods: seine nets of small mesh size.

Genus ***Brachydanio*** Weber and de Beufort

Brachydanio Weber and de Beufort, *Fish Indo-austral Archipel.* 3, p.85, 1916 (Type *Nuria albolineata* Blyth)

Brachydanio rerio (Day)
(Plate VII, Fig. 53)

Danio rerio: Day, *Fish. India*, pp. 595, 597, pl. 51, fig.4, 1878 (Type locality: Bengal and as low down as Coramandal coast at Masulipatnam)

Common name: Zebra danio **Local name:** Paral

Distinguishing characters: (Based on 12 specimens, 28-33 mm TL)

D. ii, 7; P.i,12; V.i,6; A.ii,12-13; C.19

BD 22.42-24.59 (23.6) and HL 22.48-29.15 (26.72) in SL. Eyes large, 26.14-32.14 (30.24) in HL. INTO 32.14-36.48 (34.02) in HL. Barbells absent. Dorsal fin short, HD 62.48-68.45 (64.6) in HL. HP 122.48-152.48 (146.28) in HD. HV 58.12-66.24 (61.82) in HP. LCPD 11.14-14.59 (13.31) in SL. HCPD 160.24-168.24 (165.52) in LCPD. Caudal forked, HC 26.91 in SL. Scales small, deciduous. Grayish green dorsally and flanks shining blue traversed with four shining golden stripes from head to caudal fin. Stripes are also clear on anal fin as well.

Geographical distribution: Pakistan; India:Eastern parts from West Bengal to Krishna river system; Bengladesh and Nepal (Talwar and Jhingran, 1991)

Distribution in Kerala: Wyanad (Shaji and Easa, 2001)

Habitat: slow moving channels of paddy fields or streams with sand or mud as substratum.

Fishing methods: seine nets of small mesh size.

Genus *Rasbora* Bleeker

Rasbora Bleeker, *Acta Soc. Sci. Indo-Neerl.*, 7: 435, 1860 (Type: *Cyprinus rasbora* Hamilton-Buchanan)

Rasbora daniconius (Hamilton-Buchanan)
(Plate VII, Fig. 54)

Cyprinus daniconius Hamilton-Buchanan, *Fish. Ganges*, p. 327, pl. 15, fig. 89, 1822 (Type locality: rivers of Southern Bengal)
Leuciscus daniconius: McClellad, *Asiat. Res.*, 19(2): 292, 1839
Leuciscus anjana: McClelland, *Asiat Res.*, 19(2): 1839
Parluciosoma daniconius : Howes, *Bull. Brit. Mus. Nat. Hist. (zool)* 37(3): 183, 1980 (Type: *Leuciscus argyrotaenia* Bleeker)

Common name: Rasbora **Local name:** Kaniyan paral

Distinguishing characters: (Based on 116 specimens, 32-128 mm TL)

D. ii, 7; P.i,14; V.i,8; A.ii,5; C.19; Ll. 32-34, Ltr. 5/2

BD 25.29-25.64 (25.43) and HL 25.45-30.92 (28.08) in SL. Eyes 26.73-30.12 (28.44) in HL. INTO 33.22-43.22 (37.81) in HL. HD 67.88-91.46 (79.82) in HL. HP 81.48-94.17 (87.02) in HD. HV 79.58-84.36 (82.19) in HP. LCPD 14.61-15.52 (14.92) in SL. HCPD 80-90 (85.86) in LCPD. HC 25.02-26.38 (25.65) in SL. Silvery or greenish yellow on dorsal side and flanks. A mid-dorsal dark streak present from head to dorsal fin. A wide dark longitudinal band from snout tip through eyes up to caudal peduncle present, which is even extending to caudal fin. On preservation, band become deep dark. Fins red orange or yellowish.

Geographical distribution: Pakisthan, India, Srilanka, Benglades, Burma and Mekong (Talwar and Jhingran, 1991)

Distribution in Kerala: Throughout Kerala (Ajithkumar *et al.*, 2000, Kurup *et al.*, 2004), in low land freshwater bodies (Shaji and Easa, 2001).

Habitat: Seen in both low-lying plains and ponds and extreme high altitudes.

Fishing methods: Cast nets and gill nets.

Genus ***Barilius*** Hamilton-Buchanan

Barilius Hamilton-Buchanan, *Fish. Ganges*, p. 384, 1822 (Type, *Cyprinus barila* Hamilton-Buchanan)

Body shallow to deep, laterally compressed. Abdomen rounded. Head small to moderate or even large and snout pointed. Lower jaw shorter, with a poorly developed symphysial process. Eyes large and are lateral in position, Mouth terminal. Barbells two small pairs or absent. Dorsal fin inserted behind origin of pelvic fins and extending over anal fin, without any osseous ray and with 7-10 branched rays. Pectoral fin has a well-developed axillary scale with fleshy border. Anal fin with 9-17 rays. Lateral line complete, running along lower half of body, Caudal forked. Barline fishes usually inhabit torrential waters of upstreamand middle stream of rivers and are brilliantly coloured.

Key to species

1. a) Barbells present, body with vertical bars.......................................2

   b) Barbells absent, body with row of spots.......................................3

2. a) Barbells two pairs, scales with black mottling.........*Barilius bendelisis*

   b) Barbells single pair, scales without any black mottlings ....*Barilius gatensis*

3. a) Body with a single row of spots, Maxilla reaching below middle of orbit...*Barilius bakeri*

   b) Body with two or more rows of spots, maxilla reaching to below anterior third of orbit..*Barilius canarensis*

Barilius bendelisis (Hamilton-Buchanan)
(Plate VII, Fig. 55)

Cyprinus bendelisis Hamilton-Buchanan, *Journey Mysore*, 3: 345, pl. 32, 1807 (Type locality: Vedawathi stream, headwaters of Krishna river)

Cyprinus cocsa Hamilton-Buchanan, *Fish. Ganges*, p.272, pl. 3, fig. 77, 1822 (Northern rivers of Bengal and Bihar)
Barilius bendelisis: Gunther, *Cat. Fish. Brit. Mus.*, 7:288, 1868 (Mysore and Ganges)
Cyprinus chedra: Hamilton, *Fish. Gnages*, p. 273, 1822 (Northern rivers of Bengal)

Common name: Hamilton's barila **Local name:** Pavuka

Distinguishing characters: (Based on 28 specimens, 54-98 mm TL)

D. ii, 7; P.i,12; V.i,7; A.ii,8; C.19; Ll. 42-43, Ltr. 6.5-7.5/2.5

Elongate and shallow body, dorsal profile smoothly round, BD 27.36-28.85(28.13) and HL 13.24-26.6(20.74) in SL. Maxilla extends to below anterior third of orbit. Eyes 19.02-20.98 (19.98) in HL. INTO 30.66-33.75 (31.76) in HL. Barbells two small maxillary and rostral pairs. Tubercles on snout minute. HD 72.78-78.01 (77.01) in HL. HP 99.78-119.46 (108.48) in HD. HV 68-72.1(71.20) in HP. LCPD 8.6-19.4 (12.8) in SL. HCPD 102.08-159.42 (104.57) in LCPD. HC 22.12-23.90 (22.97) in SL. PDS 19. Lateral line complete. Silvery on dorsal and flanks with 10-13 vertical bluish bands descending from dorsal towards lateral line. Scales especially above lateral line and dorsal profile are mottled with small dark spots. Fins yellowish to orange in colour. Outer margins of dorsal and caudal dusky.

Geographical distributin: Pakisthan, India, Sri Lanka, Benglades, Nepal (Talwar and Jhingran, 1991)

Distribution in Kerala: Bharathapuzha, Chalakkudy, (west flowing) and Chinnar and Pambar (east flowing) (Ajithkumar *et al.*, 2000; Shaji and Easa, 2001, Kurup *et al.*, 2004).

Habitat: run habitat at downstream with sandy bottom and riffles at upstream with rock or sandy bottom

Fishing methods: Cast nets and gill nets.

Barilius gatensis (Valenciennes)
(Plate VII, Fig. 56)

Leuciscus gatensis Valenciennes, *Hist. Nat. Poiss.*, 17: 309, pl. 503, 1844 (Type locality: Peninsular India)
Opsarius gatensis Bleeker, *Proc. Cyp.*, 288, 1853
Barilius rugosus Day, *Proc. zool. Soc. Lond.*, p. 294,1867
Barilius gatensis: Gunther, *Cat. Fish Brit. Mus.*, 7:291,1868 (Peninsular India)

Common name: River-carp baril **Local name:** Pavuka, Thuppalkothipparal

Distinguishing characters: (Based on 28 specimens, 54-98 mm TL)

D. ii, 8; P.i,13; V.i,8; A.ii,12; C.19; Ll. 38-39, Ltr. 7.5-8.5/1.5-2

Body deep, BD 25.35-30.58 (25.96) and HL 27.81-28.79 (28.00) in SL. Eyes 25.79-31.82 (30.81) HL. INTO 29.31-34.39 (31.07) in HL. Barbells absent. Tubercles on snout minute. HD 58.07-71.41 (64.93) in HL. HP 98.59-120.0 (109.71) in HD. HV 60-79.77 (69.88) in HP. LCPD 13.15-17.69 (15.03) in SL. HCPD 61.02-74.77(68.01) in LCPD. HC 22.12-23.90 in SL. PDS 19. lateral line complete. Metallic blue colour on back, flanks silvery with 10-12 vertical bluish bands. Dorsal and anal fins dark bluish and hyaline tips. Pectoral and pelvic fins dull white. Caudal grayish blue with tips of lobes hyaline.

Geographical distribution: India

Distribution in Kerala: Periyar, Kabbini, Chalakkudy, Chinnar, Bhavani, Payaswini, Chimmoney, Karuvannur, Bharathapuzha, Neyyar, Streams in Peppara wild life sanctuary,Pamba and Kallar (Shaji and Easa, 2001). Found in 28 rivers of Kerala (Ajithkumar *et al.*, 2000), Chalakkudy, Achenkil, Periyar, Manimala, Bharathapuzha, Kabbini, Meenachil (Kurup *et al.*, 2004)

Habitat: Riffle-pool habitats at middle and upper streches.

Fishing methods: Cast nets and gill nets.

Barilius bakeri Day
(Plate VII, Fig. 57)

Barilius bakeri Day, *Proc. Zool. Soc. Lond.*, p. 305, 1865 (Type locality: Mundakkayam, Kerala)
Pterosparion bakeri Gunther, *Cat. Fish. Brit. Mus.*, 7:284, 1868 (Hill ranges of Travancore)

Common name: Malabar baril **Local name:** Pavuka

Distinguishing characters: (Based on 128 specimens, 46-134 mm TL)

D. ii, 10; P.i,12; V.i,7-8; A.ii,14; C.19; Ll. 38-39, Ltr. 8-8.5/2-2.5

Body deep, BD 27.36-28.85 (28.13) and HL 13.24-26.6(20.74) in SL. Maxilla extends to below middle of orbit. Eyes 19.02-20.98 (19.98) in HL. INTO 30.66 -33.75 (31.76) in HL. Barbells absent. Tubercles on snout are well developed. HD 72.78-78.01 (77.01) in HL. HP 99.78-119.46 (108.48) in HD. HV 68-72.1(71.20) in HP. LCPD 8.6-19.4 (12.8) in SL. HCPD 102.08-159.42 (104.57) in LCPD. Dorsal fin extending up to 4th anal fin ray. HC 25.89-31.11 (28.58) in SL. PDS 15-16. lateral line complete. Metallic blue on back and flanks silvery. A row of 9-11 dark bluish spots along lateral region. Dorsal and anal fins dark bluish with hyaline tips. Pectoral and pelvic fins dull white. Caudal grayish blue with tips of lobes hyaline. During breeding periods, belly and snout of individuals become bright red in colour.

Geographical distribution: India: Western Ghats of Kerala (Talwar and Jhingran, 1991)

Distribution in Kerala: Chaliyar, Chalakkudy, Bavelippuzha, Cheenkannipuzha, Uruttipuzha, Periyar, Neyyar, Kallarand Pamba (Shaji and Easa 2001), 19 rivers of Kerala (Ajithkumar *et al.*, 2000), Periyar, Kabbini (Kurup *et al.*, 2004) .

Habitat: Riffle-pool habitats at upper streches of river systems

Fishing methods: Cast nets, gill nets of small mesh sizes.

Barilius canarensis Jerdon
(Plate VII, Fig. 58)

Opsarius canarensis Jerdon, *Madras, J. Lit. Sci.* 15 p. 329, 1849 (Type locality: Canara)
Opsarius malabaricus Jerdon, *Madras J. Lit. Sci.*, 15 p.329, 1849
Barilius canarensis: Day, *Proc.zool. Soc. Lond.*, p. 374, 1870 (Canara)

Common name: Jerdon's baril **Local name:** Thuppalkothi

Distinguishing characters: (Based on 18 specimens, 102-118 mm TL)

D. ii, 10; P.i,12; V.i,8; A.ii,15; C.19; Ll. 39, Ltr.8-8.5/2-2.5

Body deep, BD 23.67-26.96 (24.53) and HL 24.99- 29.96 (28.06) in SL. Maxilla extends to below anterior third of orbit. Eyes large, 21.41-28.22 (24.19) in HL. INTO 28.91-38.66 (32.87) in HL. Barbells absent. Tubercles on snout are well developed. HD 53.95-98.04 (64.82) in HL. HP 75.84-125.35 (107.94) in HD. HV 64.47-82.86 (69.96) in HP. LCPD 8.75-18.86 (14.80) in SL. HCPD 55.23-107.85 (73.63) in LCPD. Dorsal fin originating behind that of pelvic fins and extending up to 3rd –4th anal fin ray. HC 19.48-27.51 (23.28) in SL. PDS 16-18. lateral line complete. Metallic blue on back and flanks silvery. Generally two and rarely more rows of dark bluish spots on lateral region. Dorsal and anal fins dark bluish with tips hyaline. Pectoral and pelvic fins dull white. Caudal grayish blue with tips of lobes hyaline.

Geographical distribution: India: Western Ghats of Karnataka and Kerala (Talwar and Jhingran, 1991)

Distribution in Kerala: Cheenkannipuzha and Uruttipuzha of Aralam Wild Life Sanctuary, Bhavalipuzha originating from Kottiyoor reserved forests (Shaji and Easa, 2001), Periyar(Kurup *et al.*, 2004).

Habitat: Pool riffle habitats with rocky, sandy or gravelly bottom.

Fishing method: Cast nets.

Genus ***Danio*** Hamilton-Buchanan

Danio Hamilton-Buchanan, *Fish.Ganges*, pp. 321, 390, 1822 (Type, *Cyprinus dangila* Hamilton-Buchanan)

Fishes with an elongate, strongly compressed body. Abdomen rounded. Mouth oblique, terminal or slightly turned upwards and maxilla do not extend to vertical through front margin of eye. Lower jaw with a symphysial process. Tubercles absent. Eyes large, preorbital spine present. Barbells a pair of rostral and maxillaries. Dorsal fin inserted behind origin of pelvic fins. Anal fin with 14-20 rays. Lateral line complete, running along lower half of body, Caudal forked. These small fishes thrive mainly in mountain streams, rivulets, small water courses like pools and ditches. Brightly coloured active fishes, surface feeders, well suited for aquariums.

Key to species

1. a) Body deep, anal fin with 14-17 branched rays.......*Danio malabaricus*

   b) Body narrow, anal fin with 12-16 branched rays ....*Danio aequipinnatus*

Danio malabaricus (Jerdon)
(Plate VII, Fig. 59)

Perilampus malabaricus Jerdon, *Madras J. Lit. Sci.*, 15: 329, 1849 (Type locality: Malabar)
Paradanio aurolineatus Day, *Proc. zool. Soc. Lond.*, p. 246, 1867
Danio micronema Bleeker, *Mem. Soc. Holl. Haarlem*, p. 19, pl. 4, 1864
Eustira ceylonensis: Gunther, *Cat. Fish. Brit. Mus.*, 7: 331, 1868

Common name: Malabar Danio **Local name:** Vilanjil

Distinguishing characters: (Based on 79 specimens, 84-108 mm TL)

D. ii , 11; P.i,12; V.i,7; A.iii,14-17; C.19; Ll. 34-36, Ltr.8-8.5/2-2.5

Elongate, deep and strongly compressed body, dorsal and ventral profiles arched, BD 26.89-33.89 (29.97) and HL 22.50-25.66 (24.02) in SL. Eyes 25.62-28.80 (28.35) in HL. INTO 35.24-40.93 (38.14) in HL. HD 65.33-88.02

(76.93) in HL. HP 98.78-125.09 (119.25) in HD. HV 65.17-100 (78.21) in HP. LCPD 10.59-17.12 (13.94) in SL. HCPD 62.46-110.92 (79.69) in LCPD. HC 24.15-29.77(27.53) in SL. PDS 17-18. Lateral line complete. Bluish silvery on dorsal and flanks with three or four deep blue lines separated by golden lines which on anterior sides forming a pattern of spots and curly lines. Fins yellowish to orange.

Geographical distribution: India: Westernghats and Sri Lanka (Talwar and Jhingran, 1991; Jayaram, 1999)

Distribution in Kerala: Throughout Kerala (Ajithkumar *et al.,* 2000; Shaji and Easa, 2001), Achenkoil, Kabbini, Kallada and Meenachil (Kurup *et al.*, 2004).

Habitat: Pool-riffle or run habitats with rocky, sandy or gravelly bottom.

Fishing method: Cast nets.

Danio aequipinnatus (McClelland)
(Plate VII, Fig. 60)

Perilampus aequipinnatus McClelland, *Asiat. Res.*, 19 (2): 393, pl. 60, fig. 1, 1839 (Type locality: Assam)
Danio lineolatus: Gunther, *Cat. Fish. Brit. Mus.*, 7:282, 1868 (Sikhim)
Danio strigillifer. Myers, Amer. Mus. Novit., (150): 1, 1924 (Upper Burma)

Common name: Giant Danio **Local name:** Vilanjil

Distinguishing characters: (Based on 20 specimens, 84-108 mm TL)

D. ii,11-12; P.i,12-13; V.i,7; A.ii,12-16; C.19; Ll. 34-35 , Ltr. 7-8/1.5-2

Elongate and compressed body, comparatively less deep. Dorsal profile not so arched and more or less straight. BD 27.85-29.17(28.42) and HL 20.08-22.66 (21.47) in SL. Eyes in 29.09-32.51 (30.43) HL. INTO 43.85-47.55 (46.29) in HL. HD 71.5-95.31 (86.85) in HL. HP 61.77-80.27 (73.13) in HD. HV 62.71-78.89 (69.63) in HP. LCPD 5.8-8.36 (6.89) in SL. HCPD 141.12-199.71 (173.98) in LCPD. HC 26.73-31.50 (28.55) in SL. PDS 16-17. Lateral line complete. Brilliant bluish silvery on dorsal and flanks with three or four deep blue lines separated by thinner golden lines which on anterior sides forming a pattern of spots and lines. Fins yellowish to orange in colour.

Geographical distribution: India, Sri Lanka, Nepal, Bangladesh, Burma and Thailand (Talwar and Jhingran, 1991; Jayaram, 1999)

Distribution in Kerala: Common in rivers, streams and rivulets and low lands of Kerala (Shaji and Easa, 2001; Ajithkumar *et al.*, 2000), Valapatnam and Chaliyar river systems (Kurup et al., 2004).

Habitat: Pool riffle habitats with rocky, sandy or gravelly bottom.

Fishing method: Cast nets.

Sub family: Schizothoracinae

This sub family consist of a single genus, *Lepidopygopsis* Raj and a single species, *Lepidopygopsis typus*, distributed in Kerala. This is the only member under Snow trouts which have a geographical distribution outside Himalayan area and so has great Zoogeographical significance (Arun *et al.*, 1996).

Genus ***Lepidopygopsis*** Raj

Lepidopygopsis Raj, *Rec. Indian Mus.*, 43: 210, 1941 (Type, *Lepidopygopsis typus* Raj)

Lepidopygopsis typus Raj
(Plate VIII, Fig. 61)

Lepidopygopsis typus Raj, *Rec. Indian Mus.*, 43: 210, 1941 (Type locality: Periyar lake, Kerala)

Common name: Peninsular hill trout **Local name:** Brahmanakendai

Distinguishing characters: (Based on 10 specimens, 168-262 mm TL)

D. iii, 7; P.i,14; V.i,8; A.ii,5; C.19; Ll. 54-56

Elongate, BD 19.15-24.23 (23.27) and HL 21.25- 24.05 (22.01) in SL. BD 91.33-114.56 (104.73) in HL. Snout conical and tip bluntly round. Eyes large, 24.04-31.27(26.64) in HL. Barbells two pairs, rostral and maxillary. Mouth inferior, fairly broad and transverse. Dorsal fin inserted opposite to pelvic fin, last undivided ray osseous, elongate, strong and serrated behind, HD 112.58-141.34 (124.38) in HL. DB 52.45-57.61 (55.92) in HD. HP 65.44-76.94 (70.89) in HD. HV 86.69-91.49 (91.42) in HP. LCPD 19.4-23.03 (20.83) in SL. Caudal forked, HC 27.23-32.91(29.13) in SL. No scales on head, only few scales forming a patch on scapular region, a few scattered scales at base of dorsal spine, a continuous row of scales along lateral line and elongated tile-like scales forming a sheath at base of vent and anal fin. Back olivaceous green, flanks and ventral side of body shining golden silvery, fins generally olive green with anterior part of anal, dorsal and caudal fins dusky.

Geographical distribution: India: Periyar lake and stream system (Kerala) (Talwar and Jhingran, 1991)

Distribution in Kerala: Periyar river (Shaji and Easa, 2001) and lake (Menon, 1999; Jayaram; 1999; Kurup *et al.*, 2004)

Habitat: cascades, rapids, riffle-pool habitats with bedrock, boulders, cobbles and gravels as substratum.

Fishing methods: Cast nets and gill nets.

Sub family Garrinae

Fishes with Subcylindrical or laterally compressed body, mouth inferior, transverse and semicircular. Upper lip continuous with skin of snout and crenulated. Lower lip may be modified in to a suctorial disc as in *Garra*. Barbells one or two pairs, Paired fins horizontally arranged.

Key to genera

1. a) Body laterally compressed, sucking disc absent ....*Crossocheilus*

   b) Body sub cylindrical, lower lip modified in to a sucking disc ......*Garra*

Genus ***Crossocheilus*** Kuhl *et* van Hesselt

Crossocheilus Kuhl *et* van Hesselt, *Alg. Konst. Letter-Bode*, 2 (35) : 132, 1823 (Type, *Crossocheilus oblongus* Kuhl *et* van Hesselt)

Crossocheilus periyarensis Menon and Jacob
(Plate VIII, Fig. 62)

Crossocheilus periyarensis Menon and Jacob, *J. Bombay. Nat. Hist. Soc.*, 93 (1) : 62, 1996 (Type locality: Periyar upstream)

Common name: Periyar latia **Local name:** Karimbachi

Distinguishing characters: (Based on 8 specimens, 123-146 mm TL)

D. ii , 8; P.i,12-13; V.1,8; A.ii,6; C.19; Ll.35-36, Ltr.4.5-5/3.5

Body elongate, pre-dorsal region slightly more elevated, ventral profile normal. BD 25.20-27.62 (27.23) and HL 20.94-27.03 (24.56) in SL. Head small, snout obtusely round and overhanging mouth; covered with dense tubercles on tip and lateral sides. Mouth inferior, lips not continuous, jaws narrow with thin horny covering on inner side. Eyes large, 17.8-23.81 (19.00) in HL and placed at middle of head, not visible from ventral side. Barbells small maxillary and rostral pairs. Dorsal fin inserted distinctly near to snout. HD 105.95-129.77(118.26) in HL, HP 68.04-84.11 (76.92) in HD, HV 92.76-107.06 (99.08) in HP, LCPD 14.10-20.84 (20.46) in SL and HCPD 43.27-76.25 (52.29) in LCPD. Caudal fin deeply forked. Lateral line complete. Body brownish green on back with golden reflections, pinkish on flanks and under surface. Fins pink, dorsal and caudal fins edged with gray.

Geographical distribution: India: Kerala (Periyar upstream)

Distribution in Kerala: Periyar river (Zacharias *et. al.*, 1996; Shaji and Easa, 2001; Kurup *et al.*, 2004).

Habitat: Riffle-pool habitats with bedrock, cobbles and gravels as substratum. **Fishing methods:** Cast nets

Genus ***Garra*** Hamilton-Buchanan

Garra Hamilton-Buchanan, *Fish. Ganges*, pp. 343, 393, 1822 (Type, *Cyprinus lamta* Hamilton)

Sub-cylindrical body, Anterior portion slightly or sometimes conspicuously depressed, lower lip modified in to a suctorial disc, upper lip fimbriated. Barbells two pairs, maxillary pairs usually rudimentary. A proboscis may or may not be present. Paired fins horizontally inserted, first few rays of pectoral fins often provided with fleshy, adhesive pads on distal side, shape of caudal fin forked, truncate or emarginated. Lateral line complete and equally distant from back and belly.

Key to species

1 .a) Head with a proboscis ....*Garra gotyla stenorhynchus*

b) Proboscis absent..2

2. a) Lateral line scales 33-34, scales uniformly present on body..............3

b) Lateral line scales 35 to 40, scales uniformly present on body or absent on a part of body...4

3. a) Interorbital distance less than or about two times in head length, width of suctorial disc about 2 times in head width.............*Garra mullya*

b) Interorbital distance more than 2 times in head length, width of sucking disc less than 2 times in width of head..........*Garra ceylonensis*

4. a) Snout with a deep transverse groove, vent placed almost midway between origins of anal fin and ventral fins.......................................5

   b) No transverse groove present; if present, not deep. Vent not placed midway between origins of anal fin and ventral fins...........................6

5. a) Breast and belly scale less.................................*Garra periyarensis*

   b) Scales present uniformly on body.........................*Garra mcClellandi*

6. a) Scales absent on a part of body..7

   b) Scales present almost uniformly along body................................10

7. a) body slender, scales absent on breast and belly............................8

   b) Body robust, scales present on belly..9

8 a) Lateral line scales 35-36, eyes large, 22.45% in head length ....*Garra menoni*

   b) Lateral line scales 36-38, eyes small, 19.35% in head length ....*Garra hughi*

9. a) Lateral Line scales 37-38, body elongated, a shallow vertical groove on snout, dividing snout in to two lobes.....................*Garra travancoria*

   b) Lateral line scales 34-36, body stout and deep, no vertical grove on head...*Garra nilamburensis*

10. a) Body brownish green, scales on lateral sides with dark posterior edges...*Garra mlapparaensis*

    b) Body with back blotches or minute spots 11

11. a) Body with black blotches and dots, eyes larger, Caudal forked..*Garra surendranathani*

b) Body with minute dark dots arranged on either sides of lateral line appear as a dark band bordered with yellow bands, eyes small, Caudal emarginated...*Garra emarginata*

Garra gotyla stenorhynchus (Jerdon)
(Plate VIII, Fig. 63)

Gonorhynchus stenorhynchus Jerdon, *Madras J. Lit. Sci.*, 15: 310, 1847 (Type locality: Bhawany river, Nilghirris)
Garra gotyla Day, *Proc. zool. Soc. Lond.*, p.288, 1867
Garra jerdonia Rao (in part), *Ann. Mag. Nat. Hist.*, 6(9): 53, 1920
Garra gotyla stenorhynchus, Menon, *Mem. Indian Mus.*, 14(4): 236, 1964 (Cauvery and Krishna drainages, Western Ghats)

Common name: Nilgiris garra **Local name:** Kallemutti

Distinguishing characters: (Based on 20 specimens, 62-158 mm TL)

D. ii , 8; P.i,14; V.1,8; A.1,5; C.19; Ll. 33-34, Ltr. 4.5/2.5-3.

BD 18.46- 23.53 (21.43) and HL 27.13-36.96 (29.26) in SL. Snout with a proboscis and tuberculated. Eyes 14-24.93 (20.09) in HL and 46.61-57.45 (55.73) in INTO. INTO 30.04-40.35 (36.07) in HL. HW 82.59-91.25 (86.71) in BD. WSD 62.58 -71.29 (65.76) in HW. LSD 36.39-41.25 (37.55) in HL and 62.59-71.38 (67.27) in WSD. Dorsal fin closer to snout than caudal, HD 64.29-95.49 (86.75) in HL. HP 64.29-95.49 (86.75) in HL and 6.58-103.76 (88.57) in HD. Vt-AF 21.69-32.48 (26.43) in PF-AF. HCPD 82.76-94.62 (84.43) in LCPD. Caudal forked. Body uniformly scaled, scales larger. PDS 10. Colour olive green. Black spot at upper angle of gill opening, a row of dark spots at base of dorsal fin, Fins red orange.

Geographical distribution: India: Cauveri and Krishna drainage, Western Ghats (Talwar and Jhingran, 1991; Jayaram, 1999)

Distribution in Kerala: Kabbini, Chaliyar, Chinnar, Pambar, Bhavani rivers (Menon, 1964; Easa and Shaji, 1996; Ajithkumar *et al.,* 2000, Kurup *et al.*, 2004), Periyar Tiger Reserve (Zacharias *et al.*, 1996).

Habitat: Riffle-pool habitats with bedrock, cobbles and gravels as substratum. **Fishing methods:** Cast nets

Garra mullya (Sykes)
(Plate VIII, Fig. 64)

Chondrostoma mullya Sykes, *Trans. Zool. Soc. Lond.*, 2: 359, pl. 62, fig. 3, 1841 (Type locality: Beema river at Dounde)
Garra malabarica Day, *Proc.zool Soc. Lond.*, p. 297, 1865 (Type locality: Karrivannur river, Malabar)
Garra jerdonia var. *brevimentalia* Rao, *Ann. Mag. Nat. Hist.*, 6(9):54, pl.1,1920 (Type locality: Harangi river, Coorg)
Discognathus jerdoni Annandale, *Rec. Indian Mus.*, 16: 132, 1919

Common name: Mullya Garra **Local name:** Kallotti, Kallemutti

Distinguishing characters: (Based on 16 specimens, 76-182 mm TL)

D. ii, 8; P.i,13-14; V.1,8; A.1,5; C.19 Ll.33-34, Ltr.4.5/2.5-3.5.

BD 21.84-24.93 (22.40) and HL 24.8-28.71 (26.56) in SL. Snout with a transverse groove, tuberculated. Eyes 17.64-19.87(19.0) in HL and 40.68-47.01 (44.99) in INTO. Interorbitat slightly convex, 38.60-45.02 (42.34) in HL. HW 78.25-84.26 (82.25) in BD, WSD 61.29-71.26 (67.96) in HW. LSD 33.69-44.54 (39.56) in HL and 68.54-79.63 (76.67) in WSD. Dorsal fin closer to snout than caudal, HD 79.84-96.64 (88.75) in HL, HP 82.30-96.52 (88.93) in HL and 99.18-103.09 (100.34) in HD. Vt-AF 28.45- 42.59 (33.76) in PF-AF. HCPD 63.96-90.86 (75.81) in LCPD. Caudal slightly emarginated. Body uniformly scaled. PDS 10-11. Olive green with a broad, dark lateral band bordered by narrow yellow bands on two sides. Black spot at upper angle of gill opening, Fins red orange.

Geographical distribution: India: Throughout India except Assam and Himalayas (Talwar and Jhingran, 1991)

Distribution in Kerala: Almost all river systems of Kerala (Menon, 1964; Easa and Shaji, 1996; Ajithkumar *et al.,* 2000), Pamba, Kallada, Meenachil, Bharathapuzha river systems (Kurup *et al.*, 2004)

Habitat: Riffle-pool habitats with bedrock, boulders, cobbles and gravels as substratum.

Fishing methods: Cast nets and gill nets.

Garra ceylonensis Bleeker
(Plate VIII, Fig. 65)

Garra ceylonensis Bleeker, *Nat. Gen. Arch. Ned. India.*,3 (2): 135, 1863 (Type locality: Sri Lanka)
Discognathus lamta (*nec* Hamilton-Buchanan) Day (*partim*), 1877.

Common name: Stone sucker **Local name:** Kallotti, Kallemutti

Distinguishing characters: (Based on 8 specimens, 101 mm-121 mm TL)

D.ii, 8; P.i, 12-13; V.i, 7; A.i, 5; C.19; Ll. 33-34, Ltr. 4.5/2.5-3.5

BD 19.18-21.26 (19.12) and HL 19.92-22.92 (21.98) in SL. Snout with a transverse groove, tuberculated. Eyes 15.61-20.08 (17.60) in HL .Interorbital flat or concave, 31.99-41.78 (37.26) in HL. WSD 62.38-72.61 (69.51) in HW, LSD 98.41-116.94 (78.77) in WSD and 23.96-28.14 (20.41) in HL. Dorsal fin closer to snout, HD 88.42-96.29 (92.75) in HL, upper margin concave. HP 43.22-49.02 (46.56) in HL and 92.4-130.35 (106.89) in HD. HV 82.14-86.80 (85.34) in HP. Vt-AF 26.89-42.56 (34.69) in PF-AF. HCPD 84.78-104.39 (94.12) in LCPD. Caudal slightly forked. HC 24.13-26.06 (24.67) in SL. Body uniformly scaled. PDS 10-11. Olive green with a broad, dark lateral band bordered by narrow yellow bands on flanks. Black spot at upper angle of gill opening, Fins red orange.

Geographical distribution: Sri Lanka, India: Periyar river (New report)

Habitat: Riffle-pool habitats with bedrock, cobbles and gravels as substratum. **Fishing methods:** Cast nets and gill nets.

Garra periyarensis Gopi
(Plate VIII, Fig. 66)

Garra periyarensis Gopi, *J.Bombay nat.Hist.Soc.*, 98 (1), pp.82-83, 2001 (Type locality: Periyar lake)

Common name: Periyar Garra **Local name:** Kallemutti

Distinguishing characters: (Based on 12 specimens, 153-198 mm TL)

D. ii, 8; P.i,12-13; V.1,7; A.1,5; C.19; Ll. 37-40, Ltr. 4.5/3.5

Body elongate and slender, BD 13.61-15.82 (14.56) and HL 21.78-26.19 (23.27) in SL. Snout with a transverse groove, a prominent knob like protuberance at tip and is tuberculated. Eyes 20.37-26.80 (23.49) in HL and 63.2-97.18 (70.97) in INTO. Interorbitat flat, 27.58-32.02 (33.09) HL. HW 96.58-108.21 (104.12) in BD. WSD 71.26-88.21 (82.52) in HW. LSD 38.26-44.31 (39.25) in HL and 66.31-72.92 (68.8) in WSD. Dorsal fin closer to snout, HD 91.56-110.35 (97.52) in HL, HP 99.18-103.94 (100.34) in HD. Vt-AF 36.84-46.95 (41.26) in PF-AF. Caudal deeply forked. Scales absent on breast and belly. PDF 11. Brownish back, flanks yellowish brown. An indistinct mid-lateral band sometimes present. A faint black spot at upper angle of opercula. Fins dusky gray with yellowish tinge.

Geographical distribution: India: Western Ghats of Kerala (Gopi, 2001)

Distribution in Kerala: Thannikkudy, Periyar Tiger Reserve, Periyar river (Gopi, 2001), Periyar (Kurup *et al.*, 2004)

Habitat: Riffle-pool habitats with bedrock, cobbles and gravels as substratum. **Fishing methods:** Cast nets and gill nets.

Garra mcClellandi (Jerdon)
(Plate VIII, Fig. 67)

Gonorhynchus mcClellandi Jerdon, *Madras J. Lit. Sci.*, 15: 309, 1849 (Type locality Bawani river at foot of Nilghirris)
Garra jerdoni Day, *Proc.zool. Soc.Lond.*, p.288, 1867 (very common in the Seegoor river)
Discognathus elegans Annandale, *Rec. Indian Mus.*, 19: 76, pl.9, 1919 (Nierolay stream base of the Neilgiris)
Discognathus platycephala Rao, *Ann. Mag. Nat. Hist.*, 9(6), 1920 (Srirangapatnam, Mysore)

Common name: Cauvery Garra **Local name:** Kallemutti

Distinguishing characters: (Based on 4 specimens, 122-212 mm TL)

D. ii, 8; P.i,14; V.1,7; A.1,5; C.19; Ll. 35-38, Ltr. 4.5/3.5

Body elongate and slender, BD 14.58-18.54 (15.86) and HL 18.19-24.89 (21.39) in SL. Snout with a transverse groove, tuberculated. Eyes 22.49-26.18 (24.1) in HL Interorbitat flat, 31.08- 34.19 (32.18) HL. HW 84.59-96.58 (90.08) in BD. WSD 53.49 – 62.18 (58.54) in HW. LSD 31.29-36.49 (34.23) in HL and 71.64-74.58 (72.36) in WSD. Dorsal fin closer to snout, HD 91.28-98.26 (96.29) in HL. HP 96.58-107.84 (101.59) in HD. Vt-AF 32.16-42.86 (36.86) in PF-AF. Caudal deeply forked. Scales uniformy present except on a small part of chest. PDF 8-10. Brownish back, flanks yellowish brown. An indistinct midlateral band sometimes present. A faint black spot at upper angle of oprcula. Fins dusky gray with yellowish tinge.

Geographical distribution: India: Cauveri drainage (Talwar and Jhingran, 1991)

Distribution in Kerala: Kabbini and Periyar rivers (Arun *et al.*, 1996, Arun, 1997), Chaliyar, Periyar tiger reserve (Kurup *et al.*, 2004).

Habitat: Riffle-pool habitats with bedrock, cobbles and gravels as substratum. **Fishing methods:** Cast nets and gill nets.

Garra menoni Remadevi and Indra, 1984
(Plate VIII, Fig. 68)

Garra menoni Remadevi and Indra, *Bull. Zool. Surv. India*, 5(2): 121,1984 (Type locality: River Kunthi, Silent Valley)

Local name: Kallemutti

Distinguishing characters: (Based on 6 specimens, 56-68 mmTL)

D. ii, 8; P.i,12-15; V.1,7; A.i,5; C.19; Ll. 32-36, Ltr. 4.5/3-3.5

Body slender, BD 14.12-16.57 (15.17) and HL 21.35-23.15 (22.94) in SL. Snout broadly round and smooth, finely tuberculated in males. Eyes larger, 17.25-24.36 (22.45) in HL. Interorbital flat or slightly convex, 26.54-30.15 (29.88) in HL. HW 96.58-108.39 (106.138) in BD. WSD 81.26-86.29 (83.61) in HW. LSD 40.29-46.83 (42.25) in HL and 61.23-68.72 (66.85) in WSD. Dorsal fin equidistant between snout and caudal base, HD 78.25-82.35 (80.24) in HL. HP 118.12-121.25 (119.12) in HD. Vt-AF 29.34-37.65 (33.50) in PF-AF. HCPD 72.16-74.21 (73.36) in LCPD, caudal deeply forked. Scales absent on chest and belly. PDS 8-10. Olive brown on back, a faint dark brown lateral band from opercula to caudal base. Fins reddish brown.

Geographical distribution:India: Western Ghats of Kerala (Jayaram, 1999)

Distribution in Kerala: Kunthi river at Silent valley (Remadevi and Indra, 1981; Kurup *et al.*, 2004) and Chinnar river at Chinnar WLS (Easa and Shaji, 1995).

Habitat: Riffle-pool habitats with bed rock, cobbles and gravels as substratum. **Fishing methods:** Cast nets

Garra hughi Silas
(Plate VIII, Fig. 69)

Garra hughi Silas, *Rec. Indian Mus.*, 52: 1, 1955 (Type locality: streams in lower Vauguvarrai Estate, High Range, Travancore)

Common name: Cardamom Garra **Local name:** Kallemutti

Distinguishing characters: (Based on 11 specimens, 42-102mmTL)

D. ii, 7; P.i,13; V.i,7; A.ii,5; C.19; Ll. 35-37, Ltr. 4.5/3-3.5

Body slender, BD 11.90-24.8 (17.8) and HL 23.74-29.36 (26.63) in SL. Head slightly flat, Snout broadly round and smooth. Eyes small, 11.66-22.57 (19.35) in HL and 27.7-66.89 (54.18) in INTO. Interorbital flat, 35.24-42.07 (38.16) in HL. HW 98.24 –106.54 (102.8) in BD. WSD 71.26-79.84 (73.63) in HW. LSD 32.12- 38.49 (37.41) in HL and 58.46- 66.34 (62.33) in WSD. Dorsal fin equidistant between snout and caudal base, HD 66.86-84.56 (76.52) in HL, upper margin concave. HP 87.43-108.2 (96.43) in HD. Vt-AF 23.64 - 29.81 (25.63) in PF-AF. HCPD 80.87-126.24 (86.14) in LCPD. Caudal high, deeply forked. Scales absent on chest and belly. PDS 10-11. Grayish green on back, a conspicuous lateral band from opercula to caudal base, a light bluish mid dorsal streak. Fins dusky.

Geographical distribution: Peninsular India: Cardomon and Palani hills, Western Ghats (Talwar and Jhingran, 1991)

Distribution in Kerala: Cardomom and Palani hills, Chinnar, Pambar, Periyar (Ajith kumar *et al.*, 2000, Shaji and Easa, 2001, Gopi, 2001), Pambar, Periyar (Kurup *et al.*, 2004).

Habitat: Cascades and rapids with bedrock as substratum.

Fishing method: Cast net, Drag net

Garra travancoria Kurup and Radhakrishnan
(Plate VIII, Fig. 70)

Garra travancoria Kurup and Radhakrishnan, *J. Bombay nat. Hist. Soc.*, (in press)

Holotype: Deposited in ZSI, Calicut, No.ZSI/WGRS/CLT/V/F/13122a,133.80 mmTL, Moolavaigae of Periyar river, Periyar Tiger Reserve, 13-2-2004

Paratype: Deposited in ZSI, Calicut, No.ZSI/WGRS/CLT/V/F/13122b, 2 ex.121.56 mm and 115.7 mm TL, Moolavaigae of Periyar Tiger Reserve, 13-2-2004.

Diagnosis: An elongated species with dorsal fin inserted close to snout than caudal base, lateral line scales 37-38, scales uniformly present except on chest region, head more wide and snout broadly round, having a shallow to deep vertical vedge or groove and the goove sometimes extends even beyond, between eyes, moderate to large eyes, interorbital region slightly concave, wide and well developed sucking disc, pectoral fin less broad and comparatively small, distance between vent to anal fin forming 32.5% in interdistance between anterior origins of anal and pelvic fins. Caudal peduncle less deep, its depth forming 72% in its length, 39% in height of caudal fin and 62.63% in head length.

Distinguishing characters: (Based on 8 specimens, 98.72-133.80 mm TL)

D.ii, 7; P.i, 12; V.i, 7; A.i, 5; C.19.L.lat.37-38; Ltr. 4.5/3.5

Body elongate and slender. BD 13.12-18.65 (16.65) in SL, 56.21-81.87 (74.25) in HL. HL 21.08-23.92 (22.47) of SL. BD almost equal to HW, form 73.25-104.29 (96.66). Mental disc well developed, LSD 31.99-36.72 (34.49) in HL, 58.81-64.54(61.39) in WSD. WSD 68.48-81.33 (73.61) in HW. Snout broadly round and tuberculated at its tip. Barbells two pairs, rostral barbells slightly smaller than eye diameter, forming 75.65-98.97 (85.32) of latter. Eyes moderate to large in size and not visible from ventral side of head, diameter 18.13-20.7 (19.1) of HL, 38.43-46.67(41.67) in INTO. Interorbital region slightly concave and form 41.34-47.18 (46.95) in HL. Abdomen slightly rounded. Vt-AF 26.18-36.58(32.49) in PF-AF. LCPD 13.18-14.86 (14.33) in SL, 56.52-73.46 (64.01) in HL and HCPD 70.84-80.21 (72.01) in LCPD. PDS 11-12, pre ventral scales 12-14 and pre anal scales 25-26. Scales between pectoral and ventral fins 12-14, pelvic and anal fins 12-13. circumpeduncular scales 8-11. Dorsal fin inserted closer to snout than to caudal. Pre dorsal length form 80.59-86.63 (83.18) in post dorsal length. HD more or less equal to HL, forming 92.78-107.85 (100.84) in latter and 21.64-24.46 (22.62) in SL. Pectorals shorter than dorsal and form 88.64-98.8 (92.8) in latter and 19.72-21.38 (20.97) in SL. Ventral fins form 83.71-87.62 (86.23) in pectoral height. Pectoral not reaching ventral fins whereas latter reaches or slightly overlaps vent. Pre-anal distance 71.63-78.59 (78.24), pre dorsal distance 45.16-46.41 (44.63), Pre-ventral distance 46.12-52.32 (50.06) and pre-pectoral distance 18.77-21.03 (20.26) in SL. Caudal forked. In live, ground colour is greenish brown with scales at lateral line more brownish forming a continuous faint brown lateral streak. Ventral surface pale white. Head olivaceous green. Fins generally reddish brown. In formalin, ground colour turns brown.

Geographical distribution: India: Moolavaigae, Periyar Tiger Reserve, Periyar river, Kerala.

Etymology: Named after Travancore geographical region, to which river Periyar is a part.

Other materials examined:

Garra mullya: ZSI/SRS F5789,1 ex. 95mm SL, Harangi reservoir; *G.menoni:* ZSI/SRS F553, paratypes,31-69mmSL,Silent valley; *G.hughi:* ZSI/SRS F5328,150 ex. 39-70 mm SL,Kilakallar; *G.gotyla stenorhynchus:* ZSI/SRS F 4913, paratypes,110-111mm SL, Thirumoorthy dam; *G.mcClellendi:* ZSI/SRS

F6763, 1ex.142mm SL, Hassan dt.Karnataka; ZSI/SRS F5139, 1 ex. 138 mm SL, Moyar river; *G.kalakadensis:* ZSI/SRS F854, paratypes 26 ex.21-60mm SL, Kalakad wild life sanctuary.

Habitat: cascades, rapids and riffle-pools with bedrock, cobbles and gravels as substratum.

Fishing methods: Cast net.

Garra nilamburensis Kurup and Radhakrishnan
(Plate IX, Fig. 71)

Garra nilamburensis Kurup and Radhakrishnan, *J. Bombay nat. Hist.Soc.* (in press)

Holotype: Deposited in ZSI, Calicut, No. ZSI/WGRS/ CLT/V/F 13117a, 131.42 mm TL, Karimpuzha, Chaliyar river, 25-2-2004

Para type: 2ex. Deposited in ZSI, Calicut, No. ZSI/WGRS/ CLT/V/F 13117b, 100.54 mm and 101.46 mm TL, Karimpuzha, Chaliyar river, 25-2-2004.

Diagnosis: A short and stout species with dorsal fin inserted close to snout than caudal base, lateral line scales 34-36, scales absent on chest region, body depth high, forming 4.2-4.8 times in head length and less than 5 times standard length, head more or less round, convex interorbital region, small to moderate eyes, wide and well developed sucking disc, broad pectoral and pelvic fins with ventral fins overlapping vent, vent placed close to anal fin, caudal peduncle deep, forming 0.92-1.2 times in its length, 1.73-2 times in hight of caudal fin and 1.5-1.8 times in head length.

Distinguishing characters: (Based on 6 specimens, 100.54-131.42 mm TL)

D.i, 8; P.i, 14; V.i, 7; A.i, 5; C.19.L.lat. 34-36; Ltr. 4.5/2.5

Body short and stout. BD 18.05-22.46 (20.79) in SL, 80.65-94.02 (86.69) in HL and almost equal to or slightly higher than HW, forming 96.29-106.57(105.57) of latter. HL 23.54-26.12(24.19) of SL. Mental disc well developed. LSD 34.23-38.36 (37.42) in HL, 50.06-67.70 (58.26) in WSD and latter 72.52-79.72(75.40) in HW. Snout broadly round with a few tubercles at its tip. Barbells two pairs, rostral barbells equal to or slightly greater than diameter of eye. Eyes small to moderate in size and not visible from ventral side of head, diameter 17.22-21.05 (19.11) of HL, 40-45.35 (42.30) in INTO. Interorbital region slightly convex and form 43.04-47.29 (45.12) in HL. Abdomen slightly rounded. Vt-AF 21.69-29.26 (25.63) in PF-AF. LCPD 79-14.89 (13.94) in SL, 54.85-59.89 (57.64) in HL and HCPD 84.55-96.97(90.85) in LCPD. PDS 10-11, pre ventral scales 11 and preanal scales 26. Scales between pectoral and ventral fins11, pelvic and anal fins 13. circumpeduncular scales 12-15. Dorsal fin inserted closer to snout than to caudal. Pre dorsal length form 82.38-95.20 (86.38) in post dorsal length. HD more or less equal to head length, forming 94.39-113.39 (106.46) in latter. Pectorals equal to dorsal and form 92.41-103.36 (100.0) in latter. Ventral fins form 76.83-84.62 (80.96) in pectoral height. Pectoral not reaching ventral fins where as latter reaches or slightly overlaps vent. Pre anal distance 67.61-80.83 (76.50), pre dorsal distance 39.73-47.74 (45.06), Pre-ventral distance 44.16-53.38 (50.41), and pre pectoral distance 19.28-22.55 (21.16) in SL. Caudal forked. In live, ground colour is greenish brown with scales at lateral line more brownish forming a continuous faint brown lateral streak. Ventral surface yellowish white. Head olivaceous green with snout and cheeks brownish. Fins generally reddish brown with blackish patches. In formalin, ground colour turns brown.

Geographical distribution: India: Karimpuzha of Chaliyar river system in Nilambur reserve forest, Kerala.

Etymology: Named after the locality, Nilambur reserved forests from where specimens of new species were obtained.

Other materials examined:

Garra mullya: ZSI/SRS F5789,1 ex. 95mm SL, Harangi reservoir; *G.menoni:* ZSI/SRS F553, paratypes,31-69mmSL,Silent valley; *G.hughi:* ZSI/SRS F5328,150 ex. 39-70 mm SL,Kilakallar; *G.gotyla stenorhynchus:* ZSI/SRS F 4913, paratypes,110-111mm SL, Thirumoorthy dam; *G.mcClellendi:* ZSI/SRS F6763, 1ex.142mm SL, Hassan dt.Karnataka; ZSI/SRS F5139, 1 ex. 138 mm SL, Moyar river; *G.kalakadensis:* ZSI/SRS F854, paratypes 26 ex.21-60mm SL, Kalakad wild life sanctuary.

Habitat: Cascades, rapids with bedrock, cobbles and gravels as substratum.

Fishing methods: Cast nets.

Garra mlapparaensis Kurup and Radhakrishnan
(Plate IX, Fig. 72)

Garra mlapparaensis Kurup and Radhakrishnan, *J. Bombay nat. Hist. Soc.* (in press)

Holotype: Deposited in ZSI (WGRS) CLT. No. V/F 13032 94.58 mm TL, Mlappara, Periyar, 18-02-2002.

Para type: Nil.

Diagnosis: A species of *Garra* having an elongated and slender body with dorsal fin having 7 branched rays, lateral line complete with 36 scales, scales on lateral sides have their posterior ends blackish, distance between vent and anal fin 3.15 times in distance between anterior origin of anal and ventral fins.

Distinguishing characters (Based on one specimen, 94.58 mm SL)

D.1-II, 7; P.1, 12; V.1, 7; A. 1,5; C.19; Ll.35; Ltr. 4.5/3.5

Body elongate and slender, BD 18.64 in SL, HL 22.08 of SL, Mental disc well developed, WSD 73.22 in width of head. Snout rounded with fine tubercles. Barbells two pairs, rostral barbells slightly greater than diameter of eye and forming 106.21 of eye. Eyes moderate and not visible from ventral side of head, diameter 21.20 of HL, 43.86 in INTO. INTO 48.34 in HL. Abdomen slightly rounded Vt-AF 31.70 in PF-AF. LCPD 14.92 in SL , 65.34 in HL and HCPD 77.49 in LCPD. PDS 12, pre ventral scales 13 and pre anal scales 24. Circumpeduncular scales 12. Dorsal fin inserted closer to snout than to caudal. It is longer than HL, DB form 26.45 of height. Pectorals almost equal to head length and forms 98.70 in it. Pelvic fins smaller than head and form 89.26 in it and 90.44 in pectoral fin length. Distance between pectoral and ventral is 31.58 in SL. Distance between ventral and anal fins 24.40 in SL. Pre anal distance 77.55 in SL and pre dorsal distance 45.39 in SL. Pre-ventral distance 50.72 in SL. and pre pectoral distance forms 19.34 in SL. Caudal forked. In live, ground colour is greenish brown with ventral side pale white. Posterior edges of scales on lateral sides are blackish. Fins generally orange red and dorsal rays have blackish tips. In formalin, ground colour turns brown.

Geographical distribution: India: Mlappara at upstream of Periyar river, Kerala.

Etymology: Named after the locality from where the specimens were collected.

Other materials examined:

Garra mullya: ZSI/SRS F5789,1 ex. 95mm SL, Harangi reservoir; *G.menoni:* ZSI/SRS F553, paratypes,31-69mmSL,Silent valley; *G.hughi:* ZSI/SRS F5328,150 ex. 39-70 mm SL,Kilakallar; *G.gotyla stenorhynchus:* ZSI/SRS F 4913, paratypes,110-111mm SL, Thirumoorthy dam; *G.mcClellendi:* ZSI/SRS F6763, 1ex.142mm SL, Hassan dt.Karnataka; ZSI/SRS F5139, 1 ex. 138 mm SL, Moyar river; *G.kalakadensis:* ZSI/SRS F854, paratypes 26 ex.21-60mm SL, Kalakad wild life sanctuary.

Habitat: Riffle-pool habitats with cobbles and gravels as substratum.

Fishing methods: Cast nets.

Garra surendranathani Shaji, Arun and Easa
(Plate IX, Fig. 73)

Garra surendranathanii Shaji, Arun and Easa, *J.Bombay nat. Hist. Soc.*, 93(3), pp. 572-575, 1996 (Type locality: Chalakkudy upstream)

Common name: Nilgiri Garra **Local name:** Kallotti

Distinguishing characters: (Based on 20 specimens, 62-158 mmTL)

D. ii, 8; P.i,13; V.1,7; A.1,5; C.18; Ll. 36-37, Ltr. 4.5/3.

Body elongate, BD 15.05-17.0 (16.17) and HL 22.91-24.25 (23.70) in SL. Head broad, snout elongated, without a transverse groove but a weakly developed protuberance as in adult specimens and with spinate tubercles. Eyes 23.53-28.59 (26.7) in HL , 67.15-76.15 (73.83) in INTO. Interorbital flat, 34.48-37.69 (36.13) in HL. HW 91.68- 99.23 (95.8) in BD. WSD 70.68-74.62 (72.19) in HW. LSD 32.68-44.69 (39.54) in HL and 68.19-74.26 (70.01) in WSD. Dorsal fin close to snout than caudal, HD 82.07-101.18 (82.07) in

HL. HP 103.47-118.7 (106.21) in HD. Vt-AF 39.48-44.26 (42.38) in PF-AF. HCPD 51.27-77.82 (62.29) in LCPD. Caudal forked. Body uniformly scaled, PDS 11-13. Back dark brown-black, flanks greenish brown, scales have black edges which appear as interrupted bands or some times patches of spots. Head with patches of black dots. Fins orange with black patches.

Geographical distribution: India: Western Ghats of Kerala (Jayaram,1999)

Distribution in Kerala: Chalakkudy and Periyar rivers (Shaji *et al.,* 1996; Ajithkumar *et al.*, 2000; Kurup *et al.*, 2004)

Habitat: cascades, rapids and riffles with bedrock, cobbles and gravels as substratum.

Fishing methods: Cast nets.

Garra emarginata Kurup and Radhakrishnan
(Plate IX, Fig. 74)

Garra emarginata Kurup and Radhakrishnan, *J. Bombay nat. Hist. Soc.* (in press)

Holotype: Deposited in ZSI (WGRS) CLT.No. V/F 13033,115.26 mm TL, Pooyamkutty, Periyar river, 23 rd, May, 2003.

Paratypes: 2ex. 107.4 mm and 97.5 mm TL, Pooyamkutty, Periyar river, 23rd May, 2003 (Kept at School of Industrial Fisheries museum, Cochin University of Science and Technology)

Diagnosis: An elongate and slender species possessing an emarginated caudal fin, eyes small and interorbital flattened, dorsal fin with 8 branched rays, lateral line complete with 35 scales, body with minute black spots arranged in series on either sides of lateral line, distance between vent and anal fin 2.7-3.4 times in distance between anterior origin of anal and ventral fins.

Distinguishing characters: (Based on 4 specimens, 97.5-115.26 mm TL)

D.1I, 8; P.1, 13; V.1, 7; A.1, 5; C.19.

Body elongate and slender. BD 15.86-18.39 in SL (17.19), HL 21.85-24.07(23.40) of SL, Mental disc well developed, LSD 70.35-74. 19 (72.27) in WSD and latter 51.38-65.12(58.35) in HW. Snout round and smooth. Barbells two pairs, rostral barbells equal to or slightly greater than diameter of eye, forming 102-112.69 (108.23) of latter. Eyes smaller and not visible from ventral side of head, diameter 17.08-18.83 (19.75) of HL, 36.0-44.85 (38.28) in INTO. Interorbital distance flattened and is 46.89-52.41 (49.2) in HL. Abdomen slightly rounded. Vt-AF 29.77-32.22 (30.33) in PF-AF. LCPD 10.91-12.48 (11.25) in SL, 44.44 -50.92 (48.52) in HL and HCPD 89.38-99.63 (92.46) in LCPD. PDS 11-12, pre ventral scales 13 and preanal scales 26. Circumpeduncular scales 12. Dorsal fin inserted closer to snout than to caudal. It is shorter than HL, DB form 62.44-86.48 (75.63) of HD. Pectorals larger than head and forms 106.88-130.0 (124.29) in HL. Ventral fins almost equal or slightly larger than head and forms 89.37-106.02(100.29) in HL and 79.45-92.68(86.25) in pectoral fin length. Distance between pectoral and ventral is 33.19-35.54(34.46) in SL. Distance between ventral and anal fins 26.62-32.16(29.16) in SL. Pre anal distance 80.91-87.4 (83.61) in SL and pre dorsal distance 48.22-51.68 (49.08) in SL. Pre-ventral distance 52.06-55.39 in SL and pre pectoral distance 18.42-21.88 in SL. Caudal emarginate. In live, ground colour is grayish green with ventral side pale white. Minute dark spots are arranged on either sides of lateral line in a series. Fins generally pale orange red and dorsal rays have blackish tips. In formalin, ground colour turns brown.

Geographical distribution: India: Pooyamkutty in Periyar river, Kerala.

Etymology: Named after the emarginated nature of caudal fin, which differentiate the species from all other related species.

Other materials examined:

Garra mullya: ZSI/SRS F5789,1 ex. 95mm SL, Harangi reservoir; *G.menoni:* ZSI/SRS F553, paratypes,31-69mmSL,Silent valley; *G.hughi:* ZSI/SRS F5328,150 ex. 39-70 mm SL,Kilakallar; *G.gotyla stenorhynchus:* ZSI/SRS F 4913, paratypes,110-111mm SL, Thirumoorthy dam; *G.mcClellendi:* ZSI/SRS F6763, 1ex.142mm SL, Hassan dt.Karnataka; ZSI/SRS F5139, 1 ex. 138 mm SL, Moyar river; *G.kalakadensis:* ZSI/SRS F854, paratypes 26 ex.21-60mm SL, Kalakad wild life sanctuary.

Habitat: Pool-riffle habitats with bedrock, cobbles and gravels as substratum.

Fishing methods: Cast nets.

Family: Balitoridae

Fishes with greatly depressed (Balitorinae) or fusiform (Nemacheilinae) body, covered with small cycloid scales. Scales absent on ventral surface. Gill openings either restricted to above base of pectoral fins or extending to ventral surface for a short distance. Paired fins may or may not be placed horizontally with one or two simple unbranched rays. Outer rays of paired fins are provided with adhesive pads on ventral surface. Lateral line complete or in complete.

Key to sub-families

1. a) Paired fins horizontally inserted. Pectoral fins with atleast two simple rays...Balitoriane

b) Paired fins not inserted horizontally, only outermost pectoral fin ray is simple..Nemacheilinae

Sub-family: Balitorinae

Body streamlined, moderately or greatly depressed, ventrally flattened. Mouth inferior, at least with three pairs of barbells. Paired fins horizontally inserted, fan like and have adhesive pads on ventral surface of outer rays. Atleast two simple rays in pectoral and pelvic fins. No spine under or before eyes.

Key to Genera

1. a) Two antrose papillae between angles of mouth.............................2

   b) No antrose papillae.................. 3

2. a) Gill openings small, restricted above pectoral fin base.........*Bhavania*

   b) Gil openings extending to below pectoral base................*Travancoria*

3. a) Upper lip with labial papillae........ ....*Balitora*

   b) No labial papillae on lips..*Homaloptera*

Genus ***Bhavania*** Hora

Bhavania Hora, *Rec. India Mus.*, 39 : 11, 1937 (Type, *Platycara australis* Jerdon)

Bhavania australis (Jerdon)
(Plate IX, Fig. 75)

Platycara australis Jerdon, *Madras J. Lit. Sci.*, 15: 333, 1849 (Type locality: Walliar, Nilghirris)
Homaloptera maculata Day, Fish. India, 256, pl. 122, 1878 (Wyanad)
Bhavania annandalei Hora, *Rec. Indian Mus.*, 19: 200, 1920 (Travancore, Nilgiris and Malabar)
Bhavania australis Hora, *Rec. Indian Mus.*, 19: 205, 1920

Common name: Western Ghat loach **Local name:** Kallechari, Kallepatti

Distinguishing characters: (Based on 26 specimens, 63-116 mm TL)

D. ii, 7-8; P. viii, 10-11, V.ii,7; A.i,5; C.19.Ll. 67-68. Ltr.16-17/10.

Head and anterior part of body depressed. BD 10.69-16.56 (13.21), HL 19.75-26.10 (22.70) in SL. Snout broad with trenchant margins. Rostral groove overhung by a rostral fold. Eyes moderate, 12.81-20.82 (16.12) in HL. Lips continuous, non papillated. Dorsal fin inserted close to snout and slightly behind origin of pelvic fin, margin straight or slightly concave. Pectoral fins fan like, broad, HP 88.52-130.93(98.68) in HL. Caudal fin forked. Ground colour dark on dorsal surface with black spots and blotches irregularly distributed, but form a regular pattern on fins.

Geographical distribution: India: Extreme south of Western Ghats (Karnataka, Nilgiris and Kerala) (Talwar and Jhingran, 1991)

Distribution in Kerala: Travancore high ranges (Silas, 1951), Periyar Tiger Reserve (Arun *et al.,* 1996), 13 rivers of Kerala (Ajithkumar *et al.,* 2000), Kabbini river system(Kurup *et al.*, 2004).

Habitat: Cascades, rapids and riffles at upper streches of river systems. Depressed body, flat ventral surface, horizontally arranged and enlarged fins helps to attach itself closely to rocky substratum in fast moving waters.

Fishing method: Scoop nets and drag nets.

Genus ***Travancoria*** Hora

Travancoria Hora, *Rec. India Mus.*, 43: 228, 1941 (Type, *Travancoria jonesi* Hora)

Head and anterior part of body depressed and ventral surface flattened. Lips are thick and continuous at corners of mouth. Lower lip interrupted and median part is separated from two lateral parts. Two antrose papillae present. Rostral groove deep, 4-7 short and stumpy rostral barbells arranged in two series and a pair of maxillary barbells at corners of mouth. Gill openings extend below pectoral base for a short distance. Pectoral fins with 15-16 rays with first few rays simple. Caudal forked.

Key to species

1. a) Rostral cap is not developed in to barbells, distance between vent to anal origin 7-8 times in interdistance between origins of ventral and anal fin..*Travancoria elongata*

   b) Rostral cap developed in to barbells, distance between vent to anal origin 2-3 times in interdistance between origins of ventral and anal fin ....*Travancoria jonesi*

Trvancoria elongata Pethiyagoda and Kottelat
(Plate IX, Fig. 76)

Travancoria elongata Pethiyagoda and Kottelat, *J. South Asian nat. Hist.*, No. 1, 104, 1994 (Type locality: Upstream of Chalakkudy river)

Common name: Periyar loach **Local name:** Kallepatti, Kallenacki

Distinguishing characters: (Based on 6 specimens, 86-112 mm TL)

D. iii, 7-8; P.7, 10; V. ii, 7; A. ii,5; C.19. Ll. 74-77; Ltr. 9-10/8

Body slender, elongated and strongly depressed. BD 7.65-11.07 (9.36) and HL 14.56-15.35 (14.95) in SL. Eyes smaller, 17.96-21.85 (19.91) in HL. Rostral cap in the form of three inconspicuous lobes. Four rostral and two maxillary barbells. HCPD 17.01-17.27 (17.14) in LCPD and LCPD 21.95-24.88 (23.41) in SL. HD 116.47-130.25 (123.36) in HL. Upper margin of dorsal fin concave. HP 116.32-116.52 (116.44) in HD and HV 89.3-91.16 (90.23) in HP. Vt-AF 14.86-16.25 (14.93) in VF-AF. HC 23.46-24.79 (24.12) in SL. Greenish brown body with dark brown spots and blotches. On back, there are 9-10 saddle shaped blotches. Blotches along lateral line coalesce together and give appearance of a band. Ventral side creamy white. Head mottled with several small brownish spots. Fins dotted.

Geographical distribution: India: Western Ghats of Kerala (Jayaram, 1999; Menon, 1999)

Distribution in Kerala: Periyar river system (Kurup *et al.*, 2004).

Habitat: Rapids and cascades of upper streches. Depressed body, flat ventral surface, horizontally arranged and enlarged fins helps fish to attach it self closely to rocky substratum in fast moving waters.

Fishing methods: Scoop nets and drag nets.

Travancoria jonesi Hora
(Plate IX, Fig. 77)

Travancoria jonesi Hora, *Rec. Indian Mus.*, 43: 230, pl. 8, figs. 5 to 9, 1941(Type locality ; stream within a radius of five miles from Pampadumpara, Peerumedu, Kerala)

Common name: Travancore loach **Local name:** Kallepatti, Kallenacki

Distinguishing characters: (Based on 22 specimens, 68-108mm TL)

D.ii,7 ; P. vi,9; V. ii, 7; A.i,5 C.18.LI. 76-77; L.tr. 9-10/8

Head and body depressed. BD 12.63-14.30 (13.47) and HL 22.32-23.42 (22.87) in SL. Eyes comparatively larger, 21.09-24.13 (22.61) in HL. Rostral cap developed in to barbells. Seven rostral and two maxillary barbells. HCPD 32.86-33.15 (33.01) in LCPD. LCPD 17.43-17.51(17.47) in SL upper margin of dorsal fin straight, HD in HL. Vt-AF 37.56-48.23 (42.58) in PF-AF. HC 19.3-20.32 (19.81) in SL. Ground colour dark brown. On back, a series of 8-10 saddle shaped blotches. Head and body mottled with black spots of different sizes and pattern, some of which form a black lateral band. Ventral side creamy white. Fins with a series of dots.

Geographical distribution: India: Western Ghats – High ranges of northern Travancore and Anamalai hills (Talwar and Jhingran, 1991)

Distribution in Kerala: Chalakkudy River system (Hora, 1941., Ajithkumar *et al.*1999), Periyar river system (Kurup *et al.*, 2004)

Habitat: Rapids and cascades of upper streches. Remarkably, the species shares the same habitat of *Travancoria elongata*. Depressed body, flat ventral surface, horizontally arranged and enlarged fins are adaptations for its attachment to rocky substratum in fast moving waters.

Fishing methods: Scoop nets and drag nets.

Genus ***Balitora*** Gray

Balitora Gray, *Ill, Ind. Zoo.*, 1: pl. 88, figs. 1, 2, 1832 (Type, *Balitora brucei* Gray)

Balitora mysorensis Hora
(Plate IX, Fig. 78)

Balitora brucei var. *mysorensis* Hora, *Rec. Indian Mus.*, 43: 232, pl. 8, fig. 4, 1941(Type locality: Sivasamudram, Karnataka)
Balitora mysorensis: Menon, 1977

Common name: Slender stone loach **Local name:** Kallepatti

Distinguishing characters: (Based on three specimens, 68-73 mmTL)

D. ii, 9; P.ix,11; V.1,9; A. i, 5; C.19; Ll. 60-62

Head and body strongly depressed. BD 10.62-13.30 (11.96) and HL 19.18-23.53 (21.36) in SL. snout broadly round. Eyes small, dorsolateral in position, 11.71-13.42 (12.56) in HL. INTO 32.78-36.41 (34.59) in HL. Upper lips papillated. Barbells six, four rostral and two maxillary. HCPD 50.32-50.92 (50.62) in LCPD. LCPD 10.49-12.20 (11.34) in SL. HD 86.91-88.29 (87.6) in HL, margin concave. Pectorals broad and fan like. Anal opening close to anal fin, Caudal deeply forked. HC 24.94-29.28 (27.11) in SL. Ground colour olivaceous, a row of short saddle shaped grayish bands on back, along lateral line a diffused gray band, belly dirty white.

Geographical distribution: India: Westernghats-Cauvery and Tungabhadra river system (Karnataka) and Kolhapur (Maharashtra) (Talwar and Jhingran, 1991)

Distribution in Kerala: Kabbini, Bhavani and Periyar (Menon, 1987, Shaji *et al.*, 1996).

Habitat: Rapids and cascades of upper streches. Depressed body, flat ventral surface, horizontally arranged and enlarged fins are adaptations to attach it self closely to rocky substratum in fast moving waters.

Fishing method: Scoop nets and dragnets

Genus: ***Homaloptera*** van Hesselt

Homaloptera van Hesselt In: Kuhl & van Hesselt, *Algem, konst. En Letterbode*, 2, p.133, 1823 (Type, *Homaloptera ocellata* van der Hoeven)

Body subcylindrical or depressed. Ventral surface flattened or round. Head depressed. Snout broadly round or conical. Rostral groove absent and lips are continuous. No post labial papillae. Barbells three pairs, two rostral and one maxillary. Gill openings extending to a short distance beyond pectoral base. Dorsal fin with 8 rays, anal fin short with seven rays, of which 5 are unbranched. Caudal peduncle short and stout. Caudal fin emarginated or deeply forked. scales small and absent on head and ventral side. Lateral line complete.

Key to species

1. a) Origin of dorsal fin towards caudal than snout tip, ventral surface rounded, body with a distinct dark lateral band along lateral line, unbranched pectoral fin rays 5..............................*Homaloptera silasi*

b) Origin of dorsal fin equidistant between snout and caudal fin, ventral surface flat, body with irregular spots, unbranhced pectoral fin rays 7-9..*Homaloptera pillai*

Homaloptera pillai Indra and Remadevi
(Plate IX, Fig. 79)

Homaloptera pillai Indra and Remadevi, *Bull. Zool. Surv. India*, 4 (1): 67, 1984(River Kunthi, Silent valley, Kerala)

Common name: Silent valley loach **Local name**: Kallenacki, Kallepatti

Distinguishing characters: (Based on 8 specimens, 33-82 mm TL)

D.i,7-9; A.i-ii,4-5; P.vii-ix,11-13; V.ii-iii, 8-9; Ll. 83-93

Body depressed, ventral side flattened. BD 12.86-13.06 (12.96) in SL, Head flattened, snout broad, HL 20.74 – 22.7 (21.72) in SL. Eyes small to moderate, 14.41-14.61 (14.51) in HL. HCPD 68.19-78.23 (73.23) LCPD and LCPD 10.41-11.93 (11.17) in SL. HD 77.15-84.49 (80.02) in HL Pectorals broad almost reaching pelvics, 109.64-129.84 (119.74) in HL and 129.77-168.3 (149.04) in HD. Pelvics also broad, not reaching vent, 82.49-82.62 (82.55) in HP. Caudal emarginated, HC 17.11-19.73 (18.42) in SL. Ground colour light to dark brown, mottled with numerous irregularly placed dark dots. Head mottled with numerous irregular black dots. Fins dusky brown. Ventral side yellowish to light brown.

Geographical distribution: India: Western ghats of Kerala (Talwar and Jhingran, 1991),

Distribution in Kerala: Silent valley national park (Indra and Remadevi, 1981; Menon, 1999, Jayaram, 1999), Bharathapuzha (Kurup *et al.*, 2004).

Habitat: Rapids and cascades of higher altitudes. Depressed body, flat ventral surface, horizontally arranged and enlarged fins are adaptations to attach it self closely to rocky substratum in fast moving waters.

Fishing method: Scoop nets and dragnets

Homaloptera silasi Kurup and Radhakrishnan
(Plate IX, Fig. 80)

Homaloptera silasi Kurup and Radhakrishnan, *J. Bombay nat. Hist. Soc.* (in press)

Holotype: Deposited in ZSI, Calicut, no. ZSI/WGRS/CLT/V/F 13118a, 67.92 mm TL, Chockanpetty, Periyar Tiger reserve, 12th February, 2004

Paratypes: 2ex. Deposited in ZSI, Calicut, no. ZSI/WGRS/CLT/V/F 13118b, 49.70-51.26 mm TL, Chockanpetty, Periyar Tiger reserve, 12th February, 2004

Diagnosis:

An elongate fish with a sub cylindrical body, Head depressed, small eyes, narrowly elongated snout, dorsal fin inserted close to base of caudal fin than tip of snout, small pectoral fins, its height less than length of head and not reaching pelvic fins, pelvic fins also small, not reaching vent or anal fin, 89 to 93 lateral line scales, caudal peduncle short and stout and its least depth less than two times in its length.

Distinguishing characters: (Based on 4 specimens, 46-68 mmTL)

D i, 8; P v, 9; V ii, 8; A 1, 6; C 19; Ll. 89-93.

Body sub cylindrical and covered with scales except on ventral surface. BD14.31-17.62 (15.46) in SL. MWB 83.74-102.06 (92.05) in MDB. BD 54.44-71.93 (49.02) in HL. Scales small imbricate, covering whole body except head and ventral profile. Head depressed, snout elongated and broadly pointed. HL 49.80-58.26 (54.56) in SL and width of head form 67.01-

72.51(69.86) in length of head. Eyes small and placed at middle of head and are not visible from ventral surface of head and forming 7.76-9.84 (8.26) of HL and 22.62-60.61(41.70) in INTO. Snout 38.27-47.36 (42.85) in HL and is 92.44-105.90 (99.78) in POL. INTO form 34.32-41.31(37.73) in HL Dorsal fin situated just behind origin of pelvic fin and its origin is closer to base of caudal fin than to snout tip. PDL 49.80-58.26 (54.56) in SL and is 108-114 (112.22) in PODL. DH 70.84-84.21 (77.82) in HL and 18.05-20.63 (19.14) in SL. Pectoral fins not reaching pelvics and PH 19.58-22.16 (21.37) in SL and 106.71-118.97 (111.75) in DH. It form 80.03-92.55 (86.81) in HL. Pelvic fins are short and not reaching vent or anl fin. VH 77.14-85.57(81.25) in PH and 64.40-79.19 (70.55) of HL. Anal fins shorter than pectoral and pelvic fins and is 42.54-68.63 (56.29%) in HL and is 11.70-16.47(13.87) in SL. Vent is situated close to origin of anal fin. Vt-AF 12.14-17.90 (15.17) in PF-AF. Caudal peduncle is short and stout and LCPD 13.72-17.53 (15.56) in SL and 58.70-71.54 (63.12) in HL. HCPD 54.58-70.63 (63.48) in LCPD. Ground colour pale yellowish green with back with irregular brown blotches appear some times as short, wide bands of 7-8 numbers. Area below lateral line and to some extend ventral surface have blackish brown patches. Head is mottled with irregular brown blotches, some times coalesce together to form uniform brown colour. A dark longitudinal stripe passing from behind opercula to caudal peduncle. Fins are generally dusky with blackish patches. Base of the paired and unpaired fins are marked by darkish brown spot or band which in the case of caudal fin have a well defined deep brown to black transverse band at caudal base.

Geographical distribution: Chokkanpetty in Periyar Tiger Reserve, Kerala, South India.

Etymology: Named after Dr.E.G. Silas, Renowned fishery scientist, who has made outstanding contributions to Taxonomy of freshwater fishes of Western Ghats.

Comparative materials examined:

Homaloptera Pillai: ZSI/SRS F462, Holotype, 69mm, Silent valley,river Kunthi,Kerala; *H. Pillai:* ZSI/SRS F 463, paratypes, 2 examples, 49-57mm SL, Sayvala, New Amarambalam,Kerala; *H.santhanparaiensis:* ZSI/SRS F 5322, Holotype, 6.1mm SL, Santhanparai, Panniar stream of Periyar, Kerala; *H.santhanparaiensis:* ZSI/SRS 5323, paratype, 45mm SL, Santhanparai, Panniar stream of Periyar,Kerala.

Habitat: Small rocky pool with mud, detritous and cobbles as substratum.

Fishing method: Scoopnets of small mesh size

Sub family: Nemachilinae

Body fusiform. Mouth small and inferior, Lips are thick and fleshy, entire or furrowed and continuous at angles of mouth. Lower lip interrupted in middle. Barbells two to four pairs. Dorsal fin is with 7-20 rays. Lateral line is complete or in complete. Pectoral and pelvic fins not inserted horizontally and only outermost ray of pectoral fin is simple.

Key to sub genera

1. a) Pair of well developed nasal barbells............................*Oreonectus*

   b) No well developed nasal barbells...2

2. a) Caudal fin truncate, a black ocellus at upper margin of base of caudal fin...*Acanthocobitis*

b) Caudal fin truncate, emarginate or forked, no black ocellus at upper angle of base of caudal fin...3

3. a) Body marked by series of vertical bars.............................*Schistura*

b) Body not marked with a series of vertical bars.............................4

4. a) Body with moniliform dots which appear as dark lateral band, body without any other blotches or bands...............................*Nemacheilus*

b) Body marked with irregular network of dark brownish and whitish yellow bars...*Mesonemachilus*

Genus ***Oreonectus*** Gunther

Oreonectes Gunther, *Cat. Fish. Brit. Mus.*, 7, p. 369, 1868 (Type, *Oreonectes platycephalus* Gunther)

Oreonectus keralensis Rita and Nalbant
(Plate X, Fig. 81)

Oreonectus keralensis Rita and Nalbant, *Trans. Mus. Nat. Grigore Antipa*, 19 : 186, 1978 (Type locality: Pampadumpara, Kerala)
Noemacheilus keralensis Menon, *Faun. India Pisces*, 4(1): 193, pl.10, 1987

Common name: Kerala loach **Local name:** Koytha

Distinguishing characters: (Based on 16 specimens, 34-56 mm TL)

D.7; P. i, 10; V.1, 7, A. ii, 5 C.19

Body elongated with slightly flattened head. BD 14.23-16.21 (15.21) in SL. Eyes are smaller, 14.12-15.23 (14.63) in HL. Eight barbells present. Anterior nostrils are prolonged in to a nasal barbell. Ground colour is dark green, marked with numerous ill-defined black bands and dots. Caudal peduncle with an adipose crest. Dorsal fin origin more towards caudal and is placed behind origin of pelvic fin. Lateral line short, extending only up to tip of pectoral fin. Fins generally dusky without any markings. Caudal fin truncate.

Geographical distribution: India: Westernghats of Kerala (Talwar and Jhingran, 1991)

Distribution in Kerala: Pampadumpara (Rita and Nalbant, 1978), Moovattupuzha river, Eravikulam Natioanal park of Periayr river (Ajithkumar *et al.*, 2000), Periyar river system (Kurup *et al.*, 2004); Meenachil river(Radhakrishnan and Kurup, 2006).

Habitat: small low velocity streams and channels with cobles and muddy substratum with leaf litters.

Fishing method: Scoop nets and dragnets of small mesh sizes

Genus: ***Acanthocobitis*** Peters

Acanthocobitis Peters, *Monats. Akad. Wiss. Berlin for 1861*, p. 712, 1861 (Type, *Acanthocobitis longipinnis*)

Acanthocobitis botia (Hamilton-Buchanan)

(Plate X, Fig. 82)

Cobitis botia Hamilton-Buchanan, *Fish. Ganges*, pp. 358, 395, 1822(Type locality: Rivers of northe eastern parts of Bengal)
Cobitis botia Hamilton, *Fish. Ganges*, pp.350, 394,1822 (Type locality: Brahmaputa river)
Nemacheilus botia Gunther, *Cat. Fish. Brit. Mus.*, 7:349, 1868
Noemacheilus botia Menon, *Faun. India, Pisces*, 4(1), 1987(Ganges and Indus)

Local name: Koytha

Distinguishing characters: (Based on 8 specimens, 46-74mm TL)

D ii, 9; P. I, 10, V.i, 7; A.i, 5-6, C.19

Body larger and deeper than other most nemacheilines, BD 18.87-19.22 (19.05) of SL. Eyes moderate to large and its diameter form 17.79-20.60 (19.19) in HL. Dorsal profile is slightly arched than ventral and caudal peduncle region is compressed and deep. Head slightly compressed and snout blunt. No nasal barbells, outer margin of dorsal fin convex or straight, caudal fin straight or slightly emigrate. Lateral line incomplete, extending to base of dorsal fin. Ground color greenish yellow with varying number of wide and narrow brownish bands on flanks. Head mottled with numerous brown spots. Dorsal profile slightly brownish. Caudal fin with 5 'v' shaped rows of spots and dorsal fin with 4 rows of spots. Presence of a dark ocellus at upper angle of caudal base is a salient feature of species.

Geographical distribution: India, Pakisthan (Talwar and Jhingran, 1991)

Distribution in Kerala: Vythiripuzha, Kabbini river system (Easa and Basha,1995).

Habitat: small riffles with gravel and pebbles.

Fishing method: Cast nets and dragnets of small mesh sizes are found effective for collection.

Genus ***Schistura*** McClelland

Schistura McClelland, *Asiat. Res.*, 19, p. 309, 439, 1839 (Type, *Schistura rupecola*)

Body fusiform of uniform depth, compressed posteriorly. Snout usually blunt. Upper lip slightly furrowed. Dorsal fin with 7-10 branched rays. Caudal fin slightly emarginated, forked or truncate but never rounded. Adipose crest present. Body with vertical bars of varying numbers. A blackish brown spot at origin of dorsal fin is usually present.

Key to species

1. a) Body deep, with minute dots and bands..........*Schistura semiarmatus*

   b) Body less deep, devoid of spots..2

2. a) Lateral line complete, clour bands are narrow and numerous ....*Schistura striatus*

   b) Lateral line incomplete, bands wide and 10-12 in numbers 3

3. a) Dorsal fin with jet-black colour.........................*Schistura nilgiriensis*

   b) Dorsal fin with series of dots..............................*Schistura denisoni*

Schistura denisoni (Day)

(Plate X, Fig. 83)

Nemachilus denisonii Day, *Proc. Zool. Soc. Lond.*, 287, 1867(Type locality: Bhavani river, base of Nilghirris)
Nemachilus denisonii Gunther, *Cat, Fish. Brit. Mus.*, 7:352, 1868 (Nilgiris)
Nemachilus chryseus Day, *J. Linn. Soc.* (Zool), 11: 259, 1873

Common name: Denison's loach **Local name:** Koytha

Distinguishing characters: (Based on 12 specimens, 46-68 mm TL)

D. ii, 7; P. 1, 8-9, V. 1,5; A.ii,5; C.19

Body elongated and more or less of uniform depth. BD 13.03-14.88 (13.89) and HL 27.20-27.92 (27.56) in SL, eyes are moderate, 20.81-21.33 (21.06) in HL. Lateral line incomplete, ending just at origin of dorsal fin. Dorsal fin inserted midway between caudal and snout. Dorsal fin margin usually convex and caudal fin deeply emarginated. Body marked with 10-12 vertical brownish bars, which are wider than light interfaces. Dorsal and caudal fins with three rows of spots. A black patch at beginning of dorsal fin. Caudal base is marked by a prominent vertical black band.

Geographical distribution: Peninsular India, Chota Nagpur plateau (Bihar) and Bastar (Madhya Pradesh) (Talwar and Jhingran, 1991)

Distribution in Kerala: Hill ranges of Travancore (Silas, 1951); Pamba river (Menon, 1987); Bhavani river (Easa and Basha, 1995), Ajithkumar *et. al* (2000), Bharathapuzha, Pambar and Manimala river systems (Kurup *et al.*, 2004).

Habitat: shallow riffles with cobbles or gravels as substratum.

Fishing method: Cast nets and sccop nets

Schistura semiarmatus (Day)
(Plate X, Fig. 84)

Noemachilus semiarmatus Day, *Proc. Zool. Soc. Lond.*, 286, 1867 (Type locality: Bowani river at base of Nilghirris)
Nemacheilus semiarmatus Day, *J. Asiat. Soc.* Beng., 41(2), 1878
Noemacheilus semiarmatus Menon, *Faun. India Pisces*, 4 (1): 110, 1987 (Cauvery basin in Wynaad)

Common name: Dotted finned loach **Local name:** Koytha

Distinguishing characters: (Based on 8 specimens, 36-58 mm TL)

D. i-ii, 7-8; P. 1, 10, V. 1,7; A.i,5; C.19

Body elongated, slightly compressed laterally and deep. BD 12.29-19.62 (15.95) and HL 24.28-26.46 (25.37) in SL, eyes are moderate, 19.78-21.61 (20.69) in HL. Lips thick and furrowed. Lateral line complete. Dorsal fin inserted nearer to tip of snout than caudal. Caudal fin slightly forked. Body light greenish brown with several dark spots which extended to head region. Posterior to dorsal fin origin there are irregular narrow yellow bands which are very conspicuous in younger specimens. A black mark at origin of dorsal fin. Fins generally with multiple rows of dark spots. Patches of brownish spots in the form of a band at caudal peduncle.

Geographical distribution: Peninsular India: Cauveri basin in Wyanad, Nilgiris and Mysore; and Silent valley (Talwar and Jhingran, 1991)

Distribution in Kerala: East flowing rivers of Kerala (Shaji and Easa, 2001), Bhavani and Kabbini rivers (Easa and Basha, 1995), Pambar river, Chinnar WLS (Ajithkumar *et. al* (2000) Pambar and Kabbini river systems (Kurup *et al.*, 2004)

Habitat: Riffle-pool habitats with cobbles, gravel or sand as substratum.

Fishing methods: Cast nets or scoop nets

Schistura striatus (Day)
(Plate X, Fig. 85)

Nemachilus striatus Day, *Proc. Zool. Soc. Lond.*, 347, 1867 (Type locality: "Wynaad") 1867
Nemacheilus striatus Day, *Asiat. Soc. Beng.*, 41(2): 1872
Nemachilus bhimachari Hora, *rec. Indian Mus.*, 39 13, 1937(Type locality: Thunga river, Shimoga)
Noemacheilus striatus Menon, *Fauna. India Pisces*, 4(1): 113, 1987 (Wynaad in Kerala, Shimoga in Karnataka)

Local name: Koytha

Distinguishing characters: (Based on 6 specimens, 34-46 mm TL)

D. ii, 11; P. 1, 8-9, V. 1, 7; A.i, 5; C.19

Body elongated and cylindrical. BD 23.20-28.71 (25.95) and HL 25.57-29.00 (27.29) in SL and eyes are moderate, 20.15-26.39 (23.27) in HL. Barbells long and narrow. Dorsal fin inserted nearer to tip of snout than caudal. Dorsal fin base larger and adipose fin comparatively high. Caudal fin slightly forked. Lateral line complete. Body yellowish with several narrow brownish bands across. Number of bands increases with age. Bands anteriorly are narrow, closely arranged and some times connected and those at posterior region are wider. A black band at base of caudal fin. Multiple rows of spots on dorsal fin. Caudal fin dusky and other fins hyaline.

Geographical distribution: India: Kerala: Wynaad; and Karnataka: Shimoga (Talwar and Jhingran, 1991)

Distribution in Kerala: Wynaad (Menon, 1987; Kurup *et al.*, 2004). Fairely common in Vythiripuzha and Vythiri (Shaji and Easa, 2001).

Habitat: Riffle-pool habitats with cobbles and gravel as substratum.

Fishing methods: Cast nets or scoop nets

Schistura nilgiriensis (Menon)
(Plate X, Fig. 86)

Noemacheilus nigiriensis Menon, *Faun. India Pisces*, 4(1) : 106, pl.10, fig.8, 1987 (Type locality: Stream near Pyakara dam, Nilgri district, Tamil Nadu)

Common name: Nilgiri loach **Local name:** Koytha

Distinguishing characters: (Based on 7 specimens, 44-68 mm TL)

D. ii, 7; P. 1, 8-9, V. 1, 5; A.ii, 5; C.19

Body comparatively more elongate and cylindrical. BD 12.64-18.62 (15.82) and HL 22.61-28.64 (25.31) in SL, eyes are moderate, 17.68-21.32 (19.64) in HL. Dorsal fin inserted in middle of snout and caudal. Pelvic fins separated from anal opening by a considerable distance. Lateral line incomplete, terminating opposite to middle of pectoral fin. Body marked with 11 or 12 brown bands, broader than pale interspaces and bands are radiating in to many branches at dorsal profile. A dark band at caudal fin base. Dorsal fin has a jet black band at middle and a dark base.

Geographical distribution: India: Pyakara dam, Nigirri district (Talwar and Jhingran, 1991)

Distribution in Kerala: common in Kabbini rver (Shaji and Easa, 2001)

Habitat: Riffle-pool habitats with cobbles and gravel as substratum.

Fishing methods: Cast nets or scoop nets

Genus: *Nemacheilus* Bleeker

Nemacheilus Bleeker, *Versl. Akad.* Amsterdam, 15, p.34, 1863 (Type, *Cobitis fasciata* Valenciennes)

Nemacheilus monilis (Hora)
(Plate X, Fig. 87)

Nemachilus monilis Hora, *Rec. Indian Mus.*, 22: 19, 1921(Type locality: Bhavani river, 10 miles from Mettupalayam)
Noemacheilus monilis Menon, Faun.India Pisces, 4(1): 156, 1987(Western Ghats: Nilgirris)

Common name: Spotted loach **Local name:** Koytha

Distinguishing characters: (Based on 6 specimens, 36-74 mm TL)

D. ii, 7-8; P. 1, 10-11, V. 1,7; A.i,5; C.19

Body comparatively more elongated and cylindrical. BD 13.14-15.14 (14.07) and HL 23.04-25.68 (24.15) in SL. Head elongated, snout pointed. No sub ocular spine on head. Eyes 20.81-21.33 (21.07) in HL. Lips narrow, poorly furrowed. Barbells relatively long and thread like. Dorsal fin inserted nearer base of caudal fin than snout tip. No adipose crest on caudal peduncle. Caudal fin forked. Lateral line complete. Ground colour dirty white, a distinct moniliform black band along lateral line from snout tip to caudal fin base. The band continued as a streak in middle of caudal fin. Fins slightly yellowish.

Geographical distribution: India: Western Ghats: Nilgirris (Talwar and Jhingran, 1991)

Distribution in Kerala: Bhavani river, NBR (Easa and Basha, 1995), Pambar river in Chinnar Wild life Sanctuary (Ajithkumar *et al.,* 2000), Kabbini river system (Kurup *et al.*, 2004).

Habitat: Riffles with cobbles, pebbles and gravel as substratum.

Fishing methods Cast nets and dragnets.

Genus ***Mesonemacheilus*** Banarescu & Nalbant

Mesonemacheilus Banarescu & Nalbant In: Singh et al., *Trav. Mus. Hist. Nat. "Grigore Antipa"*, 23 (for 1981) , p. 202, 1982 (Type, *Noemacheilus triangularis* Day)

Body cylindrical, lateral line usually incomplete, ends at base of anal fin. Dorsal fin with 7-10 branched rays. Caudal fin forked. A network of bands and oval spots distributed all over body. Dorsal fin have 3-5 rows of spots and outer margin is convex or straight. Caudal, anal and ventral fins having rows of spots. Caudal fin with black spot or small dark band at its base. No nasal barbells.

Key to species

1. a) Dorsal fin with 10 branched rays ....*Mesonemacheilus pambarensis*

b) Dorsal fin with les than 10 branched rays 2

2. a) Dorsal fin with nine branched rays......*Mesonemacheilus periyarensis*

b) Dorsal fin with less than nine branched rays................................3

3. a)Two or three rows of rounded small to large yellow spots along body..*Mesonemacheilus guentheri*

b) Body with bands or a network of bands and spots..........................4

4. a) Body with oblique,' Y-'shaped bands.....*Mesonemacheilus triangularis*

b) Body with varying number of wavy bands which some times coalesce together to form reticular net works...5

5. a) Lateral line incomplete...6

b) Lateral line complete..............................*Mesonemacheilus menoni*

6. a) Small forms, Saddle-shaped 7-8 small black bands on back, sides with varying number of bands, dorsal and caudal fins with patches of spots...*Mesonemacheilus petrubanarescui*

b) Large forms, Bands on back are irregular, No colour bands on sides, dorsal and caudal fins are reddish to hyaline...........*Mesonemacheilus remadevi*

Mesonemacheilus pambarensis (Remadevi and Indra)
(Plate X, Fig. 88)

Noemacheilus pambarensis Remadevi and Indra, *Rec. Zool. Surv. India*, 94 (2): 207-210, 1994 (Type locality: Pambar river, Chinnar wild life sanctuary, Kerala)

Common name: Periyar banded loach **Local name:** Ayira

Distinguishing characters: (Based on 6 specimens, 29-38 mm TL)

D. ii, 8; P. 10, v. 1, 5; A.ii,5; C.18

Body more slender and lean. Back and flanks marked with varying number of yellow bands which often enclosing yellowish white spots, especially after dorsal fin. A rectangular deep dark patch at middle of caudal base. Cuadal fin marked with 4 rows and dorsal fin marked with two rows of black spots. Indistinct patches of spots are seen in other fins also. Origin of dorsal fin is marked with a dark coloration. Outer margin of dorsal fin concave. Lateral line complete.

Distribution in Kerala: Pambar river, Chinnar WLS (Remadevi and Indra, 1986., Ajithkumar *et.al.,* 1999), Chinnar river (Easa and Shaji, 1995).

Habitat: Small riffles at high altitudes

Fishing method: Cast nets and dragnets of fine mesh sizes

Mesonemacheilus periyarensis Kurup& Radhakrishnan
(Plate X, Fig. 89)

Mesonemacheilus periyarensis Kurup& Radhakrishnan, *J. Bombay Nat. Hist. Soc.* VOL.102 (1), pp.75-78, 2005

Holotype: Deposited in ZSI, Chennai, No. awaited. 85.2 mm TL, Periyar Lake, 18th February, 2002.

Paratypes: 2ex. Deposited in ZSI Chennai, No. awaited. 80.6-82.0 mm TL, Periyar Lake, 18th February, 2002.

Diagnosis: An elongated and slender species, dorsal fin with 9 branched rays, lateral line incomplete, ending above anal fin, body with irregular network of bands and blotches, Dorsal and caudal fins with 4 or more rows of dark bands and a black ocellus at lower angle of caudal peduncle, very near to caudal origin.

Distinguishing characters: (Based on 12 specimens, 59-78 mm TL)

D I, 9; P I, 9; VI, 6; AI, 5; C 19.

Dorsal profile slightly arched, compared to ventral. Lateral line ending above anal origin. Eyes moderately large, nostrils close to each other, Head longer than broad, mouth more or less semicircular, subterminal with upper jaw slightly prolonged. Barbells well developed, 3 pairs, BD 12.5-13.69 (13.059) and HL 17.73 - 22. 87 (20.3) in SL, SNL less than INTO, latter less than POL. Eyes not visible from ventral side of head, diameter 19.88-26.33 (23.10) of HL, shorter than INTO, 38.4-72.5 (55.45) of latter. Anterior nostrils flap-like. Mouth slightly pointed rather than semicircular, lips fleshy, lower lip interrupted in middle. Barbells well developed, broader at their bases and with pointed tips, outer rostral barbells longer than inner ones and are equal to or larger than maxillary barbells, not extending to anterior border of eye. LCPD 10.34-13.56 (11.95) in SL, HCPD 65.23 –79.83 (72.53) in HL. Lateral line incomplete, ending above origin of anal fin or slightly behind it and is followed by a shallow groove, which becomes deeper as it reaches caudal peduncle. Scales small, imbricate, covering whole body except ventral profile between pectoral and pelvic fins. Dorsal fin inserted closer to snout than to caudal. BD forms 63.97-84.74 of in HD. HD 89.18 in HL. Pectorals smaller than head length, HP 83.72 in HL. Pelvic fins smaller than head and pectoral fins, HV 70.92 in HL and 77.77 in HP. Ventral not reaching anal fins and latter not reaching caudal fin. Distance between pectoral and ventral is 26.32 in SL. Distance between ventral and anal fins 24.57-30.2 in SL. Pre-anal distance 70.11 -78.6 in SL, pre-dorsal distance smaller, 43-48 in SL. Pre-ventral distance 4.59 -5.01 in SL, pre-pectoral distance 19.49-25.20 in SL. Caudal forked. Ground colour light brown with irregularly descending narrow yellow bands which sometimes coalesce together to form reticular networks. Irregular yellow spots or bands dispersed between them. Bands also arise from ventral side towards lateral line. Pattern of colouration extends on to head and snout region. Dorsal fin marked with 4 dark bands while caudal fin has 5 narrow dark bands. Bands are also seen on paired fins. Pectoral fin rays are either dusky or with well-distinguished dark band. Ventral fins have two narrow dark coloured bands. Anal fin also with two dark narrow bands. There is a dark ocellus at lower angle of caudal peduncle, close to origin of caudal rays.

Geographical distribution: India:Thannikkudy in Periyar Lake, Kerala.

Etymology: Named after water body from where the specimens were collected.

Habitat: Small riffles with pebbles and cobbles as substratum.

Fishing method: Cast nets and dragnets of small mesh sizes.

Mesonemacheilus guentheri (Day)
(Plate X, Fig. 90)

Nemacheilus guentheri Day, *Proc. Zool. Soc. Lond.*, 285, 1867(Type locality: Rivers along lower slope and base of Nilghirris)
Nemacheilus rubripinnis Day, *J. Asiat. Soc. Beng.*, 41(2) p. 197, 1872 (Malabar)
Mesonemacheilus herrei Nalbant and Benarescu, *Trans. Mus. Hist. nat. Grigore Antipa*, 23: 203, 1981(Anamalai hills)
Noemachelus guentheri Menon, *Faun. India Pisces*, 4(1), 1987(Western Ghats)

Common name: Gunther's loach **Local name**: Koyma, Koytha, Ayira

Distingishing characters: **(Based on 16 specimens, 41-54 mm TL)**

D.ii ,8; P. I, 10; V. I, 7; A. ii, 5; C.18

Body fusiform, BD 16.48-17.01(16.52) in SL, Lateral line incomplete, ending at base of anal fin. Ground colour dark brown with 7-10 yellow, small, saddle shaped bands on back which some times coalesce together and one to three rows of small to large yellow spots on flanks. Dorsal fin with two rows of spots with a black dot at origin, Pecoral and anal fins with indistinct rows of spots, pelvic fins hyaline. Caudal fin deeply forked, with a black vertical bar at its base and with 3-4 rows of spots.

Geographical distribution: Peninsular India: Western Ghats (Talwar and Jhingran, 1991)

Distribution in Kerala: Travancore (Hora and Law 1941), High ranges of Travancore (Silas, 1951), Periyar Tigr Reserve (Arun *et al.*, 1996), Chinnar Wild life sanctuary (Easa and Shaji, 1996), Silent valley NP (Remadevi and Indra, 1986), Kallar, Pambar, Periyar and Bharathapuzha river systems (Menon, 1999), Bharathapuzha,Achenkoil, Pambar and Kabbini river systems(Kurup et al.,2004)

Habitat: Riffles of middle and upstream.

Fishing method: Scoop nets, drag nets and cast nets of small mesh sizes.

Mesonemacheilus traingularis (Day)
(Plate XI, Fig. 91)

Nemachilus triangularis Day, *Proc. Zool. Soc. Lond.*, p. 295,1865 (Type locality: Mundakkayam, Travancore)
Noemacheilus triangularis triangularis Menon, *Faun. India Pisces* 4(1): 168, 1987

Common name: Triangular banded loach **Local names**: Koytha, Koyma, Varayanparal

Distinguishing characters: (Based on 18 specimens, 36-72 mm TL)

D. ii, 7; P.1, 10-12; V.1, 7; Ai ,5, C.19

Body comparatively large, lateral line almost complete, reaching up to caudal peduncle. Ground colour brownish with 7-9 oblique, 'Y'-shaped yellow bands descending from back to ventral surface. 3 rows of spots on caudal fin and 3-4 rows on dorsal fin. Other fins have patches of dark colouration. A deep dark spot or a small band is present at caudal base. Outer margin of dorsal fin is convex or straight.

Distribution in Kerala: High ranges of Travancore (Hora and Law, 1941., Silas, 1951), Kerala part of Nilgirri biosphere (Easa and Basha,1995), Silent valley (Remadevi and Indra, 1986), Kallar, Periyar, Chaliyar, Cheenkannipuzha, Karivannurpuzah, Neyyar, Achenkoil and Bharathapuzha (Arunachalam and Sankaranarayana, 1999., Ajithkumar *et. al.*, 1999), Periyar, Bharathapuzha, Chalakkudy, Kallada, Meenachil (Kurup et al., 2004).

Geographical distribution: Peninsular India: Western Ghats of Kerala and Tamil Nadu (Talwar and Jhingran, 1991)

Habitat: Riffle-pool habitats of middle to upstream.

Fishing method: scoop nets, dragnets and cast nets of less than 5 mm mesh size.

Mesonemacheilus menoni Zacharias and Minimol
(Plate XI, Fig. 92)

Mesonemacheilus menoni Zacharias and Minimol *J.Bombay nat. Hist. Soc.*, 96:288-290, 1999
(Type locality: Mlappara, Periyar Tiger Reserve, Thekkadi, Kerala)

Common name: Periyar blothed loach **Local names:** Koyma, Koytha

Distinguishing characters: (Based on 16 specimens, 36-64 mm TL)

D.i, 7-8;P.9-10,V. 1,7; A.1,5; C.19

Body elongated and slender, BD 16.47-16.91(16.59) in SL, Eyes are moderate and 19.21-20.68 (19.73) in HL. Lateral line complete. Lower half of body with numerous yellowish square or partly rounded yellow markings enclosing brown areas. Some times instead of rounded or square structures, there is wavy yellowish band parallel to ventral profile. On back, there are 8-9 broad brownish bands. Region above lateral line is charecterised by curly yellow bands and spots. Caudal fin with 3-4 rows of spots and dorsal fin with 3 rows of spots. Caudal base is marked with a dark small band or spot.

Geographical distribution: India: Western Ghats of Kerala (Jayaram, 1999)

Distribution in Kerala: Periyar river at Mlappara (Zacharias and Minimol, 1999), Periyar upstreams (Kurup *et al.*, 2004).

Habitat: Riffle-pools with cobbles and gravelly substratum.

Fishing method: Dragnets and cast nets of small mesh size.

Mesonemacheilus petrubanarescui (Menon)
(Plate XI, Fig. 93)

Noemacheilus petrubenarescui Menon, *Cybium*, 8(2): 45, 1984 (Type locality: Netravati river, Dharmasthala, Karnataka)

Common name: Carnatic banded loach **Local name:** Koytha

Distinguishing characters: (Based on 12 specimens, 28-43 mm TL)

D .ii,8; P.1,10;V.i,7;A.i, 5; C.19

Body small, more or less cylindrical of uniform depth. BD 15.21-16.10 (15.58) in SL. Eyes comparatively larger, its diameter forms 19.78-21.24 (19.49) in head length. Lateral line incomplete, ending just before origin of anal fin. Back with 7-8 broad saddle shaped brownish bands and flanks especially posterior to dorsal fin is with varying number of bands without any regular fashion. Scales along lateral line is darkened which give appearance of continuous dark line. A small black band along caudal base. A row of dark spots present on dorsal fin and two rows on caudal fin.

Geographical distribution: India: Westernghats of Kerala and Karnataka (Menon, 1984)

Distribution in Kerala: Kabini river system (Shaji and Easa, 1995b).

Habitat: Riffles with cobbles and gravel as substratum.

Fishing method: Dragnets and cast nets of small mesh size.

Mesonemacheilus remadevi Shaji and Easa
(Plate XI, Fig. 94)

Mesonemacheilus remadevi Shaji and Easa, *Indian J.Fish.*,49 (2): 217-221, 2002 (Type locality: Kunthi river, Silent valley, Kerala)

Local names: Koyma, Koytha

Distinguishing characters: (Based on 7 specimens, 58-81 mm TL)

D.i, 7; P.i, 8; V.i, 6; A.i, 5; C. 19

Body large, elongate and slender, BD 13.91-14.28 (14.13) in SL, HL 20.16-21.28 (21.05) of SL, length of snout greater than inter orbital width, latter less than postorbital length. Eyes not visible from ventral side of head, 7.8-11.54 (9.46) of HL, shorter than INTO, 46.66-66.30 (54.47) of latter. LCPD 12.64-15.55 (13.97) in SL, HCPD 53.21-64.23 (58.98) in HL. Lateral line incomplete, ending above middle of anal fin or slightly beyond it. Dorsal fin inserted slightly closer to caudal fin. Ground colour yellowish green with irregularly descending brownish bands on back. Head and snout greenish with minute dark spots. A very faint greenish lateral band from head to caudal fin and 3-4 black blotches appear along band, which is more or less restricted to anterior 3/4th of body. A blackish narrow band is usually seen at base of caudal fin. Fins are generally reddish to hyaline and without any colour bands.

Geographical distribution: India: Western ghats of Kerala

Distribution in Kerala: Silent valley, Kunthi river (Shaji and Easa, 2001).

Habitat: Riffle-pools with boulders cobbles and gravelly substratum. It prefers substratum with lot of leaf litters.

Fishing method: Dragnets or cast nets of small mesh size.

Family: Cobitidae

Subfamily: cobitinae

Genus *Lepidocephalus* Bleeker

Lepidocephalus Bleeker, *Nat. Tijdschr. Ned. Inde.* 16, p. 303, 1858 (Type, *Cobitis macrohir* Bleeker)

Lepidocephalus thermalis (Valenciennes)
(Plate XI, Fig. 95)

Cobitis thermalis Valenciennes (in C&V), *Hist. Nat. Poiss.*, 18: 78: 1846 (Type locality: Hot springs of Kanniya, E.P., Sri Lanka)
Cobitis carnaticus Jerdon, *Madras J. Lit. Sci.*, 15: 331, 1849
Cobitis rubripinnis Jerdon, *Madras J. Lit. Sci*, 15: 333, 1849
Lepidocephalichthys thermalis : Bleeker, *Verh. Holland. Maatch. Haarlem, Cypri. Et Cobit. Ceylon*, p 6, 1864

Common name: Malabar loach **Local names:** Koyma, Koytha

Distinguishing characters: (Based on 12 specimens, 38-66 mm TL)

D.i, 6-7; P.5-7,V.i-ii,5; A.i,5; C.16

Head and body compressed. BD 15.52-18.69 (16.81) and HL 23.76-27.40 (24.87) in SL. Eyes moderate, 13.76-23.27 (17.47) in HL. An erectile spine present infront of eye. Mouth inferior, lips thick, fleshy and papillated. Three pairs of barbells present, rostral barbells only one pair. Caudal fin emarginated. Mental lobes with barbell like prolongations present. Dorsal fin inserted nearer to caudal fin than snout tip, slightly anterior to pelvic fins. Lateral line absent. Back with numerous brownish spots forming a reticular pattern which extend to head as scattered spots. A brownish line from eye to snout tip. Flanks dirty white to yellowish with dark 8-12 irregular blotches, which are connected by a narrow brownish line. A small black spot on upper half of base of caudal fin. Fins gereally with rows of spots.

Geographical distribution: Coastal districts of Maharashtra, Kerala and Karnataka; and Sri Lanka (Talwar and Jhingran, 1991)

Distribution in Kerala: Fairely common and recorded from many rivers (Shaji and Easa, 2001; Ajithkumar *et al.,* 1999), Periyar, Kallada and Chalakkudy (Kurup *et al.*, 2004).

Habitat: Riffle-pools with cobbles gravelly or sand substratum. Some times also found in ponds with muddy bottom.

Fishing method: Dragnets or scoop nets of small mesh size.

ORDER: SILURIFORMES

Family: Bagridae

Fishes with an elongate and more or less compressed body. Teeth on pre maxillaries, mandible and vomer. Nostrils widely separated, Anterior tubular at tip of mouth and posterior nearer eye than tip of snout and with nasal barbell. Barbells well developed, six or eight. Gill membranes free from isthmus. Rayed dorsal fin inserted above pectoral fins. Adipose fin not confluent with dorsal or caudal fins. Pectoral fins with a strong spine and generally serrated. Caudal fin forked. Lateral line present, usually complete.

Key to genera

1. a) Anal fin base long with 23-28 branched rays.................*Horabagrus*

   b) Anal fin base short to moderate with 8-16 branched rays...............2

2. a) Maxillary barbells short, not extending beyond head, ventral side of head with sensory pores, eyes with free orbital rim...................*Batasio*

   b) Maxillary barbells elongate, longer than head, ventral surface of head without any pores, eyes normal...*Mystus*

Genus *Horabagrus* Jayaram

Horabagrus Jayaram, *Bull. Nat. Inst. Sci. India*, No. 7, p. 261, 1955 (Type, *Pseudobagrus brachysoma*)

Elongate and compressed fishes, abdomen rounded. Head large, anteriorly depressed. Snout broad and obtusely round, mouth subterminal, transeverse and wide. Eyes large, inferior and palced along angle of mouth. Teeth uniformly villiform on jaws and palate. Four pairs of barbells, one each of maxillary, nasal and two of mandibular. Gill membranes free from each other and also from isthmus. Anal fin long and with 23-29 rays, lateral line complete.

Key to species

1. a) A round, large black spot on shoulder with a light yellow ring, body deep .... *Horabagrus brachysoma*

   b) A saddle shaped black band extending from humeral region each side over nape, bordered in paled yellow, body comparatively less deep and elongate .... *Horabagrus nigricollaris*

Horbagrus brachysoma (Gunther)
(Plate XI, Fig. 96)

Psuodobagrus brachysoma Gunther, *Cat. Fishes Br. Mus.*,5: 86, 1864 (Type locality: Cochin)
Pseudobagrus chryseus Day, *Fishes of Malabar*.185, pl. 13,1865(Karivannur river, Kerala)
Macrones chryseus Day, *Fishes of India*: 443, pl. 99, 1878
Horabagrus brachysoma: Jayaram, *Int.Revue ges. Hydrobiol.*, 51(3), 1966

Common name: Gunther's catfish **Local name:** Manjakkoori, Manjaletta

Distinguishing characters: (Based on 16 specimens from 73-630 mm TL)

D. I, 5; P.I, 7; V.1, 5; A.IV, 21-23; C.17.

Body elongate. Predorsal region slightly elevated. BD 18.16-21.23 (19.12), HL 27.64-29.25 (28.63) in SL. Occipital process extends to basal bone of dorsal fin. Eyes ventrolateral, 17.60 in HL. Mouth sub terminal, teeth in villiform bands on jaws. Maxillary barbells reach up to base of pectoral fins, others shorter. Dorsal spine strong and feebly serrated, Pectoral spine strong and strongly serrated. Adipose fin short and low. Greenish yellow above, flanks golden, belly white. A large round black mark on shoulder surrounded by a light yellow ring. Dorsal and anal fins yellowish orange with gray margins. Caudal fin yellow with a semilunar thick black ring at caudal fin base occasionally present.

Geographical distribution: India: Kerala (Talwar and Jhingran, 1991)

Distribution: Vembanad lake (Remadevi *et al.*, 1996), 8 rivers of Kerala (Ajithkumar *et al.*, 2000), abundant in Vembanad lake, Sasthamkotta lake, Chalakkudy, Kannur, Trichur, Karuvannur puzha and Periyar. Rarely occurs in rivers and low lands (Shaji and Easa, 2001), Chalakkudy, Kallada, Achenkoil and Pamba (Kurup *et al.*, 2004).

Habitat: Pool-run habitats of both middle streches and low land salinity incurring areas with sandy or muddy bottom.

Fishing method: Gill nets

Horbagrus nigricollaris Pethiyagoda and Kottelat
(Plate XI, Fig. 97)

Horbagrus nigricollaris Pethiyagoda and Kottelat, *J. South Asian nat. Hist.*, 1, No. (1), 110, 1994 (Type locality: Chalakkudy river near Vettilappara)

Common name: Periyar catfish **Local name:** Manjakkoori

Distinguishing characters: (Based on 12 specimens from 164-228 mm TL)

D. I, 5; P.I, 7; V.1, 5; A.IV, 21-22; C.17

Body elongate and dorsal profile more or less straight. BD 17.05-18.94 (18.26), HL 26.67-26.74 (26.63) in SL. Occipital process extends to basal bone of dorsal fin. Eyes ventrolateral, 17.60-18.20 (17.98) in HL. Mouth sub terminal, teeth in villiform bands on jaws. Maxillary barbells reaches beyond middle length of pectoral fin. Dorsal spine strong and feebly serrated, Pectoral spine strong and strongly serrated. Adipose fin short and low. Body dark brown, flanks light golden, belly white. A saddle shaped black band edged with white extend from humeral region to nape. Dorsal and anal fins yellow. Caudal fin yellow with a semilunar thick black ring present.

Geographical distribution: India: Kerala (Talwar and Jhingran, 1991)

Distribution: Chalakkudy river at Vettilappara (Shaji and Easa, 2001; Ajithkumar *et al.*, 2000; Shaji and Easa, 2001), Chalakkudy nd Periyar river systems (Kurup *et al.*, 2004)

Habitat: This species prefers a specific habitat of torrential streams with large boulders and bedrock, which is totally different from its closely allied species, *Horabagrus brachysoma*.

Fishing method: Gill nets

Genus ***Batasio*** Blyth

Batasio Blyth, *J. Asiat. Soc. Bengal*, 29, p. 149, 1860 (Type, *Batasio buchanani* Blyth)

Batasio travancoria Hora and Law
(Plate XI, Fig. 98)

Batasio travancoria Hora and Law, *Rec. Indian Musc.*, 43: 40, pl.2, fig.7-9, 1941 (Type locality: Perumthenaruvi, a tributary of Pamba river at Edakadathy, Kerala)

Common name: Travancore batasio **Local name:** koori

Distinguishing characters: (Based on 10 specimens from 170-178 mm TL)

D. II, 7; P.I, 7; V.1,5; A.II,11; C.17

Body small, head small with many pores on ventral and lateral sides. BD 17.10-22.08 (18.86) and HL25.99-26.04 (26.19) in SL. BD 65.86-81.92 (71.96) in HL. Median longitudinal groove on head reaching occipital process while occipital process not reaching basal bone of dorsal fin. Snout conical with smoothly rounded tip. Mouth inferior and small. Lips fleshy and fimbriated. Eyes larger, 16.29-30.32 (23.00) in HL, moderate with free orbital rim, not visible from ventral side. INTO short, 20.82-28.4 (26.69) in HL. Jaws subequal. Four pairs of barbells, all not extending beyond head. Adipose dorsal fin low, broad based, inserted after an inter space from dorsal fin. Lateral line complete and caudal forked. Uniformly grayish green in colour with fins dusky.

Geographical distribution: India: Western Ghats of Kerala (Talwar and Jhingran, 1991; Menon, 1999)

Distribution in Kerala: Kalikayam stream, Travancore (Silas, 1949), Ponnani drainage system, Anamalai hills (Silas, 1951), South and Central Travancore, (Hora and Law, 1941), Chaliyar river, Kerala part of NBR (Remadevi *et al.,* 1996), Cheenkannipuzha, Chalakkudy (Shaji and Easa, 1996), Neyyar (Easa *et al.,* 2000), Pamba, Manimal and Periyar rivers (Ajithkumar *et al.,* 2000) Achenkoil and Chaliyar (Shaji and Easa, 2001), Pamba, Achenkoil, Periyar, Chalakkudy (Kurup *et al.*, 2004)

Habitat: Pool rifle habitats with cobbles, gravels or sandy substratum

Fishing method: Cast nets

Genus *Mystus* Scopoli

Mystus Scopoli, *Introductio ad historium naruralem*, p. 151, 1777 (Type, *Bagrus halepensis* Valenciennes)

Body moderately elongate, abdomen rounded. Snout rounded or obtuse. Mouth subterminal, moderately wide. Eyes supralateral, with free circular margin. Teeth uniformly villiform in bands on jaws and palate. Four pairs of barbells, one each of maxillary, nasal and two of mandibular, generally longer than head. Dorsal fin inserted above last quarter of pectoral fins. Adipose dorsal fin of varying length, anal fin short with 9-16 rays. Lateral line complete.

Key to species

1. a) Occipital process reaching basal bone of dorsal fin........................2

   b) Occipital process not reaching basal bone of dorsal fin..................8

2. a) Adipose dorsal fin long and inserted immediately after rayed dorsal fin 3

   b) Adipose dorsal fin short or moderate, its origin after an interspace from rayed dorsal fin..4

3. a) Body with longitudinal bands, Maxillary barbells reach anal fin ....*Mystus bleekeri*

   b) Body without bands. Maxillary barbells reach caudal fin base or even beyond..*Mystus cavasius*

4 a) Adipose dorsal fin base longer than anal fin base. A black ocellus at origin of dorsal fin..*Mystus oculatus*

   b) Adipose dorsal fin base shorter than anal fin base, no black ocellus at origin of dorsal fin..5

5 a) Body without any colour bands...6

b) Body with longitudinal colour bands..7

6. a) Occipital process smooth. A dark blotch at base of caudal fin. Median longitudinal groove on head extending to base of occipital process...Mystus *armatus*

b) Occipital process rugose. No blotch at base of caudal fin. Median longitudinal groove short, extending to slightly beyond posterior border of orbit...*Mystus gulio*

7. a) Body with a single longitudinal silvery band and a dark spot at caudal base...*Mystus montanus*

b) Body with 3-4 longitudinal colour bands above and below lateral line, No spot at caudal base..*Mystus vittatus*

8. a) Median longitudinal groove on head reaching base of occipital process. Several clusters of small spots along and also vertical to lateral line...*Mystus menoda*

b) Medial longitudinal groove on head not reaching base of occipital process, a dark band only along lateral line, ending with a dark blotch at base of caudal fin..*Mystus malabaricus*

Mystus bleekeri (Day)
(Plate XI, Fig. 99)

Bagrus keletius Bleeker, *Nat. Gen. Arch. Ned. India.*,3 (2): 135, 1846 (Type locality: Bengal)
Macrones bleekeri Day, *Fishes of India*: 451, pl. 101, 1877
Mystus (Mystus) bleekeri Misra, *Fauna of India*, 3:85, 1976
Mystus bleekeri Jayaram, *Rec. zool. Surv. India Occ. Pap.*, (8): 29, 1977

Common name: Bleeker's Mystus **Local name:** Chillankoori

Distinguishing characters: (Based on 3 specimens, 90-108 mm TL)

D. i, 6-7; P.I, 10; V.i, 5; A.i,8-9; C.17.

Body elongate and compressed. BD 21-46-23.9 (22.68) and HL 23.96-27.78 (25.87) in SL. Head depressed, Occipital process extends to basal bone of dorsal fin. Median longitudinal groove on head reaches base of occipital process. Eyes 22.67-24.73(23.70) in HL. Barbells four pairs, maxillary barbells extends to posteriorly to anal fin. Dorsal spine weak and without serrations. Adipose fin long, inserted just behind rayed dorsal fin. Pectoral spine moderately strong and serrated. HCPD 62.91-69.91(66.41) in LCPD. Brownish back, whitish ventrally. Two light coloured longitudinal bands one above and other below lateral line. A dark round shoulder spot, a small spot at beginning of dorsal fin and a triangular spot at caudal peduncle present.

Geographical distribution: India, Pakistan, Bengladesh, Burma, Sumatra (Talwar and Jhingran, 1991, Jayaram, 1999)

Distribution in Kerala: Neyyar river and its tributaries, Thiruvananthapuram district (Ajithkumar *et al.*, 2000), Puzhayakkal river (Kurup *et al.*, 2004).

Habitat: Pool run habitat sandy or muddy bottom.

Fishing method: Gill nets

Mystus cavasius (Hamilton-Buchana)
(Plate XI, Fig. 100)

Pimelodus cavasius Hamilton-Buchanan, *Fish. Ganges*, pp. 203, 379, pl. 11, fig. 67, 1822 (Type locality: Gangetic provinces)
Macrones cavasius Day, *Fishes of India*: 447,1877
Mystus (Mystus) cavasius Misra, *Fauna of India, Pisces*, 3:87, 1976

Common name: Gangetic mystus **Local name:** Chillankoori

Distinguishing characters: (Based on 12 specimens, 86-228 mm TL)

D. I, 6-7; P.I, 8; V.i,5; A.ii,8; C.17.

Body elongate and compressed. BD 20.55-26.88 (23.39) and HL 23.65-25.20 (24.47) in SL. Head depressed, Occipital process extends to basal bone of dorsal fin. Median longitudinal groove on head reaches base of occipital process. Eyes 25.26-27.89 (26.20) in HL. Maxillary barbells extend beyond base of caudal fin base. Dorsal spine not so strong and with fine serrations. Adipose fin long, inserted just behind rayed dorsal fin. Pectoral spine moderately strong and serrated. HCPD 44.91-88.28 (62.10) in LCPD. Brownish gray on back, an oval or round shoulder spot, a small spot surrounded by white area at beginning of dorsal fin, a narrow light midlateral longitudinal stripe.

Geographical distribution: India, Pakisthan, Bengladesh, Burma, Sri Lanka, Nepal and Thailand.

Distribution in Kerala: 6 rivers of Kerala (Ajithkumar *et al.*, 2000), Chalakkudy, Kabbini and Chaliyar (Shaji and Easa, 2001), Kabbini (Kurup *et al.*, 2004).

Habitat: Pool-riffle habitats with gravelly or sandy bottom

Fishing method: Cast nets

Mystus oculatus (Valenciennes)
(Plate XII, Fig. 101)

Bagrus oculatus Valenciennes, *Hist. Nat. Poiss.*, 14: 424, 1839 (Type locality: Malabar)
Macrones oculatus Day, *Fishes of India*: 448, pl. 98, 1877
Mystus (Mystus) oculatus Misra, *Fauna of India, Pisces*, 3:98

Common name: Malabar mystus **Local name:** Chillankoori

Distinguishing characters: (Based on 9 specimens, 82-148 mm TL)

D. I,6-7; P.I, 8; V.i,5; A.ii,8; C.17.

Body elongate and compressed. BD 22.30-25.64 (24.30) in SL. Head depressed, occipital process extends to basal bone of dorsal fin. Median longitudinal groove on head reaches base of occipital process. Eyes 25.54-28.62 (26.30) in HL. Maxillary barbells reaches almost middle of anal fin.

Dorsal spine moderately strong and finely serrated. Adipose fin short, interdorsal distance 1.1-1.2 times in adipose base. Pectoral spine strong and serrated. HCPD 59.37-62.54 (61.23) in LCPD. Silvery gray on back, a dark spot at beginning of dorsal fin at its base, an oval or round shoulder spot, dorsal fin, adipose fin, anal and caudal fins banded with dark at their distal ends. Two light longitudinal bands one above and another faint one below lateral line.

Geographical distribution: India: Kerala and Tamil Nadu

Distribution in Kerala: Chaliyar, Travancore, Achenkoil, Deviyar and Vembanadu lake (Remadevi *et al.*, 1996).

Habitat: Pool-riffle habitats with gravelly or sandy bottom.

Fishing method: Cast nets

Mystus armatus (Day)
(Plate XII, Fig. 102)

Hypselobagrus armatus Day, *Proc. Zool. Soc. Lond.*, p. 289, 1865 (Type locality: Cochin, Malabar)
Macrones armatus Day, *Fishes of India* 450, pl. 101, 1877
Mystus (Mystus) armatus Misra, *Fauna of India*. Pisces, 3: 84
Mystus armatus: Jayaram, *Rec. zool. Surv. India Occ. Pap.*, (8):28,1977

Common name: Kerala mystus **Local name:** Chillankoori

Distinguishing characters: (Based on 12 specimens, 128-134 mm TL)

D. I, 7; P.I, 8; V.i,5; A.ii,8; C.17.

Body elongate and compressed. BD 22.26 - 27.45 (26.45) and HL16.79 - 28.44 (26.39) in SL. Head depressed, Occipital process extends to basal bone of dorsal fin. Median longitudinal groove on head not reaching base of occipital process. Eyes 10.87-28.14 (18.43) in HL. Maxillary barbells extend to base of pelvic fins. Dorsal spine moderately strong and finely serrated. Adipose fin moderate, inserted after an interspace from rayed one. its base longer than anal base, latter form 2.3 times former. Pectoral spine strong and serrated. HCPD 116.23-135.75 (129.55) in LCPD. Back brownish gray, lighter below. A brownish midlateral streak on flanks which ends at caudal peduncle in a triangular diffused spot. Fins yellowish to hyaline.

Geographical distribution: India: Wynaad hill ranges, Westernghats, Nagaland, Lower Burma (Talwar and Jhingran, 1991, Jayaram, 1999)

Distribution in Kerala: 30 rivers of Kerala (Ajithkumar *et al.*, 2000) Karuvannur river (Shaji and Easa, 2001), 18 river systems (Kurup *et al.*, 2004)

Habitat: Pool-riffle habitats with gravelly or sandy bottom.

Fishing method: Cast nets.

Mystus gulio (Hamilton-Buchanan)
(Plate XII, Fig. 103)

Pimelodus gulio Hamilton-Buchanan, *Fish. Ganges*, pp. 201, 379, pl. 23, fig. 66, 1822 (Type locality: Higher parts of Gangetic Estiuary)
Macrones gulio Day, *Fishes of India*: 445, pl. 99, 1877
Mystus (Mystus) gulio Misra, *Fauna of India, Pisces*, 3:90, 1976

Common name: Long whiskered catfish **Local name:** Chillankoori

Distinguishing characters: (Based on 7 specimens, 134-184 mm TL)

D. I, 7; P.I, 7; V.i,5; A.ii,10; C.17.

Body elongate and compressed. BD 20.56 - 22.48 (21.63) and HL 24.79-31.8 (27.71) in SL. Head depressed, upper surface of head rough and granulated. Occipital process extends to basal bone of dorsal fin. Median longitudinal groove on head short, not very conspicuous and not reaching base of occipital process. Eyes 16.56-23.88 (19.24) in HL. Maxillary barbells extend to base of pelvic fins. Dorsal spine strong and weekly serrated. Adipose fin small, inserted almost or just behind origin of anal fin and its base shorter than anal base. Pectoral spine strong and serrated. HCPD 57.43-85.99 (70.68) in LCPD. Head and back grayish brown, dull white below. Maxillary barbells black. Fins brownish especially outer half.

Geographical distribution: India, Pakisthan, Bengladesh and Burma

Distribution in Kerala: Estuaries and Backwaters of Major rivers (Ajithkumar *et al.*, 2000), Periyar (Kurup *et al.*, 2004).

Habitat: Salinity incurring low-land Pool or run habitats of rivers with muddy or sandy bottom.

Fishing method: Gill nets

Mystus montanus (Jerdon)
(Plate XII, Fig. 104)

Bagrus montanus Jerdon, *Madras J. Lit. Sci.*, 15: 337, 1849 (Type locality: Manantoddy, Wynaad, Kerala)
Macrones montanus Day, *Fishes of India*: 449, pl. 101, 1877
Mystus (Mystus) montanus Misra, *Fauna of India*, Pisces, 3:97, 1976
Mystus (Mystus) vittatus dibrugarensis Misra, *Fauna of India, Pisces*, 3:107,1976

Common name: Wynaad mystus **Local name:** Mullikkottil

Distinguishing characters: (Based on 4 specimens, 152-165 mm TL)

D. I, 8; P.I, 6-7; V.i, 5; A.ii, 10; C.17.

Body elongate and moderately compressed. BD 18.64 – 20.16 (19.79) and HL 30.54-36.48 (32.44) in SL. Head depressed, Occipital process extends to basal bone of dorsal fin. Median longitudinal groove on head short, not reaching base of occipital process. Eyes 12.64-14.21(13.94) in HL. Maxillary barbells extend to base of anal fin. Dorsal spine week and its inner edge weekly serrated. Adipose fin moderate, inserted before origin of anal fin and its base longer than anal base. Pectoral spine strong and serrated on inner side. HCPD 45.39-51.28 (47.52) in LCPD. Head and back brownish green, dull white below. Maxillary barbells black. A dark bluish streak along midlateral line, ends in a triangular spot at caudal fin base. Fins brownish.

Geographical distribution: India: Wynaad (Kerala), Karnataka, Maharashtra, Madhyapradesh and Assam (Jayaram, 1999)

Distribution in Kerala: Nilgirri biosphere, Travancore, Achenkoil river (Remadevi *et al.*, 1996); Periyar river (Ajithkumar *et al.*, 2000), Kabbini river(Kurup *et al.*, 2004)

Habitat: Deep pools at higher altitudes with sandy or muddy substratum.

Fishing method: Gill nets

Mystus vittatus (Bloch)
(Plate XII, Fig. 105)

Silurus vittatus Bloch, *Ichth. Hist. Nat.*, 11: 40, pl. 371, fig. 2, 1797 (Type locality: South India)
Macrones vittatus Day, *Fishes of India*: 448, pl. 98, 1877
Mystus (Mystus) vittatus Misra, *Fauna of India*, Pisces, 3: 105

Common name: Striped dwarf catfish **Local name:** Chillankoori

Distinguishing characters: (Based on 12 specimens, 112-124 mm TL)

D. I, 7; P.I, 9; V. i, 5; A. ii, 8; C.17.

Body elongate and moderately compressed. BD 23.95-24.3 (23.9) and HL 24.58-24.98 (24.78) in SL. Head depressed, occipital process extends to basal bone of dorsal fin. Median longitudinal groove on head not reaching base of occipital process. Eyes 24.77-27.81 (26.29) in HL. Maxillary barbells extends posteriorly beyond pelvic fins. Dorsal spine weak and finely serrated. Adipose fin short, inserted after a long interspace from rayed one. Pectoral spine strong and serrated. HCPD 116.23-135.75 (129.55) in LCPD. Body silvery gray on back with several deep brown longitudinal bands on flanks. A dusky shoulder spot present.

Geographical distribution: India, Pakistan, Bengladesh, Nepal, Sri Lanka, Burma and Thailand(Talwar and Jhingran, 1991)

Distribution in Kerala: Travancore (Hora and Law, 1941); Periyar Tiger Resserve (Chacko 1948), Periyar river system (Kurup *et al.*, 2004)

Habitat: Pool-riffle habitats with gravelly or sandy bottom.

Fishing method: Cast nets

Mystus menoda (Hamilton-Buchanan)
(Plate XII, Fig. 106)

Pimelodus menoda Hamilton-Buchanan, *Fish. Ganges*, pp. 203, 379, pl. 1, fig. 72, 1822 (Type locality: Kosi river and river Mahananda)
Macrones corsula (Valenciennes) Day, *Fishes of India*: 446,1877
Mystus (Mystus) menoda Misra, 1976, *Fauna of India, Pisces,* 3:95

Common name: Menoda catfish **Local name:** koori

Distinguishing characters: (Based on a single specimen, 207 mm TL)

D I, 7; PI, 8 Vi, 5; A 2, 8; C 16

Body elongate, compressed, BD 19.79 and HL 32.44 in SL. Head depressed. SNL 27.88 in HL, eyes with free orbital margins, 13.94 of HL, 50.0-52 of INTO. Mouth terminal and transverse, upper jaw longer. Maxillary barbells reaching middle of pelvic fins. Dorsal fin as high as body with a strong spine, twice of its distance slightly shorter than head length, serrated internally in its upper half; origin nearer to snout than to caudal peduncle. Adipose dorsal fin extended up to last ray of anal fin. HCPD 47.52 in LCPD. Greyish brown above, dull white below. Clusters of small spots along lateral line and several vertical bluish spots form these spots arranged vertically; appears as indistinct lines across body which is very characteristic of this species. Fins brownish yellow in colour.

Distribution: India: Bombay, Maharashtra, Orissa, Bihar, West Bengal, Assam, Kerala, Benglades, Nepal, Kosi river, Burma

Distribution in Kerala: Achenkoil river (New report)

Habitat: Pool-run habitats with sandy or muddy substratum.

Fishing method: Gill nets

Mystus malabaricus (Jerdon)
(Plate XII, Fig. 107)

Bagrus malabaricus Jerdon, *Madras J. Lit. Sci.*, 15 338, 1849 (Type locality: Mountain streams in Malabar)
Macrones malabaricus Day, *Fishes of India*: 450, 1877
Mystus (Mystus) malabaricus Misra, *Fauna of India, Pisces,* 3:95

Common name: Jerdon's mystus **Local name:** Chillankoori

Distinguishing characters: (Based on 12 specimens, 121-186 mm TL)

D. i 7; P.I, 9; V.i,5; A.ii,10; C.17.

Body elongate and compressed. BD 20.7-27.2 (23.9) and HL 11.33-12.29 (11.81) in SL. Head depressed. Occipital process not extends to basal bone of dorsal fin. Median longitudinal groove on head not reaching base of occipital process. Eyes 11.56-13.89 (12.73) in HL. Maxillary barbells extend to end of pelvic fins. Dorsal spine weak and finely serrated. Adipose fin moderately long, inserted after a considerably long interspace. Its base form 188.32-204.59 (198.45) in interdorsal distance. Pectoral spine strong and serrated. HCPD 79.60 –86.11 (81.55) in LCPD. Head and back brownish black and dull white below. A dark shoulder spot present. A dark brown band along mid lateral line which ends in a dusky triangular blotch at caudal peduncle. Fins brownish especially outer half.

Geographical distribution: India: Western Gnats (Jayaram, 1999)

Distribution in Kerala: Kabbini, Chaliyar, Chalakkudy, Karivannurpuzha, Cheenkannipuzha and Achenkoil (Talwar and Jhingran, 1991; Easa and Basha,1995; Jayaram,1981 and 1999), Periyar river (Kurup *et al.*, 2004).

Habitat: Pool-riffle habitats with gravelly or sandy bottom.

Fishing method: Cast nets

Family: Siluridae

Fishes with an elongate and highly or moderately compressed (sheet like) body. Teeth on pre maxillaries, mandible and vomer. Nostrils separated from each other by a short distance, anterior tubular at tip of snout and posterior situated just before eyes. Nasal barbells absent. Barbells well developed, four or six. Gill openings wide, membranes free from each other and also from isthmus. Rayed dorsal fin short with four or five rays and without a spine. No adipose fin. Pectoral fins with a strong or weak spine and generally serrated. Anal fin long, extending from anal opening to caudal fin. Caudal forked, rounded or deeply emarginate. Lateral line present, usually complete.

Key to genera

1. a) Gape of mouth wide, extending beyond eyes...................... *Wallago*

   b) Gape of mouth not extending beyond eyes..................................2

2. a) Caudal fin rounded or weakly emarginate, eyes not visible from under side of head.. *Silurus*

   b) Caudal fin forked, eyes visible from ventral side of head.......... *Ompok*

Genus ***Wallago*** Bleeker

Wallago Bleeker, *Nat. Tijdschr. Nederl. Inde*, 2, p. 265 (Type, *Silurus mulleri* Bleeker)

Wallago attu (Schneider)
(Plate XII, Fig. 108)

Silurus attu Schneider, *Syst. Ichth.*, p. 378, pl.75, 1801(Type locality: Malabar)
Silurus wallago Valenciennes, *Hist. Nat. Poiss.*, 14:354,1839 (Bengal)
Wallago russelli Bleeker, *Verh. Bat. Gen.*, 25: 108, 1853 (Culcutta and Batavia)

Wallagonia attu Hora and Misra, *J. Bombay nat. Hist. Soc.*,46 (1):128, 1946

Common name: Boal **Local name:** Attuvala, Vala

Distinguishing characters: (Based on 8 specimens from 225-689 mm TL)

D. 5; P.I, 13-15;V.1,7-9; A. iii 74-93; C.17

Body elongate and laterally compressed. Mouth wide, gape extends beyond eyes. Barbells two pairs, maxillary barbells extends slightly beyond origin of anal fin and mandibular pair short, slightly more than eye diameter. Dorsal fin short with a few rays, inserted just in advance of pelvic fins. Pectoral spine weak and poorly serrated at inner edge. Caudal fin deeply forked. Back uniformly silvery with golden reflections, sides dull white, a faint yellow band along lateral line, fins generally yellowish.

Geographical distribution: India, Pakisthan, SriLanka, Nepal, Bengladesh, Burma, Thailand, Vietnam, Kampuchea, The Malay Peninsula, Sumatra and Java (Talwar and Jhingran, 1991)

Distribution in Kerala: 24 rivers of Kerala (Ajithkumar *et al.*, 2000), Downstreams of rivers of Kerala (Shaji and Easa, 2001), 8 river systems in Kerala (Kurup *et al.*,2004).

Habitat: Pool-run habitats with sandy or muddy bottom.

Fishing method: Gill nets

Genus ***Ompok*** Lacepede

Ompok Lacepede, *Hist. Nat. Poiss.*, 5, p. 49, 1803 (Type, *Ompok siluroides* Lacepede) .

Fishes with a strongly compressed body, head depressed. Mouth oblique and gape not reaching eyes. Lower jaw longer than upper jaw. Eyes visible from ventral side of head. Barbells maxillary and mandibular pairs, mandibulars short and narrow. Dorsal fin small and with 3-5 rays. Anal fin very long with 52-75 rays. Pectoral spine weak and feebly serrated. Caudal forked.

Key to species

1. a) Anal fin with 68-69 branched rays, tips of caudal lobes pointed ....*Ompok malabaricus*

   b) Anal fin with 57 or 58 branched rays, tips of caudal lobes rounded...*Ompok bimaculates*

Ompok malabaricus (Valenciennes)
(Plate XII, Fig. 109)

Silurus malabaricus Valenciennes, *Hist. Nat. Poiss.*, 14: 353, 1839 (Type locality: Malabar)
Wallag malabaricus Bleeker, *Verh. Bat. Gen.*, 25:54, 1853
Calichromus malabaricus Day, *Fish. India*, p.478. 1877
Ompok bimaculatus Haig, *Rec. Indian mus.*, 48:103, 1950

Common name: Goan Catfish **Local name:** Ambattanvala, Thonnivala

Distinguishing characters: (Based on 23 specimens from 157-284 mm TL)

D. 3; P.I, 13;V.1,7; A. iv, 68-69; C.17.

Body elongate, maxillary barbells extend slightly beyond pelvic fin origin, manidibular pair short, extending just up to posterior boarder of eyes. Pectoral spine weak and poorly serrated inner edge. Grayish brown shot with purple becoming paler beneath black shoulder spot present colour may vary some times with body silvery white shot with purple. Fins dusky.

Geographical distribution: India: Kerala and Goa (Talwar and Jhingran, 1991)

Distribution in Kerala: Chalakkudy and Karuvannur rivers (Ajithkumar *et al.*, 2000), downstream of rivers of Kerala (Shaji and Easa, 2001), Chalakkudy, Bharathapuzha, Periyar and Chaliyar river systems (Kurup *et al.*, 2004)

Habitat: Pool habitats with muddy or sandy bottom.

Fishing method: Gill nets

Ompok bimaculatus (Bloch)
(Plate XII, Fig. 110)

Silurus bimaculatus Bloch, *Hist. Nat. Poiss.*, Par 2: 17, pl. 364, 1767 (Type locality: Malabar)
Silurus mysoricus Valenciennes, *Nat. Hist. Fish.*, 2:306 1839
Callichromus bimaculates Swainson, *Nat. Hist. Fish.*, 2:306, 1839
Ompok sindensis Day, *Fish. India*, p.476, 1877 (Type locality: Sind)

Common name: Indian Butter catfish **Local name:** Ambattanvala

Distinguishing characters: (Based on 33 specimens from 136-276 mm TL)

D. 3-4; P.I, 13; V.1, 7; A. iv, 57-58; C.17.

Body elongate and laterally compressed. Maxillary barbells extends slightly beyond anal fin origin, manidibular pair very short. Pectoral spine weak and poorly serrated at inner edge. Grayish brown shot with purple becoming paler beneath. Black shoulder spot present. Body silvery white shot with purple (colour found to be varying based on the habitat conditions from purplish to dark brown). Fins dusky.

Geographical distribution: India, Pakistan, Afghanistan, Sri Lanka, Bengladesh, Burma, Thailand, Java, Sumatra, Borneo and China (Talwar and Jhingran, 1991).

Distribution in Kerala: Throughout all major rivers of Kerala (Ajithkumar *et al.*, 2000), downstream of rivers of Kerala (Shaji and Easa, 2001), Periyar, Bharathapuzha, kabbini and Kallada river systems (Kurup *et al.*, 2004).

Habitat: Pool habitats with muddy or sandy bottom. The species is often found at the upstream of rivers in the crevisces of huge boulders and bedrock.

Fishing method: Gill nets

Genus: ***Silurus*** Linnaeus

Silurus Linnaeus, *Syst. Nat.* Ed. 10, p. 301, 1758 (Type, *Silurus glanis* Linnaeus)

Silurus wynaadensis (Day)
(Plate XIII, Fig. 111)

Silurus punctatus Day, *Proc. Zool. Soc. Lond.*, p. 155, 1868 (Type locality: Wynaad, Kerala)
Silurus cochinchinensis Bimachar and Rau, *J. Mys. Univ.*, 1(16), 1941 (Mysore)
Silurus berdmorei wynaadensis Rajan, *J. Bombay nat. Hist.* Soc., 53:45, 1955 (Bhavani river)
Silurus cochinchinensis Wynaadensis Misra, *Faun. India Pisces*, 3:202,1976 (Wynaad, Western Ghats)

Common name: Malabar silurus **Local name:** Thonnivala

Distinguishing characters: (Based on 8 specimens from 84-192 mm TL)

D. i, 3; P. i, 8;V.i, 7; A. ii, 54-65; C.17.

Body elongate and laterally compressed, BD 11.51-18.18 (16.09) and HL 17.14 -20.92 (19.46) in SL. Head broad and depressed. Upper jaw slightly longer than lower jaw, mouth slightly subterminal, gape of mouth reaching up to posterior border of eyes. Eyes small, 8.27-13.76 (99.83) in HL, not visible from ventral side of head and with a free orbital rim. Barblles two pairs, Maxillaries and mandibulars, Maxillary barbells extend beyond tip of pectorals and mandibulars shorter, extending up to gill openings. Dorsal fin short with 3 rays, anal fin long and pectoral spine weak and smooth. LCPD 1.56-5.74 (3.64) in SL and HCPD124.56-244.97 (167.24) in LCPD. Caudal fin round or slightly truncate. Body brownish, purplish below with numerous dark dots scattered over entire body. Fins generally brownish with anal fin rays tips lighter in colour.

Geographical distribution: India: Western Ghats of Kerala (Talwar and Jhingran, 1991; Jayaram, 1999).

Distribution in Kerala: Wynaad (Shaji and Easa, 2001, Kurup *et al.*, 2004).

Habitat: Rocky pools of uplands.

Fishing method: Gill nets.

Family: Schilbeidae

Genus ***Pseudeutropius*** Bleeker

Pseudeutropius Bleeker, *Versl. Akad. Amsterdam*, 14, p. 308, 1862 (Type, *Eutropius brachyoperus* Bleeker)

Pseudeutropius mitchelli Gunther
(Plate XIII, Fig. 112)

Pseudeutropius mitchelli Gunther, *Cat. Fish. Brit. Mus.*, 5: 59, 1864 (Type locality: Madras presidency)
Pseudeutropius sykesii (nec Jerdon) Day, *Fish. India*, p. 473, 1877(West coast of India)

Common name: Malabar Patashi **Local name:** Vellivala

Distinguishing characters: (Based on 12 specimens, 125- 160mm mm TL)

D. i, 6-7; P. i, 8; V.i, 5; A. 33-34; C.19

Medium sized fishes with an elongate and laterally compressed body. BD 20.41-20.86 (20.63) and HL 20.83-23.75 (22.29) in SL. Head short and snout pointed, tip blunt. Mouth sub inferior, transverse, moderate and overhung by snout. Eyes large, 24.45-31.56 (28.00) in HL and ventrolateral in position and with broad circular adipose eyelids. Barbells four well developed pairs, one each of maxillary, nasal and two of mandibular. Dorsal fin small, inserted above last quarter of pectoral fins and with a weak spine. Pectoral spine weak and serrated. Adipose fin very small. Anal fin long and separated from caudal fin. LCPD 15.11-15.44 (15.28) in SL. HCPD 47.37-55.33 (51.35) in LCPD. Caudal fin forked, caudal fin slightly bent downwards. Body naked. Lateral line complete. Bluish silvery along back, silvery white on flanks and belly. Dorsal and caudal fins grayish; other fins hyaline.

Geographical distribution: India: Kerala (Talwar and Jhingran, 1991)

Distribution in Kerala: Travancore (Hora and Law (1941), Periyar river (Ajithkumar *et al.*, 2000; Kurup *et al.*, 2004).

Habitat: Rapids or pool riffles with boulders, cobbles, gravel as substratum.

Fishing method: Cast nets

Family: Sisoridae

Genus *Glyptothorax* Blyth

Glyptothorax Blyth, *J. Asiat. Soc. Bengal*, 29, p. 151 (Type, *Glyptosternum striatus* McClelland)

Body elongate, cylindrical and posteriorly compressed, ventrally more or less flat. Head depressed. Skin of head and body granulated. Snout conical with broad tip. Eyes minute and placed on dorsal side of head, not visible from ventral side. Mouth inferior. Jaws sub equal, upper jaw longer. Ventral side of body at thoracic region provided with an adhesive apparatus with or without a central pit. Four pairs of barbells; one pair each of maxillary and nasal and, two mandibulars. Maxillary pairs longest with broad bases, reaches beyond pectoral fin origin. Adipose fin moderate. Gill membranes united with each other and also with isthmus. Lateral line complete, caudal forked. Most of the species are nocturnal and found living under crevices of big boulders and bedrocks of cascade, rapids and Riffle-pool habitats of upstream of rivers. Gill nets used should be set at night around crevices of bedrocks or boulders so as to catch these rare fishes. Adhesive apparatus is an adaptation to attach closely to substrata in torrential waters of upstream.

Key to genera

1. a) Adhesive apparatus on thorax broader than long and feebly developed..*Glyptothorax anamalaiensis*

   b) Adhesive apparatus on thorax longer than broad and well developed 2

2. a) Body dark, dorsal and caudal fins tipped with orange yellow colouration...*Glyptothorax annandalei*

   b) Body with transverse bands or without any bands or coloration 3

3. a) Paired fins plaited, body without any bands......... *Glyptothorax lonah*

   b) Paired fins non-plaited, body with transverse bands ....Glyptothorax *madraspatnam*

Glyptothorax anamalaiensis Silas
(Plate XIII, Fig. 113)

Glyptothorax anamalaiensis Silas, *J. Bombay nat. Hist. Soc.*, 50(2): 370, 1951 (Type locality: Anamalai hills, Western Ghats)

Common name: Anamalai sucker catfish **Local name:** Neykkoori

Distinguishing characters: (Based on 3 specimens from 68-93 mm TL)

D. i, 6; P.I, 10;V.i, 5; A.i,11; C.17.

BD 14.33-20.84 (17.72) and HL 25.45-28.81(27.55) in SL. Head longer than broad. Maxillary barbells extend beyond base of pectoral fin. Adipose fin comparatively long based, ADB 118-124 (122) of AB. Paired fins non-plaited. Dorsal fin inserted closer to snout. HD 75.61-80.99 (77.41) in HL and HP 56.5-80.34 (71.42) in HL. LCPD 17.87-19 50 (18.52) in SL and HCPD 40.40-

48.26 (43.06) in LCPD. Body brownish, mottled with numerous dark spots on head and body and with three broad white transverse bands; one below dorsal fin, second between rayed dorsal and adipose fins, third between adipose and caudal fin base. Fins tipped with white. A broad transverse band at bifurcation of caudal fin.

Geographical distribution: India: Base of Anamalai hills (Talwar and Jhingran, 1991)

Distribution in Kerala: Anamalai Hills, Kerala (Shaji and Easa, 2001), Kabbini (Kurup *et al.*, 2004)

Habitat: Cascade, rapids or Riffle-pool habitats with bedrock and boulders as substratum.

Fishing method: Gill nets and cast nets

Glyptothorax annandalei Hora
(Plate XIII, Fig. 114)

Glyptothorax annandalei Hora, *Rec. India Mus.*, 25: 14, pl.1, fig.3, 1923 (Type locality: Nierolay stream, Bhavani river)

Common name: Annandale's sucker catfish **Local name:** Parakkoori, Neykkoori

Distinguishing characters: (Based on 28 specimens from 98-194 mm TL)

D. i, 7; P.i, 10-12; V.i, 5; A.i, 10; C.17

BD 15.26-19.22 (17.74) and HL 23.06-27.35 (25.00) in SL. Head longer than broad. Maxillary barbells extend to anterior third of pectoral fins. Adipose fin short based, ADB 87-94 (96.02) of AB. Paired fins plaited ventrally. Dorsal fin inserted closer to snout. HD 72.8-89.49 (72.67) in HL and HP 78.17-102.79 (98.24) in HL.LCPD 12.98-21.8 (18.52) in SL and HCPD 44.52-57.58 (53.21) in LCPD. Body dark brown, with a narrow yellow stripe along lateral line reaching base of caudal fin. Fins dark brown with tips orange yellow.

Geographical distribution: India: Western Ghats and Windhyas; Nepal (Talwar and Jhingran, 1991)

Distribution in Kerala: Kunthi, Kabbini and Periyar river (Remadevi and Indra, 1986; Easa and Basha, 1995; Arun *et al.*, 1996; Gopi, 2001), Silent valley and Moovattupuzha rivers(Ajithkumar *et al.*, 2000), 7 river systems of Kerala (Kurup et al., 2004).

Habitat: Cascade, rapids or Riffle-pool habitats with bedrock and boulders as substratum.

Fishing method: Gill nets and Cast nets

Glyptothorax lonah (Sykes)
(Plate XIII, Fig. 115)

Bagrus lonah Sykes, *Proc. Zool. Soc. Lond.*, p. 164, 1838 (Type locality: Deccan)
Glyptosternum lonah Gunther, *Cat. Fish. Brit. Mus.*, 5:187, 1864
Glyptothorax dekkanensis Gunther, Cat. *Fish. Brit. Mus.,* 5:187, 1864
Glyptothorax lonah: Hora, Rec. Indian Mus., 25:30, 1923

Common name: Deccan sucker catfish **Local name:** Neykkoori

Distinguishing characters: (Based on 2 specimens from 110-124 mm TL)

D. i, 6; P.i, 9; V.i, 5; A.i, 11; C.17.

BD 14.25-19.56 (16.90) and HL 21.13-26.95 (24.04) in SL. Head as long as broad. HW 96.29-107.56 (101.97) in HL. Maxillary barbells extend to middle of pectoral fins. Adhesive thoracic apparatus longer than broad and well developed. Dorsal fin inserted closer to adipose fin. Adipose fin short based, ADB 87.26-91.25 (89.255) of AB. Paired fins plaited ventrally. HD 81.2 84.26 (82.73) in HL and HP 101.26-106.24 (101.25) in HL. LCPD 18.94-19.03

(18.99) in SL and HCPD 47.59- 53.29 (50.44) in LCPD. Brownish body and fins, ventral side light yellow.

Geographical distribution: India: Mula Muthu river at Poona, Maharashtra (Talwar and Jhingran, 1991)

Distribution in Kerala: Chalakkudy river (Hora, 1938; Ajithkumar *et al.*, 1999; Shaji and Easa, 2001; Kurup *et al.*, 2004).

Habitat: Cascade, rapids or riffle-pool habitats with bedrock and boulders as substratum.

Fishing method: Gill nets

Glyptothorax madraspatanam **(Day)**
(Plate XIII, Fig. 116)

Glyptosternum madraspatanum Day, *J. Linn. Soc. Lond.*, 11, 1873 (Type locality: Bhavani river)
Glyptothorax madraspatanus Hora, Rec. Indian Mus., 25:29, 1923 (Pampadumpara, Periyar)
Glyptothorax madraspatanum Menon, Rec. Indian Mus., 52:31, 1954(Travancore)

Common name: South Indian sucker catfish **Local name:** Parakkoori

Distinguishing characters: (Based on 2 specimens from 112-114 mm TL)

D. I, 6; P.I, 9-10; V.1, 5; A.I, 8-9; C.17.

BD 18.50-18.55 (18.53) and HL 23.8-26.87 (25.34) in SL. Head longer than broad. Adhesive thoracic apparatus longer than broad and well developed. Maxillary barbells extend to base of pectoral fins. Dorsal fin inserted closer to adipose fin, dorsal spine strong and serrated near apex on both sides. Adipose fin long based, ADB 142-148 (146) of AB. Paired fins non plaited. HD 87.10-95.65 (91.35) in HL and HP 86.38-105.26 (95.86) in HL. Caudal fin deeply forked. LCPD 19.05- 19.38 (19.21) in SL and HCPD 49.39-50.53 (49.96) in LCPD. Body brownish with yellowish transverse bands.

Geographical distribution: India: Western Ghats: Anamalai and Nilgirris, Cauveri river(Talwar and Jhingran, 1991)

Distribution in Kerala: Mettupalayam in Coimbatore district (Hora, 1923) Nulpuzha, NBR (Easa and Basha, 1995), Periyar, Chaliyar and Kabini rivers (Easa and Basha, 1995; Arun, 1997) Muvattupuzha and Periyar rivers(Ajithkumar *et al.*, 1999), Bharathapuzha (Kurup *et al.*, 2004).

Habitat: Cascade, rapids or riffle-pool habitats with bedrock and boulders as substratum..

Fishing method: Gill nets

Family: Clariidae

Genus ***Clarias*** Scopoli

Clarias Scopoli, *Introductio ad Naturalam*, p. 445, 1777 (Type, *Silurus anguillaris* Linnaeus)

Clarias dussumieri Valenciennes

(Plate XIII, Fig. 117)

Clarias dussumieri Valenciennes (in C& V), *Hist. Nat. Poiss.*, 15: 382, 1840 (Type locality: Pondichery, Malabar)
Clarias dussumieri dussumieri Silas, Proc. nat. Inst. Sci. India, 18, (2), 434, 1952

Common name: Valenciennes clariid **Local name:** Mushi, Musu

Distinguishing characters: (Based on 4 specimens from 222-272 mm TL)

D. 66-69; P.I, 10-11; V.i, 5; A. 45-49; C.17

Body elongate and cylindrical, posteriorly compressed. BD 10.16 –11.21 (11.91) and HL 18.88-20.01 (19.61) in SL. Head broad and flattened. Distance from dorsal base to occipital process 34.6 - 42.13 (39.14) in HL. Nostrils widely separated, anterior nostrils tubular, behind upper lip and posterior nostrils behind nasal Barbells. Mouth slightly sub-terminal. Eyes small, 7.89-8.94 (8.37) in HL, widely separated and dorsolateral in position.

Barbells four well developed pairs. Maxillary barbells with broad bases and extends beyond pectoral fin base. Dorsal fin base very long. No adipose fin, anal fin long and caudal fin rounded. HCPD 378.24-388.23 (383.72) in LCPD. Body naked. Dark brown above and lighter ventrally. Fins and barbells brownish.

Geographical distribution: Peninsular India: Goa, Karnataka, Kerala and Pondicherry (Talwar and Jhingran, 1991)

Distribution in Kerala: common in rivers of Kerala (Shaji and Easa, 2001), 14 river systems(Kurup *et al.*, 2004).

Habitat: Pools of lower streches of rivers with muddy substratum and stagnant water ponds.

Fishing method: Hook and line.

Family: Heteropneustidae

Genus ***Heteropneustes*** Muller

Heteropneustes Muller, *Arch. Anat. Physio.*, p. 115 (Type, *Silurus fossilis* Bloch)

Heteropneustes fossilis (Bloch)

(Plate XIII, Fig. 118)

Silurus fossilis Bloch, *Ichth. Hist. Nat. Poiss.*, 11: 36, 370, fig. 2, 1798 (Type locality: Bengal)
Silurus singio Hamilton-Buchanan, *Fish. Ganges*, pp. 147, 1822 (Bengal)
Saccobranchus fossilis Jerdon, *Madras, J. Lit. Sci.*, 15(2): 342, 1849. (South India)
Heteropneustes microps Misra, *Faun. India Pisces*, 3:137, 1976 (Ceylon)

Common name: Stinging catfish **Local name:** Kari, Kadu

Distinguishing characters: (Based on 12 specimens from 162-198 mm TL)

D. 6-7; P.I,7;V.i,5; A. 60-70; C.17

Body elongate and cylindrical, posteriorly compressed. BD 14.06-15.96 (15.30) and HL14.07-17.27 (16.16) in SL. Head broad and depressed.

Occipital process does not reach basal bone of dorsal fin. Nostrils more or less close to each other. Mouth moderate and terminal. Eyes small, 11.16-14.45 (12.31) in HL, widely separated and dorsolateral in position. Barbells four well developed pairs. Dorsal fin small, inserted slightly behind pectoral fins. Pectoral spine strong and serrated. No adipose fin, anal fin long and separated from caudal fin. Caudal fin rounded and body naked. Dark brown above and lighter ventrally. Fins and barbells light brown.

Geographical distribution: Pakistan: Indus Basin; India, Nepal, Bengladesh, Sri Lanka, Burma, Thailand and Laos (Talwar and Jhingran, 1991)

Distribution in Kerala: Common in low lands of Kerala (Shaji and Easa, 2001), Chalakkudy, Bharathapuzha, Kabbini river systems (Kurup *et al.*, 2004).

Habitat: Pool habitats where water velocity is low, stagnant waters, ponds and ditches.

Fishing method: Hook and line.

ORDER: BELONIFORMES

Family: Belonidae

Genus ***Xenentodon*** Regan

Xenentodon Regan, *Ann. Mag. Nat. Hist.*, (8) 7, p. 332, 1911 (Type, *Belone cancila* Hamilton-Buchanan)

Xenentodon cancila (Hamilton-Buchanan)
(Plate XIII, Fig. 119)

Esox cancila Hamilton-Buchanan, *Fish. Ganges*, pp. 213, 215, 380, pl. 27, fig. 70, 1822 (Type locality: Ponds and small rivers of Gangetic provinces)
Belone graii Sykes, *Trans Zool. Soc. Lond.*, 367, pl. 63, 1841 (Poona)

Belone cancila Day, *Fish Malabar*, p. 166, 1865
Xenentedon cancila Jayaram, *HBFW Fish. India*, p. 292, 1981

Common name: freshwater gar fish **Local name:** Kola, Kolan

Distinguishing characters: (Based on 12 specimens from 120-282 mm TL)

D. iii, 12; P.i,9;V.i,5; A.i,12; C.15.

Body elongate and more or less cylindrical, abdomen rounded. Head moderate, both jaws elongated as a beak armed with sharp teeth. A moderate to deep longitudinal groove on upper side of head present. BD 6.28-7.79 (7.04) HL 40.37-42.86 (41.76) in SL. Eyes moderate to large, visible from ventral side of head, located at anterior part of head, 8.07-10.96 (9.18) in HL. Mouth terminal, Dorsal fin inserted above anal fin. Pectoral fins small, pelvic fins abdominal in position and inserted far back. Caudal fin truncate. Scales present on head and are deciduous in nature. Greenish yellow above, flanks silvery, belly white. A wide silvery lateral band on flanks present. Fins generally yellowish to hyaline with dorsal and anal fins dark edged.

Geographical distribution: India, Bengladesh, Myanmar, Nepal, Pakistan, Sri Lanka and Thailand (Talwar and Jhingran, 1991)

Distribution in Kerala: Present in almost all river systems (Ajithkumar *et al.*, 2000, Shaji and Easa, 2001; Kurup *et al.*, 2004).

Habitat: Pool-run habitats with sandy or muddy bottom.

Fishing method: Cast net and gill net.

ORDER: CYPRINODONTIFORMES

Family Aplochelidae

Genus *Aplocheilus* mcClelland

Aplocheilus McClelland, *Asiat. Res.*, 19, p. 301, 1839 (Type, *Aplocheilus chrisostignus* McClelland)

Small fishes with an elongate and posteriorly compressed body. Upper surface of head and nape broad and depressed. Snout spatulated. Mouth terminal, directed slightly upwards, moderately wide, eyes prominent, superior. Upper jaw protractile, lower jaw attenuated, barbells absent. Dorsal fin inserted far backwards, above posterior end of anal fin, pelvic fin bases inserted close together, Caudal rounded, scales cycloid and lateral line absent. A pearly white spot on occipit invariably present.

Key to species

1. a) Lateral line scales 26-29.................................*Aplocheilus blocki*

   b) Lateral line scales 32-36..............................*Aplocheilus lineatus*

Aplocheilus blocki (Arnold)
(Plate XIII, Fig. 120)

Haplocheilus panchax var. *blocki* Arnold, *Wochenschr. Aquarein and Terrainkude*, 8: 672, 1911 (Type locality: Cochin, Kerala)
Panchax panchax blochii (sic) Munro, *Marine and freshwater Fishes of Ceylon*: 85
Panchax parvus Sundara Raj, *Rec. Indian Mus.*, 12(6): 249, 1916 (Madras)

Common name: Dwarf Panchax **Local name:** Manathukanni, Nettipottan

Distinguishing characters: (Based on 8 specimens, 36-68 mm TL)

D.ii, 6; P.13-14; V.6; Aiii, 11

Body elongate and compressed. BD 17.21-19.21 (18.44) and HL 24.54-28.15 (27.76) in SL. Eyes prominent, 18.21-21.34(19.31) in HL. INTO in HL. HD

48.21-51.29 (50.77) in HL, DB 54.21-61.83 (59.7) in HD. In males, 4-5 ray of dorsal fin and 11-12 ray of anal fin elongated. HP 131.26-138.2 (134.6) in HL. Pelvic fins without any prolonged ray. HV 183.54-189.39 (185.31) in HP. LCPD 11.29-14.68 (12.7) in SL. HCPD 98.21-102.32 (100.00) in LCPD, HC 30.14-32.54 (31.19) in SL. Body yellowish green with a metallic sheen and alternating rows of brassy yellow red spots. Belly shining blue green. A black spot at base of dorsal fin. Vertical fins yellowish with red dots in male.

Geographical distribution: India: India: Tamilnadu, Kerala and Kutch; Sri Lanka (Talwar and Jhingran, 1991)

Distribution in Kerala: present in almost all river systems (Ajithkumar *et al.*, 2000, Shaji and Easa, 2001), Valapatnam river system (Kurup *et al.*, 2004).

Habitat: water logged shallow areas of streams, ditches, pools, channels, canals, etc. with thick vegetation.

Fishing method: Scoop nets.

Aplocheilus lineatus (Valenciennes)
(Plate XIV, Fig. 121)

Panchax lineatum Valenciennes, *Hist. Nat. Poiss.*, 18: 381, 1846 (Type locality: Bombay)
Aplocheilus vittatus Jerdon, *Madras. J. Lit. Sci.*, 15:330,1849
Aplocheilus affinis Jerdon, *Madras. J. Lit. Sci.*, 15:331, 1849
Haplocheilus lineatus Day, *Fish. India*, p. 522, 1877 (Malabar coast of India)

Common name: Malabar Killie **Local name:** Manathukanni,Nettipottan

Distinguishing characters: (Based on 10 specimens, 32-62 mm TL)

D.ii,6; P.12-14; V.6; Aiii,12-13

Body elongate and compressed posteriorly. BD 20.45-21.79 (21.12) and HL 28.86-30.31 (29.49) in SL. Eyes prominent, 25.52- 29.42 (27.47) in HL. DB 57.21-60.29 (59.23) in HD, HP 117.33-134.37 (125.90) in HD, Pelvic fins with its second ray elongated, HV 137.12-138.32 (138.06) in HP. LCPD 15.37-15.86 (15.60) in SL. HCPD 71.43-80.26 (75.84) in LCPD, HC 30.42-34.53

(32.47) in SL. Males olive brown, flanks paler, belly yellowish, rows of metallic golden green and red spots on body. Females darker than males with 7-11 black transverse bars.

Geographical distribution: India: India: Western and South Eastern region (Talwar and Jhingran, 1991)

Distribution in Kerala: Fairly common in Kerala (Shaji and Easa, 2001); Throughout all rivers of Kerala (Ajithkumar *et al.*, 2000), Chalakkudy, Periyar, Bharathapuzha and Kallada river systems (Kurup *et al.*, 2004).

Habitat: Water logged shallow areas of streams, ditches, swmps, pools, channels, canals, etc. with thick vegetation.

Fishing method: Scoop nets.

Family: Poecilidae

Genus: ***Poecilia*** Bloch and Schneider

Poecilia Bloch and Schneider, *Syst. Icth.*, 2, p. 452, 1801 (Type, *Poecilia vivipara* Bloch and Schneider

Poecilia reticulata Peters
(Plate XIV, Fig. 122)

Poecilia reticulata Peters, *K. Preussischen Akad. Wiss., Berlin*: 412, 1859 (Type locality: Venezuela)
Lebistes reticulates Menon, *Sci. & Cult.*, 43(3):113, 1977

Common name: Guppy **Local name**: Guppy

Distinguishing characters: (Based on 12 specimens, 28-48 mm TL)

D. 1, 5; P. i, 10-11; V.i,5; Aiii,7;C.14;L.l.28-30, Ltr.2.5/3.

Small fishes with a cylindrical and posteriorly compressed body. Upper jaw protrusible, lower jaw projecting. Gill membranes free from each other and also from isthmus. BD 23.84 -24.62 (24.23) and HL 23.78-24.11 (23.95) in SL. Eyes prominent, 28.27-28.95 (28.61) in HL. INTO 42.13- 62.63 (52.38) in

HL. Dorsal fin short, inserted in front of anal fin, HD 59.21-86.67 (72. 94) in HL, HP 96.62-139.11(117.86) in HD, HV 74.52-75.08 (74.80) in HP. In males, anal fin modified to serve as a gonopodium. LCPD 26.19-27.09 (26.64) in SL, HCPD 57.84-60.05 (58.95) in LCPD, HC 32.17-34.81 (33.49) in SL. Young males easily distinguished from females by their orange, red and black dots all over body and fins. Females are olivaceous; fins hyaline.

Geographical distribution: Netherlands, The Venezuelan Islands, Trinidad and British Guiana; Introduced to India (Talwar and Jhingran, 1991).

Distribution in Kerala: Nilgiri biosphere reserve (Easa and Basha,1995), Periyar (Ajithkumar *et al.,* 2000), Chaliyar (Shaji and Easa, 2001), Chalakkudy river (Kurup *et al.*, 2004)

Habitat: Water logged shallow areas of small streams, ditches, channels, canals etc. It is also found in riffle-pools at high altitudes.

Fishing method: Scoop nets.

ORDER: SYNGNATHIFORMES

Family: Syngnathidae

Genus *Microphis* Kaup

Microphis Kaup, *Arch. Naturg.*, 19, pl. 1, p. 234, 1853 (Type, *Syngnathus deocata* Hamilton-Buchanan)

Microphis cuncalus (Hamilton-Buchanan)
(Plate XIV, Fig. 123)

Syngnathus cuncalus Hamilton-Buchanan, *Fishes of Ganges*: 12, 362, 1822 (Type locality: Estuaries of north Calcutta)
Doryichthys cuncalus Day, *Fauna Br. India, Fishes*, 2: 465, 1889

Common name: Crocodile tooth pipefish **Local name**: Pullumeen

Distinguishing characters: (Based on 16 specimens, 82-126 mm TL)

Rings (16-18) + (24-27); D 47-56; P 16-19; Sub dorsal rings (3.5-2.0)+(5.75-7.5)

Body small, slender, elongate and tubular. Tail not prehensile but elongate, body protected by a ring like arrangement of dermal plates. Head elongate, cylindrical, mouth at end of protruding tubular snout. BD 2.07-2.72 (2.39) and HL 11.33- 12.29 (11.81) in SL. Eyes prominent, 11.56- 13.89 (12.73) in HL and placed laterally and middle of head. Gill opening in the form of a pore situated above opercle. No barbells. Dorsal fin opposite to vent and without spines. HD 20.58 - 25.78 (23.15). Pectoral fins small, HP 15.89-21.56 (17.52) in HL, Pelvic fins absent. Anal fins minute with 4 rays. Caudal fin lanceolate, HC 6.32- 7.31 (6.81) in SL. Lateral line complete. Body brownish black with balckish fins.

Geographical distribution: India: West Bengal, Orissa, Tamil Nadu, Maharashtra, Goa and Kerala; Bengladesh and Sri Lanka (Talwar and Jhingran, 1991)

Distribution in Kerala: Chaliyar river system (Easa and Shaji, 1996), Nilgiri Biosphere Reserve (Easa and Basha, 1995), Aralam wild life sanctuary (Shaji *et al.*, 1995) Uppala, Periyar, Moovattupuzha and Periyar (Ajithkumar *et al.*, 2000), Valapatnam and Chalakkudy river systems(Kurup *et al.*, 2004).

Habitat: shallow areas of low-lying plains with thick grassy vegetation.

Fishing method: Scoop nets

ORDER: SYNBRANCHIFORMES

Family: Mastacembelidae

Subfamily: Mastacembelinae

Body eel-like, compressed and elongate, coverd with minutw scales. Mouth non-protractile. Snout elongate, supported by a cartilaginous rod and ending in a sensitive tip flanked by tubular nostrils. Dorsal fin long with depressible detached dorsal spines; anal fin with 1-3 spines. Pelvic fins absent. Caudal fin short, either confluent with dorsal and anal fins or narrowly separated; homocercal.

Key to Genera

1. a) Rostrum relatively large, ventral surface line with tooth plates, rim of anterior tubular nostril with six finger like projections.........*Macrognathus*

   b) Rostrum relatively small, no rostral tooth plate, rim of anterior tubular nostrils with two broad based flaps.............................*Mastacembelus*

Genus *Macrognathus* Lacepede

Macrognathus Lacepede, *Hist. Nat. Poiss.*, 2, 283, 1800 (Type, *Ophidium aculeatum* Bloch)

Macrognathus aral (Bloch and Schneider)
(Plate XIV, Fig. 124)

Rhynchobdella aral Bloch and Schneider, *Syst. Ichth.*, p. 478, 1801 (Type locality: Tranquebar, Tamil Nadu)
Macrognathus aculeatus Hamilton, *Fish. Ganges*, p. 29,1822 (Gangetic provinces)
Rhynchobdella aculeata (nec Bloch) Day, *Fish. India*, p. 338, 1876
Macrognathus jammuensis Malhotra, *Proc. nat. Acad. Sci. India*, 45 B (3), 1975 (Jammu)

Common name: One stripe spiny eel **Local name**: Aaron, Aral, Aarakan

Distinguishing characters: (Based on a single specimen, 182 mm TL)

D. XVI, 37; P.i, 18; A.ii, 46; C.14.

Elongate and compressed body, head conical, snout elongate, pointing. Rostral appendage with concave ventral surface lined with tooth plates on either sides. BD 12.34 and HL 21.99 in SL. Pre orbital and postorbital bones thin and smooth edged. Eyes small, 6.75 in HL. Mouth small,.inferior. Dorsal fin inserted far behind origin of pectoral fins. HD 13.11 in HL. Caudal rounded and distinctly separated from dorsal and anal fins, HC 8.02 in SL. Body greenish brown on back and abdomen yellowish. Two broad pale greenish bands, one above and second below lateral line. Four dark ocelli at base of rayed dorsal fin each surrounded by a yellow halo. Dorsal and caudal fin with several dark streaks.

Geographical distribution: Pakistan, India, Sri Lanka, Bengladesh, Nepal and Burma (Talwar and Jhingran, 1991).

Distribution in Kerala: rivers of Kerla (Jayaram, 1981), Periyar and northern rivers (Shaji and Easa, 2001), Periyar river system (Kurup *et al.*, 2004)

Habitat: Shallow riffles at upland and middle streches. The substratum consist of a mixture of cobbles and pebbles.

Fishing method: Cast nets and gill nets

Genus: ***Mastacembelus*** Scopoli

Mastacembelus Scopoli, *Introd. Hist. Nat.*, p. 458, 1777 (Type, *Ophidium mastacembelus* Banks and Solander)

Mastacembelus armatus (Lacepede)
(Plate XIV, Fig. 125)

Macrognathus armatus Lacepede, *Hist. Nat. Poiss.*, 2: 286, 1800 (Type locality: Bengal)
Macrognathus caudatus McClelland, *Culcutta J. Nat. Hist.*, 2:586, 1842
Macrognathus undulates: McClelland, *Culcutta J. Nat. Hist.*,1844
Mastacembelus manipurensis Hora, *Rec. Indian Mus.*, 22: 206, 1921

Common name: Tire-track spiny eel **Local name**: Aaron, Aral, Aarakan

Distinguishing characters: (Based on 11 single specimen, 181-358 mm TL)

D. XXXII-XXXVIII, 67-71; P.i, 17-20; A.ii, 64-74; C.13-14.

Elongate and compressed body, head conical, snout elongate, pointing. BD 6.21-10.25 (7.23) and HL 16.52-19.21 (17.86) in SL. Eyes moderate to small, 9.52-11.25 (10.22) in HL. Mouth small, inferior. Dorsal fin inserted above posterior third of pectoral fins. HD 14.23-17.43 (15.89) in HL. HP 191.02-198.73 (196.11) in HD. Caudal fin confluent with dorsal and anal fins, HC 4.18-7.24 (5.77) in SL. Ground colour greenish brown with a network of large brownish patches and blotches surrounded by narrow yellow halo on back, head and flanks. Pattern of blotches extend to fins. Ventral side reddish white. A dark line passing through eye ending at tip of snout.

Geographical distribution: Pakistan, India, Sri Lanka, Bengladesh, Nepal, Burma, Thailand and Southern China (Talwar and Jhingran, 1991)

Distribution in Kerala: 24 rivers of Kerala (Ajithkumar *et al.*, 2000; Kurup *et al.*, 2004), Fairly common in rivers of Kerala (Shaji and Easa, 2001).

Habitat: Riffles and runs with cobbles, pebbles and sandy substratum.

Fishing method: Cast nets.

ORDER: PERCIFORMES

Family: Ambassidae

Small fishes with oblong, elevated or slightly elongated, highly compressed and slightly translucent body. Moderate to small, deciduous, cycloid scales on body and head. Preopercle, interopercle and opercular bones are variously serrated. Dorsal fin deeply notched before last spine. Mouth moderate to large, eyes moderate to large, caudal fin forked. A forwardly directed spine in front of dorsal fin present. Lateral line complete. These fishes are a "fishermen's puzzle" as fish with procumbent and other sharp spines or dorsal fin entangled in cast nets and gillnets are very difficult to remove. Fishes with very low food value.

Key to genera

1. a) Supra orbital edge smooth or with two spines posteriorly, ventral margin of interoperculam serrated, body oblong and elevated, Jaws more or less equal.................... ....*Parambassis*

   b) Supra orbital edge finely serrated, ventral margin of interoperculam smooth, body more elongate and lower jaw prominent and projecting..*Pseudambassis*

Genus ***Parambassis*** Bleeker

Parambassis Bleeker, *Nat. Verh. Holland. Maatsch. Wetensch.*, 2 (2), p. 86, 102, 1874 (Type, *Ambassis apogonoides* Bleeker)

Key to species

1. a) Supra orbital edge smooth, lateral line scales 40-48 ....*Parambassis dayi*

   b) Supra orbital edge with two spines, lateral line scales 80-83 ....*Parambassis thomassi*

Parambassis dayi (Bleeker)
(Plate XIV, Fig. 126)

Ambassis dayi Bleeker, *Natur, Verh. Holland, Maatsch. Wetensch. Haarlem*, 2(2): 95, 1874 (Type locality: Malabar)
Ambassis nalua Day (nec Hamilton-Buchanan), *Fish. Malabar*, p. 15, 1878
Parambassis dayi Talwar and Jhingran, *Inland Fish.*, 2:801,1991(Western Coasts of Kerala)

Common name: Day's Glassy perchlet **Local name:** Arinjil, Chakkamullan

Distinguishing characters: (Based on 18 specimens, 68-133 mm TL)

D.VIII-IX+I, 10-11; P.i,11-12; V.i,5; A.III,8-9; C.17-19; Ll. 40-48, Ltr. 4.5-5/11-12.5

Body oblong and compressed. Head moderate, Snout conical, pointed, mouth large. Jaws more or less equal. BD 35.46 - 44.07 (40.67) and HL 29.82-41.30 (36.90) in SL. Eyes large, 31.35 - 40.49 (35.93) in HL. HD 60.95-

94.82 (71.39) in HL. HP 81.93-138.61(106.91) in HD. HV 61.00-95.71(81.39) in HP. LCPD 11.69-19.62 (13.69) in SL. HCPD 80.44-106.99 (92.84) in LCPD. Caudal forked, HC 27.16-37.12 (30.39) in SL. Back greenish, flanks silvery. Membranes of second and third dorsal spines dusky. Soft dorsal fin, caudal and anal fins with dusky edges.

Geographical distribution: Western Ghats of Kerala and Karnataka

Distribution in Kerala: All along Western Ghats of Kerala (Shaji and Easa, 2001; Kurup *et al.*, 2004) Almost all rivers in south of Palakkad gap (Ajithkumar *et al.*, 2000), Chalakkudy, Chaliyar, Pamba, Periyar and Bharathapuzha (Kurup *et al.*, 2004)

Habitat: low land plains, pool and run habitats with sandy and muddy bottom. Also found in middle streams with sandy and gravelly substratum, however very rare at upstream.

Fishing methods: gill nets and cast nets.

Parambassis thomassi (Day)

(Plate XIV, Fig. 127)

Ambassis thomassi Day, *Proc. Zool. Soc. Lond.*, p. 369, 1870 (Type locality: Coast of Canara)
Chanda thomassi Tilak, *Rec. Zool. Surv. India*, 67 90, 1972 (Goa)

Common name: Western ghat glassy perchlet

Local name: Arinjil, Chakkamullan, Mullan

Distinguishing characters: (Based on 12 specimens, 38-59 mm TL)

D. VII + I, 10-11; P. i, 14-15; V.i, 5; A.III, 9; C.17-19; Ll. 80-83, Ltr. 8.5-9/13.5-14

Body rather stout, deep and compressed. Head moderate to large, Snout conical, pointed, mouth large, jaws equal. BD 40.25-44.16 (42.36) and HL 31.56-42.36 (34.21) in SL. Eyes large, 31.65-41.22 (36.26) in HL. HD 69.87-

74.92 (72.56) in HL. HP 101.26-124.39 (107.26) in HD. HV 78.29-82.39 (80.26) in HP. LCPD 9.58-14.56 (11.23) in SL. HCPD 91.26-99.38 (94.56) in LCPD. Caudal forked, HC 27.59-32.17 (30.29) in SL. Back and sides silvery, fins hyaline. Soft dorsal, caudal and anal fins dusky, membranes of second and third dorsal spines black. Darkish brown patches of lines on flanks.

Geographical distribution: Western Ghats of Kerala and Karnataka

Distribution in Kerala: All along Western Ghats of Kerala (Shaji and Easa, 2001). Almost in all rivers (Ajithkumar *et al.*, 2000), Kabbini river system (Kurup *et al.*, 2004).

Habitat: Middle streams with sandy and gravelly substratum and riffle-pool habitats at upstream.

Fishing methods: gill nets and cast nets.

Genus ***Pseudambassis*** Bleeker

Pseudambassis Bleeker *Nat. Verh. Holland. Maatsch. Wetensch.*, 2 (2), p. 86, 1874 (Type, *Chanda lala* Hamilton-Buchanan)

Pseudambassis baculis (Hamilton-Buchanan)
(Plate XIV, Fig. 128)

Chanda baculis Hamilton-Buchanan, *Fish. Ganges*, pp.112, 371, 1822 (Type locality: North-east Bengal)
Ambasis baculis Day, *Fish. India*, p.51,1875
Chanda bacuilis Menon, *Inland Fish. Soc. India Spl. Publ.*, No. 1:94, 1981(Northern India, Pakistan, Burma and Thailand)

Common name: Himalayan Glassy Perchlet **Local name:** Nandan, Mullan

Distinguishing characters: (Based on 12 specimens, 61-78 mm TL)

D.VI-VII+I, 13; P.i,11-12; V.i,5; A.III,12-13; C.17-19; Ll. 88-92

Body rather slender and elongated. Head moderate, Snout conical, pointed, mouth moderate to normal. Jaws sub equal, lower jaw distinctly prominent and elongate. BD 34.56-41.29 (38.34) and HL 31.29-39.54 (33.12) in SL.

Eyes moderate, 28.56-38.49 (32.59) in HL. HD 68.59-76.58 (73.67) in HL. HP 99.16-112.57 (108.16) in HD. HV 78.39-84.16 (81.23) in HP. LCPD 9.58-12.58 (11.26) in SL. HCPD 80.29-96.58 (84.52) in LCPD. Caudal forked, HC 30.59-38.59 (32.54) in SL. Back yellowish green, flanks and belly silvery white. Tips of dorsal fin rays deep dark. Fins generally hyaline.

Geographical distribution: Pakisthan, India, Bengladesh, Thailand, Myanmar and Malaysia (Talwar and Jhingran, 1991)

Distribution in Kerala: Fairly common in Kerala (Shaji and Easa, 2001).

Habitat: middle streams with sandy and muddy substratum.

Fishing methods: gill nets and cast nets.

Family: Nandidae

Body deep, oblong and strongly compressed. Head covered with scales. A single dorsal fin, long and with spinous and soft parts. Height of soft part greater than spinous part. Lateral line interrupted. Caudal peduncle deep, caudal fin rounded. Members of this family show high salinity tolerance where some of members are also inhabit in brackish waters.

Key to subfamilies

1. a) Mouth very large and highly protractile............................*Nandinae*

   b) Mouth relatively small and only slightly producible.....*Pristolepidinae*

Sub family: Nandinae

Genus ***Nandus*** Valenciennes

Nandus Valenciennes, In: Cuvier and Valenciennes, *Hist. Nat. Poiss.*, 7, p. 481, 1831 (Type, *Nandus marmoratus* Cuvier)

Nandus nandus (Hamilton-Buchanan)
(Plate XIV, Fig. 129)

Coius nandus Hamilton-Buchanan, *Fish. Ganges*, pp.96, 370, pl. 30, fig. 32, 1822 (Type locality: Gnangetic provinces)
Nandus marmoratus Valenciennes, *Hist. Nat. Poiss.*, 7:482, pl. 207, 1831
Bengula hamiltonii Gray, *Ill. Ind. Zool.*, 2: pl.88, fig. 3, 1834

Common name: Mottled Nandus **Local name:** Muthukkila

Distinguishing characters: (Based on 12 specimens, 67-103 mm TL)

D. XIII-XIV, 11-12; P. i, 13-14; V.i, 5; A.III, 7-8; C.14; Ll. 41-46, Ltr. 5-5.5/12-13

Body fairly deep, oblong and compressed. Head large, snout pointed and conical, mouth large, lower jaw strong and longer and maxilla reaching to hind border of eye. BD 36.29-38.00 (37.22) and HL 31.65-41.21 (37.89) in SL. Eyes 18.50-24.12 (21.14) in HL. HD 32.29 - 44.82 (37.75) in HL. Pectoral fins broadly rounded. HP 45.08-56.53 (49.80) in HL and 126.12-147.99 (132.96) in HD. HV 99.62-105.20 (102.02) in HP. LCPD 10.77-13.81 (13.35) in SL. HCPD 85.61-124.32 (107.11) in LCPD. Caudal rounded, HC 20.53-27.20 (23.98) in SL. Body with ctenoid scales. PDS 12-14. Greenish brown with brassy reflections. Three irregular, brown bands across body. A dusky blotch on caudal base which often appear as a band. Fins greenish brown with soft parts of dorsal, anal and caudal fins mottled with numerous dark spots. Some dark narrow bands radiate from eyes which also found on spinous dorsal fin.

Geographical distribution: Pakstan: Indus plain; India, Nepal, Bengladesh, Burma and Thailand (Talwar and Jhingran, 1991)

Distribution in Kerala: All major rivers and associated wet lands, except seven rivers such as Manjeswaram, Uppala, Shiriya, Mogral, Ayroor, Ithikkara and Mamom (Ajithkumar *et al.*, 2000), Achenkoil, Pamba, Manimala and Chaliyar river systems (Kurup *et al.*, 2004) .

Habitat: Pool-run habitats with sandy or muddy substratum.

Fishing methods: Gill nets.

Sub family: Pristolepidinae

Genus ***Pristolepis*** Jerdon

Pristolepis Jerdon, *Madras J. Lit. Sci.*, 15, p. 141, 1849 (Type, *Pristilepis marginatus* Jerdon)

Pristolepis marginata Jerdon
(Plate XIV, Fig. 130)

Pristolepis marginatus Jerdon, *Madras J. Lit. Sci.*, 15: 141, 1848 (Type locality: Manantoddy river)
Catopra malabarica Gunther, *Ann. Mag. Nat. Hist.*, p.375, 1864 (Type locality: Hill regions of Travancore, Kerala)
Nandus malabaricus Day, *Fish. Malabar*, p. 130, pl. 8, 1865
Pristolepis malabarica Day, *Fish. India*, p. 131, pl. 32, 1889

Common name: Malabar Catopra **Local name:** Andivalli, Chemballi

Distinguishing characters: (Based on 10 specimens, 58-124 mm TL)

D. XV, 12; P.i,11; V.i,5; A.III, 8; C.14; Ll. 30-31, Ltr.4.5/10

Body fairely deep, oblong and compressed. BD 44.43-46.29 (45.28) and HL 38.71-40.71 (39.23) in SL. Snout slightly pointing or blunt. Mouth small to moderate, Maxilla ends before anterior border of eye. Eyes moderate to large, 26.02-31.42 (29.78) in HL. HD 38.54-88.43 (55.7) in HL. DB 181.19-418.7(318.54) in HD. HP 89.2-210.08 (155.78) in HD. HV 40.24-85.75 (73.07) in HP. LCPD 6.55-8.68 (7.68) in SL. HCPD 193.32-274.55 (230.44) in LCPD. Caudal rounded, HC 32.58-34.79 (33.28) in SL. Scales cycloid. PDS 9. Greenish body with brown reflections. Fins red orange or greenish orange. Membranes between dorsal and anal spines blackish.

Geographical distribution: India: Western Ghats of Kerala (Jayaram, 1999)

Distribution in Kerala: Recorded from 10 rivers of Kerala (Ajithkumar *et al.*, 2000), All rivers of Kerala (Shaji and Easa, 2001), 13 rivers of Kerala (Kurup *et al.*, 2004) .

Habitat: Pool-run or pool-riffle habitats with sandy or muddy substratum.

Fishing methods: gill nets or cast nets.

Family: Cichilidae

Body deep and compressed. Abdomen more or less round. Mouth terminal, eyes moderate to large, placed in middle of head. A single nostril on each side of head. Dorsal fin single, long, inserted above base of pectoral fin, with a spinous and soft parts, spinous portion longer than soft one. Spines on dorsal fin usually more than ten. Anal fin also with spinous and soft parts. Lateral line abrupt and interrupted. Caudal truncate or lunate. Scales may be cycloid or weakly ctenoid.

Key to Genera

1. a) Anal fin with 3-4 spines........... .... *Oreochromis*

   b) Anal fin with 12-16 spines.. *Etroplus*

Genus *Oreochromis* Gunther

Oreochromis Gunther, *Ann. Mag. Nat. Hist.*, (6), 4, p. 70, 1889 (Type, *Oreochromis hunteri* Gunther)

Oreochromis mossambica (Peters)
(Plate XV, Fig. 131)

Chromis (Tilapia) *mossambicus* Peters, *Montab. Akad. Wiss., Berlin*: 681,1852 (Type locality: Mozambique)
Tilapia mossambica Jones and Sarojini, *J. Bombay nat. Hist. Soc.*, 50 (3), 1952
Oreochromis mossambica Trewavas, *Tilapiine fishes*: 292, 1983

Common name: Tilapia **Local name:** Philoppy, Tilappia

Distinguishing characters: (Based on 16 specimens, 102-165 mm TL)

D. XV-XVI, 10-12; P.14-15; V.i, 5; A.iii, 10-11; C.19; Ll.30-32, Ltr.4.5-5.5/16.5

Elongate, deep and compressed body, BD 40.59-47.40 (44.00) and HL 41.02-45.13 (43.07) in SL. Head with a slight concavity on upper profile. Snout conical, mouth terminal and large. Eyes 17.59-20.60 (19.09) in HL. Dorsal fin has its soft portion with a filamentous tip. HD 33.43-39.68 (36.55) in HL. DB 334.54-370.31 (352.42) in HD. HP 111.28-229.52 (170.40) in HD. HV 90.8-148.88 (119.84) in HP. LCPD 12.07-15.74 (13.91) in SL. HCPD 100.36-118.36 (109.53) in LCPD Caudal truncate, HC 30.37-31.47 (30.92) in SL. Body with cycloid scales. Lateral line incomplete. In females and non breeding males, body grayish with 3-4 botches along flanks. Body of males during breeding season become deep black. Dorsal fin black with red margin, pectoral fins translucent red, caudal fin with red margin.

Geographical distribution: East Africa. Introduced to India, Pakistan and Sri Lanka etc. (Talwar and Jhingran, 1991)

Distribution in Kerala: Throughout Kerala (Ajithkumar *et al.*, 2000; Shaji and Easa, 2001), Upstream of Chalakkudy, Pambar, Kallada and Bharathapuzha river systems and low land areas of almost all river systems (Kurup *et al.*, 2004).

Habitat: It is found rarely in cascade, rapids and riffles of upstream but common in run and pool habitats of low-lying plains.

Fishing method: Gill nets and cast nets.

Genus ***Etroplus*** Cuvier

Etroplus Cuvier, In: Cuvier and Valenciennes. *Hist. Nat. Poiss.*, 5, p. 486, 1830 (Type, *Etroplus meleagris* Cuvier)

Body deep, highly compressed, snout spout like, mouth terminal and small. Members of this genus have their anal fin with 12-16 spines, caudal fin lunate or emarginate, scales weakly ctenoid. Inhabits brackish and freshwaters. Body covered with pearly or deep golden spots.

Key to species

1. a) Body with three round black blotches................*Etroplus maculatus*

   b) Body deep bluish, with oblique bands...............*Etroplus suratensis*

Etroplus maculatus (Bloch)
(Plate XV, Fig. 132)

Chaetodon maculatus Bloch, *Syst. Ichth., pl.* 427, fig. 2, 1785 (Type locality not given)
Glyphisodon kakaitsel Lacepede, *Hist. Nat. Poiss.*, 4: 235, 1803
Etroplus corutchi Cuvier, *Hist. Nat. Poiss.*, 5: 491, 1828
Glyphisodon koruschi Cuvier, *Hist. Nat. Poiss.*, p. 5, pl. 136, 1828

Common name: Orange chromid **Local name:** Pallathi, Choottachi

Distinguishing characters: (Based on 22 specimens, 68-82 mm TL)

D. XVIII-XIX, 9; P. ii, 10-11; V. I, 5; A. XII-XIII, 7-9; C.15; Ll.41, Ltr. 5.5/16.5

Both profiles equally and prominently arched, body disc like, deep and strongly compressed. BD 50.39-59.24 (55.52) and HL 41.46-49.8 (45.10) in SL. Head moderate to small, Eyes 22.30-24.03 (23.15) in HL. HD 33.43-39.68 (36.55) in HL. DB 407.49-528.74 (472.85) in HD. HP 216.63-249.29 (226.69) in HD. HV 63.24-72.07 (69.38) in HP. LCPD 6.89-8.04 (7.05) in SL. HCPD 194.52-235.29 (217.76) in LCPD. Caudal lunate, HC 28.97-35.69 (31.41) in SL. Ground colour may be yellowish orange or grayish green with several horizontal lines of golden spots. Three large round black blotches on flanks, middle one darkest. Anal fin with a black boarder and dorsal with rows of black spots.

Geographical distribution: India: Tamil Nadu, Kerala and South Karnataka; Sri Lanka (Talwar and Jhingran, 1991)

Distribution in Kerala: Throughout all rivers (Ajithkumar *et al.*, 2000; Shaji and Easa, 2001), Bharathapuzha, Kabbini, Achenkoil, Pamba, Meenachil and Kallada river systems (Kurup *et al.*, 2004).

Habitat: Riffle-pools and pool-run habitats of middle stream and downstream plains.

Fishing method: Cast nets and Gill nets.

Etroplus suratensis (Bloch)

(Plate XV, Fig. 133)

Chaetodon suratensis Bloch, *Syst. Ichth.*, *pl.* 217, fig. 3, 1785 (Type locality: Surat, Gujarat)
Chaetodon caris Hamilton, *Fish. Ganges*, pp. 125, 372, 1822
Etroplus meleagris Cuvier, *Hist. Nat. Poiss.*, 5: 486, 1853

Common name: Banded pearl spot **Local name:** Karimeen

Distinguishing characters: (Based on 12 specimens, 11-19 mm TL)

D. XVIII-XIX, 9; P. ii, 10-11; V.I, 5; A.XII-XIII, 7-9; C.15; Ll. 41, Ltr. 5.5/16.5

Ovate, deep and strongly compressed body. BD 53.54-58.7 (55.76) and HL 32.92-39.18 (35.62) in SL. Mouth small, terminal. Eyes 23.8 - 30.07 (26.71) in HL. HD 29.56-42.26 (36.41) in HL. DB 479.76-565.06 (519.14) in HD. HP 196.11-246.47 (213.01) in HD. HV 72.55-82.48 (78.07) in HP. LCPD 7.09-8.14 (7.80) in SL.HCPD 179.78-216.76 (198.88) in LCPD Caudal fin emarginate, HC 23.7-27.56 (25.16) in SL. Bluish green body with six to seven oblique vertical bands. Most of scales above lateral line have central white pearly spot. Some irregular black spots on abdomen. Fins generally dirty green. Pectoral fins with a deep blue blotch at its base.

Geographical distribution: India: Orissa, Andhra Pradesh, Tamilnadu, Kerala and Sri Lanka (Talwar and Jhingran, 1991)

Distribution in Kerala: Recorded from 29 rivers of Kerala (Ajithkumar *et al.*, 2000) Common in fresh and brackish waters of Kerala (Shaji and Easa, 2001), Chalakkudy and Bharathapuzha river systems (Kurup *et al.*, 2004).

Habitat: pool-run habitats at low land areas of river systems and reservoirs.

Fishing method: Gill nets and Cast nets

Family: Blennidae

Genus *Salarias* Beaufort and Chapman

Salarias Beaufort and Chapman, *Fish Indo-austral Archipel.* Vol. 9, pp. 484, 1951 (Type, *Salarias marmoratus*)

Salarias reticulates Kurup and Radhakrishnan

(Plate XV, Fig. 134)

Salarias reticulates Kurup, Manojkumar and Radhakrishnan, *J. Bombay nat. Hist. Soc.*, 102 (2), 195-197, 2006 (Type locality: Vettilappara, Chalakkudy river system, Kerala)

Holotype:-Deposited in ZSI Chennai, (Regn.No: awaited). 100.71 mm SL, Vettilappara, Chalakudy river, Kerala, India, 26.01.2001.

Paratype:-None

Diagnosis: Elongated, body with irregular reticulations and circular interspaces, oblong mouth, strong pectoral girdles and leathery skin. Ventrals jugular having two flexible spines. A moderately long fringed supraorbital cirrus and a simple cirri at nape and another short one at posterior rim of nostril, with 6 filaments at its base. No crest on head and pre-opercle has a posterior projection.

Distinguishing charecters: (based on a single specimen with 103.62 mm TL.)

D.XII, 15;P.14; V.2; A.18; C.12.

Body cylindrical. Ventral profile of body slightly convex than dorsal. Head globular, HL 48.4 and BD 49.2 in SL. Eyes high up with diameter 52.31 in HL and 20.61 in SL. Diameter of eye less than SNL (99.23) and HL (52.09). Wdth of snout little higher than post- orbital length (106.23). Head depth 98.35 in HL. A single row of incisor- like movable teeth on each jaw and a strong posterior canine on each side of lower jaw. Gill openings continuous from one side of head to other across ventral surface of head. Branchiostegal rays six. Dorsal fin deeply notched, first lower than second, which is nearly half of body height, while posteriorly it does not extend to caudal fin. HD 62.13 in SL, HP 38.36 in SL 97.23 and in HL. HV 60.06 in SL. Origin of anal fin opposite to origin of second dorsal fin. Caudal fin with middle rays posteriorly branched. Lateral line complete, forming an angle beyond 8^{th} dorsal spine. Scales totally absent. Head blackish, body and fins, except ventral, reticulated with brown lines enclosing circular or irregularly formed spaces. Reticulation more prominent on lateral and ventral sides. Ventral side from snout tip to origin of anal fin whitish without any prominent markings. Ventral fin hyaline with blackish tinge.

Geographical Distribution: India: Vettilappara, Chalakudy river, Kerala

Etymology: The species name is derived from its reticulated colour pattern.

Habitat: Small riffles with pebbles and cobbles as substratum.

Fishing method: Cast nets

Sub order: Gobioidei

Key to Families

1. a) Pelvic fins separate and not forming an adhesive disc .... *Eleotrididae*

   b) Pelvic fins united, usually forming an adhesive disc........... *Gobiidae*

Family: Eleotrididae

Genus: ***Eleotris*** Bloch & Schneider

Eleotris Bloch & Schneider, *Syst. Ichth.*, p. 85, 1801 (Type, *Gobius pisonis* Gmelin)

Eleotris fusca (Schneider)
(Plate XV, Fig. 135)

Poecilia fusca Schneider, *Syst. Ichth.*: 453, 1801 (Type locality: Pacific islands)
Eleotris cavifrons Blyth: Day, 1876, *Fishes of India*: 313, pl. 65, fig. 7; Day, 1889

Common name: Dusky sleeper **Local name:** Poozhon

Distinguishing characters: (Based on 2 specimen, 132-156 mm TL)

D_1 vi, D_2 I, 8-9 ; P.15-18; V.i, 5; A.i, 8; C.19; Ll. 60-68

Body elongate, anteriorly cylindrical and compressed slightly posteriorly. Head oblong, slightly depressed and scaled above from between eyes and partly on sides. BD 21.30-24.60 (23.50) and HL 31.26-34.62 (33.56) in SL. Snout blunt, mouth obliquely directed upwards, lips thick, cleft extending up to anterior 1/3 of eyes. Gill openings restricted to pectoral fin bases and gill membranes united with isthmus. Eyes small, 12.35-15.96 (14.36) in HL. Dorsal fin separate, HD 42.36-47.85 (46.53) in HL. HP 131.06-139.25 (133.00) in HD, HV 71.28-74.56 (73.23) in HP. LCPD 29.56-32.35 (30.58) in SL. Scales ctenoid. HCPD 46.26-52.36 (49.04) in LCPD. Caudal lanceolate, HC 31.24 – 36.24 (32.67) in SL. Head, body and fins dark brown to black, numerous horizontal dark lines on body.

Geographical distribution: Indo-West Pacific (Talwar and Jhingran, 1991)

Distribution in Kerala: Chalakkudy river system (Kurup *et al.*, 2004).

Habitat: Lowland areas of rivers with sand or mud as substratum.

Fishing method: Gill nets.

Family: Gobiidae

Body elongate, anteriorly cylindrical and posteriorly compressed. Head oblong, eyes dorso lateral, lips thick. Two dorsal fins present. Pelvic fins united to form an adhesive disc. Anal fin moderately elongate, caudal round. Scales ctenoid, lateral line absent.

Key to subfamilies

1. a) Eyes placed dorsally, interorbital distance greater than six times and body depth 1.75 times in head length, pelvic fin disc longer than broad ....*Gobiinae*

   b) Eyes placed laterally, interorbital distance less than 2.5 times and body depth 1.3 times in head length, pelvic fin disc broader than long ....*Sicydiaphiinae*

Sub family: Gobiinae

Key to genera

1. a) Shoulder girdle under opercula with one to three finger like projections, head oblong..*Awaous*

   b) Shoulder girdle without such finger like projections, head depressed...*Glossogobius*

Genus: ***Glossogobius*** Gill

Glossogobius Gill, *Proc. Acad. Nat. Sc. Philad.*, p. 46,1859 (Type, *Gobius platycephalus* Richardson)

Glossogobius giuris (Hamilton-Buchanan)
(Plate XV, Fig. 136)

Gobius giuris Hamilton-Buchanan, *Fish. Ganges*, pp. 51, 366, pl. 33, 1822 (Type locality: Gangetic provinces)
Gobius unicolour Gunther, *Cat. Fish. Brit. Mus.*, 3:23, 1861
Gobius spectabilis Gunther, *Cat. Fish. Brit. Mus.*, 3:45, 1861
Gobius gutum Hamilton-Buchanan, *Fish. Ganges*, pp. 50, 366, 1822 (Lower part of Padma river)

Common name: Tank goby **Local name:** Poozhan, Poolon

Distinguishing characters: (Based on 16 specimens, 132-156 mmTL)

D. vi + i , 8-9; P.i,16-21; A.i,8; C.17

Body elongate, anteriorly cylindrical and posteriorly compressed. Head depressed and scaled behind eyes, other parts of head naked. BD 14.73 - 22.54 (17.49) and HL 33.18-34.36 (33.64) in SL. Gill openings extend from rear end of preopercle to below eyes, gill membranes united with each other and also with isthmas. Snout elongate and straight, lower jaw prominent, mouth terminal or slightly upturned. Eyes 15.27-15.95 (15.06) in HL. Dorsal fin separate, HD 47.32-58.12 (52.12) in HL. DB 64.45-110.34 (84.33) in HD. Pectoral fins larger, HP 116.36-149.38 (130.4) in HD. Pelvic fins form a disc and HV 81.24 - 92.30 (86.32) in HP. LCPD 9.27-15.02 (10.72) in SL. Scales ctenoid. HCPD 74.74 -125.75 (101.30) in LCPD. Caudal lanceolate, HC 25.54-30.26 (27.10) in SL. Body yellowish brown with several patches of blotches on flanks. Sides of head with irregular violet spots. Dorsal, Pectoral and caudal fins mottled with dark spots.

Geographical distribution: Indo-West Pacific (Talwar and Jhingran, 1991)

Distribution in Kerala: 11 rivers of Kerala (Shaji and Easa, 2001). Throughout Kerala in all major rivers (Ajithkumar *et al.*, 2000), Chalakkudy and Bharathapuzha river systems (Kurup *et al.*, 2004).

Habitat: Pool-run and sheet type habitats with sandy bottom at downstreams of rivers.

Fishing method: Cast nets

Genus: *Awaous* Valenciennes

Awaous Valenciennes, In: Cuvier and Valenciennes, *Hist. Nat. Poiss.*, 12, p. 97, 1837 (Tye, *Gobius ocellaris* Broussonet)

Awaous gutum (Hamilton-Buchanan)
(Plate XV, Fig. 137)

Gobius giuris Hamilton-Buchanan, Fishes of Ganges: 50, 366, 1822 (Type locality: Padma river)
Gobius striatus Day, *Fauna Brit. India, Fishes*, 2: 262, 1876

Common name: Tank goby **Local name:** Poozhan, Poolon

Distinguishing characters: (Based on 16 specimens, 132-156 mm TL)

D. vi + i, 10; P.15-17; A.i, 10-11; C.17

Body elongate, anteriorly cylindrical and posteriorly compressed. Head more or less oblong and scaled behind eyes, other parts of head naked. BD 22.31-26.54 (25.21) and HL 31.26-36.54 (34.18) in SL. Gill openings extend from rear end of pre opercle to below eyes and gill membranes united with each other and also with isthmus. Snout curved downwards, mouth terminal or even slightly subterminal. Eyes 14.25-16.54 (15.13) in HL. Dorsal fin separate, HD 45.23-47.26 (46.75) in HL. HP 132.54 -136.48 (134.12) in HD. Pelvic fins form a disc. HV 81.24-86.54 (84.91) in HP. LCPD 9.24-11.24 (10.92) in SL. Scales ctenoid. HCPD 101.25-104.58 (103.79) in LCPD. Caudal rounded or lanceolate, HC 22.68-28.54 (27.39) in SL. Body olive green or yellowish, head and body with scattered brownish spots. Pectoral fins yellowish or greenish brown. Other fins mottled with rows of brownish spots.

Geographical distribution: India and Bengladesh (Talwar and Jhingran, 1991)

Distribution in Kerala: rivers of Kerala (Shaji and Easa, 2001) In all major rivers (Ajithkumar *et al.*, 2000), Achenkoil and chalakkudy river systems (Kurup *et al.*, 2004).

Habitat: Sheet type habitats with sandy bottom at downstreams.

Fishing method: Cast nets

Sub family: Sicydiaphiinae

The subfamily is represented by a single genus, *Sicyopterus* and a single species, *Sicyopterus griseus* (Day)

Genus *Sicyopterus* Gill

Sicyopterus Gill, *Proc. Acad. Nat. Sci. Philad.*, p. 101, 1860 (Type, *Sicyoperus simpsoni* Gill)

Sicyopterus griseus (Day)
(Plate XV, Fig. 138)

Sicydium griseum Day, *Linn. Soc. Lond.*, 13: 140, 1878 (Type locality: South canara and Travancore)
Sicyopterus griseus Koumans, *Mem. Indian Mus.*, 13 (3): 296, 1941

Common name: Clown goby **Local name:** Manal poozhon

Distinguishing characters: (Based on 10 specimens, 64-111 mm TL)

D I, vi ; D_2 I, 10; P. I, 6

Body elongate, anteriorly cylindrical and slightly compressed posteriorly. Head flat above and snout round. Scales behind eyes, other parts of head naked. BD 14.23-16.25 (15.48) and HL 34.32-38.96 (37.76) in SL. Gill membranes united with each other and also with isthmus. Isthmus broad. Mouth slightly sub terminal, lips thick and lower margin of upper lip with short papillae. Eyes slightly bulging,10.26-12.54 (11.81) in HL. Dorsal fin separate, first few spines of dorsal fin filiform, HD 62.53-66.32 (65.79) in HL. DB 194.26-202.03 (200.98) in HD. HP 81.24-84.52 (83.73) in HD. Pelvic fin disc closely attached to belly, HV 61.29-64.58 (63.69) in HP. LCPD 11.28-13.54 (12.74) in SL. Scales cycloid. HCPD 84.52-90.24 (88.56) in LCPD. Caudal rounded, HC 22.35-26.34 (25.26) in SL. Brownish body with eight to nine dark brown bands encircle body which is wider than interspaces. Fins dark brown with pale edges.

Geographical distribution: India and Bengladesh (Talwar and Jhingran, 1991)

Distribution in Kerala: 7 rivers of Kerala (Shaji and Easa, 2001) Throughout Kerala in all major rivers (Ajithkumar *et al.*, 2000), Periyar, Chaliyar and Valapatnam river systems (Kurup *et al.*, 2004).

Habitat: Sheet or run type of habitats with sandy bottom at downstreams.

Fishing method: Cast nets

Family: Anabantidae

Genus ***Anabus*** Cuvier

Anabus Cuvier, *Le Regne Animal.*, 2, p. 339, 1816 (Type, *Perca scandens* Daldorf)

Anabas testudineus (Bloch)
(Plate XV, Fig. 139)

Anthias testudineus Bloch, *Nat. Aus. Fish.*, 7: 121, pl. 322, 1795 (Type locality: mentioned Japan. Menon (1999) opined that this species does not occur in Japan)
Anabas scandens Daldorff, *Trans. Linn Soc., Lond.*, 3:62, 1797 (Tranquebar)
Amphirion testudineus Schneider, *Syst. Ichth.*, p. 204, 1801
Lutianus scandens Lacepede, *Hist. Nat. Poiss.*, 4: 239, 1803

Common name: Clmbing perch **Local name:** Karuvappu, Kallurutty

Distinguishing characters: (Based on 20 specimens, 74-147 mmTL)

D. XVII, 10; P.i, 15; V.i,5; A.XI, 10; C.17; Ll. 29-30, Ltr. 3/10

Body elongate, oblong and posteriorly compressed. Suprabranchial organ (labarynth) present. Head broad, covered with scales. Operculum serrated, two spines well developed, mouth moderate and terminal. BD 35.59-44.85 (39.79) and HL 33.15-41.32 (37.72) in SL. BD 93.28-114.75 (105.63) in HL. Eyes moderate, placed laterally and anteriorly, 18.87-22.05 (22.59) in HL. INTO 29.52-34.40 (31.10) in HL. Barbells absent. Gill membranes broadly united. Dorsal fin elongated with spinous and soft parts. HD 26.42-41.90 (36.44) in HL. Pectoral fins broadly rounded. HP 56.32-79.91 (64.42) in HL.

HV 69.57-93.49 (79.34) in HP. Anal fin long with spiny and soft parts. LCPD 9.51-13.22 (11.50) in SL. HCPD 109.22- 165.95(128.11) in LCPD. Caudal rounded, HC 21.43-29.66 (25.99) in SL. Body with ctenoid scales. PDS 4-5. Dark greenish on dorsal and flanks, pale yellow on ventral side. Faint vertical bands on flanks. A distinct dark spot at base of caudal fin. Fins generally dark green with black edges. Pectoral fins greenish yellow

Geographical distribution: Pakistan, India, Bengladesh, Sri Lanka, Burma, Malay archipelago, Singapore and Philippines (Talwar and Jhingran, 1991)

Distribution in Kerala: Throughout all rivers of Kerala except nine rivers (Ajithkumar *et al.*, 2000), Achenkoil and Chalakkudy river systems (Kurup *et al.*, 2004).

Habitat: Pool-run habitats with sandy or muddy substratum.

Fishing methods: gill nets.

Family: Belontidae

Genus *Macropodus* Lacepede

Macropodus Lacepede, *Hist.Nat.Poiss.*,7, 357, 1831 (Type, *Macropodus cupanus* Valencinnes)

Macropodus cupanus (Valenciennes)
(Plate XV, Fig. 140)

Polycanthus cupanus: Valenciennes, *Hist.nat. Poiss.*, 7:357, 1831(Type locality: Ariancoupan river at Pondicherry)
Polycanthus cupanus dayi Kohler, Bl. Aquarienkunde, Stuttgart, 20: 517, 1909 (Type locality: India)

Common name: Spike tailed paradise fish **Local name:** Karimkana

Distinguishing characters: (Based on 10 specimens, 24-32 mm TL)

D. XVII-XX, 7; P. i, 10; V.i,5; A.XVI,11-13; C.12; Ll.31-32, Ltr.3.5-4/6.5-7

Body small, oblong and compressed. Suprabranchial organ present. Mouth small, slightly protrusible, snout blunt. BD 31.56-31.36 (31.46) and HL 31.75-34.77 (33.26) in SL. Eyes 20.62-21.44 (21.03) in HL. Lower margin of preopercle serrated. Dorsal fin elongated, placed above anal fin. HD 26.85-98.15 (62.50) in HL. HP 52.71-75.69 (64.20) in HL. First ray of pelvic fin produced in to a filament. HV 82.13-110.9 (96.55) in HP. Anal fin long. Caudal lanceolate, HC 40.06-46.64 (43.23) in SL. Dark olive green, darker on back, brown spots on head, brown stripe from eye to corner of opercula, A dusky blotch on caudal peduncle. Fins pale green, soft dorsal and caudal fin with rows of spots.

Geographical distribution: India, Sri Lanka, Burma, Malay Peninsula and Sumatra (Talwar and Jhingran, 1991)

Distribution in Kerala: Throughout all rivers at low land areas (Ajithkumar *et al.*, 2000, Shaji and Easa, 2001), Valapatnam (Kurup *et al.*, 2004).

Habitat: Pool-run habitats with sandy or muddy substratum at low land areas, ditches, canals etc.

Fishing methods: Scoop nets

Family: Channidae

Body elongate, cylindrical, anteriorly and laterally compressed posteriorly. Head large, gape wide and cleft extend beyond eyes. Lower jaw slightly protruding beyond upper. Eyes moderate, anterior and dorso-lateral in position. Dorsal side of head more or less flat and have plate like scales which are larger than that of body. Snout conical and tip blunt. Gill membranes united with each other beneath isthmas. A suprabranchial organ present. Single, elongate dorsal and anal fins present. Caudal fin round. Scales cycloid and moderate. Lateral line complete.

Genus ***Channa*** Scopoli

Channa Scopoli, *Introd. Hist. Nat.*, p. 459, 1777 (Type, *Channa orientalis* Bloch and Schneider)

Key to species

1. a) 4-5 rows of scales between orbit and angle of preopercle, pre dorsal scales 12-13..*Channa orientalis*

   b) 8-17 rows of scales between orbit and angle of pre opercle, pre dorsal scales 15-22...2

2. a) 16-17 scales between orbit and angle of pre opercles, body bluish gray marked with numerous dark spots scattered.....*Channa micropeltes*

   b) 8-10 rows of scales between orbit and angle of pre opercle.............3

3. a) Several dark white striations/bands on body and fins ....*Channa striatus*

   b) No striation on body and fins, body marked with 5-6 dark blotches along flanks, a distinct ocellus at upper angle of caudal fin base ....*Channa marulius*

Channa orientalis Bloch & Schneider
(Plate XVI, Fig. 141)

Channa orientalis Bloch & Schneider, *Syst. Ichth.*: 496, pl.90, fig.2, 1801 (Type locality: India)
Ophiocephalus gachua Hamilton-Buchanan, *Fishes of Ganges*: 68, 367, 1822
Ophiocephalus Harcourt-butleri Annandale *Rec. Indian Mus.*, 14(1): 54 (Burma)
Channa burmanica Chaudhuri, *Rec. Indian Mus.*, 16(4): 284,1919 (Burma)

Common name: Asiatic snakehead **Local name:** Vatton

Distinguishing characters: (Based on 6 specimens, 80-160 mm TL)

D. I, 33; P.i, 13; V.i, 5; A.i, 20-21; C.12; Ll. 42-44, Ltr. 4/8

Elongate, BD 17.24-17.88 (17.61) and HL 30.75-34.40 (33.07) in SL. BD 51.96-56.07 (53.34) in HL. Eyes moderate, more anterior in position, 12.53-16.53 (14.68) in HL. HD 27.6-32.73 (30.70) in HL. HP 176.03-218.52 (197.42) in HD. Pelvic fins less than half length of pectoral fins, HV 40.52-52.84 (47.22) in HP. Most of scales on head are larger and that on body moderate. PDS 12-13. Dark brownish green, ventrally pale yellowish brown. Pectoral fins with a series of distinct alternating brown and pale orange vertical bands. Other fins dark brownish.

Geographical distributin: Afganistan, Iran, Pakistan, India, Nepal, SriLanka, Bengladesh, Burma and East Indies

Distribution in Kerala: Throughout Kerala (Easa *et al.*, 1996; Shaji and Easa, 2001), 17 rivers of Kerala (Ajithkumar *et al.,* 2000), Kadalundi and Chaliyar river systems (Kurup *et al.*, 2004).

Habitat: Small pools and shallow water logged areas with lot of leaf litters.

Fishing methods: Gillnets, Cast nets.

Channa micropeltes (Cuvier)
(Plate XVI, Fig. 142)

Ophiocephalus micropeltes Cuvier, *Hist.nat. poiss.*, 7:427, 1831 (Type locality: Java)

Common name: Malabar Snake head **Local name:** Vakavaral

Distinguishing characters: (Based on 12 specimens, 182- 424 mmTL)

D. 40-41 P.i-ii, 16; V.i, 5; A.27; C.14; Ll.93-97, Ltr. 6.5-7.5/16.5-18.5

Elongate, BD 15.37-18.23 (16.54) and HL 28.12-30.48 (29.48) in SL. BD 53.92-64.52 (56.82) in HL. Eyes moderate, 18.55-21.78 (19.52) in HL. HD 29.86-32.56 (27.83) in HL. HP 176.03-218.56 (188.63) in HD. Pelvic fins more than half-length of pectoral fins, HV 71.52-85.81 (78.26) in HP. Scales on body are smaller. PDS 24. Colour varies in young and adults. Adults bluish gray with numerous blackish brown spots scattered on all over. Fins grayish. In younger specimens, back and dorsal side of head light brownish, flanks and ventral side yellowish white. Two scarlet bands, one through eye to upper half of caudal fin and another from angle of mouth to lower half caudal fin.

Geographical distributin: India, Burma, Thailand, Malay Peninsula, Sumatra and Java (Jayaram, 1999)

Distribution in Kerala: Pamba (Kurup, 1990), Kallada river system (Kurup *et al.*, 2004)

Habitat: Pool-run habitats of rivers at middle streches and deep pools with sandy or muddy substratum

Fishing method: Gill nets.

Channa marulius (Hamilton-Buchanan)
(Plate XVI, Fig. 143)

Ophiocephalus marulius Hamilton-Buchanan, *Fish. Ganges*, pp.65, 367, pl.17, fig. 9, 1822 (Type locality: river Ganges)
Ophicephalus grandinosus Cuvier, *Hist. nat. Poiss.*, 7: 43, pl. 203, 1831
Ophicephlus leucopunctatus Sykes Day, *Trans. Zool. Soc. Lond.*, 2:352, pl. 60, 1876
Ophiocephalus pseudomarulius Day, *Fishes of India*: 374; 1889

Common name: Giant snake head **Local name:** Cherumeen

Distinguishing characters: (Based on 3 specimens, 241- 412 mm TL)

D. 38-42; P.i, 14-15; V.i, 5; A.21-22; C.14; 51-52, Ltr. 4.5/8

Elongate, BD16.21-19.23 (17.10) and HL 28.12-30.45 (29.87) in SL. BD 57.26-59.02 (57.54) in HL. Eyes 17.25-21.24 (19.56) in HL. HP 172.32-191.23 (189.23) in HD. Pelvic fins more than half-length of pectoral fins, HV 71.26-80.26 (79.21) in HP. Body greenish with 5-6 prominent dark spots above lateral line, surrounded by red and white rings. Distinct white spots scattered on body. White spots on dorsal and anal fins also, more distinct towards their distal ends. A distinct pale edged ocellus at base of caudal fin, towards upper side.

Geographical distribution: Pakistan, India, Sri Lanka, Bengladesh, Nepal, Burma, Thailand and China (Jayaram, 1999)

Distribution in Kerala: 23 rivers of Kerala (Ajithkumar *et al.*, 2000), low lands and rivers (Shaji and Easa, 2001), Pamba, Kallada and Achenkoil river systems (Kurup *et al.*, 2004).

Habitat: Pools and riffle pools with sandy bottom

Fishing method: Gill nets.

Channa striatus (Bloch)
(Plate XVI, Fig. 144)

Ophiocephalus striatus Bloch, *Natur. Aus. Fische*, 2: 141, pl. 359, 1791(Type locality: Malabar)
Ophiocephalus chena Hamilton-Buchanan, *Fish. Ganges*, p. 62, 1822 (Assam)
Ophiocephalus planiceps Cuvier, *Hist. Nat. Poiss.*, 7: 424, 1831(Java)
Ophiocephalus sowarah Bleeker, *Nat. Gen. Arch. Ned. Ind.*, 2(3): 519, 1845

Common name: Striped or banded snakehead **Local name:** Varal, Kaichal

Distinguishing characters: (Based on 8 specimens, 192-271 mm TL)

D. 38-42; P.i, 14-15; V.i, 5; A.21-22; C.14; 51-52, Ltr. 4.5/8

Elongate, BD 17.60-19.36 (18.20) and HL 31.26-35.25 (33.15) in SL. BD 52.13-56.98 (54.90) in HL. Eyes 10.26-12.48 (11.91) in HL. HP 192.56-199.36 (197.20) in HD. Pelvic fins more than half-length of pectoral fins, HV 62.39-66.95 (64.54) in HP. Adults greenish brown on back with several dark oblique striations, flanks lighter and below lateral line marked with several oblique and whitish striations, which even extend to ventral side. Belly more or less pure white or yellowish white. Anal and dorsal fins are also distinctively marked with whitish striations. Narrow concentric striations are also seen on caudal fin. A dark brown band runs obliquely upwards from snout to edge of gill cover.

Geographical distribution: Pakistan, India, SriLanka, Bengladesh, Nepal, Burma, Malay archipelago, Thailand and south China (Jayaram, 1999)

Distribution in Kerala: Common in rivers, paddy fields and Kole wet lands of the state (Easa and Shaji, 1996; Kurup *et al.*, 2004), 15 rivers of Kerala (Ajithkumar *et al.,* 2000), Chalakkudy, Achenkoil, Kabbini, Kallada, Bharathapuzha river systems (Kurup *et al.*, 2004).

Habitat: stagnant pools with sand or mud as substratum.

Fishing method: Gillnets and Hook and line.

Order: Tetradontiformes

Genus: ***Tetradon*** Linnaeus

Tetradon Linnaeus, *Systema naturae*, Ed. 10, p. 332, 1758 (Tetradon lineatus Linnaeus)

Tetradon travancoricus Hora & Nair
(Plate XVI, Fig. 145)

Tetradon (*Monopterus*) *travancoricus* Hora & Nair, *Rec. India Mus.*, 43: 391, 1941 (Type locality: Pamba river, Central Travancore)

Common name: Malabar puffer fish Local name: Thavalapottan, Attunda

Distinguishing characters: (Based on 11 specimens, 22-34 mm TL)

D. 7- 8; A. 8; P.16-17

Body rounded or broad, inflatable. Caudal peduncle compressed. Head oval shaped, snout blunt, mouth terminal, directed upwards. BD 37.84-38.11 (37.98) in SL, 100.48-108.7 (104.59) in HL, HL 34.82-37.93 (36.37) in SL. Eyes large, 30.40 - 38.32 (34.36) in HL. Lips thick and fleshy. Nostrils in the form of an elevated short, round tube. Gill openings narrow, immediately in front of pectoral fins. Jaws equal, with a cutting edge and with a hard bony covering. Dorsal fin without spines, inserted far back, slightly in front of anal fin. HD 47.03 - 53.13 (50.08) in HL. HP 76.21-86.38 (82.30) in HD and 40.49-41.75 (41.03) in HL. Pelvic fins absent. Caudal fin emarginated. HC 26.77-28.56 (27.67) in SL. Body partially covered with hard dermal spines. Upper lateral line not reaching end of tail. Body interspersed with black patches and spots on back on a yellowish orange back ground. Ventral side white. Two black patches on dorso-lateral surface, in front of dorsal fin. Posterior to these, a dark broad band running to caudal fin. Other dark patches are seen behind pectoral fin and just behind eyes. Fins yellowish.

Geographical distribution: India: Kerala (Talwar and Jhingran, 1991)

Distribution in Kerala: 13 rivers of Kerala (Ajithkumar *et al.*, 2000) South of Chaliyar river (Shaji and Easa, 2000). Pamba river, Kerala (Jayaram, 2000), Pamba, Bharathapuzha, Chalakkudy and Periyar river systems (Kurup *et al.*, 2004).

Habitat: Shallow bank sides of downstream of rivers among thick vegetation with sand or muddy substratum.

Fishing methods: Scoop nets.

2.4. Discussion

Precise identification of a species is an essential pre-requisite for any type of study related to biodivesirty conservation. Rainboth (1996) also emphasized that the correct species identification is the fundamental starting point for any type of biological studies particularly on wild population. Menon (1967) stressed the necessity for intensive taxonomic work in the tropical areas due to the rapid rate of speciation. Rivers of south India constitute one of the most fertile fields for ichthyological discoveries and so any intensive investigation on fishes could help to locate new species or to find out new facts regarding the status or distribution of species already described (Menon, 1999).

Early ichthyologists had the disadvantage of having only a very few and poorly preserved specimens. With the then prevailing species concept, they usually conservatively concluded the observed variability for intraspecific rather than ontogenic, geographic or interspecific (Ng and Kottelat, 2000). Menon (1999) commented about the then state of Ichthyological studies in the country as "Paucity of specimens made it difficult to ascertain the specific differences existing amongst freshwater fishes of the country. This lead to several fundamental gaps. Some species have not been able to collect since the time of Hamilton-Buchanan (19^{th} centuary) while some species are still buried in synonymy whereas some species do have the invalid species status due to constant misidentification. Rare species with restricted distribution seldom turned up in general collections. Subsequent collections having low species representation almost invariably caused authors to synonymise species, which had similarity in descriptions. Early field workers undoubtedly observed many more species than are observed today in areas subjected to extensive human modifications and therefore, quite a number of species might have already vanished due to serious habitat alterations and modifications".

It is very exciting to report that Systematics have a remarkable renaissance during recent years. The reasons for this change are diverse.

There is a strong feeling among taxonomists that they have to play a leading role in the new syntheses of evolutionary theory and they have demonstrated that the study of organic diversity, the main concern of systematics, is a major and integral branch of biology (Mayr, 1942). With the signing of Convention on Biological diversity in 1992, considerable attention is being paid all over the world on species Identification, listing and prioritization of species which are basic pre-requisites for ecosystem conservation. Nowadays, there is a strong enthusiasm among ichthyologists in undertaking surveys of unexplored regions and little known habitats, analyzing and comparing more number of samples from varied habitats, filling the gaps of taxonomic ambiguities, validating and standardizing the species names, unraveling the status of the rare and extinct species and cataloguing their fish germplasm resources. More taxonomic revisions and examining wider scope of characters through sophisticated technologies are also gaining importance. Menon (1999) rightly pointed out that the studies of the Indian fish systematics can be expected to yield interesting and possible dramatic results with this pace. The present effort to consolidate the list of freshwater fishes of Kerala got its vital encouragement mostly from earlier sturdy movements.

145 fish species belonging to 12 orders, 28 families and 66 genera were collected, identified, classified and described in this study with illustrations. 8 fish species were found new to science. Kurup *et al.* (2004) finalized the list of 175 freshwater fish species from Kerala. While comparing with this, 31 fish species were found missing in the present study. The drastic reduction in population size or even complete eradication of some of these

species due to the recent spurt in anthropogenic activities evokes strong anxiety. Family Cyprinidae represented by 69 species has emerged as the group having highest species strength in the river systems of Kerala. Cyprinids comprising carps and minnows are the most dominant family of freshwater fishes in Asia accommodating more genera and species than any freshwater fish family (Roberts, 1989). The family Cyprinidae also represents as world's largest primary freshwater fish family (Nelson, 1994). The Cyprinidae is followed by family Balitoridae with 20 species, Bagridae with 11, Siluridae, Sisoridae and Channidae with 4 species each. Ambassidae, Cichilidae and Gobiidae having 3 species each; Anguillidae, Aplocheilidae and Mastacembelidae with 2 species each while the rest of the families are represented only by a single species each.

While scanning of the literatures on taxonomic studies on freshwater fishes of India, it became obvious that there exist a number of examples which show ambiguous and overlapping taxonomic descriptions and merging, splitting and erection of new species, genera and new families. The nomenclature used in the present description are the most revalidated and widely accepted by most of the taxonomists. Strengthening of some of the genera was possible by the addition of species new to science. Some of the taxa still implicates serious taxonomic bias and require further sophisticated studies for resolving and updating the systematic status.

There had been inconsistency and confusion in using the names *Barbus* Cuvier and or *Puntius* Hamilton-Buchanan. Hamilton-Buchanan placed some species under the genus *Puntius* while a few others under *Cyprinus*. Gunther (1868), Day (1878, 1889) and Weber and Beufort (1916) used the genus name *Barbus*. De Witt (1960) and Myers (1990) were of the opinion that the name *Barbus* be retained in its broad sense while Smith (1945) and Misra (1962) used the genus name *Puntius*. Hora (1939 & 1942) and Hora and Law (1941) treated *Puntius* as a subspecies of *Barbus*. It is now widely accepted that the name *Barbus* be used to represent the Barbs of European continent and *Puntius* for Asiatic, especially for Indian fishes (Talwar and Jhingran, 1991, Jayaram, 1999 and Menon, 1999). The usage of the genus name *Puntius* in the present study is fully concurring with the recent descriptions and literatures.

Instances of taxonomic ambiguities were also encountered during this study. Under the genus *Puntius*, Yazdani *et al.* (2001) reported the fishes from Nilgiri biosphere reserve which included two species, *P. mahecola* and *P. filamentosus*. While Day (1878) treated them as two species on the basis of prominent maxillary barbells present in *Barbus mahecola*, Hora (1937) was of the opinion that *P. mahecola* is the females of *P. filamentosus*. Selvaraj and Abraham (1987), based on several morphomeristic studies, treated them as such while Thobias (1974) based on detailed morphomeristic studies undoubtedly stated that *Puntius mahecola* and *Puntius filamentosus* are one and the same. Talwar and Jhingran (1991), Jayaram (1999) and Menon (1999) were also of the opinion that only *P. filamentosus* do exists. The results of the present study also strongly cuncur with the above observations and therefore *Puntius filamentosus* was only treated as a valid species.

Interestingly, the specimens of *Puntius filamentosus* collected from Kallada river system had three black blotches on body. Senanayake (1982) described *Puntius arulius srilankensis*, a variety of *Puntius arulius* on the basis of filamentous dorsal rays in addition to the blotches. The specimens collected form Kulathupuzha showed remarkable similarity with the above in terms of colour pattern, however it resembles *P.filamentosus* in terms of its morphomeristic characters. According to Jayaram (1991), the three spots on the back often perisist in the adults of *P.filamentosus*. During the present study also, the specimens were identified as *Puntius filamentosus*. *Puntius arulius* is one of the rare and endangered barbs in Kerala which is very much endemic to Pookkode lake of Kabbini river in Wynaad (Shaji and Easa 2001). On the contrary, according to Ajithkumar *et al.* (2000) this species is found in 25 river systems of Kerala and is also very common in Periyar and Moovattupuzha river systems. However, the latter observation requires further clarification. It is strongly doubted that the authors might have misidentified the fingerlings of *P. filamentosus* having spots on body as *P. arulius*.

Menon (1999) described the new species, *Puntius chalakkudiensis* from Chalakkudy river which shows very close resemblance with *P. denisoni*, however, it differs from the latter in having an inferior mouth and a black blotch on its dorsal fin. There was no report on the rediscovery of this species from anywhere in India. Chalakkudy river system is one of the water bodies in Kerala where *Puntius denisoni* is available in moderate numbers and the presence of a light shade of blackish tinge (the salient character of *P.chalakkudiensis*) and inferior mouth position have also been observed in a number of specimens of *P. denisoni* both collected from Chalakkudy and other river systems of Kerala. Infact, Day (1865) initially placed the species under *Labeo*, which might be due to the sub-inferior lips. Thus the validity of

P.chalakkudiensis and so evokes strong confusion during the present study. The specimens collected from different river systems sharing the above said characters were identified only as *P. denisoni*.

Members of the genus *Tor* had been subjected to serious discussion for their taxonomic ambiguities. Jerdon (1849) described *Barbus khudree malabaricus* from the mountain streams of Malabar and reported it as the only *Tor* species found in Kerala. Day (1878) also treated *T. khudree malabaricus* as a valid species on the basis of elongated snout and osseous dorsal spine. However, Menon (1992) after conducting several biometric analysis on the populations of *Tor khudree* collected from Western Ghat river systems such as Krishna, Godavari and Cauveri and comparing it with the populations of *Tor khudree malabaricus* came to the conclusion that the characters of these two species were highly overlapping and therefore both of them are same. However, Arunachalam (2000) validated the status of *Tor khudree malabaricus* based on the specimens of *Tor* collected from Tambraparni river, Western Ghats. Shaji and Easa (2001) reported the populations of *Tor khudree malabaricus* from Poringalkuthu and Pooyamkutty tributaries of Periyar river system. It was Jayaram (1997) who confirmed the occurrence of *Tor mussullah* in Kerala based on specimens from Karimpuzha, a tributary of Chalayar river system with distinct hump over the occipit, distinctly separating the species from *T.khudree*. Hora (1942) was initially of the opinion that *T. mussullah* is not different from *Puntius carnaticus*. However, Menon (1992) on the basis of comparisons of standard deviation and standard errors concluded that *Tor mussulla* and *Tor khudree* are the same. Later Raju Thomas *et al.* (2000) registered the occurrence of

Tor tor from the upstream of Chandragiri river system, thus raising the numerical strength of species under the genus Tor in to 3. Though a number of ambiguous specimens (especially of morphomeristic in nature) have been observed in *Tor khudree* collected from diverse river systems of Kerala as part of the present study, all of them were treated as *Tor khudree* since no distinct variation in salient characters were observed to be treated as another species. However, a new species, *Tor remadevii* described from Pambar river system as a new species which showed remarkable variation from *Tor khudree* and *Tor mussullah* due to the presence of a strong and osseous spine in the dorsal fin and an elongate head which is more than body depth. The species, however, shows close similarity with the Himalayan Yellow fin Mahaseer, *Tor putitora*; however, strongly differs from the latter due to the presence of a characteristic hump at the occipit, presence of straight head and snout and possession of a terminal or slightly upturned mouth in the new species.

In the present study, six species were described under the genus *Gonoproktopterus* from Kerala. This is inclusive of rare species, such as *G. micropogon periyarensis* and *G. kolus*. Silas (1951), Talwar and Jhingran (1991) and Jayaram (1981,1991) have treated *Gonoproktopterus curmuca* and *G.kolus* as two distinct species based on the morphomeristic charectes. In contrast, Menon and Remadevi (1995) restored the Bleekerian name, *Hypselobarbus* and synonimised these two species by ignoring the number of barbells and also erected a new species *Hypselobarbus kurali* from the collection made from the Western side of Western ghats from Dakshina Kannada and Travancore on the basis of possession of four barbells, a weak last undivided dorsal ray and presence of 41-43 lateral line scales. The specimens of *G. kurali* were colleted from the torrential streams of Periyar river system in the present study which confirms with the views made by many scientists that the species is usually seen in torredntial streams. The identity of *G. kurali* has also been well established in this study which distinctly differs from its related species on the basis of colour pattern on the body and fins, possession of more elongated head and snout and slender body shape. The taxonomic identity of this species was subjected to serious discussions since many have synonimised the species with the widely distributed *G. curmuca*. *G. kolus* can easily be diagnosed from its related species in the group by noting its shorter body with uniform silvery colour, presence of a single pair of barbells and dusky gray fins. *G. micropogon micropogon* reported (Easa and Basha, 1995) from Nilgiri biosphere is having high resemblence with *G. micropogon periyarensis* in morphomeristic characters. However, the two species were described from the two different drainages (east flowing and west flowing). Jayaram (1991) accommodated this species under the genera *Puntius* and named as *Puntius micropogon periyarensis* and also differentiated it from *P.micropogon micropogon*. Shaji and Easa (2001) separated these two species on the basis of colour pattern (Slaty in *G. micropogon periyarensis* and silvery in *G. micropogon micropogon*) and reported it as fairly abundant in Kabbini river. However, in the present study, only *G. dubius* could be collected from Kabbini river system with fairly good abundance. *G. dubius* also has strong, osseous and elongated dorsal spine similar to that of *G.micropogon micropogon* and there is every reason to suspect that the earlier workers might have misidentified the former with that of latter. Jayaram (1991) is of the opinion that *P.kolus* has remarkable affinity towards *B. mussullah* and they possess certain common features such as deep body, conical snout and horny tubercles on snout of males. In contrast, there are very distinct characters which can be used for the separation of these species (Jayaram, 1999)

It was Howes (1980) who erected the genus *Parlusciosoma* to accommodate his species *Parlusciosoma daniconius*. Menon (1999) and Shaji and Easa (2001) reported the occurrence of two separate genus, *Parlusciosoma* and *Rasbora* in Western Ghats based on the morphometry and colour pattern The former has a larger body with a broad lateral band which is continuous from snout to caudal, while the latter has a lean body with upwardly directed mouth and the lateral band on body restricted to posterior portion only. Ajith kumar *et al.* (2000) also followed the same generic name, *Parlusciosoma*. However, Kottelat and Vithayanon (1993) have clarified the distinct identity of the species *Rasbora daniconius* which is followed in this thesis. None of the characters described above were discussed in the present study and therefore all the specimens were accommodated under the genus *Rasbora*.

The taxonomic identity of the two species of *Danio*, *Danio malabaricus* and *D. aequipinnatus* is showing high degree of ambiguity. Day (1878) differentiated *D. malabaricus* from *D. aequipinnatus* on the basis of number of lateral line scales and number of anal fin rays. Deraniyagala (1930) followed Day in treating *D. malabaricus* as a separate species in his list of fishes of Sri Lanka. Hora and Mukerji (1934) differentiated *D. malabaricus* by the presence of a black mark near the upper angle of gill opening. The authors also reported the lateral line scale counts as 32-34. Hora and Law (1941) are of the view that *D. malabaricus* is a probable synonym of *D. aequipinnatus* without assigning any reason. Hora and Nair (1941) confirmed this synonymy by saying that south Indian specimens grow large size than its counterpart in the north India. Many of the subsequent workers (Silas, 1951; Menon, 1951; Rajan, 1955; Jayaram *et al.*, 1976; Jayaram, 1981) did not report *D. malabaricus* and treated all of their specimens as *D. aequipinnatus.* Barman (1984) in his work on the Danio of Indian region, not at all discussed any type of variations in *D. aequipinnatus.* Kottelat and Pethiyagoda (1990) used the specific name *D. malabaricus* for the common Sri Lankan Danio without giving much effort to make a thorough identification of the specimens. However, Jayaram (1991) distinctly separated these two species on the basis of morphomersitic characters in a sizable number of specimens and affirmed that in *D. malabaricus* body is more deep, with more number of lateral line scales and more branched dorsal rays. Conversely, in the present study, the two species were distinguished on the basis of body depth and number of rays on anal fin. Also, the number of anal fin rays were found more in *D. malabaricus* than in *D. aequipinnatus* besides its deep body In the present study.

The genus *Garra* (Hamilton) is represented by 24 species in Indian subcontinent (Jayaram 1999) among them 19 species are distributed in India, including the new species reported in the past two decades. The Genus is so far represented by seven species in Kerala. Recently Kurup and Radhakrishnan (2001 and 2003 in press) described four more new species viz. *Garra emarginata*, *Garra mlapparaensis*, *G.travancoria* from Periayr river and *G.nilamburensis* from Chaliyar river and also reported *Garra ceylonensis*, a Sri Lnakan species under the genus *Garra* from Periyar river (Radhakrishnan and Kurup, 2004 in press). Thus the total species known from Kerala is 12. While classifying species under the genus *Garra* collected from different draingages in Kerala, It appears that the chances of misidentification are invariably high. *Garra mullya* being a widely distributed species, exhibit high disparity in morphomeristic characters between different drainages and micro and macro habitats, thus leading to great confusion and misidentificantion with some other species. Hora (1921) opined that there exists wide controversy on the systematic position of *Garra mullya* as this species is still in the process of ecological adaptation. The newly recorded Sri Lankan species, *Garra ceylonensis* has great resemblance with *Garra mullya* in body stature and in the colour pattern. But according to Menon (1964), the two species strongly differs in the interorbital width to head length ratio *ie*, 2 times or less than 2 times in head length in *Garra mullya* but greater than 2 times on *Garra ceylonensis*. Also, the width of suctorial disc to head width ratio is lesser in *Garra ceylonensis* when compared to *Garra mullya*. Majority of the species under the genus *Garra* have a fold or ridge at the snout but in varying degrees of depth, shape and size which are also subjected to a great deal of regional variations. This arouse strong dilemma in determining the acceptable limit of such morphometric variation for species segregation. However, the ridge, cut or protuberance on the snout is still considered as valid characters to distinguish the majority of species under the genus *Garra*.

The newly described species, *Garra travancoria*, shows some resemblance with *Garra mcClellandi* in its broad sucking disc, lateral line scale count and placement of vent. However, unlike in *Garra mcClellandi*, the new species has a shallow vertical groove on the snout wherein in some mature specimens, the groove apparently divide the snout in to two lobes. In *G. mcClellandi*, there is a horizontal cut at the snout, forming a protuberance at the tip of the snout. Unlike in *G. hughi*, the new species is more robust and uniformly scaled except on the chest region. The species differs from *G. periyarensis* mainly in the complete absence of scales on the ventral profile as in the latter and in the absence of a snout protuberance. Dorsal fin inserted close to snout than caudal in new species while in *Garra menoni* it is close to caudal. The new species also differ from *Garra mullya* and *Garra surendranathani* in a variety of characters such as body morphometry, head shape, width of sucking disc, eye diameter, colour pattern on body, etc.

The second new species, *Garra nilamburensis* shows some resemblance with *Garra menoni*, in its broad and well developed sucking disc, lateral line scale count, placement of vent and the colour pattern. However, the new species can be differentiated from *Garra menoni* in the body form i.e, *Garra nilamburensis* is a short and stout species with a more deep body where as *Garra menoni* is a more elongate and slender species. The head is more or less round or semicircular with swollen cheeks and the ratio of head length in standard length is smaller in the new species while in *Garra menoni*, the head is more elongate and the length of head in SL ratio is relatively high. Body depth is almost equal or higher than the head width in the new species where as in *Garra menoni*, it is lesser than head width. Dorsal fin inserted closer to snout than caudal in the new species while in the latter it is close to caudal. Further, the new species has its caudal peduncle deep and its least depth form 1.5-1.8 times in head length while in *Garra menoni*, it is less deep and form 2 or more than 2. The new species show resemblance with *Garra hughi* in colour pattern and dimensions of sucking disc but differs from the latter in the position of insertion of dorsal fin, which is equidistant in *Garra hughi* and in the scale pattern ie, scales present uniformly on body except on chest region in the new species whereas it is absent on breast and belly in *Garra hughi*. The new species differ from *Garra mullya* and *Garra surendranathani* in respect of body morphometry, head shape, sucking disc width and length ratio, eye diameter, colour patter on body, etc.

The third new species, *Garra mlapparaensis* is closely related to *Garra hughi* in the number of lateral line scales, wide and well developed sucking disc, however, differs from the latter in the presence of larger eyes and also in the position of insertion of dorsal fin *i.e*, dorsal fin placed close to snout than the caudal fin in the new species and is equidistantly between snout and caudal fin in *Garra hughi*. It can be differentiated from *Garra periyarensis* in the absence of deep cut at the snout, presence of scales on the breast and belly regions and placement of the vent, which is almost midway between the anterior origins of anal fin and ventral fins in the latter.

Garra emarginata is different from its closely related species *Garra hughi*, *Garra surendranathani* and *Garra periyarensis* in many respects. Unlike in *Garra hughi*, the new species is having prominent scales on the predorsal, breast and belly regions and presence of lesser number of lateral line scales. The new species also differes from *Garra periyarensis* in the absence of a deep cut and a knob like protuberance in the snout and also due to the presence of scales on the breast and belly region. The species do not have any black blotches, unlike in *Garra surendranathani* in which the presences of blotches are characteristic. It is also different from *Garra mullya* in the presence of more lateral line scales, broad and round head and snout, more flattened and wide interorbital region and smaller eyes when compared to head length. The new species can easily be differentiated from *Garra menoni* in the presence of more number of lateral line scales, presence of scales in the breast and belly regions, wide interorbital distance and in its colour pattern *i.e,* the new species possess minute dark spots arranged on either sides of the lateral line in a series. The emarginated nature of caudal fin differentiates the species under the Genus *Garra* inhabiting Western ghat region, however this character is found shared with *G. manipurensis* recorded from Manipur. Nevertheless, *G. emarginata* can be differentiated from *G. manipurensis* by observing the morphometric characters such as presence of scales on the chest region, width of mental disc in relation to width of head, difference in lateral line scale counts, shape of head, colour pattern, etc.

The identity of *Garra periyarensis* (Gopi, 2001) has been distinctly confirmed in the present study which totally disagrees with the views of some of the scientists that the species is same as *Garra mcClellandi* described from Periyar lake and Nigiris. Arun *et al.*, 1996 and Arun (1997) are of the opinion that the deep vertical cut at the snout and elongate body are the characters of *Garra mcClellandi* and therefore, the specimens of *Garra* species collected from Periyar lake and upstream are *G. mcClellandi.* However, the presence of protuberance on snout, absence of scales on ventral region, the larger anus to anal distance, greater number of gill rakers and more lateral line scales are enough to justify the erection of a distinct species. However, there exist a strong dilemma on the report of *Garra mcClellandi* in Kerala waters. However, the specimens collected from east flowing Bhavani river system during the present study showed much affinity towards *G. mcClellandi*. Menon (1964) was of the opinion that the species is restricted to the headwaters of Nilgiris. It is worth reporting that the specimens examined as *G. mcClellandi* from ZSI, Madras (Reg. No. F. 6763, Hassan district, Karnataka (1ex.) and Reg. No. F. 5139, Moyar river (1ex.) showed close affinity to *G. mullya*. It would thus appear that the taxonomic identity *G. mcClellandi* is still ambiguous and requires molecular level investigations.

The identity of *Garra menoni* (Remadevi and Indra, 1981) has also been confirmed in the present study. Although the authors who had erected the species have clearly shown the differences, Shaji and Easa (2001) and Talwar and Jhingran (1991) synonimised the species with *Garra mullya*. Later, Easa and Shaji collected *G. menoni* from Chinnar river at Chinnar WLS (Easa and Shaji, 1995) and confirmed its taxonomic validity. By general appearance, the two species have close similarity, however, *G. menoni* can easily be distinguished by the absence of scales on chest and belly, absence of deep cut at snout and have a smaller body. The species can be easily differentiated from *Garra hughi* Silas in the lesser number of lateral line scales, larger eyes and smaller interorbital width.

Silas (1951) while describing the new species, *Garra hughi* clearly stated that the scales are absent on chest, belly and also on the dorsum of the species and these features have been considered as the main diagnostic characters to distinguish this species from other related species, both scaled and scaleless. Subsequently, Remadevi and Indra (1999) collected specimens both with a few ill-defined scales on the ventral surface and rudimentary scales on the pre dorsal area from Anamalai hills (where the type specimens were collected) and asserted that there exist high variation in squamation in this species and therefore this character can not be relied upon for species distinction. In the present study, this species have been invariably collected from various drainages and on examination of scales, it was found that the scales were generally absent on chest and belly, however, the scales were either present or absent along the pre dorsal area. These findings concur with Remadevi and Indra (1999). Shaji and Easa (2001) reported that all specimens of *G. hughi* collected by the authors were having scales on mid dorsal streak. Paradoxically, they distinguished the species from others based on absence of scales. Talwar and Jhingran (1991) and Jayaram (1999) still consider the absence of scales as a valid character to distinguish the species. Thus the group remains to be one of the most notorious group sharing high degree of taxonomic ambiguity.

The genus *Horalabiosa* is represented by a single species, *Horalabiosa joshuai* Silas in Kerala. This genus had been considered as a hybrid between *Garra* and *Rasbora*. The record of 598 specimens of this species from the type locality (Silent valley) by Remadevi (1992) confirmed its validity. Surprisingly, not even a single specimen of this species was encountered during the present study from the same area. Interestingly, this species was not listed in the list of fishes from Silent valley (Remadevi and

Indra, 1986). Shaji and Easa (1996) reported *Puntius melanampyx* from Silent valley, but not examined any of the species for its affinity with *Horalabiosa*. It can, therefore, be inferred that the populations of *H. joshuai* might have undergone drastic decline in Silent valley or even might have disappeared from this unique ecosystem. Later Raju Thomas *et al.* (1998a) recorded the species from Eravikulam National park, thus confirming the presence of this species in Kerala waters.

It was Hamilton-Buchanan (1822) who first described the Nemacheiline species from India. Subsequently, McClelland (1839), Gunther (1868), Day (1878), Hora (1949) and Menon (1987) described a number of new species, under this group. According to Menon (1987), the species under this group are similar in general morphology, however, they lack spines, scutes and various other processes and features of taxonomical interest, thus making this group as the most difficult group to distinguish and differentiate. The variation in colour pattern is largely used to separate the species under this subfamily along with the nature of lateral line and number of branched rays on the dorsal fin. Menon (1999) accommodated a large number of loach species under a single genus, *Noemacheilus*. He argued that this generic name couldn't be changed until and unless International Commission on Zoological Nomenclature has decided to do so. According to him, *Noemacheilus* is the widely used name and is not preoccupied by a senior synonym. Kottelat (1984) claims that *Noemacheilus* van Hesselt is a Nomen nudum, therefore the name should be rejected. Talwar and Jhingran did not mention any of these genera proposed by Menon (1999) and all the species of the subfamily have been placed under a single genus, *Nemacheilus*. Later, Jayaram (1999) erected 5 genera under the subfamily Nemacheilinae viz. *Oreonectes, Acanthocobitis, Nemachilus, Schistura* and *Mesonemacheilus*. In the present study, the generic classification of Jayaram (1999) was followed to distinguish the various species under the sub family Nemacheilinae in view of the fact that there is marked variation in morphometry and colour pattern among the species.

Practically, no attempt has so far been made to revise the Nemacheilinae species inhabiting Indian waters barring the partial revision of the genus from Eastern Himalays and the revision of the Cobitoid fishes by Menon (1987). More than 450 species have been described under the subfamily Nemacheilinae (Kottelat, 1990) of which seventy-nine Nemacheiline species are known from Indian waters (Menon 1987). Ten species have so far been described under the genus *Nemacheilus* in Kerala waters (Jayaram 1999). The new species, *Mesonemacheilus periyarensis* Kurup and Radhakrishnan (2005) described during the present study shows close resemblance to *Nemacheilus pulchellus* (Day 1873) described from Northern India in its colouration and body characteristics. However, the new species can easily be distinguished from *Nemacheilus pulchellus* by the presence of 9 branched rays on the dorsal fin against 10 branched rays observed in the latter. Further, unlike in *N. pulchellus*, only the lower lip is interrupted in the middle and the lateral line is not complete in the new species. The new species also shows similarity with *Nemacheilus petrubanarescui* (Menon 1984) in colour pattern and ratio of body depth to standard length. However, the dorsal fin is not inserted equidistantly between the snout and caudal fin in *Nemacheilus periyarensis*. Also, in the former, the dorsal fin has only 8 rays.

The taxonomic status of the three recently described new species, *Mesonemachelus remadevi* (Shaji and Easa, 2001), *Mesonemacheilus pambarensis* (Remadevi and Indra, 1994) and *Mesonemacheilus menoni* (Zacharias and Minimol, 1999) were confirmed beyond doubt during the present study with the help of adequate number of specimens collected from their type localities. *Noemacheilus sinuatus*, a rare loach which was described from Wynaad streams (Easa and Basha, 1995) could not be collected in the present study. *N. petrubenarescui* (Menon, 1984) was described based on specimens collected from Karnataka streams. Subsequently Shaji reported this species from Noolpuzha of Kabbini river system. However, the affinity of this species with it closely related ones coult not be worked out properly due to the dirth of adequate number of specimens and therefore the validity of this species was questionable. With the collection of adequate specimens of this species in the present study, the erection of this species is fully justified. Hora and Law (1941) reported *N. evezardi* from Periyar river and remarked on the marked variations exhibited in colour pattern in this species. Subsequently Rita *et al.* (1978) described *Oreonectes keralensis* from Periyar river by differentiating it from *Oreonectes evezardi* based on differences in colour pattern and relative lengths of nasal barbells. However, it is worth reporting that the length of nasal barbells can vary depending on the life stages of the fish and the available description on colour pattern of the two species are highly overlapping. Rita *et al.* (1978) also remarked on the probability of Hora and Law's specimens being *O.*

keralensis. It appears that, *O. evezardii* collected from Periyar by Chacko (1948) and Zacharias *et al.* (1996) can also be of *O. keralensis*. However, Biju *et al.* (2000) recently reported the occurrence of *O. evezardii* from Eravikulam national park. The taxonomic ambiguity seen between these two species need to be resolved by conducting detailed studies.

Homalopterinae loaches inhabit fast flowing water of the hill streams and are endured with morphological adaptations such as flattened head and body, horizontally oriented enlarged paired fins bearing adhesive pads covered with urculi on the ventral surface which helps them to live in mountain streams and rivulets (Kottelat, 1989). The Genus *Homaloptera* van Hasselt is so far known by four species in Kerala viz. *Homaloptera montana* Herre, (Menon 1987), H*omaloptera pillai* Indra and Remadevi (1981) and *Homaloptera menonii* (Shaji and Easa, 1995c) besides a new species, *Homaloptera santhamparaiensis,* described from the Panniar tributary of Periyar river at Santhanparai (Arunachalam *et al.*, 2002). The rare Balitorid fish, *Homaloptera montana* Herre reported from Anamalai and Nelliampathy hills were not obtained during the present study. Menon (1987) synonymised *H. montana* and *H. pillai* without any justification. Talwar and Jhingran (1991) also treated *H. pillai* as a synonym of *H. montana*. However, Pethiyagoda (1991) separated the above two species based on the number of lateral line scales (83-93 in *H. pillai* and 72 in *H. montana*), shape of the snout (broadly round in *H. pillai* and pointed in *H. montana*) and colour pattern (Uniform dark brown with conspicuous blotches in *H. pillai* and prominent blotches in yellowish background in *H. montana*). In the present study, adequate number of specimens of *H. pillai* were collected besides erecting new species, *H.*

silasi from Periyar Tiger reserve. *Homaloptera silasi* can be differentiated from the other three closely related species such as *H. montana, H. pillai* and *H. menoni* by observing the position of insertion of dorsal fin, small eyes, small pectoral and pelvic fins and characteristic colour pattern. The new species shows some similarity with *H. santhamparaiensis* in the lateral line scale counts and also in the smaller eyes but totally disagrees in the shape of head and snout, pectoral fin counts, colour pattern etc.

H. silasi was found to inhabit in a peculiar microhabitat unlike the general cascade habitats with high water velocity where the Homalopterid fishes are seen closely attached to bedrocks. In contrast, the specimens of the new species were collected from a small rocky pool near a cascade with abundant leaf litters where the members of Nemacheilinae usually seen abundant. The new species also showed various morphometric relations with loaches by possessing a conical and pointed head, deep body which is oval in cross section, round belly, small paired fins with lesser number of simple and branched rays which are invariably disagree with the morphology of Homalopterids (Homalopterids have a depressed body, flattened belly, broad and much flattened paired fins with large number of simple and branched rays). According to Hora (1932), the body of *Homalopterids* is usually sub cylindrical shows close similarity with loaches of the genus *Nemacheilus*. While comparing the new species with the other closely related species of Western Ghats, it become evident that there exist two different morphological forms under the same genera. *H. menoni* and *H. santhamparaiensis* showed high resemblence to *H. silasi* in having a deep body and conical snout whereas *H. montana* and *H. pillai* have a much flattened body with broad and round snout like the genus, *Bhavania*. The great diversity of form and structure seen among the members of the genus *Homaloptera*, has resulted in attempts to split in to several subgenera (Silas, 1952). Silas also observed two different morphometric forms, with pointed snouts (*Helgia*) and broad snout (*Bhavania* like) in the genus *Homaloptera*. According to him, the habitudinal variations between the different drainges might have brought about repeated divergence or convergence in the family and geographical and ecological isolation might have played a great role in the evolutionary divergence of the species. However, it should be stated that further intensive, phylogenic studies are necessary to resolve all the ambiguities relating to this rare group of fishes. Application of sophisticated genetic and molecular technologies are highly in need to support these types of attempts.

Much confusion has come across while identifying the specimens under the genus *Clarias* since the literatures are giving overlapping morpho-meristic characters for *Clarias batrachus* and *C. dussumeiri*. *Clarias dussumeiri* has been wrongly identified as *C. batrachus* in many of the literatures. Cherian *et al.* (2001) while studying the ichthyofauna of Trivandrum district reported *C. batrachus*. Jayaram (1980) distinguished the two species based on the distance between the occipital process and base of dorsal fin (larger in *C. dussumeiri* than *C. batrachus*). Silas (1952) while discussing the species composition of the genus pointed out that *C. dussumeiri* is the south Indian form while *C. batrachus* is widely distributed all over India. Day (1877) collected a single specimen of *Clarias dayi* from Wynaad hills of Kerala. But he misidentified it as *Clarias dussumeiri*. Hora (1936) re-examined the specimens and described it as the new species, *C.*

dayi. According to IUCN (1994), *C. dayi* is almost extinct as it has not been reported anywhere in India. Though many faunestic studies have been carried out in Western Ghats of Nigiri and Wynaad hills (Hora, 1937, 1938, 1942, Silas, 1951, Rajan, 1955, Jayaram, 1981, Jayaram *et al.,* 1982, Remadevi and Indra, 1984, Easa and Basha, 1995 and Easa and Shaji, 1997), the species, *C. dayi* has not been reported again. According to Menon (1999), *Clarias batrachus*, *C. dussumeiri dayi* and *C. dussumieri dussumieri* are the three Indian species among them *C. dussumieri dussumieri* is only have a geographical distribution in Kerala. Talwar and Jhingran (1991) also reported the restricted distribution of *C. dussumieri dussumieri* to Kerala waters. In the present study, only *C. dussumieri* was collected from various freshwater bodies in Kerala following the descriptions of Jayaram (1980, 1999).

The taxonomic identity of the two species under the genus *Ompok* viz. *O. malabaricus* and *O. bimaculates* remain to be ambiguous due to want of adequate descriptions and contradictions seen in the available literatures. Hora and Law (1941) treated *O. bimaculates* and *O. malabaricus* as synonyms while Parameswaran (1967) treated them as two separate species. According to Talwar and Jhingran (1991), *O. bimaculates* has 57-58 anal fin rays (in the Plate I, fig. for the species they have shown 76 anal fin rays). According to Jayaram (1999) the anal fin rays of *O. bimaculates* is 60-75. Jayaram (1999) reported that the species with the caudal lobes rounded and lower boarder of eye on level with cleft of the mouth are *O. malabaricus* while *O. bimacuates* is having caudal lobes pointed, eye below level of the cleft of the mouth. He did not take the anal fin ray count as a valid character for species segregation. Shaji and Easa (2001) distinguished the two species mainly based on barbell length, anal fin ray count and shape of caudal fin (Barbells Short, anal fin rays 68-69 and caudal lobes rounded in *O. malabaricus*, barbells long, ray count 57-58 and lobes pointed in *O. bimaculates*). The authors also considered colour pattern as a valid character to segregate the two species. However, the length of the maxillary barbells found varying based on the life stage of the fishes besides perceptible variation in the shape of caudal lobes are also observed in a large number of specimens, in contrast, the colour pattern of both the species are found highly unstable from dirty white to brown, grayish and even black in the different draingas and habitats. Anal fin ray count and shape of the caudal fin were used for identifying the two species in the present study. The taxonomic ambiguities exist in this group deserves immediate attention.

The members of the genus *Glyptothorax* are relatively rare especially with regard to *G. anamalaiensis* and *G. lonah*. Hora (1938) reported that *Glyptothorax annandalie* might be considered as a race of *G. lonah* since both have their outer rays of paired fins plaited below. According to Menon (1999), the species are closely allied except in the much longer and narrower caudal peduncle seen in *G. annandalie*. He added that the plaited condition and its development depend upon the rapidity of water in which the fish lives and could not be considered as a valid character. In the present study, the two species were distinguished mainly based on colour pattern (Body brownish, the fins tipped with orange yellow in *G. annandalie* and body without any colour bands in *G. lonah*) since all the other salient characters were found overlapping. Manimekalan and Das (1998) described a new fish species, *Glyptothorax davissinghi* based on five specimens collected from Karimpuzha (Chaliyar river system) and its tributaries. No other report of this species is seen anywhere from India. While comparing the present collection of *G. annandalie* from Karimpuzha with the type specimens of *G. davissinghi* (ZSI Chennai, (3 ex. 89-114mm, Karimpuzha, Chaliyar, 7th April 1995, without any reg. no.) the morpho-meristic characters were found highly overlapping between the two species. It appears that the taxonomic validity of the species is very much suspicious.

Day (1875-78) in his description on the rare species, *Silurus wynaadensis* has reported that the species has two pairs of mandibular barbells. Bhimachar and Rao (1941) observed variation in number of mandibular barbells, some specimens with two and others with one pair. They opined that the variability found in the number of mandibular barbells in *S. wynaadensis* is due to the atrophy of one of the pairs during the growth and development of the fish and, therefore it has no taxonomic significance. Gopi and Radhakrishnan (2001) in their collection of *S. wynaadensis* from Chandragiri river found two juvenile specimens with two pairs of mandibular barbells and all other specimens with single pairs. Interestingly, Jayaram (1999) considered the number of mandibular barbells as a salient character to classify species under the genus *Silurus* and only those with two pairs of barbells strictly are treated as *S. wynaadensis*. According to Talwar and Jhingran (1991), the number of mandibular barbells can vary based on the life stage of this species and the adult fishes generally have two pairs of manndibular barbells. In the present study, the specimens of *Silurus* collected from rapid habitats of Kabbini, Karyangod and Chandragiri river systems were all with single pair of mandibular barbells and were identified as *S. wyanaadensis* following Gopi and Radhakrishnan (2001).

Hitherto there is no report on the occurrence of *Salarias* species in freshwaters of India (Day, 1889). The description of a new species of blenny, *Salarias reticulates* Kurup *et al.* (2006) from the Vettilappara region of Chalakudy river in the present study increases the number of species of this family from 98 to 99 and also supports Day's (1878) view that some blennies can even extend their geographical range of distribution to freshwater. According to him, this peculiar distribution pattern happens due to the migration undertaken by these species upstream during heavy floods against the floodwaters, in the monsoon months, and a sudden subsidence thenceforth may result in their being trapped in isolated pools on the mainland. Those, which can survive in the new habitat, will later reach their original habitat along with subsequent floodwaters.

The nomenclature and systematic status of many species solely based on morphometric and meristic characters are making serious confusions (Gopalakrishnan and Basheer, 2000). The systematic information in fish, including endangered and exotic species is still based on measurements and counts of comparable body parts and characters. It has already been accepted that morphological characters upon which systematics are based, may be influenced by environmental conditions and also, the same morphometric measurements within different populations of a species can produce different results. This often presents a dilemma to systematics while determining acceptable limits for variation in morphological character within a taxonomic unit (Srivastava, 2000). This is attributed to the reason why a lot of taxonomic ambiguities are reported and still exist in many of the Indian freshwater fishes, especially of Western Ghats. There is an urgent requirement for resolving the taxonomic disputes by making use of sophisticated biochemical and molecular genetic tools. The paucity of specimens for comparisons further magnifies the problem. There are still a lot of species entrapped in synonymy and a number of invalid species as well. Even the agencies like Zoological Survey of India does not have a full collection of all of the type specimens of new species described and new reports and most of the new species described just remain buried in the published manuscripts without the material become available to the researchers for comparison and future studies. A strong step towards these problems and collective and honest efforts from different sides of ichthyological studies are inevitable for the time being for resolving the ambiguities exist in systematics of freshwater fishes of Kerala.

Fig. 2.1. Map of Kerala showing river systems

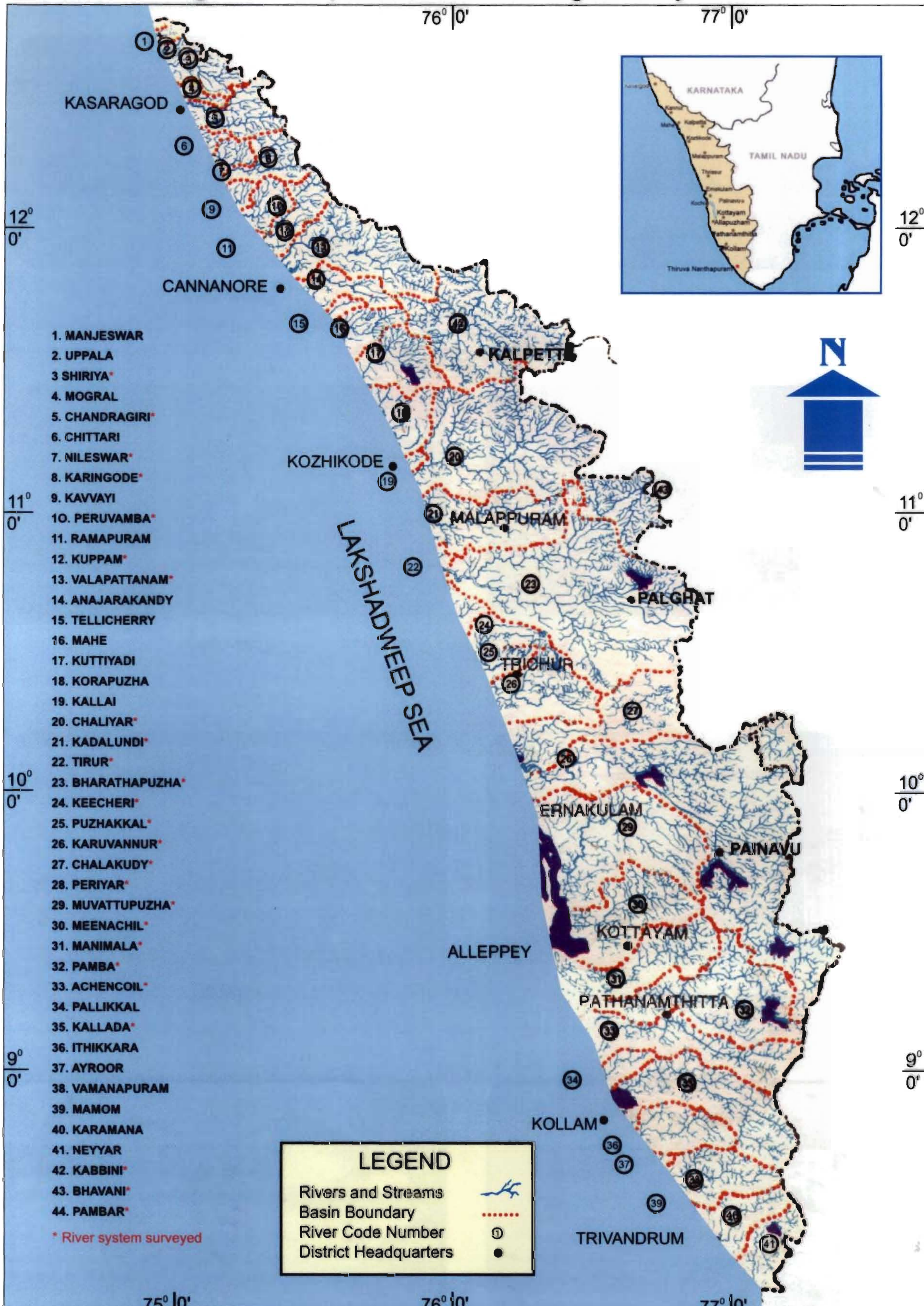
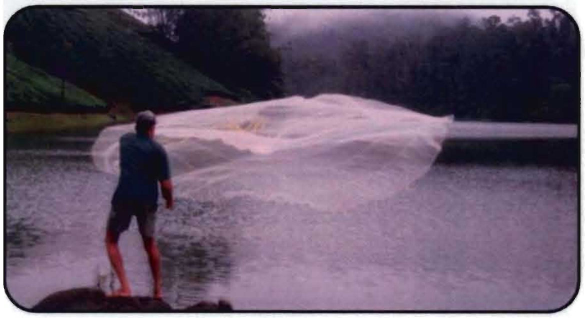


Plate I



Cast netting

Drag netting

Cast netting

Scoop netting

Gill netting

Traditional Trap (Koodu)

Gill netting

Collection from landing centre

Plate II

Fig. 1. *Notopterus notopterus* (Pallas)

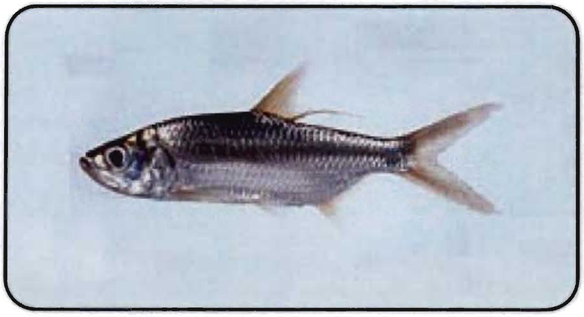


Fig. 2. *Megalops cyprinoides* (Broussonet)

Fig. 3. *Anguilla bicolor bicolor* McClleland

Fig. 4. *Anguilla bengalensis bengalensis* (Gray)

Fig. 5. *Dayella malabarica* (Day)

Fig. 6. *Cirrhinus reba* (Hamilton-Buchanan)

Fig. 7. *Cirrhinus mrigala* (Hamilton-Buchanan)

Fig. 8. *Cyprinus carpio* Linnaeus

Fig. 9. *Catla catla* (Hamilton-Buchanan)

Fig. 10. *Neolissochilus wynaadensis* (Day)

Plate III

Fig. 11. *Tor khudree* (Sykes)

Fig. 12. *Tor remadeviae* Kurup and Radhakrishnan

Fig. 13. *Tor putitora* (Hamilton-Buchanan)

Fig : 14 *Osteobrama bakeri* (Day)

Fig : 15 *Osteochilus (Kantaka) brevidorsalis* (Day)

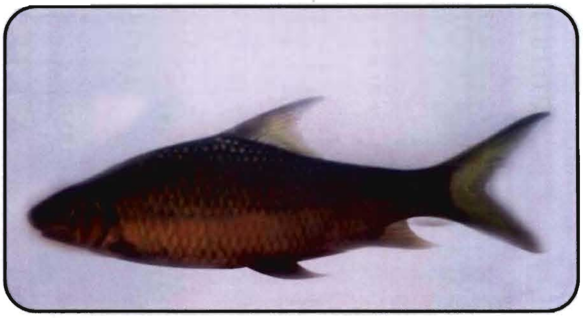


Fig. 16. *Osteochilus longidorsalis* Pethiyagoda and Kottelat

Fig. 17. *Osteochilus nashii* (Day)

Fig. 18. *Gonoproktopterus kolus* (Sykes)

Fig. 19. *Gonoproktopterus dubius* (Day)

Fig. 20. *Gonoproktopterus micropogon periyarensis* Raj

Plate IV

Fig. 21. *Gonoproktopterus thomassi* (Day)

Fig. 26. *Labeo nigriscens* Day

Fig. 22. *Gonoproktopterus curmuca* (Hamilton-Buchanan)

Fig. 27. Labeo kontius (Jerdon)

Fig. 23. *Gonoproktopterus kurali* (Menon and Remadevi)

Fig. 28. *Labeo calbasu* (Hamilton-Buchanan)

Fig. 24. *Labeo dussumieri* (Valenciennes)

Fig. 29. *Labeo rohita* (Hamilton-Buchanan)

Fig. 25. *Labeo fimbriatus* (Bloch)

Fig. 30. *Puntius chola* (Hamilton)

Plate V

Fig. 31. *Puntius parrah* (Day)

Fig. 36. *Puntius denisoni* (Day)

Fig. 32. *Puntius dorsalis* (Jerdon)

Fig. 37. *Puntius amphibius* (Val.)

Fig. 33. *Puntius filamentosus* (Val.)

Fig. 38. *Puntius sarana subnasutus* (Val.)

Fig. 34. *Puntius arulius* (Jerdon)

Fig. 39. *Puntius carnaticus* (Jerdon)

Fig. 35. *Puntius bimaculates* (Bleeker)

Fig. 40. *Puntius bovanicus* (Day)

Plate VI

Fig. 41. *Puntius fasciatus* (Jerdon)

Fig. 42. *Puntius jerdoni* (Day)

Fig. 43. *Puntius ophicephalus* (Raj)

Fig. 44. *Puntius vittatus* Day

Fig. 45. *Puntius ticto (Hamilton-Buchanan)*

Fig. 46. *Puntius conchonius* (Hamilton-Buchanan)

Fig. 47. *Chela dadiburjuri* (Menon)

Fig. 48. *Chela fasciata* Silas

Fig. 49. *Salmostoma acinaces* (Valenciennes)

Fig. 50. *Salmostoma boopis* (Day)

Plate VII

Fig. 51. *Esomus thermoicos* (Valenciennes)

Fig. 56. *Barilius gatensis* (Valenciennes)

Fig. 52. *Amblypharyngodon microlepis* (Bleeker)

Fig. 57. *Barilius bakeri* Day

Fig. 53. *Brachydanio rerio* (Day)

Fig. 58. *Barilius canarensis* (Jerdon)

Fig. 54. *Rasbora daniconius* (Hamilton-Buchanan)

Fig. 59. *Danio malabaricus* (Jerdon)

Fig. 55. *Barilus bendelisis (Hamilton-Buchanan)*

Fig. 60. *Danio aequipinnatus* (McClelland)

Plate VIII

Fig. 61. *Lepidopygopsis typus* Raj

Fig . 66. *Garra periyarensis* Gopi

Fig. 62. *Crosocheilus periyarensis* Menon and Jacob

Fig . 67. *Garra mcClellandii* (Jerdon)

Fig. 63. *Garra gotyla stenorhynchus* (Jerdon)

Fig . 68. *Garra menoni* Remadevi and Indra

Fig. 64. *Garra mullya* (Sykes)

Fig . 69. *Garra hughi* Silas

Fig. 65. *Garra ceylonensis* Bleeker

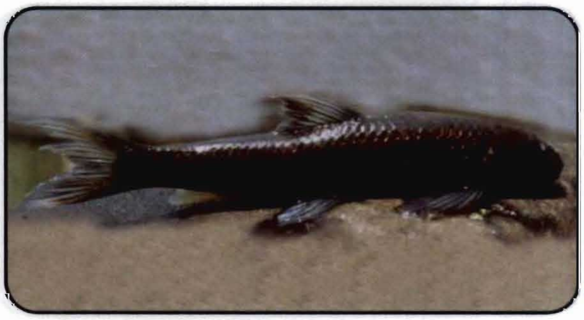


Fig . 70. *Garra travancoria* Kurup and Radhakrishnan

Plate IX

Fig . 71. *Garra nilamburensis* Kurup and Radhakrishnan

Fig. 72. *Garra mlapparaensis* Kurup and Radhakrishnan

Fig. 73. *Garra surendranathani* Shaji, Arun and Easa

Fig. 74. *Garra emarginata* Kurup and Radhakrishnan

Fig. 75. *Bhavania auatralis* (Jerdon)

Fig. 76. *Travancoria elongata* Pethiyagoda and Kottelat

Fig. 77. *Travancoria jonesi* Hora

Fig. 78. *Baltora mysorensis* Hora

Fig. 79. *Homaloptera pillai* Indra and Remadevi

Fig. 80. *Homaloptera silasi* Kurup and Radhakrishnan

Plate X

Fig. 81. *Oreonectes keralensis* Rita and Nalbant

Fig. 82. *Acanthocobitis botia* (Hamilton-Buchanan)

Fig. 83. *Schstura denisoni* (Day)

Fig. 84. *Schistura semiarmatus* (Day)

Fig. 85. *Schistura striatus* (Day)

Fig. 86. *Schistura nilgiriensis* (Menon)

Fig. 87. *Nemacheilus monilis* Hora

Fig. 88. *Mesonemacheilus pambarensis* (Remadevi and Indra)

Fig. 89. *Mesonemacheilus periyarensis* Kurup and Radhakrishnan

Fig. 90. *Mesonemacheilus guntheri* (Day)

Plate XI

Fig. 91. *Mesonemacheilus triangularis* (Day)

Fig. 92. *Mesonemacheilus menoni* Zacharias and Minimol

Fig. 93. *Mesonemacheilus petrubenarescui* (Menon)

Fig. 94. *Mesonemacheilus remadevi* Shaji and Easa

Fig. 95. *Lepidocephalus thermalis* (Valenciennes)

Fig. 96 *Horabagrus brachysoma* (Gunther)

Fig. 97.*Horabagrus nigricollaris* Pethiyagd and Kottelat

Fig. 98. *Batasio travancoria* Hora and Law

Fig : 99 *Mystus bleekeri* (Day)

Fig : 100 *Mystus cavasius* (Hamilton-Buchanan)

Plate XII

Fig. 101. *Mystus oculatus* (Valenciennes)

Fig. 102. *Mystus armatus* (Day)

Fig. 103. *Mystus gulio* (Hamilton-Buchanan)

Fig. 104. *Mystus montanus* (Jerdon)

Fig : 105. *Mystus vittatus* (Bloch)

Fig. 106. *Mystus menoda* (Hamilton-Buchanan)

Fig. 107. *Mystus malabaricus* (Jerdon)

Fig. 108. *Wallago attu* (Schneider)

Fig. 109. *Ompok malabaricus* (Valenciennes)

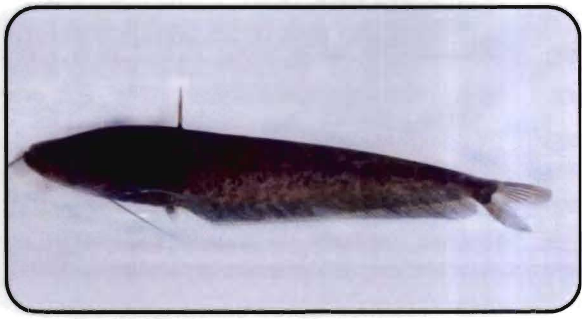


Fig. 110 *Ompok bimaculatus* (Bloch)

Plate XIII

Fig. 111. *Silurus wynaadensis* (Day)

Fig. 112. *Pseudeutropius mitchelli* Gunther

Fig. 113. *Glyptothorax anamalaensis* Silas

Fig. 114. *Glyptothorax annandalei* Hora

Fig. 115. *Glyptothorax lonah* (Sykes)

Fig. 116. *Glyptothorax madraspatnam* (Day)

Fig. 117. *Clarias dussumieri* Valenciennes

Fig. 118. *Heteropneustes fossilis* (Bloch)

Fig. 119. *Xenentodon cancila* (Hamilton-Buchanan)

Fig. 120. *Aplocheilus blocki* (Arnold)

Plate XIV

Fig. 121. *Aplocheilus lineatus* (Valenciennes)

Fig. 122. *Poecilia reticulata* Peters

Fig. 123. *Microphis cuncalus* (Hamilton-Buchanan)

Fig. 124. *Macrognathus aral* (Bloch and Schneider)

Fig. 125. *Mastacembelus armatus* (Lacepede)

Fig. 126. *Parambassis dayi* (Bleeker)

Fig. 127. *Parambassis thomassi* (Day)

Fig. 128. *Pseudambassis bacuilis* (Hamilton-Buchanan)

Fig. 129. *Nandus nandus* (Hamilton-Buchanan)

Fig. 130. *Pristolepis marginatus* Jerdon

Plate XV

Fig. 131. *Oreochromis mossambica* (Peters)

Fig. 132. *Etroplus maculates* (Bloch)

Fig. 133. *Etroplus suratensis* (Bloch)

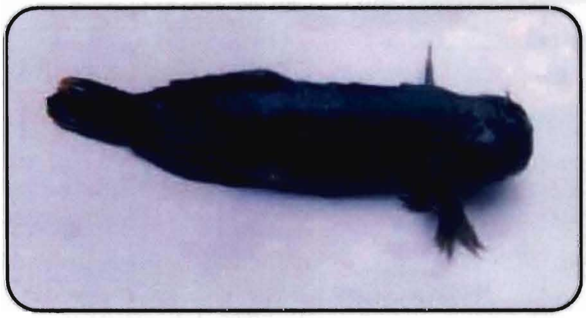


Fig. 134. *Salarias reticulates* Kurup and Radhakrishnan

Fig. 135. *Eleotris fusca* (Schneider)

Fig. 136. *Glossogobius giuris* (Hamilton-Buchanan)

Fig. 137. *Awaous gutum* (Hamilton-Buchanan)

Fig. 138. *Sicyopterus griseus* (Day)

Fig. 139. *Anabas testudineus* (Bloch)

Fig. 140. *Macropodus cupanus* (Valenciennes)

Plate XVI

Fig. 141. *Channa orientalis* Bloch and Schneider

Fig. 143. *Channa marulius* (Hamilton-Buchanan)

Fig. 142. *Channa micropeltes* (Cuvier)

Fig. 144. *Channa striatus* (Bloch)

Fig. 145. *Tetradon travancoricus* Hora and Nair

Chapter 3

GERMPLASM INVENTORY AND DISTRIBUTION PATTERN OF FISHES IN THE RIVER SYSTEMS OF KERALA

3.1. Introduction

The international Convention on Biodiversity conservation held at Rio in December 1992 emphasized the need to conserve the areas of mega biodiversity and to give priority for endemic species in aquaculture practices. The approaches for setting conservation plans are becoming a matter of concern in view of the accelerating and potentially catastrophic loss of biotic diversity unlike other environmental threats, which is irreversible (Mittermeir *et al.*, 1998). Selection of a precise area for planning and policy making aiming at biodiversity conservation is itself difficult, and it is impractical to conserve every thing, therefore, prioritization is essential (Sahotra and Margules, 2002). Understanding how biodiversity is distributed and maintained; in particular, within the species rich tropical regions and prioritizing those areas which are vulnerable to species endangerment and being rapidly depleted in quality is the key step aiming at biodiversity conservation (Daniels, 1992). Strengthening the database on population size and distribution of fishes by undertaking extensive surveys and sampling are prerequisites of conservation (Kurup, 1994). Knowledge on the types of fishes that constitute the ichthyofauna and their limits of distribution is indispensable for any programme designed for their conservation (Menon, 1999). Limited information are available on these issues, much of it are in the form of scattered investigations on a few localities invoving a few taxa (Dahanukar *et al.*, 2004). Meaningful fish species inventory surveys along a time scale representing all the climatic and other natural periods which would unravel the diversity, distribution patterns and status of the fishes are all essential inputs for prioritizing a particular species or a particular water body or a particular region for effective conservation.

A review of the history of fish species inventory reveals that studies have been mostly conducted during the colonial period (Hamilton-Buchanan 1822; Hamilton, 1877). This was in fact customary that the colonial rulers map the distribution and availability of the bioresources immediately after conquering an area. The fauna volumes available to us, albeit not all, are nothing but the outcomes of such extensive surveys. The priorities of the rulers coupled with the naturalistic approach provided valuable and precise information for generations (Jayaram, 1999)

The Western Ghats of India is recognized as one of the 21 biological hotspots of the world and the richest expression in diversity, abundance and endemism of freshwater fishes are met in the drainages of these mountain ranges in India (Anon, 1998). The fish germplasm inventory of river systems of Western Ghats, their distribution, endemism and threat status were subjects of study for many of the Indian Ichthyologists. Notable among them are those of Acharya and Iftekhar (2000), Bhat (2000), Arunachalam *et al.* (2000), Chandrasekhariah *et al.* (2000), Gopalakrishnan and Ponniah (2000), Gopi (2000), Grubh *et al.* (2000), Lazarus *et al.* (2000), Remadevi and Indra (2000), Thampi and Jayaraj (2000) and Yadav (2000a,b). 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. Kapoor and Dayal (2000) had evaluated the conservation status of endemic fish fauna of Western Ghats. Recently Dahanukar *et al.* (2004) listed 288 fish species belonging to 12 orders, 41 families and 109 genera from this region. Several authors found new fish species and engaged in resolving the taxonomic ambiguities of quite a large number of species. Srivasthava (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.

In the World Bank technical report, streams of Kerala have been identified as one of the few sites in the world showing exceptional biodiversity and high degree of endemism with respect to freshwater fishes (Kottelat and Whitten, 1996). Several workers had contributed to the knowledge on the fish fauna, their distribution and diversity in the various rivers of Kerala. Day's (1865) 'Fishes of Malabar' is the pioneer 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, Indra and Remadevi (1990) of Thekkadi Wild life reserve, Easa and Basha (1995) of the Kerala part of Nilgiri bioreserve, Easa and Shaji (1995) of Pambar river, Biju *et al.* (1996) of Manjeswaram river system, Ajithkumar *et al.* (1999) of Chalakkudy river system, Bijukumar and Sushama (2001) of Bharathapuzha river system, Lalmohan and Remadevi (2000) of Chaliyar river system and Cherian *et al.* (2001) of Trivandrum district. Previous studies on the fish fauna of Trivandrum district include those of Pillai (1929), John (1936), Hora and Law (1941), Hora and Nair (1941) and Silas (1951). Recent additions to the fish fauna of Trivandrum district are those of Remadevi *et al.* (1996) and Raju Thomas *et al.* (1999).

Kurup (1994) proposed the management plans required to arrest the decline of freshwater fish diversity of Kerala. Jayasree *et al.* (1993) reported the distribution of indigenous freshwater fishes in the central coastal region of Shertallai. Raju Thomas *et al.* (2002) published the list of freshwater fishes of southern Kerala, highlighting the distribution of endemic and endangered fishes. The fish diversity in Aralam and Parambikulam wild life sanctuaries were reported by Shaji *et al.* (1995) and Biju *et al.* (1999 b) respectively. Menon (1997) gave an account of the rare and endangered fishes of Malabar. Around 150 fish species were recorded from the Kerala part of Western Ghats and other water bodies of the state (Jayaram, 1999). Mini (2000) studied fish species of Periyar Lake. 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. The areas lying north of Palaghat gap gained the attention of researchers only in the 1980s, except the study by Rajan (1955). Recent studies from this region are those of Indra and Remadevi (1981), Remadevi and Indra (1986), Shaji *et al.* (1995), Easa and Basha (1995), Easa and Shaji (1995 and 1996), Manimekalan and Das (1998) and Reghunathan (1998). The rivers of Waynad district were studied for their fish fauna by Arunachalam *et al.* (2000).

A number of species are being added recently to the ichthyofaunal diversity of the state as new descriptions, new records, new extension ranges etc. Details of species found new to science are given in Chapter-1. Remadevi and Menon (1994) recorded the extended distribution of *Horalabiosa sp.* to Silent valley while Shaji and Easa (1995a) reported the extension range of *Danio* (*Brachydanio*) *rerio* to the Wynaad. The extended distribution of *Silurus wynaadensis* to Kasargod district and *Hypselobarbus kolus* to Parambicualm wild life sanctuary were reported by Gopi (1996) and Vairavel *et al.* (1997) respectively. The occurrence of *Glyptothorax lonah* in Chalakkudy river, *Tetradon travancoricus, Sicyopterus griseus* and *Osteobrama cotio peninsularis* in Periyar river and *Macrospinosa cuja* in freshwaters of Kerala was registered for the first time by Biju *et al.* (1997, 1998; 1999 a). *Barilius bendelisis,* so far reported only from the east flowing rivers, was recorded from a west flowing river *viz.* Chalakkudy river by Raju Thomas *et al.* (1998b). Raju Thomas *et al.* (1999) also reported the new extension ranges of *Mystus bleekeri* to Neyyar river of Kerala, *Esomus thermoicos* to Mangalampuzha, a tributary of river Bharathapuzha and *Pangio goaensis* to Manimala river of southern Kerala. Recent reports on the extension range of other fish species include those of Raju Thomas and Biju (2000) on *Nemacheilus keralensis,* Gopi *et al.* (2004) on *Horadandia atukorali* Deraniyagala (endemic species of Sri Lanka).

In spite of conducting a great deal of work on fish fauna, hardly any efforts were made to prepare a river system wise database on fish germplasm resources. Development of database on this subject is very vital in prioritization of those river system or species in specific river systems for biodiversity conservation. Since Day, no concerted attempts are made to revalidate the fish fauna of various river systems of Kerala. Available studies are more or less fragmentary in nature mostly confined to some of the major river systems such as Kabbini, Chandragiri, Chaliyar, Valapatnam, Chalakkudy and Bharathapuzha. The fish fauna of most of the major and minor rivers remain to be unknown. On the contrary, most of the recent surveys are focused at some of the geographically significant or biodiversity rich areas such as Nilgiri Biosphere and Travancore streams, Wild life sanctuaries such as Aralam, Parambikulam, Chinnar and National Parks such as Silent valley and Eravikulam. Consolidation of fish faunal strength of river systems of Kerala is found imperative in view of discovery of several species new to science, reporting of new records and new extension ranges of fishes. No attempt was also made to evaluate the fish species of different river systems for their sustainable utilization as ornamental, cultivable and food fishes. Lack of information on biodiversity status of the fish species based on IUCN criteria is another major lacuna. The endemism of freshwater fishes of Kerala is also not properly evaluated which is very essential for the preservation of the unique fish germplasm resources. Information on the spatial and longitudinal distribution patterns of fish species within and between different river systems are prerequisites for implementation of location or habitat specific *insitu* conservation programmes and demarcation of aquatic sanctuaries. 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. Furthermore, virtually no effort is made to correlate the geometrical parameters of the river systems such as river length, catchment area etc. with fish species diversity and abundance. Influence of latitude on species richness and distribution is another field which is remaining uninvestigated. It is against this background that the present study was undertaken with the following objectives.

1. To generate an authentic revalidated database on the freshwater fish fauna of Kerala
2. To prepare a river wise inventory of freshwater fishes of Kerala
3. To evaluate the fishes based on their commercial utilization
4. To assess the biodiversity status based on IUCN criteria
5. To bring out the degree of endemism
6. To delineate the regional, longitudinal and latitudinal distribution patterns of the fishes
7. To compare the different river systems on the basis of geomorphology and species diversity in order to prioritise the species, river systems and area/areas within the river systems which require priority for conservation.

3.2. Materials and methods

The study was carried out during April 2000 to Decemeber 2004. Extensive surveys and sampling were carried out in the 25 major river systems of Kerala to document the fish fauna. Photographs of the upper, middle and lower streches of some of the major the river systems surveyed are given in Plate I to IV. The details of river systems surveyed such as total length and catchment area of individual river systems, the month and season during which survey has been carried out, frequency of survey and the number of locations surveyed in each river system are given in Table 3.1. The details of the river systems surveyed such as origin, primary and secondary tributaries and reservoirs, reserved forests, wild life sanctuaries and National parks surveyed are given in Table 3.2. All the primary and secondary fresh water fishes that could be collected within the limits of freshwater area of different river systems (the lower limit of a river system from where the salinity observed as '0'ppt.) were brought under this study. Fishes were collected from 474 locations of the 25 river systems surveyed. 1:50,000 topographical maps of Survey of India and Water Atlas of Kerala (Anon, 1991) were used to trace the river system, their secondary and tertiary tributaries and pinpoint the location sites. The habitat diversity was given prime importance in the selection of locations within the river system. The fishes were collected using diverse types of fishing gears such as cast nets (16mm, 18mm, 22mm), gill nets (32mm, 38mm, 64mm, 78mm, 110mm), drag net (4mm), scoop nets and other local contrivances like ottal, mada vala, etc. Collections were made from all selected locations during 8:00-18:00 h and 20:00-06:00 h. Visual observations were also carried out depending on the clarity of water to assess the distribution of the fishes. The entire strech of a river system is divided based on altitudinal gradient and habitat condition and the divisions so made are lower streches or low land area or downstream; middle streches or midland and upper streches or up land or upstreams for perceiving the dispersal of fishes at the different altitudinal ranges of the river systems. Generally, the upstream of the river systems are characterized by cascade or rapid type of habitat with bedrock and boulders as substratum; middle streches by pool-riffle, glider or even pool-run habitat with cobbles and gravel as substratum and lower streches by run or sheet type of habitat with gravel, sand or mud as substratum (Manojkumar and Kurup, 2002) and falls under the gradient level <70m above msl (Low land), 70-450 m above msl (midland) and >450 m above msl (Upland) respectively (Raju Thomas et al. (2002). Ornamental, cultivable and food fishes were demarcated based on their colouaration, size, growth rate, compatibility under aquarium and culture conditions, local acceptance and information gathered from field trips and other publications (Gopalakrishnan and Ponniah, 2000; Kowtal, 1994; Sreenivasan, 1995, 1996; Chakraborty, 1996; Shaji and Easa, 2000). The endemic nature of the fishes were studied following Anon (1998); Gopalakrishnan and Ponniah (2000), Gopi, 2000; Shaji and Easa, 2000. The biodiversity status of the fishes were assessed based on IUCN criteria (IUCN, 1994). About 125 research papers on the freshwater fish fauna of Kerala published during 1965-2000 were also consulted towards compiling the past data of abundance and availability for assessing biodiversity status. In addition to the scientific data, informal or traditional knowledge was also applied to evaluate the conservation status of fishes. For this purpose, information were collected through interviews with experienced fishermen, fish vendors, local people and tribals. The different river systems were compared for their similarities and differences in the nature of fish fauna based on Jaccard index of similarity (Ludwig and Reynolds, 1988). The index has the following formula:

$$Sj = j / (x + y - j)$$

Where Sj is the similarity between any two river systems X and Y, j is the number of species common to both the river systems X and Y, x is the total number of species in the river sytem X and y is the total number of species in the river system Y. The analysis has been carried out using the statistical software, PAST. The similarity or differences in species composition between the different streches of the river systems were also carried out based on Jaccard's similarity coefficient. The river systems were compared against a set of parameters such as number of fish species collected from the river system, number of ornamental, cultivable and food fishes collected, number of critically endangered, endangered and vulnerable fishes reported during the study period, number of fishes which are endemic to the partuclar river system and also endemic to Kerala. Certain points were given to each or 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., Endagered fishes (EN)=3.,Vulneralbe fishes (VU) = 2., 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 (RD). Based on these results the river systems were compared for their diversity and decisions are made whether a particular river system can be considered as a hot spot of diversity. The area/areas of each of such river system require protection as an aquatic sanctuary were also identified and demarcated. The diversity was correlated with the total length and total cathcment 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. The whole geographical area of Kerala has been divided in to five zones on the basis of 1^0 latitude division viz. zone I (13^0-12^0 S, zone II (12^0-11^0 S), zoneIII (11^0-10^0 S), zone IV (10^0-9^0 S) and zone V (9^0-8^0 S) to bring out the latitude wise distribution pattern of fishes based on latitude (Fig.3.1). The nature of fish fauna in the different latitudinal zones were compared based on Jaccard index and the similarities or differences in the species diversity were found out. The faunal diversity at the different zones were also correlated with the dimensions of the river systems within each zone and the relation between fish species diversity and the geometrical area of the diiferent latitudinal zones are brought out. An attempt is done to correlate the latitudinal species diversity with the geography of Kerala and the possible reasons for variations in speies diversity observed in different latitudes are also explained.

3.3. Results

3.3.1. Inventory of freshwater fishes of Kerala

Fish germplasm resources:

145 fish species belong to 12 orders, 28 families and 66 Genera were collected from 25 river systems of Kerala. The list of fishes collected from diverse river systems together with their commercial utilization such as ornamental, cultivable or food fishes, biodiversity status of the fishes assessed based on present study and also NBFGR CAMP list and the endemic nature of the fishes are given in Table 3.3. Among the orders, Cypriniformes was the largest in the numerical strength of species, with 87 species followed by Siluriformes with 23 species. Order Perciformes consisted of 21 species while Cyprinodontiformes was with 4 species and Anguillidae with 2 species. All other orders were represented by single species each. The species wise strength of fish families reported from Kerala is given in Fig.3.2. Family Cyprinidae was the largest family accommodating 21 Genera and 67 species while the genus *Puntius* of this family ranked first among the genera in its numerical strength with 17 species. Genus *Garra* comprised of 12 members. Family *Balitoridae* ranked next to *Cyprinidae* with 5 genera and 20 species while genus *Nemacheilus* was represented by 14 species. Family Bagridae is having 12 species and the genus *Mystus* of this family accommodated 9 species. Siluridae and Sisoridae of Siluriformes consisted of 4 memebrs each and family Cichilidae and Ambassidae of Perciformes were represented by 3 memebrs each. 15 families were having

single members each.

Discovery of fish species new to science:

8 fish species which are new to science were described from different river systems of Kerala. This included 5 species viz. *Nemacheilus periarensis, Homaloptera silasi, Garra mlapparaensis, Garra travancoria* and *Garra emarginata* from Periyar river system; and *Salarias reticulates, Tor remadevii* and *Garra nilamburensis* from Chalakkudy, Pambar and Chaliyar river systems respectively. The new species collected together with their region of inhabitation is shown in Table 3.4.

New record of fish species from Indian Region:

Garra ceylonensis belong to the family Cyprinidae has been reported as a new record from Indian region. The specimens of this species were collected from Valiyaparakutty of Muthirappuzha triburtary of Periyar river system. The species was so far known only in Sri Lanka.

Extension of distributional ranges of Fish Species:

a) Species showing extension of distribution range towards peninsular region:

1. The Himalayan species *Tor putitora* was collected from the Kabbini river system. The presence of this species in Kerala evokes curiosity among the Ichthyologists and this observation would strengthen the Satpura Hypothesis (Hora, 1936). The presence of small specimens in Kabbini would manifest the possibility of establishment of natural breeding population in peninsular India.

2. *Mystus menoda* (Hamilton), whose distribution is recorded only from *Maharashtra* and Gujarat states has been found as a new distributional record in Pamba River, Kerala
3. *Labeo kontius* (Day) is so far been reported from rivers of Tamilnadu and Karnataka, especially from Cauvery river system has been found for the first time from Kabbini river system, Kerala.
4. *Puntius bovanicus* (Day) is so far been recorded only in Bovani River and Cauveri river basin. This species was collected from Bharathapuzha, which is a west flowing river in Kerala.

b) Description of new distribution ranges between the river systems of Kerala:

1. The critically endangered species, *Horabagrus nigricollaris* is hitherto known only from the Chalakkudy river system, has been reported from the Pooyamkutty tributary of the river Periyar.
2. *Osteochilus longidorsalis,* another critically endangered species is known only from the Chalakkudy river was collected from Pooyamkutty tributary of river Periyar.
3. The endangered species, *Gonoproktopterus thomassi* is having a restricted geographical distribution in Kabbini and Chalakkudy rivers. The distribution of this species has been found extended to Kallada river. The specimens of the species were also collected from the Pooyamkutty tributary of the river Periyar.
4. The critically endangered fish species, *Travancoria elongata* is known so far only from Chalakkudy river system at Vettilappara. During the present study, two specimens this species was collected from Periyar

river system at Pooyamkutty.

5. The threatened fish species, *Nemacheilus keralensis* is known only from upstreams of Kabbini and Periyar river systems. Specimens of this species was collected from Meenachil river system at Vagamon.
6. The endangered fish species, *Puntius ophicephalus* is known only from upstreams of Periyar river system till date. This species was collected from Meenachil river system at Vazhikkadavu.
7. The endangered species, *Neolissochilus wynaadensis*, so far known only from the Kabbini river in Wyanaad was recorded from Kalakkanpuzha of the river Chaliyar which is the first record from a west flowing river.
8. *Bhavania australis* coming under the family Balitoridae has been reported for the first time from Silent valley national park. With this discovery, the total fish species strength of this national park has raised to 10.
9. *Gonoproktopterus dubius* which was known to be a fish endemic to Kabbini river system was collected from Siruvani locality of Bhavani river
10. *Batasio travancoria*, a *siluroid* fish has been reported for the first time from Parambiculam Wild Life Sanctuary.
11. The endangered fish, *Brachydanio rerio* which was known to have a distribution in Kabbini river system was recorded from Chandragiri river system. This is the first report of this species from a west flowing river system
12. The endangered fish, *Nemacheilus petrubenarescui* which is so far

known only in Kabbini river system is collected from Chandragiri river system. This is the first report from a west flowing river system

13. *Glyptothorax anamalaiensis* so far was known only from Anamalai and Chaliyar river systems is collected from Kuruvadeep locality of Kabbini river system.
14. *Pseudeutropius mitchelli*, the endangered fish species whose distribution is known only from distributed in Periyar river system was collected from Pamabr rive system at Chinnar in the Chinnar Wild Life Sanctuary.

Evaluation of fish germplasm for commercial utilization:

Of the total 145 species collected, 76 are categorized as ornamental, while 47 as food and 22 cultivable species (Fig.3.3).

Nature of Endemism:

While assessing the endemic nature of the fishes so collected, it was found that 52 species were characterized by their distribution in the Western Ghats of peninsular India (EN-WG) while 21 species were found strictly endemic to Kerala waters. 14 species are endemic to India (EN-I), while 14 species are endemic to Indian Sub continent (EN-IS) whereas 3 species are Introduced (Intr.) or exotic in their status.

Biodiversity status:

Biodiversity status of the freshwater fishes of Kerala were assessed as per IUCN criteria and the results revealed that 59 species belonged to threatned category while 68 are non-threatened. 13 species were categorized under Data deficient (DD) group while 3 species were transplanted from other countries. Among the threatened fishes, 8 are critically endangered (CR) and

36 are endangered while 15 species belong to vulnerable (VU) category. Wihtin the non-threatened group, 23 species were categorized as Low risk nearly threatned (LRnt), 47 species are under Low risk least concern (LRlc) category (Fig.3.4). The list of critically endangered and endangered caterogy, river source and region of inhabitation together with the details such as number of times the sampling were carried out in the specific river system and the location and number of times the species encountered in the collection are shown in Table 3.5& 3.6.

3.3.2. Riverwise fish germplasm inventory

3.3.2.1. Achenkoil river system

A map of Achenkoil river basin showing the locations surveyed are given in Fig.3.5.

Fish germplasm resources:

The fish germplasm resources comprised of 49 species belonging to 4 orders, 18 families and 32 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.7. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.6. Order Cypriniformes and Perciformes ranked first and second positions with 26 species and 14 species respectively while families Cyprinidae and Bagridae were found richest in accommodating maximum number of species with 22 and 4 respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 9 species.

Evaluation of fish germplasm for commercial utilization:

25 species were adjudged for ornamental purposes while 18 are having food value whereas 7 species can be utilized for aquaculture (Fig.3.7).

Biodiversity status:

12 species of belonged to threatened category whereas 35 fishes were categorized as non-threatened. Among the threatened category, *Balitora mysorensis* was endangered (EN) while 8 species belonged to vulnerable category (VU). Among the non-threatened fishes, 16 are under Low risk nearly threatened (LRnt) while 22 fishes are under Low risk and least threatened category (LRlc) (Fig.3.8).

Nature of Endemism:

20 species were found to be endemic to Western Ghats (EN-WG) among them 7 species were endemic to Kerala (EN-K), while 6 were endemic to India (EN-I) and 5 were endemic to Indian sub continent (EN-IS). *Oreochromis mossambicus* is the only exotic (Ex). No species was found strictly endemic to this river system.

Distribution pattern:

10 species were distributed at the upper streches of which *Anguilla bengalensis*, *Puntius carnaticus*, *Garra ceylonensis*, *Garra surendranathanai*, *Balitora brucei*, *Bhavania australis* and *Glyptothorax annandalie* were collected from single location each. Among the 6 species collected from the middle streches, *Puntius vittatus* and *Mystus cavasius* were found only from single location each whereas the remaining species were encountered from

multilocations. *Puntius denisoni*, *Puntius fasciatus*, *Barilius bakeri*, *Barilius gatensis*, *Danio malabaricus* and *Garra mullya* were found in the upper and middle streches, among these the distribution of *Puntius fasciatus* alone was found confined to two locations where the rest of the species were found distributed at multilocations. The presence of 20 species were recorded from the lower reaches, among them *Puntius ticto*, *Mystus armatus*, *Wallago attu* and *Heteropneustes fossilis*, *Pseudambassis bacuilis*, *Glossogobius giuris* and *Macropodus cupanus* were found only at single locations while species such as *Labeo dussumieri*, *Amblypharyngodon microlepis*, *Mystus gulio*, *Ompok bimaculates*, *Channa orientalis* and *Channa marulius* were collected from more than two locations. 8 species were found common in the middle and lower streches, among them *Rasbora daniconius*, *Xenentedon cancila* and *Etroplus suratensis* were encountered from two locations each whereas the precence of the rest of the species were encountered from more than two locations.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system: Nil

3.3.2.2. Bharathapuzha river system

A map of Bharathapuzha river basin showing the locations surveyed are given in Fig.3.9.

Fish germplasm resources:

The fish germplasm resources comprised of 63 species belonging to 4 orders, 18 families and 40 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.8. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.10. Order Cypriniformes and Perciformes ranked first and second positions with 37 and 13 species respectively while family Cyprinidae found richest in accommodating maximum number of species (31 species) followed by Bagridae and Balitoridae (4 species each). Genus *Puntius* showed the richest germplasm with a numerical strength of 12 species.

Evaluation of fish germplasm for commercial utilization:

36 species are having all desireable qualities for ornamental, where 20 were food fishes and 8 were cultivable (Fig.3.11).

Biodiversity status:

16 species were belonged to threatened category while 45 were categorized as non-threatened. *Oreochromis mossambicus* was the exotc (Ex). *Homaloptera pillai* and *Mesonemacheilus remadevi* were critically endangered (CR) while 5 species were endangerd (EN) and 6 species belonged to vulnerable category (VU). 22 species were under low risk and nearly threatened (LRnt) while 26 species were under Low risk and least concern (LRlc) category. (Fig.3.12).

Nature of Endemism:

19 species were found endemic to Western Ghats (EN-WG), among them 7 are endemic to rivers of Kerala (EN-K). 7 species endemic to India (EN-I) and 9 to Indian Sub continent (EN-IS). Most importantly, *Homaloptera pillai* and *Mesonemacheilus remadevi* were found strictly endemic to this river system.

Distribution pattern:

The presence of *Garra menoni*, *Bhavania australis*, *Garra surendranathani*, *Nemacheilus denisoni*, *Mesonemacheilus remadevi* and *Homaloptera pillai* were found restricted to the upper reaches while 21 species were restricted to the middle streches whereas the distribution of nine species were confined to the lower streches. 8 species were found common in both upper and middle streches whereas 14 were distributed in both middle and lower streches. *Puntius filamentosus* was the only species found distributed in the upper, middle and lower reaches.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system: Nil

3.3.2.3. Bhavani river system

A map of Bhavani river basin showing the locations surveyed are given in Fig.3.13.

Fish germplasm resources:

The fish germplasm resources comprised of 16 species belonging to a single order, 3 families and 11 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.9. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.14. Families Cyprinidae and Balitoridae were found richest in accommodating maximum number of species with 12 species. *Puntius* and *Barilius* were the genera showing the richest germplasm with a numerical strength of 3 species each.

Evaluation of fish germplasm for commercial utilization:

12 out of the 16 species identified were ornamental while there was only one each of food and cultivable species viz. *Garra gotyla stenorhynchus* and *Puntius carnaticus* respectively (Fig.3.15).

Biodiversity status:

The biodiversity status of the fishes showed that 5 species were threatened while 11 were non-threatened category. *Gonoproktopterus dubius* was found as the only endangered species (EN) of the river system, while *Puntius carnaticus* and *Nemacheilus monilis* were vulnerable (VU). Under the non-threatened category, *Salmostoma boopis*, *Barilius canarensis*, *Nemacheilus denisoni* and *Garra gotyla stenorhynchus* were under Low risk nearly threatened (LRnt) category while 9 species belonged to Low risk least concern (LRlc) category (Fig.3. 16).

Nature of Endemism:

8 species were endemic to the Western Ghats (EN-WG). *Nemacheilus monilis* is endemic to Kerala state (EN-K). Three species were endemic to the Indian region (EN-I) while 2 are endemic to Indian sub continent (EN-IS). No endemic fish species confined to this river system was observed.

Distribution pattern:

The locations sampled and surveyed in this river system were all located at the upper streches. Interestingly, *Puntius filamentosus* and *Salmostoma boopis* were found common in the middle and upper stretches while *Rasbora daniconius* was collected only from the upper streches. 9 species were found only at a single location and *Salmostoma boopis* and *Garra gotyla stenorhynchus* were distributed in two locations whereas *Puntius fasciatus*, *Barilius bakeri*, *Danio malabaricus*, *Rasbora daniconius* and *Garra mullya* were found distributed at 3 locations.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

Gonoproktopterus dubius which was known to be a fish endemic to Kabbini river system was collected from Siruvani locality of Bhavani river system.

3.3.2.4. Chalakkudy river system

A map of Chalakkudy river basin showing the locations surveyed are given in Fig.3.17.

Fish germplasm resources:

The fish germplasm resources comprised of 67 species belonging to 4 orders, 20 families and 32 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.10. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.18. Order Cypriniformes and Perciformes ranked first and second positions with 26 and 14 species respectively while families Cyprinidae and Bagridae were found richest in accommodating maximum number of species with 19 and 9 respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 13 species.

Evaluation of fish germplasm for commercial utilization:

36 were ornamental fishes while 23 were food fishes whereas 7 species were cultivable (Fig.3.19).

Biodiversity status:

15 species belong to threatened category while 49 were non-threatened category whereas 2 were exotic and one species belonged to data defficient category (Fig.3.20). Among the threatened species, 9 were endangered (EN) and 6 were vulnerable (VU). Among the non-threatened category, 34 belonged to Low risk least concern (LRlc) while 15 were categorized under low risk least threatened category (LRnt).

Nature of Endemism:

32 species belonged to endemic category of the Westernghats among them 14 were endemic to Kerala. No species was found strictly endemic to this particular rivers sytem.

Distribution pattern:

Gonoproktopetus kolus, Puntius bimaculates, Osteochilus logidorsalis, Barilius bendelisis, Esomus thermoicos, Garra surendranathani, Puntius dorsalis, Bhavania australis and Travancoria jonesi were collected from the upper starches while *Gonoproktoptersu curmuca, Osteobrama bakeri, P.carnaticus, P.denisoni, Puntius fasciatus, Puntius filamentosus, Puntius jerdoni, Batasio travancoria, Horabagrus nigricollaris, Horabagrus brachysoma, Mystus armatus, Aplocheilus lineatus, Pristolepis marginatus, Etroplus maculatus,Mastacembeles armatus, Tor khudree, Salmostoma boopis, Salmostoma acinaces, Barilius gatensis, Barilius canarensis, Danio malabaricus, Danio aequipinnatis, G.mullya, Nemachelus guentheri,* *Mesonemacheilus triangularis, Lepidocephalus thermalis, Parambassis dayi, Parambassis thomassi, Salarias reticulates, Sicyoptersu griseus* were found in the middle streches whereas the distribution of *Puntius amphibius,Puntius parrah, Puntius chola, Puntius vittatus, Puntius ticto, Puntius sarana subnasutus, Rasbora daniconius, Mystus gulio, Tetradon tancoricus, Anabas testudineus, Channa striatus, Eleotris fusca, Awaous gutum, Oreochromis mossambicus, Etroplus suratensis, Clarias dussumeiri, Xenentedon cancila, Aplocheilus blocki, Microphis cuncalus and Pseudambassis bacuilis* were found in the lower streches. *Puntius carnaticus, Puntius fasciatus, Puntius jerdoni, Tor khudree, Garra mullya, Nemacheilus guntheri, Nemachelius triangularis* and *Heteropneustes* were also encountered from the upper streches. *Gonoproktopterus curmuca, Osteobrama bakeri, Puntius filamentosus, Aplochelus lineatus, Pristolepis marginatus, Salmostoma boopis, Salmostoma acinaces, Parambassis dayi and Parambassis thomassi* were also recorded from the lower stretches. *Xenentedon cancila, Puntius vittatus* and *Rasbora daniconius* were also collected from middle streches. The occurance of *Puntius filamentosus* was observed along the entire stretch while *Danio malabaricus* and *Garra mullya* were found common in the middle. *Gonoproktopterus curmuca* was encountered both in the lower and middle stretches while its occurrence in the upper stretches was quiet sporadic.

Fishes discovered new to science:

Salarias reticulates, a new freshwater blenny belonging to the family *Blennidae* was discovered from Vettilappara during the post monsoon season of 2001 (Kurup *et al.*, 2006).

New additions to the fish germplasm resources of the river system:

Puntius bimaculates and *Batasio travancoria* were the two new additions to the river system.

3.3.2.5. Chaliyar river system

A map of Chaliyar river basin showing the locations surveyed are given in Fig.3.21.

Fish germplasm resources:

The fish germplasm resources comprised of 40 species belonging to 4 orders, 15 families and 29 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.11. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.22. Order Cypriniformes and Perciformes ranked first and second positions with 24 and 10 species respectively while family Cyprinidae found richest in accommodating maximum number of species with 19 species. Genus *Puntius* showed the richest germplasm with a numerical strength of 7 species.

Evaluation of fish germplasm for commercial utilization:

24 species belonged to ornamental category while 12 species are food fishes and 4 as cultivable (Fig.3.23).

Biodiversity status:

5 species belonged to threatened category which require special concern for conservation while 33 fishes were under non threatened category. Of the total threatened fishes, 2 species viz. *Neolissochilus wynadensis* and *Balitora*

mysorensis were endangered (EN) and 3 species were vulnerable (VU) in their status. Of the non-threatened fishes, 14 species were under Low risk nearly threatened (LRnt) and 19 species were under Low risk least concern (LRlc) (Fig.3.24).

Nature of Endemism:

11 species are endemic to Western Ghats (EN-WG) *Pristolepis marginata* and *Tetradon travancoricus* were endemic to Kerala waters (EN-K). 2 species were having a geographical distribution restricted to Indian waters (EN-I) where as 4 species are restricted to the Indian Subcontinent (EN-IS). Only one species belongs to exotic (EX) viz. *Oreochromis mossambicus* wihile no species was found strictly endemic to this river system.

Distribution pattern:

The occurance of 13 species were observed in the upper streches among them *Neolissochilus wynaadensis*, *Garra nilamburensis*, *Balitora mysorensis*, *Mesonemacheilus guentheri* and *Sicyopterus griseus* were encountered from single location each while *Osteochilus nashii*, *Mesonemacheilus triangularis* and *Glyptothorax annandalie* were collected from two locations each. In the middle stretches, the presence of 8 species were encountered, among them, *Rasbora daniconius*, *Amblypharyngodon microlepis* and *Puntius denisoni* were collected from single locations each while the presence of *Puntius amphibius*, *Mystus cavasius*, *Heteropneustes fossilis*, *Pristolepis marginatus* and *Mastacembeles armatus* were encountered from two locations each. *Gonoproktopterus curmuca*, *Puntius fasciatus*, *Danio malabaricus*, *Garra mullya* were found common in both upper and middle streches of the river system. 8 species were found in the lower streches of which *Puntius sarana* *subnasutus*, *Puntius chola*, *Horabagrus brachysoma* and *Tetradon travancoricus* were distributed at single locations while *Puntius ticto* and *Oreochromis mossambicus* were distributed in two locations whereas all the remaining species were collected from multilocations. *Salmostoma boopis*, *Ompok bimaculates*, *Parambassis thomassi* and *Glossogobius giuris* were found in the middle and lower streches while *Puntius filamentosus* was encountered throughout the river system.

Fishes discovered new to Science:

Garra nilamburensis, a new Cyprinid fish under the genus Garra has been described from Arookkallanpuzha, a secondary tributary of Karimpuzha at Mayiladipotty in Nilambur reserve forest (Kurup and Radhkrishnan, in press).

New additions to fish germplasm resources of the river system: Nil

3.3.2.6. Chandragiri river system

A map of Chandragiri river basin showing the locations surveyed are given in Fig.3.25.

Fish germplasm resources:

The fish germplasm resources comprised of 33 species belonging to 4 orders, 12 families and 25 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.12. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.26. Order Cypriniformes ranked first in the numerical strength of species with 18 species followed by Perciformes and Siluriformes with six species each. Family Cyprinidae was found richest in accommodating maximum number of species with 15 species. Genus *Puntius* showed the richest germplasm with a numerical strength of 5 species.

Evaluation of fish germplasm for commercial utilization:

21 species were having the desirable traits to develop as ornamental fishes while 10 were categorized as food fishes whereas 2 species were found to have aquaculture potential (Fig.3.27).

Biodiversity status:

6 species out of the total species collected were having the threatened status and 23 species were coming under non-threatened category. Of the total threatened fishes, viz. *Silurus wynaadensis*, *Nemacheilus petrubenarescu, Labeo nigrescens* and *Brachydanio rerio* were belonging to the endangered category. *Batasio travancoria* and *Mystus malabaricus* were vulnerable. Under the non-threatened fishes, 24 species were under Low risk least concern (LRlc) category while 3 species were under Low risk nearly threatened category (LRnt) (Fig.3. 28).

Nature of Endemism:

11 species were found endemic to Western Ghats (EN-WG) and 2 species were endemic to Kerala waters (EN-K). The distribution of 2 species confined to Indian waters (EN-I) where as 4 were restricted to the Indian Subcontinent (EN-IS). *Oreochromis mossambicus* is the only exotic species (EX) present in the river system. No species was found strictly endemic to this river system.

Distribution pattern:

6 species were found in the upper streches and all of them were distributed in two locations each. 7 species were collected from the middle streches which were encountered from two locations each. The presence of 13 species were

found in both upper and middle streches *Puntius amphibius*, *Puntius vittatus* and *Channa striatus* were collected from the lower streches. Interestingly, *Salmostoma acinaces* was found as the only species common in the middle and lower streches whereas *Puntius filamentosus* was collected from the entire river system.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

Brachydanio rerio and *Mesonemacheilus petrubenarescu* which were known to have distribution in Kabbini river system was discovered from Vettathur and Parappa localities of Chandragiri river system thus showing their presence in a west flowing river system for the first time.

3.3.1.7. Kabbini river system

A map of Kabbini river basin showing the locations surveyed are given in Fig.3.29.

Fish germplasm resources:

The fish germplasm resources comprised of 53 species belonging to 5 orders, 10 families and 30 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.13. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.30. Families Cyprinidae and Balitoridae were found richest in accommodating maximum number of species with 28 and 9 respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 11 species.

Evaluation of fish germplasm for commercial utilization:

26 species were evaluated for ornamental while 20 as food fishes whereas 7 species as cultivable species (Fig.3.31).

Biodiversity status:

18 species belonged to threatened category and 28 species were under non-threatened category. Within the threatened group, *Kantaka brevidorsalis* was placed in the critically endangered category (CR), 10 species were endangered (EN) while 7 as vulnerable (VU). In the non-threatened category, 12 were under low risk nearly threatened (LRnt) and 20 species were under Low risk least concern (LRlc). *Oreochromis mossambicus* represented the introduced category (Intr)(Fig.3.32).

Nature of Endemism:

24 species were demarcated as endemic to Western Ghats (EN-WG), among them 4 were strictly endemic to rivers of Kerala (EN-K) whereas four species were found endemic to India (EN-I) and 5 species were endemic to the Indian Sub continent (IN-IS). *Kantaka brevidorsalis* and *Schistura striatus* were found strictly endemic to Kabbini river system.

Distribution pattern:

26 species were found distributed in the upper streches, among them, the presence of *Labeo kontius*, *Puntius arulius*, *Tor putitora*, *Nemacheilus striatus*, *Glyptothorax annandalie*, *Glyptothorax anamalaiensis* and *Silurus wynaadensis* were restricted to single location each. Among them, *Kantaka brevidorsalis* is critically endangered and all the other species were belong to the endangered cateogory. 8 species were distributed in the ,middle streches of the river system and among them *Cirrhinus mrigala* and *Puntius amphibius*

were restricted to one location each. *Puntius filamentosus* were collected from 2 locations while *Puntius chola* and *Notopterus notopterus* were found in three locations each whereas all other species distributed in the middle streches were collected from more than three locations. *Puntius fasciatus*, *Barilius gatensis*, *Danio malabariucs* and *Mystus armatus* were collected both from upper and middle streches whereas 12 species showed their presence only at the lower streches. Among them, *Puntius ticto*, *Horabagrus brachysoma*, *Mystus gulio*, *Wallago attu*, *Etroplus suratensis* and *Etroplus maculates* were encountered only from one location each while *Puntius vittatus*, *Puntius sarana subnasutus*, *Heteropneustes fossilis*, *Oreochromis mossambicus* and *Channa striatus* were collected from 2 locations each.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

Tor putitora, the great Himalayan species was reported for the first time from a Peninualar India river system, Kabbini. The specimens were collected from a secondary tributary of the river system, Nulpuzha at Muthanga locality. Besides, Labeo *kontius* which was known to be distributed in rivers of Tamilnadu and Karnataka, especially from Cauvery river system was located for the first time from this river system at Muthanga. *Glyptothorax anamalaiensis* reported so far from Anamalai and Chaliyar river systems were encountered from Kuruvadeep locality of Kabbini river system.

3.3.2.8. Kadalundi river system

A map of Kadalundi river basin showing the locations surveyed are given in Fig.3.33.

Fish germplasm resources:

The fish germplasm resources comprised of 23 species belonging to 4 orders, 10 families and 19 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.14. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.34. Order Cypriniformes and Perciformes ranked first and second positions with 12 and 7 species respectively while family Cyprinidae found richest in accommodating maximum number of species with 11 members. Genus *Puntius* showed the richest germplasm with a numerical strength of 5 species.

Evaluation of fish germplasm for commercial utilization:

12 species were having ornamental potential while 9 species were food fishes whereas 2 species were having cultivable importance (Fig.3.35)

Biodiversity status:

Fishes of the river system belong to the non-threatened category, under Low risk and least concern (LRlc).

Nature of Endemism:

10 species are endemic to Western Ghats (EN-WG) of which *Parambassis dayi* and *Pristolepis marginata* were endemic to Kerala (EN-K). 4 species are endemic to Indian Sub continent (EN-IS) and a single species, *Garra mullya* is endemic to India. *Oreochromis mossambicus* was found as the only introduced species (Intr.).

Distribution pattern:

The distribution pattern of fishes in Kadalundi river system showed that *Garra mullya* was the only species restricted to the upstream, in a single location. *Danio malabaricus*, *Ompok bimaculates* and *Aplocheilus lineatus* were distributed in the middle streches and were located from a single location. 7 fish species were found common in the upper and middle streches, among them, *Mystus armatus*, *Parambassis dayi* and *Pristolepis marginata* showed their presence in two locations while *Gonoproktopterus curmuca*, *Puntius fasciatus*, *Barilius gatensis*, *Mesonemacheilus triangularis* and *Mystus armatus* were distributed in three locations. *Puntius sarana subnasutus*, *Xenentedon cancila*, *Anabas testudineus* and *Channa striatus* were distributed in the lower streches of the river system, among them *Anabas testudineus* was the only species found distributed in 2 locations and all other species were collected from one location each. 7 species were collected from the middle and lower streches. *Puntius filamentosus* was the only species collected from all the three streches of this river system.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

This is the pioneer study in this river system. Therefore, all the species collected during the present study are new reports from this river system.

3.3.2.9. Kallada river system

A map of Kallada river basin showing the locations surveyed are given in Fig.3.36.

Fish germplasm resources:

The fish germplasm resources comprised of 41 species belonging to 4 orders, 12 families and 25 genera. The list of fish species collected and

identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.15. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.37. Order Cypriniformes and Perciformes ranked first and second positions with 24 and 9 species respectively while families Cyprinidae and Bagridae were found richest in accommodating maximum number of species with 22 and 4 respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 8 species.

Evaluation of fish germplasm for commercial utilization:

19 species were ornamental, 17 food and 5 species were having cultivable importance (Fig.3.38).

Biodiversity status:

6 species under threatened category and 34 species as non-threatened category. *Oreochomis mossambicus* as the only exotic fish (EX). Within the threatened fishes, *Channa micropeltes* was critically endangered (CR), while *Gonoproktopterus kurali*, *G.thomassi* and *Puntius arulius* were endangered (EN), whereas *Osteobrama bakeri* and *Channa micropeltes* were categorized under vulnerable category (VU). Under non-threatened category, 11 species were coming under Low risk and nearly threatened group (LRnt), 23 species were under Low risk least concern (LRlc) (Fig.3.39).

Nature of Endemism:

16 species were endemic to Western Ghats (EN-WG), among them, the distribution of 5 species were confined to Kerala waters (EN-K). 3 species

were confined to in Indian region (EN-I) and 5 species (EN-IS) were restricted to Indian subcontinent. *Channa micropeltes* was found strictly endemic to this river system.

Distribution pattern:

11 species were restricted to the upper streches, among them, 8 species viz. *Puntius arulius*, *Puntius fasciatus*, *Garra mcClellandi*, *Bhavania australis*, *Glyptothorax annandalie*, *Channa marulius*, *Channa micropeltes* and *Mastacembeles armatus* were restricted to one location each. *MesoMesonemacheilus triangularis* was collected from 3 locations at the upper streches whereas all other species were distributed in more than three locations. The ocurrance of 11 species were restricted to the middle streches, of which, 8 species were distributed to single location each. *Gonoproktopterus kurali*, *Mystus cavasius* and *Mystus gulio* were collected from two locations each. 9 fishes were distributed at the lower reaches of which *Puntius vittatus*, *Puntius sarana subnasutus*, *Heteropneustes fossilis* and *Xenentedon cancila* were distributed at single location each. *Puntius amphibius* and *Puntius ticto* were collected from two locations each at the lower streches while *Puntius filamentosus*, *Oreochrmis mossambicus* and *Glossogobius giuris* were collected from three or more than three locations at the lower strech. *Gonoproktopterus curmuca*, *G. thomassi*, *Barilius bakeri*, *B. gatensis*, *Danio malabaricus*, *Horabagrus brachysoma* and *Ompok bimaculates* were found common both at upper and middle streches while *Parambassis dayi* was collected from lower and middle streches. *Rasbora daniconius* was observed for its uniform presence along the entire river system.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

Gonoproktopterus thomassi, an endangered species whose distribution is so far known only from Kabbini and Chalakkudy was found from Kallada at Thenmala.

3.3.2.10. Karuvannur river system

A map of Karuvannur river basin showing the locations surveyed are given in Fig.3.40.

Fish germplasm resources:

The fish germplasm resources comprised of 18 species belonging to 4 orders, 11 families and 14 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.16. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.41. Order Cypriniformes and Perciformes ranked first and second positions with 9 and 5 species respectively while family Cyprinidae found richest in accommodating maximum number of species with 9 members. Genus *Puntius* showed the richest germplasm with a numerical strength of 5 species.

Evaluation of fish germplasm for commercial utilization:

9 species were ornamental and 9 as food fish category (Fig.3.42).

Biodiversity status:

The fish species belong to non-threatened species among them, *Mastacembeles armatus* was categorized as low risk nearly threatened

(LRnt) category while the remainig 17 species were under Low risk least concern group (LRlc)(Fig.3.43).

Nature of Endemism:

6 species were endemic to Western Ghats (EN-WG) and *Parambassis dayi*, was found as the only species endemic to Kerala (EN-K). 5 were endemic to Indian sub continent (EN-IS), while no species was found strictly endemic to this river system.

Distribution pattern:

Puntius fasciatus was found at the upstream, only from a single location. *Ompok bimaculates* and *Mastacembeles armatus* were collected from the middle streches, which were found restricted to single location each whereas the presence of *Puntius filamentosus*, *Danio malabaricus*, *Danio aequipinnatus* and *MesoMesonemacheilus guentheri* were found common to both the upper and middle streches. *Puntius filamentosus* was collected only from a single location. The ocurrance of *Danio malabaricus* and *Danio aequipinnatus* were found from more than three locations whereas *Mesoemacheilus guentheri* was collected from two locations. 7 species were collected from lower streches of which *Puntius sarana subnasutus*, *Heteropneustes fossilis*, *Xenentedon cancila* and *Channa striatus* were collected only from single locations while the presence of *Nandus nandus*, *Etroplus maculates* and *Mystus gulio* were encountered from two locations each. *Puntius amphibius*, *Rasbora daniconius* and *Parambassis dayi* were collected from the lower and middle streches. *Puntius ticto* was found common to all the three streches of the river system surveyed.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system: Nil

3.3.2.11. Karyangod river system

A map of Karyangod river basin showing the locations surveyed are given in Fig.3.44.

Fish germplasm resources:

The fish germplasm resources comprised of 33 species belonging to 4 orders, 16 families and 25 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.17. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.45. Order Cypriniformes ranked first position with 18 species while families Cyprinidae and Bagridae were found richest in accommodating maximum number of species with 14 and 6 respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 3 species.

Evaluation of fish germplasm for commercial utilization:

Among 33 species collected and identified, 19 were ornamental, 9 were food fishes and 5 species had esteem for its aquacultre potential (Fig.3.46).

Biodiversity status:

3 species were threatened among them *Silurus wynaadensis* was endangered (EN) and *Mystus malabaricus* and *Garra hughi* belong to vulnerable (VU) category. 30 species belonging to non-threatened category,

among them 5 belonged to Low risk nearly threatened (LRnt) and 25 species under Low risk least concern (LRlc)(Fig.3 47).

Nature of Endemism:

17 species are endemic to Western Ghats (EN-WG) while 4 are strictly endemic to Kerala (EN-K). Interestingly, 9 are endemic to the Indian sub continent (EN-IS) and 2 species are endemic to the Indian region (EN-I). No species was found strictly endemic to this particular river system.

Distribution pattern:

7 species were distributed in the upper streches of which *Garra hughi*, *Mesonemacheilus guentheri*, *Silurus wynadensis* and *Glyptothorax annandalie* were found only from single location each while *Tor khudree* and *Mesonemacheilus triangularis* were encountered from two locations each. *Bhavania australis* was collected from more than three locations. 8 species were collected from the middle streches of which *Mystus malabaricus* and *Mastacembeles armatus* were seen only from a single location whereas *Puntius denisoni*, *Lepidocephalus thermalis*, *Ompok malabaricus* were collected from two locations each. The presence of *Salmostoma acinaces*, *Barilius canarensis* and *Rasbora daniconius* were observed from more than two locations. 7 species were found common in upper and middle streches while 6 species were seen both the middle and lower streches whereas *Glossogobius giuris*, *Oreochromis mossambicus* and *Channa striatus* were found distributed in the lower streches of the river system. The ocurrance of *Puntius filamentosus* was seen in all the three streches.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

This is the pioneer study on the fish fauna in this river system. Therefore, all the species collected during the present study are new reports for this river system.

3.3.2.12. Keecheri river system

A map of Keecheri river basin showing the locations surveyed are given in Fig.3.48.

Fish germplasm resources:

The fish germplasm resources comprised of 12 species belonging to 4 orders, 6 families and 11 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.18. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.49. Order Cypriniformes and Perciformes ranked first and second positions with 5 species and 4 species respectively while families Cyprinidae and Cichilidae were found richest in accommodating maximum number of species with 5 and 2 respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 2 species.

Evaluation of fish germplasm for commercial utilization:

5 species are ornamental and 6 species with food value (Fig.3.50)

Biodiversity status:

11 species belonged to Low risk and least concern (LRlc) while *Oreochromis mossambicus* was found as exotic (Intr.)(Fig.3.51)

Nature of Endemism:

4 species are endemic to the Western Ghats (EN-WG) among them *Parambasis dayi* is endemic to Kerala (EN-K). 3 species are endemic to Indian sub continent (EN-IS) where *Oreochromis mossambicus* is the only exotic species (EX). No species was found strictly endemic to this river system.

Distribution pattern:

Puntius amphibius, Mystus gulio, Channa striatus and *Oreochromis mossambicus* were found in the lower streches among them *Mystus gulio, Oreochromis mossambicus* and *Channa striatus* were collected from single locations each while the ocurrence of *Puntius amphibius* was observed from three locations. *Ompok bimaculates* was collected from the middle strech while *Barilius gatensis*, *Rasbora daniconius*, *Parambassis dayi* and *Etroplus maculates* were found common in the middle and lower streches. *Puntius filamentosus, Danio malabaricus* and *Xenentedon cancila* were found common in all the three streches.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system: Nil

3.3.2.13. Kuppam river system

A map of Kuppam river basin showing the locations surveyed are given in Fig.3.52.

Fish germplasm resources:

The fish germplasm resources comprised of 34 species belonging to 4 orders, 15 families and 25 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.19. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.53. Order Cypriniformes and Perciformes ranked first and second positions with 17 species and 8 species respectively while families Cyprinidae and Bagridae were found richest in accommodating maximum number of species with 13 and 5 respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 4 species.

Evaluation of fish germplasm for commercial utilization:

20 species were having high ornamental value while 10 were food fishes whereas 4 fish species offer scope for development for aquaculture (Fig.3.54).

Biodiversity status:

The biodiversity status of the fishes assessed showed that *Garra hughi, Batasio travancoria and Mystus malabaricus* are coming under vulnerable (VU) category. Under the non-threatened category there were 31 fish species, 4 of which belong to Low risk nearly threatened (LRnt) while 27 belong to low risk least concern category (LRlc)(Fig.3.55).

Nature of endemism:

17 species are endemic to Western Ghats (EN-WG), among them 6 are endemic to Kerala (EN-K). 2 species are found endemic to Indian region (EN-I) while 7 are endemic to Indian sub continent (EN-IS). No species was found strictly endemic to this river system.

Distribution pattern:

9 species were found restricted at the upper streches, among them, the presence of *Tor khudree*, *Mesonemacheilus triangularis* and *Garra hughi* were observed at a single location. *Bhavania australis* and *Lepidocephalus thermalis* were distributed in three locations each. *Mastacembeles armatus* was the single species distributed only in the middle streches. *Gonoproktopterus curmuca*, *Puntius fasciatus*, *Salmostoma acinaces*, *Barilius bakeri*, *Barilius gatensis* and *Danio malabaricus* were distributed in the upper and middle streches whereas 7 species were distributed in the middle and lower streches. 6 species were distributed only in the lower streches, among them *Puntius vittatus*, *Horabagrus brachysoma* and *Channa striatus* were collected from single locations whereas the ocurrence of *Puntius amphibius*, *Mystus gulio* and *Mystus armatus* were seen from 2 locations each. *Puntius filamentosus*, *Rasbora daniconius*, *Garra mullya*, *Ompok bimaculates* and *Clarias dussumieri* were collected from the upper, middle and lower streches.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

This is the pioneer study in this river system. Therefore, all the species collected during the present study are new reports for this river system.

3.3.2.14. Manimala river system

A map of Manimala river basin showing the locations surveyed are given in Fig.3. 56.

Fish germplasm resources:

The fish germplasm resources comprised of 28 species belonging to 4 orders, 8 families and 22 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.20. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.57. Order Cypriniformes and Siluriformes ranked first and second positions with 17 and 6 species respectively while family Cyprinidae was found richest in accommodating maximum number of species with 14 members. Genus *Puntius* showed the richest germplasm with a numerical strength of 6 species.

Evaluation of fish germplasm for commercial utilization:

14 species were having high food value while 13 species were ornamental. *Labeo dussumieri* was identified as having high cultivable importance (Fig.3.58).

Biodiversity status:

Labeo dussumeiri and *Wallago attu* belonged to threatened category, under the vulnerable group (VU). 11 species belong to non- threatened category, among them 3 were under Low risk and least concern (LRlc) category while 23 species were Low risk and nearly threatened category (LRnt)(Fig.3.59).

Nature of Endemism:

12 species are endemic to Western Ghats (EN-WG) while *Oreochromis mossambicus* represented as the single exotic (EX) category. No species was found strictly endemic to this river system.

Distribution pattern:

Mesonemacheilus guentheri, *Mesonemacheilus triangularis* and *Lepidocephalus thermalis* were found to inhabit in the upper reaches, whose presence was recorded from single location each. *Gonoproktopterus curmuca* and *Labeo dussumieri* were encountered from the middle streches while 9 species were observed in the lower streches. 4 species were found common in the upper and middle streches among them *Puntius fasciatus* was distributed in 4 locations. The fish fauna of the lower streches were represented by 9 species of which *Puntius vittatus*, *puntius ticto*, *Amblypharyngodon microlepis*, *Horabagrus brachysoma*, *Ompok bimaculates*, *Wallago attu*, *Clarias dussumieri*, *Heteropneustes fossilis* and *Channa striatus* recorded only from single location each. 5 species were found common in the middle and also at the lower streches whereas *Puntius filamentosus* was the only species found common in all the three streches.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system: Nil

3.3.2.15. Meenachil river system

A map of Meenachil river basin showing the locations surveyed are given in Fig.3.60.

Fish germplasm resources:

The fish germplasm resources comprised of 21 species belonging to 4 orders, 12 families and 16 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system

and nature of endemism are given in Table 3.21. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.61. Order Cypriniformes and Perciformes ranked first and second positions with 12 and 5 species respectively while families Cyprinidae and Cichilidae were found richest in accommodating maximum number of species with 10 and 3 respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 4 species.

Evaluation of fish germplasm for commercial utilization:

12 species were ornamental while 9 were food fishes (Fig.3.62).

Biodiversity status:

Puntius ophicephalus and *Nemacheilus keralensis* were endangered (EN). 18 species belong to non-threatened category. Among the non-threatened species, 5 were under Low risk nearly threatened (LRnt) and 13 were under Low risk least concern (LRlc). *Oreochrmis mossambicus* was found as exotic (Fig.3.63).

Nature of Endemism:

10 species were restricted to Western Ghats (EN-WG) among them *Nemacheilus keralensis*, *Puntius ophicephalus* and *Pristolepis marginatus* were endemic to Kerala (EN-K). Four species were endemic to Indian sub continent (EN-IS) and a single species, *Garra mulla* was found to be endemic to Indian region (EN-I). *Oreochromis mossambicus* was found as exotic. No species was found strictly endemic to this river system.

Distribution pattern:

Puntius ophicephalus and *Nemacheilus keralensis* were found highly endemic to the upper streches, which were collected from single location each. *Puntius sarana subnasutus*, *Salmostoma acinaces*, *Mesonemacheilus triangularis* and *Mystus cavasius* were found distributed in the middle streches. The presence of these species were confined to single locations each. Five species viz. *Brilius bakeri*, *Barilius gatensis*, *Danio malabaricus*, *Garra mullya* and *Mastacembeles armatus* were found distributed in the upper and middle streches while the presence of *Puntius filamentosus*, *Puntius ticto*, *Ompok bimaculates*, *Heteropneustes fossilis*, *Xenentedon cancila* and *Parambassis dayi* were recorded from the middle and lower streches. The distribution of *Pristolepis marginata*, *Etroplus maculates* and *Oreochromis mossambica* were found only in the lower streches while *Rasbora daniconius* was the only species found common in all the three streches.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

Nemacheilus keralensis, the threatened species has so far known only from upstreams of Kabbini and Periyar was encountered from Vagamon locality. Besides, the endangered fish species *Puntius ophicephalus* which was so far been known only from upstreams of Periyar river system was encountered from Vazhikkadavu region of this river system.

3.3.2.16. Moovattupuzha river system

A map of Moovattupuzha river basin showing the locations surveyed are given in Fig.3.64.

Fish germplasm resources:

The fish germplasm resources comprised of 28 species belonging to 3 orders, 11 families and 19 genera. The list of fish species collected and

identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.22. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.65. Order Cypriniformes and Perciformes ranked first and second positions with 17 species and 6 species respectively while families Cyprinidae and Bagridae were found richest in accommodating maximum number of species with 17 and 4 respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 6 species.

Evaluation of fish germplasm for commercial utilization:

18 were ornamental, 9 as food fishes while *Wallago attu* belonged to cultivable category (Fig.3.66).

Biodiversity status:

3 species belong to threatened category while 24 were under non-threatened category. Within the threatened group, *Glyptothorax madraspatnam* was the only endangered species (EN) while *Chela fasciata* and *Wallago attu* as vulnerable fishes (VU). Under the non-threatened group, 3 belonged to Low risk nearly threatened category (LRnt) while 21 belonged to the Low risk least concern group (LRlc). (Fig.3.67).

Nature of Endemism:

7 species were endemic to Western Ghats (EN-WG) while 3 were endemic to Indian sub continent (EN-IS). *Garra mullya* was endemic to Indian region. No species was found strictly endemic to Kerala or this particular river system.

Distribution pattern:

Among the 8 species found at the upper streches, *Puntius fasciatus*, *Garra mullya*, *Garra emarginata*, *Mesonemachelus guentheri*, *Mesonemacheilus triangularis* and *Glyptothorx madraspatnam* were collected from a single location. *Barilius bakeri* and *Barilius gatensis* were collected from 2 locations each at the middle streches. The presence of *Salmostoma boopis*, *Pristolepis marginata* and *Mastacembeles armatus* were confined to middle streches of which the presence of *P.marginata* was observed only from a single location whereas the other two were collected from two locations each. *Gonoproktopterus curmuca* and *Danio malabaricus* were collected from the upper and middle streches. The occurrance of Puntius *chola*, *Chela fasciata*, *Wallago attu*, *Xenentedon cancila* and *Channa striatus* were found restricted to the lower streches of which *Xenentedon cancila* was collected from 2 locations whereas the remaining species were observed from one location each. 7 species were found common in both and lower streches of the river system while *Puntius filamentosus* and *Rasbora daniconius* were observed as common species in all the three streches.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system: Nil

3.3.2.17. Nileswaram river system

A map of Nileswaram river basin showing the locations surveyed are given in Fig.3.68.

Fish germplasm resources:

The fish germplasm resources comprised of 16 species belonging to 4 orders, 9 families and 12 genera. The list of fish species collected and

identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.23. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.69. Order Cypriniformes and Siluriformes ranked first and second positions with 8 and 2 species respectively while family Cyprinidae was found richest in accommodating maximum number of species with 7 members. Genus *Puntius* showed the richest germplasm with a numerical strength of 4 species.

Evaluation of fish germplasm for commercial utilization:

11 were ornamental, 4 as food fishes while *Clarias dussumieri* is endowed with aquaculture potential (Fig.3.70).

3. Biodiversity status:

Only non-threatened category among them *Clarias dussumeiri* was under Low risk nearly threatened while 15 species were under Low risk least concern category (Fig.3.71).

Nature of Endemism:

5 species were endemic to Western Ghats (EN-WG) among them *Parambassis dayi* alone is restricted to Kerala (EN-K). 5 fish species were endemic to the Indian sub continent (EN-IS) and *Clarias dussumeiri* is the only species found endemic to Indian region (EN-I). No species was found strictly endemic to this river system.

Distribution pattern:

The presence of *Danio malabaricus* was found in the upper streches while *Puntius fasciatus* was collected from both upper and middle streches. The occurrence of *Puntius filamentosus, Salmostoma acinaces, Lepidocephalus thermalis, Clarias dussumeiri, Channa striatus, Xenentedon cancila* and *Aplocheilus lineatus* were found from the middle streches. The presence of *Mystus gulio, Parambasis dayi, Etroplus suratensis* and *Etroplus maculates* were encountered from the lower streches. *Rasbora daniconius* was found common at middle and lower streches.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

This is the pioneer study in this river system. Therefore, all the species collected during the present study are new reports for this river system.

3.3.2.18. Pamba river system

A map of Pamba river basin showing the locations surveyed are given in Fig.3.72.

Fish germplasm resources:

The fish germplasm resources comprised of 55 species belonging to 5 orders, 16 families and 32 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.24. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.73. Order Cypriniformes and Perciformes ranked first and second positions with

32 and 13 species respectively while families Cyprinidae and Bagridae were found richest in accommodating maximum number of species with 28 and 5 respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 9 species.

Evaluation of fish germplasm for commercial utilization:

25 were ornamental, 19 as food fishes and 11 species were cultivable (Fig.3.74).

Biodiversity status:

10 species were threatened vulnerable category while 42 were under non-threatened. *Cyprinus carpio* as exotic fish species. Among the non-threatened category, 3 species as under Low risk nearly threatened (LRnt) while 39 species as Low risk least concern (LRlc) group (Fig.3. 75).

Nature of Endemism:

18 species were endemic to Western Ghats (EN-WG) of which 8 species are strictly endemic to Kerala waters (EN-K). Three species have a geographical distribution confined to Indian waters (EN-I) while 6 species (EN-IS) were endemic to Indian subcontinent. No species was found strictly endemic to this river system.

Distribution pattern:

10 species were found in the upper streches of which *Cyprinus carpio*, *Garra surendranathani*, *Bhavania australis*, *Mesonemachelius triangularis*, *M. guentheri* and *Lepidocephalus therrmalis* were collected from single location each while *Puntius fasciatus* was collected from two locations and *Barilius bakeri* and *B. gatensis* were collected from more than two locations. The presence of *Puntius vittatus*, *Pristolepis marginatus* and *Etroplus maculates*

were found in the middle streches among them the occurrence of *Puntius vittatus* was observed from a single location while the remaining species were collected from two locations each. 7 species were restricted to the upper and middle streches of the river system of which *Gonoproktopterus curmuca*, *Danio aequipinnatus*, *Batasio travancoria* and *Glossogobius giuris* were collected from two locations each. 20 species were distributed in the lower streches among them, 11 species were distributed in single location each at the lower streches. 8 species were distributed in the upper and middle streches and *Puntius filamentosus* was the only species found common in all the three streches.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

Mystus menoda (Hamilton) whose distribution is so far known from Maharashtra and Gujarat states was found as a new addition to fish faua of Kerala by encountering from this river system. The specimens were collected from Prayikkara locality of this river.

3.3.2.19. Pambar river system

A map of Pambar river basin showing the locations surveyed are given in Fig.3.76.

Fish germplasm resources:

The fish germplasm resources comprised of 26 species belonging to 3 orders, 9 families and 16 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system

and nature of endemism are given in Table 3.25. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.77. Order Cypriniformes and Siluriformes ranked first and second positions with 19 and 4 species respectively while families Cyprinidae and Balitoridae were found richest in accommodating maximum number of species with 13 and 5 respectively. Genus *Nemacheilus* showed the richest germplasm with a numerical strength of 5 species.

Evaluation of fish germplasm for commercial utilization:

18 species were ornamental and 5 as food fishes while 3 species were having aquaculture potential (Fig.3.78).

Biodiversity status:

9 species were threatened and 15 as non-threatened. *Oreochromis mossambicus* is the single exotic species of this river system. Among the threatened fishes, *Nemacheilus pambarensis* was critically endangered whereas *Barilius bendelisis* and *Pseudeutropius mitchelli* were belonged to endangered category (EN). 6 species were vulnerable (VU). Under the non-threatened, 4 species as Low risk nearly threatened (LRnt) category while 11 species under Low risk and least concern category (LRlc) (Fig.3.79).

Nature of Endemism:

14 species were restricted to the Western Ghat region (EN-WG) alone among them *Pristolepis marginatus, Garra hughi, Nemacheilus pambarensis* and *Batasio travancoria* were restricted to Kerala only (EN-K). Five species were endemic to Indian region (EN-I) while 3 are restricted to Indian sub continent (EN-IS). *Oreochromis mossambicus* is the only exotic fish (EX) species. No species was found strictly endemic to this river system.

Distribution pattern:

The upstream region of this river system belongs to Kerala and therefore only surveyed and the fishes collected include *Puntius carnaticus*, *Puntius fasciatus*, *Danio malabaricus*, *Garra gotyla stenorhynchus*, *Garra mullya* and *Garra hughi* were seen from multilocations while *Tor remadevii*, *Barilius bakeri*, *Barilius gatensis*, *Garra mcClellendi* and *Oreochromis mossambicus* were encountered from two locations whereas the occurrence of the remaining species were found restricted to one location each.

Fishes discovered new to Science:

Tor remadevii, a new species under the genus *Tor* has been described based on the specimens collected from Chambakkad and Koottar.

New additions to fish germplasm resources of the river system:

Pseudeutropius mitchelli, the endangered fish species so far known only from Periyar river system has been encountered from this river system at Chinnar in the Chinnar Wild Life Sanctuary.

3.3.2.20. Periyar river system

A map of Periyar river basin showing the locations surveyed are given in Fig.3.80.

Fish germplasm resources:

The fish germplasm resources comprised of 77 species belonging to 7 orders, 19 families and 42 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.26. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.81.

Order Cypriniformes and Siluriformes ranked first and second positions with 44 and 14 species respectively while families Cyprinidae and Balitoridae were found richest in accommodating maximum number of species with 33 and 10 respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 8 species.

Evaluation of fish germplasm for commercial utilization:

40 species were ornamental, 25 as food fish species while 11 were having cultivable traits (Fig.3.82).

Biodiversity status:

21 species belonged to threatened category while 48 species were non-threatened. Under the threatened group, *Gonoproktopterus micropogon periyarensis*, *Crossocheilus periyarensis* and *Lepidopygopsis typus* were having the status of critically endangered (CR), while 13 species were belonged to endangered (EN) and there are 5 species under the vulnerable category (VU). Among the 48 non-threatened species, 37 were under Low risk least concern category (LRlc) while 11 species were under Low risk nearly threatened category (LRnt). *Oreochromis mossambicus* and *Cyprinus carpio* belonged to the exotic category (Intr.). (Fig.3.83).

Nature of Endemism:

36 species were endemic to Western Ghats (EN-WG) of which 21 species were strictly endemic to Kerala waters (EN-K). *Cyprinus carpio* and *oreochromis mossambicus* were exotic (EX), 5 species were found as endemic to Indian waters (EN-I) where as 9 species were endemic to Indian subcontinent. *Gonoproktopterus micropogon periyarensis*, *Garra periyarensis*, *Crossocheilus periyarensis*, *Mesonemacheilus menoni* and

Lepidopygopsis typus were found strictly endemic to the Periyar Tiger Reserve of Periyar river system.

Distribution pattern:

10 species were restricted to the upper streches. The presence of *Cyprinus carpio*, *Gonoproktopterus thomassi* and *Garra mlapparaensis* were found restricted to single location each while *Oreonectes keralensis* and *Mesonemacheilus periyarensis* were restricted to two locations each and all other species were distributed in multilocations at the upper streches. 32 species were distributed in the middle streches of which 24 species were restricted to one location each. *Labeo nigrescens*, *Garra ceylonensis*, *Garra emarginata*, *Horabagrus brachysoma* and *Glyptothorax annandalie* were found from two locations each. 13 species were found commonly present in the upper and middle streches, whose occurrence were registered from more than three locations. The occurrence of *Osteobrama bakeri*, *Puntius sarana subnasutus*, *Mystus gulio* and *Aplocheilus blocki* were observed from the lower streches. 12 species were found common in the middle and lower streches, among them *Puntius amphibius*, *Ompok bimaculates*, *Ompok malabaricus*, *Heteropneustes fossilis*, *Parambassis thmassi*, *Pristolepis marginata* and *Etroplus suratensis* were found in two locations each whereas the remaining species were observed from more than two locations. *Puntius fialmentosus*, *Rasbora daniconius* and *Oreochromis mossambicus* were found common in all the three streches whose occurrence were encountered from more than three locations.

Fishes discovered new to Science:

Five species viz. *Nemachelus periyarensis*, *Garra emarginata*, *Garra mlapparaensis*, *Homaloptera silasi* and *Garra travancoria* were discovered as species new to science from this river system. Among them, *N.periyarensis* was collected from Periyar lake and Thannikkudy of Periyar Tiger Reserve while *Garra mlapparaensis* was collected from Mlappara and *G. travancoria* from Moolavaigae of Periyar Tiger Reserve. *Garra emarginata* was collected from Pooyamkutty of the Muthirappuzha tributary of Periyar river system.

New additions to fish germplasm resources of the river system:

Travancoria elongata, *Osteochilus longidorsalis* and *Horabagrus nigricollaris* so far known in Chalakkudy river system and *Gonoproktopterus thomassi* from Kabbini river system were recorded from this river system served as new addition to this river system. All these species were collected from the Pooyamkutty region of Muthirappuzha tributary of the river system.

3.3.2.21. Peruvamba river system

A map of Peruvamba river basin showing the locations surveyed are given in Fig.3.84.

Fish germplasm resources:

The fish germplasm resources comprised of 22 species belonging to 4 orders, 14 families and 17 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.27. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.85.

Order Cypriniformes and Perciformes ranked first and second positions with 11 and 5 species respectively while families Cyprinidae and Cichilidae were found richest in accommodating maximum number of species with 10 and 3 respectively. Genus *Puntius* showed the richest germplasm with a numerical strength of 4 species.

Evaluation of fish germplasm for commercial utilization:

13 species were ornamental, 7 species as food and 2 species having aquaculture potential (Fig.3.86).

Biodiversity status:

All the species collected from this river system belonged to non-threatened category while 2 species were under Low risk nearly threatened category whereas 20 species are under Low risk least concern group (Fig.3.87).

Nature of Endemism:

8 species were endemic to Western Ghats (EN-WG) among them, *Parambassis dayi* was restricted to Kerala region. 6 species were endemic to Indian sub continent (EN-IS) while 2 species were endemic to Indian region (EN-I). *Oreochromis mossambicus* was the only exotic species. No species could be identified strictly endemic to this particular river system.

Distribution pattern:

The presence of 6 species were found in the upper streches of which *Garra mcClellendi*, *Clarias dussumeiri* and *Heteropneustes fossilis* were collected from single locations each. *Xenentedon cancila* was collected from a single location at the middle streches. Four species were collected from the lower streches of which the presence of *Ompok bimaculates* and *Oreochromis mossambicus* were encountered only from single location each while *Puntius* *amphibius* and *Channa striatus* were recorded from two locations each. *Danio malabaricus* was found common to both upper and middle streches of the river system. Eight species were distributed both at the middle and lower streches. *Puntius filamentosus* and *Lepidocephalus thermalis* were collected from all the three streches.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

This is the pioneer study in this river system. Therefore, all the species collected during the present study are new reports for this river system.

3.3.2.22. Puzhaykkal river system

A map of river Puzhakkal basin showing the locations surveyed are given in Fig.3.88.

Fish germplasm resources:

The fish germplasm resources comprised of 20 species belonging to 5 orders, 10 families and 15 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.28. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.89. Order Cypriniformes and Perciformes ranked first and second positions with 8 and 4 species respectively while family Cyprinidae was found richest in accommodating maximum number of species with 8 members. Genus *Puntius* showed the richest germplasm with a numerical strength of 5 species.

Evaluation of fish germplasm for commercial utilization:

9 species each as ornamental and food while 2 species were cultivable (Fig.3.90).

Biodiversity status:

Channa marulius was the only threatened species, coming under vulnerable (VU) category while 19 species belonged to non-threatened category. *Mastacembeles armatus* of this river system belonged to Low risk nearly threatened (LRnt) group while 18 species were under low risk and least concern (LRlc) category (Fig.3.91).

Nature of Endemism:

6 species were endemic to Western Ghats (EN-WG) and among them *Parambassis dayi* and *Pristolepis marginatus* were having restricted distribution in Kerala (EN-K). 4 species have a geographical distribution in Indian sub continent (EN-IS). No species was found strictly endemic to this river system.

Distribution pattern:

Species such as *Garra mullya* and *Pristolepis marginata* were found strictly inhabiting the upper streches and both were collected from single locations each. No species could be collected from the middle streches. *Danio malabaricus* showed distribution in the upper and middle streches of the river system.16 species were collected from the lower streches of the river system among them 15 were recorded from a single location while *Xenentedon cancila* was the only species found in the two locations at the downstream.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system: Nil .

3.3.2.23. Shiriya river system

A map of Shirya river basin showing the locations surveyed are given in Fig.3.92.

Fish germplasm resources:

The fish germplasm resources comprised of 13 species belonging to 6 orders, 9 families and 11 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.29. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.93. Order Cypriniformes and Siluriformes ranked first and second positions with 6 and 3 species respectively while family Cyprinidae was found richest in accommodating maximum number of species with 6 members. Genus *Puntius* showed the richest germplasm with a numerical strength of 3 species.

Evaluation of fish germplasm for commercial utilization:

7 were ornamental while 6 were having importance as food fishes (Fig.3.94).

Biodiversity status:

2 speceis belonged to threatened category and 11 under non-threatened. Of the threatened fishes, *Silurus wynadensis* was endangered (EN) while *Mystus malabaricus* was vulnerable (VU). Under the non-threatened category, all the 11 species were belonging to the Low risk least concern category (LRlc) (Fig.3.95).

Nature of Endemism:

5 species were found to be endemic to Western Ghats (EN-WG) and among them *Mystus malabaricus*, *Silurus wynadensis* and *Parambassis dayi* were endemic to Kerala (EN-K). 3 species were endemic to Indian sub continent while *Garra mullya* was endemic to Indian region (EN-I). No species was found strictly endemic to this river system.

Distribution pattern:

Silurus wynaadensis was found strictly restricted to the upper stretches whose presence was recorded only from a single location. *Garra mullya* and *Danio malabaricus* were distributed at the middle and upper streches of the river system. *Puntius vittatus*, *Mystus gulio* and *Aplocheilus lineatus* were found from the lower streches of the river system. The occurrence of *Xenentedon cancila*, *Mystus malabaricus*, *Parambassis dayi* and *Etroplus suratensis* were found in the middle and lower streches of the river system and all of them were restricted to single location each. *Puntius fasciatus*, *Puntius filamentosus* and *Rasbora daniconius* were found in all the three streches.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

This is the pioneer study in this river system. Therefore, all the species collected during the present study are new reports for this river system.

3.3.2.24. Tirur river system

A map of Tirur river basin showing the locations surveyed are given in Fig.3.96.

Fish germplasm resources:

The fish germplasm resources comprised of 15 species belonging to 4 orders, 9 families and 12 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system and nature of endemism are given in Table 3.30. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.97. Order Perciformes and Cypriniformes ranked first and second positions with 7 species 6 species respectively while family Cyprinidae was found richest in accommodating maximum number of species with 6 members. Genus *Puntius* showed the richest germplasm with a numerical strength of 4 species.

Evaluation of fish germplasm for commercial utilization:

8 species were ornamental while 7 as high valued food fish. No species could be identified as having aquaculture importance (Fig.3.98).

Biodiversity status:

All species belonged to Low risk least concern (LRLc) category.

Nature of Endemism:

6 species were endemic to Western Ghats (EN-WG), among them, *Parambassis dayi* and *Pristolepis marginatus* were having restricted distribution in the rivers of Kerala only (EN-K). Three species were endemic to the Indian sub continent (EN-IS). No species was found strictly endemic to this river system.

Distribution pattern:

No species could be found strictly endemic to the upper streches. The occurrence of *Puntius fasciatus*, *P. ticto*, *Xenentedon cancila* and *Parambassis dayi* were recorded only from the middle streches of which *Puntius fasciatus*, *P. ticto* and *Parambassis dayi* were collected from only a single location. *Danio malabaricus* was found common both in the upper and middle streches. 8 species were found to be distributed in the lower streches of which *Mystus armatus*, *Anabas testudineus*, and *Mastacembeles armatus* were collected only from single location each. *Rasbora daniconius* was collected from middle and lower streches of the river system while *Puntius filamentous* was collected from upper, middle and lower streches of the rive system.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

This is the pioneer study in this river system. Therefore, all the species collected during the present study are new reports for this river system.

3.3.2.25. Valapatnam river system

A map of Valapatnam river basin showing the locations surveyed are given in Fig.3.99.

Fish germplasm resources:

The fish germplasm resources comprised of 46 species belonging to 5 orders, 17 families and 33 genera. The list of fish species collected and identified from the river system together with the local name, location from where the species were encountered and their stretch wise availability, evaluation for commercial utilization, biodiversity status in the river system

and nature of endemism are given in Table 3.31. The numerical strength of different families of fishes inhabit in the river system is depicted in Fig.3.100. Order Cypriniformes and Perciformes ranked first and second positions with 24 and 11 species respectively while family Cyprinidae was found richest in accommodating maximum number of species with 20 members. Genus *Puntius* showed the richest germplasm with a numerical strength of 7 species.

Evaluation of fish germplasm for commercial utilization:

Of the total 46 species collected and identified, 28 species were ornamental, 13 food fishes and 5 species are having cultivable importance (Fig.3.101).

Biodiversity status:

6 species were threatened among them *Puntius jerdoni*, *Microphis cuncalus* and *Osteochilus nashii* were endangered (EN) while *Osteobrama bakeri*, *Chela fasciata* and *Sicyopterus griseus* were vulnerable (VU). Among the non-threatened species, 7 were under Low risk and nearly threatened (LRnt) while 32 species belonged to Low risk least concern (LRlc) category. *Oreochromis mossambicus* was found as the only exotic species (Fig.3.102).

Nature of Endemism:

13 species as endemic to Western Ghats (EN-WG) among them *Puntius denisoni*, *Horabagrus brachysoma*, *Parambassis dayi*, *Pristolepis marginatus* and *Tetradon travancoricus* were endemic to Kerala (EN-K). 6 species were found endemic to Indian sub continent (EN-IS) and 3 species were endemic to India (EN-I). No species was found strictly endemic to this river system.

Distribution pattern:

8 species were distributed in the upper streches of which *Osteobrama bakeri*, *Labeo calbasu*, *Puntius jerdoni*, *Chela fasciata*, *Bhavania australis* and *Osteochilus nashii* were collected from single locations each. 13 species were distributed in the middle streches of which *Megalops cyprinoides*, *Mesonemacheilus guentheri*, *Ompok malabaricus*, *Clarias dussumeiri*, *Heteropneustes fossilis*, *Microphis cuncalus*, *Ambassis gymnocephalus*, *Pristolepis marginatus*, *Etroplus suratensis*, *Channa striatus* and *Mastacembeles armatus* were distributed at single locations each. *Mesonemacheilus triangularis* and *Mystus armatus* were distributed in two locations at the middle streches. 8 species were distributed in the middle and upper streches while 6 species were found at the lower streches and 8 species were recorded from the middle and lower streches.

Fishes discovered new to Science: Nil

New additions to fish germplasm resources of the river system:

This is the pioneer study for the fish fauna in this river system. Therefore, all the species collected during the present study are new reports of this river system.

3.3.3. Nature and level of fish species diversity - A comparitive study among river systems of Kerala:

While studying the type of species diversity exist in the river systems by comparing the river systems and observing the similarities or dissimilarities in species diversity based on the Jaccard's similarity coefficient and the dendrogram thus obtained, a distinct variation was found in the nature of fish fauna between east fowing and west flowing river systems. Within the west flowing river systems, 2 major groups could be differentiated, the former representing river systems with total length and catchment areas above average while the latter represents smaller river systems having total length and catchment areas below average. Highest similarities were observed between Nileswaram and Peruvamba (0.7) river systems followed by Kuppam and Chandragiri and Achenkoil and Pamba (<0.6). Relatively high similarity was also observed between the river systems Chalakkudy and Valapatnam (>0.6), Chaliyar and Kallada (<0.6) Puzhaykkal and Tirur (>0.5). An inverse relationship was observed in the increase of distance between the river systems in the dendrogram and the dissimilarity of species and therefore, in compliance with this, least similarity observed was between Chalakkudy and Pambar river systems. Interestingly, Kabbini river system showed more similarity with west flowing rivers in the nature of fish fauna, however, its similarity with the major west flowing river systems were only <40% and that with the smaller river systems were only 30%. The other east flowing rivers, Bhavani and Pambar have a similarity of only 30% and their similarity with Kabbini was only 20% (Fig.3.103).

While comparing the river systems based on species level diversity, Periyar river system showed richest fish species diversity in terms of total number of species, endemic fishes of Kerala, endemic to the particular river system, number of critically endangerd and endangered species and was also charecterised by the highest river index value of 512.2. Chalakkudy river system occupied second position in terms of total number of species, number of ornamental fishes, number of endemic fishes of Kerala and recorded an index value of 301.5. This is followed by Bharathapuzha river system with an index value 262 and abound 7 endemic fishes of Kerala besides 2 species endemic to this particular river system. Kabbini river system stands next with an index value of 215.5, is endowed with 4 endemic species of Kerala and 2 endemic species unique to this river system. Pamba, Achenkoil, Kallada and Valapatnam river systems were the other river systems showing relatively rich species diversity as indicated by their indices values 200.5,179, 161.5 and 150.5 respectively, while Kuppam, Chaliyar, Karyangod, Chandragiri and Pambar river systems have moderate species diversity with indices values of 129, 106, 108.5, 92 and 109.5 respectively. All other river systems were having low indices values and these were showing low species diversity (Fig.3.104). It would thus appear that Chalakkudy, Kabbini, Bharathapuzha and Periyar were "excellent" as hot spots of fish diversity and Pamba, Achenkoil, Kallada and Valapatnam were 'Good' while Kuppam, Chaliyar, Karyangod, Chandragiri and Pambar river systems were 'moderate'. Bhavani, Kadalundi, Karuvannur, Keecheri, Nileswaram, Peruvamba, Shiriya and Tirur were found as 'poor' owing to their poor species diversity. The areas harbouring rich species diversity and deserving immediate protection were demarcated for each river system. While comparing the river systems based on the river index values per km^2 of the catchment area of the river systems, a different picture is emerging (Fig.3.105). Tirur river system, which was one among those recorded low index value, showed highest (0.38) whih is followed by Pambar (0.29), Kuppam (0.27), Karyangod (0.25). Nileswaram, Puzhaykkal and Shiriya also recorded relatively high indices values, 0.21,0.2,0.2 respectively. Karuvannur (0.04), Moovattupuzha (0.04) and

Chaliyar (0.041) were showing lowest index values per km^2. The large and highly diversified river system such as Periyar (0.094), Bharathapuzha (0.06), Pamba (0.089), Achenkoil (0.012) were showing only low indices values (Table 3.32).

3.3.4. Regional and longitudinal distribution of freshwater fishes of Kerala – A comparison between river systems

While comparing the fishes from different river systems based on the regional distribution, it was found that species such as *Puntius filamentosus* and *Rasbora daniconius* of the order Cypriniformes and family Cyprinidae were found abundant in all the river systems and therefore emerged as species having wide range of distribution. On the otherhand, *Danio malabaricus* of the same family was collected from 24 river systems. *Puntius fasciatus*, *Garra mullya*, *Xenentedon cancila*, *Barilius gatensis*, *Etroplus maculates* and *Channa striatus* were found distributed in 23 river systems and *Gonoproktopterus curmuca*, *Barilius bakeri*, *Puntius amphibius*, *Puntius ticto*, *Puntius sarana subnasutus*, *Mesonemacheilus guentheri*, *N.triangularis* and *Ompok bimaculates* were distributed in 15-20 river systems. *Puntius denisoni*, *Tor khudree*, *Bhavania australis*, *Horabagrus brachysoma*, *Clarias dussumeiri* and *Glossogobius giuris* were recorded from 7-15 river systems while the distribution of *Salostoma boopis*, *Barilius canarensis*, *Tetradon travancoricus*, *Garra hughi* were found restricted to 5-7 river systems. *Anguilla bengalensis*, *Puntius carnaticus*, *Channa marulius*, *Sicyopterus griseus*, *Nandus nandus*, *Wallago attu* and *Nemacheilus denisoni* were distributed in 4-5 river systems. Species such as *Gonoproktopterus dubius*, *G. kurali*, *G.thomassi*, *Labeo nigrescens*, *L. dussumeiri*, *Horabagrus nigricollaris*, *Neolissochilus wynadensis*, *Osteochilus nashii*, *O.longidorsalis*, *Silurus wyandensis* etc. were distributed in 2-3 river systems. Species such as *Lepidopygopsis typus*, *Cirrhinus reba*, *Osteochilus (Kantaka) brevidorsalis*, *Mesonemacheilus remadevi*, *M. pambarensis*, *Homaloptera pillai*, *Nemacheilus petrubenarescu*, *Glyptothorax lonah*, *G. anamalaiensis*, *Mystus montanus*, *Crossochelus periyarensis*, *Gonoproktopterus micropogon periyarensis* and *Channa micropeltes* were collected only from single locations in different river systems. New report of fishes such as *Tor putitora*, *Labeo kontius*, *Puntius bovanicus* and *Mystus menoda* and new species described such as *Salarias reticulates*, *Nemacheilus periyarensis*, *Garra mlapparaensis*, *Garra travancoria*, *Garra nilamburensis*, *Tor remadevii*, *Homaloptera silasi* were recorded from single river systems each while *Garra emarginata* was reported from two river systems. The regional distribution pattern of the fishes in different river systems of Kerala are shown in Table 3. 33.

The logitudinal availability of the species showed a highly diversified pattern of species distribution within the different altitude ranges of a river system. Though more or less identical pattern of longitudinal distribution was observed for a particular species in different rivers, the distribution pattern showed variation slightly or some times radically in the case of a few species. It was observed that, among those species which have a wide horizontal or spatial distribution, *Puntius filamentosus* and *Rasbora daniconius* showed its presence in all the three streches in most of the rivers surveyed. On the contrary, the occurrence of *Puntius fasciatus*, *Barilius gatensis*, *Garra mullya* and *Barilius bakeri* were recorded from both the upper and middle streches in majority of the river systems, however, were found confined to the upper streches in a few other river systems. *Xenentedon cancila* and *Etrplus maculates* were recorded both from the middle and lower streches. However, their occurrence in the upper streches were very sporadic. Species such as *Tor khudree*, *Mesonemacheilus triangularis*, *Lepidocephalus thermalis*, *Glyptothorax annandalei*, *Nemachelus guentheri*, *Danio aequipinnatus* and *Gonoproktopterus curmuca* were invariably observed from upper and middle streches, among these, the occurrence of *T. khudree*, *N.triangularis*, *G. annandalei* and *N.guentheri* were mostly observed from upper streches. The presence of *Bhavania auastralis* was found more or less confined to the upper streches while *Channa striatus* and *Nandus nandus* were found confined to the lower streches. Species such as *Parambassis dayi*, *Puntius vittatus*, *Aplocheilus lineatus*, *Aplocheilus blocki* and *Wallago attu* were encountered mostly from the middle and lower streches whereas *Mastacembeles armatus* was more or less cofined to the middle streches. *Osteobrama bakeri*, one of the rare species, showed a mixed pattern of distribution, either in the middle, lower or upper streches. *Osteochilus nashii* and *Garra hughi* were distrubted in the upper streches while *G. surendranathanii* and *Puntius carnatiucs* were mostly seen in the upper streches and rarely in the middle streches. *Puntius bimaculates* and *Barilius canarensis* were observed from the upper and middle streches. *Batasio travancoria* was mostly confined to the middle streches and *Tetradon travancoricus* was encountered mostly from lower streches. The occurrence of endagered species such as *Nemacheilius monilis*, *Oreonectes keralensis*, *Silurus wynaadensis* and *Gonoproktopterus kolus* were found restricted to the upper streches while *Mystus malabaricus*, *Osteochilus longidorsalis*, *Gonoproktopterus thomassi* and *Labeo nigrescens* were observed in the upper and middle streches where as *Horbagrus nigricollaris*, *Travancoria elogata* and *T. jonesi* were collected from the middle streches. Critically endangered species such as *Channa micropeltes*, *Mesonemacheilus remadevii*, *Homaloptera pillai*, *Lepidopygopsis typus*, *Gonoproktopterus micropogon periyarensis*, *Crossocheilus periyarensis*, *Osteochilus* (*Kantaka*) *brevidorsalis* and *Mesonemacheilus pambarensis* were restricted to the upper streches of specific river systems. The logitudindal distribution pattern of various fish species are given in Table 3.34.

While comparing the fish fauna in the different altitudinal zones of the river systems following Jaccard's similarity coefficient, three more or less distinct clusters were emerged for major and longer river systems representing the similarities between upper streches, middle streches and lower streches. Other clusters at right hand side of the dendrogram represent the species similarities between (1) middle and lower streches, (2) upper and middle streches and extreme right, the similarity between upper streches of smaller river systems. The dendrogram indicated highest resemblence in fish fauna among the upper streches of major river systems followed by middle and then lower streches. The similarity between middle and lower streches and also those between upper and middle streches shown by smaller river systems in the dedrogram are not so strong when compared to the major and longer river systems (Fig.3. 106).

3.3. 5. Species diversity Vs Length of the river system

The species diversity values (in terms of total no.of species collected 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 indicate that there exist a direct relationship between species diversity and length of the river system (Fig.3.107). The highest diversity was shown by Periyar river system (75 species) (Fig.3.108), which has a length of 244km whereas Bharathapuzha with a total length of 209 km is endowed with 62 species while Chalakkudy river system with 144 km length abound 67 fish species. Minimum species diversity was observed for Keecheri, Tirur and Bhavani river systems (12,15 and 16 respectively), the respective lengths are 51, 48 and 37.5 kms. It can therefore be concluded that, higher the length of the river system, higher the species diversity and vise 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.3.109). It appeared that by every increase in length of the river system, the species availability 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.

3.3.6. Species diversity Vs Catchment area of the river system

The species diversity (in terms of total no. of species collected from a river system) was plotted against the increasing order of catchment area of the river systems in a scatter diagram (Fig.3.110) and the results revealed that species diversity generally increases with increase in catchment area. Periyar, Bharathapuzha and Chalakkudy river systems which are having the largest catchment areas (5398 and 4400 km^2 respectively) harbour a large number of species (75 and 62) whereas rivers having smaller catchment ares such as Tirur, Nileswaram, Puzhaykkal (117,190,234 km^2 area respectively) showed minimum number of species (15,16,20 respectively). However, when the species diversity in unit area were plotted against the increasing order of catchment area, a declining trend was observed in the scatter diagram (Fig.3.111) 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 (0.013 and 0.014) were obtained for larger river systems such as Periyar, Bharathapuzha (catchment areas 5398 and 4400 km^2 respectively) in contrast it was high (0.128,0.08, 0.08) for smaller river systems such as Tirur (117km^2), Nileswaram (190km^2), Puzhaykkal (234km^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 decreses with increase in catchment area.

3.3.7. Lattitudinal variation in fish speies diversity in the river systems of Kerala

When the river systems were arranged in the decreasing order of latitude from north to south to assess the influence of latitude on fish species diversity, it was seen that the species diversity showed an increase from north up to central Kerala and thereafter showed a declining trend (Fig.3.112). The variation can be attributed to the differences in the length and catchment ares of the river systems. Smaller river systems generally showed less species diversity and vise versa in the case of large river systems. When the river systems of Kerala were divided in to five zones based on 1^0 lattitude and compared for their fish diversity, the results revealed that the Central Kerala region (zone III) abounds the maximum number of species (295 species) owing to the largest catchment area (13692) which is followed by zone II with 210 species. Zones IV have 181 and zone I have 116 species. The least number of species were recorded from Zone V (Fig.3.113). However, while assessing the species diversity available per km^2 catchment area of each zone, zone I ranked highest followed by zone II. Zone III appeared as the least (Fig.3.114). When these five zones were compared for their similarities or differences based on Jaccard index values, two distinct clusters appeared representing a high similarity between zones I and V (55%) and a relatively low similar cluster representing zones II and IV (50%). Zone III stands out as separate zone. Further, when the zones were compared based on the number of ornamental, cultivable, Food fishes, threatened fishes, endemic fishes of Kerala and also number of endemic fishes of the particular zone, the zone III emerged as the sensitive zone in possessing many species belonged to the above various categories and quite interestingly, as in the case of nature of fish fauna and species richness, there were high similarity between zone II and zone IV and between zone I and zone V (Fig.115). It can thus be ostensibly concluded that latitude has no bearing on species diversity; in contrast, the length and catchment area of the river system have profound influence in supporting rich and diversified fish biodiversity.

3.4. Discussion

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 with respect to freshwater fishes (Kottelat and Whitten, 1996). Dahanukar *et al.* (2004) while studying the nature of fish distribution in the Western Ghat rivers opined that, southern region of Western Ghats including Kerala showed more uniqueness in species diversity. According to the authors, connectivity of the rivers of southern Ghat region with the rivers of central and northern Ghat region are not extensive, thus restricting the dispersal of the species only to the southern region. The results of the present study on the freshwater fish germplasm resources, their commercial utilization, biodiversity assessment, endemism and distribution pattern fully concur with the findings of Kottelat and Whitten (1996). The discovery of eight new species new to science and record of one species new to fish fauna of the country, besides 4 new records of species from Kerala and 14 new distributional ranges of fishes within the river systems of Kerala explicitly undermine and assert the fact that the fish fauna of Kerala calls for further investigations and every effort should be made to conserve this unique germplasm resources which are facing the threats of endangerment and extintion due to various anthropogenic interventions.

145 freshwater fish species of 12 orders, 28 families and 66 genera were collected and identified in the present study. According to Matthews (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. Conversely, in Kerala, three among the 28 families such as Cyprinidae (68 speceis), Balitoridae (18) and Bagridae (10) together accounted for 67% of the total species collected. The results of the present study revealed that the fish fauna of Kerala shares similarity not only with the taxa that are common with the other river systems of Western ghats but also to those in many south-east Asian riverine ecosystems. Many of the species found in this study included Cyprinids (e.g. *Barilius, Garra, Labeo),* Siluriform catfishes (e.g. *Clarias),* murrels *(Channa),* Mastacembelids *(Mastacembelus)* and Notopterid which are all invariably common to south- east Asia. The preponderance of Cyprinids and Balitorids in most Southeast Asian rivers, as well as those in the Indian subcontinent are well documented (Bhat, 2003). Dahanukar *et al.* (2004) collected 288 species from Western Ghats, among them Cypriniformes was the most predominant order (57% of fish species) followed by Siluriformes (18%). Family Cyprinidae (45%) appeared as richest followed by Balitoridae (9%). In the present study, 60% of the fish species belonged to Cypriniformes, which further explicates the preponderance of this order in the rivers of Kerala. The genera such as *Puntius, Danio* etc. are enjoying the widest range of distribution, conversely, the members of the family Balitoridae were found rare whose distribution is very much confined to a few river systems of Kerala.

Day (1865), in his monumental treatise, 'The Fishes of Malabar' had listed 228 species from Malabar region and it is after six years that Pillay (1929) listed 236 species. John (1936) listed 124 species from Travancore while Hora and Law (1941) reported 76 species from Travancore region among them 9 are common to Ceylon. Menon (1997) listed 18 threatened fishes from Malabar, among them 7 were rare while 11 were endangered. In the present study, 59 species were found threatened which included 8 critically endangered, 36 endangered and 15 vulnerable species. High number of threatened fish species so recorded is an indication of the high rate of endangerment the fish fauna had undergone in Kerala during the past one decade. The present assessment on threatened fishes fully agree with that of Ajithkumar *et al.* (2000) who reported 115 fish species belonging to 58 genera, 27 families and 10 orders from Kerala part of Western Ghats. According to the authors, 63 species are threatened (Critically endangered - 7, Endangered-28, Vulnerable-28) and 43 non-threatened fishes (Low risk early threatened-12, Low risk least concern-31) while 9 were introduced species. Cyprinidae was the richest family with 20 genera (53 species) followed by Balitoridae and Bagridae while *Puntius* (12 species) and *Mystus* (9 species) were the strongest genera. 35 species were endemic to Western Ghats, among them 11 were endemic to Kerala. Gopi (2000) listed 165 primary freshwater fish species based on the data compiled from literatures while 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 endagered species, of which 13 are endemic to the state. Later, Kurup *et al.*

(2004), based on extensive sampling surveys and scanning the literature, listed 175 freshwater fish species from different water bodies of Kerala which is inclusive of 4 exotic species. The authors demarcated 106 ornamental and 67 food fishes and also prioritized the fishes based on their commercial value as important, highy important and very highly important. The biodiversity status of the fishes assessed based on IUCN showed 18 critically endangered, 28 vulnerable, 21 low risk nerly threatened and 34 low risk least concern species. 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 communis*, *Poecilia reticulata* and *Tilapia mossambica* which are exotic. *Pangio bashai* (Easa and Shaji) and *Homaloptera menoni* (Shaji and Easa) were the new species discovered while *Labeo potail*, *Danio rerio*, *Noemacheilus petrubenarescui*, *Osteochilus longidorsalis* and *Schismatogobius deraniyagalai* were the new additions to the fish fauna of Kerala. Gopalakrishnana and Ponniah (2000), while listing the cultivable, ornamental, sport and food fishes of Peninsular India, reported 31 species from Kerala of which 19 were food fishes, 8 cultivable and 4 sport fishes. There were 76 ornamental, 22 cultivable and 47 food fishes in the present collection from the river systems of Kerala.

Studies concentrated to a specific stream or a group of streams at a geographical entity 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 comprised of 5 critically endangered and 31 endangered species. The list included 11 species endemic to Kerala. Endemic fish species such as *Lepidopygopsis typus*, *Crossocheilus periyarensis*, *Gonoproktopterus micropogon periyarensis*, *Garra periyarensis*, *Mesonemachelius menoni* collected from Periyar and *Garra menoni*, *Labeo nigrescens*, *Homaloptera silasi*, etc. recorded from other river systems in the present study were not reported by Raju Thomas *et al.* (2002). Conversely, *Pisodonophis boro*, *Osteobrama cotio peninsularis*, *Osteochilus thomassi*, *Esomus danricus*, *Horalabiosa joshuai*, *Nemacheilius evezardi* and *Pangio goaensis* reported by the above authors could not be encountered in the present collections.

Cherian *et al.* (2001) reported 24 species of primary freshwater fishes from Trivandrum district which are common to that of Sri Lanka, which revealed substatially the close affinity in the ichthyofauna of Sri Lanka and the southern Western Ghats. The record of a Sri Lankan Cyprinid fish, *Garra ceylonensis* in the present study support the ancient zoogeographical co-existance of these two countries. 40 freshwater fish species belonging to 4 orders, 15 families and 29 genera were collected and identified from Chaliyar river system in the present study and this in comparison with Lal Mohan and Remadevi (2000) are very high. However, Easa and Basha (1995) recorded 50 fish species belonging to 34 genera and 21 families from 11 locations of this water body, among them 4 are endemic to Western Ghats (*Puntius denisoni*, *Osteobrama bakeri*, *Batasio travancoria* and *Tetradon travancoricus*) besides describing *Pangio bashai* (Easa and Shaji), a new species to science. *Osteochilus nashii* was reported for the first time from a west flowing river, Chaliyar by the authors. Nevertheless, *Garra mcClellandii*, *Esomus danricus*, *Amblypharyngodon melettinus*, *Mystus oculatus* etc. were not encountered in the present collection.

Easa and Shaji (1995) reported *Garra menoni* and *Barilius bendelisis*, the two endangered fish species from Pambar river system in the Chinnar wild life sanctuary besides the vulnerable species like *Puntius carnaticus* and *Garra gotyla stenorhynchus*. In the present study, 26 species under 3 orders, 9 families and 16 genera were collected from Pambar river system inclusive of a new species, *Tor remadevii* and another endemic species, *Mesonemacheilus pambarensis*. Except *Garra menoni*, all the previously reported species from this river system were collected now. In addition, *Pseudeuotropius mitchelli*, an endangered species, so far known only from Periyar river system was encountered for the first time from this river system. Bijukumar and Sushama (2001) reported 61 species of fishes under 11 orders, 30 families and 50 genera from Bharathapuzha river system. Of these, *Batasio travancoria* and *Tetradon travancoricus* are endemic to Kerala while *Corica soborna*, *Chela dadiburjori* and *Lepidocephalus guntea* are new records. Their collection also included 13 secondary freshwater fishes. The authors also confirmed the occurrence of *Barilius bendelisis* in Kerala. Among the species collected, 24.59% were very rare while 31.15% were rare. In Bharathapuzha, 63 species belonging to 4 orders, 18 families and 39 genera were encountered in the present study however, no secondary freshwater fishes or new records except *Chela dadiburjori* was observed. On the other hand, *Mesonemacheilus remadevi* (Shaji and Easa, 2002), the new fish species recently described and threatened fishes like *Garra surendranathani*, *G. menoni*, *Glyptothorax madraspatnam*, *Sicyopterus* *griseus* etc. were recorded in the present study. *Puntius bovanicus* was the first report from Kerala in this study. Biju *et al.* (1996) reported 20 species belonging to 11 families from Manjeswaram river flowing through Kasargod district. From Chandragiri river system, 33 species under 4 orders, 12 families and 24 genera were collected and endangered species like *Brachydanio rerio*, *Labeo nigrescens* and *Silurus wynaadensis* and two vulnerable species, *Mystus malabaricus* and *Batsio travancoria* were also observed in the present study. Rajan (1955) recorded 45 species from the headwaters of Bhavani river system. In the survey conducted in the Kerala part of this river system, 16 fish species belonging to Cypriniformes, under 3 families and 10 genera were collected in the present study. Easa and Basha (1995) recorded 24 species from Bhavani river system and described a new species, *Homaloptera menoni* Shaji and Easa from Siruvani. *Tilapia mossambica* and *Balitora mysorensis* were new additions to this river system. Mukerjee (1931) reported *Callichrous bimaculatus*, *Aoria punctatus*, *Barbus arulius*, *Barbus camaticus*, *Barbus micropogon mysorensis*, *Danio aequipinnatus*, *Barbus gatensis*, *Scaphiodon brevidorsalis* and *Scaphiodon nashii* from Bhavani. *Gonoproktopterus dubius* is the new record made in the present study in a river other than Kabbini. 67 fish species belonging to 4 orders, 20 families and 32 genera were collected and identified from Chalakkudy river system, among them, the richest order was Cypriniformes while the family Cyprinidae was the strongest. The fish fauna of this river system included one new species, *Salarias reticulates*, discovered from Vettilappara while *Batasio travancoria* was a new record from Parambiculam wild life sanctuary of this river system. Ajithkumar *et al.* (1999) identified 83 fish species from this river system. The total number of fish species of this river system including those reported in the past (Silas, 1951; Thobias, 1973; Antony, 1977; Inasu, 1991; Pethiyagoda and Kottelat, 1994; Biju *et al.*, 1998 and 1999) thus worked out to be 98 which are coming under 34 families and 10 orders. A classification of fishes based on the commercial utilization showed that 36 species are ornamental, 23 food fishes and 7 as cultivable. Raju Thomas *et al.* (2000) reported 37 freshwater fishes belonging to 15 families from Chimmony and Peechi-Vazhani Wild Life Sanctuaries, drained by Karuvannur and Keecheri river systems. Their collection also included four alien and exotic species viz. *Cyprinus carpio*, *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala* which were stocked in the reservoirs as part of augmenting fish production. Probably, the authors might have collected these fishes from Peechi reservoir. In the present study, 18 species belong to 4 orders, 11 families and 14 genera have collected from Karuvannur river system while the fish fauna of Keecheri river system comprised of 12 fish species belong to 4 orders, 6 families and 11 genera. However, no cultivable species was evaluated in the collection. 51 fish species belonging to 5 orders, 10 families and 29 genera could be collected from Kabbini river system and its tributaries during the period of study. Hora (1942) listed 63 fish species from Wyanaad and adjacent areas of Nigiri biosphere. Easa and Basha (1995) listed 58 species belonging to 17 families and 31 genera from 15 locations of Kabbini river system. The authors also recorded *Osteochilus brevidorsalis*, *Labeo potail*, *Poecilia reticulata*, *Danio* (*Brachydanio*) *rerio*, *Noemacheilus nilgiriensis* and *N.petrubenarescui* for the first time from Kerala. However, *Labeo potail*, *Poecilia reticulates*, *N.petrubenarescui* and the introduced species like *Tilapia mossambica* and *Cyprinus carpio* were not encountered in the present study. Arunachalam *et al.* (2000) reported 37 species including 12 economically important cultivable and 13 ornamental fishes from various streams of Wyanad.

Despite these sporadic attempts of fish faunistic listing of a particular river system or a few rivers, majority of the studies were carried out 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 study for its ichthyodiversity for many researchers. 75 species under 7 orders, 19 families and 40 genera were collected from Periyar river system in the present study. Chacko (1948) reported 33 species from Periyar lake and stream system and this in comparison with the present findings showed that some of the fish species have already disappeared in recent years from the lake-stream system. The fishes so disappeared include cyprinids such as *Puntius melanostigma, P.arulius, P. amphibius, P.pinnaratus and Barilius bendelesis*, stone suckers (*Garra lampta*). Minnows (*Chela boopis*), catfishes (*Mystus vittatus*) and feather back (*Notopterus notopterus*). However, *Bhavania australis, Nemacheilus denisonii, Mesonemacheilus guentheri, Travancoria jonesi, Crosssocheilus periyarensis* and *Nemacheilus periyarensis* which were not listed by Chacko (1948) were found from this water body in the present study. Indra and Remadevi (1990) gave a faunistic list and brief descriptions of 19 species belong to 8 families collected from Thekkadi Wild life reserve. Later, Zacharias *et al.* (1996) identified 35 fish species representing 21 genera and 11 families from Periyar lake. However, *Acanthocobitis botia. N. evezardi, Barilius bendelisis* and

Garra gotyla stenorhynchus collected by them were not encountered in the present collection. 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 *Gonoproktopterus curmuca* are the most abundant species while species such as *Travancoria jonesi, Channa gauchua, C. striatus* and *Glyptothoax madraspatnam* are very rare. The presence of *G. mcClelandi* was not encountered from the Periyar lake In the present study. Arun *et al.* (1996) reported the occurrence of two exotic species, *Cyprinus carpio* and *Orecchromis mossambica* in the lake proper for the first time and was of the view that the endemic fishes were heavily posing threats by the invasion of above exotics besides habitat alterations by human interventions and indiscriminate fishing activities by the tribals. According to Zacharia *et al.* (1996) the distribution of the above two exotic species were strictly restricted to the lentic waters of the reservoir. More recently, Kurup and Ranjeet (2002) reported the high invasion of these exotic species as potential threats to the indigenous and endemic fish fauna of the lake. 35 fish species could be collected from Periyar lake in the present study among them *C. carpio* and *O. massambicus* were found very invasive.

Shaji *et al.* (1995) reported 33 species belong to 15 families from 5 localities of Aralam wild life sanctuary part of Valapatnam river system. The authors reported the extension ranges of *Osteochilus nashii*, *Puntius denisoni* and *Nemacheilus nilgiriensis* to Valapatnam river. 46 fish species could be collected from Valapatnam river system in the present survey, which belong to 5 orders, 17 families and 33 genera. *Nemacheils nilgiriensis* was the missing species in the present study while *O. nashii* was recorded from outside the sanctuary area. The presence of three endangered fishes, *Puntius jerdoni*, *O. nashii* and *Microphis cuncalus* would justify the declaration of this region as an aquatic sanctuary for fishes. Remadevi and Indra (1986) reported 9 species form Silent Valley National park and later Remadevi and Menon (1994) extended the distribution of *Horalabiosa sp.* to this region. Easa and Basha (1995) however, could collect 11 species from Silent valley. The authors also recorded *Puntius melanampyx* (*Puntius fasciatus*) from this region for the first time. Later, *Mesonemacheilus remadevi* (Shaji and Easa, 2002), a new species was added to the streams of Silent Valley. 10 species were collected in the present study in the national park which included the critically endangered species viz. *Homaloptera pillai* and *Mesonemacheilus remadevi* and the endangered fish, *Garra menoni*. The streams of Parambikulam wild life sanctuary were surveyed for fishes extensively by Biju *et al.* (1999b) and 40 species belonging to 12 families were recorded. *Osteochilus logidorsalis*, *Garra surendranathani*, *Barilius bendelisis* and *Glyptothorax lonah* were also recorded from here by the authors. 28 fish species could be collected from the sancturay area in the present study, which is also inclusive of the endangered species *Puntius jerdoni* and *Gonoproktopterus kolus*.

The global distribution pattern of biological diversity shows 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 & Gopalakrishnan 2001). However, the dynamics of species aggregation and dispersal patterns within and among the river systems of Kerala were not known so far. Very little is known of the community ecology in relation to distribution patterns of fish fauna in the streams and rivers of this region barring a few reports (Arunachalam, 2000; Bhat, 2003).

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). These factors are reflected in the results of the present study while comparing the river systems based on species diversity (in terms of species richness). The pattern of similarity or differences in species diversity between the river systems of Kerala are so complex that not a single factor can be taken as a decisive factor. Rivers which share the same geographical area or close to each other showed more similarity as shown by Pamba and Achenkoil and Chandragiri, Kuppam and Karyangod. The nature of directon of flow can be considered as one of the decisive factors as there were two distinct categories of rivers viz. the east flowing and west flowing were emerged in the dendrogram. It is worth reporting that, there exist a strong similarity among the fish fauna of smaller river sytems such as Nileswaram, Peruvamba, Shiriya, Karuvannur, Puzhaykkal, Tirur, Keecheri and Kadalundi. Similarly, the fish fauna of larger river systems such as Chalakkudy, Valapatnam, Bharathapuzha, Achenkoil, Pamba and Periyar was also exhibited high similarity. This can be well attributed to the similarities in the habitat divesity prevailing in these river systems. The influence of both habitat availability and its diversity on the composition of riverine fish communities is well documented and the greatest species diversity is found associated with regions endowed with rich habitat diversity (Sheldon 1968; Gorman and Karr 1978; Evans and Noble 1979; Lake 1982; Beecher *et al.* 1988; Pusey *et al.,* 1995). In respect of smaller river systems, the habitats are less complex, consisting mainly of pool-run, pools or sheet type of habitats where usually the species diversity will be very poor and chances of endemism and speciation are also meagre. The downstream of most of the river systems are interconnected with the backwaters serve as a passage for fish movements and migration and therefore, the down stream of most of the rivers have more or less similar fish fauna. As far as smaller river systems are concerned, the species diversity is mostly contributed by fishes seen in the downstream regions. In respect of larger river systems, a highly complex and dynamic habitat conditions (cascades, rapids, riffles, riffle-pool, run, pool-run, deep pools) prevail from its origin to its course to the sea. So, the chances of endemism and speciation are high and a very diversified fish fauna exist in these water bodies. Since these river systems exhibit high habitat similarties, the nature of fish fauna within them are more or less similar. The east flowing river systems share some unique fish fauna. However, the species diversity of Kabbini river system is very rich when comapred to Pambar and Bhavani river systems due to the presence of many species found in west flowing river systems. Interestingly, Kabbini showed more similarity with the west flowing rivers systems. It can therefore be concluded that the nature of species diversity of a particular river system can strongly be correlated with its habitat diversity. As the habitat become more complex, the species diversity will become more rich and the similarity in habitat conditions would result in high species similarity. However, habitat diversity alone cannot be accounted as the only factor which determine the species diversity. The available results suggest that habitat structure along with the water chemistry, channel morphology, food base, hydrologic regime, competition, and predation are the important parameters which determine the species richness and their distribution pattern (Karr & Dudley, 1981; Oberdorff *et al.*, 1995; Mandrak, 1995; Eadie *et al.*, 1986; Larsen *et al.*, 1986).

The composition and distribution of fish species in a river system can be well demarcated based on altitude in to those representing upper, middle and lower stretches. The gradient of the geographical region is known to have a profound influence in segregating fish communities (Gehrke, 2001). At the local scale, species richness was correlated with elevation, stream gradient, stream order and drainage area (Beecher *et al.*, 1988). It appears that the species distribution in the river systems of Kerala is not random and fishes occupy certain or often specific streches or gradient level of the river system. *Puntius filamentosus* and *Rasbora daniconius* which occupy all the three streches of the river systems while *Homaloptera pillai*, *Lepidopygopsis typus*, *Gonoproktopterus micropogon periyarensis* and *Crossocheilus* *periyarensis* occupy only upper streches. This type of biotic zonation cuncur with the findings of similar studies conducted in streams elsewhere (Rahel and Hubert 1991; Paller 1994; Lake 1982; Pusey *et al.*, 1995; Hurlbert, 1971). While comparing the species diversity of various altitudinal zones in the river systems, it appears that the diversity at the same altitudinal regime(and river gradient) were more similar than across different altitudinal regimes. For the larger river systems, the upper reaches were having similar habitats (Cascades, rapids and riffles) and the nature of fish fauna accommodated in these habitats are almost similar. The physico-chemical and other habitat parameters at the high altitude zones of the river systems are very characterestic in providing shelter to a very specific group of fishes which form a discrete cluster, distinctly different from all other assemblages observed from middle and lower streches. In contrast, the middle and lower streches of these river systems do not have any specific types of habitats, so similarity was less strong. These findings cuncur with Bhat (2003), who observed that the upper reaches of four river systems of Uttar Kannada were more similar to each other than lower reaches, even while comparing upper and lower reaches on the same river.

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. Studies on relation between fish fauna and morphometry of rivers of French Guiana and elsewhere proved that catchment size is one of the main factors determining fish species richness. (Livingstone *et al.*, 1982; Hugueny 1989; Welcomme, 1990; Oberdorff *et al.*, 1995). Lake (1982) also reported similar results 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 provide 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 this. The rich species diversity was found associated with increse in length and catchment area as observed in respect of Periyar, Bharathapuzha, Pamba, Chalakkudy which are the largest river systems of Kerala while poor species diversity was seen in Kecheri, Puzhaykkal, Keecheri, Tirur which are comparatively smaller. Interstingly, Kabbini river system is an exception to this situation, though the length of this river system is only 56.6 km, it abound 51 species. This is because Kabbini is a major tributary of biodiversity rich Cauveri river system in TamilNadu. 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. He also added that grid cells with current or historical stream connections to major river basins contained more species than those lacking such links. While comparing the species diversity in terms of river index values computed in the present study, it was seen that, the larger river systems such as Periyar, Bharathapuzha and Chalakkudy 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 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 shows 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 & Karr, 1978; Schlosser, 1982; Angermeier & 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).

Following Terentev (1963), many biogeographic analyses of species richness was done applying the methods known as gross geographic lumping (Pianka, 1966), grid analysis (McAllister *et al.*, 1986), or quadrate analysis (Kiester, 1971). This method overlays a geometric grid on a map, and for each cell the number of species with some part of their known ranges falling within the cell is summed. The cumulative patterns formed within the grid are then assessed. This approach has been applied to birds (Cook, 1969; Bohning-Gaese, 1997), mammals (Simpson, 1964; Wilson, 1973), amphibians and reptiles (Kiester, 1971; Rogers, 1976), and fish (McAllister *et al.*, 1986; Mandrak, 1995). Dividing a geographical region based on on a scale such as latitude can be considered as a method which is more pragmatic as it gives the investigator a chance to analyse the pattern of dissimilarity with increasing or decreasing order of scale more than comparing the zones having similar geographical area. While studying the ichthyofaunestic similarities between 6 zones of Western Ghats which are separated by 2^0 latitude, Dahanukar *et al.* (2004) concluded that the similarities between the species among the zones decrease as the distance between the zones increases. In other words, there were more similarities between the zones, which are geographically closer together. The authors also asserted that zones at lower latitudes harboured more fish species than those at the upper latitudes. Paradoxically, in the present study, a similar type of analysis has been carried out by dividing the geographic area of Kerala based on 1^0 latitude and the results revealed that the zones, which are situated geographically distantly registered highest species similarity while the middle zone stood isolated from the other zones at the upper and lower latitudes. The middle zone (Zone III) of Kerala is characterised by the presence of longest and species rich river systems such as Periyar, Chalakkudy and Bharathapuzha. According to Wiley and Mayden (1985), speciation rates may be greater in larger drainages. It may seen that both the diversity and endemism of the zone III river systems are extremely rich and very rare and endangered species such as *Lepidopygopsis. typus, Crossochilus periyarensis, Gonoproktopterus micropogon periyarensis, Garra periyarensis, Travancoria elongate, Travancoria jonesi* and *Horabagrus nigricollaris* find their natural habitats only in these river systems. Besides, 6 of the total new species described in the present study were also discovered from these river systems, thus elevating this region as a unique zone which is distinctly different from other zones. The 11 river systems at the higher latitudes (except Kabbini) such as Shiriya, Nileswaram, Kadalundi etc. and 6 river systems representing the lower latitudes such as Moovattupuzha, Manimala, Kallada etc. showed relatively low species diversity when compared to zone III. By length and catchment areas, the river systems of the zone II and IV showed high resemblence, which might be the reason for the high habitat and species similarities observed in these zones. Similar inference can be drawn with regard to zone I and V.

Identification of the forces that determine spatial patterns in community composition is a central aim of ecology (Begon *et al.*, 1996). The contrasting results obtained in the present study on zonal diversity (diversity versus latitude) when compared to Western Ghats denotes the significance of biogeography on the distribution patterns of freshwater fishes of Kerala. With regard to freshwater fish fauna of Kerala, the only study which have an implication on biogeography is on Palaghat gap (Bhimachar, 1945; Silas, 1951). According to them, the Palghat gap isolated the southern region from rest of the Western Ghats and nested the fish fauna of the southern region which later lead to the evolution of high endemic fish fauna at this region. The present results well confirmed this observation. It is very interesting to state that the biodiversity rich Periyar, Chalakudy and Bharathapuzha river systems are originating from the south of Palaghat gap and species diversity observed within them are very high when compared to other river systems. The zonal dissimilarity in species diversity of freshwater fishes of Kerala can be well explained by correlating the geographical configuration of Kerala, river system length, catchment area with species distributions. The geographical area of Kerala is bordered at the eastern side with almost a continuous chain of Western Ghat mountains and at the western side by the Arabian sea. The geographical shape of Kerala has its maximum width at the centre (encompassing Zone III and IV) and then tapering towards both sides. The island biogeography and species-area theories (MacArthur and Wilson, 1967) hypothesizes that larger geographical areas contain a wider array of habitats and food resources and more heterogeneous physical and biological conditions have been hypothesized to provide more available niches and so allow greater species richness (Sanders, 1968; Rogers, 1976; Currie, 1991). Being the widest and largest regions, the river systems originating from Western Ghats at zone III and IV naturally are invariably the longest rivers, which are endowed with high habitat and species diversity. The zone II occupies the next wider region which is reflected in their less species diversity when compared to zone III and IV. Being the narrowest geographical regions, least species diversity was observed in the zones I and V. However, zone IV which occupies the widest geographical region of Kerala has less species diversity when compared to zone III. This might be due to the high species diversity observed in Periyar, Bharathapuzha and Chalakkudy river systems in the zone III, thus scoring highest index values. The influence of climatic, ecological factors etc. in providing high species richness at the Zone III also can not be ruled out. However, the present study did not taken in to the cognisance of the historic, evolutionary or climatic factors contributing to the distribution patterns of fish fauna. An exhaustive study taking in to account all the biogeographical and other factors determining the species distribution is strongly in need for a proper undertanding the diverse distribution patterns of freshwater fishes of Kerala. Buhrnheim and Fernandes (2003), based on the study on Amazonian streams, suggested that habitat heterogeneity and stream geometry is not the only factors that shapes community diversity. The streams might carry unique characteristics that affect fish assemblage structure, even though the habitats within streams exhibited only slight variations in their physical parameters. Closer examination of the streams might therefore provide insight into the causes of differences in assemblage structure among streams. A very remarkable study on the influence of scale and geography on relationships between stream community composition and landscape variables in Australian fish fauna suggests the importance of Sea, climate, drainage divides and ecology in dividing the different provinces based on fish distribution pattern (Townsend *et al.*, 2003). In spite of an extensive and a well accomplished study, the authors added that the reasons why some species are common to many regions, some are shared by only a few, and some by only two and why a few species have common range boundaries, why might some species have been exchanged and colleagues not (assuming the cause of exchange did not discriminate between species), are quite confusing. So the present results can be explained and concluded following Leopold *et al.* (1964) and Richards (1982) that a mixture of ecological and evolutionary processes governed by the template of watershed geometry is capable of producing a strong positive dependence of fish diversity on a particular drainage area. Further, the relationships between populations of widespread species will be complex and difficult to unravel, as a result of possible faunal exchange from several regions and possibly multiple times and/or directions.

Fig. 3.1. Geographical zonation of Kerala based on 1^0 latitude

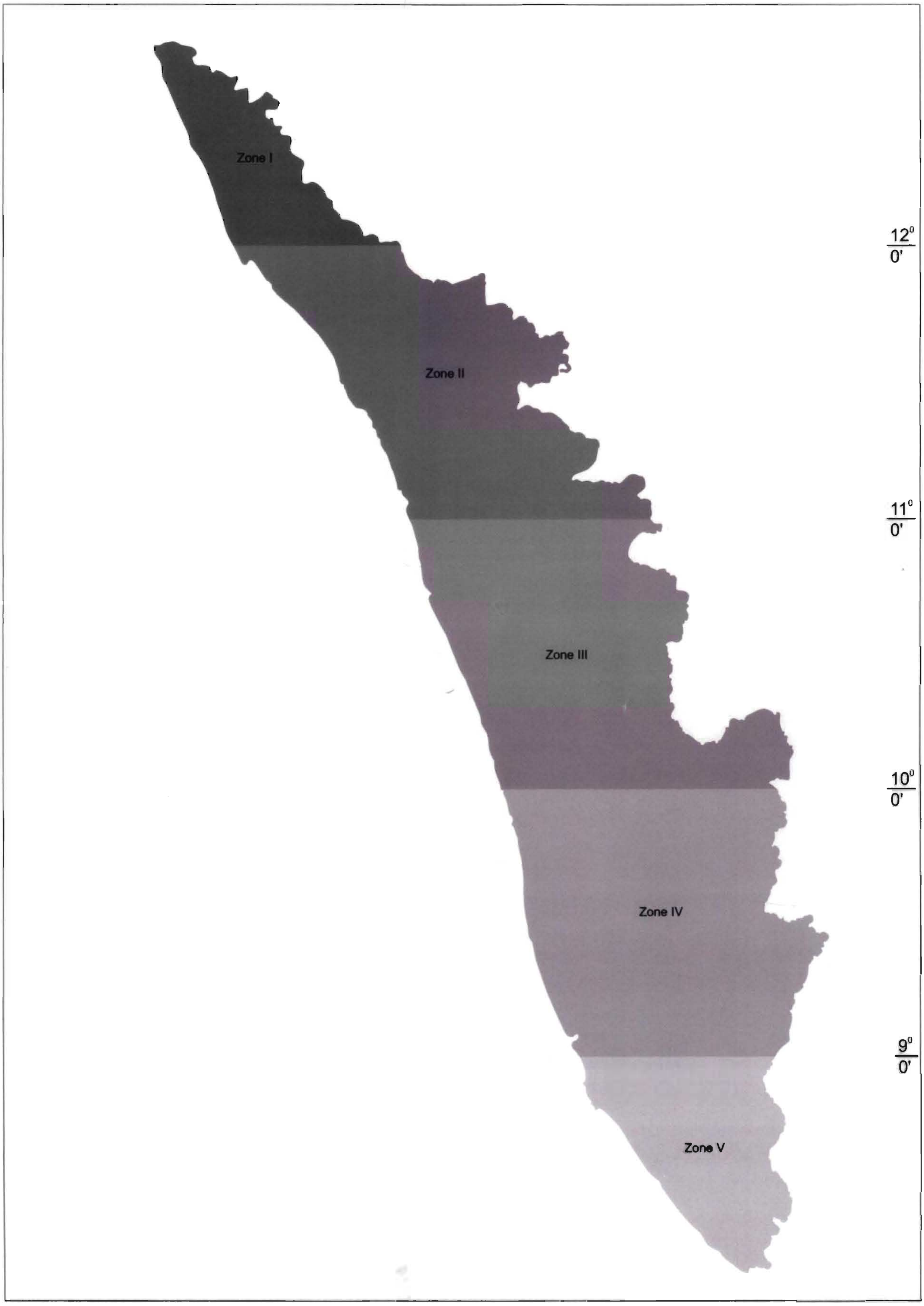


Fig.3.2. Numerical strength of various fish families recorded from the river systems of Kerala

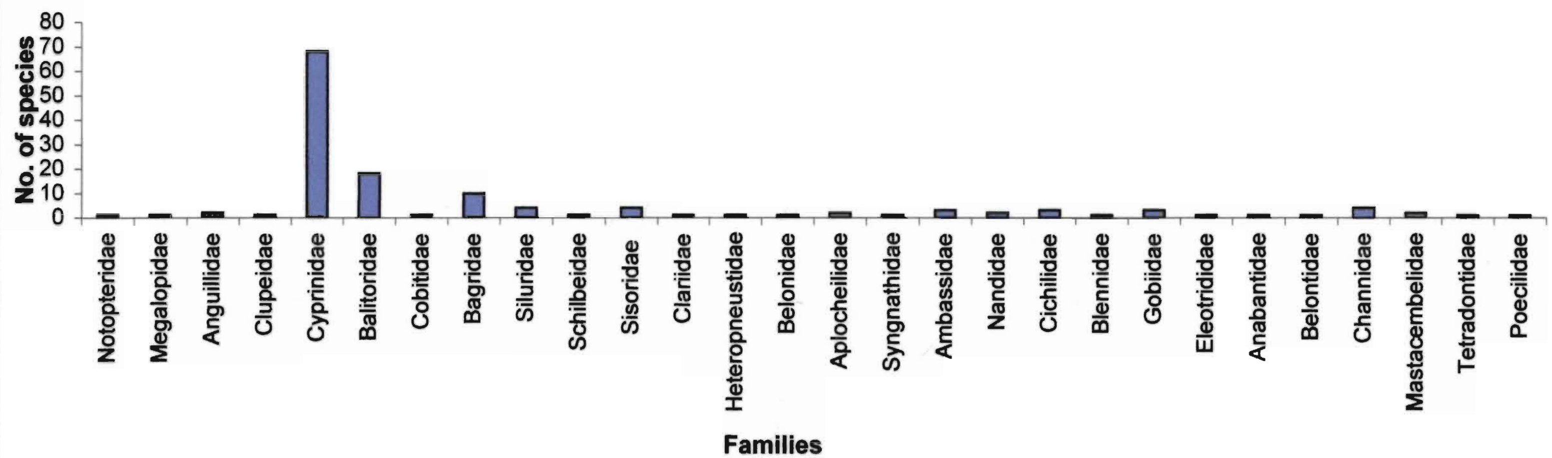


Fig.3.3. Cultivable, ornamental and Food fishes from Kerala

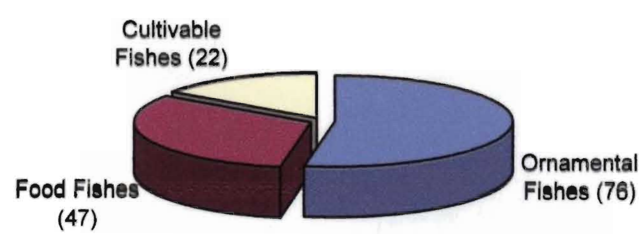


Fig.3.4. Biodiveresity status of the freshwater fishes of Kerala

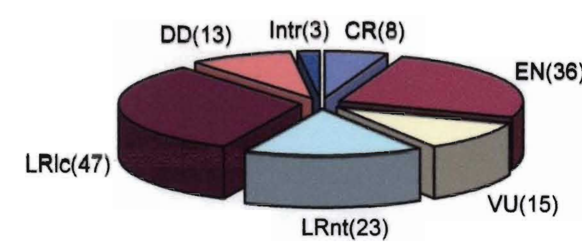
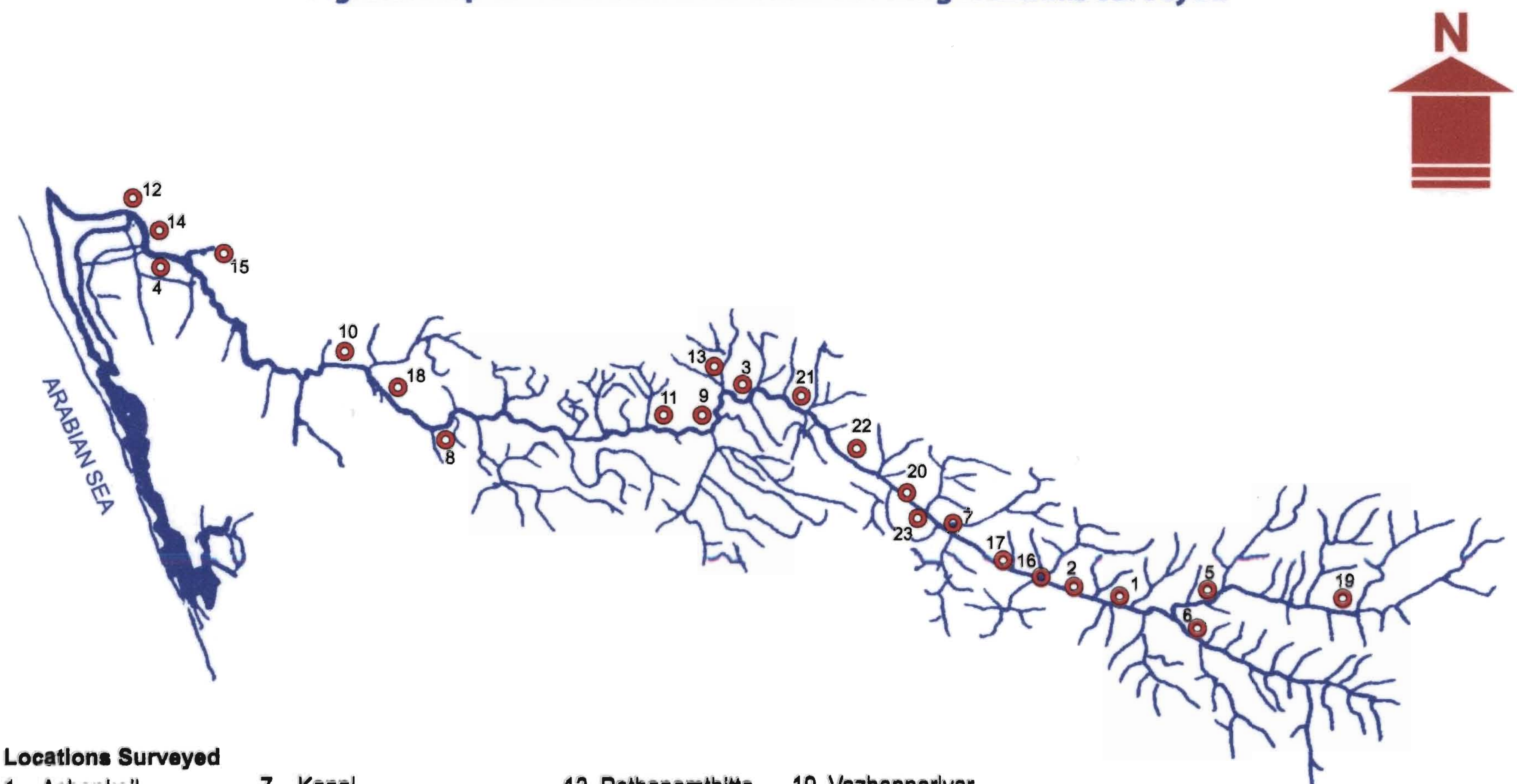


Fig. 3.5. Map of Achenkoil river basin showing locations surveyed



Locations Surveyed

1 Achenkoil	7 Konni	13 Pathanamthitta	19 Vazhapperiyar
2 Aruthalakkayam	8 Kozhanchery	14 Payippad	20 Vettoor
3 Chuttippara	9 Kumbazha	15 Prayikkara	21 Valanchuzhi
4 Edathua	10 Omallur	16 Pulikkayam	22 Kalleli
5 Kallar	11 Pandalam	17 Thura	23 Konnimoozhi
6 Chittar	12 Parumalakkadavu	18 Vallakadavu	

Fig.3.6. Species-wise abundance of fish families in the Achenkoil river system

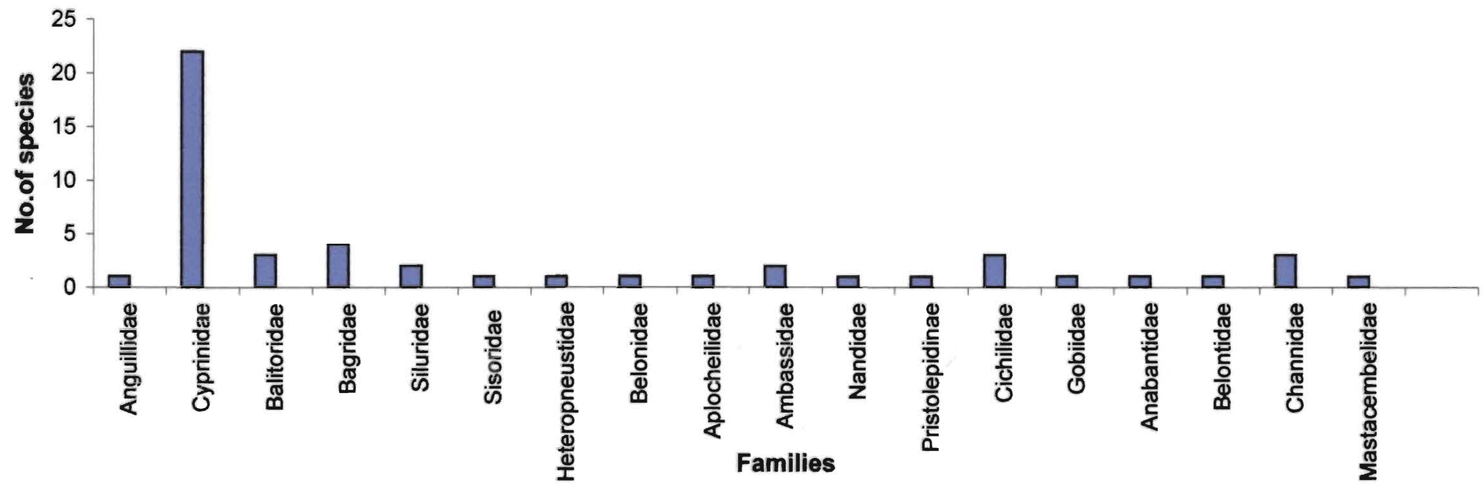


Fig. 3.7. Cultivable,Ornamental and Food fishes reported from AchenKoil river system during the study period

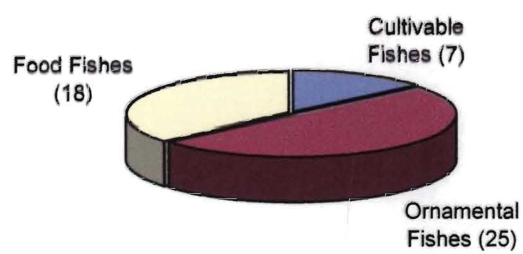


Fig.3.8. Biodiversity status of fishes reported from Achenkoil river during The study period

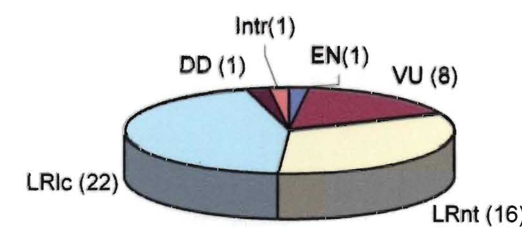
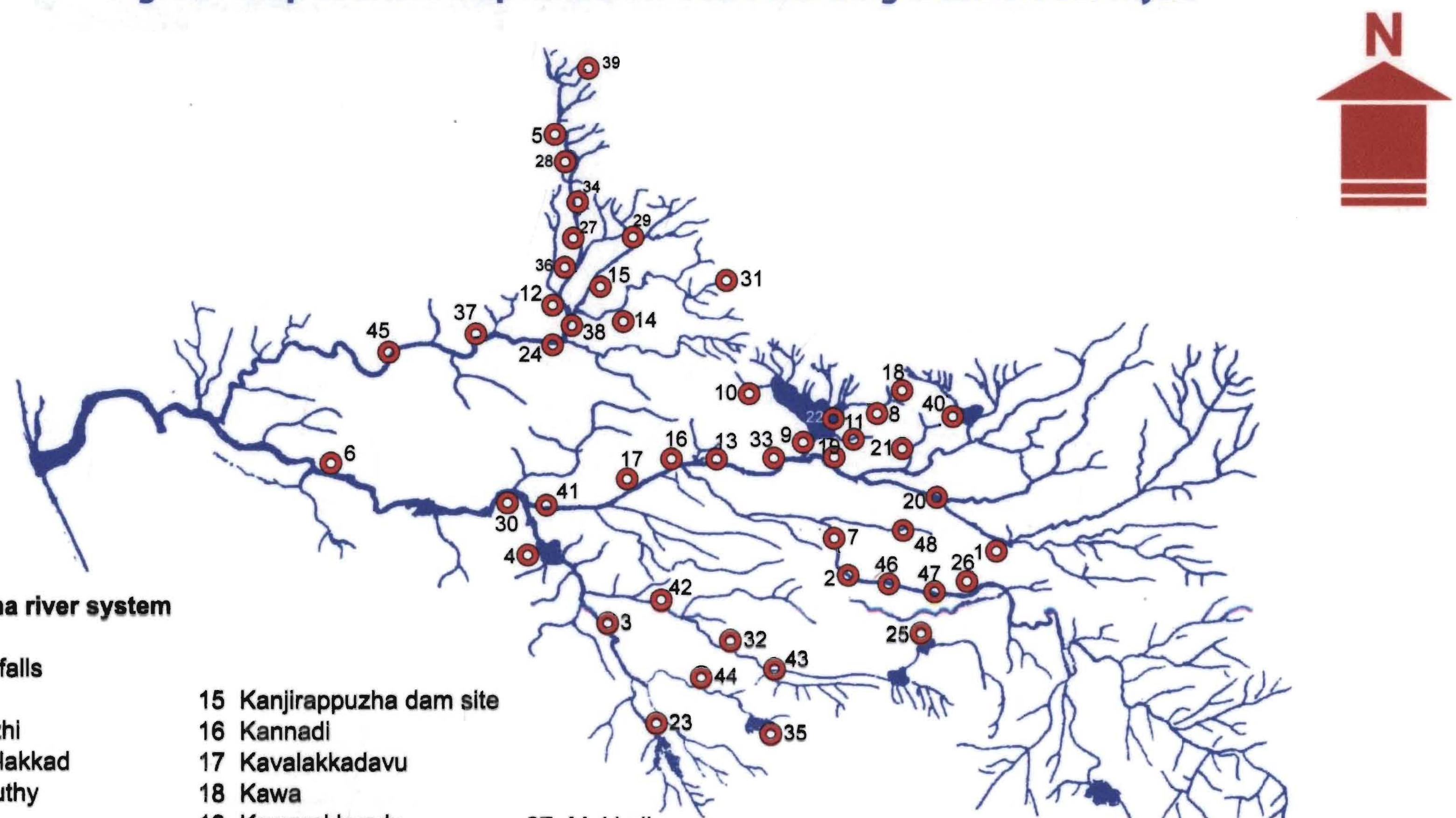


Fig. 3.9. Map of Bharathapuzha river basin showing locations surveyed



Bharathapuzha river system

1 Aaliyar
2 Atla water falls
3 Ayiloor
4 Cheerakuzhi
5 Cheriyawalakkad
6 Cheruthuruthy
7 Chittor
8 Cholagu
9 Choorapara
10 Parli
11 Dhoni
12 Irumbakachola
13 Kalpathy
14 Kanjirappuzha
15 Kanjirappuzha dam site
16 Kannadi
17 Kavalakkadavu
18 Kawa
19 Kawarakkundu
20 Koottilakkadavu
21 Mailadippuzha
22 Malampuzha dam
23 Mangalam dam site
24 Mannarkkadu
25 Meenkara dam site
26 Meenvallam
27 Mukkali
28 Neelickal
29 Nellipuzha
30 Nenmara
31 Palakkayam
32 Pallavoor
33 Pampady
34 Poochippara
35 Pothundy
36 Syrendri
37 Thathamangalam
38 Thippilikkayam
39 Walakkad
40 Walayar
41 Yakkara
42 Edapungal
43 Gayathrippuzha
44 Karimalappuzha
45 Kodambu
46 Sarkkarpuzha
47 Thamrachalla
48 Kaliyara

Fig.3.10. Numerical strength of various fish families recorded from Bharathapuzha river system

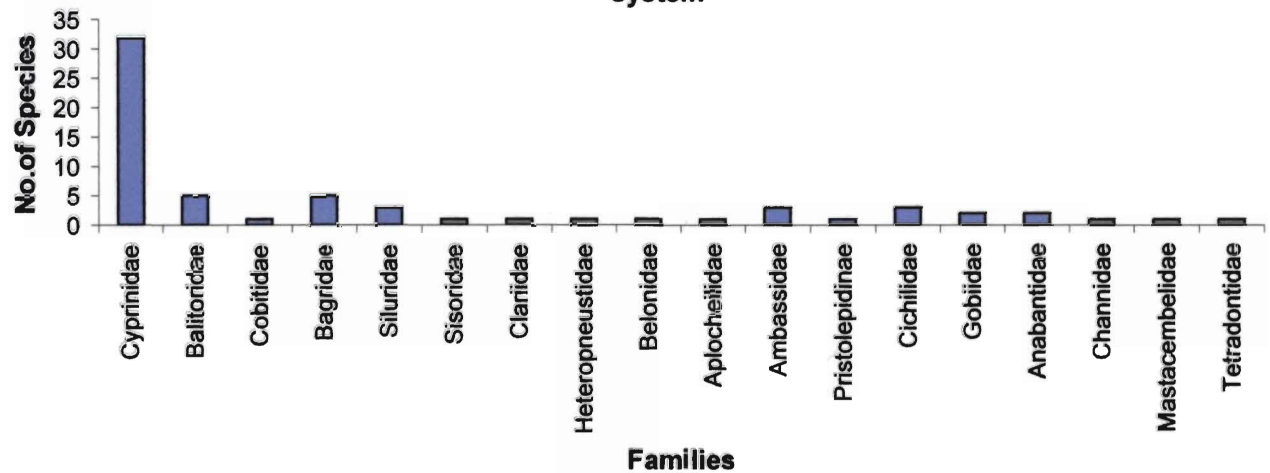


Fig.3.11. Cultivable, Ornamental and Food fishes in Bharathapuzha river system

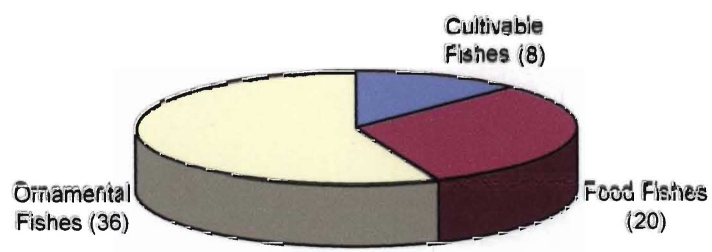


Fig.3.12. Biodiversity status of fishes in Bharathapuzha river system

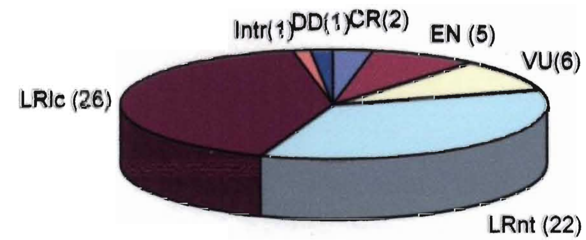


Fig. 3.13. Map of Bhavani river basin showing locations surveyed

Fig.3.14. Numerical strength of various fish families recorded from Bhavani river system

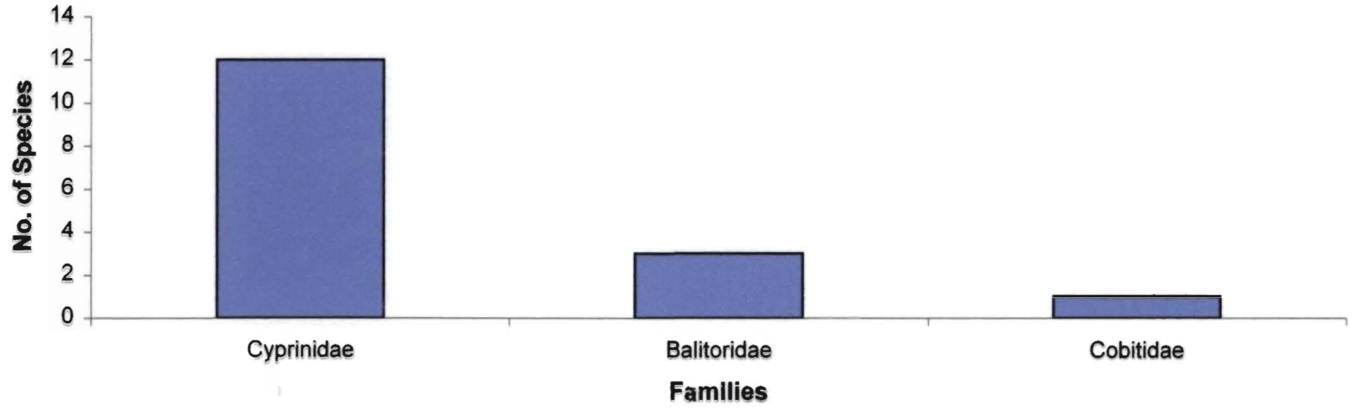


Fig.3.15. Ornamental, Cultivable and Food fishes in Bhavani river system

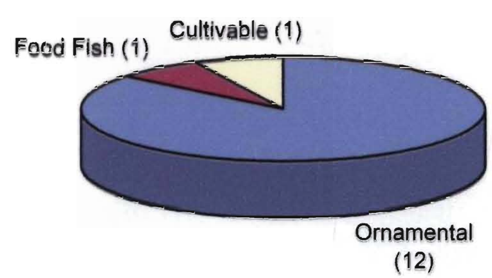


Fig.3.16. Biodiversity status of fishes in Bhavani river system

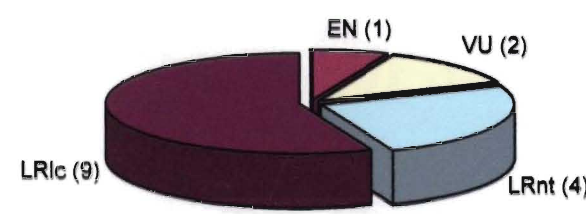


Fig. 3.17. Map of Chalakudy river basin showing locations surveyed

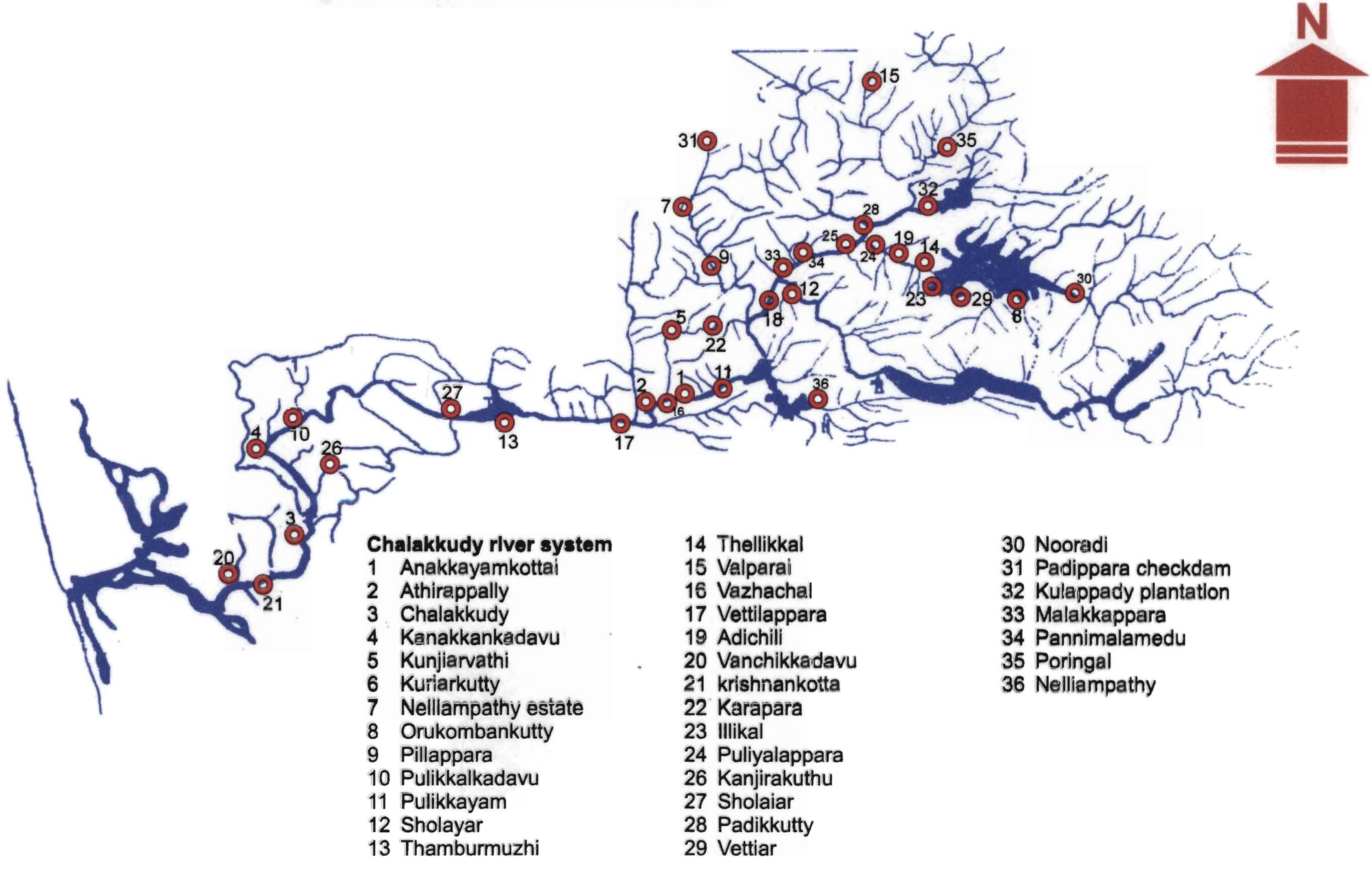


Fig.3.18. Numerical strength of various fish families recorded from Chalakkudy river system

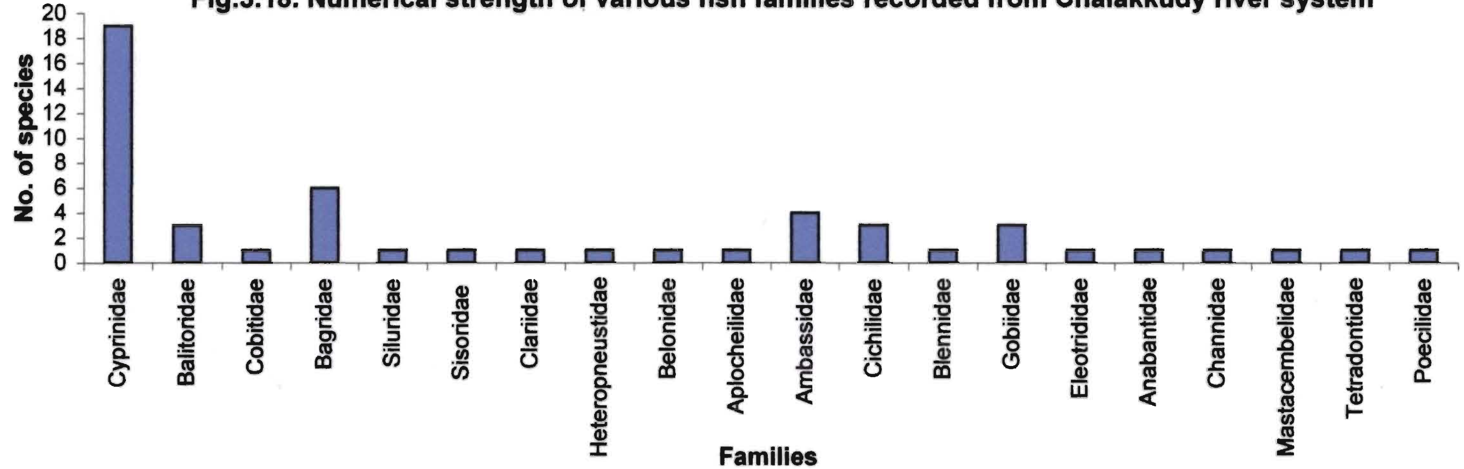


Fig.3.19. Cultivable,Ornamental and Food fishes in Chalakkudy river system

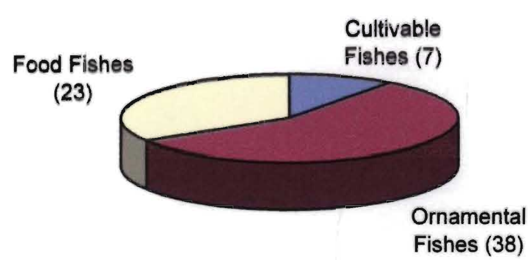


Fig.3.20. Boidiversity status of fishes in Chalakkudy river system

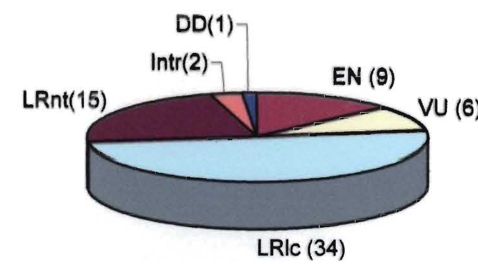
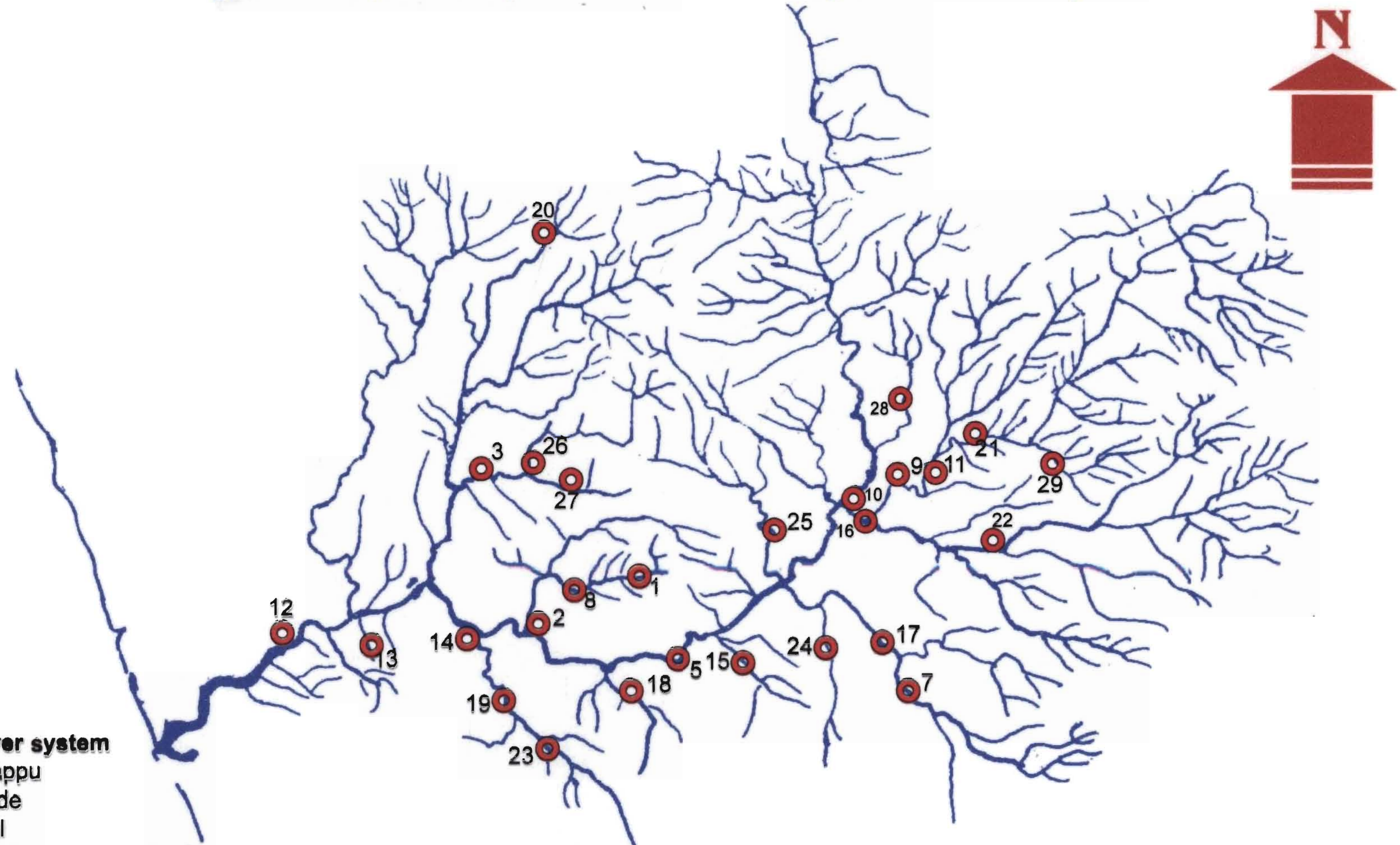


Fig. 3.21. Map of Chaliyar river basin showing locations surveyed



Chaliyar river system

1 Appankappu
2 Areekkode
3 Chalikkal
4 Cheruvadi
5 Chunkatahra
6 Edakkara
7 Karimpuzha
8 Kunduthodu
9 Mancheri
10 Manjeri
11 Mayiladippotti
12 Mukkam
13 Munda
14 Munderi
15 Muttikkadavu
16 Nedumkayam
17 Panangayam
18 Vallakktta
19 Vallikuthukadavu
20 Vazhikkadavu
21 Meenmutty
22 Kallankode
23 Kannappankundu
24 Veedukuzhi
25 Kinaloor
26 Kathiroor estate
27 Kannar
28 Kalakkanpuzha
29 Arukkayampuzha

Fig.3.22. Numerical strength of various fish families recorded from Chaliyar river system

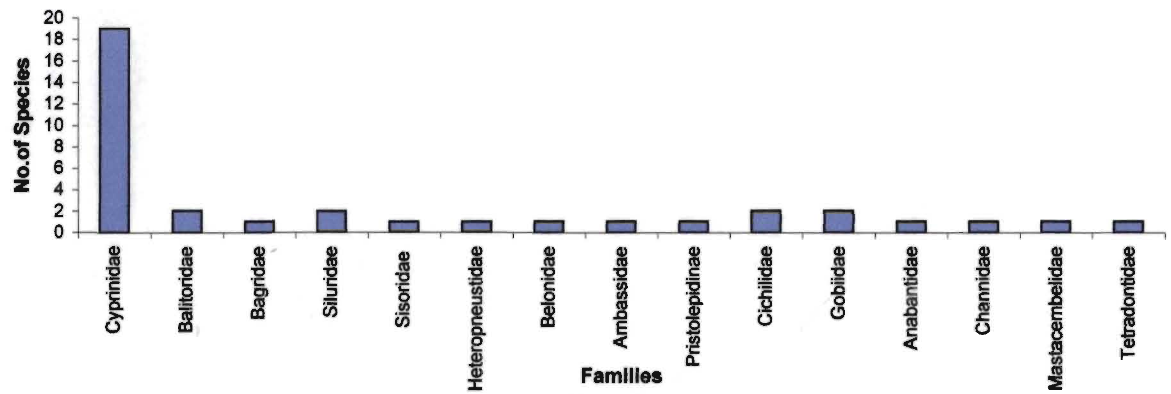


Fig.3.23. Cultivable, Ornamental and Food fishes in Chaliyar river system

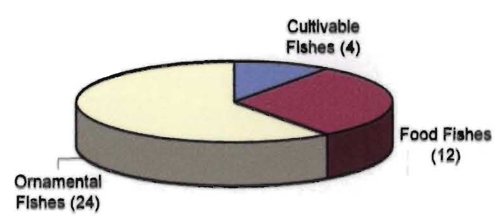


Fig.3.24. Biodiversity status of fishes in Chaliyar river system

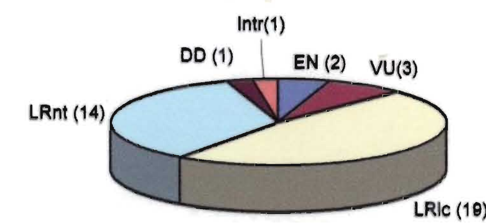
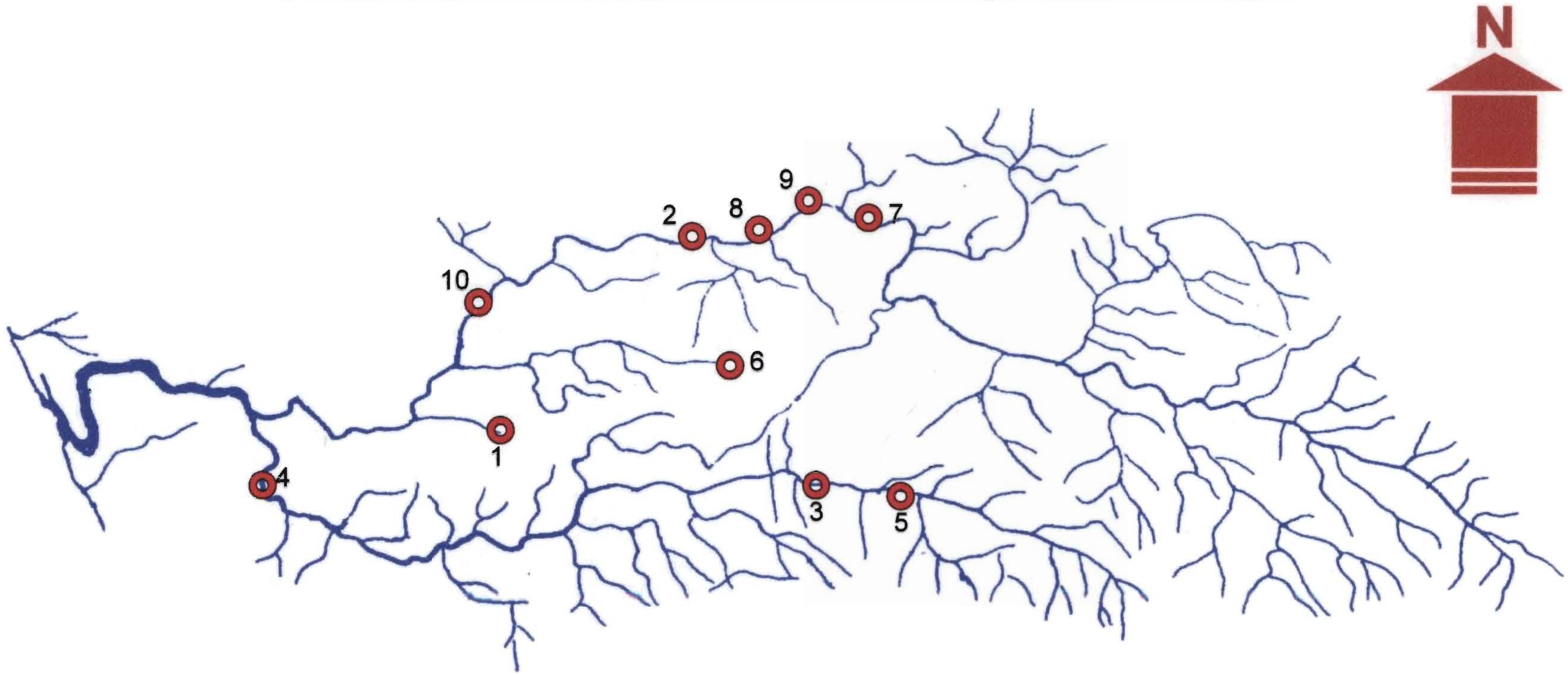


Fig. 3.25. Map of Chandragiri river basin showing locations surveyed



Chandragiri river system

1 Parappa
2 Mulleria
3 Sampaji
4 Panchikkal
5 Adukkasthala
6 Sullya
7 Madikkeri
8 Tenth mile
9 Vettathur
10 Adur

Fig.3.26. Numerical of various fish familes reported from Chandragiri river system

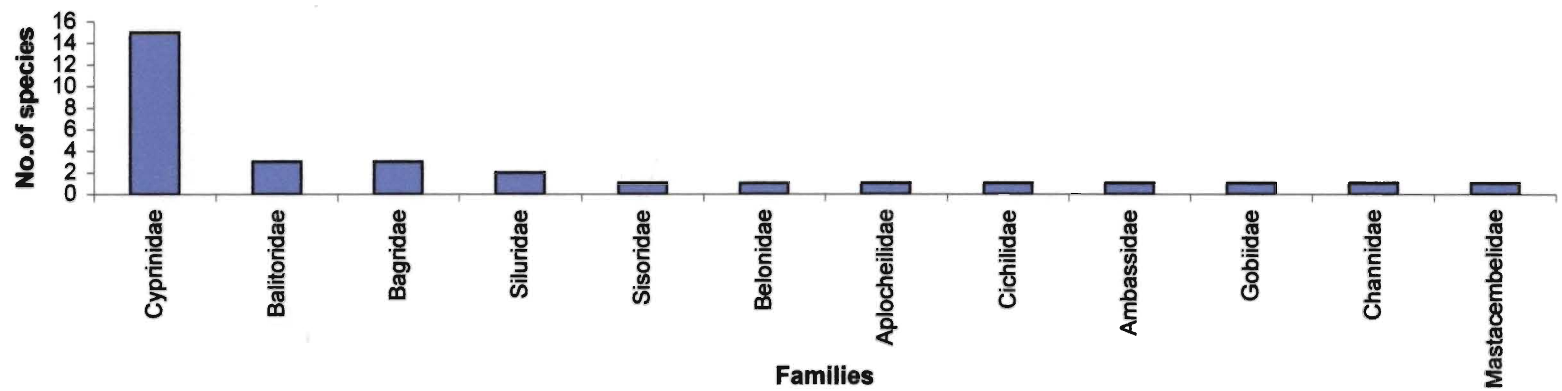


Fig.3.27. Cultivable, Ornamental and Food fishes in Chandragiri river sytem

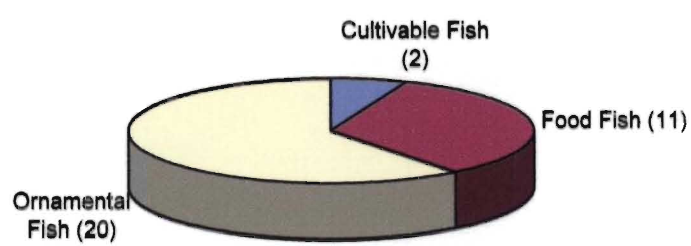


Fig.3.28. Biodiversity status of fishes in Chandragiri river sytem

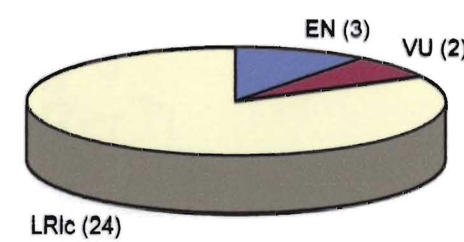


Fig. 3.29. Map of Kabbini river basin showing locations surveyed

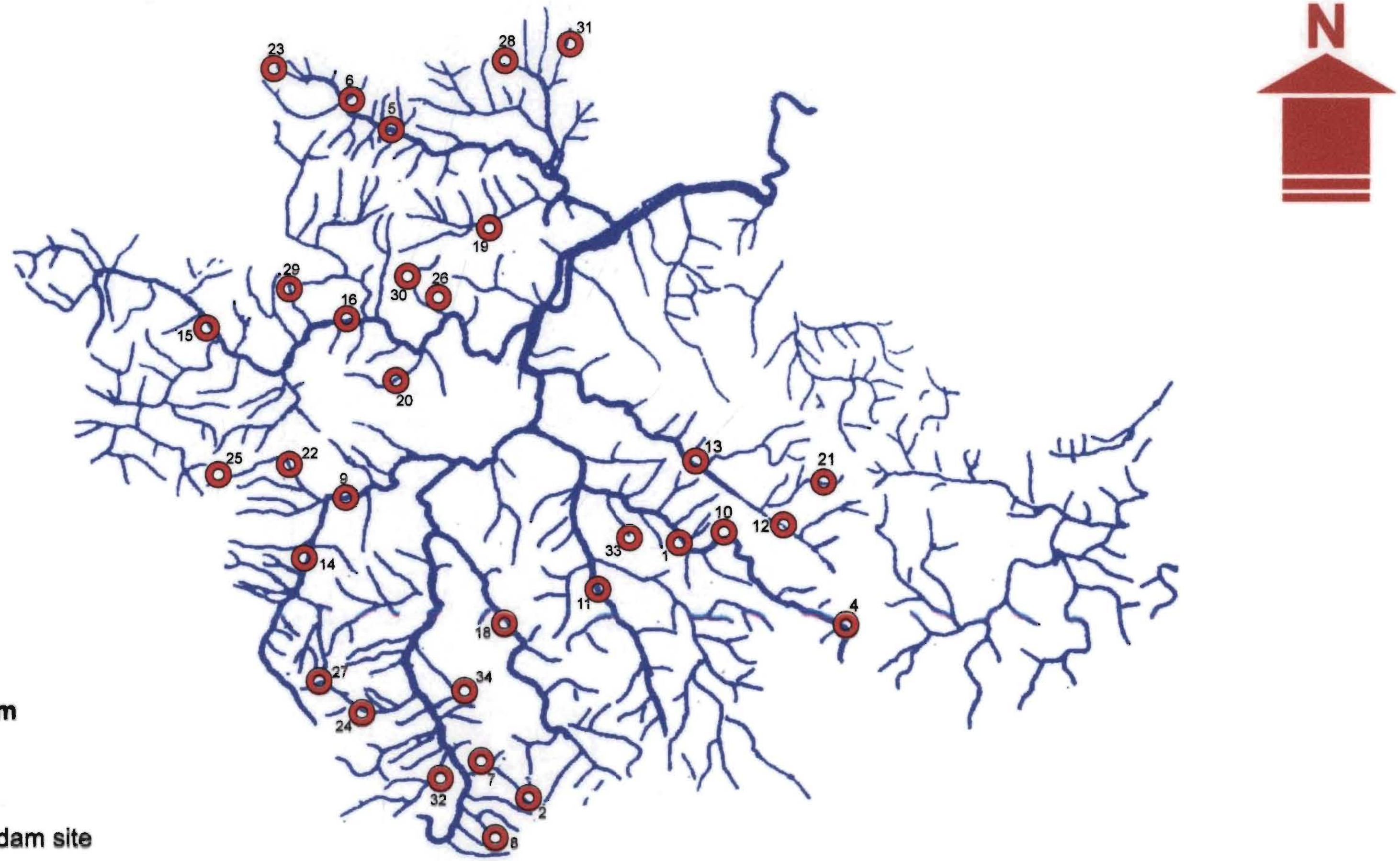


Fig.3.30. Numerical strength of various fish families recorded from Kabbini river system

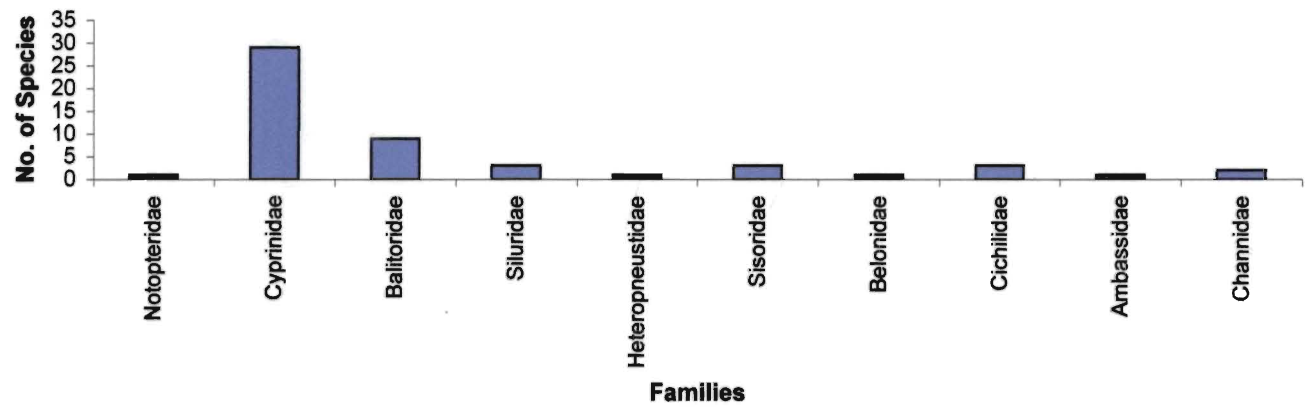


Fig.3.31. Cultivable,Ornamental and Food fishes in Kabbini river system

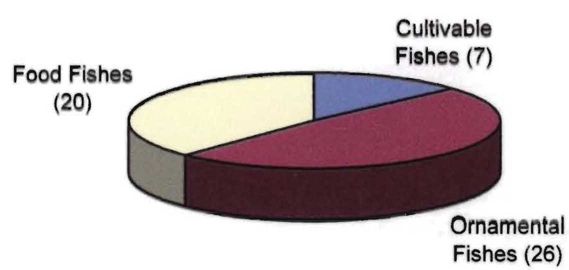


Fig.3.32. Blodiversity Status of Fishes in Kabbini river systrem

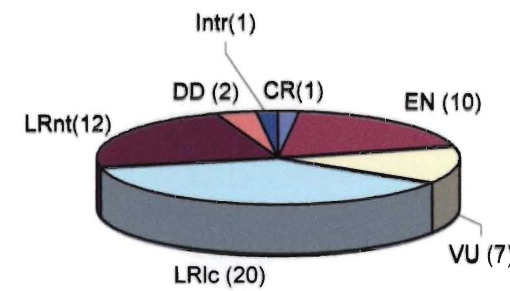


Fig. 3.33. Map of Kadalundi river basin showing locations surveyed

Kadalundi river system

1 Velliar
2 Palappuram
3 Chathanpara

Fig.3.34. Numerical strength of various fish families recorded from Kadalundi river system

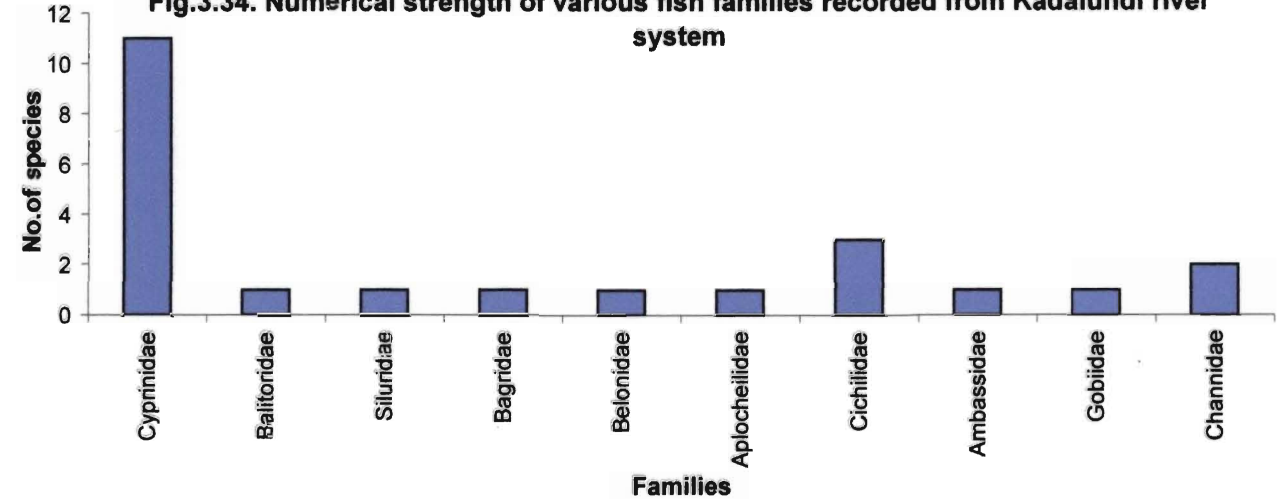


Fig. 3.35. Cultivable,Ornamental and Food fishes in Kadalundi river system

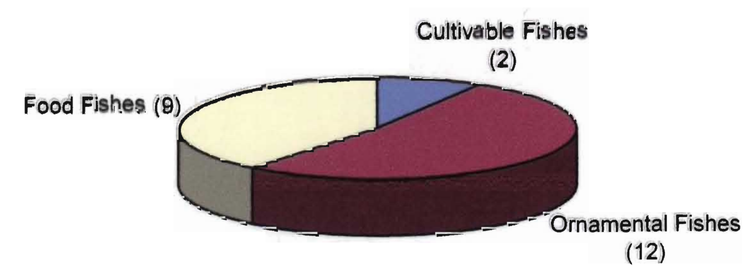
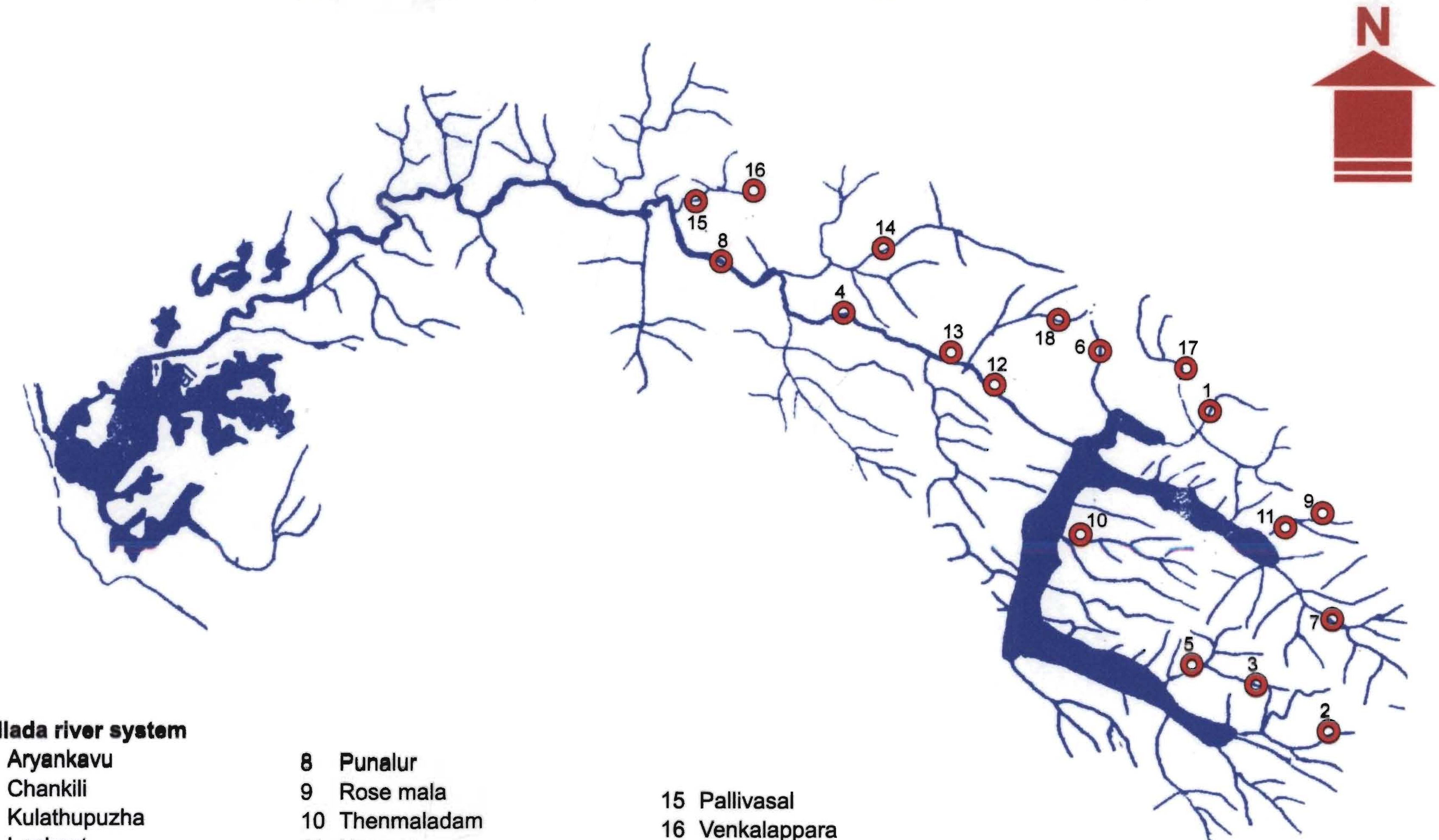


Fig. 3.36. Map of Kallada river basin showing locations surveyed



Kallada river system

1 Aryankavu
2 Chankili
3 Kulathupuzha
4 Lookout
5 Meenmudy
6 Mukkadavu
7 Palaruvi downstream
8 Punalur
9 Rose mala
10 Thenmaladam
11 Umayar
12 Urukunnu
13 O ttakkal
14 Kazhuthurutti
15 Pallivasal
16 Venkalappara
17 Edappalayam
18 Neduvannurkkadavu

Fig.3.37. Numerical strength of various fish families recorded from Kallada river System

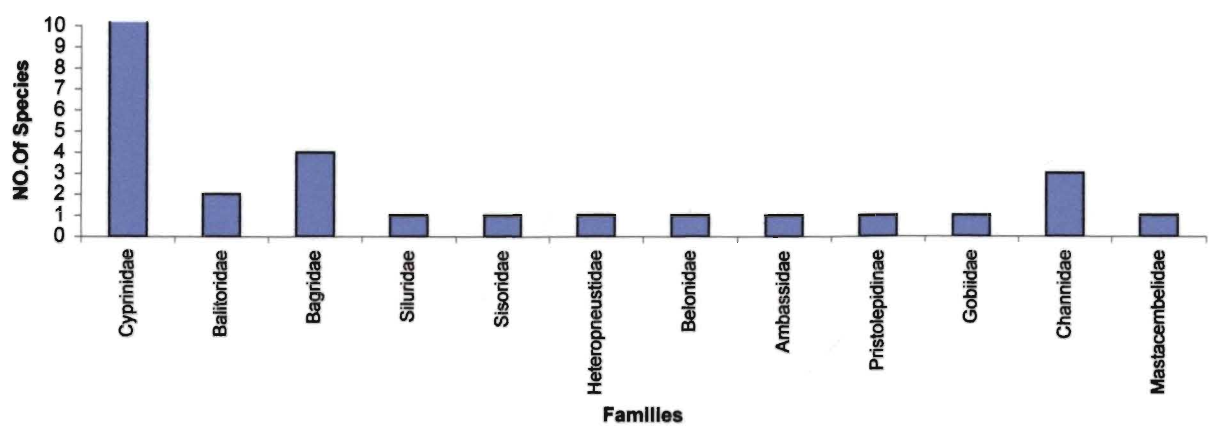


Fig.3.38. Cultivable,Ornamental and Food fishes in Kallada river system

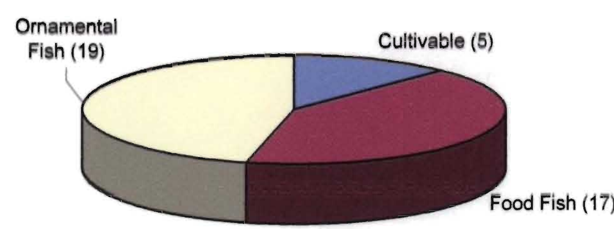


Fig.3.39. Biodiversity status of fishes in Kallada river system

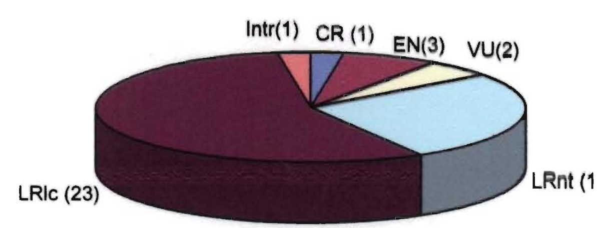
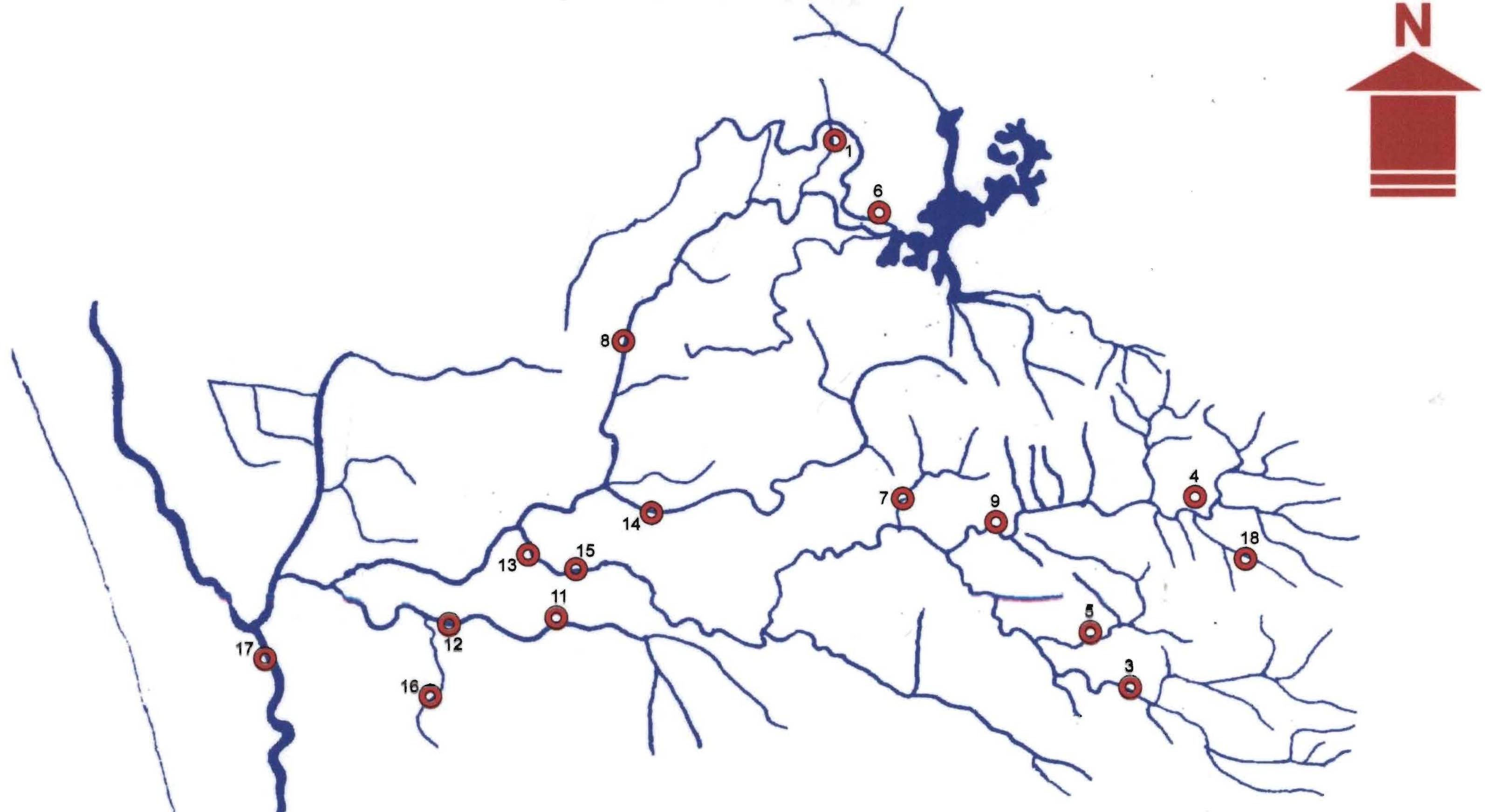


Fig. 3.40. Map of Karavannur river basin showing locations surveyed



Karuvannur river system

1	Elikkode	6	Peechi	13	Marottikkavu
2	Moorkkinikkavu	7	Kannara	14	Kalkuzhi
3	Muppilithode	8	Manali	15	Kurumalipuzha
4	Puthukkad estate	9	Chimoni	16	Pillathode
5	Valakkavu	11	Puthoor	17	Canolithode
		12	Kainoor	18	Chimoni damsite

Fig.3.41. Numerical strength of various fish families recorded from Karuvannur river system

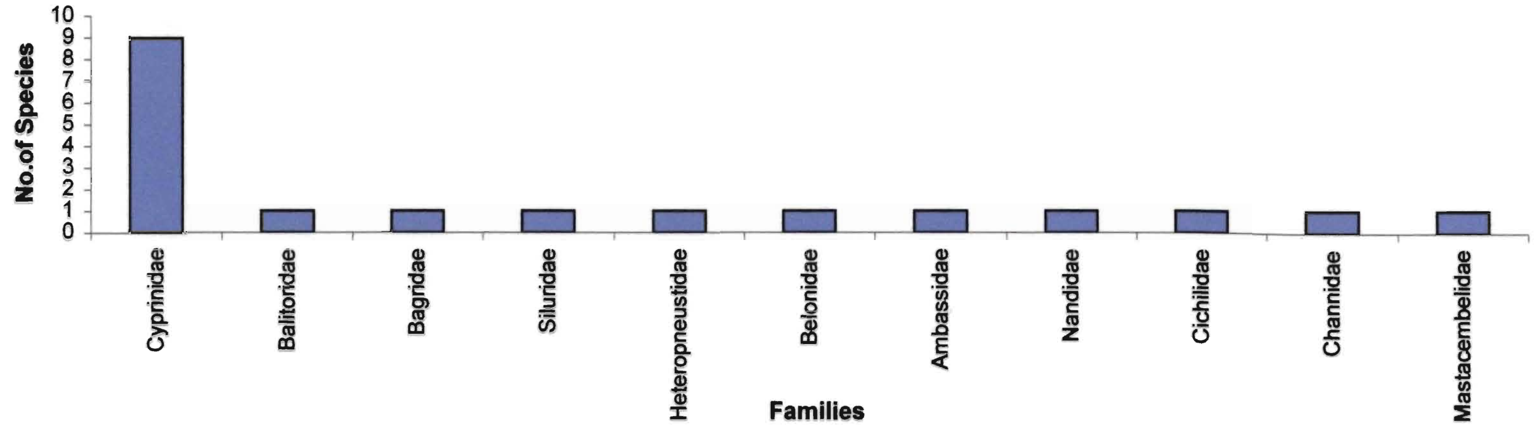


Fig.3.42. Cultivable, Ornamental and Food fishes in Karuvannur river system

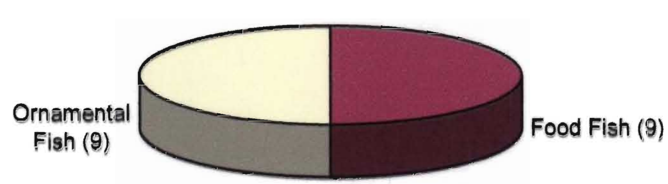


Fig.3.43. Biodiversity status of fishes in Karuvannur river system

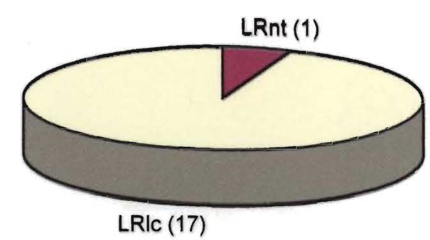


Fig. 3.44. Map of Karingode river basin showing locations surveyed

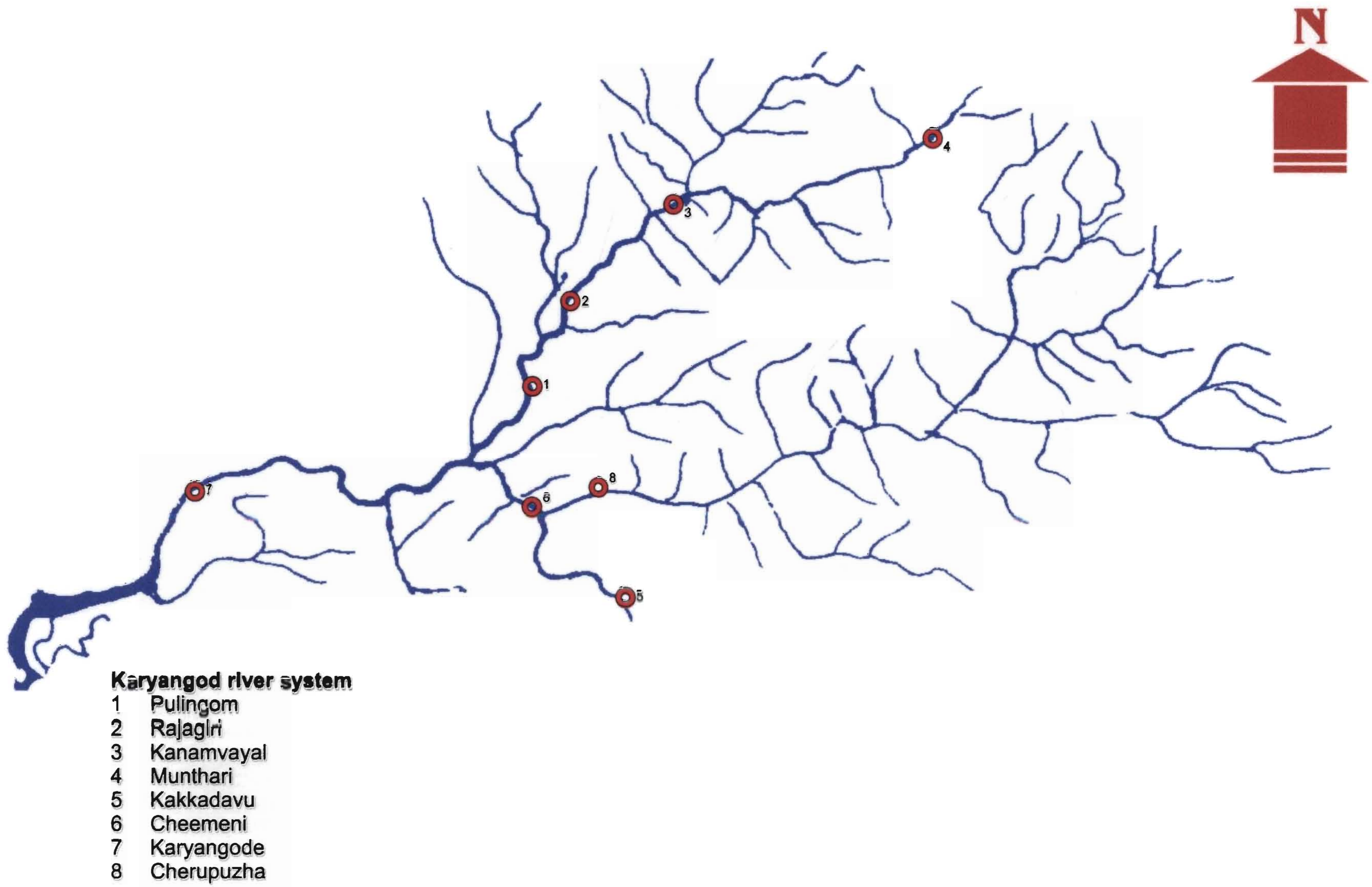


Fig. 3.45. Numerical strength of various fish families recorded from Karyangod river system

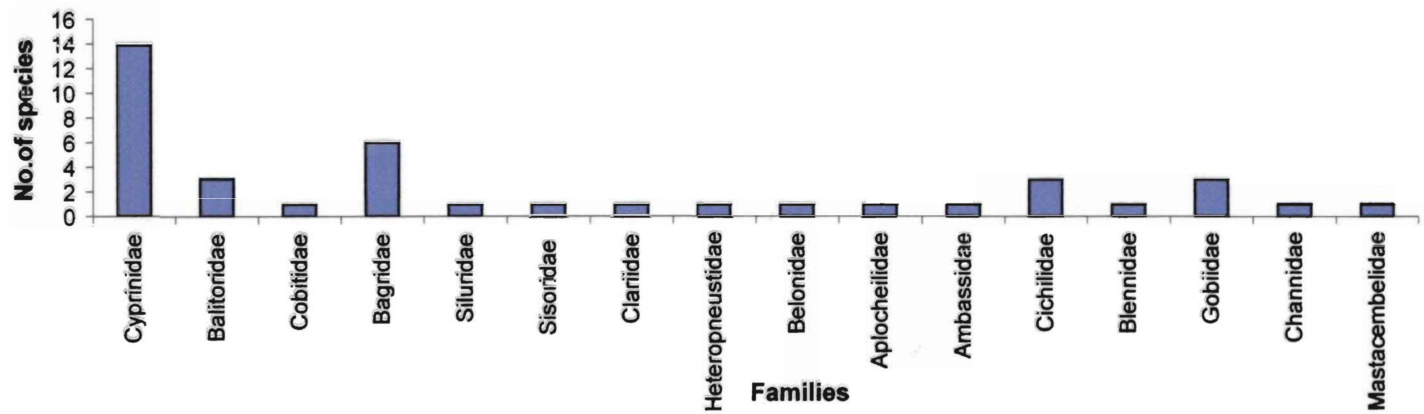


Fig.3.46. Ornamental, cultivable and food fishes in Karyankode river system

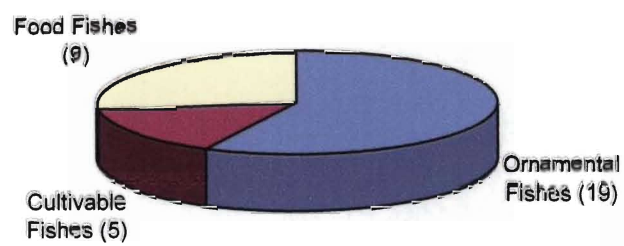


Fig.3.47. Biodiversity status of fishes in Karyankode riversytem

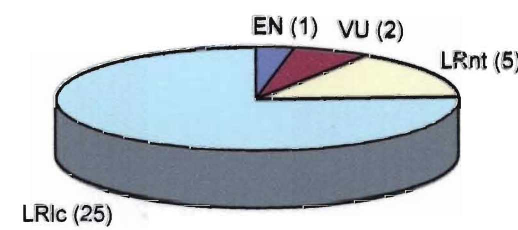


Fig. 3.48. Map of Keecheri river basin showing locations surveyed

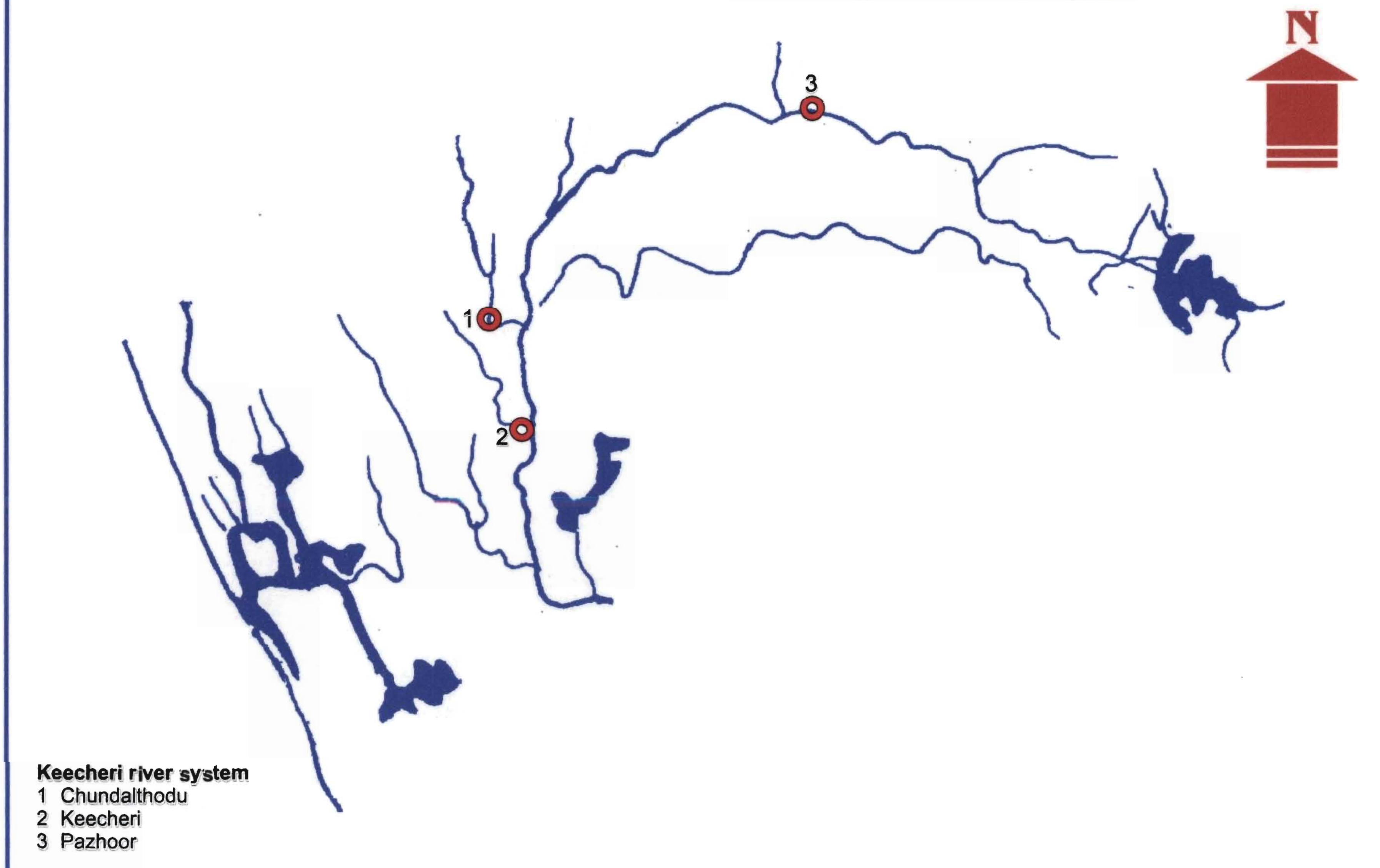


Fig.3.49. Numerical strength of various fish families recorded from Keecheri river system

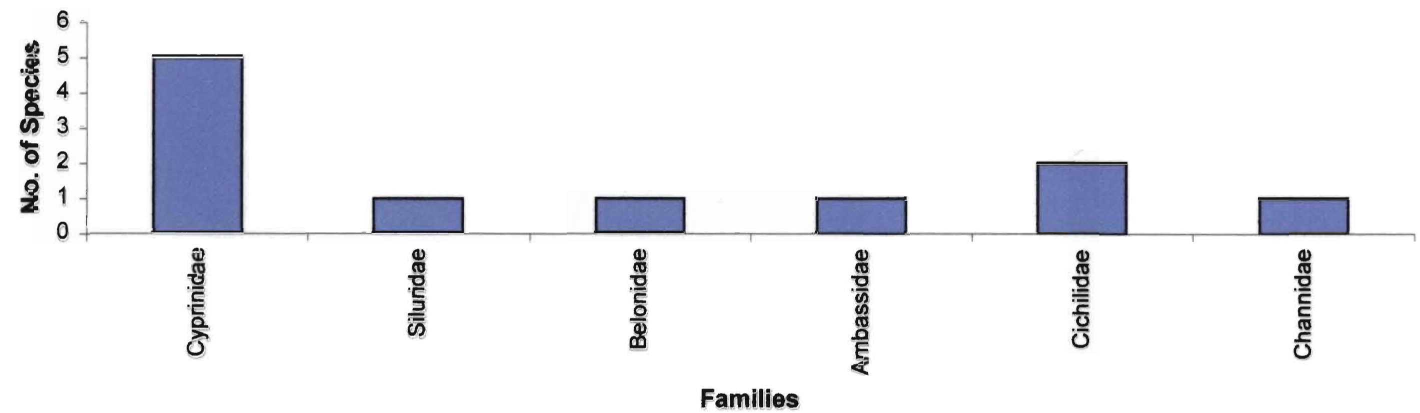


Fig.3.50. Cultivable, Ornamental and food fishes in Keecheri river system

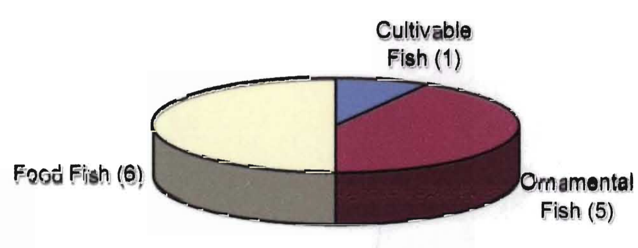


Fig.3.51. Biodiversity status of fishes in Keecheri river system

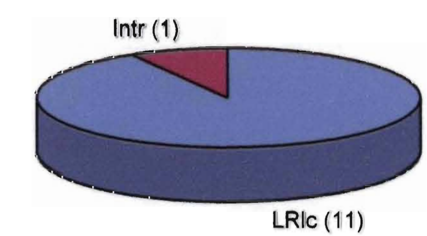


Fig. 3.52. Map of Kuppam river basin showing locations surveyed

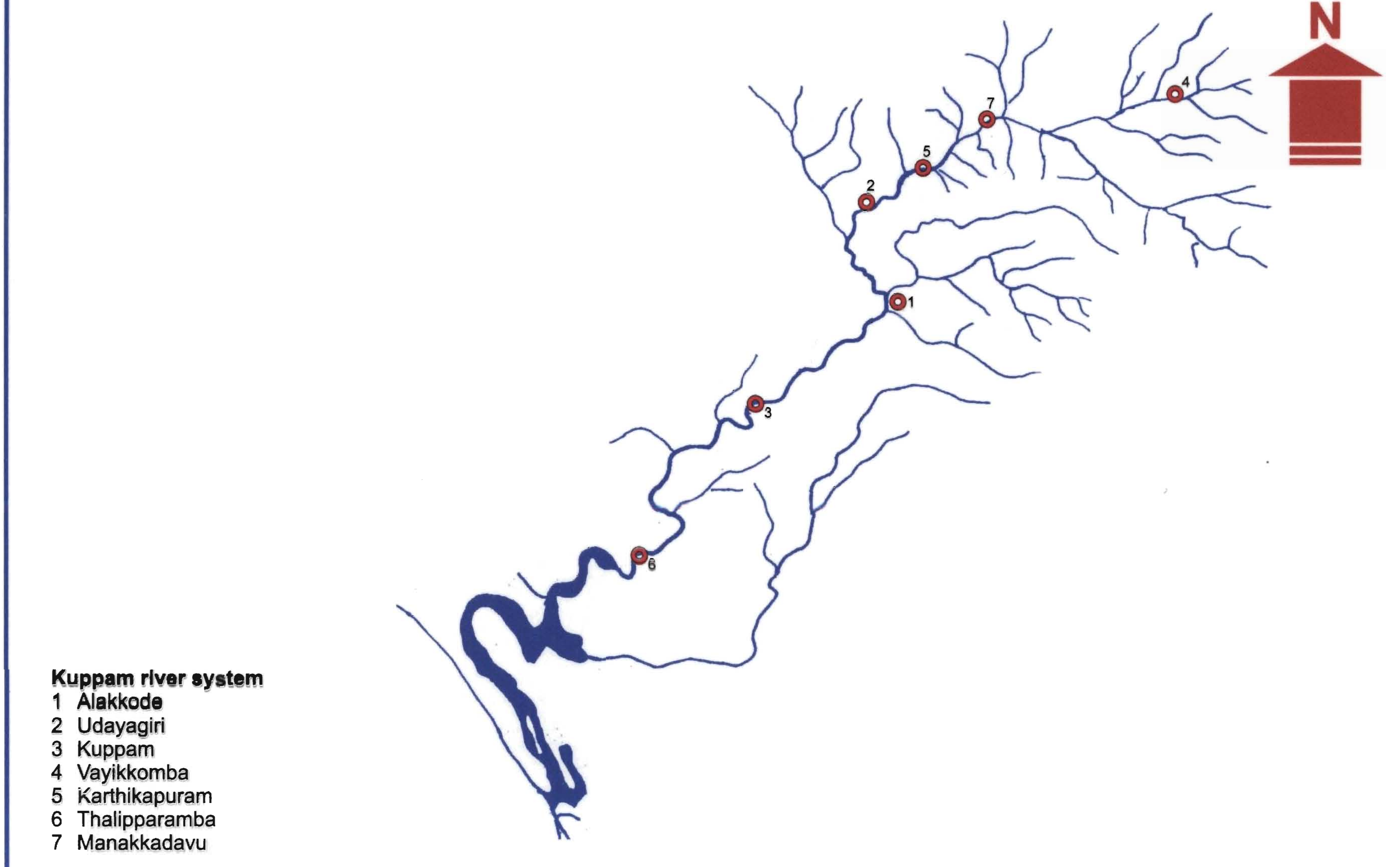


Fig.3.53. Numerical strength of various fish families recorded from Kuppam river system

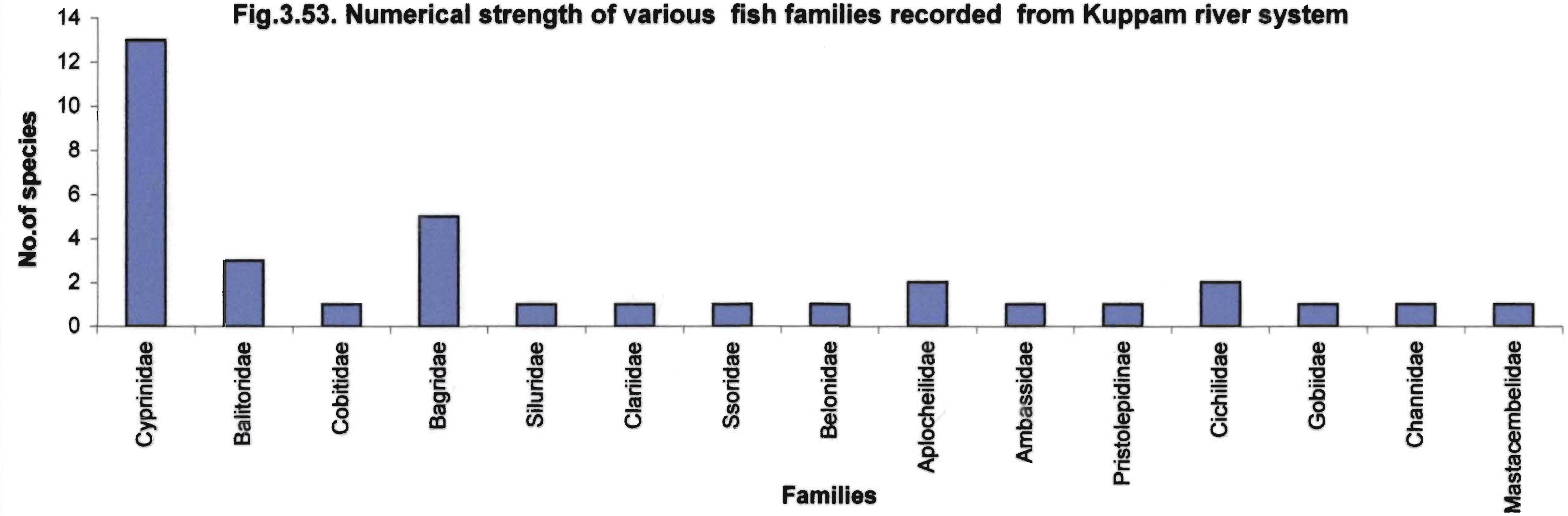


Fig.3.54. Cultivable,Ornamental and Food fishes In Kuppam river sytem

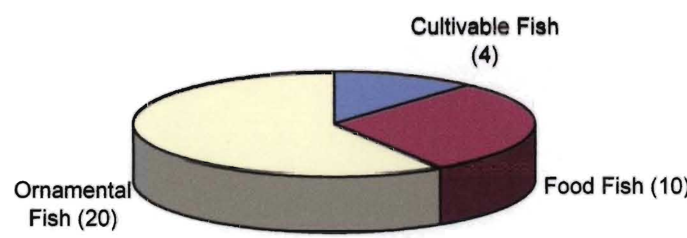


Fig.3.55. Biodiversity status of fishes in Kuppam river system

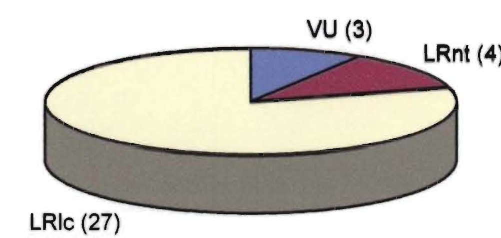


Fig. 3.56. Map of Manimala river basin showing locations surveyed

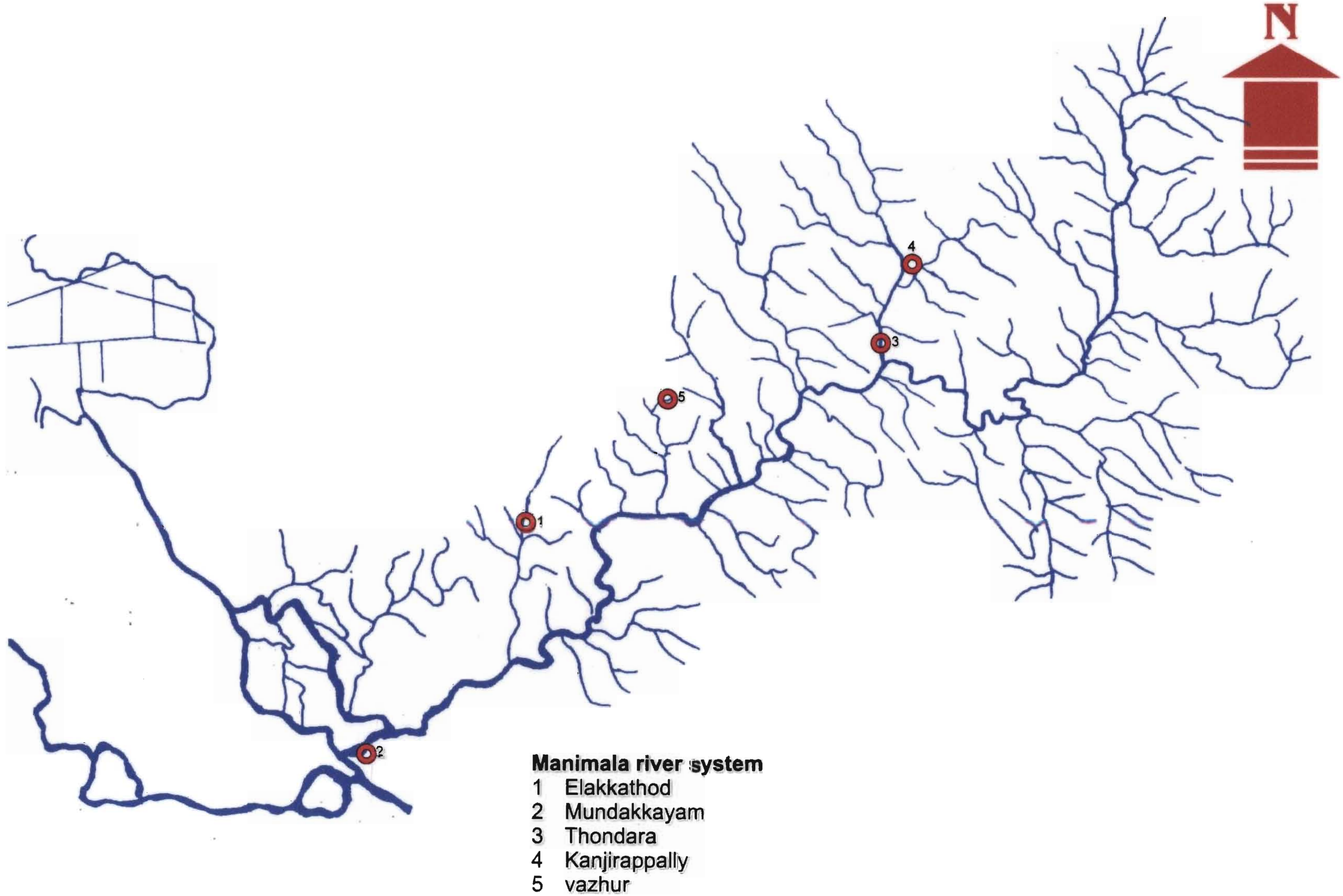


Fig.3.57. Numerical strength of various fish families recorded from Manimala river system

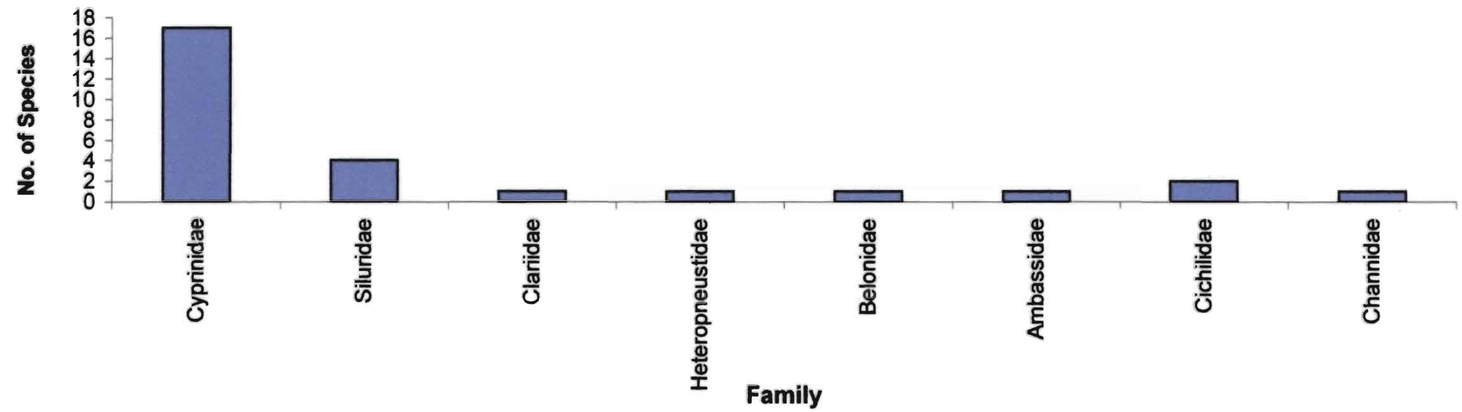


Fig.3.58. Cultivable, Ornamental and Food fishes in Manimala river sytem

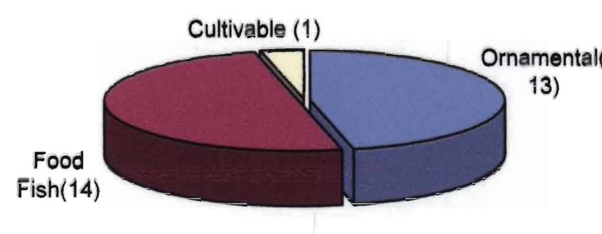


Fig.3.59. Biodiversity status of fishes in Manimal river system

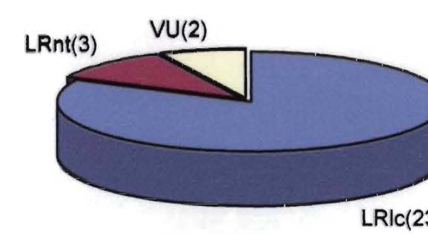
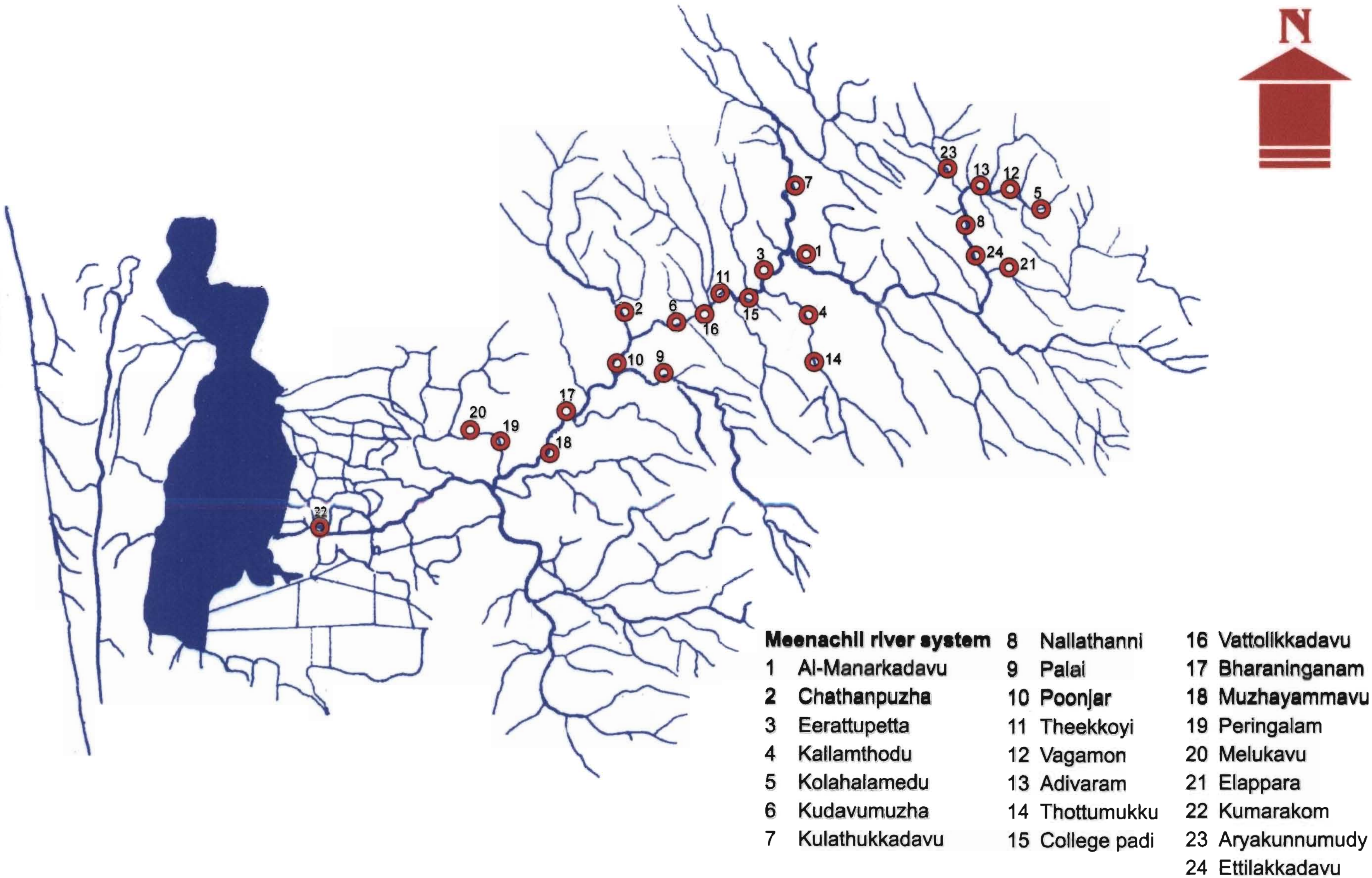


Fig. 3.60. Map of Meenachil river basin showing locations surveyed



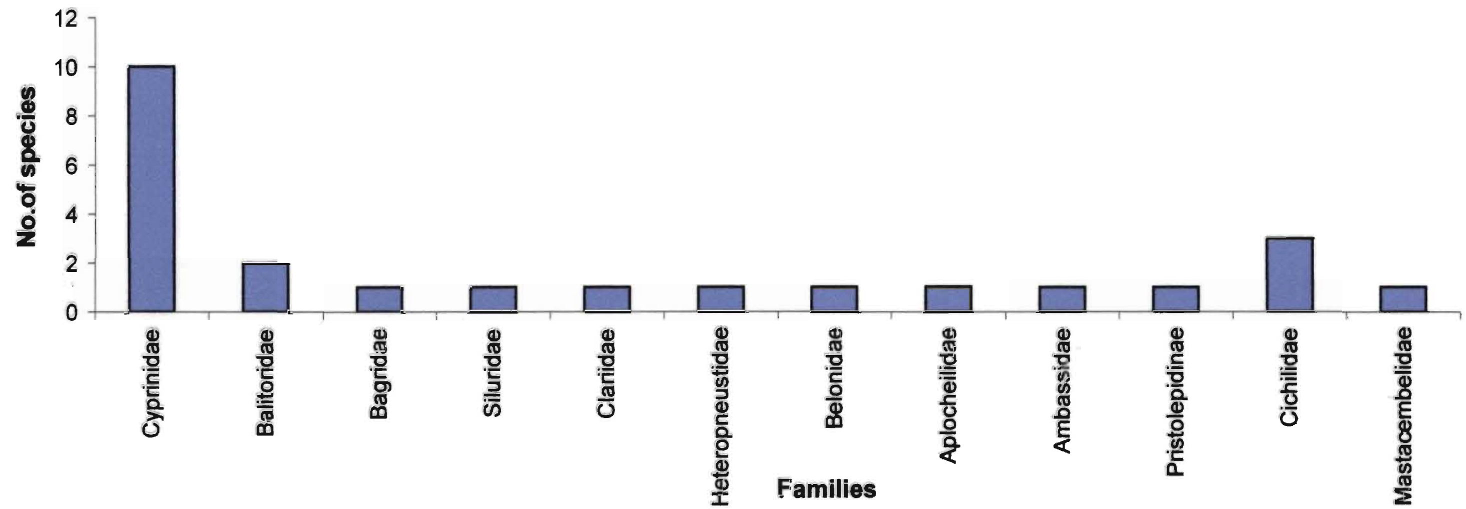


Fig.3.61. Numerical strength of various fish families recorded from Meenachil river sytem

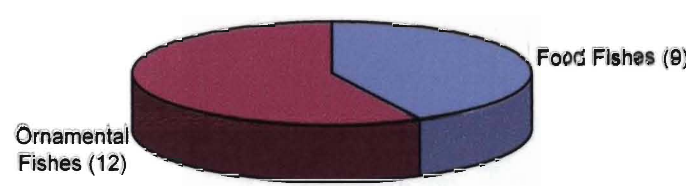


Fig.3.62. Ornamental and Food fishes in Meenachil river system

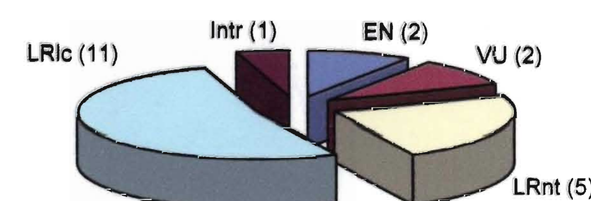


Fig.3.63. Biodiversity status of fishes in Meenachil river system

Fig. 3.64. Map of Muvattupuzha river basin showing locations surveyed

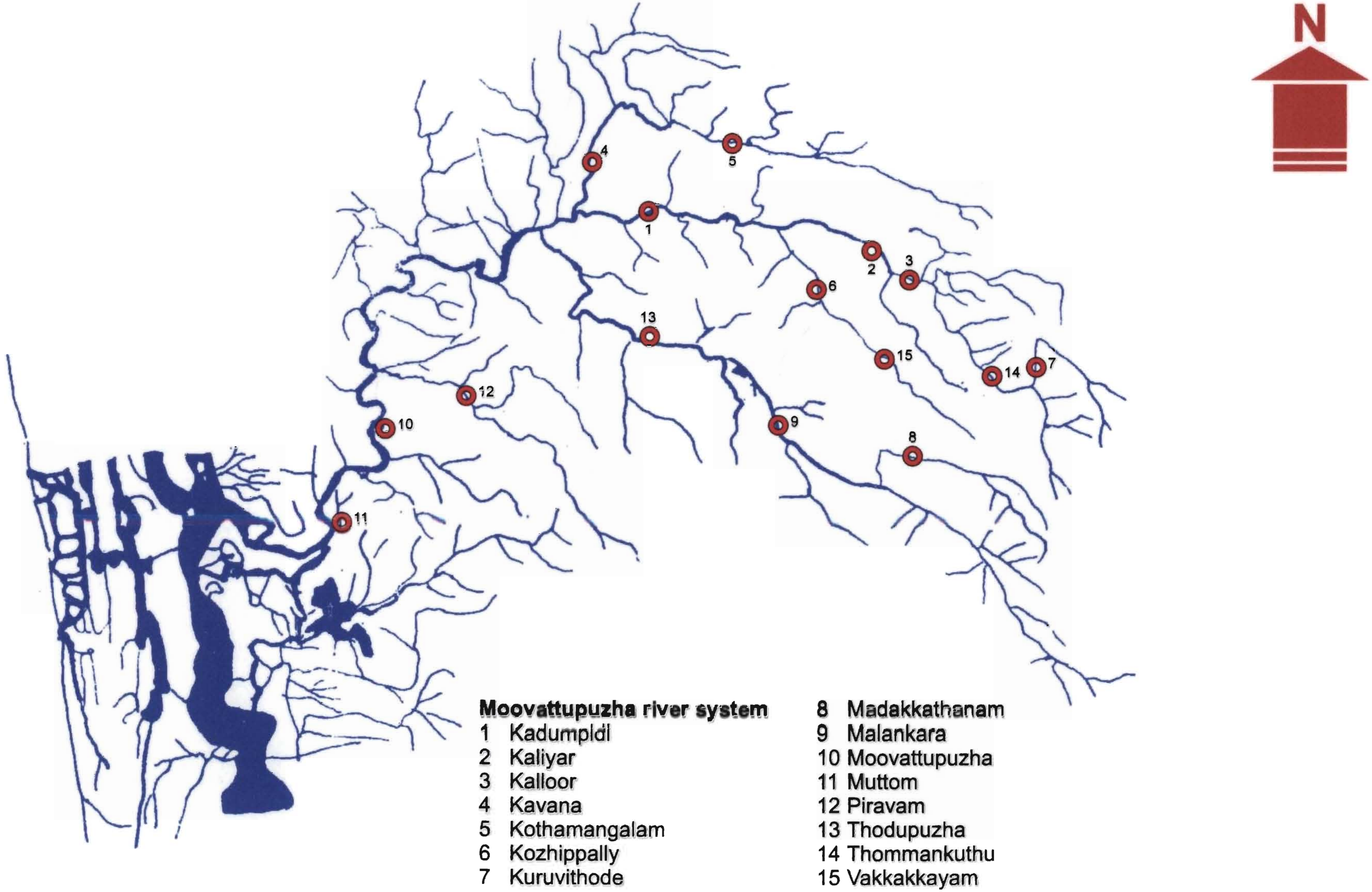


fig.3.65. Species Wise Abundance of Families in the Moovattupuzha River System

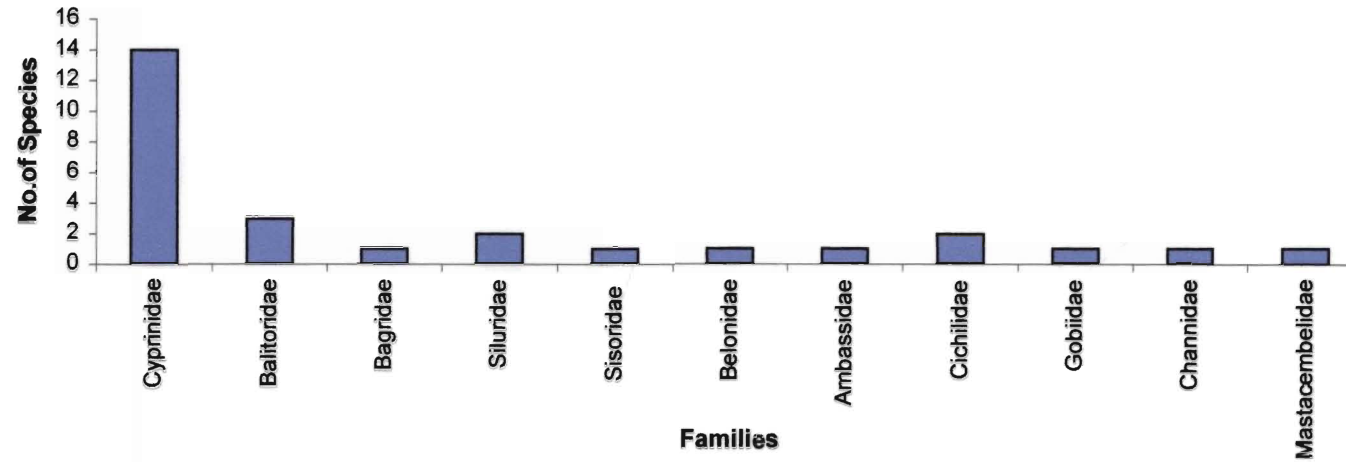


Fig.3.66. Cultivable,Ornamental and Food fishes reported from Moovattupuzha river system during the study period

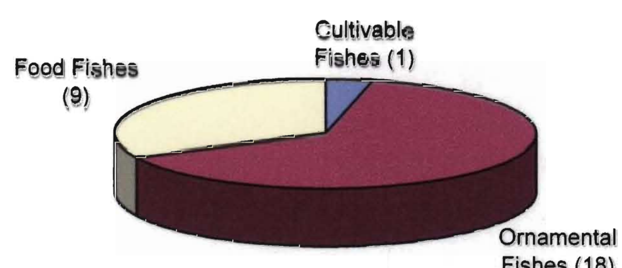


Fig.3.67. Biodiversity status of fishes Reported from Moovattupuzha river during the study period

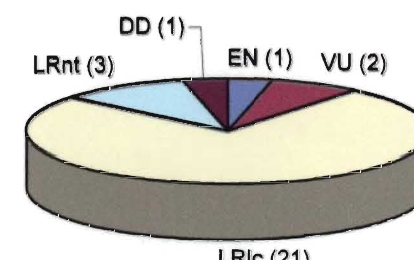


Fig. 3.68. Map of Nileswaram river basin showing locations surveyed

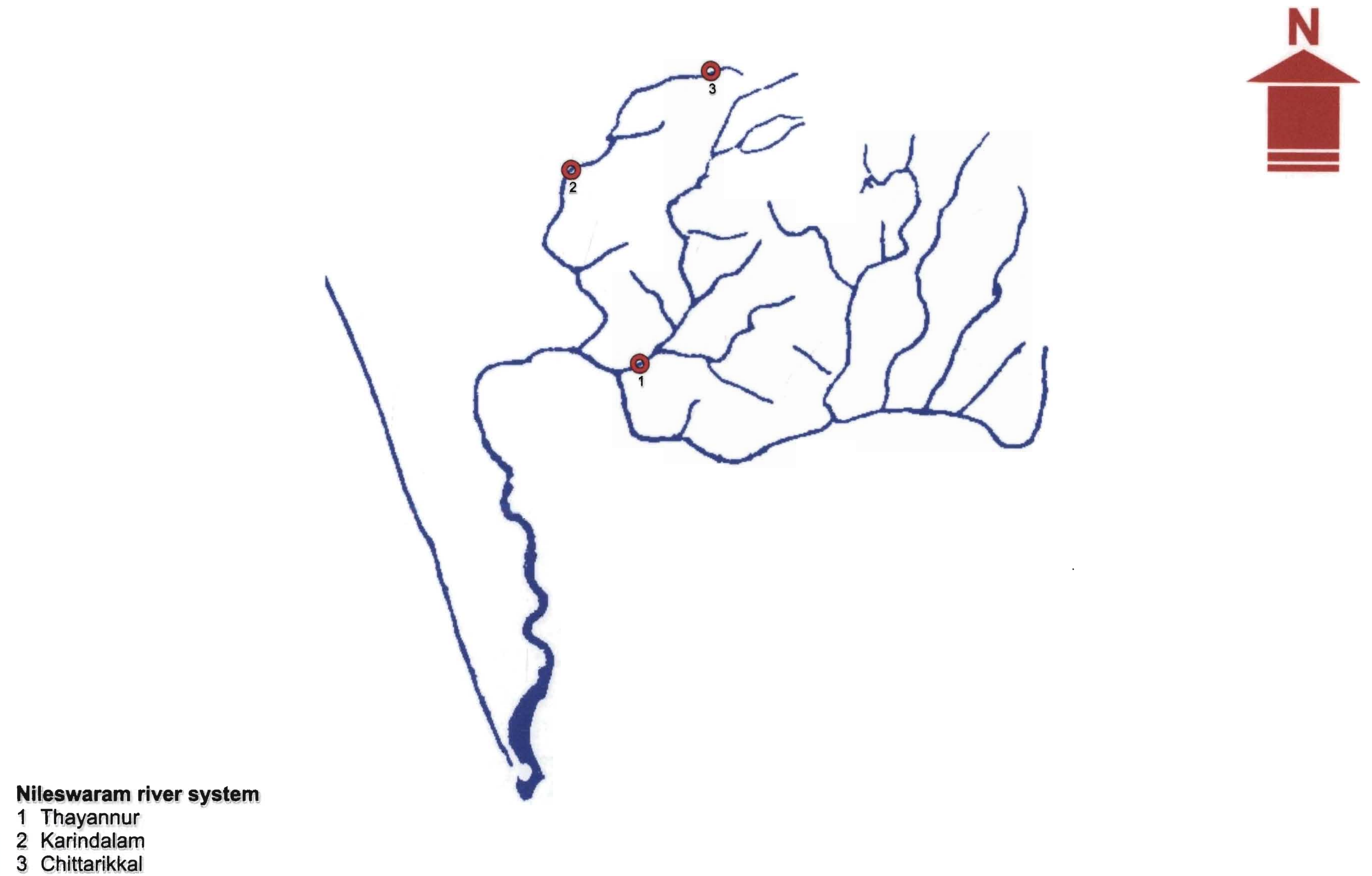


Fig.3.69. Numerical strength of various fish families recorded from Nileswaram river system

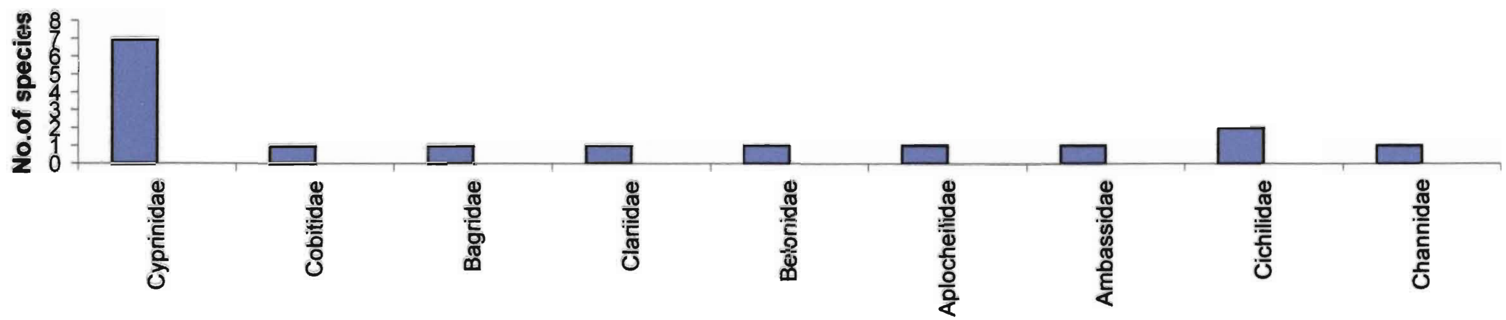


Fig.3.70. Ornamental, cultivable and food fishes in Nileswaram river system

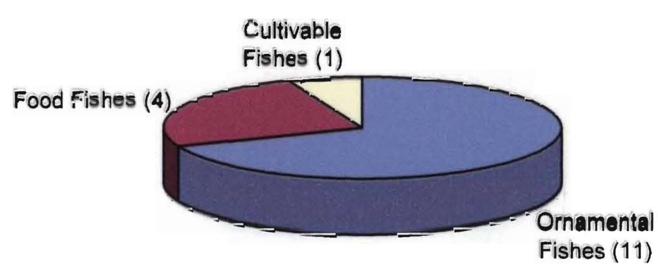


Fig.3.71. Biodiversity status of fishes in Nileswaram river system

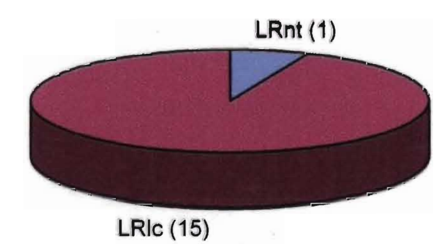
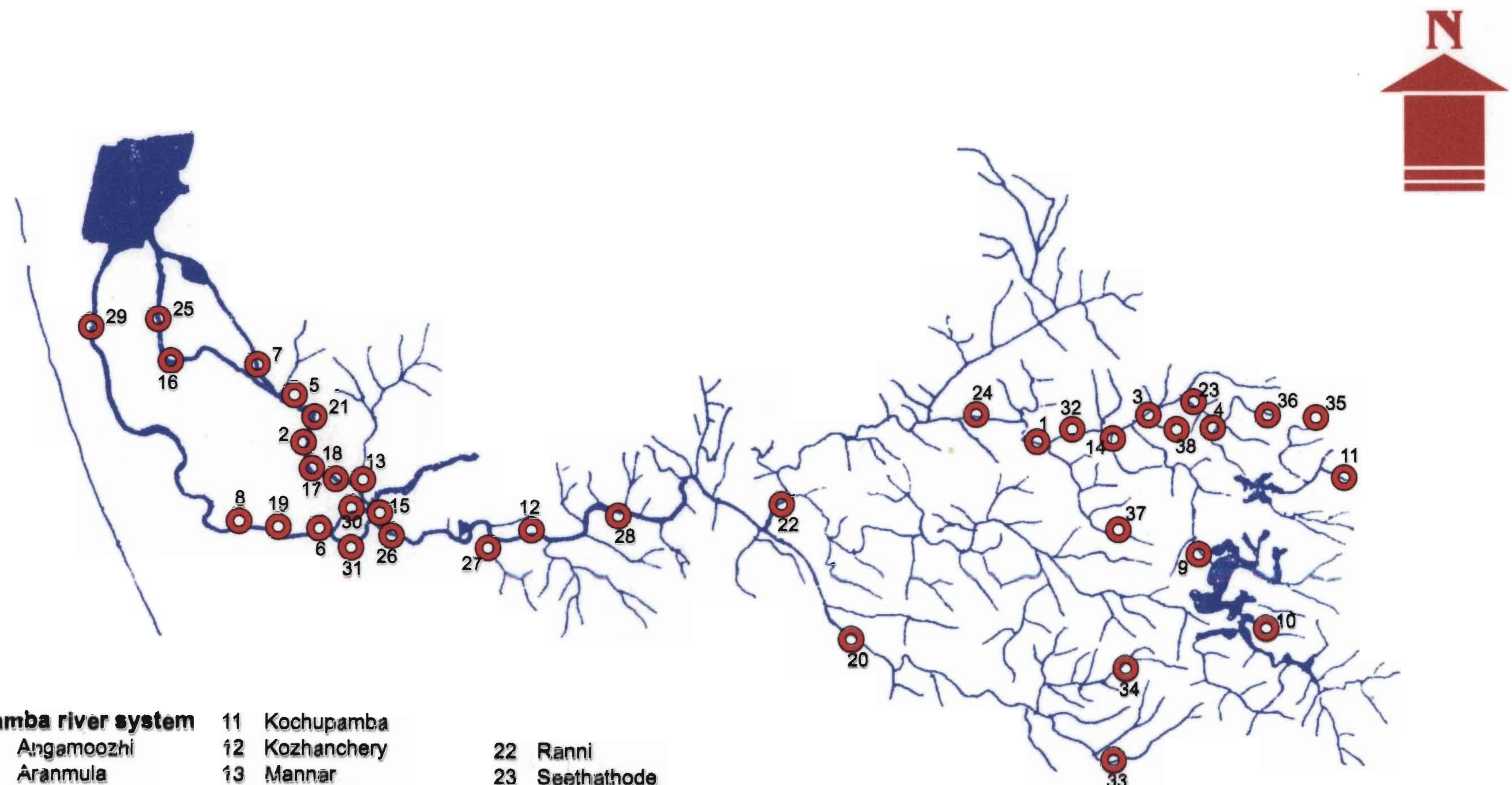


Fig. 3.72. Map of Pamba river basin showing locations surveyed



Pamba river system							
1	Angamoozhi	11	Kochupamba				
2	Aranmula	12	Kozhanchery	22	Ranni		
3	Athikkayam	13	Mannar	23	Seethathode		
4	Azhutha	14	Moozhiyar	24	Vadasserikkara	32	Nilakkal
5	Chakkulam	15	Mundakkayam	25	Viyyapuram	33	Pachakkanam
6	Chengannur	16	Neerettupuram	26	Vallakkadavu	34	Maniyadippalam
7	Edathuva	17	Parumala	27	Puthiyakavu	35	Pambavalley
8	Edayaranmula	18	Pavukkara	28	Puthankavu	36	Attathode
9	Gavi	19	Payippad	29	Kinadi	37	Veliyankadavu
10	Kakki	20	Perumthenaruvi	30	Randattinkara	38	Kalaketti
		21	Prayikkara	31	Tiruvillapuram		

Fig.3.73. Numerical strength of various fish families recorded from Pamba riversytem

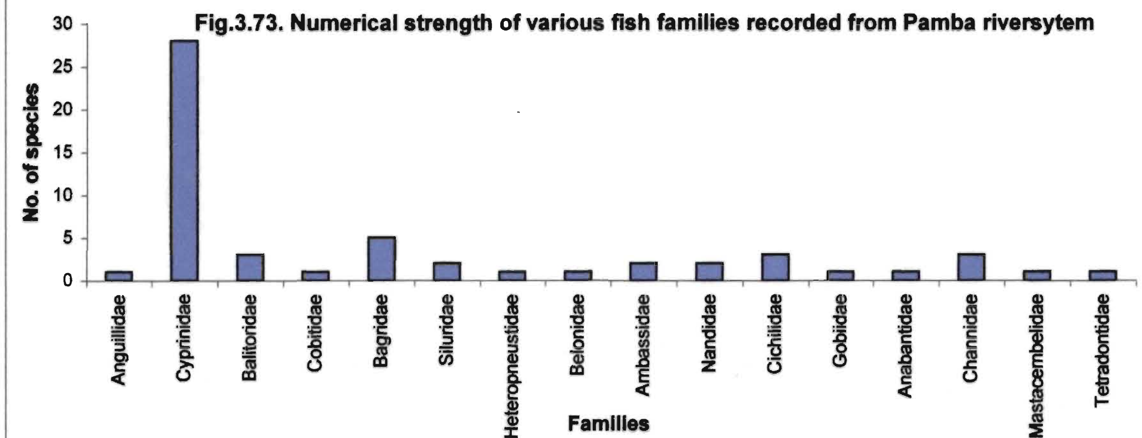


Fig.3.74. Cultivable, Ornamental and Food fishes in Pamba river system

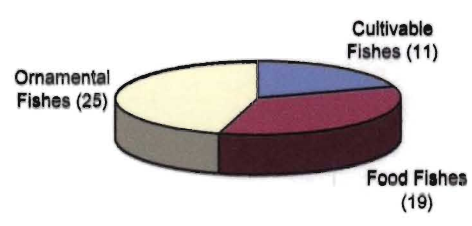


Fig.3.75. Biodiversity status of fishes in Pamba river system

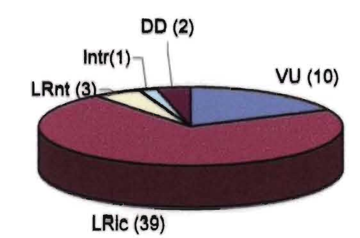


Fig. 3.76. Map of Pambar river basin showing locations surveyed

Fig.3.77. Numerical strength of various fish families recorded from Pambar river system

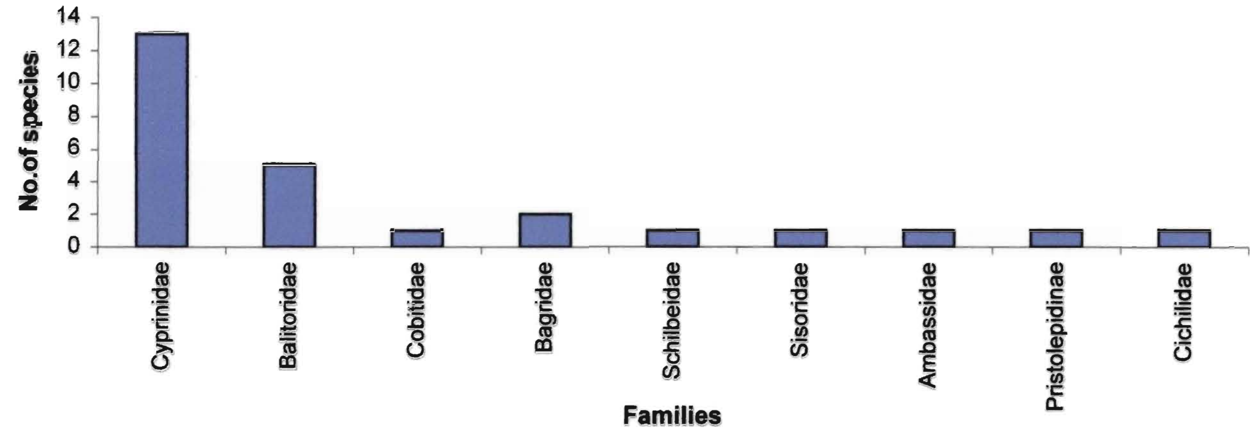


Fig.3.78. Cultivable, Ornamental and Food fishes in Pambar river system

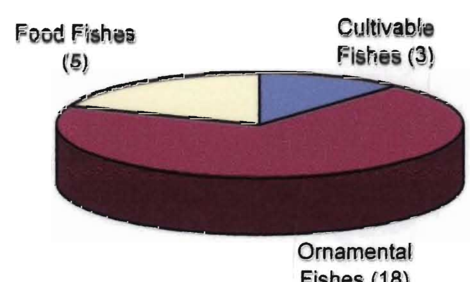


Fig.3.79. Biodiversity status of fishes in Pambar river system

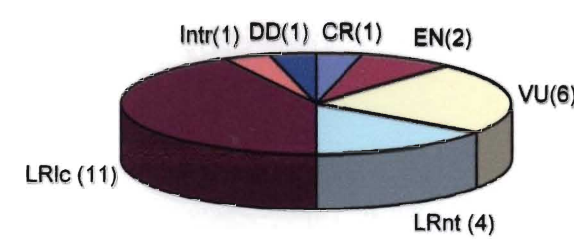


Fig. 3.80. Map of Periyar river basin showing locations surveyed

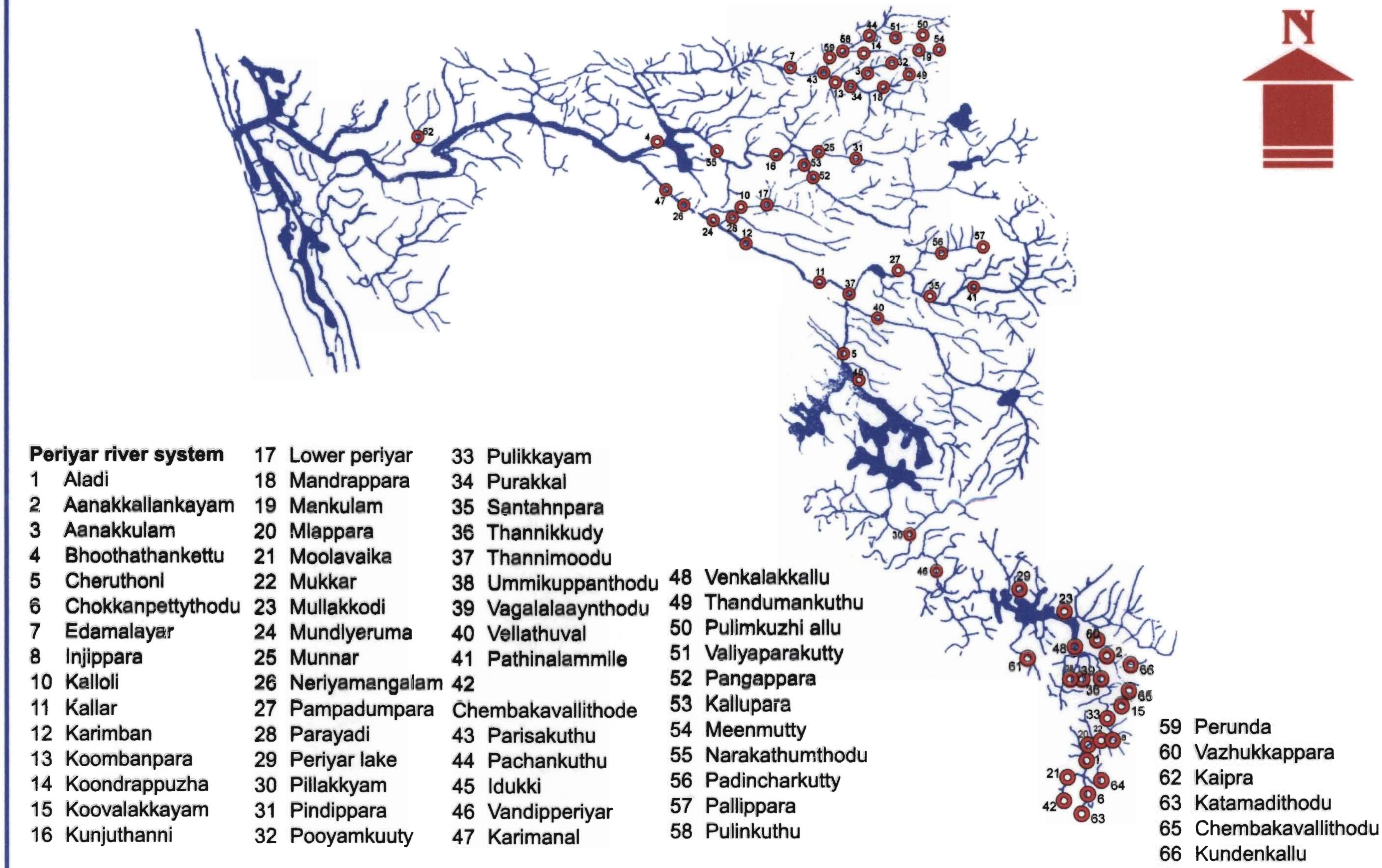


Fig.3.81. Numerical strength of various fish families recorded from Periyar river system

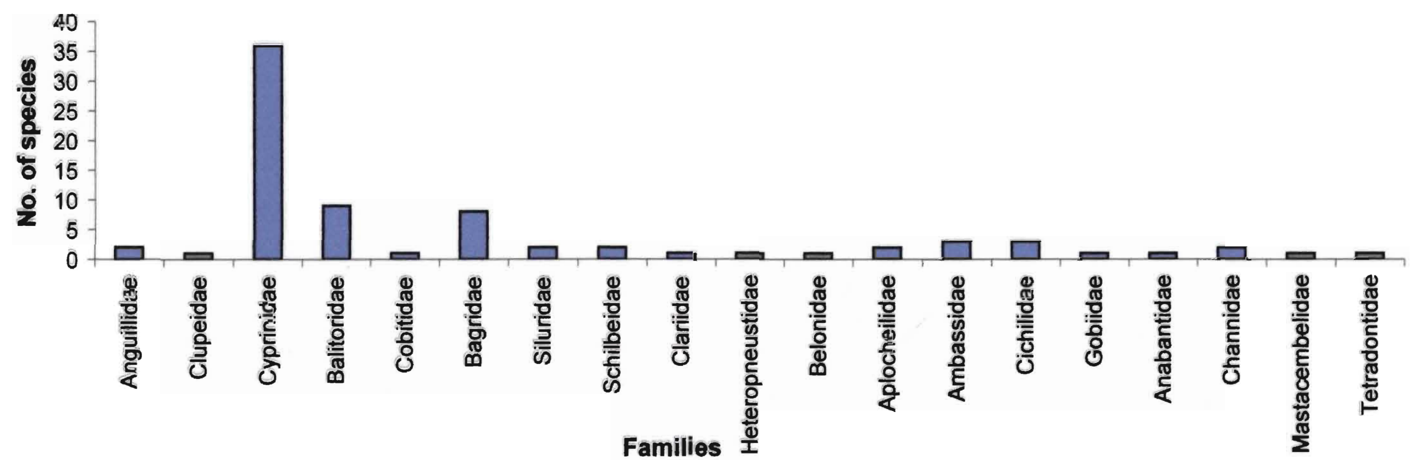


Fig.3.82. Cultivable, Ornamental and Food fishes in Periyar river system

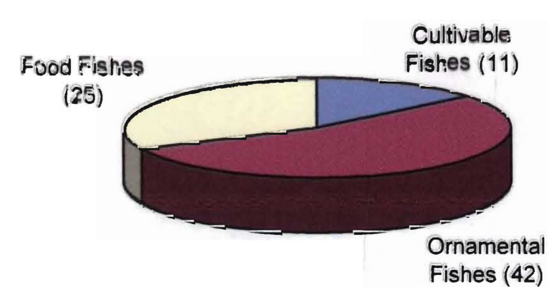


Fig. 3.83. Biodiversity Status of fishes in Periyar rivers system

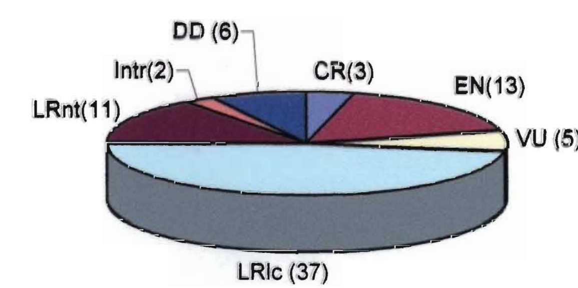


Fig. 3.84. Map of Peruvamba river basin showing locations surveyed

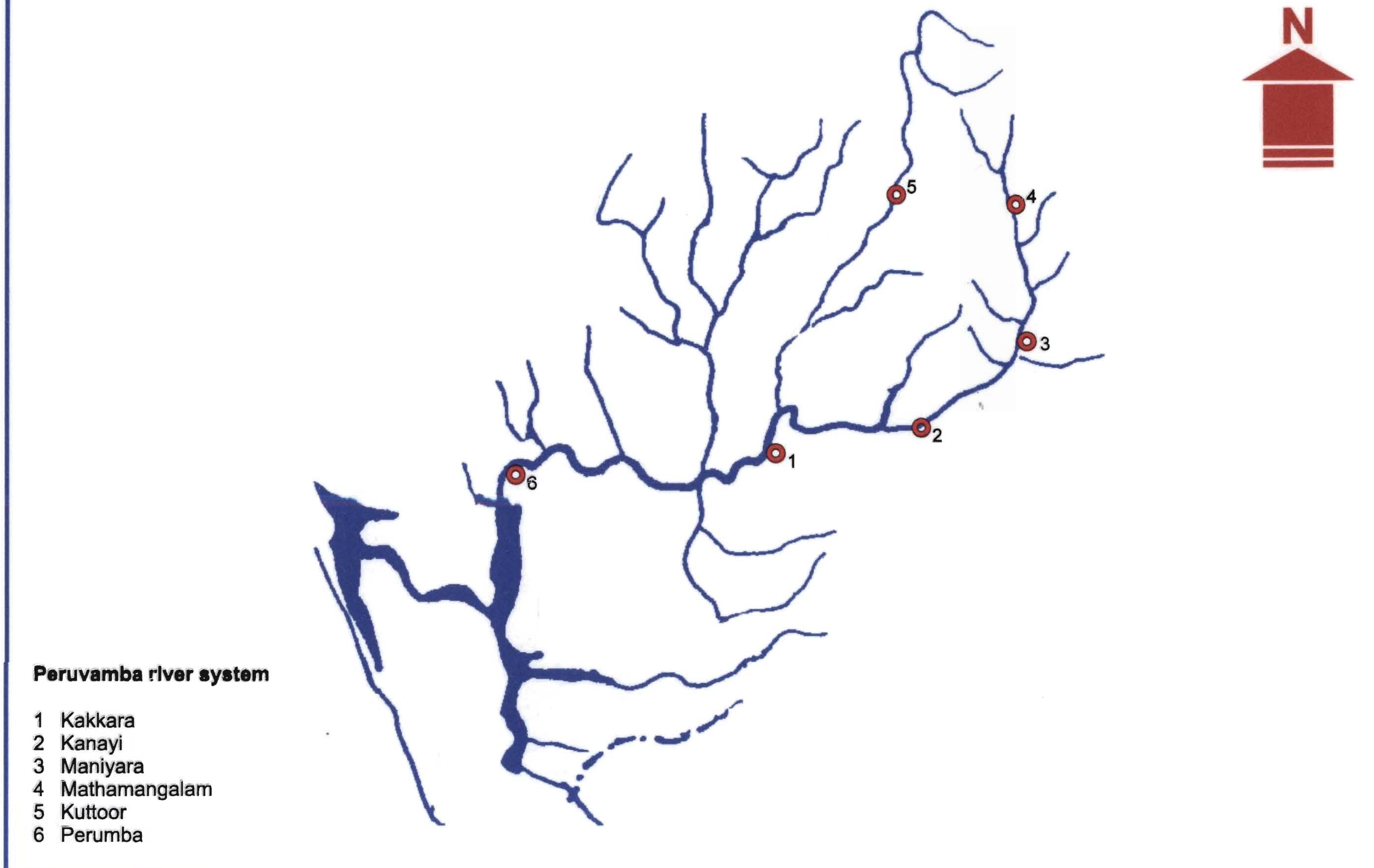


Fig.3.85. Numerical strength of various fish families recorded from Peruvamba river system

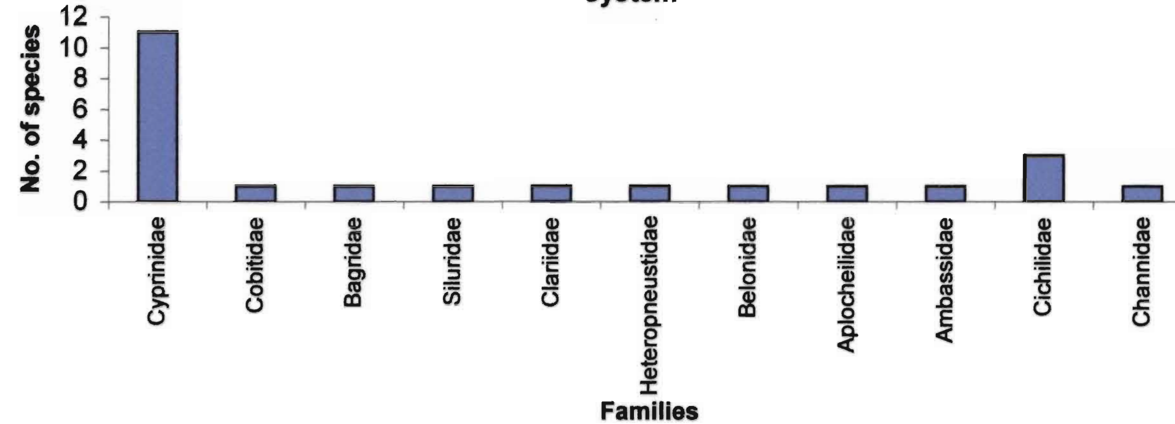


Fig.3.86. Ornamental, cultivable and food fishes in Peruvamba riversystem

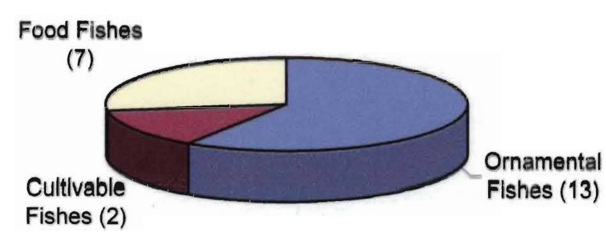


fig.3.87. Biodiversity status of fishes in Peruvamba river system

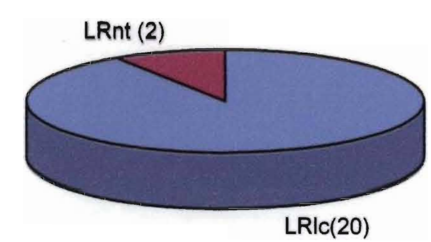


Fig. 3.88. Map of Puzhakkal river basin showing locations surveyed

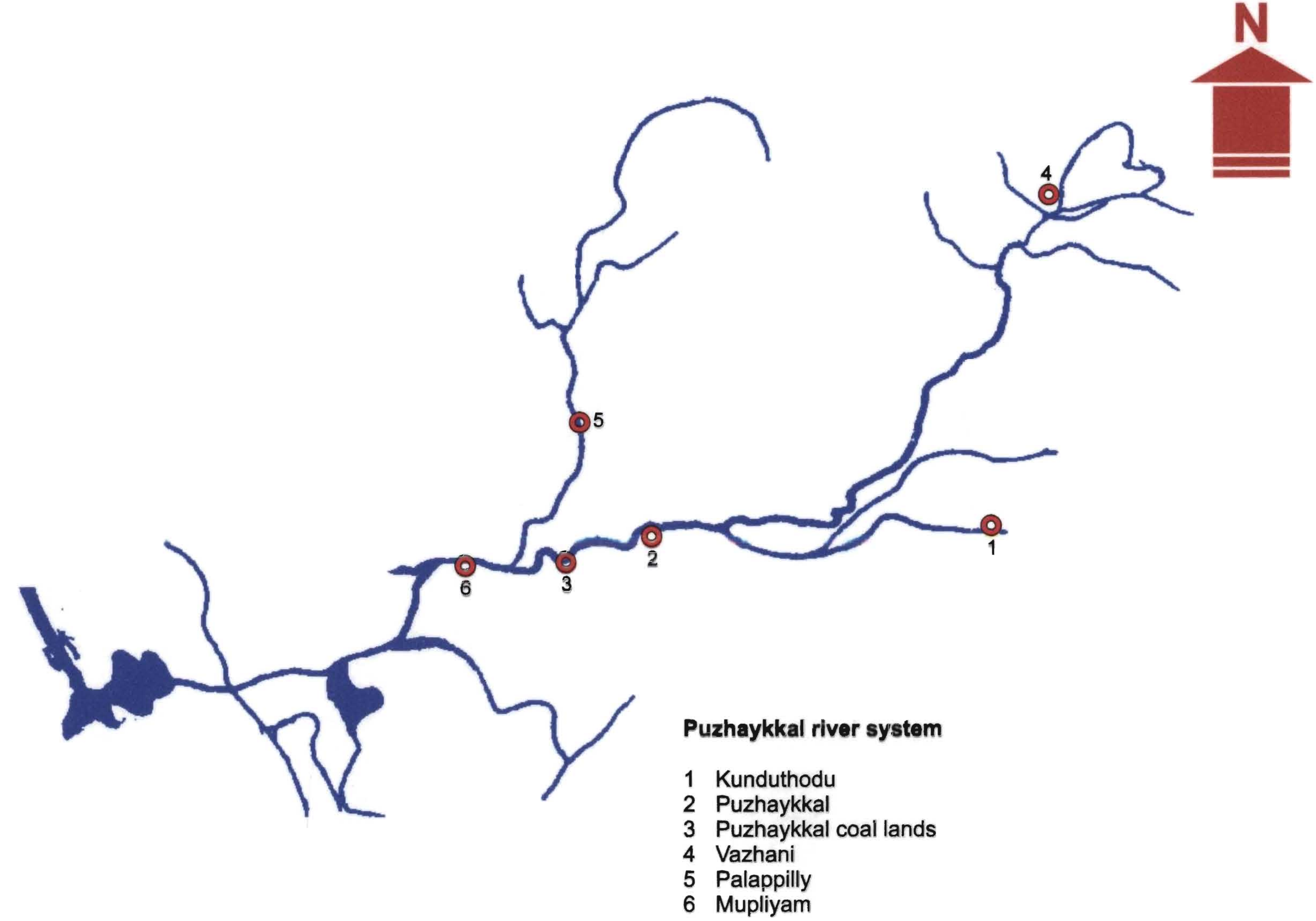


Fig.3.89. Numerical strength of various fish families recorded from Puzhaykkal river system

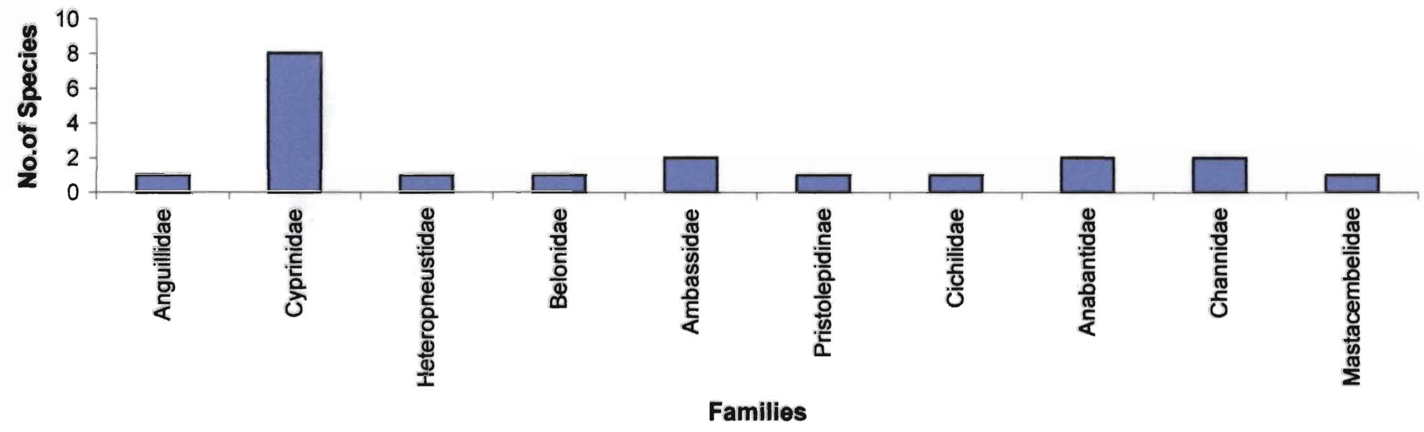


Fig.3.90. Cultivable, Ornamental and food fishes in Puzhaykkal river system

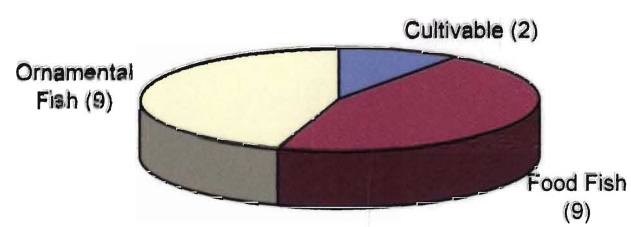


Fig.3.91. Biodiversity status of fishes in Puzhaykkal river system

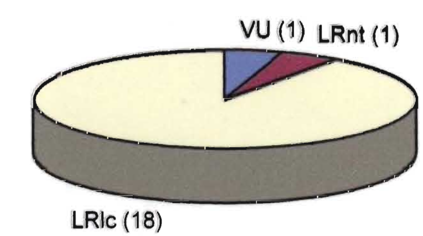


Fig. 3.92. Map of Shiriya river basin showing locations surveyed

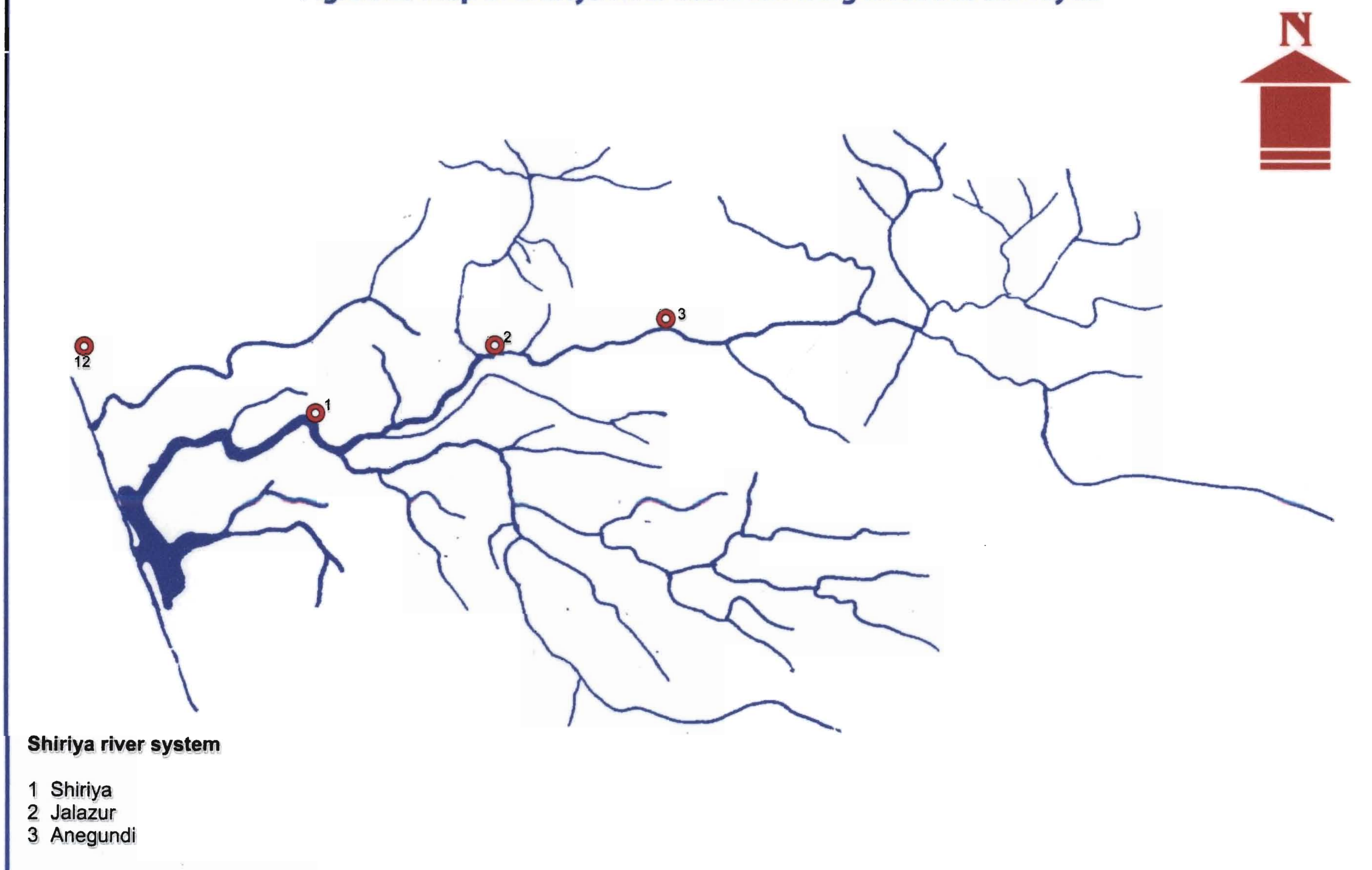


Fig.3.93. Numerical strength of various fish families recorded from Shiriya river system

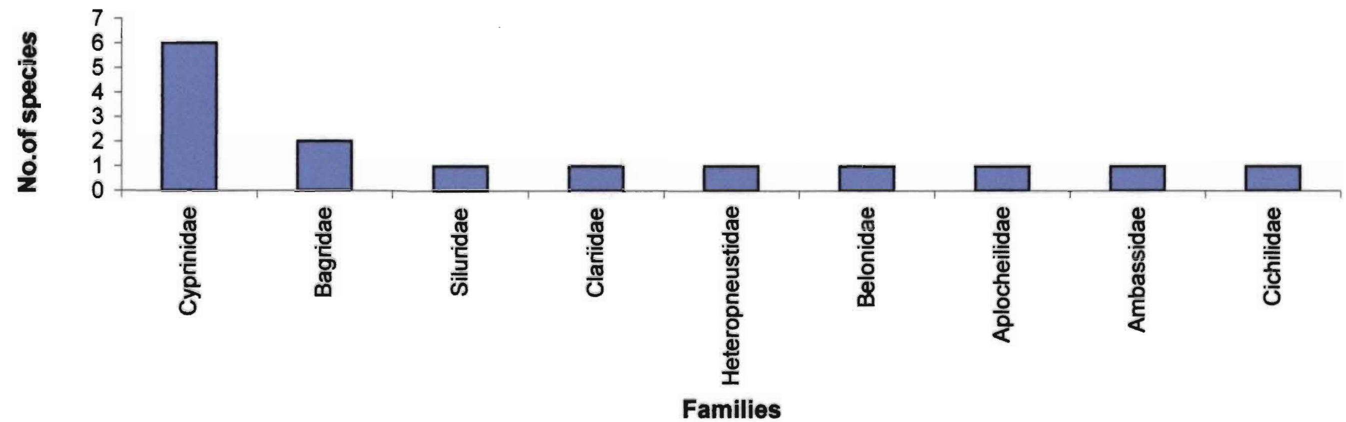


Fig.3.94. Cultivable, Ornamental and Food fishes in Shiriya river system

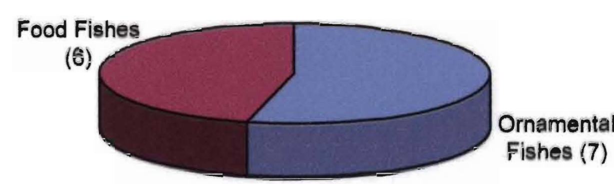


Fig.3.95. Biodiversity status of fishes in Shiriya river system

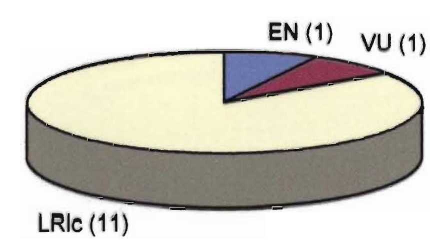


Fig. 3.96. Map of Tirur river basin showing locations surveyed

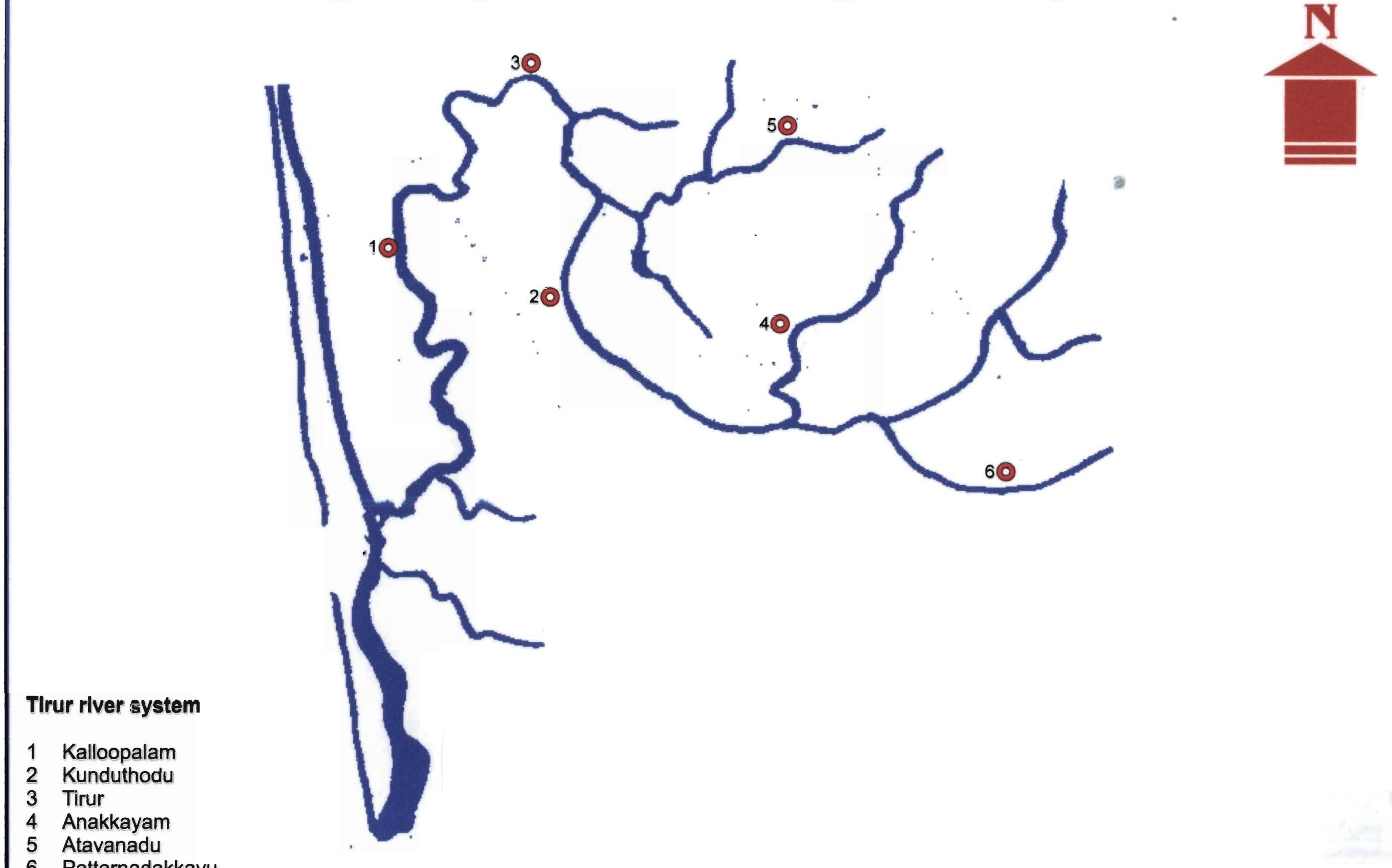


Fig.3.97. Numerical strength of various fish families recorded from Tirur river system

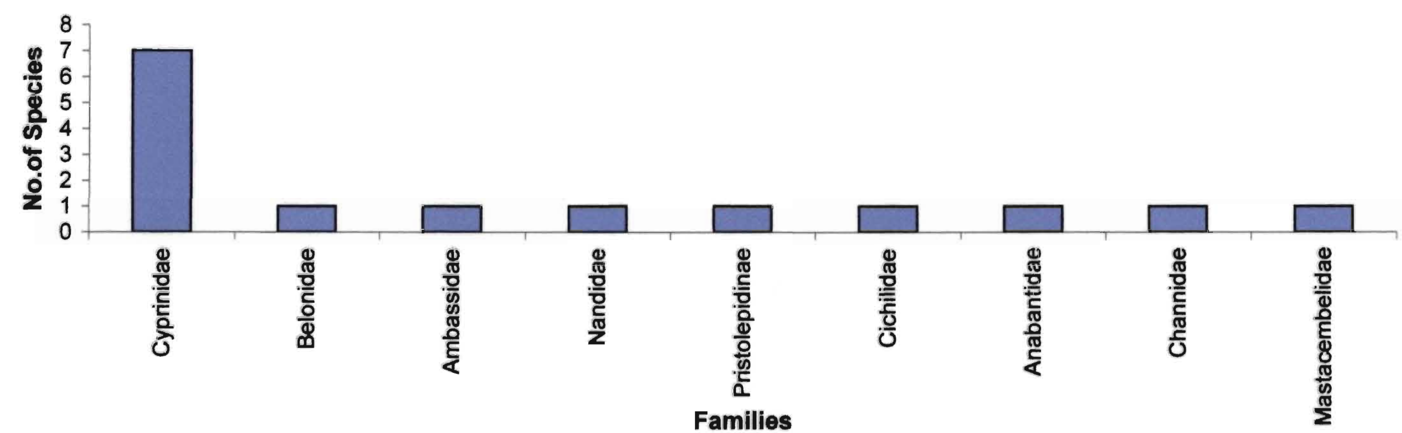


Fig.3.98. Ornamental and Food fishes in Tirur river sytem

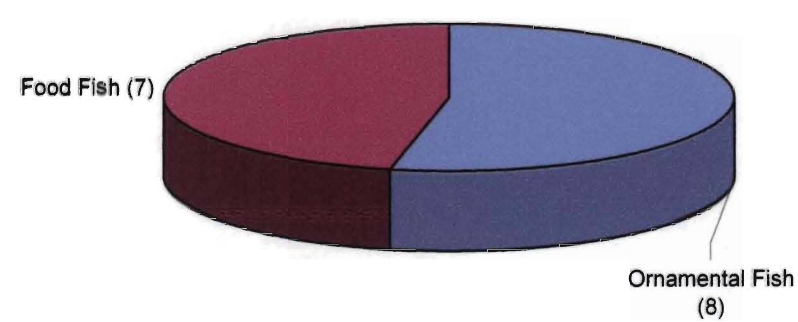
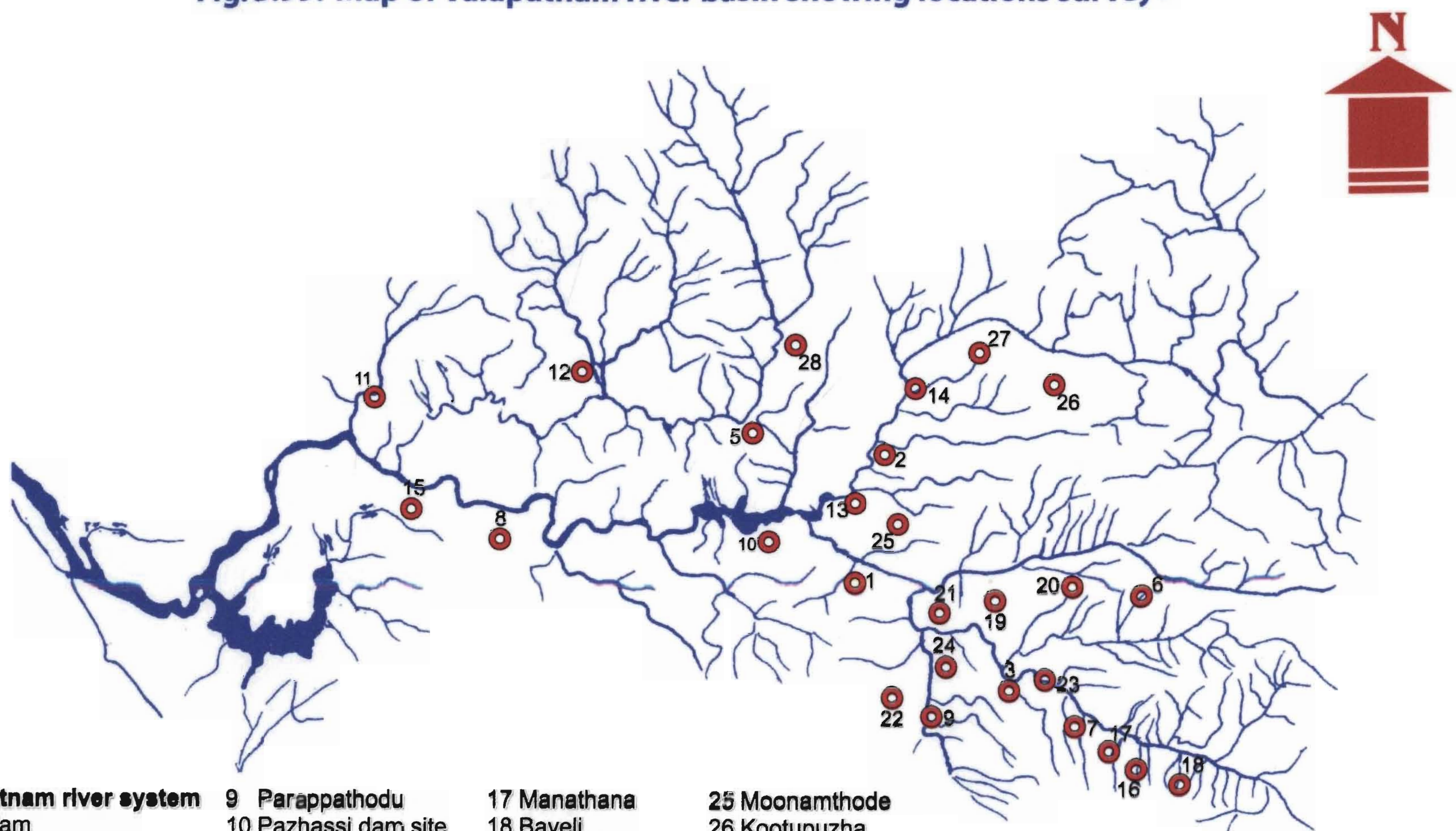


Fig. 3.99. Map of Valapatnam river basin showing locations surveyed



Valapatnam river system
1 Aralam
2 Iritti
3 Kurukkathode
5 Malappattam
6 Meenmutty
7 Narikkadavu
8 Parassinikkadavu
9 Parappathodu
10 Pazhassi dam site
11 Pazhayangadi
12 Srekandapuram
13 Karingalkuzhi
14 Kattampilly
15 Karimbam
16 Kottiyoor
17 Manathana
18 Baveli
19 Peravoor
20 Nadukani
21 Kanichar
22 Adakkathode
23 Chavachithode
24 Karimkappu
25 Moonamthode
26 Kootupuzha
27 Keezhpally
28 Pemboor

Fig.3.100. Numerical strength of various fish families recorded from Valapatnam river system

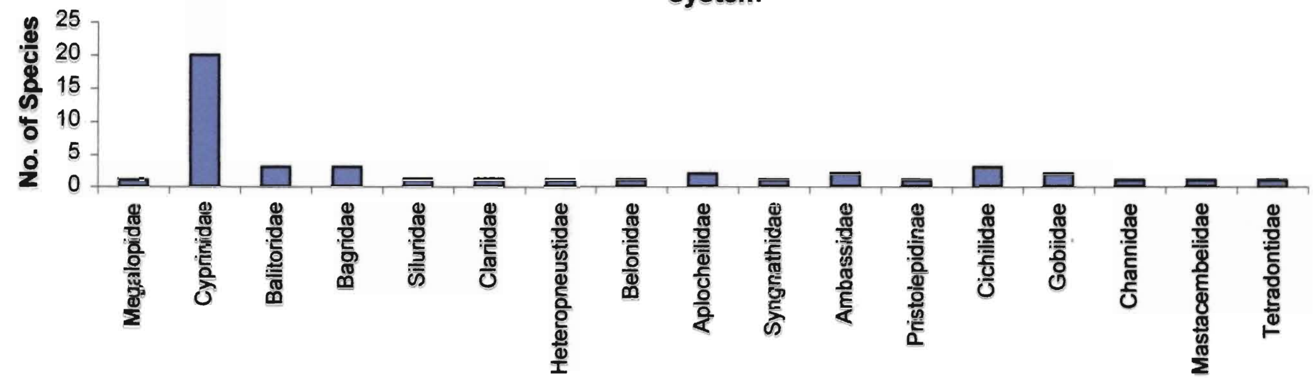


Fig.3.101. Cultivable, Ornamental and Food fishes in Valapatnam river system

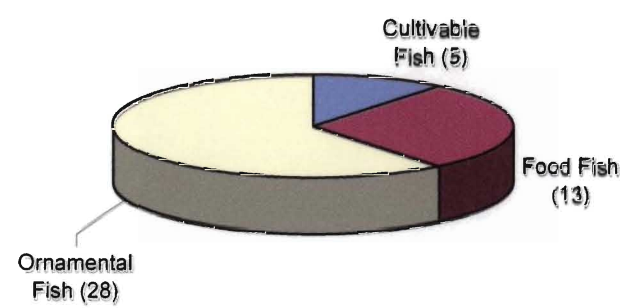
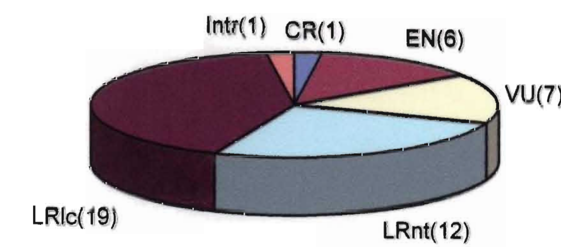


Fig.3.102. Biodiversity status of fishes in Valapatnam river system



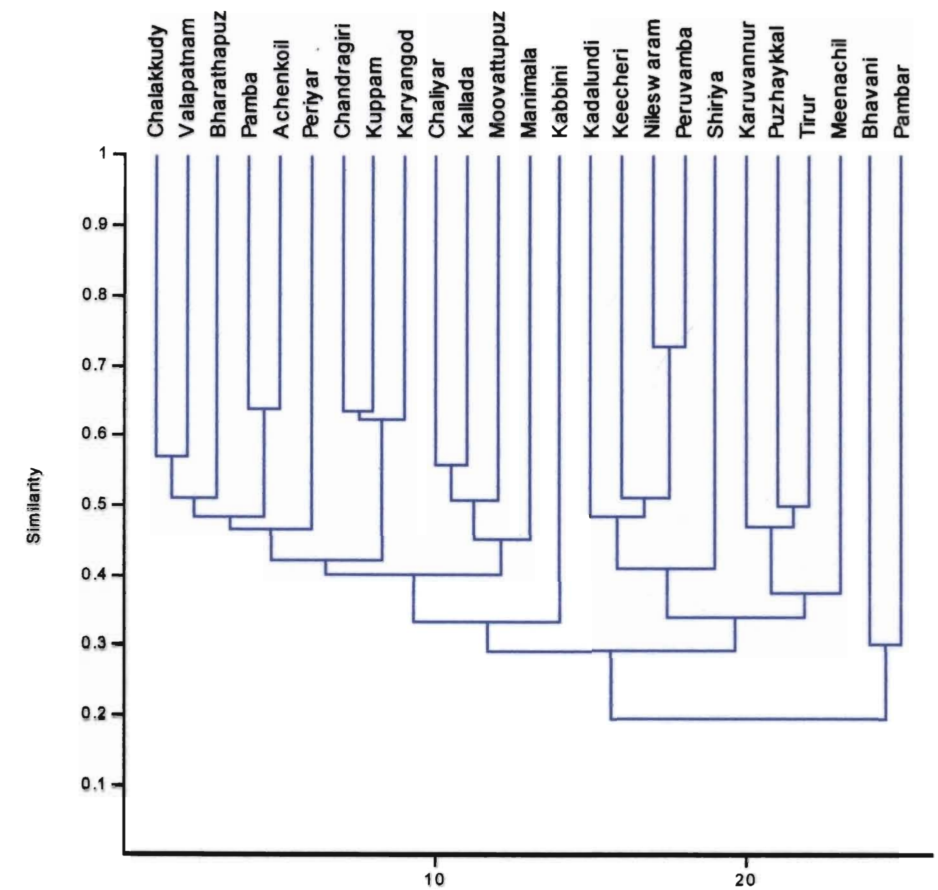


Fig.3.103. Similarity in fish species diversity among the river systems of Kerala

Fig.3.104. Comparison of river systems of Kerala based on river index values

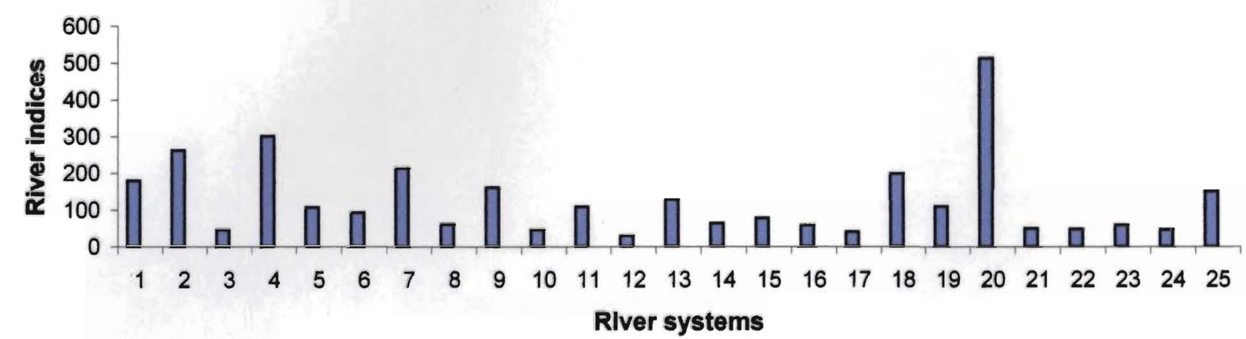
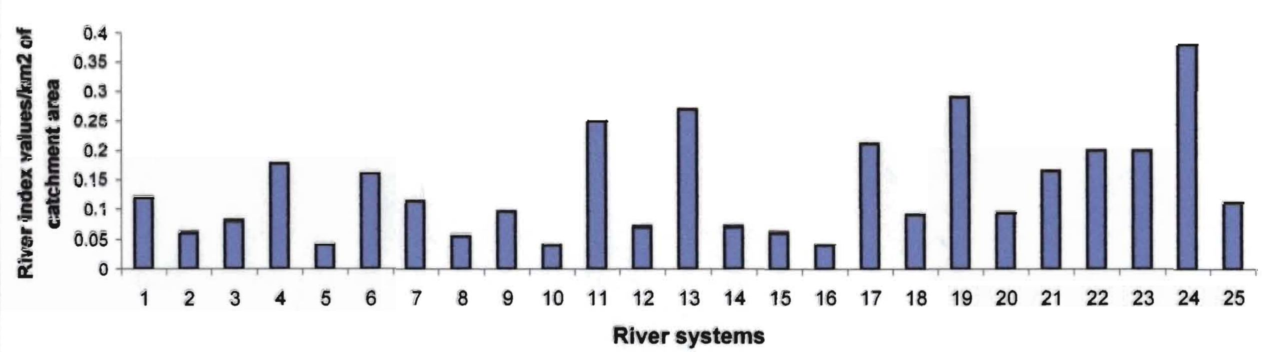


Fig.3.105. Comparison of river systems of Kerala based on river index values/km2 of the catchment area



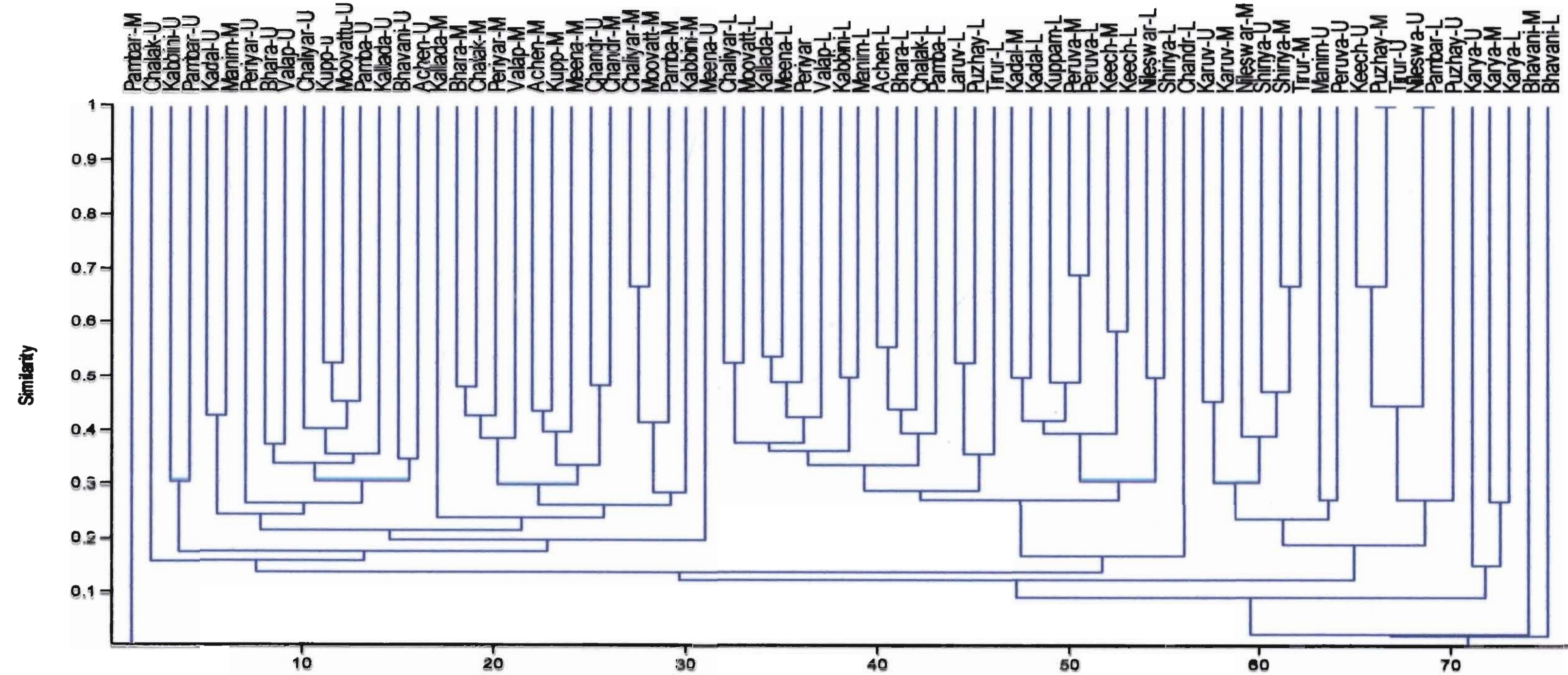


Fig.3.106. Comparison of species diversity of river systems of Kerala based on longitudinal distribution of fishes

Fig. 3.107. Species diversity vis-a-vis total lenth of the river system

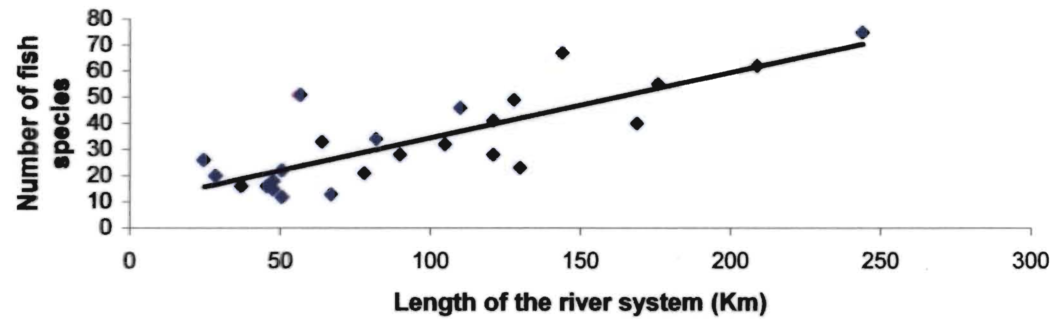


Fig.3.108. Species diversity Vs length of the river system

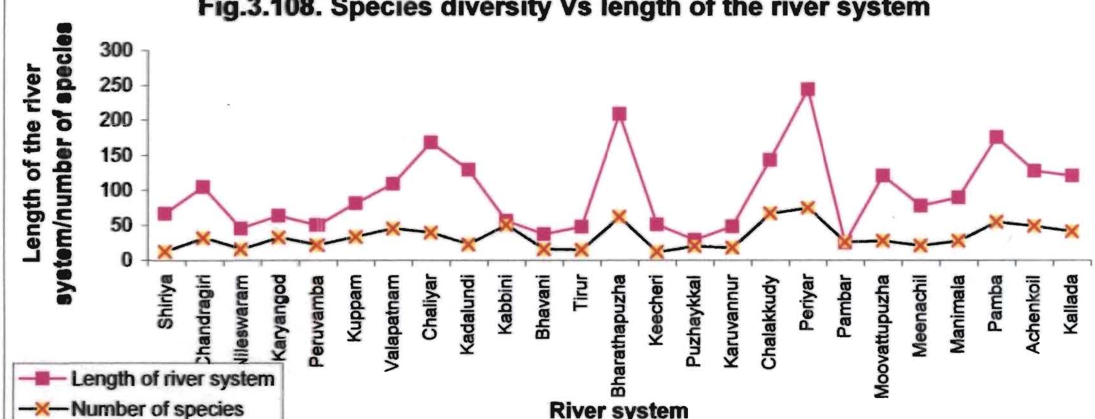


Fig.3.109. Species diversity/km2 vis-à-vis total length of the river systems

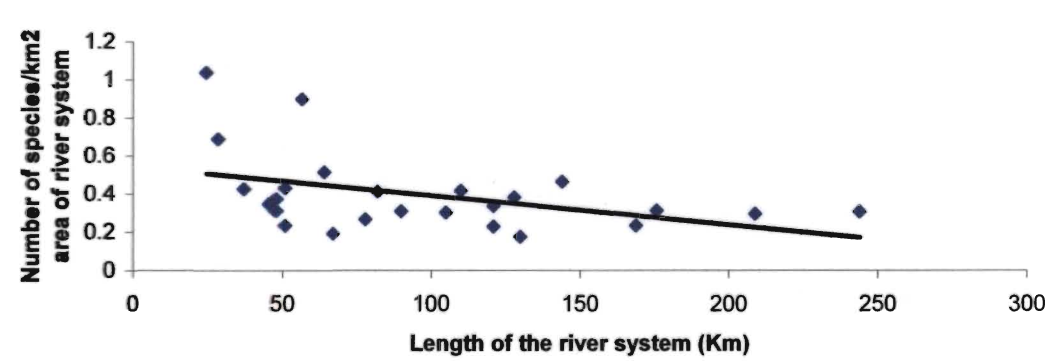


Fig.3.110. Species diversity vis-a vis total catchment area of the river system

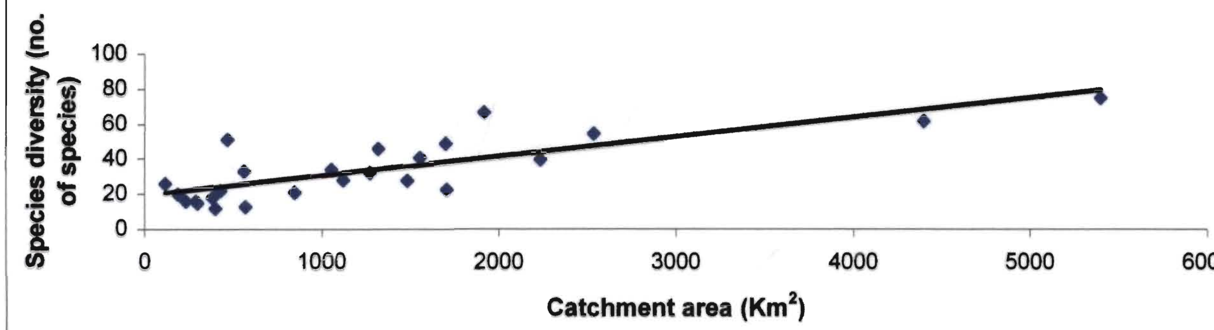


Fig.3.111. Species diversity/km2 vis-a-vis catchment area of the river system

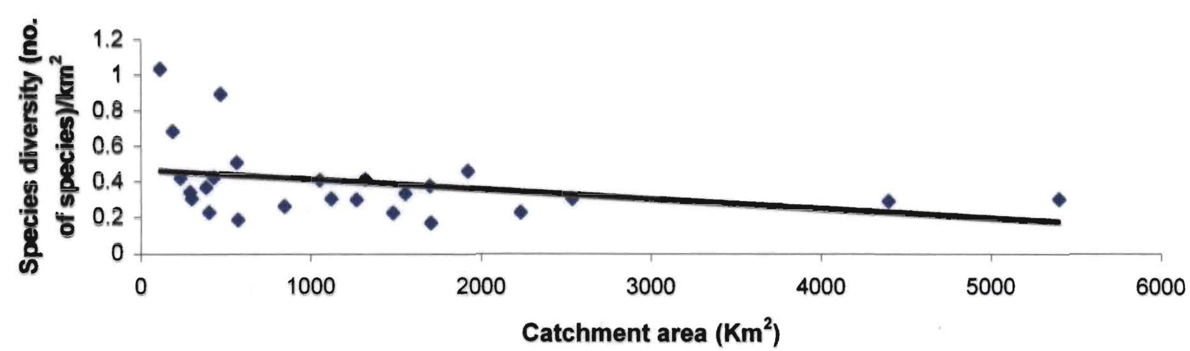


Fig.3.112. Fish species diversity in different river systems of Kerala with river systems arranged in the decreasing order of latitude

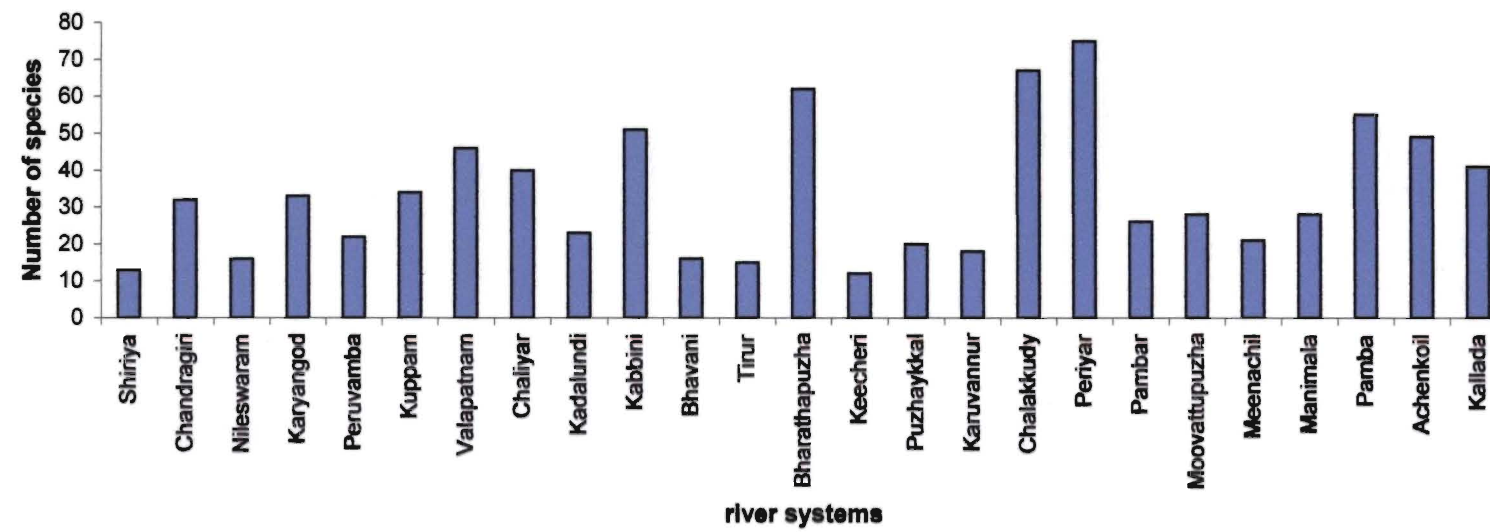


Fig.3.113. Species diversity in the different lattitudinal zones of Kerala

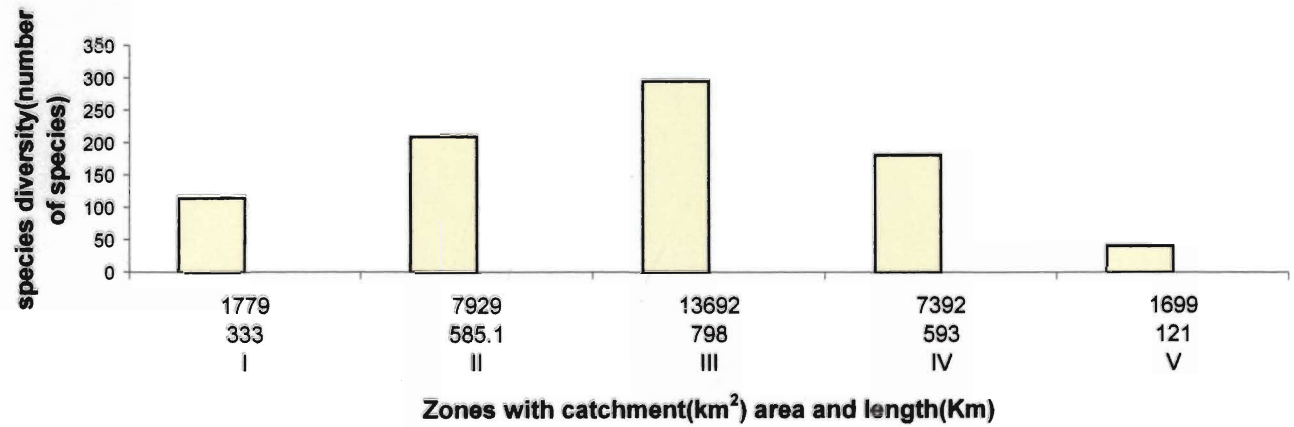
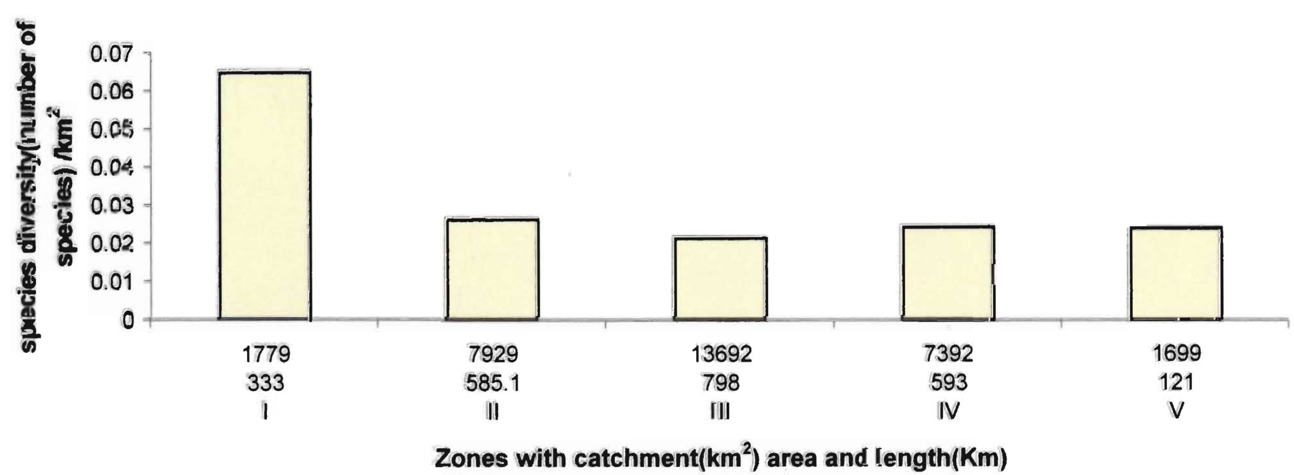


Fig.3.114. Species diversity/km^2 in the different lattitudinal zones of Kerala



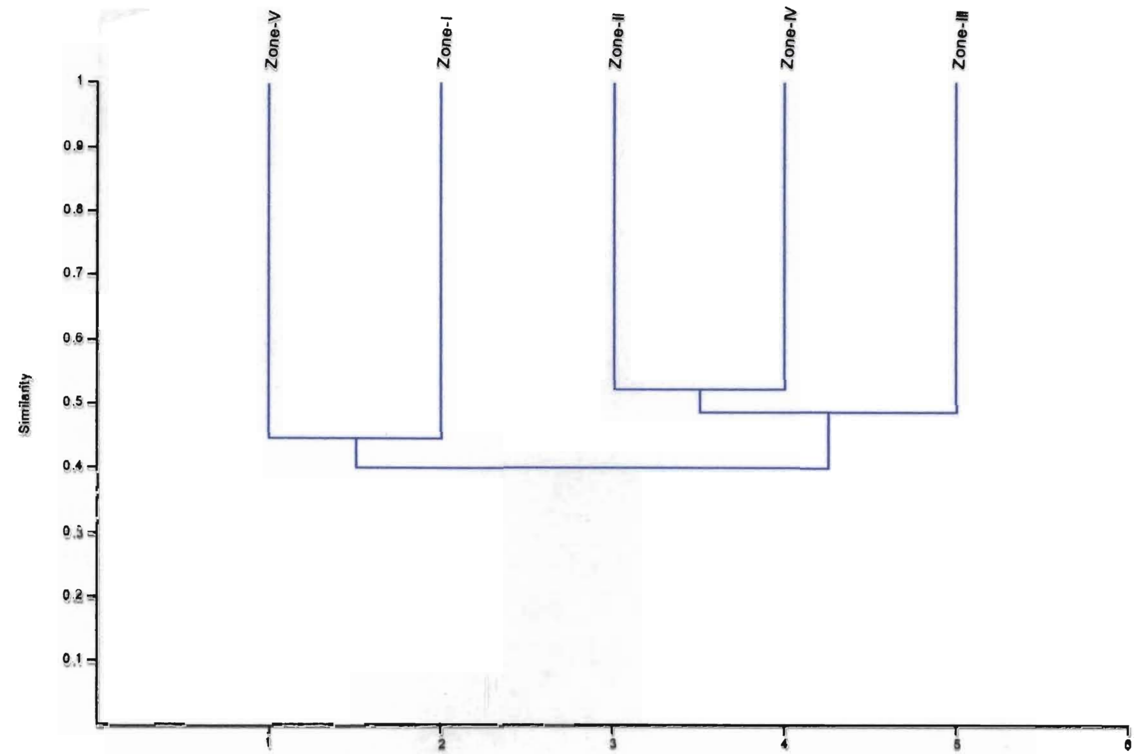


Fig.3.115. Similarity dendrogram of lattitudinal zones of Kerala based on species diversity

Table 3.1. Details of survey and sampling carried out in different river systems of Kerala

Sl.No.	River system	Length of the river system(Km)	Catchment area(Km2)	Month of survey	Season of survey	No. of times surveyed	No. of locations surveyed
1	Achenkoil	128	1484	June 2000; August 2001;Jan.2002;May 2003	Premonsoon,Monsoon	4	24
2	Manimala	90	847	August 2001,Dec.2003	Monsoon,Post monsoon	2	5
3	Meenachil	78	1272	Dec 2000,Dec.2001;Feb.2002	Post monsoon	2	24
4	Moovattupuzha	121	1554	August 2001, Nov.2003	Monsoon,Post monsoon	2	14
5	Karuvannur	48	1054	Nov.2001; March 2002	Post monsoon	1	18
6	Keecheri	51	401	Dec.2001;March2002	Post monsoon	1	3
7	Puzhaykkal	29	234	Dec.2001;March 2002	Post monsoon	1	6
8	Tirur	48	117	Nov.2001; March 2002	Post monsoon	1	9
9	Pambar	25	384	August 2001; May 2002; June 2003	Monsoon	3	11
10	Bhavani	37.5	562	Jan 2002;Jan 2003	Post monsoon	2	3
11	Shiriya	67	290	Jan.2004; March 2004; Sept. 2004	Premonsoon,Monsoon,Post monsoon	3	3
12	Kariamgode	64	429	Jan.2004; March2004; Sept.2006	Premonsoon,Monsoon,Post monsoon	6	8
13	Peruvamba	51	300	Jan.2004, March 2004, Sept.2004	Premonsoon,Monsoon,Post monsoon	4	6
14	Neeleswaram	46	190	Jan.2004, March2004, Sept.2004	Premonsoon,Monsoon,Post monsoon	2	8
15	Periyar	244	5398	Feb. 2001, June 2001; Nov.2001;Feb.2002, August, 2002,Spt.2002,Feb.2003,.May,2003,Spt.2003; April 2004	Premonsoon,Monsoon,Post monsoon	10	66
16	Chalakkudy	144	1704	3/1/2001,August 2000,March,2001,July,2001,Nov.2001,Feb.2002,Jan.2003,Nov.2003	Premonsoon,Monsoon,Post monsoon	9	37
17	Pamba	176	2235	May,2001,June,2001,Dec.2001,March,2003,Oct.2003,Dec.2003	Premonsoon,Monsoon,Post monsoon	6	38
18	Bharathapuzha	209	4400	Sept.2001,April,2001,Nov.2001,Jan.2002,August,2002,Jan.2003,Sept.2003,Dec.2003	Premonsoon,Monsoon,Post monsoon	9	48
19	Kabbini	56.6	1920	Oct.2000,Jan.2001,July,2000,Jan.2001,April,2001,Oct.2001,Jan.2002,O ct.2003	Premonsoon,Monsoon,Post monsoon	9	34
20	Kallada	121	1699	Nov.2000,Oct.2001,July,2002,Sept.2003	Premonsoon,Monsoon,Post monsoon	9	21
21	1.Valapatnam	110	1321	July,2000,Oct.2001,May,2003,Nov.2003	Premonsoon,Monsoon,Post monsoon	4	28
22	2.Chaliyar	169	2535	Sept.2001,June,2003	Monsoon,Post monsoon	2	29
23	3.Chandragiri	105	570	Jan.2004, March2004, Sept.2007	Premonsoon,Monsoon,Post monsoon	4	12
24	4.Kuppam	82	469	July,2000,Oct.2001,May,2003,Nov.2003	Premonsoon,Monsoon,Post monsoon	4	7
25	5.Kadalundi	130	1122	Jan.2004, March2004, Sept.2007	Premonsoon,Monsoon,Post monsoon	4	3

Table 3.2. Details of river systems surveyed in Kerala

Sl.No.	River system	Origin/elevation(m msl)	Districts through which flowing	Tributaries	Secondary tributaries	Reservoirs	Protected areas surveyed	Wild life sanctuaries/ National parks surveyed
1	Achenkoil	Pasukkidamettu(700m)	Pathanamthitta,Quilon,Aleepy	Kallar	Nil	Nil	Achenkoil, Konni	
2	Bharathapuzha	Anamalai(1964m)	Palakkad,Malappuram,Thrissur	Gayathrippuzha, Chitturpuzha, Kalpathipuzha,Thuthapuzha	Kunthippuzha	Mangalam,Pothundy, Chulliar,Meenkara, Malampuzha, Walayar, Kanjirappuzha	Mannarkkad	Silent valley
3	Bhavani	Bhavaniar Betta 2500 m	Palaghat	Siruvani and Varayar	Nil	Nil	Siruvani	Silent valley
4	Chalakkudy	Anamalai and Nelliampathy hills	Palaghat, Thrissur	Sholayar, Parambikulam, Kuriarkutty and Karapara	Nil	Parambikulam,Parambikulam, Thunakkadavu, Peruvaripallam, Malakkappara, lower sholaya and Poringalkuthu	Nelliampathy, Vazhachal, Sholayar	Parambikulam
5	2.Chaliyar	Ilambalari hills (2066 m)	Kozhikkode ,Malappuram and Wynaad	Chalipuzha, Punnapuzha, Karimpuzha, Cherupuzha, Kanjirapuzha, Kurumbanpuzha, Vadapurampuzha and Iruthillypuzha.	Nil	Nil	Nilambur	
6	3.Chandragiri	Patlighat taka(1350 m)	Kasargod district	Payaswini and Chandragiri.	Nil	Nil	Sullya	
7	Kabbini	Thondarmudi Malai(1500 m)	. Wynaad and Malappuram	Mananthavadippuzha, Panamarampzha, Bavelipuzha and Noolpuzha	Nil	Nil	Tholpetty	Muthanga wild life sanctuary, Banipur National parks
8	5.Kadalundi	Cherakobbanmala in Palaghat district at an elevation of 1160 m	Malappuram and Palaghat districts	Olipuzha and Velliar	Nil	Nil	Nil	
9	Kallada	Karimalaikadakkal (1524 m)	Quilon, Pathanamthitta and Trivandrum districts	Kulathupuzha, Chenduruniar, Kalthuruthiar.	Nil	Thenmala	Chankili, Kallada	
10	Karuvannur	Pumalai at an elevation of 1100	Trichur district	include Manali, Kurumali, Chimoni and Muppili	Nil	Peechi,Chimoni	Peechi	
11	Kariamgode	Padinalkad Ghats (1520 m)	Kasargod and Kannur distric	Mundore, Padiamala hole and Ariakadavu hole	Nil	Nil	Nil	
12	Keecheri	Machadmalai at an elevation of 365 m.	Trichur district	Chundalthode.	Karanirapuzha and Chetluvayil puzha	Nil	Nil	Vazhani-Chimony

Continued

Table 3.2 Continued

13	4.Kuppam	Padinalkad Ghats at 1630 m	Kannur district	Pakkattupoya, Alakuttathode, Kuttikkolpuzha, Mukkuttathode and Chiriyathodu	Nil	Nil	Nil	
14	manimala river	Talamala at an elevation of 1156 m	Kottayam and Pathanamthitta	Kokayar and Elakkalthode	Nil	Nil	Nil	
15	Meenachil	Araikunnumudi at an elevation of 1097 m.	Kottayam district	Kadapuzha, Minadamar, Kalathukadavu, Trikovil, Kurusumalai and Punjar	Nil	Nil	Nil	
16	Moovattupuzha	Taragamkanam at an elevation of 1094 m	Ernakulam and Kottayam districts	Kaliyar, Thodupuzha and Kothamangalam		Nil	Thommankuthu	
17	Neeleswaram	Kinanur area near Karindalam in Kasargod district, at 140 m	Kasargod district	Aryangal thodu and Baigote hole	Nil	Nil	Nil	
18	Pamba	Pulachimala: at an elevation of 1650 m	Pathanamthitta, Idukki and Alleppey districts	Kakkiyar, Arudai, Kakkadar, Kallar, Pambi and Pambiar	Erappuzha	Nil		Kakki elephant sanctuary Part of Periyar Tiger Reserve
19	Pambar	Benmore, at an elevation of 1950 m	Idukki district	Chinnar and Pambar	Nil	Nil		Chinnar Wild life sanctuary, par of Indiara Gandhi Wild life sanctuary
20	Periyar	Sivagiri hills of Western Ghats at an elevation of 1830 m	Idukki and Ernakulam	Muthirappuzha Ar, Perinjankutty, Idamalayar and Mangalampuzha	Kallar, Pooyamkutty	Pooyamkutty, Edamalayar, Neryamangalam, Idukki		Periyar Tiger Reserve
21	Peruvamba	Pekunnu at Kannnur district at an elevation of 325 km	Kasargod and Kannur districts	Macharuthode, Mathamangalam, Challachal, Mukkuttenkarachal and Nitaringapuzha	Nil	Nil		
22	Puzhaykkal	Machadmalai at an elevation of 525 km	Thrissur district	Parathodu, Poomalathodu, Naduthodu and Kattachirathodu	Nil	Vazhani	Vazhani	
23	Shiriva	Anegundi Reserved forests at 230m	Kasargod	Kallajethodu, Kanyanathodu, Eramatti Hole and Kumbla	Nil	Nil	Anegundi	
24	Tirur	Atavanad at an elevation of 86 m	Malappuram district	Vallilapuzha	Nil	Nil		
25	Bhavani	Bhavaniar Betta 2500 m	Palaghat	Siruvani and Varayar	Nil	Nil		
25	Valapatnam	Brahmagiri hills at an elevation of 1350 m	Kannur district	Srikandapuram, Valiapuzha, Venipuzha and Aralampuzha	Nil	Pazhassi		

Table 3.3. List of fish species collected and identified together with commercial importance, biodiversity status and nature of endemism.

Order	Family	Sl.No.	Name of the Species	Cultivable/ Ornamental /Food fish	Status as per present study	Status as per NBFGR report	Endemism
Osteoglossiformes	Notopteridae	1	*Notopterus notopterus*	Food fish	LRnt	LRnt	Not known
Elopiformes	Megalopidae	2	*Megalops cyprinoides*	Food fish	LRlc	Not listed	Not known
Anguilliformes	Anguillidae	3	*Anguilla bengalensis*	Cultivable	LRnt	EN	Not known
		4	*Anguilla bicolor*	Cultivable	EN	Not listed	Not known
Clupeiformes	Clupeidae	5	*Dayella malabarica*	Food fish	VU	CR	EN-WG
Cypriniformes	Cyprinidae	6	*Catla catla*	Cultivable	LRlc	VU	EN-I
		7	*Cirrhinus reba*	Food fish	EN	VU	EN-IS
		8	*Cirrhinus mrigala*	Cultivable	LRlc	LRnt	EN-I
		9	*Cyprinus carpio*	Cultivable	Intr	Intr	Intr.
		10	*Gonoproktopterus curmuca*	Food fish	LRlc	EN	EN-WG
		11	*Gonoproktopterus kurali*	Food fish	VU	EN	EN-WG
		12	*Gonoproktopterus dubius*	Food fish	EN	EN	EN-WG
		13	*Gonoproktopterus micropogon periyarensis*	Cultivable	CR	Not listed	EN-K
		14	*Gonoproktopterus thomassi*	Cultivable	EN	EN	EN-WG
		15	*Gonoproktopterus kolus*	Food fish	EN	EN	EN-K
		16	*Labeo calbasu*	Cultivable	LRlc	LRnt	EN-I
		17	*Labeo rohita*	Cultivable	LRlc	LRnt	EN-I
		18	*Labeo nigriscens*	Cultivable	EN	Not listed	EN-WG
		19	*Labeo fimbriatus*	Cultivable	LRnt	LRnt	EN-IS
		20	*Labeo dussumieri*	Cultivable	VU	EN	EN-K
		21	*Labeo kontius*	Cultivable	EN	EN	EN-WG
		22	*Neolissocheilus wynaadensis*	Food fish	EN	CR	EN-K
		23	*Osteobrama bakeri*	Ornamental	LRnt	EN	EN-K
		24	*Osteochilus (Kantaka) brevidorsalis*	Food fish	CR	EN	EN-K
		25	*Osteochilus nashii*	Ornamental	EN	Not listed	EN-WG
		26	*Osteochilus longidorsalis*	Food fish	EN	CR	EN-K
		27	*Puntius amphibius*	Ornamental	LRlc	Not listed	Not known
		28	*Puntius arulius*	Ornamental	EN	EN	EN-WG
		29	*Puntius bovanicus*	Foodfish	DD	CR	Not known
		30	*Puntius ophicephalus*	Foodfish	EN	EN	EN-K
		31	*Puntius parrah*	Foodfish	LRlc	EN	EN-WG
		32	*Puntius bimaculates*	Ornamental	LRlc	Not listed	EN-WG
		33	*Puntius carnaticus*	Cultivable	LRnt	LRnt	EN-WG
		34	*Puntius conchonius*	Ornamental	VU	VU	Not known
		35	*Puntius chola*	Food fish	LRnt	VU	Not known
		36	*Puntius vittatus*	Ornamental	LRlc	VU	Not known
		37	*Puntius ticto*	Ornamental	LRlc	Not listed	EN-WG
		38	*Puntius denisonii*	Ornamental	LRnt	EN	EN-K
		39	*Puntius dorsalis*	Ornamental	EN	EN	Not known
		40	*Puntius fasciatus*	Ornamental	LRlc	EN	EN-WG
		41	*Puntius filamentosus*	Ornamental	LRlc	Not listed	EN-WG
		42	*Puntius jerdoni*	Ornamental	EN	Not listed	EN-K
		43	*Puntius sarana subnasutus*	Food fish	LRlc	Not listed	Not known
		44	*Tor khudree*	Cultivable	LRnt	VU	Not known
		45	*Tor remadevii*	Cultivable	DD	Not listed	Not known
		46	*Tor putitora*	Cultivable	DD	EN	Not known
		47	*Chela fasciata*	Ornamental	VU	Not listed	EN-I
		48	*Chela dadiburjuri*	Ornamental	LRnt	EN	EN-I
		49	*Salmostoma boopis*	Ornamental	LRlc	Not listed	EN-I
		50	*Salmostoma acinaces*	Food fish	LRlc	Not listed	EN-WG
		51	*Amblypharyngodon microlepis*	Ornamental	LRlc	Not listed	EN-I
		52	*Barilius bakeri*	Ornamental	LRlc	VU	EN-WG
		53	*Barilius bendelisis*	Ornamental	EN	LRnt	EN-IS
		54	*Barilius gatensis*	Ornamental	LRlc	Not listed	EN-WG
		55	*Barilius canarensis*	Ornamental	LRnt	DD	EN-WG
		56	*Brachydanio rerio*	Ornamental	EN	Not listed	EN-IS
		57	*Danio malabaricus*	Ornamental	LRlc	Not listed	EN-IS
		58	*Danio aequipinnatus*	Ornamental	LRlc	LRnt	EN-IS
		59	*Esomus thermoicos*	Ornamental	EN	Not listed	EN-WG
		60	*Rasbora daniconius*	Ornamental	LRlc	Not listed	Not known
		61	*Lepidopygopsis typus*	Ornamental	CR	CR	EN-K
		62	*Crossocheilus periyarensis*	Food fish	CR	VU	EN-K
		63	*Garra gotyla stenorhynchus*	Food fish	VU	EN	EN-WG
		64	*Garra mullya*	Ornamental	LRlc	Not listed	EN-I
		65	*Garra menoni*	Ornamental	EN	VU	EN-K
		66	*Garra periyarensis*	Food fish	EN	Not listed	EN-K
		67	*Garra surendranathani*	Ornamental	VU	EN	EN-K
		68	*Garra ceylonensis*	Ornamental	DD	Not listed	Not known
		69	*Garra emarginata*	Ornamental	DD	Not listed	EN-K
		70	*Garra hughi*	Ornamental	VU	EN	EN-K
		71	*Garra mlapparaensis*	Ornamental	DD	Not listed	Not known
		72	*Garra mcClellandi*	Food fish	LRnt	Not listed	EN-WG
		73	*Garra nilamburensis*	Ornamental	DD	Not listed	Not known
		74	*Garra travancona*	Ornamental	DD	Not listed	Not known

Continued.........

Table 3.3 Continued

	Balitoridae	75	*Baltora mysorensis*	Ornamental	EN	Not listed	EN-WG
		76	*Bhavania auatralis*	Ornamental	LRlc	EN	EN-WG
		77	*Homaloptera pillai*	Ornamental	CR	Not listed	EN-K
		78	*Homaloptera silasi*	Ornamental	DD	Not listed	Not known
		79	*Travancoria jonesi*	Ornamental	EN	EN	EN-K
		80	*Travancoria elongata*	Ornamental	EN	CR	EN-K
		81	*Oreonectes keralensis*	Ornamental	VU	EN	EN-K
		82	*Acanthocobitis bolia*	Ornamental	EN	LRnt	EN-WG
		83	*Schistura semiarmatus*	Ornamental	VU	VU	EN-WG
		84	*Schistura striatus*	Ornamental	EN	Not listed	EN-K
		85	*Schistura nilgiriensis*	Ornamental	EN	Not listed	EN-K
		86	*Schstura denisoni*	Ornamental	LRlc	Not listed	EN-I
		87	*Nemacheilus monilis*	Ornamental	VU	EN	EN-WG
		88	*Mesonemacheilus pambarensis*	Ornamental	CR	Not listed	EN-K
		89	*Mesonemacheilus periyarensis*	Ornamental	DD	Not listed	EN-K
		90	*Mesonemacheilus guntheri*	Ornamental	LRlc	LRlc	EN-WG
		91	*Mesonemacheilus triangularis*	Ornamental	LRlc	LRlc	EN-WG
		92	*Mesonemacheilus menoni*	Ornamental	EN	Not listed	EN-K
		93	*Mesonemacheilus petrubanarescui*	Ornamental	EN	Not listed	EN-WG
		94	*Mesonemacheilus remadevi*	Ornamental	CR	Not listed	EN-K
	Cobitidae	95	*Lepidocephalus thermalis*	Ornamental	LRlc	Not listed	EN-IS
Siluriformes	Bagridae	96	*Batasio travancoria*	Food fish	VU	EN	EN-K
		97	*Horabagrus nigricollaris*	Food fsih	EN	CR	EN-K
		98	*Horabagrus brachysoma*	Cultivable	LRnt	EN	EN-K
		99	*Mystus cavasius*	Food fish	LRnt	LRnt	EN-WG
		100	*Mystus gulio*	Food fish	LRlc	Not listed	Not known
		101	*Mystus vittatus*	Ornamental	EN	VU	EN-WG
		102	*Mystus armatus*	Food fish	LRlc	Not listed	EN-IS
		103	*Mystus bleekeri*	Ornamental	EN	VU	EN-K
		104	*Mystus malabaricus*	Food fish	VU	EN	EN-K
		105	*Mystus menoda*	Food fish	DD	Not listed	EN-IS
		106	*Mystus oculatus*	Food fish	LRlc	Not listed	Not known
		107	*Mystus montanus*	Food fish	EN	Not listed	EN-WG
	Siluridae	108	*Ompok bimaculatus*	Food fish	LRlc	EN	Not known
		109	*Ompok malabaricus*	Food fish	LRnt	CR	EN-IS
		110	*Silurus wynaadensis*	Food fish	EN	CR	EN-WG
		111	*Wallago attu*	Cultivable	VU	LRnt	Not known
	Schilbeidae	112	*Pseudeutropius mitchelli*	Food fish	EN	DD	EN-I
	Sisoridae	113	*Glyptothorax lonah*	Ornamental	EN	LRnt	EN-WG
		114	*Glyptothorax annandalei*	Ornamental	LRnt	Not listed	EN-IS
		115	*Glyptothorax madraspatnam*	Ornamental	EN	VU	EN-WG
		116	*Glyptothorax anamalaensis*	Ornamental	DD	CR	EN-K
	Clariidae	117	*Clarias dussumieri*	Cultivable	LRnt	VU	EN-I
	Heteropneustidae	118	*Heteropneustes fossilis*	Food fish	LRlc	VU	EN-IS
Beloniformes	Belonidae	119	*Xenentodon cancila*	Food fish	LRlc	LRnt	EN-IS
Cyprinodontiformes	Aplocheilidae	120	*Aplocheilus lineatus*	Ornamental	LRlc	Not listed	EN-WG
		121	*Aplocheilus blocki*	Ornamental	LRlnt	Not listed	EN-WG
	Poecilidae	122	*Poecilia reticulata*	Ornamental	Intr	Intr	Intr.
Syngnathiformes	Syngnathidae	123	*Microphis cuncalus*	Ornamental	VU	Not listed	EN-IS
Synbranchiformes	Mastacembelidae	124	*Macrognathus guentheri*	Food fish	EN	VU	EN-I
		125	*Mastacembelus armatus*	Food fish	LRlc	LRnt	Not known
Perciformes	Ambassidae	126	*Parambassis dayi*	Food fish	LRlc	EN	EN-K
		127	*Parambassis thomassi*	Ornamental	LRnt	VU	EN-WG
		128	*Pseudambassis baculis*	Ornamental	LRlc	Not listed	Not known
	Nandidae	129	*Nandus nandus*	Ornamental	LRnt	LRnt	Not known
		130	*Pristolepis marginatus*	Ornamental	LRlc	VU	EN-K
	Cichilidae	131	*Etroplus suratensis*	Ornamental	LRlc	Not listed	EN-IS
		132	*Etroplus maculatus*	Ornamental	LRlc	Not listed	EN-IS
		133	*Oreochromis mossambicus*	Cultivable	Intr	Intr	Intr.
	Blennidae	134	*Salarias reticulates*	Food fish	DD	Not listed	EN-K
	Gobiidae	135	*Glossogobius giuris*	Food fish	LRlc	LRnt	Not known
		136	*awaous gutum*	Food fish	LRlc	Not listed	Not known
		137	*Sicyopterus griseus*	Ornamental	LRnt	Not listed	Not known
	Eleotrididae	138	*Eleotris fusca*	Food fish	LRlc	Not listed	Not known
	Anabantidae	139	*Anabas testudineus*	Food fish	LRlc	VU	Not known
	Belontidae	140	*Macropodus cupanus*	Ornamental	LRlc	Not listed	Not known
	Channidae	141	*Channa striatus*	Food fish	LRlc	LRlc	EN-WG
		142	*Channa orientalis*	Food fish	LRnt	LRlnt	Not known
		143	*Channa marulius*	Cultivable	LRnt	LRnt	Not known
		144	*Channa micropeltes*	Cultivable	CR	CR	EN-K
Tetradontiformes	Tetradontidae	145	*Tetradon travancoricus*	Ornamental	LRnt	EN	EN-K

CR = Critically endangered
EN = Endangered
VU = Vulnerable
LRnt = Low risk nearly threatened
LRlc = Low risk least concern

EN -I = Endemic to India
EN-IS = Endemic to Indian sub continent
EN - WG = Endemic to Westernghats
EN-K = Endemic to Kerala
Intr = Introduced

Table 3.4. Fish species discovered new to science , their region of inhabitation, river source

Sl. No	Species	Location	River sosure
1	*Nemacheilus periyarensis*	Thannikkudy	Periyar
2	*Salarias reticulatus*	Thumburmuzhi	Chalakkudy
3	*Garra emarginata*	Mandrappara	Periyar
4	*Garra mlapparaensis*	Mlappara	Periyar
5	*Garra travancoria*	Chokkanpetty	Periyar
6	*Homaloptera silasi*	Kattamadithode	Periyar
7	*Garra nilamburensis*	Arukkallan puzha	Chalakkudy
8	*Tor remadevi*	Chambakkad	Pambar

Table 3.5. Critically endangered freshwater species of Kerala

Sl. No.	Species	River source	Number of surveys conducted	No. of locations surveyed and repeatedly surveyed	Name of the location from where the species was collected	Number of occurrence of the species
1	*Lepidopygopsis typus*	Periyar	14	20	Periyar Tiger Reserve	3
2	*Channa micropeltes*	Kallada	6	12	Thenmala dam	2
3	*Kantaka brevidorsalis*	Kabbini	12	14	Muthanga	2
4	*Crossocheilus periyarensis*	Periyar	14	20	Periyar Tiger Reserve	4
5	*Homaloptera pillai*	Bharathapuzha	12	12	Silent valley	4
6	*Schislura pambarensis*	Chinnar	4	6	Chnnar	6
7	*Mesonemachilus remadevi*	Bharathapuzha	12	12	Silent valley	6
8	*Gonoproklopterus micropogon periyarensis*	Periyar	14	20	Periyar Tiger Reserve	4

Table 3.6. Endangerd freshwater fishes of Kerala collected during the period of study

Sl.No.	Species	River	Number of surveys conducted	No. of locations surveyed and repeatedly surveyed	Name of the location from where the species was collected	Number of occurrence of the species
1	*Balitora mysorensis*	Achenkovil	9	11	Kanayar	1
		Chaliyar	5	8	Kalakkanpuzha	1
2	*Cirrhinus reba*	Kabini	12	14	KuruvadeepKunnumbatta, Noolpuzha	1
						1
						1
3	*Garra periyarensis*	Periyar	14	20	Thannikkudy	3
					Mullakkodi	1
4	*Glyptothorax lonah*	Chalakudy	10	14	Vazhachal, Malakkappara	1
5	*Gonoproktopterus dubius*	Kabini	12	14	Baveli,	3
					Noolpuzha,	3
					Vythiri	1
6	*Labeo nigrescens*	Periyar	14	20	Pooyamkutty	4
		Valapatnam	7	12	Koolupuzha	3
7	*Neolissocheilus wynaadensis*	Kabini	12	14	Aranagiri	3
					Kunnumbotta	1
					Pozhuthana	1
					Kattikunnu	2
					C.C. puzha	1
					Vythiri	1
8	*Osteochilichthys nashii*	Kabini	12	14	Aranagiri,	4
					Kunnumbotta	3
					Baveli,	1
					Noolpuzha,	4
					Begur,	3
					Pookode	1
		Chaliyar	5	8	Mayiladipotti	2
		Valapatnam	4	8	Koottupuzha	2
9	*Osteochilichthys longidorsalis*	Chalakudy	10	14	Malakkapara,	3
					Athirapilly	2
					Orukombankutty	1
		Periyar	14	20	Pooyamkutty	7
10	*Puntius arulius*	Kabbini	12	14	Pookkode	4
11	*Puntius ophicephalus*	Periyar	14	20	Ummikkuppanthode	2
		Meenachil	4	7	Vagamon	1
		Pamba	7	10	Kakki dam	1
12	*Horabagrus nigricollaris*	Chalakudy	10	14	Vettilappara	1
					Thumburmuzhi	1
		Periyar	14	20	Pooyamkutty	3
13	*Anguilla bicolor bicolor*	Periyar	14	20	Pooyamkutty	1
		Puzhaykkal	2	6	Puzhaykkal	1

Continued.........

Table 3.6 Continued......

14	*Barilius bendelisis*	Chalakudy	10	14	Malakkapara	1
					Kuriyarkutty	1
					Athirapilly	1
		Bharathapuzha	12	12	Cheruthuruthi,	1
					Cholagu	1
15	*Gonoproktopterus kolus*	Chalakudy	10	14	Kuriyarkutty, Parambikulam	1
					Parambikkulam	2
16	*Nemacheilus monilis*	Kabbini	12	14	Baveli	3
		Bhavani	2	8	Syrendri	2
		Chinnar	3	6	Chinnar	2
17	*Gonoproktopterus thomassi*	Kallada	6	12	Meenmutty.	2
					Thenmala dam	1
		Periyar	14	20	Pooyamkutty	1
18	*Travancoria jonesi*	Chalakudy	10	14	Nelliampathi (Karappara)	1
		Periyar	14	20	Pooyamkutty	1
					Pillakkayam	1
19	*Mystus bleekeri*	Puzhaykkal	2	6	Puzhaykkal	1
20	*Travancoria elongata*	Periyar	14	20	Pooyamkutty	1
21	*Silurus wynaadensis*	Kabini	12	14	Aranagiri,	2
					Kattikunnu	1
					C.C Puzha	1
		Karyangode	4	6	Munthari	1
		Chandragiri	4	8	Vettathur	1
22	*Glyptothoraz madraspatnam*	Kabini	12	14	Noolpuzha,	1
		Bharathapuzha	12	12	Kanjirappuzha	1
23	*Macrognathus guentheri*	Chalakudy	10	14	Thumbormuzhi	1
		Periyar	14	20	Pooyamkutty	1
24	*Puntius jerdonii*				Orukomban	1
		Chalakkudy	10	14	Athirapally	5
		Valapatnam	7	12	Iritti	2
25	*Puntius dorsalis*	Chalakkudy	10	14	Nelliampathy	2
26	*Chela dadiburjuri*	Bharathapuzha	12	12	Kanhirappuzha	1
27	*Brachydanio rerio*	Kabbini	12	14	Makkilayam	1
		Chandragiri	7	12	Vettathur	1
28	*Esomus thoramoicos*	Chalakkudy	10	14	Parambikulam	2
29	*Garra menoni*	Bharathapuzha	12	12	Silent valley	4
30	*Longishistura striatus*	Kabbini	12	14	Makkilayam	2
31	*N.menonii*	Periyar	14	20	Thannikkudy	5
32	*Nemacheilus botia*				Sugandagiri	4
					Nirvilpuzha	2
		Kabbini	12	14	Makkilayam	2
33	*Nemacheilus keralensis*	Periyar	17	20	Mlappara	1
		Kabini	12	14	Sugandagiri	2
		Meenachil	4	8	Vagamon	4
34	*Mystus vittatus*	Periyar	12	20	Pooyamkutty	8
		Puzhaykkal Periyar	2	6	Puzhaykkal Pooyamkutty	1
35	*Pseudeutropius mitchelli*	Periyar	12	20	Bhoothathanke	2

Table 3.7.List of fish species collected from Achenkoil river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Anguilla bengalensis*	Mananjil	15	U	Food fish	LRlc	EN	Not Known
2	*Gonoproktopterus curmuca*	Kooral	7,13,17,3,2,2	M, L	Food fish	LRnt	EN	EN-WG
3	*Labeo dussumieri*	Thooli	15,12	L	Cultivable	VU	EN	EN-K
4	*Puntius amphibius*	Paral	8,13,9,14,24	L	Ornamental	LRlc	Not Isited	Not Known
5	*Puntius bimaculatus*	Paral	13	M	Ornamental	VU	Not Isited	Not Known
6	*Puntius carnaticus*	Katti	1	U	Cultivable	VU	LRnt	EN-K
7	*Puntius denisoni*	Chenkaniyan	6,9,5,24	U, M	Ornamental	LRnt	EN	EN-K
8	*Puntius fasciatus*	Vazhakkavarayan	6,24	U, M	Ornamental	LRlc	EN	EN-WG
9	*Puntius filamentosus*	Poovalipparal	,13,20,17,2, 1,19,4,23,24	M, L	Ornamental	LRlc	Not Isited	EN-WG
10	*Puntius sarana subnasutus*	Kuruva	8,18,15,4,14	L	Food fish	LRnt	Not Isited	Not Known
11	*Puntius ticto*	Kumbazha	9	L	Ornamental	LRnt	Not Isited	Not Known
12	*Puntius vittatus*	Paral	13	M	Ornamental	LRlc	VU	Not Known
13	*Tor khudree*	Katti	1,19	U	Cultivable	LRnt	VU	Not Known
14	*Salmostoma acinaces*	Paral	9,17,2,23	M	Ornamental	LRnt	Not Isited	EN-WG
15	*Amblypharyngodon microlepis*	Vavambu	12,15	L	Ornamental	LRlc	Not Isited	EN-I
16	*Barilius bakeri*	Thuppalkothiparal	6,7,13,23,24	U, M	Ornamental	LRlc	VU	EN-WG
17	*Barilius galensis*	Thuppalkothiparal	2,6,7,23	U, M	Ornamental	LRlc	Not Isited	EN-WG
18	*Danio malabaricus*	Vilanjil	6,13,5,7,19, 1,17	U, M	Ornamental	LRlc	Not Isited	EN-IS
19	*Rasbora daniconius*	Kaniyan	8,23	M, L	Ornamental	LRlc	Not Isited	Not Known
20	*Garra mullya*	Kallemutti	13,9,19,6,1,2	U,M	Ornamental	LRlc	Not Isited	EN-I
21	*Garra hughi*	Kallemutti	6,5	U	Ornamental	VU	EN	EN-K
22	*Garra ceylonensis*	Kallemutti	16	U	Food fish	DD	Not Isited	Not Known
23	*Garra surendranatahni*	Kallemutti	24	U	Ornamental	VU	Not Isited	Not Known
24	*Baltora mysorensis*	Kallepatti	6,16	U	Ornamental	EN	Not Isited	EN-WG
25	*Bhavania auatralis*	Kallechari	6	U	Ornamental	LRnt	EN	EN-WG
26	*Horabagrus brachysoma*	Manjakkori	4,15,12	L	Food fish	VU	EN	EN-K
27	*Mystus cavasius*	Chillankoori	1	M	Food fish	LRnt	LRnt	EN-WG
28	*Mystus gulio*	Koori	1,15	L	Food fish	LRnt	Not Isited	Not Known
29	*Mystus armatus*	Koori	23	L	Food fish	LRnt	Not Isited	Not Known
30	*Ompok bimaculatus*	Thalamban	12,15	L	Cultivable	LRnt	EN	Not Known
31	*Wallago attu*	Attuvala	15	L	Cultivable	VU	LRnt	Not Known
32	*Glyptothorax annandalei*	Kallelotti	6	U	Ornamental	LRnt	VU	EN-WG
33	*Heteropneustes fossilis*	Kari	18	L	Food fish	LRlc	VU	EN-IS
34	*Xenentedon cancila*	Kola	8,10	M,L	Food fish	LRlc	LRnt	EN-IS
35	*Aplocheilus lineatus*	Poonjan	3,2,17	M, L	Ornamental	LRlc	Not Isited	EN-WG
36	*Parambassis dayi*	Arinjil	4,15,12,14,2	L	Food fish	LRlc	EN	ENK
37	*Pseudambassis bacuilis*	Arinjil	12	L	Food fish	LRlc	Not Isited	Not Known
38	*Nandus nandus*	Muthukkila	4,15,12,14	L	Ornamental	LRlc	LRnt	Not Known
39	*Pristolepis marginatus*	Andivalli	4	L	Ornamental	LRnt	VU	EN-K
40	*Etroplus suratensis*	Karimeen	15,10	M,L	Food fish	LRlc	Not Isited	EN-IS
41	*Etroplus maculatus*	Pallathi	7,15,23,24	M	Ornamental	LRlc	Not Isited	EN-IS
42	*Oreochromis mossambicus*	Philoppy	15,10,11	L	Cultivable	Intr	Intr	EX
43	*Glossogobius giuris*	Poolon	5	L	Food fish	LRnt	Not Isited	Not Known
44	*Anabas testudineus*	Kallemutty	18,4,14,12	M	Food fish	LRnt	VU	Not Known
45	*Macropodus cupanus*	Not Known	3	L	Ornamental	LRlc	Not Isited	Not Known
46	*Channa striatus*	Varal	15,14,12	L	Food fish	LRlc	LRlc	EN-WG
47	*Channa orientalis*	Varal	12,15	L	Food fish	LRnt	LRnt	Not Known
48	*Channa marulius*	Cherumeen	15,12	L	cultivable	VU	Not Isited	Not Known
49	*Mastacembeles armatus*	Aarakan	13,12,24	M	Food fish	LRnt	LRnt	Not Known

Table 3.8. List of fish species collected from Bharathapuzha river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Cultivalbe/ Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Catla catla*	Catla	35	M	Cultivable	LRlc	VU	EN-I
2	*Cirrhinus mrigala*	Mrigal	40,10	M	Cultivable	LRlc	Not listed	Not Known
3	*Gonoproktopterus curmuca*	Kooral	41,13,40,35,	U, M	Food fish	LRlc	EN	EN-WG
4	*Labeo rohita*	Rohu	35,22	M	Cultivable	LRlc	LRnt	EN-I
5	*Puntius amphibius*	Paral	41,22,13	M, L	Ornamental	LRlc	Not listed	Not Known
6	*Puntius bovanicus*	Not Known	3	M	Ornamental	DD	Not listed	Not Known
7	*Puntius conchonius*	Not Known	41,47	M	Ornamental	VU	Not listed	Not Known
8	*Puntius chola*	Paral	14,13	M, L	Food fish	LRnt	Not listed	Not Known
9	*Puntius parrah*	Paral	41,13	M, L	Foodfish	LRnt	EN	EN-WG
10	*Puntius vittatus*	Paral	18	M, L	Ornamental	LRnt	VU	Not Known
11	*Puntius denisoni*	Chorakkombi	14,29	M	Ornamental	LRnt	EN	EN-K
12	*Puntius fasciatus*	Vazhakkavarasu	24,21,11,19, 8	U, M	Ornamental	LRlc	EN	EN-WG
13	*Puntius filamentosus*	Valekkodiyan	3,22,9,33,18	M, L, U	Ornamental	LRlc	Not listed	EN-WG
14	*Puntius sarana subnasutus*	Kuruva	41,13,33	L	Food fish	LRlc	Not listed	Not Known
15	*Puntius ticto*	Not Known	9,15,17	L	Ornamental	LRnt	Not listed	Not Known
16	*Tor khudree*	Kuyil	19,48,2	U, M	Cultivable	LRnt	VU	Not Known
17	*Chela fasciata*	Paral	31	M	Ornamental	VU	Not listed	EN-I
18	*Chela dadiburjuri*	Paral	31	M	Ornamental	EN	DD	EN-I
19	*Salmostoma acinaces*	Not Known	14	M	Food fish	LRnt	Not listed	EN-WG
20	*Amblypharyngodon microlepis*	Not Known	6	M, L	Ornamental	LRlc	Not listed	Not Known
21	*Barilius bakeri*	Paralodi	24,14,11,21, 2	U, M	Ornamental	LRlc	VU	EN-WG
22	*Barilus bendelisis*	Paralodi	6,8.	L	Ornamental	EN	LRnt	EN-IS
23	*Barilius galensis*	Paralodi	21,19,11,18	M	Ornamental	LRnt	Not listed	EN-WG
24	*Barilius canarensis*	Paralodi	19,8	M	Ornamental	LRlc	DD	EN-WG
25	*Danio malabaricus*	Vilanjil	24,13,33,18, 41	U, M	Ornamental	LRlc	Not listed	EN-IS
26	*Danio aequipinnatus*	Vilanjil	6,21,9,11,19 .8	U, M	Ornamental	LRlc	LRnt	EN-IS
27	*Rasbora daniconius*	Kaniyan	14,13,21,9,3 3,18	M, L	Ornamental	LRlc	Not listed	Not Known
28	*Garra mullya*	Kallotti	41,13,6.	U, M	Ornamental	LRlc	Not listed	EN-I
29	*Garra menoni*	Kallotti	5,39	U	Ornamental	EN	VU	EN-K
30	*Garra surendranathani*	Not Known	15	U	Ornamental	VU	Not listed	Not Known
31	*Bhavania auatralis*	Parepatti	17,44,2,11	U	Ornamental	LRlc	EN	EN-WG
32	*Schistura denisoni*	Koytha		U	Ornamental	LRnt	Not listed	EN-I
33	*Mesonemacheilus triangularis*	Koytha	24,22,13,19	U, M	Ornamental	LRnt	LRlc	EN-WG
34	*Mesonemacheilus remadevi*	Koytha	36,39	U	Ornamental	CR	Not listed	EN-K
35	*Homaloptera pillai*	Not Known	39	U	Ornamental	CR	Not listed	Not Known
36	*Lepidocephalus thermalis*	Koytha	36	M	Ornamental	LRlc	Not listed	EN-IS
37	*Batasio travancoria*	Neykkori	15,31	M	Ornamental	VU	EN	EN-K
38	*Horabagrus brachysoma*	Manjakkori	47	M, L	Food fish	LRnt	EN	EN-K
39	*Mystus armatus*	Not Known	6,22	M, L	Food fish	LRnt	Not listed	Not Known
40	*Mystus vittatus*	Chillan	15	M, L	Food fish	LRnt	Not listed	Not Known
41	*Mystus cavasius*	Not Known	3,6,13,17,24 ,47	M	Food fish	LRnt	Not listed	Not Known
42	*Ompok malabaricus*	Thalamban	41	M	Cultivable	LRnt	CR	EN-IS
43	*Ompok bimaculatus*	Not Known	13,41	M, L	Cultivable	LRlc	Not listed	Not Known
44	*Wallago attu*	Vala	23	M, L	Food fish	VU	LRnt	Not Known
45	*Glyptothorax madraspatanam*	Not Known	24,14,31	M	Ornamental	EN	Not listed	Not Known
46	*Clarias dussumieri*	Mushi	41,47	M, L	Cultivable	LRnt	VU	EN-I
47	*Heteropneustes fossilis*	Kadu	41,47,13	L	Food fish	LRlc	VU	EN-IS
48	*Xenentodon cancila*	Kolan	14,6,22,13,4 0	M, L	Food fish	LRlc	LRnt	EN-IS
49	*Aplocheilus lineatus*	Not Known	6	L	Ornamental	LRlc	Not listed	Not Known
50	*Ambassis gymnocephalus*	Not Known	6	L	Food fish	LRlc	Not listed	Not Known
51	*Parambassis dayi*	Mullan	35,6,41	M, L	Food fish	LRlc	EN	EN-K
52	*Parambassis thomassi*	Mullan	35	M	Ornamental	LRnt	VU	EN-WG
53	*Pristolepis marginatus*	Chemballi	24,33	M	Ornamental	LRnt	VU	EN-WGK
54	*Etroplus suratensis*	Karimeen	41,22	M, L	Food fish	LRnt	Not listed	EN-IS
55	*Etroplus maculatus*	Pallathi	41,6,40,41,3 3,18,21	M, L	Food fish	LRlc	Not listed	EN-IS
56	*Oreochromis mossambicus*	Philoppy	22,40	L	Cultivable	Intr	Intr	EX
57	*Glossogobius giuris*	Poolon	6.	L	Food fish	LRnt	LRnt	Not Known
58	*Sicyopterus griseus*	Poolon		M	Ornamental	VU	Not listed	Not Known
59	*Anabas testudineus*	Kallemutti		M	Food fish	LRnt	VU	Not Known
60	*Macropodus cupanus*	Not Known	24	L	Ornamental	LRlc	Not listed	Not Known
61	*Channa striatus*	Varal	41,13,47	M, L	Food fish	LRnt	LRlc	EN-WG
62	*Mastacembelus armatus*	Aron	41,24,22	M	Food fish	LRlc	LRnt	Not Known
63	*Tetradon travancoricus*	Not Known	33	M, L	Ornamental	LRnt	EN	EN-K

Table 3.9. List of fish species collected from Bhavani river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Gonoproktopterus dubius*	Not Known	4	U	Food fish	EN	EN	EN-WG
2	*Puntius carnaticus*	Not Known	4	U	Cultivable	VU	LRnt	EN-WG
3	*Puntius filamentosus*	Kalakkodian	3	U	Ornamental	LRlc	Not listed	Not Known
4	*Puntius fasciatus*	Vazhakkavarayan	1,2,3	U	Ornamental	LRlc	EN	EN-WG
5	*Salmostoma boopis*	Not Known	2,3	U	Ornamental	LRnt	Not listed	EN-I
6	*Barilius bakeri*	Thuppalkothi	1,2,3	U	Ornamental	LRlc	VU	EN-WG
7	*Barilius gatensis*	Thuppalkothi	3	U	Ornamental	LRlc	Not listed	Not Known
8	*Barilius canarensis*	Thuppalkothi	3	U	Ornamental	LRnt	DD	EN-WG
9	*Danio malabaricus*	Vilanjil	1,2,3	U	Ornamental	LRlc	Not listed	EN-IS
10	*Rasbora daniconius*	Kaniyan	1,2,3	U	Ornamental	LRlc	Not listed	Not Known
11	*Garra gotyla stenorhynchus*	Kallemutti	2,3	U	Food fish	LRnt	EN	EN-WG
12	*Garra mullya*	Kallemutti	1,2,3	U	Ornamental	LRlc	Not listed	EN-I
13	*Bhavania australis*	Kallepatti	4	U	Ornamental	LRlc	EN	EN-WG
14	*Schistura denisoni*	Ayira	3	U	Ornamental	LRnt	Not listed	EN-I
15	*Nemacheilus monilis*	Ayira	3	U	Ornamental	VU	Not listed	EN-K
16	*Lepidocephalus thermalis*	Ayira	3	U	Ornamental	LRlc	Not listed	EN-IS

Table 3.10. List of fish species collected from Chalakkudy river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Cyprinus carpio*	Not Known	7	U	Cultivable	Intr	Intr	EX
2	*Gonoproktopterus curmuca*	kooral	15,9,16,2	U,M	Food fish	LRlc	EN	EN-WG
3	*Gonoproktopterus kolus*	kooral	6,14,8,32	U	Food fish	EN	EN	EN-WG
4	*Osteobrama bakeri*	Mulanpaval	4,9	M,L	Ornamental	VU	EN	EN-WGK
5	*Osteochilus longidorsalis*	Not Known	2,18,12	M	Cultivable	EN	CR	EN-WGK
6	*Puntius amphibius*	Not Known	3	L	Ornamental	LRlc	Not listed	Not Known
7	*Puntius parrah*	Not Known	3	L	Foodfish	LRlc	EN	ENWG
8	*Puntius bimaculatus*	Not Known	7	U	Ornamental	VU	Not listed	EN-WG
9	*Puntius carnaticus*	Pachilavetti	8,14,16,18,32	U,M	Cultivable	VU	LRnt	EN-WG
10	*Puntius chola*	Not Known	3	L	Ornamental	LRnt	VU	Not Known
11	*Puntius dorsalis*	Not Known	7	U	Food fish	EN	Not listed	Not Known
12	*Puntius vittatus*	Not Known	3	L	Ornamental	LRlc	VU	Not Known
13	*Puntius denisoni*	Chenkaniyan	17	M	Ornamental	LRnt	EN	ENK
14	*Puntius fasciatus*	Vazhakkavaray	2,16,17,9,33	U,M	Ornamental	LRlc	EN	EN-WG
15	*Puntius filamentosus*	Poovalipparal	15,12,9,16,2,14,17,13,32,33	U,M,L	Ornamental	LRlc	Not listed	EN-WG
16	*Puntius jerdoni*	Paral	2,16,8	U,M	Ornamental	EN	Not listed	EN-WGK
17	*Puntius ticto*	Paral	9,13	L	Ornamental	LRlc	Not listed	Not Known
18	*Puntius sarana subnasutus*	Kuruva	2	L	Food fish	LRlc	Not listed	Not Known
19	*Tor khudree*	Kuyil	2,16,1,6,8,14,7,5,32	U,M	Cultivable	LRnt	VU	Not Known
20	*Salmostoma boopis*	Puzhamathi	3	L	Ornamental	LRlc	Not listed	EN-I
21	*Salmostoma acinaces*	Puzhamathi	3,7	U,L	Ornamental	LRlc	Not listed	EN-WG
22	*Barilius bakeri*	Thuppalkothi..a	12,17,16,2,9,33	U,M	Ornamental	LRlc	VU	EN-WG
23	*Barilius bendelisis*	Paral	14	U	Ornamental	EN	LRnt	EN-IS
24	*Barilius gatensis*	Thuppalkothipa	6,8,14,2,16,1,9,17,13,5,33	U,M	Ornamental	LRlc	Not listed	EN-WG
25	*Barilius canarensis*	Not Known	16	M	Ornamental	LRlc	DD	EN-WG
26	*Danio malabaricus*	Vilanjil	15,12,9,16,2,6,8,14,17,13,31,35	U,M	Ornamental	LRlc	Not listed	EN-IS
27	*Danio aequipinnatus*	Vilanjil	16	M	Ornamental	LRlc	LRnt	EN-IS
28	*Esomus thermoicos*	Not Known	30	U	Ornamental	EN	Not listed	EN-WG
29	*Rasbora daniconius*	Kaniyan	7,3,31	U,M,L	Ornamental	LRlc	Not listed	Not Known
30	*Garra mullya*	Kallemutti	15,12,9,16,2,6,8,14,5,7,33	U,M	Ornamental	LRlc	Not listed	EN-I
31	*Garra surendranathani*	Kallemutti	8,7	U	Ornamental	LRnt	EN	EN-WGK
32	*Bhavania auatralis*	Pareppatti	7,11	U	Ornamental	LRnt	EN	ENWG
33	*Travancoria jonesi*	Not Known	22,37	U	Ornamental	EN	EN	EN-WGK
34	*Mesonemacheilus guentheri*	Not Known	2,16,17	U,M	Ornamental	LRnt	LRlc	EN-WGK
35	*Mesonemacheilus triangularis*	Not Known	2,16,17	U,M	Ornamental	LRlc	LRlc	EN-WGK
36	*Lepidocephalus thermalis*	Not Known	2,16,17,13	U,M	Ornamental	LRlc	Not listed	EN-IS
37	*Batasio travancoria*	Neykkori	9,11	M	Food fish	VU	EN	EN-WGK
38	*Horabagrus nigricollaris*	Manjaletta	17	M	Food fish	EN	CR	EN-WGK
39	*Horabagrus brachysoma*	Manjakkori	17	M	food fish	LRnt	EN	EN-K
40	*Mystus cavasius*	Koori	32	U	Food fish	LRlc	LRnt	NE-WG
41	*Mystus gulio*	Chillankoori	10	L	Food fish	LRlc	Not listed	Not Known
42	*Mystus armatus*	Not Known	13	M	Food fish	LRlc	Not listed	EN-IS
43	*Ompok bimaculatus*	Not Known	2	M	Cultivable	LRlc	EN	Not Known
44	*Glyptothorax lonah*	Not Known	2	M	Ornamental	EN	LRnt	en-wg
45	*Clarias dussumieri*	Not Known	14	U	Foodfish	LRnt	VU	EN-I
46	*Heteropneustes fossilis*	Kari	3,14	U,L	Food fish	LRnt	VU	EN-IS
47	*Xenentodon cancila*	Kola	3,9	M,L	Food fish	LRlc	LRnt	EN-IS
48	*Aplocheilus lineatus*	Manathukanni	3	L	Ornamental	LRlc	Not listed	EN-WG
49	*Aplocheilus blocki*	Manathukanni	3	L	Ornamental	LRlc	Not listed	EN-WG
50	*Poecilia reticulata*	Not Known	15	U	Ornamental	LRlc	Intr	EX
51	*Microphis cuncalus*	Not Known	3	L	Ornamental	VU	Not listed	EN-IS
52	*Parambassis dayi*	Not Known	3,2,13	M,L	Food fish	LRlc	EN	EN-K
53	*Parambassis thomassi*	Arinjil	9,14	U,M	Ornamental	LRlc	VU	EN-WG
54	*Ambassis gymnocephalus*	Not Known	3	L	Food fish	LRlc	Not listed	Not Known
55	*Pristolepis marginatus*	Andivalli	12,4,2,9,17	M	Ornamental	LRlc	VU	EN-WGK
56	*Etroplus suratensis*	Kanmeen	2,6,8,14	M,L	Cultivable	LRlc	Not listed	EN-IS
57	*Etroplus maculatus*	Pallathi	2,6,8,14,9,17	M,L	Ornamental	LRlc	Not listed	EN-IS
58	*Oreochromis mossambicus*	Tilapia	12,4,17,13,31,32	U,M	Cultivable	Intr	Intr	EX
59	*Salarias reticulates*	Not Known	13	M	Food fish	DD	Not listed	EN-WK
60	*Glossogobius giuris*	Poolon	10	L	Food fish	LRnt	LRnt	Not Known
61	*Sicyopterus griseus*	Not Known	17	M	Ornamental	VU	Not listed	Not Known
62	*Awavous gutum*	Not Known	10	L	Food fish	LRnt	Not listed	Not Known
63	*Eleotris fusca*	Karimpoolon	10	L	Food fish	LRnt	Not listed	Not Known
64	*Anabas testudineus*	Kallemutti	10,3	L	Food fish	LRnt	VU	Not Known
65	*Channa striatus*	Not Known	3	L	Food fish	LRlc	LRlc	EN-WG
66	*Mastacembelus armatus*	Arakan	9,13,2	U,M	Food fish	LRnt	LRnt	Not Known
67	*Tetradon travancoricus*	Not Known	3	L	Ornamental	LRnt	EN	EN-K

Table 3.11. List of fish species collected from Chaliyar river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Cultivable / Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Gonoproktopterus curmuca*	Kooral	6,5,14,13,27	U, M	Food fish	LRlc	EN	EN-WG
2	*Osteochilus nashii*	Arana	11,9	U	Ornamental	VU	Not listed	EN-WG
3	*Neolissochilus wayanadensis*	Arana	28	U	Food fish	EN	Not listed	EN-K
4	*Puntius amphibius*	Paral	6,18	M	Ornamental	LRlc	Not listed	Not Known
5	*Puntius chola*	Paral	1	L	Ornamental	LRnt	VU	Not Known
6	*Puntius denisoni*	Paral	13	M	Ornamental	LRnt	Not listed	Not Known
7	*Puntius fasciatus*	Vazhakkavarayan	1,9,11,16,23,28,27	U, M	Ornamental	LRlc	EN	EN-WG
8	*Puntius filamentosus*	Poovalipparal	6,13,5,14,18,26,27	U, M,L	Ornamental	LRlc	Not listed	EN-WG
9	*Puntius sarana subnasutus*	Kuruva	6	L	Food fish	LRlc	Not listed	Not Known
10	*Puntius ticto*	Paral	6,5	L	Ornamental	LRlc	Not listed	Not Known
11	*Tor khudree*	Kadanna	18,10,11,1	U	Cultivable	LRlc	VU	Not Known
12	*Amblypharyngodon microlepis*	Vayambu	23	M	Ornamental	LRlc	Not listed	Not Known
13	*Salmostoma boopis*	Mathipparal	15,7,14,6	M, L	Food fish	LRlc	Not listed	EN-I
14	*Barilius bakeri*	Thuppalkothi	13,7,16,20,1,9, 11,26,27	U	Ornamental	LRlc	VU	EN-WG
15	*Barilius gatensis*	Not Known	1,26,27	U	Ornamental	LRlc	Not listed	Not Known
16	*Danio malabaricus*	Vilanjil	6,13,5,14,10,18,9,11,26,27	U,M	Ornamental	LRlc	Not listed	EN-IS
17	*Rasbora daniconius*	Kaniyan paral	1	M,L	Ornamental	LRlc	Not listed	Not Known
18	*Garra gotyla stenorhynchus*	Not Known	10,11,21	U	Food fish	VU	EN	EN-WG
19	*Garra mullya*	Mookkan	10,1,9,11,7,27	U,M	Ornamental	LRlc	Not listed	EN-I
20	*Garra mcClellandi*	Kallemutti	7,14,26	U	Ornamental	LRnt	Not listed	EN-WG
21	*Garra nilamburensis*	Kallemutti	29	U	Ornamental	DD	Not listed	Not Known
22	*Balitora mysorensis*	Kallepatti	28	U	Ornamental	EN	Not listed	Not Known
23	*Mesonemacheilus guentheri*	Ayira	9	U	Ornamental	LRnt	LRlc	EN-WG
24	*Mesonemacheilus triangularis*	Ayira	9,16	U	Ornamental	LRnt	Not listed	Not Known
25	*Horabagrus brachysoma*	Koori	4	L	Cultivable	LRnt	Not listed	Not Known
26	*Mystus cavasius*	Not Known	1,20	M	Food fish	LRnt	Not listed	Not Known
27	*Ompok bimaculatus*	Not Known	2,12,14	M,L	cultivable	LRnt	EN	Not Known
28	*Glyptothorax annandalei*	Parakkoori	9,21	U	Ornamental	LRnt	Not listed	EN-IS
29	*Heteropneustes fossilis*	Kari	15,4	M	Food fish	LRlc	VU	EN-IS
30	*Xenentedon cancila*	Kola	7	M,L	Food fish	LRlc	LRnt	EN-IS
31	*Parambassis thomassi*	Arinjil	6,5,14	M,L	Ornamental	LRlc	VU	EN-WG
32	*Pristolepis marginatus*	Not Known	6,15	M	Ornamental	LRnt	VU	EN-K
33	*Etroplus maculatus*	Pallathi	6,7,14	M,L	Ornamental	LRlc	Not listed	Not Known
34	*Oreochromis mossambicus*	Philoppy	2,12	L	Cultivable	Intr	Intr	EX
35	*Glossogobius giuris*	Poolon	15,16,7,14	M,L	Food fish	LRnt	LRnt	Not Known
36	*Sicyopterus griseus*	Poolon	9	U	Ornamental	VU	Not listed	Not Known
37	*Anabas testudineus*	Not Known	3,4,5,6	L	Food fish	LRnt	VU	Not Known
38	*Channa striatus*	Varal	3,4,5,6	L	Food fish	LRlc	Not listed	Not Known
39	*Mastacembelus armatus*	Aron	1,6	M	Food fish	LRnt	LRnt	Not Known
40	*Tetradon travancoricus*	Attunda	6	L	Ornamental	LRnt	EN	EN-K

Table 3.12. List of fish species collected from Chandragiri river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Gonoproktopterus curmuca*	Koori	1,2,3,4,8,10	M,U	Food fish	LRlc	EN	EN-WG
2	*Labeo nigriscens*	Not Known	8,10	U	Food fish	EN	Not listed	EN-WG
3	*Puntius amphibius*	Paral	2,3	L	Ornamental	LRlc	Not listed	Not Known
4	*Puntius vittatus*	Paral	1,2,3	L	Ornamental	LRlc	VU	Not Known
5	*Puntius denisoni*	Not Known	4,6,8	U,M	Ornamental	LRnt	EN	EN-K
6	*Puntius fasciatus*	Not Known	8,9,10	U,M	Ornamental	LRlc	EN	EN-WG
7	*Puntius filamentosus*	Paral	1,2,4,9	M,U,L	Ornamental	LRlc	Not listed	EN-WG
8	*Tor khudree*	Kuyil	1,2,4,9	M,U	Cultivable	LRnt	VU	Not Known
9	*Salmostoma acinaces*	Not Known	6,7,8	M,L	Food fish	LRlc	Not listed	EN-WG
10	*Barilius bakeri*	Paralodi	3,4,8,10	M,U	Ornamental	LRlc	VU	EN-WG
11	*Barilius gatensis*	Not Known	1,4,6,7,8,9,10	U,M	Ornamental	LRlc	Not listed	EN-WG
12	*Brachydanio rerio*	Not Known	9,10	U	Ornamental	EN	Not listed	EN-IS
13	*Danio malabaricus*	Vilanjil	10	U	Ornamental	LRlc	Not listed	EN-IS
14	*Rasbora daniconius*	Kaniyan	9,10	U,M	Ornamental	LRlc	Not listed	Not Known
15	*Garra mullya*	Kallotti	8,9,10	U,M	Ornamental	LRlc	Not listed	EN-I
16	*Bhavania auatralis*	Not Known	9,10	U	Ornamental	LRlc	EN	EN-WG
17	*Schistura denisoni*	Not Known	8,9,10	U,M	Ornamental	LRlc	Not listed	EN-I
18	*Mesonemacheilus guentheri*	Not Known	7,8,9,10	U,M	Ornamental	LRlc	LRlc	EN-WG
19	*Batasio travancoria*	Koori	8,10	M	Ornamental	VU	EN	EN-K
20	*Mystus gulio*	Koori	8,10	M	Food fish	LRlc	Not listed	Not Known
21	*Mystus malabaricus*	Koori	9,10	U	Food fish	VU	EN	EN-K
22	*Ompok malabaricus*	Vala	6,7,8,10	U,M	Cultivable	LRlc	CR	EN-IS
23	*Silurus wayanadensis*	Vala	8,9,10	U	Food fish	EN	CR	EN-WG
24	*Glyptothorax annandalei*	Koori	4,5,6	U,M	Ornamental	LRnt	Not listed	EN-IS
25	*Xenentodon cancila*	Kola	7,8,9,10	U,M	Food fish	LRlc	LRnt	EN-IS
26	*Aplocheilus lineatus*	Poonjan	2,3	M	Ornamental	LRlc	Not listed	EN-WG
27	*Parambassis dayi*	Mullan	9,10	M	Food fish	LRlc	EN	EN-K
28	*Etroplus suratensis*	Karimeen	7,8	M	Ornamental	LRlc	Not listed	EN-IS
29	*Etroplus maculatus*	Choottachi	9,10	U,M	Ornamental	LRlc	Not listed	EN-IS
30	*Glossogobius giuris*	Poolon	6	M	Food fish	LRlc	LRnt	Not Known
31	*Channa striatus*	Kaichal	4	L	Food fish	LRlc	LRlc	EN-WG
32	*Mastacembelus armatus*	Aaron	4,6	M	Food fish	LRlc	LRnt	Not Known

Table 3.13. List of fish species collected from Kabbini river system

Sl. No.	Species	Local name	Locations	Strech wise distribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Notopterus notopterus*	Pulluvala	13,22,26	M	Food fish	LRnt	LRnt	Nor Known
2	*Cirrhinus reba*	Kavorimeen	13,11	U	Food fish	EN	VU	EN-IS
3	*Cirrhinus mrigala*	Mrigal	12	M	Cultivable	LRlc	LRnt	EN-I
4	*Gonoproktopterus dubius*	Kadanna	13,17,19,23,6,14 ,1,20,18	U	Food fish	EN	EN	EN-WG
5	*Labeo kontius*	Kadanna	23	U	Food fish	EN	EN	EN-WG
6	*Neolissochilus wayanadensis*	Manjakadanna	2,11,25,8,7,34	U	Food fish	EN	CR	EN-K
7	*Osteochilus (Kantaka) brevidorsalis*	Kadanna	19	U	Food fish	CR	EN	EN-K
8	*Osteochilus nashii*	kadanna	6,11,19	U	Food fish	VU	Not listed	EN-WG
9	*Puntius amphibius*	Paral	22	M	Ornamental	LRlc	Not listed	Nor Known
10	*Puntius arulius*	Arulipparal	13	U	Ornamental	LRnt	EN	EN-WG
11	*Puntius bimaculatus*	Paral	1,14,20,22	M	Ornamental	LRlc	Not listed	Nor Known
12	*Puntius carnaticus*	Palkkadanna	19,6,7,16,11,13	U	Cultivable	VU	LRnt	EN-WG
13	*Puntius conchonius*	Vattapparal	13,25,19,26,16,6,5	U	Ornamental	LRnt	VU	Nor Known
14	*Puntius chola*	Paral	19,28,24	M	Ornamental	LRnt	VU	Nor Known
15	*Puntius vittatus*	Paral	22,15	L	Ornamental	LRlc	VU	Nor Known
16	*Puntius fasciatus*	Vazhakkavarayan	13,23,19,24,2,6,28	U, M	Ornamental	LRlc	EN	EN-WG
17	*Puntius filamentosus*	Paral	6,13	M	Ornamental	LRlc	Not listed	Nor Known
18	*Puntius sarana subnasutus*	Kuruva	3,15	L	Food fish	LRnt	Not listed	Nor Known
19	*Puntius ticto*	Paral	25	L	Ornamental	LRlc	EN	EN-WG
	Tor putitora	Kadanna	19	U	Cultivable	DD	EN	EN-I
20	*Salmostoma acinaces*	Puzhamathi	1,20,19,21,23,14 ,16,14,18	U	Food fish	LRlc	Not listed	EN-I
21	*Salmostoma boopis*	Puzhamathi	13,19	U	Ornamental	LRlc	Not listed	EN-WG
22	*Barilius bakeri*	Paralodi	19,17,8,28,26,11 ,4,16,9	U	Ornamental	LRlc	VU	EN-WG
23	*Barilius gatensis*	Paralodi	13,26	U, M	Ornamental	LRlc	Not listed	EN-WG
24	*Brachydanio rerio*	Nor Known					Not listed	Nor Known
25	*Danio malabaricus*	Vilanjil	17,6,13,7,24,26, 11,4,19,9,28	U, M	Ornamental	LRlc	Not listed	EN-IS
26	*Rasbora daniconius*	Kaniyan	5,15,16	M	Ornamental	LRlc	Not listed	
27	*Garra gotyla stenorhynchus*	Kallotti	6,19,13	U	Food fish	VU	EN	EN-WG
28	*Garra mullya*	Kallotti	17,6,13,7,5,28	U	Ornamental	LRlc	Not listed	EN-I
29	*Bhavania auatralis*	Kalleppatti	27,13	U	Ornamental	LRlc	EN	EN-WG
30	*Nemacheilus monilis*	Ayira	5,14	U	Ornamental	VU	EN	EN-WG
31	*Acanthocobitis botia*	Manali	25,27,1,14	U	Ornamental	EN	LRnt	EN-WG
32	*Schistura striatus*	Manali	14	U	Omametnal	EN	Not listed	EN-K
33	*Schistura semiarmatus*	Manali	1,14,18	U	Ornamental	VU	VU	EN-WG
34	*Horabagrus brachysoma*	Manjakkoori	4	L	Food fish	VU	Not listed	
35	*Mystus cavasius*	Chakkamullan	17,19	U	Food fish	LRnt	LRnt	EN-WG
36	*Mystus armatus*	Chakkamullan	,1	U, M	Food fish	LRnt	Not listed	EN-IS
37	*Mystus montanus*	Chakkamullan	13	M	Food fish	EN	Not listed	Nor Known
38	*Mystus gulio*	Chakkamullan	19	L	Food fish	LRnt	Not listed	Nor Known
39	*Mystus oculates*	Chakkamullan	22	L	Food fish	LRlc	Not listed	Nor Known
40	*Ompok bimaculatus*	Vala	6,13,9	M,L	Cultvable fish	LRnt	EN	Nor Known
41	*Silurus wayanadensis*	Thonnivala	2	U	Food fish	EN	CR	EN-WG
42	*Wallago attu*	Vala	6	L	Cultible fish	VU	LRn t	Nor Known
43	*Heteropneustes fossilis*	Kadu	24,26	L	Food fish	LRlc	VU	EN-IS
44	*Glyptothorax madraspatanam*	Parakkoori	8,13,11	U	Ornamental	EN	VU	EN-WG
45	*Glyptothorax annandalie*	Parakkoori	2	U	Ornamental	LRlc	Not listed	Nor Known
46	*Glyptothorax anamalaiensis*	Parakkoori	13	U	Ornamental	DD	CR	EN-K
47	*Xenentodon cancila*	Kolan	15,1,14	L	Food fish	LRlc	Not listed	Nor Known
48	*Oreochromis mossambica*	Philoppy	24,12	L	Cultivable	Intr	In tr	EX
49	*Etroplus suratensis*	Karimeen	22	L	Cultivable	LRnt	Not listed	EN-IS
50	*Etroplus maculatus*	Choottachi	22	L	Ornamental	LRlc	Not listed	EN-IS
51	*Parambassis thomassi*	Arinjil	9,28,13	U	Ornamental	LRnt	VU	EN-WG
52	*Channa striatus*	Varal	25,15	L	Food fish	LRlc	LRlc	EN-WG
53	*Mastacembelus armatus*	Aaron	13,24,26,9	M	Food fish	LRnt	LRnt	Nor Known

Table 3.14. List of fish species collected from Kadalundi river system

Sl.No.	Species	Local name	Strech wise distribution	Locations	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Gonoproktopterus curmuca*	Kooral	U,M	1,2,3	Food fish	LRlc	EN	EN-WG
2	*Puntius amphibius*	Paral	M,L	1,2	Omamental	LRlc	Not listed	Not Known
3	*Puntius vittatus*	Paral	M,L	2,3	Omamental	LRlc	VU	Not Known
4	*Puntius fasciatus*	Paral	U,M	1,2,3	Omamental	LRlc	EN	EN-WG
5	*Puntius filamentosus*	Valechuttipparal	U,M,L	1,2,3	Omamental	LRlc	Not listed	EN-WG
6	*Puntius sarana subnasutus*	Kuruva	L	3	Food fish	LRlc	Not listed	Not Known
7	*Salmostoma acinaces*	Paral	M,L	2,3	Food fish	LRlc	Not listed	EN-WG
8	*Barilius gatensis*	Paralodi	U,M	1,2,3	Omamental	LRlc	Not listed	EN-WG
9	*Danio malabaricus*	Paralodi	M	3	Omamental	LRlc	Not listed	EN-IS
10	*Rasbora daniconius*	Kaniyan	M,L	1,2	Omamental	LRlc	Not listed	Not Known
11	*Garra mullya*	Kallotti	U	3	Omamental	LRlc	Not listed	EN-I
12	*Mesonemacheilus triangularis*	Not Known	U,M	1,2,3	Omamental	LRlc	LRlc	EN-WG
13	*Mystus armatus*	Koori	M,U	1,3	Food fish	LRlc	Not listed	EN-IS
14	*Ompok bimaculatus*	Vala	M	3	Cultivable	LRlc	EN	Not Known
15	*Xenentodon cancila*	Kola	L	2	Food fish	LRlc	LRnt	EN-IS
16	*Aplocheilus lineatus*	Poonjan	M	1	Omamental	LRlc	Not listed	EN-WG
17	*Parambassis dayi*	Mullan	M,U	2,3	Food fish	LRlc	EN	EN-K
18	*Pristolepis marginata*	Not Known	U,M	2,3	Omamental	LRlc	VU	EN-K
19	*Etroplus maculatus*	Choottachi	M,L	1,3	Omamental	LRlc	Not listed	EN-IS
20	*Oreochromis mossambicus*	Philoppy	M,L	2,3	Cultivable	LRlc	Intr	EX
21	*Glossogobius giuris*	Poolon	M,L	1,2,3	Food fish	LRlc	LRnt	Not Known
22	*Anabas testudineus*	Kallemutti	L	2,3	Food fish	LRlc	VU	Not Known
23	*Channa striatus*	Eral	L	1	Food fish	LRlc	LRlc	EN-WG

Table 3.15. List of fish species collected from Kallada river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Gonoproktopterus curmuca*	Kooral	3,10,2,8,7,18,10	M,U	Food fish	LRlc	EN	EN-WG
2	*Gonoproktopterus kurali*	Kooral	21,11	M	Food fish	EN	Not listed	Not Known
3	*Gonoproktopterus thomassi*	Kadirneen,Chekkali	10,4,3	M,U	Food fish	EN	EN	EN-WG
4	*Osteobrama bakeri*	Not Known	12	M	Ornamental	VU	EN	EN-K
5	*Puntius amphibius*	Paral	10,18	L	Ornamental	LRlc	Not listed	Not Known
6	*Puntius arulius*	Not Known	2	U	Ornamental	EN	EN	EN-WG
7	*Puntius chola*	Paral	10	M	Ornamental	LRnt	Not listed	Not Known
8	*Puntius vittatus*	Not Known	21	L	Ornamental	LRlc	VU	Not Known
9	*Puntius fasciatus*	Vazhakkavarayan	7	U	Ornamental	LRlc	EN	EN-WG
10	*Puntius filamentosus*	Kalakkodiyan	10,3,2,4,1,8,6,21,18	L	Ornamental	LRlc	Not listed	EN-WG
11	*Puntius ticto*	Paral	6,12	L	Ornamental	LRlc	Not listed	Not Known
12	*Puntius sarana subnasutus*	Kuruvapparal	10	L	Food fish	LRlc	Not listed	Not Known
13	*Tor khudree*	Katti	3,2,11,10,5,1,21,10	U	Cultivable	LRnt	VU	Not Known
14	*Salmostoma boopis*	Not Known	21	M	Food fish	LRlc	Not listed	EN-I
15	*Amblypharyngodon microlepis*	Not Known	21	M	Ornamental	LRlc	Not listed	EN-I
16	*Barilius bakeri*	Thuppalkothi	3,10,2,12,4,8,21,20,7,17,18	U,M	Ornamental	LRlc	VU	EN-WG
17	*Barilius gatensis*	Thuppalkothi	2,12,3,8,20,10	U,M	Ornamental	LRlc	Not listed	EN-WG
18	*Danio malabaricus*	Vilanjil	7,3,10,2,4,12,11,21,18	U,M	Ornamental	LRlc	Not listed	EN-IS
19	*Danio aequipinnatus*	Vilanjil		M	Ornamental	LRlc	Not listed	Not Known
20	*Rasbora daniconius*	Kaniyan	10,7,6,20,17,18	U,M,L	Ornamental	LRlc	Not listed	Not Known
21	*Garra mullya*	Kallemutti	10,2,7,11,1,7,3,8,21,17,18	U	Ornamental	LRlc	Not listed	EN-I
22	*Garra mcClellandi*	Kallemutti	9	U	Food fish	LRnt	Not listed	EN-WG
23	*Bhavania auatralis*	Parepatti	7	U	Ornamental	LRlc	EN	EN-WG
24	*Mesonemacheilus triangularis*	Ayira,Koytha	7,1,10	U	Ornamental	LRlc	LRlc	EN-WG
25	*Horabagrus brachysoma*	Not Known	10	U,M	Food fish	LRnt	EN	EN-K
26	*Mystus cavasius*	Not Known	10,7	M	Food fish	LRnt	LRnt	EN-WG
27	*Mystus gulio*	Not Known	10,3	M	Food fish	LRlc	Not listed	Not Known
28	*Mystus armatus*	Chillankoori	10	M	Food fish	LRnt	Not listed	EN-IS
29	*Ompok bimaculatus*	Thalamban	10	U,M	cultivable	LRnt	EN	Not Known
30	*Glyptothorx annandalei*	Not Known	3	U	Ornamental	LRnt	Not listed	Not Known
31	*Heteropneustes fossilis*	Not Known	12	L	Food fish	LRlc	VU	EN-IS
32	*Xenentodon cancila*	Not Known	12	L	Food fish	LRlc	LRnt	EN-IS
33	*Parambassis dayi*	Arinjil	10	M,L	Food fish	LRlc	EN	EN-K
34	*Pristolepis marginata*	Not Known		M	Ornamental	LRnt	VU	EN-K
35	*Etroplus maculatus*	Not Known	18	M	Food fish	LRlc	Not listed	EN-IS
36	*Oreochromis mossambicus*	Philoppy	10,1,21,17	L	cultivable	Intr	Intr	EX
37	*Glossogobius giuris*	Poolon	12,3,21,18	L	Food fish	LRnt	LRnt	Not Known
38	*Channa striatus*	Not Known	3	M	Food fish	LRlc	LRlc	EN-WG
39	*Channa marulius*	Not Known	3	U	cultivable	VU	Not listed	Not Known
40	*Channa micropeltes*	Vakavaral	10	U	cultivable	CR	CR	EN-K
41	*Mastacembelus armatus*	Not Known	5	U	Food fish	LRnt	LRnt	Not Known

Table 3.16. List of fish species collected from Karuvannur river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Ornamental/ Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Puntius amphibius*	Paral	5,2	L,M	Ornamental	LRlc	Not listed	Not Known
2	*Puntius fasciatus*	Vazhakkavarayan	4	U	Ornamental	LRlc	EN	EN-WG
3	*Puntius filamentosus*	Valechuttipparal	5	M,U	Ornamental	LRlc	Not listed	EN-WG
4	*Puntius sarana subnasutus*	Kuruva	1	L	Food fish	LRlc	Not listed	
5	*Puntius ticto*	Paral	4,5,1,3	M,L,U	Ornamental	LRlc	EN	EN-WG
6	*Danio malabaricus*	Vilanjil	5,2,4	M,U	Ornamental	LRlc	Not listed	EN-IS
7	*Danio aequipinnatus*	Vilanjil	2,3,4,8,15	M,U	Ornamental	LRlc	LRnt	EN-IS
8	*Rasbora daniconius*	Kaniyan	5,2,4	M,L	Ornamental	LRlc	Not listed	Not Known
9	*Mesonemacheilus guentheri*	Koytha	3,15	U,M	Ornamental	LRlc	LRlc	EN-WG
10	*Mystus gulio*	Koori	7,8	L	Food fish	LRlc	Not listed	Not Known
11	*Ompok bimaculatus*	Vala	2	M	Food fish	LRlc	EN	Not Known
12	*Heteropneustes fossilis*	Kari	2	L	Food fish	LRlc	VU	EN-IS
13	*Xenentodon cancila*	Kola	8	L	Food fish	LRlc	LRnt	EN-IS
14	*Parambassis dayi*	Arinjil	7,8	M,L	Food fish	LRlc	EN	EN-K
15	*Nandus nandus*	Muthukkila	2,1	L	Ornamental	LRlc	Not listed	Not Known
16	*Etroplus maculatus*	Pallathi	1,12	L	Food fish	LRlc	Not listed	EN-IS
17	*Channa striatus*	Varal	13	L	Food fish	LRlc	LRlc	EN-WG
18	*Mastacembeles armatus*	Arakan	2	M	Food fish	LRnt	LRnt	Not Known

Table 3.17. List of fish species collected from Karyangod river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Gonoproktopterus curmuca*	Kooral	1,2,3	M	Food fish	LRlc	EN	EN-WG
2	*Puntius denisoni*	Paral	1,2	M	Ornamental	LRnt	EN	EN-K
3	*Puntius fasciatus*	Vazhaykkavarayan	,2,3,4	U,M	Ornamental	LRlc	EN	EN-WG
4	*Puntius filamentosus*	Valekkodiyan	1,2,3,4	U,M,L	Ornamental	LRlc	Not listed	EN-WG
5	*Tor khudree*	Kuvil	3,4	U	Cultivable	LRnt	VU	Not Known
6	*Salmostoma acinaces*	Not Known	1,2,3	M	Food fish	LRlc	Not listed	EN-WG
7	*Barilius bakeri*	Paralodi	3,4	U,M	Ornamental	LRlc	VU	EN-WG
8	*Barilius gatensis*	Parlodi	1,2,3,4	U,M	Ornamental	LRlc	Not listed	EN-WG
9	*Barilius canarensis*	Not Known	1,2,3,4	M	Ornamental	LRnt	DD	EN-WG
10	*Danio malabaricus*	Vilanjil	1,2,3,4	M,U	Ornamental	LRlc	Not listed	EN-IS
11	*Danio aequipinnatus*	Vilanjil	1,2,4	U,M	Ornamental	LRlc	LRnt	EN-IS
12	*Rasbora daniconius*	Kaniyan	1,2,3,4,5	M	Ornamental	LRlc	Not listed	Not Known
13	*Garra mullya*	Kallotti	3,4	M,U	Ornamental	LRlc	Not listed	EN-I
14	*Garra hughi*	Kallotti	3	U	Ornamental	VU	EN	EN-K
15	*Bhavania auatralis*	Kallepalti	1,2,3,4	U	Ornamental	LRlc	EN	EN-WG
16	*Mesonemacheilus guentheri*	Ayira	3	U	Ornamental	LRlc	LRlc	EN-WG
17	*Mesonemacheilus triangularis*	Ayira	3,4	U	Ornamental	LRlc	LRlc	EN-WG
18	*Lepidocephalus thermalis*	Ayira	3,4	M	Ornamental	LRlc	Not listed	EN-IS
19	*Mystus malabaricus*	Chillan	4	M	Food fish	VU	EN	EN-K
20	*Ompok malabaricus*	Vala	4,5	M	Cultivable	LRlc	CR	EN-IS
21	*Silurus wayanadensis*	Vala	4	U	Food fish	EN	CR	EN-WG
22	*Glyptothorax annandalei*	Koori	4	U	Ornamental	LRnt	Not listed	EN-IS
23	*Clarias dussumieri*	Musu	5,6	U,M	Cultivable	LRlc	VU	EN-I
24	*Heteropneustes fossilis*	Kadu	5,6	M,L	Food fish	LRlc	VU	EN-IS
25	*Xenentodon cancila*	Kola	7	M,L	Food fish	LRlc	LRnt	EN-IS
26	*Aplocheilus lineatus*	Poonjan	5,6,7,8	M,L	Ornamental	LRlc	Not listed	EN-WG
27	*Parambassis dayi*	Mullan	4,5	M,L	Food fish	LRlc	EN	EN-K
28	*Etroplus suratensis*	Karimeen	6,7,8	M,L	Ornamental	LRlc	Not listed	EN-IS
29	*Etroplus maculatus*	Choottachi	7,8	M,L	Ornamental	LRlc	Not listed	EN-IS
30	*Oreochromis mossambicus*	Philoppy	6	L	Cultivable	LRlc	Intr	EX
31	*Glossogobius giuris*	Poolon	6	L	Food fish	LRlc	Not listed	EN-IS
32	*Channa striatus*	Kaichal	8	L	Food fish	LRlc	LRlc	EN-WG
33	*Mastacembelus armatus*	Not Known	4	M	Food fish	LRnt	LRnt	Not Known

Table 3.18. List of fish species collected from Keecheri river system

Sl.No.	Species	Local name	Locations	Srech wise distribution	Ornamental/ Food fish	Status as per present	Status as per NBFGR	Endemism
1	*Puntius amphibius*	Paral	1,2,3	U,M,L	Ornamental	LRlc	Not listed	Not Known
2	*Puntius filamentosus*	Valekkodiyan	1,2,3	U,M,L	Ornamental	LRlc	Not listed	EN-WG
3	*Barilius gatensis*	Paralodi	1,2,3	U,M,L	Ornamental	LRlc	Not listed	EN-WG
4	*Danio malabaricus*	Vilanjil	1,2,3	U,M,L	Ornamental	LRlc	Not listed	EN-IS
5	*Rasbora daniconius*	Kaniyan	1,2,3	U,M,L	Ornamental	LRlc	Not listed	Not Known
6	*Mystus gulio*	Koori	3	L	Food fish	LRlc	Not listed	Not Known
7	*Ompok bimaculatus*	Thalamban	2	M	Food fish	LRnt	EN	Not Known
8	*Xenentodon cancila*	Kola	1,3	U,L	Food fish	LRlc	LRnt	EN-IS
9	*Parambassis dayi*	Arinjil	2,3	M,L	Food fish	LRlc	EN	EN-K
10	*Etroplus maculatus*	Pallathi	2,3	M,L	Food fish	LRlc	Not listed	EN-IS
11	*Oreochromis mossambicus*	Philoppy	3	L	Cultivable	Intr	Intr	EX
12	*Channa striatus*	Varal	3	L	Food fish	LRlc	LRlc	EN-WG

Table 3.19. List of fish species collected from Kuppam river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Gonoproktopterus curmuca*	Kooral	1,2,3,4,5	U,M	Food fish	LRlc	EN	EN-WG
2	*Puntius amphibius*	Paral	3,8	L	Ornamental	LRlc	Not listed	Not Known
3	*Puntius vittatus*	Paral	3	L	Ornamental	LRlc	VU	Not Known
4	*Puntius fasciatus*	Paral	1,2,7	U,M	Ornamental	LRlc	EN	EN-WG
5	*Puntius filamentosus*	Valechuttipparal	1,2,3,4,5,6,7	U,M,L	Ornamental	LRlc	Not listed	EN-WG
6	*Tor khudree*	Kuyil	4	U	Cultivable	LRnt	VU	Not Known
7	*Salmostoma acinaces*	Paral	2,4	U,M	Food fish	LRlc	Not listed	EN-WG
8	*Barilius bakeri*	Paralodi	2,4,7	U,M	Ornamental	LRlc	VU	EN-WG
9	*Barilius gatensis*	Paralodi	2,4,7,	U,M	Ornamental	LRlc	Not listed	EN-WG
10	*Danio malabaricus*	Paralodi	1,2,4,7	U,M	Ornamental	LRlc	Not listed	EN-IS
11	*Rasbora daniconius*	Kaniyan	3,4,7	U,M	Ornamental	LRlc	Not listed	Not Known
12	*Garra mullya*	Kallotti	1,2,4,7	U,M	Ornamental	LRlc	Not listed	EN-I
13	*Garra hughi*	Kallotti	4	U	Ornamental	VU	EN	EN-K
14	*Bhavania auatralis*	Not Known	2,4,7	U,M	Ornamental	LRlc	EN	EN-WG
15	*Mesonemacheilus guentheri*	Not Known	4	U	Ornamental	LRlc	LRlc	EN-WG
16	*Mesonemacheilus triangularis*	Not Known	4,2,1	U,M	Ornamental	LRlc	LRlc	EN-WG
17	*Lepidocephalus thermalis*	Not Known	4,2,1	U,M	Ornamental	LRlc	Not listed	EN-IS
18	*Batasio travancoria*	Koori	4	U	Ornamental	VU	EN	EN-K
19	*Horabagrus brachysoma*	Etta	3	L	Cultivable	LRnt	EN	EN-K
20	*Mystus gulio*	Koori	3,6	L	Food fish	LRlc	Not listed	Not Known
21	*Mystus armatus*	Koori	3,6	L	Food fish	LRlc	Not listed	EN-IS
22	*Mystus malabaricus*	Koori	4	U	Food fish	VU	EN	EN-K
23	*Ompok bimaculatus*	Vala	2,3,4,5	U,M	Cultivable	LRlc	EN	Not Known
24	*Glyptothorax annandalei*	Koori	4	U	Ornamental	LRnt	Not listed	EN-IS
25	*Clarias dussumieri*	Musu	2,4,5	U	Cultivable	LRnt	VU	EN-I
26	*Xenentodon cancila*	Kolan	3,5	L,M	Food fish	LRlc	LRnt	EN-IS
27	*Aplocheilus lineatus*	Poonjan	3,6	L	Ornamental	LRlc	Not listed	EN-WG
28	*Parambassis dayi*	Mullan	3 5,6	M,L	Food fish	LRlc	EN	EN-K
29	*Pristolepis marginata*	Not Known	3 4,5	M,L	Ornamental	LRlc	VU	EN-K
30	*Etroplus suratensis*	Karimeen	6	L	Ornamental	LRlc	Not listed	EN-IS
31	*Etroplus maculatus*	Chottachi	1,6	M,L	Ornamental	LRlc	Not listed	EN-IS
32	*Glossogobius giuris*	Poolon	3,6	L	Food fish	LRlc	LRnt	Not Known
33	*Channa striatus*	Kaichal	6	L	Food fish	LRlc	LRlc	EN-WG
34	*Mastacembelus armatus*	Aaron	2	M	Food fish	LRlc	LRnt	Not Known

Table 3.20. List of fish species collected from Manimala river system

Sl. No.	Species	Local name	Locations	Strech wise distribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Gonoproktopterus curmuca*	Kooral	2,3	U,M	Food fish	LRlc	LRlc	EN-WG
2	*L.dussumieri*	Thholi	2,3	U,M	Cultivable	VU	EN	EN-K
3	*Puntius amphibius*	Chelikuthiparal	1,4,5	M,L	Ornamental	LRlc	LRlc	EN-WG
4	*Puntius vittatus*	Paral	4	M	Ornamental	LRlc	LRlc	Not Known
5	*P.fasciatus*	Vazhakkavarayan	1,2,3,4	U,M	Ornamental	LRlc	LRlc	EN-WG
6	*P.filamentosus*	Valekkodiyan	1,2,3,4	U,M	Ornamental	LRlc	LRlc	EN-WG
7	*P.sarana subnasutus*	Kuruva	3,4,5	M,L	Food fish	LRlc	LRlc	Not Known
8	*P.ticto*	paral	4	M	Ornamental	LRlc	LRlc	Not Known
9	*Salmostoma boopis*	paral	1,5	M,L	Food fish	LRlc	LRlc	Not Known
10	*Amblypharyngodon microlepis*	vayambu	5	L	Ornamental	LRnt	LRnt	Not Known
11	*Barilius bakeri*	Pavuka	2,3	U,M	Ornamental	LRlc	LRlc	Not Known
12	*B.gatensis*	Pavuka	2,3	U,M	Ornamental	LRlc	LRlc	Not Known
13	*D.aequipinnatus*	Vilanjil	2,3	U,M	Ornamental	LRlc	LRlc	Not Known
14	*Rasbora daniconius*	Kaniyan	3,5	M,L	Ornamental	LRlc	LRlc	Not Known
15	*Mesonemacheilus guentheri*	Varayanparal	2	M	Ornamental	LRlc	LRnt	EN-WG
16	*M.triangularis*	Varayanparal	2	M	Ornamental	LRlc	LRnt	EN-WG
17	*Lepidocephalus thermalis*	Varayanparal	2	M	Ornamental	LRlc	LRlc	Not Known
18	*Horabagrus brachysoma*	Manjakkoori	2	M	Food fish	LRnt	LRnt	EN-WG
19	*Mystus armatus*	Koori	2,3	U,M	Food fish	LRlc	LRlc	EN-WG
20	*Ompok bimaculatus*	Thalamban	5	L	Food fish	LRlc	LRlc	Not Known
21	*Wallago attu*	Vala	5	L	Food fish	VU	VU	Not Known
22	*Clarias dussumieri*	Kari	3	U	Food fish	LRnt	LRnt	Not Known
23	*Heteropneustes fossilis*	Kadu	5	L	Food fish	LRlc	LRnt	Not Known
24	*Xenentodon cancila*	Kola	2	M	Food fish	LRlc	LRlc	EN-WG
25	*Parambassis dayi*	Arinjil	3,5	U,M	Food fish	LRlc	LRlc	EN-WG
26	*Etroplus maculatus*	Pallathi	3,5	U,M	Food fish	LRlc	LRlc	EN-WG
27	*Oreochromis mossambicus*	Tilapia	5	L	Food fish	LRlc	LRlc	EX
28	*Channa striatus*	Varal	5	L	Food fish	LRlc	LRlc	Not Known

Table 3.21. List of fish species collected from Meenachil river system

Sl.No.	Species	Local name	Locations	Strechwise distribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Puntius filamentosus*	Poovalipparal	7,3,6,10	M,L	Ornamental	LRlc	Not listed	EN-WG
2	*Puntius sarana subnasutus*	Not Known	7	M	Food fish	LRlc	Not listed	Not Known
3	*Puntius ophicephalus*	Not Known	12	U	Food fish	EN	EN	EN-K
4	*Puntius ticto*	Ticto barb	3,1,2	L, M	Ornamental	LRlc	EN	EN-WG
5	*Barilius bakeri*	Thuppalkothi	7,8,4,11,6,1	U,M	Ornamental	LRnt	VU	EN-WG
6	*Barilius gatensis*	Thuppalkothi	7,4,11,6,1	U,M	Ornamental	LRlc	Not listed	EN-WG
7	*Danio malabaricus*	Vilanjil	7,5,8,4,3,11,10,9,1	U,M	Ornamental	LRlc	Not listed	EN-IS
8	*Rasbora daniconius*	Kaniyan	3,1	U,M,L	Ornamental	LRlc	Not listed	Not Known
9	*Salmostoma acinaces*	Not Known	24	M	Ornamental	LRnt	Not listed	Not Known
10	*Garra mullya*	Kallemutti	7,4,11,3,6,1	U,M	Ornamental	LRlc	Not listed	EN-I
11	*Mesonemacheilus triangularis*	Not Known	1	M	Ornamental	LRlc	LRlc	EN-WG
12	*Mesonemacheilus keralensis*	Ayira	12	U	Ornamental	EN	EN	EN-K
13	*Mstus cavasius*	Chillankoori	7	M	Food fish	LRnt	LRnt	EN-WG
14	*Ompok bimaculatus*	Not Known	1,24	M,L	Food fish	LRnt	EN	Not Known
15	*Heteropneustes fossilis*	Not Known	1,24	M,L	Food fish	LRlc	VU	EN-IS
16	*Xenentodon cancila*	Kola	3,1	M,L	Food fish	LRlc	LRnt	EN-IS
17	*Parambassis dayi*	Arinjil	7,8	M,L	Food fish	LRlc	EN	EN-K
18	*Pristolepis marginata*	Andivalli	8	L	Ornamental	LRlc	VU	EN-K
19	*Etroplus maculatus*	Pallathi	7	L	Ornamental	LRlc	Not listed	EN-IS
20	*Oreochromis mossambicus*	Philoppy	11	L	Food fish	Intr	Not listed	Not Known
21	*Mastacembelus armatus*	Aarakan	7,3,1,2	U,M	Food fish	LRnt	LRnt	Not Known

Table 3.22. List of fish species collected from Moovattupuzha river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Gonoproktopterus curmuca*	Kooral	2,10,12	U,M	Food fish	LRlc	EN	EN-WG
2	*Puntius amphibius*	Paral	10,1	M,L	Ornamental	LRlc	Not listed	Not Known
3	*Puntius chola*	Chelikuthiparal	10	L	Ornamental	LRlc	Not listed	Not Known
4	*Puntius fasciatus*	Vazhakkavaayan	14	U	Ornamental	LRlc	Not listed	Not Known
5	*Puntius filamentosus*	Kalakkodiyan paral	10,1,14,3,15	U,M,L	Ornamental	LRlc	Not listed	EN-WG
6	*Puntius sarana subnasutus*	Kuruvaparal	14,3,1,15	M,L	Food fish	LRnt	Not listed	Not Known
7	*Puntius ticto*	Paral	6,7	M,L	Ornamental	LRlc	Not listed	Not Known
8	*Salmostoma boopis*	Kokkuparal	7,15	M	Ornamental	LRlc	Not listed	Not Known
9	*Chela fasciata*	Paral	12	L	Ornamental	VU	Not listed	Not Known
10	*Barilius bakeri*	Thuppalkothi	7,14	U	Ornamental	LRlc	VU	EN-WG
11	*Barilius gatensis*	Thuppalkothi	7,14	U	Ornamental	LRlc	Not listed	EN-WG
12	*Danio malabaricus*	Vilanjil	7,14,1,11,15	U,M	Ornamental	LRlc	Not listed	EN-IS
13	*Rasbora daniconius*	Kaniyan	6,7,3	U,M,L	Ornamental	LRlc	Not listed	Not Known
14	*Garra mullya*	Kallemulti	14	U	Ornamental	LRlc	Not listed	EN-I
15	*Garra emarginata*	Kallemutti	14	U	Ornamental	DD	Not listed	Not Known
16	*Mesonemacheilus triangularis*	Ayira	14	U	Ornamental	LRlc	LRlc	EN-WG
17	*Mesonemacheilus guentheri*	Ayira	14	U	Ornamental	LRlc	Not listed	Not Known
18	*Mystus cavasius*	Chillan	10,14	M,L	Food fish	LRnt	Not listed	Not Known
19	*Ompok bimaculatus*	Ambattanvala	10,3,1	M,L	Food fish	LRnt	EN	Not Known
20	*Wallago attu*	Vala	10	L	Cultivable	VU	Not listed	Not Known
21	*Glyptothorax madraspatanam*	Kallechan	14	U	Ornamental	EN	VU	EN-WG
22	*Xenentodon cancila*	Kolan	10,1	L	Food fish	LRlc	LRnt	EN-IS
23	*Parambassis thomassi*	Arinjil	10,15	M,L	Ornamental	LRlc	VU	EN-WG
24	*Etroplus maculatus*	Pallatni	10,11,12,15	M,L	Food fish	LRlc	Not listed	EN-IS
25	*Pristolepis marginata*	Andivalli	10	M	Ornamental	LRlc	Not listed	Not Known
26	*Glossogobius giuris*	Poolon	10,3	M,L	Food fish	LRlc	LRnt	Not Known
27	*Channa striatus*	Varal	7	L	Food fish	LRlc	LRlc	Not Known
28	*Mastacembelus armatus*	Aaron	10,1	M	Food fish	LRlc	LRnt	Not Known

Table 3.23. List of fish species collected from Nileswaram river system

Sl.No.	Species	Local name	Strech wise distribution	Locations	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Puntius amphibius*	Paral	L	1	Ornamental	LRlc	Not listed	Not Known
2	*Puntius vittatus*	Paral	L	1,2,3	Ornamental	LRlc	VU	Not Known
3	*Puntius fasciatus*	Paral	U, M	2,3	Ornamental	LRlc	EN	EN-WG
4	*Puntius filamentosus*	Paral	M	1,2	Ornamental	LRlc	Not listed	EN-WG
5	*Salmostoma acinaces*	Not Known	M	1,2	Ornamental	LRlc	Not listed	EN-WG
6	*Danio malabaricus*	Vilachil	U	1	Ornamental	LRlc	Not listed	EN-IS
7	*Rasbora daniconius*	Kaniyan	M, L	1,2	Ornamental	LRlc	Not listed	Not Known
8	*Lepidocephalus thermalis*	Not Known	M	3	Ornamental	LRlc	Not listed	EN-IS
9	*Mystus gulio*	Koori	L	1,2	Food fish	LRlc	Not listed	Not Known
10	*Clarias dussumieri*	Musu	M	1	Cultivable	LRnt	VU	EN-I
11	*Xenentodon cancila*	Kola	M	2	Food fish	LRlc	LRnt	EN-IS
12	*Aplocheilus lineatus*	Nettipottan	M	1,2	Ornamental	LRlc	Not listed	EN-WG
13	*Parambassis dayi*	Mullan	L	2	Food fish	LRlc	EN	EN-K
14	*Etroplus suratensis*	Karimeen	L	1,2	Ornamental	LRlc	Not listed	EN-IS
15	*Etroplus maculatus*	Choottachi	L	2,3	Ornamental	LRlc	Not listed	EN-IS
16	*Channa striatus*	Kaichal	M	1	Food fish	LRlc	LRlc	EN-WG

Table 3.24. List of fish species collected from Pamba river system

Sl.No.	Species	Local name	Locations	Distribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Anguilla bengalensis*	Mananjil	18	L	Cultivable	LRnt	EN	Not Known
2	*Cyprinus carpio*	Cypnnus	10	U	Cultivable	Intr	Intr	EX
3	*Cirrhinus mrigala*	Not Known	21	L	Cultivable	LRlc	Not listed	Not Known
4	*Gonoproktopterus curmuca*	Kooral	3,22	M,U	Food fish	LRlc	EN	EN-WG
5	*Labeo dussumieri*	Thooli	21,18,19 17	L	Cultivable	VU	EN	EN-K
6	*Labeo fimbriatus*	Not Known	17	L	Cultivable	VU	Not listed	Not Known
7	*Puntius amphibius*	Paral	12,24	L,M	Ornamental	LRlc	Not listed	Not Known
8	*Puntius bimaculatus*	Paral	24	M	Ornamental	VU	Not listed	Not Known
9	*Puntius chola*	Paral	12	L	Food fish	LRlc	VU	Not Known
10	*Puntius denisonii*	Chenkaniyan	4	M	Ornamental	VU	EN	EN-K
11	*Puntius vittatus*	Not Known	22	M	Ornamental	LRlc	VU	Not Known
12	*Puntius fasciatus*	Vazhakkavarayan	4,15	U	Ornamental	LRlc	EN	EN-WG
13	*Puntius filamentosus*	Poovalipparal	15,1,4,3,23,22	U,M,L	Ornamental	LRlc	Not listed	EN-WG
14	*Puntius ticto*	Paral	12,22,24	M,L	Ornamental	LRlc	EN	EN-WG
15	*Puntius sarana subnasutus*	Kuruva	21,18,26,17	M,D	Food fish	LRlc	Not listed	Not Known
16	*Tor khudree*	Katti	10	L,M	Cultivable	LRnt	VU	Not Known
17	*Salmostoma acinaces*	Not Known	6,12,5	M,L	Food fish	LRlc	Not listed	Not Known
18	*Salmostoma boopis*	Mathipparal	1,4,24	M,L	Food fish	LRlc	Not listed	EN-I
19	*Amblypharyngodon microlepis*	Vayambu	17,18,19	L	Ornamental	LRlc	Not listed	EN-I
20	*Barilius bakeri*	Thuppalkothi	4,10,11,20,24,2 2,9,15	U	Ornamental	LRlc	VU	EN-WG
21	*Barilius gatensis*	Thuppalkothi	4,10,11,20,24,2 2,9,16	U	Ornamental	LRlc	Not listed	EN-WG
22	*Danio malabaricus*	Vilanjil	15,1,4,3,23,22,2 4,10,9	U,M	Ornamental	LRlc	Not listed	EN-IS
23	*Danio aequipinnatus*	Vilanjil	1,35	U,M	Ornamental	LRlc	Not listed	Not Known
24	*Rasbora daniconius*	Kaniyan	20	M,L	Ornamental	LRlc	Not listed	Not Known
25	*Garra ceylonensis*	Not Known	20	U	Food fish	DD	Not listed	Not Known
26	*Garra mullya*	Kallepatti	4,1,23,9,11,15,2(	U,M	Ornamental	LRlc	Not listed	EN-I
27	*Garra hughi*	Kallepatti	11,1	U	Ornamental	VU	EN	EN-K
28	*Garra surendranathani*	Kallepatti	4	U	Ornamental	VU	EN	EN-K
29	*Bhavania australis*	Not Known	20	U	Ornamental	LRlc	EN	EN-WG
30	*Mesonemacheilus triangularis*	Not Known	20	U	Ornamental	LRlc	LRlc	EN-WG
31	*Mesonemacheilus guentheri*	Not Known	20	U	Ornamental	LRlc	Not listed	Not Known
32	*Lepidocephalus thermalis*	Not Known	20	U	Ornamental	LRlc	Not listed	Not Known
33	*Batasio travancoria*	Not Known	1,32	U,M	Food fish	VU	Not listed	Not Known
34	*Horabagrus brachysoma*	Manjakkoori	21,18,17	M,L	Cultivable	LRlc	EN	EN-K
35	*Mystus gulio*	Koori	21,18	L	Food fish	LRlc	Not listed	Not Known
36	*Mystus armatus*	Not Known	1,32	U,M	Food fish	LRlc	Not listed	EN-IS
37	*Mystus menoda*	Koori	21	L	Food fish	DD	Not listed	Not Known
38	*Ompok bimaculatus*	Thalamban	21,17	M,L	Cultivable	LRlc	EN	Not Known
39	*Wallago attu*	Not Known	21	L	Cultivable	VU	LRnt	Not Known
40	*Heteropneustes fossilis*	Not Known	17	L	Food fish	LRlc	VU	EN-IS
41	*Xenentodon cancila*	Kola	22	L	Food fish	LRlc	LRnt	EN-IS
42	*Parambassis dayi*	Arinjil	21,18	L	Food fish	LRlc	EN	EN-K
43	*Parambassis thomassi*	Arinjil	21,18	L	Ornamental	LRlc	VU	EN-WG
44	*Nandus nandus*	Muthukkira	21,18	L	Ornamental	LRlc	LRnt	Not Known
45	*Pristolepis marginatus*	Andivalli	15,22	M	Ornamental	LRlc	VU	EN-K
46	*Etroplus suratensis*	Karimeen	21	L	Cultivable	LRlc	Not listed	EN-IS
48	*Etroplus maculatus*	Pallathi	18,1	M	Ornamental	LRlc	Not listed	EN-IS
49	*Glossogobius giuris*	Poolon	3,4	U,M	Food fish	LRlnt	Not listed	Not Known
50	*Anabas testudineus*	Kallemutti	17,18,19	L	Food fish	LRlc	VU	Not Known
51	*Channa striatus*	Varal	19	L	Food fish	LRlc	LRlc	EN-WG
52	*Channa orientalis*	Varal	19	L	Food fish	LRlc	LRnt	Not Known
53	*Channa marulius*	Cherumeen	17,21,18,7	L	Cultivable	VU	LRnt	Not Known
54	*Mastacembelus armatus*	Aarakan	21,12	L	Food fish	VU	LRnt	Not Known
55	*Tetradon travancoricus*	Thavalappathal	13	L	Ornamental	LRlc	EN	EN-K

Table 3.25. List of fish species collected from Pambar river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Cultivalbe / Ornamental / Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Puntius carnaticus*	Kendameen	3,6,11	U	Cultivable	VU	LRnt	EN-WG
2	*Puntius fasciatus*	Paral	7,5,1,8,4,3,10,1	U	Ornamental	LRlc	EN	EN-WG
3	*Tor remadevi*	Kuyil	1,9	U	Cultivable	DD	EN	Not Known
4	*Salmostoma acinaces*	Kokkuparal	1	U	Food fish	LRlc	Not listed	EN-I
5	*Barilius bakeri*	Thuppalkothi	1,2	U	Ornamental	LRlc	VU	EN-WG
6	*Barilius bendelisis*	Not Known	1	U	Ornamental	EN	Not listed	EN-I
7	*Barilius gatensis*	Not Known	1,11	U	Ornamental	LRlc	Not listed	Not Known
8	*Danio malabaricus*	Not Known	1,3,10,11	U	Ornamental	LRlc	Not listed	EN-IS
9	*Rasbora daniconius*	Kaniyan	1	U	Ornamental	LRlc	Not listed	Not Known
10	*Garra gotyla stenorhynchus*	Kallemutti	1,8,11	U	Food fish	VU	EN	EN-WG
11	*Garra mullya*	Kallemutti	1,8,10,11	U	Ornamental	LRlc	Not listed	EN-I
12	*Garra hughi*	Kallemutti	4,2,5	U	Ornamental	VU	EN	EN-K
13	*Garra mCClellandii*	Kallemutti	1,8	U	Ornamental	LRnt	Not listed	EN-WG
14	*Schistua denisonii*	Not Known	2	U	Ornamental	LRnt	Not listed	EN-I
15	*Nemacheilus monilis*	Not Known	2	U	Ornamental	VU	EN	EN-WG
16	*Shistira pambarensis*	Not Known	2	U	Ornamental	CR	Not listed	EN-K
17	*Mesonemacheilus triangularis*	Not Known	2	U	Ornamental	LRlc	LRlc	EN-WG
18	*Mesonemacheilus semiarmatus*	Not Known	2	U	Ornamental	VU	VU	EN-WG
19	*Lepidocephalus thermalis*	Not Known	2	U	Ornamental	LRlc	Not listed	EN-IS
20	*Batasio travancoria*	Koori	2	U	Food fish	VU	EN	EN-K
21	*Mstus cavasius*	Koori	2	U	Food fish	LRnt	LRlc	EN-WG
22	*Pseudeutropius mitchelli*	Not Known	1	U	Food fish	EN	DD	EN-I
23	*Glyptothorax annandalei*	Koori	7	U	Ornamental	LRnt	Not listed	EN-IS
24	*Parambassis thomassi*	Not Known	6	U	Ornamental	LRlc	VU	EN-WG
25	*Pristolepis marginatus*	Not Known	1	U	Ornamental	LRlc	VU	EN-K
26	*Oreochromis mossambicus*	Philoppy	1,11	U	Cultivable	Intr	Intr	EX

Table 3.26. List of fish species collected from Periyar river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Cultivalbe/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Anguilla bengalensis*	Mananjil	26	M	Cultivable	LRnt	EN	Not Known
2	*Anguilla bicolor bicolor*	Mananjil	32	M	Cultivable	EN	Not listed	Not Known
3	*Dayella malabarica*	Not Known	32	M	Food fish	VU	CR	EN-WG
4	*Cyprinus carpio*	Cyprinus	29	U	Cultivable	Intr	Intr	EX
5	*Gonoproktopterus curmuca*	Kooral	58	M	Food fish	LRlc	EN	EN-WG
6	*Gonoproktopterus kurali*	Kooral	29,36,21,41,61	U,M	Food fish	LRnt	EN	EN-WG
7	*Gonoproktopterus thomassi*	kadimeen	49	U	Food fish	EN	Not listed	Not Known
8	*Gonoproktopterus micropogon periyarensis*	Kariyan	37,33,1,8,2	U	Cultivable	CR	Not listed	EN-K
9	*Labeo nigriscens*	Chekida	32,44	M	Food fish	EN	Not listed	EN-WG
10	*Osteobrama bakeri*	Mullanpaval	62	L	Ornamental	LRnt	EN	EN-K
11	*Osteochilus longidorsalis*	Aameen	32	M	Cultivable	EN	CR	EN-K
12	*Puntius amphibius*	Paral	5,12	L, M	Ornamental	LRlc	Not listed	
13	*Puntius ophicephalus*	ilakkenda	9,38,6,42,22,1	U	Foodfish	EN	EN	EN-K
14	*Puntius denisonii*	Chenkaniyan,Chorakkakniyan	32	M	Ornamental	LRnt	EN	EN-K
15	*Puntius filamentosus*	Kalakkodiyan paral	16,36,33,19,32,4,27,24,26,40,31,5,55,57	U,M,L	Ornamental	LRlc	Not listed	EN-WG
16	*Puntius fasciatus*	Not Known	16,36,32,26,34,27,24,13,14,3,20,21,40,56,57	U,M	Ornamental	LRlc	Not listed	Not Known
17	*Puntius vittatus*	Not Known	52	M	Ornamental	LRlc	Not listed	Not Known
18	*Puntius ticto*	Not Known	5,12,14,31,26	M,L	Ornamental	LRlc	Not listed	Not Known
19	*Puntius sarana subnasutus*	Kuruva	26,12	L	Food fish	LRlc	Not listed	Not Known
20	*Tor khudree*	Kuyil	16,36,32,19,29,23,20,21,18,14,15,34,1,2,4,61	U,M	Cultivable	LRnt	VU	Not Known
21	*Salmostoma acinaces*	Kokkuparal	57	M	Ornamental	LRlc	Not listed	EN-I
22	*Amblypharyngodon microlepis*	Vayambu	32	M	Ornamental	LRlc	Not listed	EN-I
23	*Barilius bakeri*	Pavuka	32,5,29,30,12,13,3,6,15,19,35,55,56,57,61	U,M	Ornamental	LRlc	VU	EN-WG
24	*Barilius gatensis*	Pavuka	14,32,3,30,17,5,18,33,24,10,4,16,36,22	U,M	Ornamental	LRlc	Not listed	EN-WG
25	*Barilius canarensis*	Pavuka	5	M	Ornamental	LRnt	DD	EN-WG
26	*Danio malabaricus*	Vilanjil, Thuppalkothi	36,16,19,5,32,23,27,34,40,31,12,38,26,4,8,15,17,21,56	U,M	Ornamental	LRlc	Not listed	EN-IS
27	*Danio aequipinnatus*	Vilanjil, Thuppalkothi	34,40,31,12,38,26,4,8,15,17,21,56	U,M	Ornamental	LRlc	LRnt	EN-IS
28	*Rasbora daniconius*	Kaniyan paral	29,5,12,18,4,13,19,56,57	U,M,L	Ornamental	LRlc	Not listed	Not Known
29	*Lepidopygopsis typus*	Brahmanakkenda	36,33,31,8,15,1,60	U	Ornamental	CR	CR	EN-K
30	*Crosocheilus periyarensis*	Karuvachi, Karimbachi	32,8,19,18,60,61	U	Food fish	CR	VU	EN-K
31	*Garra mullya*	Kallemutti	16,36,33,19,29,32,40,31,12,4,38,56,57	U,M	Ornamental	LRlc	Not listed	EN-I
32	*Garra travancoria*	Kallemutti	21	U	Ornamental	DD	Not listed	Not Known
33	*Garra periyarensis*	Kallemutti	36,23,33,20,30,21,8	U	Food fish	EN	Not listed	EN-K
34	*Garra surendranathani*	Kallemutti	36,20,55	M	Ornamental	VU	EN	EN-K
35	*Garra ceylonensis*	Kallemutti	53,59	M	Ornamental	DD	Not listed	Not Known
36	*Garra emarginata*	Kallemutti	59,59	M	Ornamental	DD	Not listed	EN-K
37	*Garra mlapparaensis*	Kallemutti	20	U	Ornamental	DD	Not listed	EN-K
38	*Homaloptera silasi*	Kallepatti	63	U	Ornamental	DD	Not listed	Not Known
39	*Bhavania auatralis*	Parepatti	14,29,18,27,31,12,11,6	U,M	Ornamental	LRlc	EN	EN-WG
40	*Travancoria jonesi*	Parepatti	32,20,30,31	M	Ornamental	EN	EN	EN-K
41	*Travancoria elongata*	Parepatti	49	M	Ornamental	EN	CR	EN-K
42	*Schistura denisoni*	Varayan paral,Ayira	20,36,15,64,65,66	U,M	Ornamental	LRlc	Not listed	EN-I
43	*Mesonemacheilus guentheri*	Varayan paral,Ayira	36,20,33,29,65,64,66	U,M	Ornamental	LRlc	LRlc	EN-WG
44	*Mesonemacheilus triangularis*	Varayan paral,Ayira	36,20,33,30,65	U,M	Ornamental	LRlc	LRlc	EN-WG
45	*Mesonemacheilus menoni*	Varayan paral,Ayira	36,20,30,21,1,8,64,65,66	U	Ornamental	EN	Not listed	EN-K
46	*Mesonemacheilus periyarensis*	Varayan paral,Ayira	29,33	U	Ornamental	DD	Not listed	EN-K
47	*Oreonectes keralensis*	Varayan paral,Ayira	64,66	U	Ornamental	EN	EN	EN-K
48	*Lepidocephalus thermalis*	Varayan paral	27,40,31,36,32,29,35,16	U,M	Ornamental	LRlc	Not listed	EN-IS
49	*Balasio travancoria*	Koori	32	M	Food fish	VU	EN	EN-K
50	*Horabagrus nigricollaris*	Manjakkoori	32	M	Food fish	EN	CR	EN-K
51	*Horabagrus brachysoma*	Manjakkoori	4,32	M	Cultivable	VU	EN	EN-K
52	*Mystus cavasius*	Koori	32	M	Food fish	LRlc	LRnt	EN-WG
53	*Mystus gulio*	Koori	62	L	Food fish	LRlc	Not listed	Not Known
54	*Mystus vittatus*	Koori	32	M	Ornamental	EN	VU	EN-WG
55	*Mystus armatus*	Koori	17	M	Food fish	LRlc	Not listed	EN-IS
56	*Mystus malabaricus*	Koori	32	M	Food fish	EN	EN	EN-K

Continued... ....

Table 3.26 continued.... ....

57	*Ompok bimaculatus*	Thalamban	7,26,21	M,L	Cultivable	LRlc	EN	Not Known
58	*Ompok malabaricus*	Thalamban	32,49	M,L	Cultivable	LRlc	CR	EN-IS
59	*Pseudeutropius mitchelli*	Vellivala	4	M	Food fish	VU	DD	EN-I
60	*Glyptothorax annandalei*	Parakkoori	32,49	M	Ornamental	LRnt	Not listed	EN-IS
61	*Clarias dussumieri*	Kari	49	M	Food fish	LRlc	Not listed	Not Known
62	*Heteropneustes fossilis*	Koori	26,36	M,L	Food fish	LRlc	Not listed	Not Known
63	*Xenentodon cancila*	Kolan	19,4,26	M,L	Food fish	LRlc	LRnt	EN-IS
64	*Aplocheilus lineatus*	Poonjan	35,24,12,26	M,L	Ornamental	LRlc	Not listed	EN-WG
65	*Aplocheilus blocki*	Poonjan		L	Ornamental	LRlc	Not listed	EN-WG
66	*Parambassis dayi*	Arinjil	26,7,24,10,22,36,26,31 ,4,12,17	M,L	Food fish	LRlc	EN	EN-K
67	*Parambassis thomassi*	Arinjil	7,12	M,L	Ornamental	LRnt	VU	EN-WG
68	*Pristolepis marginatus*	Andivalli	4,32	M,L	Ornamental	LRlc	VU	EN-K
69	*Etroplus suratensis*	Karimeen	4,12	M,L	Cultivable	LRlc	Not listed	EN-IS
70	*Etroplus maculatus*	Pallathi	4,26,32,24,29	M,L	Ornamental	LRlc	Not listed	EN-IS
71	*Oreochromis mossambicus*	Philoppi	29,4,40,12	U,M,L	cultivable	Intr	Intr	EX
72	*Glossogobius giuris*	Poolon	4	M	Food fish	LRnt	Not listed	Not Known
73	*Anabas testudineus*	Karuvappu	32	M	Food fish	LRlc	VU	Not Known
74	*Channa striatus*	Varal	12	M	Food fish	LRlc	LRlc	EN-WG
75	*Channa orientalis*	Varal	5	M	Food fish	LRnt	LRnt	Not Known
76	*Mastacembelus armatus*	Aron	29,7,12,4	M	Food fish	LRlc	LRnt	Not Known
77	*Tetradon travancoricus*	Thavalappolan	32	M	Ornamental	LRnt	EN	EN-K

Table 3.27. List of fish species collected from Peruvamba river sytem

Sl.No.	Species	Local name	Locations	Strech wise distribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Puntius amphibius*	Paral	1,2	L	Ornamental	LRlc	Not listed	Not Known
2	*Puntius vittatus*	Paral	3,4	M,L	Ornamental	LRlc	VU	Not Known
3	*Puntius fasciatus*	Paral	1,2,3,4	U	Ornamental	LRlc	EN	EN-WG
4	*Puntius filamentosus*	Paral	1,2,3,4,5	U,M,L	Ornamental	LRlc	Not listed	EN-WG
5	*Salmostoma acinaces*	Not Known		M,L	Food fish	LRlc	Not listed	EN-WG
6	*Barilius gatensis*	Thuppalkothi	2,3,4	U	Ornamental	LRlc	Not listed	EN-WG
7	*Danio malabaricus*	Vilangil	5,6	U,M	Ornamental	LRlc	Not listed	EN-IS
8	*Rasbora daniconius*	Kaniyan	2,3,4	M,L	Ornamental	LRlc	Not listed	Not Known
9	*Garra mullya*	Kallotti	1,2	U	Ornamental	LRlc	Not listed	EN-I
10	*Garra mcClellendi*	Kallotti	2,	U	Ornamental	LRnt	Not listed	EN-WG
11	*Lepidocephalus thermalis*	Not Known	1,2,3,4,5	M,U,L	Ornamental	LRlc	Not listed	EN-IS
12	*Mystus gulio*	Koori	2,4	M,L	Food fish	LRlc	Not listed	Not Known
13	*Ompok bimaculatus*	Vala	2	L	Food fish	LRlc	EN	Not Known
14	*Clarias dussumieri*	Musu	1	U	Cultivable	LRnt	VU	EN-I
15	*Heteropneustes fossilis*	Kadu	1	U	Food fish	LRlc	VU	EN-IS
16	*Xenentodon cancila*	Kola	2	M	Food fish	LRlc	LRnt	EN-IS
17	*Aplocheilus lineatus*	Nettipottan	3,4,5	M,L	Ornamental	LRlc	Not listed	EN-WG
18	*Parambassis dayi*	Mullan	3,4,5	M,L	Food fish	LRlc	EN	EN-K
19	*Etroplus suratensis*	Karimeen	1,2,3,4	M,L	Ornamental	LRlc	Not listed	EN-IS
20	*Etroplus maculatus*	Choottachi	2,3,4,5,6	M,L	Ornamental	LRlc	Not listed	EN-IS
21	*Oreochromis mossambicus*	Philoppy	6	L	Cultivable	LRlc	Intr	EX
22	*Channa striatus*	Kaichal	3,4	L	Food fish	LRlc	LRlc	EN-WG

Table 3.28. List of fish species collected from Puzhaykkal river system

Sl.No.	Species	Local name	Locations	Strech wise istribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Anguilla bengalensis*	Mananjil	2	L	Cultivable	LRlc	EN	Not Known
2	*Puntius amphibius*	Paral	3	L	Omamental	LRlc	Not listed	Not Known
3	*Puntius parrah*	Paral	2	L	Foodfish	LRlc	EN	EN-WG
4	*Puntius filamentosus*	Valechuttipparal	2,5,6	L,M	Omamental	LRlc	Not listed	EN-WG
5	*Puntius sarana subnasutus*	Kuruva	2	L	Food fish	LRlc	Not listed	Not Known
6	*Puntius ticto*	Paral	2	L	Omamental	LRlc	Not listed	Not Known
7	*Danio malabaricus*	Vilanjil	1,5	U,M	Omamental	LRlc	Not listed	EN-IS
8	*Rasbora daniconius*	Kaniyan	2	L	Omamental	LRlc	Not listed	Not Known
9	*Garra mullya*	Not Known	1	U	Omamental	LRlc	Not listed	Not Known
10	*Mystus cavasius*	Chillankoori	3	L	Food fish	LRlc	LRnt	EN-WG
11	*Heteropneustes fossilis*	Kari	3	L	Food fish	LRlc	VU	EN-IS
12	*Xenentodon cancila*	Kola	2,3	L	Food fish	LRlc	LRnt	EN-IS
13	*Parambassis dayi*	Arinjil	2	L	Food fish	LRlc	EN	EN-K
14	*Nandus nandus*	Not Known	2	L	Omamental	LRlc	Not listed	Not Known
15	*Pristolepis marginatus*	Andivalli	4	U	Omamental	LRlc	VU	EN-WGK
16	*Etroplus maculatus*	Pallathi	3	L	Omamental	LRlc	Not listed	EN-IS
17	*Anabas testudineus*	Kallemutti	3	L	Food fish	LRlc	VU	Not Known
18	*Channa marulius*	Cherumeen	3	L	Cultivable	VU	Not listed	Not Known
19	*Channa striatus*	Varal	3	L	Food fish	LRlc	LRlc	EN-WG
20	*Mastacembelus armatus*	Arakan	3	L	Food fish	LRnt	LRnt	Not Known

Table 3.29. List of fish species collected from Shiriya river system

Sl.No.	Species	Local name	Locations	Srech wise istribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Puntius vittatus*	Paral	1	L	Ornamental	LRlc	Not listed	Not Known
2	*Puntius fasciatus*	Paral	1,2,3	U,M,L	Ornamental	LRlc	Not listed	Not Known
3	*Puntius filamentosus*	Kalakkodian	1,2,3	U,M,L	Ornamental	LRlc	Not listed	EN-WG
4	*Garra mullya*	Not Known	2,3	U,M	Ornamental	LRlc	Not listed	EN-I
5	*Danio malabaricus*	Vilanjil	2 3	U,M	Ornamental	LRlc	Not listed	EN-IS
6	*Rasbora daniconius*	Not Known	1,2,3	U,M,L	Ornamental	LRlc	Not listed	Not Known
7	*Mystus gulio*	Vilanjil	1	L	Food fish	LRlc	Not listed	Not Known
8	*Xenentodon cancila*	Vilanjil	1,2	M,L	Food fish	LRlc	LRnt	EN-IS
9	*Mystus malabaricus*	Not Known	1,2	M,L	Food fish	VU	EN	EN-K
10	*Silurus wynaadensis*	Not Known	3	U	Food fish	EN	Not listed	EN-K
11	*Aplocheilus lineatus*	Not Known	1	L	Ornamental	LRlc	Not listed	EN-WG
12	*Parambassis dayi*	Chakkamullan	1,2	M,L	Food fish	LRlc	EN	EN-K
13	*Etroplus suratensis*	Karimeen	1,2	M,L	Food fish	LRlc	Not listed	EN-IS

Table 3.30. List of fish species collected from Tirur river system

Sl.No.	Species	Local name	Locations	Strech wise distribution	Cultivable/Ornamental/Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Puntius amphibius*	Paral	1,3	L	Ornamental	LRlc	Not listed	Not Known
2	*Puntius fasciatus*	Paral	2	M	Ornamental	LRlc	EN	EN-WG
3	*Puntius filamentosus*	Valechuttipparal	1,3,4	M,L,U	Ornamental	LRlc	Not listed	EN-WG
4	*Puntius ticto*	Paral	2	M	Ornamental	LRlc	Not listed	Not Known
5	*Danio malabaricus*	Vilanjil	2,4	M,U	Ornamental	LRlc	Not listed	EN-IS
6	*Rasbora daniconius*	Kaniyan	2,1,3	M,L	Ornamental	LRlc	Not listed	Not Known
7	*Mystus armatus*	Chillan	3	L	Food fish	LRlc	LRnt	EN-WG
8	*Xenentodon cancila*	Kolan	2,6	M	Food fish	LRlc	LRnt	EN-IS
9	*Parambassis dayi*	Arinjil	1	M	Food fish	LRlc	EN	EN-K
10	*Nandus nandus*	Muthukkila	1,3	L	Ornamental	LRlc	LRnt	Not Known
11	*Pristolepis marginatus*	Chemballi	3	L	Ornamental	LRlc	VU	EN-WGK
12	*Etroplus maculatus*	Pallathi	2,6	L	Ornamental	LRlc	Not listed	EN-IS
13	*Anabas testudineus*	Kallotti	6	L	Food fish	LRlc	VU	Not Known
14	*Channa striatus*	Varal	1,3	L	Food fish	LRlc	LRlc	EN-WG
15	*Mastacembelus armatus*	Arakan	3	L	Food fish	LRlc	LRnt	Not Known

Table 3.31. List of fish species collected from Valapatnam river system

Sl.No.	Species	Local name	Locations	Strech wise istribution	Ornamental/ Food fish	Status as per present study	Status as per NBFGR report	Endemism
1	*Megalops cyprinoides*	Palankanni	10	M	Food fish	LRlc	Not listed	Not Known
2	*Gonoproktopterus curmuca*	Kooral	26,27	U	Food fish	LRlc	Not listed	Not Known
3	*Osteobrama bakeri*	Not Known	26	U	Ornamental	VU	Not listed	Not Known
4	*Labeo calbasu*	Kakkamalari	26	U	Food fish	LRlc	Not listed	Not Known
5	*Osteochilichthys nashil*	Not Known	26	U	Ornamental	EN	Not listed	Not Known
6	*Puntius amphibius*	Paral	26,27	U,M	Ornamental	LRlc	Not listed	Not Known
7	*Puntius denisonii*	Paral	26,27	U,M	Ornamental	LRnt	EN	EN-K
8	*Puntius jerdoni*	Not Known	26	U	Ornamental	EN	Not listed	Not Known
9	*Puntius fasciatus*	Vazhakkavarayar	7,3,1,9	U,M	Ornamental	LRlc	EN	EN-WG
10	*P.filamentosus*	Valekkodiyan	7,3,9,5,1	U,M,L	Ornamental	LRlc	Not listed	EN-WG
11	*Puntius sarana subnasutus*	Kuruva	2	M,L	Food fish	LRlc	Not listed	Not Known
12	*Puntius ticto*	Not Known	26	L	Ornamental	LRlc	Not listed	Not Known
13	*Tor khudree*	Kuyil	26,27	U,M	Food fish	LRnt	Not listed	Not Known
14	*Barilius bakeri*	Paralodi	3,7,9,1	U,M,L	Ornamental	LRlc	VU	EN-WG
15	*Barilius canarensis*	Paralodi		U	Ornamental	LRnt	Not listed	Not Known
16	*Barilius gatensis*	Paralodi	3,7,9,1	U,M	Ornamental	LRlc	Not listed	EN-WG
17	*Chela fasciata*	Not Known	26	U	Ornamental	VU	Not listed	Not Known
18	*Danio malabaricus*	Vilanjil	9	U,M	Ornamental	LRlc	Not listed	EN-IS
19	*Danio aequipinnatus*	Vilanjil	27	U,M	Ornamental	LRlc	Not listed	Not Known
20	*Rasbora daniconius*	Kaniyan	3,7,9,5	L	Ornamental	LRlc	Not listed	Not Known
21	*Salmostoma boopis*	Not Known	26	L	Ornamental	LRlc	Not listed	Not Known
22	*Garra mullya*	Kallelotti	26,27	U,M	Ornamental	LRlc	Not listed	EN-I
23	*Bhavania auatralis*	Kallelotti	6	U	Ornamental	LRlc	EN	EN-I
24	*Mesonemacheilus triangularis*	Koytha	3,1	M	Ornamental	LRlc	LRlc	EN-WG
25	*Mesonemacheilus guntheri*	Koytha	27	M	Ornamental	LRlc	Not listed	Not Known
26	*Horabagrus brachysoma*	Manjaletta	8	M,L	Cultivable	LRnt	EN	EN-K
27	*Mystus gulio*	Koori	4	L	Food fish	LRlc	Not listed	Not Known
28	*Mystus armatus*	Koori	26,27	M	Ornamental	LRnt	Not listed	Not Known
29	*Ompok malabaricus*	Vala	10	M	Cultivable	LRlc	CR	EN-IS
30	*Clarias dussumieri*	Musu	4	M	Cultivable	LRnt	VU	EN-I
31	*Heteropneustes fossilis*	Kadu	4	M	Food fish	LRlc	VU	EN-IS
32	*Xenentodon cancila*	Kolan	7,10,5	M,L	Food fish	LRlc	LRnt	EN-IS
33	*Aplocheilus lineatus*	Nettipottan	1,4	M,L	Ornamental	LRlc	Not listed	EN-WG
34	*Aplocheilus blocki*	Nettipottan	4	L	Ornamental	LRlc	Not listed	EN-WG
35	*Microphis cuncalus*	Not Known	28	M	Ornamental	EN	Not listed	Not Known
36	*Parambassis dayi*	Chakkamullan	7,10,11,8	M,L	Food fish	LRlc	EN	EN-K
37	*Pseudambassis bacuilis*	Kozhua	10	M	Ornamental	LRlc	Not listed	Not Known
38	*Pristolepis marginatus*	Chemballi	10	M	Ornamental	LRlc	VU	EN-K
39	*Etroplus suratensis*	Karimeen	8	M	Cultivable	LRlc	Not listed	EN-IS
40	*Etroplus maculatus*	Chootachi	11,8,4	M,L	Food fish	LRlc	Not listed	EN-IS
41	*Oreochromis mossambicus*	Philoppy	10,11	M,L	Cultivable	Intr	Intr	EX
42	*Glossogobius giuris*	Poolon	28	L	Food fish	LRlc	LRnt	Not Known
43	*Sicyopterus griseus*	Poolon	26,27,28	M,L	Ornamental	VU	Not listed	Not Known
44	*Channa striatus*	Kaichal	4	M	Food fish	LRlc	LRlc	EN-WG
45	*Mastacembelus armatus*	Aaron	2	M	Food fish	LRlc	LRnt	Not Known
46	*Tetradon travancoricus*	Thavalappathal	10	L	Ornamental	LRnt	EN	EN-K

Table 3.32. 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
Total species	49	62	16	67	40	32	51	23	41	18	33	12
Ornamental fishes	25	35	12	37	24	20	25	12	19	9	19	5
Food fishes	9	10	0 5	11.5	6	5	9 5	4.5	8 5	8	4 5	3
Cultivable fishes	7	8	1	7	4	2	7	2	5	1	5	0
Critically End. species	0	10	0	0	0	0	5	0	5	0	0	0
Endangered species	3	15	3	27	6	9	24	0	9	0	3	0
Vulnarable species	15	12	4	12	6	4	14	0	4	0	4	0
Endemic fishes of Kerala	70	70	10	140	20	20	40	20	50	10	40	10
Endemic species to the particular river system	0	40	0	0	0	0	40	0	20	0	0	0
River index	179	262	46 5	301 5	106	92	215 5	61.5	161.5	46	109	30
index value per Km2	0 12	0.06	0 08	0.177	0.041	0.16	0 1122	0.055	0 095	0 04	0 25	0 07
Status of river system as hot spot	good	Excellent	Moderate	Excellent	Good	moderate	Excellent	Poor	Good	Poor	good	poor
Biodiversity rich areas/Area which requires protection	Achenkoil	*Silent valley, Kawarakkundu	*Siruvani	*Parambiculam, Vettilappara	*Mancheri	*Parappa	*Begur	Chathanpara	Thenmala, *Chankili	Moorkkinikkadavu	*Muntihari	Keecheri

Species characterestics	13	14	15	16	17	18	19	20	21	22	23	24	25
Total species	34	28	21	26	16	55	26	75	22	20	13	15	46
Ornamental fishes	20	14	12	18	11	25	18	40	13	9	7	8	28
Food fishes	5	6.5	4.5	4.5	2	9 5	2 5	12.5	1.5	4.5	3	3.5	6 5
Cultivable fishes	4	1	0	1	1	11	3	10	3	2	0	0	5
Critically End. species	0	0	0	0	0	0	0	15	0	0	0	0	0
Endangered species	0	0	6	3	0	0	0	39	0	0	3	0	9
Vulnarable species	6	4	4	4	0	20	20	10	0	2	2	0	6
Endemic fishes of Kerala	60	10	30	0	10	80	40	210	10	10	30	20	50
Endemic species to the particular river system	0	0	0	0	0	0	0	100	0	0	0	0	0
River index	129	63 5	77 5	58 5	40	200 5	109.5	511 5	49.5	47.5	58	46 5	150 5
index value per Km2	0 27	0.07	0 06	0 04	0 21	0 089	0.29	0.094	0.165	0.2	0.2	0 38	0 11
Status of river system as hot spot	Moderate	Moderate	moderate	Good	poor	Good	Good	Excellent	Poor	moderate	Poor	Pooe	Moderate
Biodiversity rich areas/Area which requires protection	Vayikkomba	Mundakkayam	Eerattupetta	*Thommankuthu, Moovattupuzha	Chittarikkal	*Azhutha	*Chambakkad, *Chinnar	*Pooyamkutty	Mathamangalam	Puzhaykkal	*Anegundi	Kallupalam	Iritti

* Areas or locations already under protection

River systems

1 Achenkoil
2 Bharathapuzha
3 Bhavani
4 Chalakkudy
5 Chaliyar
6 Chandragiri
7 Kabbini
8 Kadalundi
9 Kallada
10 Karuvannur
11 Karyangod
12 Keechen
13 Kuppam
14 Manimala
15 Meenachil
16 Moovattupuzha
17 Nileswaram
18 Pamba
19 Pambar
20 Pariyar
21 Peruvamba
22 Puzhaykkal
23 Shiriya
24 Tirur
25 Valapatnam

Table 3.33. Comparison of species inventory between river systems of Kerala based on regional distribution

	Fish species reported	River systems surveyed																								
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
1	*Notopterus notopterus*							+																		
2	*Megalops cyprinoides*																									+
3	*Anguilla bengalensis*	+																	+		+		+			
4	*Anguilla bicolor*																				+					
5	*Dayella malabarica*																				+					
6	*Catla catla*		+																							
7	*Cirrhinus reba*							+																		
8	*Cirrhinus mrigala*		+					+											+							
9	*Cyprinus carpio*				+														+		+					
10	*Gonoproktopterus curmuca*	+	+		+	+	+		+	+		+		+	+		+		+		+					+
11	*Gonoproktopterus kurali*									+											+					
12	*Gonoproktopterus dubius*			+				+																		
13	*G. micropogon periyarensis*																				+					
14	*G.thomassi*									+											+					
15	*G.kolus*				+																					
16	*Labeo calbasu*																									+
17	*Labeo rohita*		+																							
18	*L.nigriscence*						+														+					
19	*L.fimbriatus*																		+							
20	*L.dussumieri*	+													+				+							
21	*L.kontius*							+																		
22	*Neolissocheilus wynaadensis*					+		+																		
23	*Osteobrama bakeri*				+					+											+					+
24	*Kantaka brevidorsalis*							+																		
25	*Osteochilichthys nashii*					+		+																		+
26	*Osteochilus longidorsalis*				+																+					
27	*Puntius amphibius*	+	+		+	+	+	+	+	+	+		+	+	+		+	+	+		+	+	+		+	+
28	*Puntius arulius*							+		+																
29	*Puntius bovanicus*																									
30	*Puntius ophicephalus*															+					+					
31	*Puntius parrah*		+		+																		+			
32	*Puntius bimaculates*	+			+			+											+							
33	*Puntius carnaticus*	+		+	+			+												+						
34	*Puntius conchonius*		+					+																		
35	*P.chola*		+		+	+		+		+							+		+							
36	*Puntius vittatus*		+		+		+	+	+	+				+	+			+	+		+	+		+		
37	*P.denisonii*	+	+	+	+	+	+					+							+		+					+
38	*P.dorsalis*				+																					
39	*P.fasciatus*	+	+	+	+	+	+	+	+	+	+	+		+	+		+	+	+	+	+	+		+	+	+
40	*P.filamentosus*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+
41	*Puntius jerdonii*				+																					+
42	*P.sarana subnasutus*	+	+		+	+		+	+	+	+				+	+	+		+		+		+			+
43	*P.ticto*	+	+		+	+		+		+	+				+	+	+		+		+		+		+	+
44	*Tor khudree*	+	+		+	+	+			+		+		+					+		+					+
45	*Tor putitora*							+																		
46	*Tor remadevi*																			+						
47	*Chela fasciata*		+														+									+
48	*Chela dadiburjuri*		+																							
49	*Salmostoma boopis*			+	+	+		+		+					+		+		+							+
50	*Salmostoma acinaces*	+	+		+		+	+	+			+		+		+		+	+	+	+	+				
51	*Amblypharyngodon microlepis*		+			+				+					+				+		+					
52	*Barilius bakeri*	+	+	+	+	+	+	+		+		+		+	+	+	+		+	+	+					+
53	*Barilus bendelisis*		+		+															+						
54	*B.gatensis*	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+		+	+	+	+				+
55	*B.canarensis*		+	+	+							+									+					+
56	*Brachydanio rerio*						+																			
57	*D.malabaricus*	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+
58	*D.aequipinnatus*		+		+					+	+	+			+				+		+					+
59	*Esomus thermoicos*				+																					
60	*Rasbora daniconius*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
61	*Lepidopygopsis typus*																				+					
62	*Crosocheilus periyarensis*																				+					
63	*Garra gotyla stenorhynchus*			+		+		+												+						
64	*Garra mullya*	+	+	+	+	+	+	+	+	+		+		+		+	+		+	+	+	+	+	+		+
65	*Garra menonii*		+																							
66	*G. periyarensis*																				+					
67	*G.surendranathanii*	+	+		+														+		+					
68	*G.ceylonensis*	+																	+		+					
69	*G.emarginata*																+				+					
70	*Garra travancoria*																				+					
71	*Garra nilamburensis*					+																				
72	*G hughi*	+										+		+					+	+						
73	*G.mlappuraensis*																				+					
74	*G.mcClellandii*					+				+										+		+				
75	*Baltora mysorensis*	+				+																				
76	*Bhavania australis*	+	+	+	+		+	+		+		+		+					+		+					+
77	*Homaloptera pillai*		+																							
78	*Homaloptera silasi*																				+					
79	*Travancoria jonesi*				+																					
80	*Travancoria elongata*																				+					
81	*Nemacheilus denisonii*		+				+													+	+					
82	*N.guentheri*				+	+	+				+	+		+	+		+		+		+					+
83	*N.monilis*			+				+												+						
84	*Nemacheilus remadevi*																									
85	*N.pambarensis*																			+						
86	*N.menonii*																				+					

Continued

Table 3.33 Continued........

87	*N.triangularis*		+		+	+			+	+		+		+	+	+	+		+	+	+					+
88	*N.periyarensis*																				+					
89	*N.petrubenarescui*																									
90	*Nemacheilus bolia*							+																		
91	*Nemacheilus semiarmatus*							+												+						
92	*Nemacheilus keralensis*															+					+					
93	*Nemacheilus striatus*							+																		
94	*Lepidocephalus thermalis*		+	+	+							+		+	+			+	+	+	+	+				
95	*Batasio travancoria*		+		+		+							+					+	+	+					
96	*Horabagrus nigricollaris*				+																+					
97	*Horabagrus brachysoma*	+	+		+	+		+		+				+	+				+		+					+
98	*Mystus cavasius*	+	+		+	+		+		+						+	+			+	+		+			
99	*Mystus gulio*	+			+		+	+		+	+		+	+				+	+		+	+		+		+
100	*Mystus vittatus*		+																		+					
101	*Mystus armatus*	+	+		+			+	+	+				+	+				+		+				+	+
102	*Mystus bleekeri*																									
103	*Mystus malabaricus*						+					+		+							+			+		+
104	*Mystus montanus*							+																		
105	*Mystus menoda*																		+							
106	*Ompok bimaculatus*	+	+		+	+		+	+	+	+		+	+	+	+	+		+		+	+				
107	*Ompok malabaricus*		+				+					+									+					
108	*Silurus wynaadensis*						+	+				+												+		
109	*Wallago attu*	+	+					+							+		+		+							
110	*Pseudeutropius mitchelli*																			+	+					
111	*Glyptothorax lonah*				+																					
112	*Glyptothorax annandalei*					+	+	+		+		+		+						+	+					
113	*Glyptothorax madraspatnam*		+					+									+									
114	*Glyptothorax anamalaensis*							+																		
115	*Clarias dussumieri*		+		+							+		+	+			+			+	+				+
116	*Heteropneustes fossilis*	+	+		+	+		+		+	+	+			+	+			+		+	+	+			+
117	*Xenentodon cancila*	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+
118	*Aplocheilus lineatus*	+	+		+		+		+			+		+				+			+	+		+		+
119	*Aplocheilus blocki*				+																+					+
120	*Poecilia reticulata*				+																					
121	*Microphis cuncalus*				+																					+
122	*Parambassis dayi*	+	+		+		+		+	+	+	+	+	+	+	+		+	+		+	+	+	+	+	+
123	*Parambassis thomassi*		+		+	+		+									+		+	+	+					
124	*Pseudambassis bacuilis*	+	+		+																					+
125	*Nandus nandus*	+									+								+				+		+	
126	*Pristolepis marginatus*	+	+		+	+			+	+				+		+	+		+	+	+		+		+	+
127	*Etroplus suratensis*	+	+		+		+	+				+		+				+	+		+	+		+		+
128	*Etroplus maculatus*	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+		+	+
129	*Oreochromis mossambicus*	+	+		+	+		+	+	+		+	+		+	+				+	+	+				+
130	*Salarias reticulates*				+																					
131	*Glossogobius giuris*	+	+		+	+	+		+	+		+		+			+		+		+					+
132	*awaous gutum*				+																					
133	*Sicyopterus griseus*		+		+	+																				+
134	*Eleotris fusca*				+																					
135	*Anabas testudineus*	+	+		+	+			+										+		+		+		+	
136	*Macropodus cupanus*	+	+																							
137	*Channa striatus*	+	+		+	+	+	+	+	+	+	+	+	+	+		+	+	+		+	+	+			+
138	*Channa orientalis*	+																	+		″					
139	*Channa marulius*	+								+									+				+		+	
140	*C.micropeltes*									+																
141	*Macrognathus guentheri*																						+			
142	*Mastacembelus armatus*	+	+		+	+	+	+		+	+	+		+		+	+		+		+		+		+	+
143	*Tetradon travancoricus*		+		+	+													+		+					+

Table 3.34. Comparison of species inventory between river systems of Kerala based on longitudinal distribution of fishes

Sl.No.	Fish species reported	River systems surveyed																								
		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
1	*Notopterus notopterus*							M																		
2	*Megalops cyprinoides*																									M
3	*Anguilla bengalensis*	U																	L		M		L			
4	*Anguilla bicolor*																				M					
5	*Dayella malabarica*																				M					
6	*Catla catla*		M																							
7	*Cirrhinus reba*							U																		
8	*Cirrhinus mrigala*		M					M											U							
9	*Cyprinus carpio*				U														L		U					
10	*Gonoproktopterus curmuca*	M,L	U,M		M,L	U,M	M,U		U,M	M,U		M		U,M	M		U,M		M,U		M					U
11	*Gonoproktopterus kurali*									M											U,M					
12	*Gonoproktopterus dubius*			U				U																		
13	*G. micropogon periyarensis*																				U					
14	*G.thomassi*									M,U											M					
15	*G.kolus*				U																					
16	*Labeo calbasu*																									U
17	*Labeo rohita*		M																							
18	*L.nigrscence*						U														M					
19	*L.fimbriatus*																		L							
20	*L.dussumieri*	L													M				L							
21	*L.kontius*							U																		
22	*Neolissocheilus wynaadensis*					U		U																		
23	*Osteobrama bakeri*				M,L					M,U											L					U
24	*Kantaka brevidorsalis*							U																		
25	*Osteochilichthys nashii*					U		U																		U
26	*Osteochilus longidorsalis*				U																M					
27	*Puntius amphibius*	L	L		L	M	L	M	M,L	L	L,M		L	L	L		M,L	L	L,M		L,M	L	L		L	U,M
28	*Puntius arulius*							U		U																
29	*Puntius bovanicus*		M																							
30	*Puntius ophicephalus*															U					U					
31	*Puntius parrah*		M,L		L																		L			
32	*Puntius bimaculates*	M			U			M											M							
33	*Puntius carnaticus*	U		U	M,U			U												U						
34	*Puntius conchonius*		M					U																		
35	*P.chola*		M,L		L	L		M		M							L		L							
36	*Puntius vittatus*	M	M,L		M,L		L	L	M,L	M				L	L			L	M		M	M,L		L		
37	*P.denisonii*	U,M	M	U	M	M	U,M					M							M		M					U,M
38	*P.dorsalis*				U																					
39	*P.fasciatus*	U,M	U,M	U	M,U	U,M	U,M	U,M	U,M	U	U	U,M		U,M	M,U		U,M	U,M	U	U	U,M	U		U,M,L	M	U,M
40	*P.filamentosus*	M,L	M,L,U	U	M,L,U	U,M,L	M,U,L	M	U,M,L	L	M,U	U,M,L	M,L,U	U,M,L	U,M,L	M,L	U,M,L	M	U,M,L		U,M,L	U,M,L	L,M	U,M,L	M,L,U	U,M,L
41	*Puntius jerdonii*				M,U																					U
42	*P.sarana subnasutus*	L	L		L	L		M	L	L	L				L	M	M,L		M,L		L		L			M,L
43	*P.ticto*	L	L		L	L		L		L	M,L,U				L	L,M	M,L		M,L		M,L		L		M	L
44	*Tor khudree*	U	U,M		M,U	U	M,U			U		U		U					L,M		U,M					U,M
45	*Tor putitora*							M																		
46	*Tor remadevi*																			U						
47	*Chela fasciata*		M,														L									U
48	*Chela dadiburjun*		M																							
49	*Salmostoma boopis*			U	M,L	M,L		U		M					M	M	M		M,L							L
50	*Salmostoma acinaces*	M	M		M,L		M,L	U	M,L			M		M		M		M	M,L	U	M	M,L				

Continued

Table 3.34 continued.....

51	*Amblypharyngodon microlepis*	L	M.L			M				M					L				L		M					
52	*Barilius bakeri*	U.M	U.M	U	U.M	U	M.U	U		U.M		U.M		U.M	M	U.M	U		U	U	U.M					U.M
53	*Barilius bendelisis*		L		U															U						
54	*B.gatensis*	U.M	M	U	M	U	U.M	U.M	U.M	U.M		U.M	M.L	U.M	M	U.M	U		U	U	U.M	U				U.M
55	*B.canarensis*		M	U	M							M									M					U
56	*Brachydanio rerio*						U																			
57	*D.malabaricus*	U.M	U.M	U	M	U.M	U	U.M	M.L	U.M	M.U	M.U	U.M.L	U.M		U.M	U.M	U.M	U.M.L	U	U.M	U.M	U.M	U.M	U.M	U.M
58	*D.aequipinnatus*		UM		M					M	M.U	U.M			M				U.M.L		U.M					U.M
59	*Esomus thermoicos*				U																					
60	*Rasbora daniconius*	M.L	M.L	U	M.L	M.L	U.M	M	M.L	U.M.L	M.L	M	M.L	U.M.L	M.L	U.M.L	U.M.L	M.L	M.L	U	U.M.L	M.L	L	U.M.L	M.L	L
61	*Lepidopygopsis typus*																				U					
62	*Crossocheilus periyarensis*																				U					
63	*Garra gotyla stenorhynchus*			U		U		U												U						
64	*Garra mullya*	U.M	U.M	U	M.U	U.M	U.M	U	U	U		M.U		U.M.L		U.M	U		U	U	U.M	U	U	L		U.M
65	*Garra menonii*		U																							
66	*G. periyarensis*																				U					
67	*G.surendranathanii*	U	U		U														U.M		M					
68	*G.ceylonensis*	U																	U		M					
69	*G.emarginata*																U				M					
70	*Garra travancona*																				U					
71	*Garra nilamburensis*					U																				
72	*G.hughi*	U										U		U					U	U						
73	*G.mlapparaensis*																				U					
74	*G.mcClellandii*					U				U										U		U				
75	*Baltora mysorensis*	U				U																				
76	*Bhavania australis*	U	U	U	U		U	U		U		U		U					U		U.M					U
77	*Homaloptera pillai*		U																							
78	*Homaloptera silasi*																				U					
79	*Travancoria jonesi*				U																M					
80	*Travancoria elongata*																				M					
81	*Nemacheilus denisonii*		U				U.M													U	U.M					
82	*N.guentheri*				M.U	U	U.M				U.M	U		U	U		U		U		U.M					M
83	*N.monilis*			U				U												U						
84	*Nemacheilus ramadevi*		U																							
85	*N.pambarensis*																			U						
86	*N.menonii*																				U.M					
87	*N.triangularis*		U.M		M.U	U			U.M	U		U		U	U	M	U		U	U	U					M
88	*N.periyarensis*																				U					
89	*N.petrubenarescui*																									
90	*Nemacheilus botia*							U																		
91	*Nemacheilus semiarmatus*							U												U						
92	*Nemacheilus keralensis*															U					U					
93	*Nemacheilus striatus*							U																		
94	*Lepidocephalus thermalis*		M	U	M							M		U	U			M	U	U	U.M	M.L.U				
95	*Batasio travancoria*		M		M		M							M					U.M	U	M					
96	*Horabagrus nigricollaris*				M																M					
97	*Horabagrus brachysoma*	L	M.L		M	L		M		U.M				L	L				M.L		M					M.L
98	*Mystus cavasius*	M	M		M	M		U		M						M	M.L			U	M		L			
99	*Mystus gulio*	L			L		M	L		M	L		L	L				L	L		L	M.L		L		L
100	*Mystus vittatus*		M.L																		M					
101	*Mystus armatus*	L	M.L		M			M	M.U	M				L	M				U.M		M				L	M
102	*Mystus bleekeri*																									
103	*Mystus malabaricus*						U					M		U							M			M.L		M

Continued

Table 3.34 continued......

104	*Mystus montanus*							M											L							
105	*Mystus menoda*																		L							
106	*Ompok bimaculatus*	L	M,L		L	M,L		M,L	M	U,M	M		M	U,M,L	L	M,L	M,L		M,L		M,L	L				
107	*Ompok malabaricus*		M				U,M					M									M,L					
108	*Silurus wynaadensis*						U	U				U												U		
109	*Wallago attu*	L	M,L					L							L		L		L							
110	*Pseudeutropius mitchelli*																			U	M					
111	*Glyptothorax lonah*				M																					
112	*Glyptothorax annandalei*	U				U	U,M	U		U		U		U						U	M					
113	*Glyptothorax madraspatnam*		M,L					U									U									
114	*Glyptothorax anamalaensis*							U																		
115	*Clarias dussumieri*		M,L		L							U,M		U,M,L	L			M			M	U				M
116	*Heteropneustes fossilis*	L	L		U	M		L		L	L	M,L			L	M,L			L		M,L	U	L			M
117	*Xenentodon cancila*	M,L	M,L		L,M	M,L	U,M	L	L	L	L	M,L	U,M,L	L	L	M,L	L	M	L		M,L	M	L	M,L	M	M,L
118	*Aplocheilus lineatus*	M,L	L		M,L		M		M			M,L		L,M				M			M,L	M,L		L		M,L
119	*Aplocheilus blocki*				L																L					L
120	*Poecilia reticulata*				U																					
121	*Microphis cuncalus*				L																					M
122	*Parambassis dayi*	L	M,L		M,L		M		M,U	M,L	M,L	M,L	M,L	M,L	M	M,L		L	L		M,L	L,M	L	M,L	M	M,L
123	*Parambassis thomassi*		M		M,L	M,L		U									M,L		L	U	M,L					
124	*Pseudambassis baculis*	L	L		L																					M
125	*Nandus nandus*	L									L								L				L		L	
126	*Pristolepis marginatus*	L	M		M,L	M			U,M	M				M		L	M,L		M,L	U	M,L		U		L	M
127	*Etroplus suratensis*	M,L	M,L		L		M	L				M,L		L				L	L		M,L	M,L		M,L		M
128	*Etroplus maculatus*	M	M,L		M	M,L	U,M	L	M,L	M	L	M,L	M,L	L	L	L	M,L	L	M		M,L	M,L	L		L	M,L
129	*Oreochromis mossambicus*	L	L		L	L		L	M,L	L		M	L		L	L				U	U,M,L	M,L				M,L
130	*Salarias reticulates*				M																					
131	*Glossogobius giuris*	L	L		L	M,L	M		M,L	L		L		L			M,L		U,M		M					L
132	*awaous gutum*				L																					
133	*Sicyopterus griseus*		M		M	U																				M,L
134	*Eleotris fusca*				L																					
135	*Anabas testudineus*	M	M		L	L			L										L		M		L		L	
136	*Macropodus cupanus*	L	L																							
137	*Channa striatus*	L	M,L		L	L	L	L	L	M	L	L	L	L	L		L	M	L		M	L	L		L	M
138	*Channa orientalis*	L																	L		M					
139	*Channa marulius*	L								U									L				L			
140	*C.micropeltes*									U																
141	*Macrognathus guentheri*																						L			
142	*Mastacembelus armatus*	M	M		M	M	M	M		U	M	M		M		U,M	M		L		M		L		L	M
143	*Tetradon travancoricus*		M,L		L	L													L		M					L

River systems survyed

1 Achenkoil	6 Chandragiri	11 Karyangod	16 Moovattupuzl	21 Peruvamba
2 Bharathapuzha	7 Kabbini	12 Keechen	17 Nileswaram	22 Puzhaykkal
3 Bhavani	8 Kadalundi	13 Kuppam	18 Pamba	23 Shiriya
4 Chalakkudy	9 Kallada	14 Manimala	19 Pambar	24 Tirur
5 Chaliyar	10 Karuvannur	15 Meenachil	20 Periyar	25 Valapatnam

U- Upper streches of the river syst (>500 m msl)
M- Middle streches of the river system(70-500 m msl)
L- Lower streches of the river system(<70 m msl)

Plate I

Bharathapuzha river system: Upstream at Dhoni

Chalakkudy river system: Middlestream at Malakkappara

Pamba river system: Upstream at Kakki

Achenkovil river system: Upstream at Vazhaperiyar

Chalakkudy river system: Upstream at Nelliampathy

Chalakkudy river system : Middlestream at Athirappally

Chalakkudy river system: Middle stream at Vazhachal

Chalakkudy river system: Upstream at Orukomban

Kallada river system : Middlestream at Orukunnu

Chalakkudy river system : Middlestream at Vettilappara

Plate II

Periyar river system : Upstream at Moolavaigae

Periyar river system : Upstream at Vagalalayanthodu

Bharathapuzha river system : Downstream at Cheruthuruthy

Kallada river system : Upstream at Chenthuruny

Valapatanam river system : Upstream at Munthari

Kallada river system : Downstream at Punalur

Pamba river system : Upstream at Gavi

Kabbini river system : Upstream at Kuruvadeep

Periyar river system : Upstream at Mlappara

Kallada river system : Upstream at Palaruvi

Plate III

Achenkovil river system : Middlestream at Thura

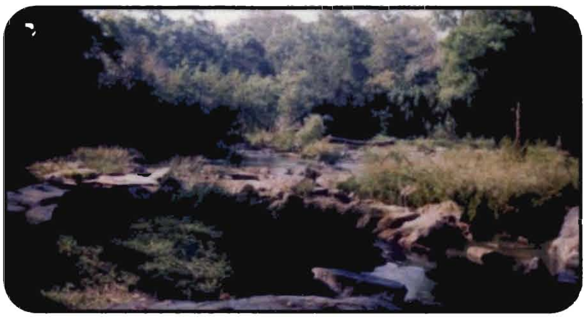
Periyar river system : Upstream at Mullakkody

Bharathapuzha river system: Upstream at Silent Valley

Meenachil river system: Middlestream at Palai

Kuppam river system : Upstream at Vayikkomba

Periyar river system : Periyar Lake



Karyangod river system : Upstream at Munthari

Chandragiri river system : Upstream at Madikkeri

Pamba river system : Downstream at Viyyapuram

Kallada river system : Middlestream at Kulathupuzha

Plate IV

Periyar river system : Upstream at Munnar

Chaliyar river system : Upstream at Vazhikkadavu

Manimala river system : Downstream at Kanjirappally

Keechei river system : Downstream at Keecheri

Moovattupuzha river system : Middlestream at Kalloor

Bharathapuzha river system : Upstream at Syrendri

Periyar river system : Upstream at Aaladi

Periyar river system : Upstream at Thannikudy

Kadalundy river system : Upstream at Velliar

Kallada river system : Thenmala reservoir

Chapter 4

SPATIO-TEMPORAL VARIATION IN FISH SPECIES ABUNDANCE AND ASSEMBLAGE IN SIX MAJOR RIVER SYSTEMS

4.1. Introduction

Population monitoring is crucial in understanding and managing ecosystems, and the need for generating long-term data is widely recognized as an essential pre-requisite for fisheries resource management (Likens, 1992; Thomas, 1999). A complicating factor in such studies is that community patterns may differ among spatial and (or) temporal scales or be random in nature and a decision of management become vital (Pegg and McClelland, 2004). However, any such attempts assume high significance, given the large-scale physical and chemical changes brought about in both aquatic and terrestrial ecosystems across much of the world over the last 150 years. Understanding spatial and temporal changes in river-stream systems is important not only in formulating management and environmental policies (Likens, 1989), but also in assisting to understand the fundamental nature of environmental changes (Bruns *et al.,* 1984; Rice, *et al.*, 2001; Poole, 2002). Knowledge on the spatial and temporal scale of ecological processes is fundamental in interpreting patterns in the environment and are valuable for (1) correctly interpreting time-series data on fish assemblages (Schlosser, 1990; Levin, 1992), (2) classifying the determining sources of a particular species assemblages across different stream types and regions (Grossman *et al.*, 1998a and 1998b), (3) identifying species or assemblages with high rates of habitat specificity (Gowan *et al.,* 1994), (4) designing the appropriate monitoring and research approaches for conservation (Maxell, 1999). Comparison of spatial and temporal variations can guide the decisions regarding the most efficient distribution of sampling effort (e.g. greater temporal versus greater spatial coverage (Matthews, 1990).

According to Lowe-McConnell (1975), tropical continental stream habitats present temporal and spatial variability in population structure as a function of rainfall and draught periods. Several studies suggest that tropical fish communities even do not exhibit a clear organizational pattern (Goulding *et al.*, 1988; Saint-Paul *et al.*, 2000). Fish communities exposed to periodic disturbance caused by annual and seasonal floods and drought influence and determine the assemblage structures (Meffe and Minckley 1987; Resh *et al.*, 1988; Poff and Ward ,1990). Buhrneim and Fernandez (2003) are of the opinion that the fish assemblage composition within habitat types are variable due to high spatial and temporal heterogeneity, characteristic of tropical rivers. These arguments virtually agrees with the Montgomery's Process Domains Concept (PDC) that the spatial and temporal variability in geomorphic processes governs and influence the stream habitat and that determine ecosystem structure and dynamics. In many types of tropical south-Asian waters, stream fish populations appear to fluctuate in abundance and species composition from year to year (Starret, 1951). Matthews (1990) and Meador and Matthews (1992) reported that environmental conditions vary through the year due to differences in solar irradiation and rainfall influencing community patterns and species diversity. Chick *et al.*(2004) reported the periodic change in fish assemblages at a given site in tune with the seasonal environmental changes in streams of Florida. Schlosser (1982) argues that temporal variability tends to be high in warm tropical streams and higher still in anthropogenically disturbed waters. Fish assemblage structure at (and within) the landscape scale also could be influenced by species interactions (Buhrneim and Fernandez, 2003). According to them, patterns observed are most likely driven by species-specific habitat affinities, manifest in variation in relative abundance of common species and the presence/absence of rare species in certain habitat types.

Habitat models relating physical characteristics to population features (occurrence, abundance or density) are widely used in applied ecology (Boyce and McDonald, 1999; Nelson *et al.*, 1992; Osborne and Wiley,1992; Mandrak, 1995). Predictive models have many potential applications for the conservation and management of freshwater fishes. Recent studies have used predictive models to measure impacts of habitat alteration (Oberdorff *et al.*, 2001), examine the influence of scale and geography on relationships between fishes and landscape variables (Townsend *et al.*, 2003), assess habitat suitability for species re-introductions (Harig and Fausch, 2002), predict the likelihood of species invasions (Vander Zanden *et al.*, 2004) and identify areas of persistence for threatened or endangered species (Wiley and Mayden, 1985). With greater number of species are in need of protection and limited financial resources to devote to surveying stream habitats and finer-scale data collection, predictive models adopting a few major scale variables provide scientists with a powerful time and economic tool, which can be used to assess the population and suitability of habitat for fish species across the landscape and facilitate the prioritization of areas for conservation (Townsend *et al.*, 2004; Minckley, 1959; Gido *et al.*, 2002). The development of significant predictive models using GIS-derived habitat variables is promising, because of the accuracy besides the high time and monetary advantages of these data (Smith and Powell, 1971).

Controlling anthropogenic risks to biodiversity require knowledge of the natural characteristics and processes that create, support, or limit diversity (Rathert *et al.*, 1999). Rare species with strict habitat requirements are often among the first species to be adversely affected by anthropogenic changes (Allan and Flecker, 1993). Monitoring data used to examine the influence of human actions or natural events on fish assemblages generally cannot be interpreted reliably without knowledge of temporal variation in the assemblage prior to an event (Schlosser, 1990). Fragmentation, isolation of habitats and other anthropogenic disturbances to ecosystems and landscapes can be viewed as new scales imposed on natural systems. Examining how patterns vary across various spatio-temporal scales, including human imposed scales, may be a useful tool to detect effects of, and/ or establish hypotheses regarding, anthropogenic changes to ecosystems (Schlosser, 1990). 1982). The ever increasing anthropogenic invasions in the aquatic habitats have resulted in drastic variation in flow regime and species assemblage structure in the diverse river systems of Kerala as a result of which many fish species have already become endangered and some even extinct. Quite pathetically, this situation has been observed for the bulk of the freshwater fish species all over the world. Identification of species and communities which are subjected to such a large-scale variation and diminution in assemblage structure and abundance should be given adequate attention and prime concern for adopting and setting up of adequate conservation measures to hoard them from looming endangerment. Besides, the specific ecological parameters, which determine and influence the specific community structure at the particular habitat should also be conserved.

An array of work have been carried out on diverse river systems all over the world on the fish faunistic assemblages, variations in species richness and abundance on different scales and also, correlation of assemblages and abundance with environmental parameters. Among them, the species rich north and south American river systems, Australia, New Zealand, Brazil, Africa and France were explored exhaustively for species quantification studies. It was Vannote *et al.* (1980) who proposed the River Continuam Concept. Spatial and temporal patterns in fish communities along the Illinois River, USA have been studied by Pegg and McClelland (2004). Renowned ecologists of United states such as Sheldon (1998) unraveled the distribution, abundance and conservation status of fishes of drainages connected with the Mississippi river system. Adamsq *et al.* (2004) studied spatial and temporal patterns in fish assemblages of upper coastal plain streams of Mississippi. The species richness and abundance of Native freshwater fishes of Oregon has been studied extensively investigated by Rathert *et al.* (1999). Merigoux *et al.* (1998) studied the fish species richness and species-habitat relationships in two coastal streams of French Guiana. The assemblage structure and changes in distribution and abundance pattern of fishes in Ozark river before and after the construction of an impoundment has been studied by Quinn *et al.*(2003). Chick *et al.* (2004) studied the spatial scale and abundance patterns of large fish communities in freshwater marshes of the Florida everglades. The patterns and processes in the geographical ranges of freshwater fishes in

North America was studied by Rosenfield (2002). Other researchers such as Pringle *et al.* (1988) and Townsend (1989) have promoted the concept of patch dynamics to characterize patterns and processes in heterogeneous stream environments. Vadas and Orth (2000) worked on the habitat use of fish assemblages in the streams of Virginia. It is Newall and Magnuson (1999) who investigated the correlation of eco-region and drainage area on fish distributions in the St.Corix river and its Wisconsin tributaries. Other relevant works in the similar lines in American waters include those of Page (1983); Gilbert (1976); Hocutt and Wiley (1986); Moyle and Cech (1988); McAllister *et al.* (1986) and Underhill (1986). Distribution and abundance of large fishes (SL>100 mm) in the Rio Cinaruco, a floodplain river in the Venezuelan llanos, were examined by Layman and Winemiller (2005). The biogeography of Australian freshwater fishes with the diversity, factors affecting species richness, abundance and endemism were detailed by Unmack (2001). Gehrke (2001) studied exhaustively the species richness and composition of freshwater fishes of New South Wales rivers of Australia. Russell *et al.* (2003) worked on the species diversity and spatial variation in fish assemblage structure of streams in northern Australia and also the occurrence and possible dangers of exotic and translocated species. Distribution and abundance of freshwater fishes in the New Zealand rivers were investigated by Jowett and Richardson (1996). Casatti (2005) worked on the fish assemblage structure, longitudinal distribution, seasonality and microhabitat diversity of a first order stream of south-eastern Brazil. Smith and Powell (1971) studied the fish fauna of Sorocaba river basin of Brazil. Other workers who focused on the faunal assemblages and abundance of this portion include Castro and

Arcifa (1987) and Barrela (1998). Galacatos *et al.* (2004) studied the seasonal and habitat influences on fish communities within the lower Yasuni river basin of the Ecuadorian Amazon. Buhrnheim and Fernandes (2003) reported the structure of fish assemblages in Amazonian rainforest streams. The modern freshwater fish fauna of Africa has attracted much scientific attention, fueling debate on evolutionary issues related to species assemblages (Greenwood 1984; Fryer *et al.* ,1985), conservation (Fryer, 1972) and abundance and diversity (Beadle 1981; Lundberg *et al.*, 2000). Moore *et al.* (2003) studied extensively on the germplasm diversity, distribution, abundance and seasonality of fishes of West river in Connecticut. Distribution and assemblage patterns of indigenous freshwater fishes of Tagus river basin of Spain was studied by Carmona *et al.* (1999). Estimation of total abundance of fishes based on calibration experiments rather than the much traditional catch and effort methods were done by Reid and Harris (2002). Several studies have made to establish the correlation of habitat variables and stream fishes (Schlosser, 1982; Rahel and Hubert, 1991) and tried to predict the stream assemblages over a period of time. Townsend *et al.* (2003) put forward the prediction techniques of the influence of scale and geography on relationships between stream community composition and landscape variables. Biggs *et al.* (1990) correctly predicted the presence/ absence and abundance of individual species with 58 % to 85 % success, based on discriminant models. Hayes *et al.* (1989) discussed the correlation between land use and distance from the sea and effectively predicted the stream fish assemblage and abundance in Mokau catchment.

Studies on the freshwater fish distributions, assemblages and abundance in Asian and south-Asian waters are relatively scanty. Some of such sparse but significant investigations included those of Moyle and Senanayake (1984); Wickramanayake and Moyle (1989); Wickramanayake (1990); Kortmulder *et al.*(1990) and Lamouroux *et al.* (1999). Studies on fish assemblage structure, species richness and abundance and their habitat requirements in Indian streams are lacking, though few initiatives were taken in the 1980's in south Indian (Arunachalam *et al.,* 1988; Bhat, 2003 and 2004) and Himalayan waters (Edds, 1993). The Western Ghats while being extremely rich in its fish biodiversity has not so far been investigated with regards to species distributions and their interactions with environmental and physical parameters (Bhat, 2003). Very little is known on the community ecology and distribution patterns of fish fauna in the streams and rivers of this region but for some isolated attempts (Arunachalam, 2000; Sivaramakrishnan *et al.*,1995). Arunachalam (2000) worked on the stream fish assemblages of Peninsular India. Dahanukar *et al.* (2004) made an attempt to study the distribution, endemism and threat status of Western Ghats. Bhat (2003 and 2004) studied the diversity, composition, distribution patterns and correlation of these parameters with the habitat ecology of fishes in the rivers of Central Western Ghats. Ganasan and Hughes (1998) reported the fish assemblages of Khan and Kshipra rivers of Madhyapradesh and brought out the Index of biotic integrity scores for these rivers. Efforts were made recently to compile the available data on WG (Ponniah and Gopalakrishnan, 2001). However, as large parts of northern WG are as still remain unexplored, the extent of diversity and distribution of many of the species inhabiting this region is not known.

As far as Kerala is concerned, no significant work has been carried out with regard to spatio-temporal variations in species richness and abundance with the scale in any of the water bodies. Given the high levels of fish faunal diversity and endemism recorded so far, there is an urgent necessity to have a new approach and a comprehensive study on the fish assemblage structure, species abundance and its spatio-temporal variations. The major geomorphic parameters which are playing a decisive role in determining the assemblage structure in various water resources of Kerala require an in-depth investigation. Before the rich species diversity of this region of the subcontinent is lost forever by the surging anthropogenic threats, the documentation of and quantification of fish population and its dynamics are found crucial. It is against this background that the present study was undertaken with the following objectives:

1. Investigate the status of spatial and temporal variation in fish abundance in different river systems of Kerala
2. Study the spatio-temporal similarity/shift pattern in fish assemblages based on abundance at species and location level and analyze whether assemblages were more similar over time or space
3. Study the pattern of community structure of the major six river systems on a temporal scale
4. Bring out the best predictive model for the species abundance of a river system relying on three geomorphic parameters viz. altitude, latitude and distance from the sea.

4.2. Materials and methods

a) *Sampling protocol*

Six of the 44 river systems of Kerala which represent the whole geographical scale of the state were selected for the present study. This included two river systems from northern Kerala (Kabbini and Bharathapuzha), two from central Kerala (Periyar and Chalakkudy) and two from the southern Kerala (Pamba and Kallada). Fishes in these rivers were sampled regularly for a period of three years (2001-2003) giving due representation to pre monsoon, Monsoon ad post monsoon in these years. The number of sampling locations in each river system is fixed based on the length and catchment area of the river system and generally more number of stations were surveyed for larger river systems. The location for survey is fixed at every 10 km stretch of the river system including the tributaries and sampling was carried out on 100 m of stretches of the river at each location selected. Habitat diversity was also given prime importance in the site selection and care was taken to sample all fish microhabitats within the study area in proportion to their availability. The geographical position of the locations was fixed using GPS and the parameters such as latitude, altitude and distance from the sea to the location were measured (Appendix 1). Sample collection was made from all selected locations during 8:00-18:00 hrs and 20:00-06:00 hrs. Methodology for fish sampling was standardized and followed throughout the study period to ensure comparison within and between years. Fish samples were collected using gill nets and cast nets of different mesh sizes and the catches from these gears were made uniform following Bhat (2003) (one hour of 20 cast net operations is equal to 3 hrs of gill netting). The catch/hour of different species at the selected locations of all the river systems were quantified and this value is used as basis for various statistical analyses.

b) *Data Analyses*

Analysis of the data on catch/hr. of the different species during different seasons was done with the help of statistical packages such as PRIMER-6 and SPSS-11.5 along with other programme (Jayalakshmy, 1984)

Three-way ANOVA

The three-way ANOVA is used for comparing the data based on three variables at a time. In the present study the seasons (A), stations (B) and species (C) were taken as the variables and their first order interactions (season-station, station-species and season-species interaction) as the source variables to examine how the species abundance varied over time and among locations within a river system. The analysis has the advantage over the one-way and two-way ANOVA in that the interaction effects can readily be tested for their significance along with the significance of individual variables (Snedcor and Cohran, 1967).

Bray-Curtis similarity index

Bray–Curtis coefficient (Bray and Curtis, 1957) has a dominant role in ecological studies. It satisfies the practical desirable criteria that it takes the value '100' when two samples are identical and takes the value '0' when two samples have no species in common. A change of measurement unit does not affect the value. Its value is also unchanged by inclusion or exclusion of a species, which is jointly absent from the two samples, a condition which many coefficients fail because they depend on same form of standardization carried out for each species. Inclusion of a third sample 'C' in the data set make no change in the similarity between samples 'A' and 'B'. This coefficient has the flexibility to register differences in total abundance for two samples as a less than perfect similarity when the relative abundances for all species are identical.

The Bray-Curtis coefficient of similarity between i^{th} and j^{th} samples is

$$S'_{ij} = 100\left[1 - \left\{\frac{\sum_{k=1}^{n}\left|y_{ik} - y_{jk}\right|}{\sum_{k=1}^{n}\left(y_{ik} + y_{jk}\right)}\right\}\right]$$

Where y_{ik} = abundance of the i^{th} species at the k^{th} location and y_{jk} = abundance of the j^{th} species in the k^{th} station for species wise similarity and,

y_{ik} = abundance of the k^{th} species at the i^{th} location and y_{jk} = abundance of the k^{th} species in the j^{th} station wise similarity.

For species and also station similarities, Bray-Curtis coefficient is calculated on standardized fourth-root transformed data. Dendrograms were drawn to obtain the species clusters which are linked at high similarity levels.

Multi-dimensional scaling (MDS)

Two-dimensional non-metric, multidimensional scaling ordination of the species abundance of the different stations of a particular river system over time was examined. MDS is used to compare fish assemblage similarity/dissimilarity based on Mean catch/hour. MDS constructs a two dimensional ordination in a manner that represent the relationship vividly among the samples in a similarity matrix (Field *et al.*, 1982; Clark and

Warwick, 2001). In ordination plots, the relative distance between the points reflects the dissimilarity of species abundance in those sites. Similarity matrices were calculated using the Bray-Curtis similarity index and MDS are drawn as different stress levels to get unique station clusters.

Diversity indices

A variety of different statistics (a constant calculated from the sample) can be used as measures of some attribute of community structure in a sample. These include the total number of individuals (N), the total number of species (S), total biomass (B) and ratios such as (B/N), the average size of an organism in a sample and (N/S) the average number of individuals per species. Abundance and biomass are all absolute measures and are not dimensionless quantities and so tend to be less informative than diversity indices such as richness of the sample defined in terms of the number of species for a given number of individuals, dominant in a way in which the total number of individuals in the sample is divided up among the different species (technically referred to as the species abundance and distribution).

In this study, four diversity/evenness indices were calculated to study the community structure in the different river systems viz. Periyar, Chalakkudy, Kabbini, Bharathapuzha, Pamba and Kallada. Simpson's (1949) concentration index, Margalef's (1951) richness index, and Pielou's (1971) evenness index. Shannon-wiener's diversity index is the only index having a defined probability distribution even though it is a biased estimate of diversity. This index describes the average degree of uncertainty of predicting the species of an individual chosen randomly from the biotic community. It is the most promising index of diversity derived from the information theory (Margalef, 1958 and Patten, 1962).

Margale'f index $= d = (S-1)/(\log_{10} N)$

Simpson's index $= \lambda = \sum_{i=1}^{S} n_i(n_i - 1) \big/ N(N-1)$

Shannon-Weiner index $H(S) = -\sum_{i=1}^{S} p_i(\log_2 p_i)$

Where $p_i = n_i/N, i = 1, 2, 3 \ldots\ldots S$

Pielou's index $= H(S)/H(S)_{max}$

Shannon-Weiner index, $H(S)$ is a biased estimate of the population index of diversity. The expected value of H is

$$E(H) = \left[-\left(\sum_{i=1}^{S} p_i (\log_2 p_i)\right) - \left(\frac{(S-1)}{2N}\right) + \frac{\left(1 - \sum(1/p_i)\right)}{12N^2}\right]$$

Corrected to the third term in the expansion. The variance of the estimate is given by

Var: $(H(S))[= \sum\left|\left(p_i (\log_2 p_i)^2\right) - \left(\sum p_i \log_2 p_i\right)^2 / N + \left((S-1)/2N^2\right)\right|$

Corrected to the second term when 'N' is large the first term is sufficient (Hutcheson, 1970). The diversity indices of two stations is compared by a Students t-test given by

$$t = \frac{(H_{11} - H_{21})}{\sqrt{Var(H_{11}) + Var(H_{21})}}$$

The null hypothesis is $H_0 : H_{11} = H_{21}$. The degrees of freedom of t is

$$df = \frac{\{Var(H_{11}) + Var(H_{21})\}^2}{\frac{(Var(H_{11}))^2}{N_1} + \frac{(Var(H_{21}))^2}{N_2}}$$

Where 'N_1' is the number of individuals in the first sample and 'N_2' is the number of individuals in the second sample.

Predictive multiple regression model

The abundance / biomass can be related to the environmental parameters by means of a linear regression. But this relation gives only the predictive efficiency of a single factor at a time assuming that there are no other factors controlling it or the total effect or the individual effect of other factors is a constant. In ecosystems a number of factors are jointly controlling the bioactivities at a point of time or space. Therefore, it is very essential that all the quantifiable parameters be considered simultaneously to have the best predictive model. Pederson *et al.* (1995) have given a method for choosing the minimal set of environmental variables that explain the variation in the plankton data. Ter Braak (1990) has given a Monte-Carlo permutation test, which replaces the F-test or t-test in forward selection in univariate multiple regression. Evonne *et al.* (1995) have used the interaction effect of cell mass 'M' and taxonomic categories D1 to D5 in the multiple regression of respiration in cell mass.

Multple regression model fitted is $y = a_0 + a_1x_1 + a_2x_2 + ... + a_nx_n$

where y is the abundance /biomass $x_1, x_2, ... x_n$ are the input parameters which can be individual parameters or the first order interaction effects of the input parameters. $a_1, ... a_n$ are called the practical regression coefficients when the data are standardized, where the standardized variable is $z_i = \left(\frac{X_i - \overline{X}}{\sigma_x} \right)$

In this case the regression coefficients are the relative importance of the input parameters. In this model about 2K models are fitted and among these models the one which explained the highest variability is taken as the best model.

The method is employed in the present study for calculating correlations and understanding the association of species abundance and composition to the various environmental parameters such as altitude, latitude and distance from the sea and predicts the species abundance with the help of these independent factors. This multiple regression method is using a stepwise selection of parameters starting with single parameters and ending with the maximum number of independent variables along with all possible first order interaction effects when the number of independent parameters are more than one (Jayalakshmy, 1984).

4.3. Results

4.3.1. Spatio-temporal variation in species abundance

The results of three-way ANOVA applied in the six river systems for comparing species abundance between seasons, species and stations are shown in Table 4.1. In Periyar river system, significant difference was observed for species abundance between seasons, between stations and between species invariably in all the three years ($P<0.05$). High seasonal specificity and high location specificity were observed for species in 2001 and

2003 ($p<0.05$) as indicated by high significant season-species interactions (A*C) and station-species interactions (B*C).

In Chalakkudy river system, fish species abundance was found to vary with season, with location and also between species ($p<0.05$). In this river system also, fish species were observed to be highly selective for seasonal variations and spatial variations as indicated by significantly high season-species interactions ($p<0.05$) and high station-species interaction ($p<0.05$). In all the three years, which justifies the fact that in this river system, fish species varied from station to station and also from season to season and these changes can be expected as an ever lasting phenomena as indicated by the insignificant station-station interaction ($p>0.05$).

In Kabbini river system, during 2001 and 2002, seasonal differences were high but not in the year 2003. Species abundance varied significantly with species, invariably in all the three years ($p<0.05$). The variation in species abundance was found to be influenced by seasons as indicated by high season-species interaction (A*C)($p<0.05$) in all the years. During 2001, high season-station interaction was obvious (A*B) ($P<0.05$) but were insignificant during 2002 and 2003 ($P>0.05$).

In Bharathapuzha, highly significant variations were observed for species abundance between stations, species and seasons ($p<0.01$) in the year 2001. Among the three interactions, only season-species interaction was found significant indicating the high season specificity of the species. In other words, the species occurrence would also be influenced by the seasonal variation ($p<0.05$). Station-season and station-species interactions were not found to be high, inferring that the seasonal variations remain the same at almost all the stations. In other words, the spatial variations whatever observed also remains the same irrespective of the changes in the seasons and the habitat specificity for the species were negligible ($p > 0.05$). In 2002, the changes were significantly high between seasons and species ($p<0.01$) and of the interaction effects, as in 2001, only the season-species interaction was found significant ($p<0.05$). During 2003, significant difference between seasons, between stations as well as between species ($p < 0.01$) were obvious as observed in 2001. Highly significant station-species and season species interactions were observed during this year ($p< 0.01$), which showed the high station specificity for the species and high influence of season over the species abundance.

In Pamba river system, invariably in all the years studied, fish species abundance differed from location to location and also from species to species ($p<0.05$). Seasonal variations were observed only during 2003 which differentiated year 2003 from previous two years ($p<0.05$). Only in 2001, species abundance was found varying with seasons and with stations as indicated by high season-station (A*B) interaction ($p<0.05$). In all the years, fish species abundance are season specific as indicated by high season-species interactions (A*C), ($p<0.05$).

In the Kallada river system, seasonal variations were obvious only during 2001. In 2002 and 2003, while the species abundance was not significantly different between seasons ($p>0.05$), however, station wise difference was not negligible in any of the years ($p<0.05$); so also was the abundance with respect to species ($p<0.05$). In all the years, species abundance varied with respect to locations ($p<0.05$). However, species abundance, which was found to be controlled by seasonal variations during 2001 and 2003 has to be investigated further for its nature of periodicity since this phenomenon was not recorded during 2002.

4.3.2. Spatio-temporal similarities in fish assemblages based on species abundance

The dendrogram drawn on group linkage clustering of species based on Bray-Curtis similarity index on standardized 4th root transformed data on fish species has divided the fish species obtained during pre-monsoon season 2001 in Periyar river system, where 50 species were grouped into five clusters (Fig.4.1) of which cluster 1 consist 14 species which has no common station occurrence whereas cluster 2 contained 8 species which inhabited at Bhoothathankettu and Pooymkutty, but all are very rare, with relative abundance <12.15%. Clusters 3 and 4 consist of 11 and16 species respectively. During monsoon 2001, 24 species were grouped into 8 clusters(Fig.4.2) which contained at most 3 species, with highest relative abundance of 73.29% for *Gonoproktopterus kurali* in cluster 3 at Mlappara. All other clusters had elements with relative abundance < 25% except *Tetradon travancoricus* (53.3%) in Kaipra, in cluster 1. *Lepidocephalus thermalis* and *Barilius gatensis* showed co-existance at 5 stations. During post-monsoon season 2001, 9 clusters were formed by the grouping of 43 species (Fig.4.3). All the clusters were characterized by species with low relative abundance (<23%) and the highest observed was for *Barilius gatensis* at Pooyamkutty. Cluster 1 which contained 6 species emerged as the major cluster and it consisted of species present at Mlappara and Pooyamkutty with relative abundance $\leq$ 22.05%.

During pre-monsoon 2002, 48 species encountered in the pre-monsoon season were grouped into 8 clusters (Fig.4.4) with highest relative abundance for the cluster 1 (~ 26.0%). The clusters were formed on the basis of a maximum of 3 stations and all the species showed moderate abundance. *Microphis cuncalus* showed highest abundance at Kaipra (30.17%) which was presented only at this station. 7 clusters were obtained during monsoon of 2002 (Fig.4.5), clubbed based on 22 species and the highest abundance was noted for *Tetradon travancoricus* at Kaipra (95.30%). *Tor khudree* and *Barilius gatensis* showed co-existence in 7 stations and in all the stations their relative abundances were in the range 3-57%. All the clusters showed moderate to high relative abundance. 9 clusters were formed in post-monsoon of 2002 (Fig.4.6) based on 52 species. Clusters 3 and 7 appeared as the major clusters during monsoon while clusters 4 and 6 were the dominant clusters during post-monsoon season.

During 2003, the number of clusters developed on the basis 47 species of pre-monsoon, 27 species in monsoon and 52 of post-monsoon season were 8, 4 and 10 respectively. The dendrogram showing the clustering pattern of fish species in Periyar during the respective seasons of the year 2003 are given in Fig. 4.7-4.9. The major clusters so formed were cluster 1 and 2 of pre-monsoon, clusters 2 and 3 of monsoon, clusters 4, 6 and 9 of post-monsoon season. All the clusters in pre-monsoon accommodated species having low relative abundance (<21%) of which *Labeo nigrescens* and *Osteochilus longidorsalis* showed least values. *Barilius bakeri* showed highest abundance during this season (21%, in Periyar lake). Relatively high relative abundance was exhibited by species clustered during monsoon with the highest value recorded for *Barilius gatensis* at Kundrapuzha and lowest for *Puntius vittatus* at Lower Periyar (1.06%). Low to moderate abundance were shown by the species in post-monsoon season (<35%) and the cluster 6 contained 12 relatively rare species co-existed at Pooyamkutty with a relative abundance <2%. The highest abundance was shown by *Barilius bakeri* at Edamalayar. Stations such as Kundrapuzha and Thannikkudy were inhabited by relatively high abundant species during this season.

Clusters accommodating highly habitat specific species such as *Lepidopygopsis typus*, *Crossocheilus periyarensis* and *Gonoproktopterus micropogon periyarensis* occurred in the pre-monsoon and post-monsoon seasons repeatedly in all the years. Clusters containing *Puntius filamentosus* and *Danio malabaricus* occurred consistently in all the seasons of the three years which showed their high inter-specific relationships, similar habitat requirements and high resistance even to major changes in environment. Occasionally repeating clusters containing *Osteochilus longidorsalis* and *Puntius denisoni*, *Tor khudree* and *Barilius gatensis* etc. showed their grouping at the presence of suitable environmental conditions only. Season specific clusters containing *Tetradon travancoricus* and *Osteobrama bakeri* (monsoon) showed the high seasonal affinity of these species. Generally, the clusters showed repeating tendency between pre-monsoon and post-monsoon seasons while during monsoon, the composition of clusters appeared to be highly unpredictable.

In the Chalakkudy river system, during 2001, 7, 2 and 11 clusters were formed in the respective seasons. The dendrogram showing the clustering pattern of fish species in Chalakkudy during the respective seasons of the year 2001 are given in Fig.4.10-4.12. Of the 7 clusters of pre-monsoon season, cluster 6 contained 9 species which were formed together only at Athirapally while cluster 7 contained three species grouped at two stations, Athirapally and Vazhachal with relative abundance <8%. All the clusters contained species with relative abundance <6% except cluster 6. *Puntius filamentosus* stood first among the species with highest relative abundance (19.9% at Athirapally). Monsoon season is quite different from the other two seasons due to the fact that only two clusters were obtained with 7 species in cluster 1 at Athirapally and Vazhachal and cluster 2 contained 8 species, which occurred together at chalakkudy and Kanakkankadavu with a highest relative abundance of 30% only. *Puntius filamentosus* (37.7%) was the most abundant species and *Puntius ticto* and *Horabagrus brachysoma* were the rare ones in this season. In the post-monsoon season, cluster 9, 10 and 11 contained species with occurrence at 3 stations. Cluster 4 contained 4 species which occurred together only at Athirapally. All other clusters contained species with common occurrence only at 1 station. The highest abundance was recorded for *Osteobrama bakeri* at Kanakkankadavu. However, generally the species in different clusters showed only low abundance during this season.

During 2002, 6, 4 and 5 clusters were formed in the pre-monsoon, monsoon and post-monsoon respectively. The dendrogram showing the clustering pattern of fish species in Chalakkudy river system during the respective seasons of the year 2002 are given in Fig.4.13-4.15. Among the 6 clusters obtained during pre-monsoon, cluster 6 contained 12 species grouped at Athirapally, cluster 3 contained 4 species with common occurrence only at Chalakkudy and Kanakkankadavu. In the 4 clusters obtained during monsoon, 2 contained 3 species occurring at Athirapally and Malkapara with relative abundance < 6.42% while cluster 3 was the most abundant cluster with 13 species with relative abundance < 8% except *Garra mullya* (relative abundance = 16.4%), *Puntius filamentosus* (10.18%) and *Barilius gatensis* (relative abundance = 34.97%), which were the dominant species of this cluster. Cluster 1 contained 6 species with common occurrence at Kanakkankadavu with relative abundance < 6.28% except *Osteobrama bakeri* (relative abundance = 27.36%), *Puntius amphibius* (relative abundance = 36.82%) and *Puntius vittatus* (relative abundance = 13.78%). During post-monsoon season, out of the 5 clusters formed, cluster 2 was the biggest one, containing 8 species with common occurrence at stations Athirapally (relative abundance > 4%), Kuryarkutty (relative abundance > 3%), Orukomban (relative abundance > 6%), Thellikkal (relative abundance > 4.8%) and Vazhachal (relative abundance > 7). Cluster 4 was dominated by *Puntius amphibius* (relative abundance =61%) whereas all the other species of this cluster were rare (relative abundance < 3.64%) cluster 5 with 3 species grouped at 3 stations with relative abundance $\leq$ 9 % except *Rasbora daniconius* at chalakkudy (relative abundance =13.88%) and Pulickakkadavu (relative abundance = 16.21%).

In 2003, 6, 7 and 3 clusters were obtained in the pre-monsoon, monsoon and post-monsoon samples The dendrogram showing the clustering pattern of fish species in Chalakkudy river system during the respective seasons of the year 2003 are given in Fig.4.16-4.18. In pre-monsoon, clusters 2, 3, 5 and 6 contained 4, 13, 6 and 3 species respectively which grouped in common at Athirapally, Vazhachal., only at Athirapally (relative abundance > 2%) and only at Chalakkudy with relative abundance > 2.05% except for *Aplocheilus lineatus* (relative abundance = 0.88%) whose presence was recorded from 3 stations. In the monsoon season, out of 7 clusters, cluster 2 was the biggest one with 9 species occurring in 4 stations having relative abundance $\geq$ 3% with the highest values for *Danio malabaricus* at Malakkappara (29%). Cluster 4 was also a dominant cluster, next to cluster 2, with 8 species which occurred together at 4 stations, but all the species were very rare with relative abundance < 2.01% except *Parambassis dayi* (relative abundance >4.70%) at Chalakkudy, Kanakkankadavu and Tamburrmuzhi. Cluster 4 was followed by cluster 5 with 3 species occurring in common at 3 stations with relative abundance > 1.42% except for *Barilius canarensis* at Chalakkudy (relative abundance = 0.31%). In the post-monsoon period, of the 3 clusters, cluster 2 was the abundant cluster with 10 species but with common occurrence at only two stations, Athirapally (2.11% $\leq$ Relative Abundance $\leq$ 21.88%) and Vazhachal (2.66 $\leq$ Relative Abundance $\leq$ 20.11%). Cluster 1 contained 8 species with occurrence only at one station, Kanakkankadavu (2.44 $\leq$ relative abundance $\leq$ 31.08%). Cluster 3 was a cluster of rare species occurring together only at Athirapally (relative abundance < 4.13%).

Four species viz. *Puntius filamentosus*, *Danio malabaricus*, *Barilius gatensis* and *Garra mullya* were clustered consistently in all the seasons of the study period. This showed their remarkable similarity in abundance and inter-specific associations. Other clusters which showed similarity were between *Puntius fasciatus* and *Barilius bakeri* and *Parambassis dayi* and *Xenentedon cancila*. The relative abundance and the locations by which they were grouped varied from season to season, indicated their high uniformity in distribution throughout the river system. Extremely habitat restricted cluster included clusters of *Puntius jerdoni* and *Esomus thermoicos*. However, no season specific clusters were observed.

In the Kabbini river system, during 2001, 8, 2 and 10 clusters were obtained during pre-monsoon, monsoon and post-monsoon season respectively. The dendrogram showing the clustering pattern of fish species in Kabbini river system during the respective seasons of the year 2001 are given in Fig.4.19-4.21. During pre-monsoon, clusters 1, 2, 4, 5, 6, 7 and 8 contained 4 species (relative abundance > 3.63%), 4 species (relative abundance > 5.07%), 4 species (relative abundance > 2.51%) 2 species (relative abundance $\geq$ 5%), 5 species occurring at 2 stations (relative abundance > 5.37%), 3 species occurring together at 4 stations (relative abundance > 4%) and 4 species occurring together at two stations (relative abundance > 5%). The highest relative abundance was obtained for *Danio malabaricus* at Puthusserikkadavu (45.04%). During monsoon, 2 clusters contained 2 species occurring together at two stations with relative abundance > 11% and 2 species occurring together at 2 stations with relative abundance > 21%. Cluster 2 was the one comprised of abundant species. *Parambassis dayi* was obtained having highest relative abundance (89%, at Pookkode lake). The 10 clusters obtained in the post-monsoon period contained species of high abundance values. Cluster 6 had 2 species occurring together at 3 stations (relative abundance > 5.64%) cluster 7 has 3 species occurring together at 3 stations (3.21 $\leq$ relative abundance $\leq$ 38.49%) cluster 8 with 4 species occurring together at 4 stations with 1.45 $\leq$ relative abundance $\leq$ 29.29% and cluster 9 with 5 species occurring together at 2 stations with relative abundance > 4.29%, except for *Acanthocobitis botia* at Achoor (relative abundance = 2.40%). *Garra gotyla stenorhynchus* (36.9% at Begur) and *Barilius gatensis* (36.20% at Sugandagiri) were seen as the highest abundant species during this season. Cluster 10 was a group of 6 rare species indicated by relatively low abundance values (<3.0%) occurring only at a single station.

In 2002, 10, 7 and 8 clusters were emerged in the 3 seasons viz. pre-monsoon, monsoon and post-monsoon respectively. The dendrogram showing the clustering pattern of fish species in Kabbini river system during the respective seasons of the year 2002 are given in Fig.4.22-4.24. Clusters 1-3 of pre-monsoon were abundant clusters with relative abundance > 12.8%, relative abundance > 6.10% and relative abundance > 9.21% respectively. But these clusters had species occurring together at only one station. Cluster 5 contained 7 species occurring together only at one station with relative abundance > 3.92%. Cluster 7 contained 2 species, which are highly abundant at 4 stations with 4.29 $\leq$ relative abundance 43.57%. Cluster 8 was a group of 4 species present at only 1 station with 0.67% $\leq$ relative abundance $\leq$ 12.19%. Cluster 9 was a group of 3 moderately abundant species coexisting together at 3 stations with relative abundance > 3.01%. *Barilius gatensis* stood as the most dominant species represented by the highest relative abundance (43.57%) at Kunnumpotta. In the monsoon season, out of the 7 clusters obtained, cluster 7 contained 3 species occurring together at 4 stations with very high relative abundance, (14.77% ≤ relative abundance ≤ 50.60%), cluster 6 contained 2 species co-existed at 4 stations with relative abundance, 2.48 ≤ relative abundance ≤ 66.67%, while cluster 5 was a rare species cluster. Clusters 1to cluster 4 contained one species with highest relative abundance 84.55%, 49.03%, 21.70% and 94.26% respectively and very low relative abundance for other species of these clusters indicating that the presence of opportunistic and highly location specific species within them. *Puntius fasciatus* emerged as the most abundant species with a relative abundance of 94.26% at Sugandagiri. In the post-monsoon season, out of the 8 clusters, cluster 7 contained 5 species occurring together at 2 stations with 3.17% ≤ relative abundance ≤ 28.7% at Niravilpuzha and 3.89% ≤ relative abundance ≤ 14.75% at Pozhuthana. Cluster 1 contained 5 species occurring only at one station with 7.21% ≤ relative abundance ≤ 21.62%, cluster 2 contained highly abundant species occurring only at one station 8.97% ≤ relative abundance ≤ 58.48%, cluster 3 was a rare group of species occurring together at 2 stations with 2.25% ≤ relative abundance ≤ 12.08%, cluster 4 was a cluster of moderately abundant species occurring only at one station with 6.71% ≤ relative abundance ≤ 13.48%, cluster 5 contained 6 species occurring together only at one station with relative abundance < 26.55%.

During 2003, 7, 2 and 5 clusters were formed in pre-monsoon, monsoon and post-monsoon season respectively. The dendrogram showing the clustering pattern of fish species in Kabbini river system during the respective seasons of the year 2003 are given in Fig.4.25-4.27. In pre-monsoon season clusters 1-4 contained only 2 species each occurring only at one station with least relative abundance value of 3.58%. Cluster 5 was a reasonably big one with 4 species occurring together at 2 stations with 3.65% $\leq$ relative abundance $\leq$ 20.83%. Cluster 6 contained 6 species, which occurred together at only one station, Begur, with 1.55 $\leq$ relative abundance $\leq$ 16.08%. Cluster 7 contained 3 species, which occurred together at 2 stations with 4.57 $\leq$ relative abundance $\leq$16.38%. In the monsoon season, only 2 clusters were obtained indicating the stability of the environment during this season which is further supported by the existence of high number of species in each cluster. Cluster 1 contained 5 species occurring together at 2 stations, Kunnumpotta (16.46% $\leq$ relative abundance $\leq$ 25.27%) and at MakKilayam (5.57% $\leq$ relative abundance $\leq$ 37.16%). On the other hand, cluster 2 contained 4 species, which also occurred at two stations, Begur (2.64% $\leq$ relative abundance $\leq$ 20.86%) and Muthanga (9.55% $\leq$ relative abundance $\leq$ 29.80%). In the post-monsoon season, out of the 5 clusters, cluster 3 was reasonably big one containing 4 species occurring together at 3 stations viz. Makkilayam (2.94% $\leq$ relative abundance $\leq$ 11.94%), Niravilpuzha (2.49% $\leq$ relative abundance $\leq$ 19.60%) and Vythiri (1.16% $\leq$ relative abundance $\leq$ 15.89%). Cluster 4 contained 6 species, which occurred only at one station, Begur with 3.08% $\leq$ relative abundance $\leq$ 22.85%. Cluster 5 contained 3 species with relative abundance 7.6% to 18.26% , this again occurring only at one station.

Barilius gatensis and *Danio malabaricus* co-existed consistently in all the seasons of the three-year study period. Consistent seasonal clusters of *Schisura semiarmatus* and *Acanthocobitis botia*, *Puntius carnaticus* and *Osteochilus nashi* were appeared in the pre and post-monsoon seasons of respective years. However, no cluster was appeared as strictly season specific. Highly habitat specific clusters represented by 100% relative abundance for species in their respective locations include clusters such as *Silurus wynaadensis* and *Glyptothorax annandalie* (Kattikunnu) and *Labeo kontius* and *Kantaka brevidorsalis* (Muthanga). However, they were present only in pre and post-monsoon periods of 2002 and 2003 respectively.

In Bharathapuzha river system, during 2001, 8, 5 and 7 clusters were delineated in pre-monsoon, monsoon and post-monsoon respectively. The dendrogram showing the clustering pattern of fish species in Bharathapuzha river system during the respective seasons of the year 2001 are given in Fig. 4.28-4.30. which showed the similarity among 52 species, 38 species and 44 species in the respective seasons. Of these clusters 1, 2 and 3 of pre-monsoon, 1 and 4 of monsoon, 1 and 6 of post-monsoon contained abundant species with relative abundance > 20%. In the pre-monsoon season, the highest relative abundance was noted for *Rasbora daniconius* at Tamrachalla (74%) while in monsoon, the highest abundance was shown by *Barilius canarensis* at Choorapara (57%) and in the post-monsoon season, it was for *Danio aequipinnatus* at the same locality (68%).

During 2002, 4, 6 and 7 were the respective clusters obtained during pre-monsoon, monsoon and post-monsoon seasons. The dendrogram showing the clustering pattern of fish species in Bharathapuzha river system during the respective seasons of the year 2002 are given in Fig.4.31-4.33. Of these clusters, clusters 2 and 3 of pre-monsoon, clusters 2, 5 and 6 during monsoon season and clusters 6 and 7 of post-monsoon contained at least 3 species each with relative abundance > 20%. The clusters during monsoon were of moderately abundant (<56%) species and the highest abundance was noted for *Puntius amphibius* at Cheerakuzhi (55%). During monsoon, the clusters comprised of highly abundant species.

During 2003, 7, 6 and 7 clusters respectively were obtained in pre-monsoon, monsoon and post-monsoon seasons. The dendrogram showing the clustering pattern of fish species in Bharathapuzha river system during the respective seasons of the year 2001 are given in Fig.4.34-4.36. Of these, clusters 4 and 5 of pre-monsoon, 1, 3, 4 and 5 of monsoon, 1,3,4 and 5 of post-monsoon showed rare species with relative occurrence < 20%. Cluster 7 of pre-monsoon, 3rd of monsoon and 7 of post-monsoon were formed as the major clusters. Cluster 7 of pre-monsoon, 6 of monsoon and 7 of post-monsoon contained relatively abundant species.

No specific clusters were observed having consistency in all the seasons of all years. However, the association between *Danio malabaricus* and *Garra mullya* were appeared uniformly in 2003. *Cirrhinus mrigala* and *Labeo rohita* were found associated in the pre-monsoon of 2001 and post-monsoons of both 2001 and 2002. *Tor khudree*, *Barilius gatensis* and *Puntius fascaitus* were grouped only during post-monsoon seasons of 2001 and 2002. Hence these two species could be listed as post monsoon species. No specific cluster of species appeared which shows high location affinity.

In the Pamba river system, 9 clusters were obtained during pre-monsoon 2001 (Fig.4.37) of which cluster 8 comprising of 6 species was the biggest as well as the cluster accommodating moderately abundant species among the 9 clusters. All other clusters contained at most 5 species, which may be abundant or very rare indicating the occurrence of the opportunistic species as in clusters 2-6. *Barilius bakeri* registered highest abundance among the species in Pambavalley (48%). In monsoon season, 7 clusters were obtained (Fig.4.38) of which clusters 4 and 6 contained species which occurred in at least 4 stations and at high relative abundance. These clusters consisted of species which are very common in this river system. The other clusters contained species, which are station specific, occurring only at 1 or 2 stations as indicated by the significant station-species specificity in 3-way ANOVA. In the post-monsoon season, 7 clusters of species were demarcated (Fig.4.39) of which cluster 7 was the biggest as well as the widely spread cluster. Cluster 7 was characterized by a set of species showing high abundance in the stations where their presence was reported. This contained species with high relative abundance in the stations in which these occurred. Cluster 4 also contained species which occurred in 4 stations with high relative abundance for *Rasbora daniconius* in all the 4 stations whereas Tor *khudree* occurred with high relative abundance only at Pamba valley.

In 2002, 8, 6 and 6 clusters were obtained in pre-monsoon, monsoon and post-monsoon seasons respectively. The dendrogram showing the clustering pattern of fish species in Pamba river system during the respective seasons of the year 2002 are given in Fig.4.40-4.42. Clusters 1-5, 7 and 8 are clusters with rare species, which occurred only at 1 or 2 stations in the range of 3-11% relative abundance. But cluster 6 contained 10 species which occurred only at Perumthenaruvi with relative abundance in the range 4-13%. *Tor khudree* and *Salmostoma boopis* were the most rare ones (relative abundance < 2 %). In the monsoon season, out of the 6 clusters obtained, cluster 1, the biggest cluster, contained 10 species which occurred at Prayikkara with relative abundance ranging from 1.1 – 3.3%. Clusters 2-4 with 2 species each were all very rare. Cluster 5 contained 3 species which occurred with high relative abundance in 4 stations except *Salmostoma boopis* (< 7%). Cluster 6 contained 7 species occurring together only at Angamuzhi with relative abundance in the range, 4-15% for *Gonoproktopterus curmuca*, *Tor Khudree* and *Barilius bakeri* and relative abundance in the range 9%-32.5% for *Danio aequipinnatus*, *Danio malabaricus*, *Garra mullya* and *Batasio travancoria*. In the post-monsoon season, cluster 6 containing 11 species was the biggest cluster with relative abundance in the range 2.09% - 7.5% for most species and relative abundance in the range 10.54% 22.4% for *Puntius fasciatus*, *Barilius bakeri*, *Danio aequipinnatus* and *Garra mullya*. Clusters 3-5 contained very rare species (relative abundance < 2.9% mostly) cluster 1 with 2 species occurred with moderately high relative abundance (>16.97%) for *Amblypharyngodon microlepis* and low relative abundance, < 8.2% for *Xenentedon cancila* at Mannar and Payippad.

During 2003, 6, 4 and 5 clusters were obtained in the 3 seasons of pre-monsoon, monsoon and post-monsoon respectively. The dendrogram showing the clustering pattern of fish species in Bharathapuzha river system during the respective seasons of the year 2001 are given in Fig.4.43-4.45. Peculiarity of pre-monsoon season was that, cluster 2-4 contained at least 5 species each where highest of 10 species was seen in cluster 2. Of the 5 clusters obtained in monsoon season, cluster 1 contajned 3 species occurring together at 3 stations with relative abundance > 5.45% up to a highest abundance of 70%. In the post-monsoon season, 5 clusters were obtained and comprised of only rare species with relative abundance < 13.5% and, each of these clusters represented not more than 3 species.

Clusters representing the species, (1) *Garra mullya* and *Danio malabaricus*, and (2) *Puntius filamentosus* and *Barlius gatensis* were recorded continuously in all the seasons of all the years, indicating their tolerance to seasonal variations. Clusters containing *Mesonemacheilus guentheri* and *Mesonemacheilus trinagularis*, *Mastacembales armatus* and *Ompok bimaculates* appeared in 2002 and 2003. Clusters formed by (1) *Puntius denisoni* and *Glossogobius giuris* (2) *Mesonemacheilus guentheri* and *Mesonemacheilus tringularis* and (3) *Puntius chola* and *Etroplus maculates* in pre-monsoon 2003, Monsoon 2002 and pre-monsoon 2002 showed extreme habitat specificity, high inter-species association between the clustered species. No clusters were identified as indicators of season specificity.

In the Kallada river system, during 2001, the numbers of clusters obtained are 7, 4 and 9 during pre-monsoon, monsoon and post-monsoon respectively. The dendrogram showing the clustering pattern of fish species in Kallada river system during the respective seasons of the year 2001 are given in Fig.4.46-4.48. All the clusters of pre-monsoon contained rare species with relative abundance < 10% except cluster 4 with contained *Puntius chola* (12%) and *Tor Khudree* (21%) and *Danio aequipinnatus* (26% in Punalur) which were moderately abundant. In monsoon season, clusters 2, 3 and 4 were of abundant species mostly, with relative abundance > 22%. In post-monsoon season, only cluster 6 contained moderately abundant species with relative abundance > 10% and cluster 3 accommodated species with relative abundance varying mostly between 8 and 22%.

During 2002, 9 clusters were obtained during pre-monsoon season (Fig.4.49) of which cluster 9 contained highest number of species (6 species), all with relative abundance > 8% in Punalur and > 7% in Edapalayam. *Puntius filamentosus*, *Barilius bakeri* and *Danio aequipinnatus* showed>14% relative abundance in Neduvannurkadavu. During monsoon, 6 clusters were obtained (Fig.4.50) of which, cluster 3 represented by 8 species was emerged as the major one. During post-monsoon, 4 clusters were obtained (Fig.4.51) of which cluster 4 containing 4 species stood as the major cluster.

During 2003, in pre-monsoon, number of clusters obtained was 4 (Fig.4.52) with cluster 1 containing 6 species, all with abundance > 8% in the Chankili except *Rasbora daniconius* and *Puntius filamentosus* and all in Palaruvi with relative abundance > 10% except *Puntius filamentosus*. During monsoon season, 5 clusters were obtained (Fig.4.53) and contained species with relative abundance > 6% in cluster 1, > 6% in clusters 2 and 3 and > 13% in cluster 4 and ≥ 10% except *Puntius filamentosus* (<6%) in cluster 5. In the post-monsoon season, the fish samples were grouped into 4 clusters (Fig.4.54) of which cluster 3 contained highest number of species (6 species) with highest relative abundance, 34% for *Puntius filamentosus* at Neduvannurkadavu, 12% for *Barilius bakeri* at the same location, 17% for *Barilius gatensis* at chankili and 15% for *Rasbora daniconius* at Neduvannurkadavu and > 26% for *Garra mullya* at Chankili, Palaruvi and Neduvannurkadavu and highest of 32% for *Puntius fasciatus* at Palaruvi.

Cluster 4 comprised of 3 species which had a relative abundance $\geq$ 6% in the stations from where these species were reported.

Species clusters containing *Puntius filamentosus, Rasbora daniconius, Barilius gatensis* and *Garra mullya* showed their repeated consistently in all the seasons of the three years which is indicative of their tolerance to changes in environmental conditions, similar habitat requirements and remarkable similarity in abundance. Their uniform appearance in all the seasons, generally in every river system further shows their clear dominance over the other species. No clusters showed neither seasonal specificity nor strict location specificity.

When the clustering pattern obtained were examined against the altitude/altitudinal range of locations based on which the species were grouped, it was observed that each assemblage (represented by a cluster) occupies definite altitudinal zone for a particular season in a river system. The altitudinal segregation of species clusters obtained from dendrogram in Bray-Curtis similarity studies is shown in Table 4.2. In Periyar river system during 2001, the clusters of species formed in all the three seasons represented distinct altitudinal ranges of inhabitation. However, large number of altitudinal zones which could be distinguished into upper, middle and low land clusters and also several micro habitats (represented by a single altitude or a small altitudinal range) appeared in the pre-monsoon and post-monsoon seasons indicating high habitat diversity and habitat-species specificity during these seasons. Each cluster had limited number of species and the assemblages were more representing the middle and higher altitudes (478-1044m msl), which further confirms the presence of highly specialized habitat-species assemblages in the river system. Comparatively, monsoon season had clusters representing more of the lower altitudes. Highest numbers of species were clustered in the altitudinal range 478-1359 m msl and the specific altitude, 478 m msl (Pooyamkutty) was found repeated in a number of clusters which indicated that a large number of species abound at this location. A more or less similar clustering pattern of species repeated in all the years indicating low inter-annual variability. It is highly evident from the clustering pattern of the species in Chalakkudy river system during 2001 and 2002 that distinct altitudinal segregation of species clusters were obvious in pre-monsoon and post-monsoon seasons where as during monsoon, the clusters represented large habitat ranges accommodating a large number of species. More clusters represented the upper and middle altitudes indicating the existence of distinct habitat species assemblages in the river system. However, in 2003, the monsoon season also represented distinct and specific zones. Athirapally (104m msl), Chalakkudy (24 m msl) and Kanakkankadavu (16 m msl) were found to have high influence in shaping several assemblages in this river system. In Kabbini river system like Periyar and Chalakkudy, the assemblages exhibited high altitudinal segregation in pre-monsoon and post-monsoon seasons of 2001 and 2003. As in the former two, the monsoon season represented minimum number of clusters. However, in 2002, the monsoon season also represented distinct habitat zones for the species assemblages. Generally the clusters were represented by small altitudinal ranges due to the low-level altitudinal segregation of locations. In Bharathapuha river system, a more or less distinct altitudinal segregation of species assemblages were found uniformly in all the three seasons of all the years. The clusters represented more of the middle and downstream habitats, which manifest the deficiency of rare species/highly specific assemblages in this river system. In Pamba river system also, the clusters were represented more by the middle and lower stretches especially, in pre-monsoon and post-monsoon seasons. Seasonal variation in the altitudinal segregation of the assemblages were minimum. Here also, distinct and specialized habitat-species assemblages were minimum. A more or less similar pattern of altitudinal segregation of assemblages like that of Bharathapuzha and Pamba river systems were observed in Kallada river system also in the different seasons of the three year period. Unlike other years, 2001 monsoon season had only limited number of clusters. The clusters were more representing the middle and lower stretches of the river system indicating the absence of moderate to high habitat diversity and distinct habitat linked species assemblages.

4.3.3. Spatial scale similarities in species assemblages based on MDS grouping of station

The Multi-Dimensional Scaling results support the dendrogram studies, revealing the seasonal grouping of stations in different river systems based on species abundance similarities. The MDS analysis carried out for different river systems for the different years and the respective seasons are given in Fig.4.55-4.108. The clustering pattern for stations in different river systems in different seasons and years showed high seasonal variability but relatively low inter-annual variability with the temporal shift. A seasonal comparison based on Bray-Curtis similarity indices of stations in MDS analysis for different river systems is given in Table 4.3. In Periyar river system, of all the years, the clustering pattern of pre-monsoon was more variable spatially than other two seasons. Higher the number of clusters, greater is the environmental variation. The ratio of number of species (S) to number of clusters (C) could be taken as index of the extent of variability in the environment. Both the number of species and the S/C ratio were fluctuated highly between the different seasons and different years but were consistently low during monsoon, which indicated the uniformity of habitats/environment during this season. The number of species clustered during each season, number of species in the major clusters and number of stations based on which the clusters were formed showed high seasonal and inter-annual variation especially between years 2001 and 2003. However, a more or less consistent pattern was observed in 2002. These results justify the significant season-species and station-species interactions in the years 2001 and 2002 as indicated by the 3-way ANOVA mentioned earlier. The biggest clusters were formed based on the occurrence of one or 2 species in all the seasons during 2001 and 2002 in the Periyar river system. In the year 2003, there were clusters during pre-monsoon and post-monsoon seasons with less number of stations grouped based on more number of species.

In Chalakkudy river system, invariably in all years, two clusters were emerged in all seasons which contained 13-14 stations and these stations were clustered based on the highest occurrence of 2 or 3 species. However, in general, the number of clusters formed were less. Similar to river Periyar, here also, clusters with two or three stations were seen with 4-8 common species. The S/C ratio obtained for different seasons of the respective years in Chalakkudy river system showed consistently low values for the post-monsoon season and were generally high during monsoon though numbers of clusters recorded low during this season. There is more uniformity in the number of clusters during the year 2002 and 2003. The number of species grouped in the major clusters and the number of stations based on which the assemblage formed were also differed between the seasons and years indicating the season-station, season-species and station-species interactions are significant, justifying the 3-way ANOVA results.

In Kabbini river system, station clusters recorded more in number during pre-monsoon and post-monsoon seasons. The biggest cluster contained 5-8 stations, clustered based on one or 2 species during 2001 and 2002 while in 2003, only 4-6 stations were clustered during pre-monsoon and post-monsoon seasons based on 1 or 3 species. But in monsoon season of the year, the biggest cluster contained 10 stations. The S/C ratio did not show significant variation among seasons, which showed a stable environment throughout the study period. However, the numbers of clusters were lowest during monsoon indicating the highly stable environment during this season when compared to other seasons. The number of clusters, the number of species in the dominant clusters and the number of stations based on which the species are grouped varied throughout the three-year period.

In Bharathapuzha river system, not much variations were formed in the number of clusters and in all seasons, which varied between 3 and 5. During pre- monsoon, the clusters obtained were containing 6-10 stations based on a single species occurrence. During monsoon, the highest number of stations in the biggest cluster varied between 5 to 13, based on a single species of common occurrence. In the post-monsoon season, the number of stations in the biggest clusters varied between 5 and 8 which were also based on a single species of occurrence. The S/C ratio for different seasons of different years showed a more or less consistent pattern but the number of clusters generally were low during monsoon season indicating the uniformity of habitats during this season. The number of clusters, major clusters, number of species in the major clusters and number of stations based on which they were clubbed showed variation in all the years.

In the Pamba river system, number of clusters were more or less consistent during monsoon season. Pre-monsoon and post-monsoon seasons showed year wise variations. Highest number of stations in a cluster were obtained during monsoon season. In the pre-monsoon and post-monsoon seasons, the clusters of less number of stations were formed based on more number of common species. The S/C ratio followed the same pattern as in river Bharathapuzha. However, the number of clusters formed showed seasonal and annual variation. The number of clusters formed, number of species in the major clusters and the number of stations based on which they were grouped showed least inter-annual variation but high seasonal variations especially in the years 2002 and 2003. This was indicated by the significant season-species and station-species interactions in these years.

In Kallada river system, the number of clusters in all the seasons were highest during the year 2001 and least during 2002 showing distinct inter-annual variability for the common occurrence of species. The number of stations in the biggest cluster varied 2-16 in pre-monsoon, 2-7 in monsoon and 2-7 in post-monsoon. Thus the three-year study in this river system also indicated the possibility of inter-annual variability. More or less similar S/C ratio obtained for different seasons indicated high similarity in environmental conditions. Only in this river system, the number of clusters formed during monsoon season was equal to or higher compared to other seasons. The major clusters, number of species in the major clusters and the stations based on which they were clubbed showed dissimilarity. This was also indicated by the high station-species and season-species interactions in 2001 and 2003 in the 3-way ANOVA exercises. Though the station-species interaction was significant in the year 2002, the number of species in the major clusters did not vary between the seasons and so the season-species interaction effect was not significant.

While segregating the locations based on the altitude, it is obvious that the groups of locations could be differentiated in to distinct zones such as lower, middle and lower stretches of the river systems. The altitudinal segregation of locations obtained in MDS analysis for the different river systems is shown in Table 4.4. In Periyar river system, distinct upper, middle and lower stretches were distinguished in the pre and post-monsoon seasons of the three years while during monsoon, the zonation become comparatively less. Quite remarkably, in Chalakkudy river system, despite the seasonal environmental dissimilarity, the stations were grouped in two altitudinal zones, one representing the lower altitude (16-24 m msl) and other representing a much larger range encompassing the lower, middle and upper stretches (38-1002). Though there was not much variation in altitude between the stations in Kabbini river system, the stations were grouped into distinct altitudinal ranges especially during pre-monsoon and post-monsoon seasons.

Bharathapuzha also followed similar trend as that of Periyar and Chalakkudy having considerably more number of clusters representing distinct altitudinal zones and the same pattern was also followed by Kallada river system except that in 2003, the number of clusters were remarkably low. Same was the case with Pamba river system in 2002 where the clusters were low in number and also represented a very low range of altitudinal segregation. However, in 2001 and 2003, distinct clusters were obtained representing much differentiated altitudes.

4.3.4. Spatio-temporal variation in species Community structure

The fish community structure analyzed in different seasons of respective years in the six major river systems showed highly different patterns for the different indices. The distribution parameters, average value, standard deviation and coefficient of variation of different community structure indices for the different river systems are given in Table 4.5. In Periyar river system, during 2001, average species richness was highest in pre-monsoon season followed by post-monsoon and least during monsoon season. On the other hand, the spatial variability for species richness was least during post-monsoon period. Species concentration was highest during monsoon period followed by post-monsoon period. Species concentration was highly variable during the off monsoon season. Shannon-wiener diversity was least during monsoon period while highest during pre-monsoon period. Spatial variability showed more or less the same pattern over space during the off monsoon seasons. Pielou's index of evenness was found to be more or less of same uniformity in the distribution of individuals among the various fish species. Average number as well as average abundance of species were highest during pre-monsoon season where as the least values were obtained during monsoon. Distribution of individuals and the average abundance of species showed a seasonal influence with least spatial variation for the average number of species during post-monsoon period where as it was in reverse order in the case of spatial variability of the average abundance, being the least during monsoon season followed by pre-monsoon season and highest during post-monsoon period. During 2002, species richness followed the same seasonal trend as that during 2001 with least richness during monsoon and highest richness during post-monsoon season. A steady decreasing trend from pre-monsoon to post-monsoon was observed for species concentration while for species diversity, species evenness, species number and abundance, a steady increase from monsoon to post-monsoon season was observed. Species evenness was observed to be a more consistent parameter to define community structure during this period. In 2003, all the community structure indices steadily increased from monsoon through pre-monsoon to post-monsoon except that of species concentration index which decreased from monsoon to post-monsoon through pre-monsoon or it can be stated that monsoon period showed the least value for all the indices except that of concentration factor where it was highest during monsoon season. During this year also invariably species evenness index was the most consistent index and hence could be suggested to define the structure of the community.

In chalakkudy river system, during 2001, unlike in periyar river system, species richness was highest during post-monsoon season, but not in pre-monsoon season. Species concentration index was almost same in all the seasons with least values during post-monsoon. But spatial variation was very low during monsoon season. Shannon-Weiner index followed the same trend as that of richness with more spatial uniformity during monsoon season. Pielou's evenness index showed a steady increase from the beginning to the end of the year. This index was found to be the highest consistent parameter and hence could be suggested to define the community structure. Average species number decreased from 9. 72 to 5.4 and then increased to 11.28 during the course of the 1-year period. Average abundance was highest during pre-monsoon and minimum during monsoon period. Spatial variation was highest during monsoon season in the case of number of individuals of fish species. During 2002, in Chalakkudy river system, species richness showed a steady decrease during the course of the year from pre-monsoon through monsoon season to post-monsoon with highest spatial variation during monsoon season. In the case of concentration index, a reverse trend was observed seasonally of that in the case of richness. But in the case of diversity, same trend as that of species richness was observed. Species evenness showed a normal pattern of distribution with a peak value during monsoon season. Average species number and average abundance showed opposite trends, the former showed a steady decrease from pre-monsoon to post-monsoon through monsoon period while the latter showed a steady increase. As in Periyar river system, species evenness index is a better index for comparison of seasons, being the most consistent index throughout the year. During 2003, a significant difference for the pattern of distribution was observed in the case of species richness where a steady decrease from pre-monsoon to post-monsoon was observed when compared to previous years where a depression was observed during monsoon season. Pattern of distribution of species concentration was also different from that of previous years. Species diversity was following the same pattern as that of richness during 2003 also. Species evenness followed a pattern diametrically opposite to that of concentration with highest values during monsoon season. Average number of species and average abundance followed the same pattern as that of previous years. In this year, species diversity as well as species evenness were more significant indices of community compared to other community structure defining indices.

In Kabbini river system, during the study period from 2001 to 2003, a steady increase in the species richness was observed from the monsoon period to post-monsoon period through pre-monsoon season. It was about 8 times during post-monsoon season when compared to monsoon period in 2001, while it was twice the value in 2002 and it was only 1.34 times in 2003. During 2001, highest concentration was observed in monsoon season which was same in the case of 2002 and also in 2003. Species diversity was highest during post-monsoon season in 2001 and 2003 and during pre-monsoon season in 2002. Invariably in all the years, monsoon season was least productive. Species evenness followed the identical pattern of distribution of species diversity in the three years of study. Average number of species and average abundance also exhibited the same pattern of seasonal distribution in the years 2001 and 2002 but in 2003, average abundance was highest during monsoon season. As in Periyar and Chalakkudy river system, species evenness was found as a better index for comparison followed by species diversity index, both having the least spatial variation in the three-year study period.

In Pamba river system, during the three years of study, pre-monsoon was observed as the best productive season with respect to the species richness, diversity, evenness and also with respect to the number of species. But with respect to the concentration and average number of individuals, post-monsoon period was observed as the most productive period, showing highest value for these indices. In all the cases of community structure indices, values during post-monsoon period were higher than that of monsoon. During 2002, species concentration was highest during monsoon season while species richness, diversity, evenness, average number of species and average abundance of species were highest during pre-monsoon. During 2003, the pattern of distribution of the community structure indices were same as that of year 2002 indicating that inter-seasonal variability was much higher than the inter-annual variability with peak values observed mostly during pre-monsoon season and the same pattern followed in the successive years with not much significant difference between years as indicated by the 3-way ANOVA mentioned earlier.

In Kallada river system, during 2001, Pre-monsoon recorded highest species richness and diversity, monsoon with higher species concentration, and highest uniformity during post-monsoon period. During 2002, in Kallada river system, it was observed that the seasonal distribution was same as that observed during 2001 however, monsoon season recorded more uniformity in the distribution of the species. Year 2003 differed from that of the previous years with respect to the distribution of species concentration, where post-monsoon was a season with highest species concentration and all other characteristics remained the same as in 2001. In all the years, pre-monsoon season was a period of least spatial variation for the community structure indices.

Since the seasonal variability was found higher than the inter-annual variability, 3-way ANOVA was applied to compare the seasonal variation in fish species abundance in the different river system and the results are given in Table 4.6. The results showed that, in majority of the river systems, the difference in species community structure in each river system was found significantly varying between seasons ($p>0.05$). However, significant inter-annual variations were noted for monsoon season in Chalakkudy, monsoon and post-monsoon in Kabbini, all the seasons in Bharathapuzha and Pamba and in pre-monsoon and monsoon seasons in Kallada. In all the river systems, species-wise difference was highly significant ($p<0.01$) during all the seasons, similar results were also seen in the location wise difference in fish abundance ($p<0.05$).

4.3.5. Step up multiple regression analysis and prediction

1. Periyar river system- Pre-monsoon 2001

Total number of fish species in the 30 stations (y) in the Periyar river system is regressed on latitude (X_1), altitude (X_2) and distance from the sea (X_3) after standardizing the log transformed values of Y and X's to predict Y from X's. The simple model of Y on X alone is determined as

$$z = -0.75169 \times 10^{-5} + 0.09927\, z_1 + 0.4617\, z_2 - 0.87098\, z_3$$

This model could explain only 14.86% of the spatial variation in z where

$$z = \frac{Y'-\overline{Y'}}{\sigma_{Y'}} \text{ and } z_i = \frac{X_i'-\overline{X_i'}}{\sigma_{X'_i}}$$

where

$$Y' = \log_{10}(Y+1)\ ;\ X_i' = \log_{10}(X_i+1);\ i = 1,2,3, F(3,26) = 2.687, (p < 0.05)$$

The model factor could be graded according to their relative importance as X_3 (distance from the sea)> X_2 (altitude) > X_1 (latitude).

Altitude alone could explain only 3.22% of the variability where as distance from the sea could explain 14.67%. Hence a better model is determined by step up method and the model is that of z on z_2 and z_3. The fitted equation is $z = 0.2188 - 0.12457\ Z_2 + 0.61249\ Z_3 - 0.2495\ Z_2Z_3$

This model could explain only 29.16% of the spatial variation in fish abundance, $F(3,6) = 4.9793, (p < 0.05)$. The relative importance of the model variables could be given as distance from the sea > altitude> (distance from sea * altitude).

2. Periyar river system- monsoon 2001

In this case the best model is that of standardised Y on log transformed standardised values. The model fitted using the factors, latitude (X_1), altitude (X_2) and distance from the sea (X_3) alone is,

$$Y' = -0.21652 \times 10^{-4} + 2.8023\ z_1 - 0.39668\ z_2 - 0.3238\ z_3$$

and this model could explain about 29.48% of the spatial variability in fish total abundance, $F(3,26) = 5.0413$ where $Y' = \frac{Y-\overline{Y}}{\sigma_Y}$, $z_i = \frac{X_i'-\overline{X_i'}}{\sigma_{X_i'}}$,

$X_i' = \log_{10}(X_i + 1)$

Model factor are graded as altitude (X_1)> distance from the sea (X_2) > latitude (X_3). In this case latitude could not predict fish abundance ($r = -0.0969$) where as altitude ($r = -0.5503$) and distance from the sea ($r = -0.5402$) could explain about 27.09 % and 26.65% of the spatial variation in the fish abundance respectively. Hence a better model using step up method is determined. The best one is that of y_i on z_1 and z_2. The equation is,

$$y' = 0.1903 + 0.2766\, z_1 - 1.0144\, z_2 - 0.4093\, z_1 * z_2$$

and this model could explain about 41.36% of the spatial variation in fish abundance , $F(3, 26) = 7.8174$. The order of importance of the model factor could be given as, altitude (X_2) > altitude * latitude ($X_1 * X_2$) > latitude (X_1)

3. Periyar river system- Post-monsoon 2001

In this case, the best model obtained is that of standardised $\log_{10}$ transformed $Y(z)$ and standardised $\log_{10}$ transformed $X_i(z_i)$. The simple model of z on z_i alone is

$$z = -0.12763 \times 10^{-4} + 0.1315\, z_1 - 0.12366\, z_2 - 0.1414\, z_3.$$

This could not extract any spatial variation in fish abundance (P> 0.05). The parameters, latitude ($r = 0.0188$), altitude ($r = -0.1879$) and distance from the sea ($r = -0.1929$) could not explain any substantial amount of spatial variation in fish abundance (p> 0.05). Hence the step up multiple regression model is applied. The most suitable model obtained is that of z on z_1, z_2, z_3 and their first order interactions.

The fitted model is

$$z = 0.3343 + 0.30459 z_1 - 0.6845 z_2 + 0.01632 z_3 - 0.3434 (z_1 * z_2) + 0.80719 (z_1 * z_3) - 0.62455 (z_2 * z_3)$$

This model could explain only 6% of the spatial variation which implied that fish species distribution during this season in Periyar river system is controlled by other biotic and abiotic factors $F(6,21) = 1.2919$. Among the model factors, the relatively important model parameters could be arranged as (latitude * distance from the sea) > altitude > (altitude * distance from the sea) > (latitude * altitude) > latitude > distance from the sea. In this case the individual effect of these factors were negligible ($|r| < 0.193, p > 0.05$), F (1,26)< Table value of F at 5% level of significance)

4. Periyar river system- Pre-monsoon 2002

The data on fish abundance during pre-monsoon, monsoon and post-monsoon seasons when subjected to regression analysis showed that the model fitted for z on z_i's is the optimal one when compared to other two forms already mentioned. During pre-monsoon, the optimal model is that of z on $z_1 - z_3$. The fitted equation is

$$z = 0.2403 + 0.2551 z_1 - 0.4737 z_2 - 0.6157 z_3 - 0.7452 (z_1 * z_2) + 0.7731 (z_1 * z_3) - 0.2904 (z_2 * z_3)$$

and this could explain about 22.22% of the spatial variation, $F(6, 23) = 2.3813$, $(p < 0.05)$. It is also observed that the model with altitude and distance from the sea and their first order interaction effect as the input factors also could explain 22.12% of the spatial variation in fish species abundance. In the three factor model, the order of importance of the model factors could be given as (Lat *dist) > (Lat * alt) > distance from the sea >

altitude > (Alt * dist.) > latitude. In the two factor case the order of importance could be given as distance from the sea > altitude > (alt * dist). This showed that since the significance of information is not reduced by removal of the factor latitude, altitude and distance from the sea alone are sufficient to extract 22% of the spatial variation in the fish species' abundance.

5. Periyar river system- Monsoon 2002

In the case of monsoon 2002, highest variability is obtained for the model of z on z_2 & z_3 along with their first order interaction effects. The model equation is $z = 0.2046 - 0.5182\ z_2 - 0.4682\ z_3 - 0.2333\ (z_2 * z_3)$ and this could explain about 47.37% of the variation in the abundance, $F\ (3, 26) = 9.7028, (p < 0.01)$. The order of importance could be given as altitude > distance from the sea > (altitude * distance from the sea). It is also observed that two factor models are better than single factor model as well as the simple model of z on $z_1 - z_3$ alone, emphasizing the fact that first order interactions are also to be ecologically defined and incorporated into the model to extract the maximum information about the fish abundance.

6. Periyar river system-Post-monsoon 2002

In the case of post-monsoon season, as in previous seasons, altitude and distance from the sea were formed as the controlling factors and the model using these two together with their first order interaction effects is obtained as the optimal model. The model can be represented as,

$z = 0.2542 - 0.1626\ z_2 - 0.6186\ z_3 - 0.2899\ (z_2 * z_3)$ and this could explain only 35.14% of the variation $F\ (3, 26) = 6.2378, (p < 0.01)$. The order of importance could be shown as distance from the sea > (altitude * distance from the sea) > altitude. The model using single factor at a time could explain only 0.00% for latitude $(r = -0.1620)$, 2.08% for altitude $(r = -0.2337)$ and 13.85% for distance from the sea $(r = -0.4101)$. The model using $z_1 - z_3$ alone could give only 14.91% of the variability as well as the model on $z_1 - z_3$ and their first order interactions could give only 28.62% of the variations in the fish abundance inferring that altitude and distance from the sea together are to be given due importance in future studies in Periyar river system.

7. Periyar river system- Pre-monsoon 2003

During the pre-monsoon season, the model considered as the optimal one is that of z on z_i, $i = 1, 2, 3$ as described in earlier years. The best model determined for this season is

$z = 0.21668 - 0.5221\, z_2 - 0.3003\, z_3 - 0.2471\,(z_2 * z_3)$ explaining 26.84% of the spatial variation, $F\,(3, 26) = 4.5465$, $(p < 0.05)$. The most important factors appeared as altitude > distance from the sea > (altitude * distance from the sea). The model of z on z_i's alone could give only 13.82%. The model of z on single factors could extract 0.0% for latitude $(r = -0.1190)$, 11.67% for altitude $(r = -0.3836)$, and 18.23% for distance from the sea $(r = -0.4589)$. The two factor models other than the one given above could explain only 16.78%. So also the 3 factor model could explain only 25.91%. Hence it could be concluded that we need to consider only altitude and distance from the sea as the species abundance controlling factors in this season.

8. Periyar river system- Monsoon 2003

During monsoon season, the best model is z on z_2, z_3 and $z_2 * z_3$. The model equation is

$z = 0.2486 - 0.5058\, z_2 - 0.5098\, z_3 - 0.2835\, (z_2 * z_3)$ explaining about 50.27% of the spatial variation in fish abundance, $F\,(3, 26) = 10.7710, (p < 0.01)$. The order of importance of the parameters is, distance from the sea (X_3) > altitude (X_2) > (distance from the sea * altitude). The model of z on z_i's alone could explain 31.46% delineating distance from the sea as the most important factor followed by altitude and then latitude. Hence this analysis implies, distance from the sea - altitude interaction is a better factor to latitude, increasing the efficiency of the model by 19%. The model of z on each z_i independently showed about 2.03% for latitude $(r = -0.2335)$, 21.50% for altitude $(r = -0.4921)$, and 34.98% for distance from the sea $(r = -0.6102)$. Similarly the two factor model explained a maximum of 45.99% other than the one mentioned as the best one. The three factor model could explain only 48.12%.

9. Periyar river system- Post-monsoon 2003

During post-monsoon season, the best model is that of z on z_2 and z_3. The equation is

$z = 0.2699 - 0.6208\, z_2 - 0.06606\, z_3 - 0.3077\, (z_2 * z_3)$ explaining 18.03% of the spatial variations in fish abundance, $F\,(3, 26) = 3.1259, (p < 0.05)$. The order of importance of factors is altitude (X_2)> (altitude * distance from the sea) > distance from the sea (X_3). The model of z on z_i's, $i = 1, 2, 3$ alone as well as that on single factors could explain only 2.28% of the spatial variation. The model with latitude as one of the factors could explain only < 18% of the spatial variation. The simple linear correlations of fish abundance with latitude ($r = -0.0078$), altitude ($r = -0.17840$), and distance from the sea ($r = -0.2378$) were not high.

10. Chalakkudy river system - Pre-monsoon 2001

In this case also standardized log transformed value of fish abundance $Y(z)$ were regressed on standardized log transformed values of the factors latitude (X_1), altitude (X_2) and distance from the sea (X_3). The model fitted using only the individual effects of the input factors, $X_1 - X_3$ is

$$z = -0.37745 \times 10^{-5} + 0.52298\, z_1 - 0.9666 z_2 + 0.9217\, z_3$$

and this function explained about 29.52% of the spatial variation in fish abundance $F(3,14) = 3.3723, (p < 0.05)$. The input factors could be graded as, altitude > distance from the sea > latitude. The factors when independently used for fitting the model, the variability explained were, for latitude, 17.56% ($r = 0.4735$), for altitude ($r = 0.0095$), not significant and for distance from the sea also ($r = 0.2043$) not significant. Hence the step up model using the first order interaction effects of these input factors also is considered. A better model obtained is that of z on z_1 and z_2. The equation is,

$z = -0.1322 + 0.6537\, z_1 + 0.01072\, z_2 + 0.4462\, (z_1 * z_2)$. This model could explain about 31.55% of the spatial variation in the total fish abundance, $F(3,14) = 3.6128, (p < 0.05)$. The order of importance of the model variables is, latitude (z_1) > (latitude * altitude) > altitude (z_2). The best model obtained is that of z on z_1, z_2 and z_3 and their first order interaction effects. The fitted equation is

$$z = 0.1116 + 0.5907\, z_1 - 0.62098\, z_2 + 0.5033\, z_3 + 0.4727\,(z_1 * z_2) - 0.03114\,(z_1 * z_3) - 0.2729\,(z_2 * z_3)$$

This function could explain about 44.82% of the spatial variation in the total fish abundance, $F(6,11) = 3.3012,\ p < 0.05$. The model variables could be arranged as, altitude (z_2) > latitude (z_1) > distance from the sea (z_3) > (Lat * Alt.) > (Alt* Dist.) > (Lat*Dist.). Since the interaction effects are at the extreme end of the order of importance, it could be inferred that the habitat parameters are independently controlling the fish abundance.

11. Chalakkudy river system - Monsoon 2001

The model fitted on the individual effects alone is,

$z = 0.4214769 \times 10^{-5} + 0.5332\, z_1 - 1.0656\, z_2 + 1.0661\, z_3$ and this could explain 38.25%

of the spatial variation, F (3,14) = 4.5106. The order of importance of model factors is, distance from the sea > altitude > latitude. The factors when fitted independently, the explained variability are 19.68% for latitude ($r = 0.4940$), 0.00 for altitude ($r = 0.0421$) and 1.11% for distance from the sea ($r = 0.2632$). These factors when taken in pairs along with their interactions could explain not more than 29.13% of the variability. Hence all these together with their interactions are taken and the model so obtained is,

$$z = 0.3407 + 0.5321\, z_1 - 0.5706\, z_2 + 0.2816\, z_3 + 0.2489\,(z_1 * z_2) + 0.1733\,(z_1 * z_3) - 0.5187\,(z_2 * z_3)$$

This model explained about 55.89% of spatial variation in the fish abundance model, $F(6,11) = 4.5897$. The relative importance of the model factor could be given as altitude (X_2) > latitude(X_1)> (altitude * distance from the sea) > distance form the sea (X_3) > (latitude * altitude) > (latitude * distance from the sea).

12. Chalakkudy river system - Post-monsoon 2001

In this case the same model ie, standardized $\log_{10}$ transformed $Y(z)$ on standardized $\log_{10}$ transformed X_i's (z_i's) is obtained as the best transformation. The model fitted for z on z_i's alone is

$z = -0.32628\times10^{-5} + 0.3943\, z_1 - 1.0003\, z_2 + 1.3108\, z_3$. This explained 48.92% of the spatial variation $F(3,14) = 6.4266$ (p<0.01). The factors X_1, X_2 and X_3 when considered independently could explain only 15.11% for latitude ($r = 0.4483$), 2.3362 for altitude ($r = 0.2843$) and 23.36% for distance from the sea ($r = 0.5281$). When considered in pairs along with their first order interactions, could explain only a highest of 69.80% (by altitude and distance from the sea, In the other two cases, it is < 28.84%). The model with the three factors and their first order interactions is,

$$z = 0.7197 + 0.2758\, z_1 - 0.2889\, z_2 - 0.06535\, z_3 + 0.05728(z_1 * z_2) + 0.2009(z_1 * z_3) - 0.8889(z_2 * z_3)$$

This model could explain about 76.23% of the spatial variations. $F(6,11) = 10.0858$. The model factors could be arranged as, (altitude * distance from the sea) > altitude (X_2) > latitude (X_1) > (latitude * distance from the sea) > distance from the sea (X_3) . (latitude * distance from the sea

13. Chalakkudy river system-Pre-monsoon 2002

Invariably in all the seasons during this year, the model is fitted for z on z_i's as in the case of 2001. During pre-monsoon season the best model is that of z on z_i's and their first order interactions. The model can be represented as,

$$z = 0.1968 + 0.6254\,z_1 - 0.7042\,z_2 + 0.3642\,z_3 + 0.7325\,(z_1 * z_2) - 0.4396\,(z_1 * z_3) - 0.3290\,(z_2 * z_3)$$

and this could explain about 59.68% of the spatial variation in fish abundance, $F\,(6, 11) = 5.1930, (p < 0.01)$. The model variables could be arranged as, (Lat * Alt) > altitude > latitude > (Lat * dist) > distance from the sea > (Alt * dist.) simple linear model on $z_1 - z_3$ alone could explain only 37.03% where as the single factor models could explain 19.01% for latitude $(r = 0.4875)$,0.0% for altitude $(r = -0.0957)$ and 0.0% for distance from the sea $(r = +0.1124)$. Similarly, the two factor models along with their first order interactions could explain only to a highest of 32.71% (latitude and altitude and latitude * altitude). Hence, in this case it is confirmed that the three factors and their first order interactions should be considered in order to get the highest information about the fish species' abundance.

14. Chalakkudy river system- Monsoon 2002

During monsoon season, the optimal model is that of z on $z_1 - z_3$ and their first order interaction effects. The equation so obtained is

$$z = 0.33096 + 0.5987\,z_1 - 0.3246\,z_2 - 0.06960\,z_3 + 0.5743\,(z_1 * z_2) - 0.23848\,(z_1 * z_3) - 0.4889\,(z_2 * z_3)$$

with an explained variability of 48.95%, $F\,(6, 11) = 3.7177, (p < 0.05)$. The order of importance of parameters of the model is latitude > (Lat. * Alt.) >

(Alt. * distance from the sea) > altitude > (Lat. * Dist.) > distance from the sea. The model based on $z_1 - z_3$ alone could explain about 32.95% indicating the importance of the first order interactions by the enhancement in the explained variability of 16%. Also the model of z on z_i, $i = 1, 2, 3$, alone were significant only in the case of latitude ($r = 0.5209$, V.E.=22.58%). Similarly model of z on z_i, z_j & $z_i * z_j, i \neq j,\ i, j = 1, 2, 3$ could explain only a maximum of 32.95% (latitude and altitude). This justifies the superiority of the 3 factor model over lower numbered factor models.

15. Chalakkudy river system-Post-monsoon 2002

During post-monsoon season, also the best model is that of z on $z_1 - z_3$ and $z_i * z_j, j \neq i,\ i, j = 1, 2, 3$. The fitted model is

$$z = 0.4877 + 0.5260 z_1 - 0.5650 z_2 + 0.5914 z_3 + 0.1060 (z_1 * z_2) + 0.2385 (z_1 * z_3) - 0.6561 (z_2 * z_3)$$

explaining about 59.08% of the spatial variation in the fish species' abundance distribution, $F\ (6, 11) = 5.0902, (p < 0.01)$. The order of importance of the models factors could be given as (Alt. * Dist.) > altitude > latitude > (Lat. * Dist.) > (Lat. * Alt.) > distance from the sea. The model of z on $z_1 - z_3$ alone could explain 42.98% of the spatial variation whereas model on z_i, $i = 1, 2, 3$, could not explain more than 22.13%.(latitude ($r = 0.5160$) of the spatial variability. Similarly, the model on z_i, z_j $z_i * z_j$, $i \neq j$ were inferior to the 3 factor model since the highest explained variability is 36.15% (altitude and distance from the sea and Alt.* dist).

16. Chalakkudy river system- Pre-monsoon 2003

During pre-monsoon and post-monsoon seasons, the model is fitted for z on $z_i's$, $i = 1, 2, 3$ whereas during monsoon the model is fitted for Y' on $z_i's$ where Y' and z_i are defined earlier. During pre-monsoon season the best model is obtained as that of z on z_1, z_2 *and* z_3 alone. The fitted equation is,

$z = -0.29770 \times 10^{-4} + 0.5486\, z_1 - 0.7925\, z_2 + 0.9518\, z_3$ explaining 34.78% of the spatial variation in fish abundance, $F(3, 14) = 4.0229, (p < 0.05)$. The order of importance of the factors is, distance from the sea > altitude > latitude. The model of z on z_i alone could extract 22.83% in the case of latitude ($r = 0.5231$), 0.0% in the case of altitude ($r = 0.2067$), and 9% in the case of distance from the sea ($r = 0.3860$). The two factor models along with their interactions could extract a highest of 23.73% (latitude and distance from the sea) and the one containing altitude along with (1) latitude and (2) distance from the sea could extract only 26.10%. This suggests that the individual effects of the taken habitat factors are contributing more to the ecosystem than the interaction effects.

17. Chalakkudy river system- Monsoon 2003

During monsoon the model is fitted for Y' on $z_i, i = 1, 2, 3$. The best model obtained is that of z on z_1, z_2, z_3 and their first order interactions. The equation is,

$$Y' = 0.5768 + 0.2702\, z_1 - 1.2228\, z_2 + 0.3331\, z_3 - 0.2632\,(z_1 * z_2) + 0.3213\,(z_1 * z_3) - 0.6582\,(z_2 * z_3)$$

explaining 64.04% of the spatial variation in fish abundance, $F(6,11) = 6.0447$, $(p < 0.05)$. The model of Y' on $z_i's$ alone expalined 57.94% delineating altitude as the most important factor. The model of Y' on z_1, z_2 and z_3 separately could extract 0.0% for latitude $(r = 0.2403)$, 9.03% for altitude $(r = -0.3792)$, and 0.0% for distance from the sea $(r = -0.0573)$. The two factor models which explained the highest variability is that of Y' on z_2, z_3 and $z_2 * z_3$ and it could extract 62.12% variability with altitude followed by altitude * distance from the sea and distance from the sea as the relatively most important factors. This shows that interaction effects are more important than the individual effects.

18. Chalakkudy river system- Post-monsoon 2003

During post-monsoon season, the best model obtained is that of z on $z_i's$ and their first order interactions. The fitted equation is,

$$z = 0.2906 + 0.5905\, z_1 - 0.4507\, z_2 + 0.4266\, z_3 + 0.4365\,(z_1 * z_2) - 0.009319\,(z_1 * z_3) - 0.4588\,(z_2 * z_3)$$

explaining 71.28% of the spatial variation in fish abundance, $F(6,11) = 8.0336$, $(p < 0.01)$. The model factors are graded based on their significance as latitude (X_1) > (Alt. * Dist.) > altitude (X_2)> (Lat. * Alt.) > distance from the sea (X_3)> (Lat. * Dist.). The model of z on $z_i's$ alone could explain 49.95% whereas z on z_1, z_2, z_3 separately could extract, 26.90% for latitude $(r = 0.5586)$, 0.73% for altitude $(r = 0.2564)$, and 17.14% for distance from the sea $(r = 0.4692)$, whereas the two factor models could explain a highest of 42.08% (latitude and distance from the sea). This model further emphasizes the fact that interaction effects are better than single factor effects during this season.

19. Kabbini river system- Pre-monsoon 2001

In this case the model obtained as the best one is that of standardized Y (Y') on standardized X_i (X_i'). The fitted equation is,

$Y' = 0.150406 \times 10^{-4} - 0.53459\, X_1' + 0.1681\, X_2' + 0.4609\, X_3'$. This explained only 16.85% of the variations over stations, F (3,20) = 2.5540 (p<0.05). The model fitted taking these factors each one independently could explain only 0.28% for latitude $(r = -0.2148)$, 0.00% for altitude $(r = 0.1024)$ and 6.01% for distance from the sea $(r = 0.3177)$. Similarly the model with two factors and their interaction effects as input model variables could not explain even 5% variability in species abundance pattern, except the one obtained as the best one. The best one obtained is that of Y' on X_1' and X_3' (distance) and it is

$$Y' = -0.03175 - 0.5128\, X_i' + 0.5398\, X_3' + 0.07121\,(X_1' * X_3')$$

This model could explain about 15.52% of the spatial variability in abundance. $F\,(3, 20) = 2.4077, (P < 0.05)$. The relatively important factors are distance > latitude > (Lat * distance). This study hence suggests that altitude is a factor superior to latitude *Distance from the sea) as indicated by the enhanced explained variability in the former case).

20. Kabbini river system- monsoon 2001

The best model is that of z on z_i, $i = 1, 2, 3$. The one containing these factors namely z_1 (latitude), z_2 (altitude) and z_3 (distance from the sea) could explain no spatial variation $(P > 0.05)$. Similarly latitude and altitude could not control the fish abundance to a significant level (V.E = 0 for latitude and V.E = 0.5% for altitude).

But the one with distance from the sea alone as the input factor could explain 16.32% of the spatial variation in fish abundance $F(1, 22) = 1.3815$. The model is $z = 0.74382 \times 10^{-6} + 2.4306\, z_3$. Hence distance from the sea is the most important factor compare to the other two.

21. Kabbini river system- Post-monsoon 2001

In this case the best transformation is only standardization for both $Y\,(Y')$ and X_i's (X_i') $i = 1,2,3$, for latitude, altitude and distance from the sea respectively. The fitted model is,

$Y' = 0.60998 \times 10^{-5} - 0.1029\, X_1' + 0.6123\, X_2' + 0.04131\, X_3'$ and this could explain about 23.32% of the variability in fish abundance over the sampled stations, $F(3, 14) = 2.7231$. The model with the factors taken one at a time could explain only 0.00% for latitude $(r = 0.1467)$, 31.73% for altitude $(r = 0.5979)$ and 13.88% for distance from the sea. The best model obtained is that of Y' on X_1', X_2' and $X_1' + X_2'$. The fitted equation is,

$$Y' = -0.2923 - 0.2155\, X_1' + 1.0552\, X_2' + 0.7076\,(X_1' * X_2')$$

This could explain about 49.56% of the spatial variability in fish abundance, $F(3, 14) = 6.5672$. The order of importance is altitude > (Alt. * Lat.) > latitude.

22. Kabbini river system-Pre-monsoon- 2002

During the three seasons, the model is fitted for standardized Y, $Y' = \dfrac{Y - \overline{Y}}{\sigma_Y}$ on standardized X, $\overline{X}_i' = \dfrac{X_i - \overline{X}_i}{\sigma_{X_i}}$, $i = 1, 2, 3$ except post-monsoon season where the model is fitted for z on z_i's as discussed earlier. During pre-monsoon season, the best model is that of Y' on X_1', X_2' *and* X_3' only. The model equation is

$Y' = 0.618096 \times 10^{-5} - 0.39026\, X_1' - 0.07529\, X_2' - 0.4816\, X_3'$ and this expalined only 8.89% of the spatial variations in fish abundance, $F(3, 19) = 1.7157, (p < 0.10)$. All other models, which included all combinations of the three factors are significant, $(p < 0.01)$. In this significant case the factors could be graded as distnce from the sea > latitude > altitude. These three factors are correlated with the total fish species abundance with r values, -0.2154 for latitude, -0.0430 for altitude and 0.2621 for distance from the sea.

23. Kabbini river system- Monsoon 2002

During monsoon season, the best model is that of Y' on X_1', X_3' and its interaction effect. The fitted equation is ,

$Y' = 0.10862 - 0.2881\, X_1' + 0.42397\, X_3' - 0.2395\, (X_1' * X_3')$ with 17.10% of the spatial variation being explained by this model, $F(3, 19) = 2.5145$ (p<0.05). The model of Y' on X_1'–X_3' alone could explain 16.71% of the spatial variation in fish species abundance, $F(3, 19) = 2.4711$. The model of Y' on $X_i', i = 1, 2, 3$ could explain not more that 3.36% since these factors are very feebly correlated with fish abundance ($r = -0.2415$, for latitude, $r = -0.1385$, for altitude and $r = 0.2784$, for distance from the sea). In this case also a two-factor with interaction effect is found to be the optimal one and for this model the order of factors could be arranged as, distance from the sea > latitude > (Lat. * distance from the sea).

24. Kabbini river system- Post-monsoon 2002

During post-monsoon season, the best model is that of z on z_3 alone and the fitted equation is $z = 0.115079 \times 10^{-5} + 0.49044\, z_3$ explaining a highest variability of 20.44%, $F\,(1, 21) = 6.6519$, $(p < 0.01)$. The model of z on $z_1 - z_3$ alone could extract only 12.93% of the variation in the fish abundance. The model on z_1 and z_2, independently extracted only 0.0% for latitude $(r = 0.1507)$ and 2.87% for altitude $(r = 0.2698)$. The model of z on $z_1 - z_3$ and $z_i * z_j$, $i, j = 1, 2, 3, i \neq j$ is not significant in this case also.

25. Kabbini river system- Pre-monsoon 2003

During pre-monsoon season the model fitted is that for Y' on X_i' where $Y' = \dfrac{Y - \overline{Y}}{\sigma_Y}$ and $X_i' = \dfrac{X_i - \overline{X_i}}{\sigma_{X_i}}$. The best model obtained is that of Y' on X_1', X_2', X_3' alone without interaction effects. The model equation is

$Y' = 0.73550 \times 10^{-6} - 0.4076\, X_1' - 0.01212\, X_2' + 0.3721\, X_3'$, explaining 4.46% of the spatial variation. No other model is better than this implying that the fish habitat in this river system is controlled by other abiotic and biotic factors The linear correlations of abundance with latitude $(r = -0.2481)$, altitude $(r = -0.0546)$, and distance from the sea $(r = 0.1807)$ are insignificant.

26. Kabbini river system- Monsoon 2003

During monsoon season, the model is fitted for z on z_i's as described earlier. The best model is that of z on z_3, the equation is $z = 0.93007 \times 10^{-6} + 0.2512\, z_3$ and this could also explain only 2.05% of the spatial variations in fish abundance. Since all other models are inferior to this it could be inferred that during this season also other factors such as food availability, water current, nature of substratum, etc. are controlling the fish abundance of this river system. The linear correlations of abundance with latitude $(r = -0.0057)$, altitude $(r = 0.1394)$, and distance from the sea $(r = 0.2512)$ are not high.

27. Kabbini river system- Post-monsoon 2003

During post-monsoon season also the model is fitted for z on z_i's and the best one is obtained as that of z on z_3. This again could explain only 0.84% of the spatial variation. Hence invariably in all the three seasons Kabbini river system is being controlled by habitat factors other than these considered at present.

28. Bharathapuzha river system- Pre-monsoon-2001

Here the best transformation obtained is standardization of $\log_{10}$ values of both Y and X_i's, $i = 1, 2, 3$. The simple multiple regression model fitted is,

$z = -0.50492 \times 10^{-4} - 0.10987\, z_1 - 0.17749\, z_2 - 0.45889\, z_3$, explaining about 34.77% of the spatial variation in Y, $F\,(3, 25) = 5.9744, (p < 0.05)$.

The factors are arranged as distance from the sea > altitude > latitude. The simple linear model of z on z_i, independently considered, showed that only 2.21%, 23.97% and 33.35% of the variability could be explained by latitude $(r = -0.2389)$, altitude $(r = -0.51661)$ and distance from the sea $(r = -0.5978)$. The model fitted by taking the input factors in pairs, along with their first order interaction could not explain more than 33.93% of the variability in fish abundance and the best model is a three factor model and it is

$z = 0.0042273 - 0.1044\, z_1 - 0.5864\, z_3 - 0.05075\, (z_1 * z_3)$ explaining about 33.93% of the spatial variability $F\,(3, 25) = 5.7956, (p < 0.05)$. It is further inferred that in future studies we need not consider altitude and latitude and distance from the sea together. Distance from the sea alone would be sufficient to extract 33.35% of the information about the spatial distribution of fish species total abundance. The order of importance of variables could be written as distance from the sea > latitude > (dist. * lat.). This study further emphasizes that more the number of independent variables, more is the explained variability is ruled out.

29. Bharathapuzha river system- Monsoon 2001

The model is fitted for z on z_i's, $i = 1, 2, 3$ for latitude (X_1), altitude (X_2) and distance from the sea (X_3). The linear multiple regression model fitted for z on z_i's alone is

$z = -0.45003 \times 10^{-4} - 0.09734\, z_1 - 0.3167\, z_2 - 0.2129\, z_3$ explaining 20.09% of the spatial variability in fish species abundance, $F\,(3, 25) = 3.3465, (p < 0.05)$. The model with only one factor at a time could explain only 0.7% for latitude $(r = -0.2003)$, 17.06% for altitude $(r = -0.4758)$ and 17.52% for distance from the sea $(r = -0.4525)$. The corresponding value for the models containing 2 independent factors and their first order interaction effects were not greater than 19.5%. Also the three-parameter model is found inferior to these. Hence the one selected as the optimal one is the model based on altitude alone. The equation is $z = 2.1877 \times 10^{-7} - 0.4758\, z_1$, explained variability =19.77%, $F\,(1, 27) = 7.9002$.

30. Bharathapuzha river system- Post-monsoon 2001

In this case also, the model is fitted for z on z_i's as in earlier cases. The single factor models could explain only 0.0% for latitude $(r = -0.1146)$,17.64% for altitude $(r = -0.4537)$ and 15.57% for distance from the sea $(r = -0.4311)$. Among the higher factor models, the model for z on z_2 and z_3 is obtained as the optimal. The model equation is $z = 0.13596 - 0.18835\, z_2 - 0.3335\, z_3 - 0.1861\,(z_2 * z_3)$ and this could explain about 21.23% of the spatial variability in fish species abundance, $F\,(3, 25) = 3.5152, (p < 0.05)$. Even the three factor model could explain only 16.7% of the spatial variations, the order of importance of the model variables could be recorded as distance from the sea (X_3)> altitude (X_2)> (distance from the sea * altitude).

31. Bharathapuzha river system-Pre-monsoon 2002

In this river system during the three seasons, the model fitted is for z on z_i's, $i = 1, 2, 3$, as described earlier during pre-monsoon season, the best model is that of z on z_3 only and it is $z = 1.79060 \times 10^{-7} + 0.3211\, z_3$ and explained only 6.99 % of the spatial variation in fish abundance $F\,(1, 27) = 3.1039, (p < 0.05)$ whereas all other models are inferior to this model. It might be due to the low linear correlation for fish abundance with the factors, latitude $(r = 0.1276)$, altitude $(r = -0.2962)$, and distance from the sea $(r = -0.3211)$.

32. Bharathapuzha river system-monsoon 2002

During monsoon season the best model is that of z on z_i's and their first order interaction effects. The fitted model is

$$z = 0.08835 - 0.02344\, z_1 - 0.5351\, z_2 - 0.07888\, z_3 + 0.07447\, (z_1 * z_2) - 0.2664\, (z_1 * z_3) - 0.09376\, (z_2 * z_3)$$

explaining about 39.43% of the spatial variation in fish abundance, $F\,(6, 22) = 3.9886$, $(p < 0.05)$. The relative importance of the model factors could be arranged as altitude (X_2)> (latitude * distance from the sea) > (altitude * distance from the sea) > distance from the sea (X_3)> (latitude * altitude) > latitude (X_1). The model of z on z_i's alone could extract 30.04% with altitude as the most important factor. The single factor model could explain 0.0% for latitude $(r = -0.1005)$, 34.36% for altitude $(r = -0.6058)$, and 18.10% for distance from the sea $(r = -0.4585)$. The two factor model along with their first order interactions could extract about 38.68% (latitude and altitude). Hence it could be suggested that since the increment in the explained variability for model with 3 factors is very minimum (0.36%) the fish abundance could be predicted based on latitude and altitude alone in this season and considering the cost of collection of the data involved, the variable, distance from the sea could be skipped during data collection.

33. Bharathapuzha river system-Post-monsoon 2002

During post-monsoon season, the best model is that of z on z_i's, $i = 1, 2, 3$ alone. The equation is

$z = -0.58410 \times 10^{-4} - 0.1244\, z_1 - 0.5752\, z_2 + 0.06093\, z_3$, explaining about 38.78 % of the spatial variation in the fish abundance, $F\,(3, 25) = 6.9008$, $(p < 0.05)$. The model of z on z_i alone taken one at a time could explain only, 3.28% in the case of latitude ($r = -0.2595$), 36.71% in the case of altitude ($r = -0.6247$), and 21.36% in the case of distance from the sea ($r = -0.4916$). Similarly the model of z on z_i, z_j and $z_i * z_j, i \neq j, i, j = 1, 2, 3$ could extract a highest of 38.57% (latitude, altitude) whereas the 3 factor model could give only 35.32%. In the best model case, the contribution of the factors could be graded as altitude (X_2) > latitude (X_1) > distance from the sea (X_3).

34. Bharathapuzha river system- Pre-monsoon 2003

During pre-monsoon the model fitted is for Y' on $X_i', i = 1, 2, 3$. The best model is that of Y' on X_1' and X_3'. The equation is,

$Y' = 0.01462 + 0.1387\, X_1' - 0.3126\, X_3' - 0.2711\,(X_1' * X_3')$ explaining 10.08% of the spatial variation in fish abundance, $F(3, 25) = 2.046,\ (p < 0.05)$. The model of Y' on $X_1' - X_3'$ could extract only 3.34% whereas that on $X_1 - X_3$ separately could extract only 0.0% for latitude ($r = 0.1073$), 7.26% for altitude ($r = -0.3250$), and 7.84% for distance from the sea ($r = -0.3337$). The other two factor models and the three factor model could explain only a maximum of 7.08% for latitude and altitude.

35. Bharathapuzha river system- Monsoon 2003

During monsoon period, the model fitted is that of Y' on $X_i', i = 1, 2, 3$. The best model is that of Y' on $X_1' - X_3'$ and their first order interactions. The equation, is

$$Y' = -0.6303 - 0.09646\, X_1' - 0.7331\, X_2' - 0.2760\, X_3' - 0.2608\,(X_1' * X_2') - 0.1536\,(X_1' * X_3') + 0.8012\,(X_2' * X_3')$$

explaining 22.32% of the spatial variability in fish species abundance, $F\,(6, 22) = 2.3410,\ (p < 0.05)$. The order of importance is (altitude * distance from the sea) > altitude > distance from the sea > (latitude * altitude) > (latitude * distance from the sea) > latitude. The model of Y' on $X_1'-X_3'$ alone could extract only 2.12% and also that of Y' on X_1', X_2', X_3'. Separately could extract 0% for latitude $(r = -0.0311)$ and altitude $(r = -0.1390)$, and 5.44% for distance from the sea $(r = -0.2969)$ justifying the importance of the first order interactions. The two factor models could also extract a maximum of 16.72% (altitude and distance from the sea as the input factors along with their interactions).

36. Bharathapuzha river system- Post-monsoon 2003

During post-monsoon season, the model is fitted for z on $z_i, i = 1, 2, 3$. The best model is that of z on z_2. The equation is $z = 0.49918 \times 10^{-6} - 0.2475\, z_2$ and this could explain only 2.64% of the variations in fish species abundance, $F\,(1, 27) = 1.7615,\ (p < 0.05)$. No other model is significant implying that there are other habitat factors controlling fish abundance in this river during post-monsoon season because linear correlation of fish abundance with latitude $(r = -0.0869)$, altitude $(r = -0.24750)$, and with distance from the sea $(r = -0.10018)$ are very meager.

37. Pamba river system- Pre-monsoon 2001

In this case, the model is based on standardized $\log_{10}$transformed $Y\,(z)$ on standardized $\log_{10}$transformed $X_i's\,(z_i), i = 1, 2, 3$ for latitude, altitude and distance from the sea respectively. The model of z on $z_i's$ alone is,

$z = -0.87858 \times 10^{-7} - 0.01575\, z_1 - 0.4751\, z_2 + 1.1353\, z_3$. This could explain about 41.53% of the spatial variation in fish species abundance, $F\,(3,16) = 5.4987$, (p<0.05). The relative importance of the parameters of model is distance > altitude > latitude.

Model based on single factor effects could explain only 0.0% for latitude $(r = -0.0364)$,30.69% for altitude $(r = 0.5861)$ and 44.97% for distance from the sea $(r = 0.6919)$. The model based on two factors taken at a time along with their first order interactions could explain not more than 45.17%. The model based on all the three factors and their interaction effects is,

$$z = 0.9230 + 0.001677 z_1 + 0.8952 z_2 - 0.5419 z_3 + 0.1370(z_1 * z_2) + 0.2469(z_1 * z_3) - 0.9773(z_2 * z_3)$$

and this explained only about 46.56% of the variations in fish abundance over the study area, $F\,(6,13) = 3.7579, (p < 0.05)$. The model factors could be graded based on their relative importance as (altitude * distance from the sea) > altitude (X_2) > distance from the sea (X_3) > (latitude * distance from the sea) > (latitude * altitude) > latitude (X_1).

38. Pamba river system - Monsoon 2001

The model based on the same transformation as applied in pre-monsoon season is obtained as the best model in this case also. The model with individual factor effects as the inputs as well as that with factors taken one at a time and that with two at a time along with their first order interactions are obtained as inferior models $(p > 0.05)$ to the model based on all the three factors along with their first order interactions. The best model is,

$$z = 1.49706 + 0.2592\,z_1 + 2.1066\,z_2 \quad 2.6651\,z_3 - 0.6326\,(z_1 * z_2) + 1.3852\,(z_1 * z_3) - 1.5770\,(z_2 * z_3)$$

and this model could explain only 21.81% of the spatial variation in fish abundance, $F\,(6,13) = 1.8834, (p < 0.05)$. The model factors could be arranged as, distance from the sea (X_3) > altitude (X_2) > (altitude * distance from the sea) > (latitude * distance from the sea) > (latitude * altitude) > latitude (X_1).

39. Pamba river system- Post-monsoon 2001

The model is fitted on z and z_i, $i = 1, 2, 3$ values of factors already stated simple regression model of z on z alone is

$z = -0.31072 \times 10^{-5} + 0.04848\,z_1 - 0.52801\,z_2 + 1.1840\,z_3$ and this model explained 42% of the spatial variation in fish species abundance with significance, $F\,(3,16) = 5.6073$ at 5% level, $(p < 0.05)$. The model variables could be arranged as distance from the sea (X_3) > altitude (X_2) > latitude (X_1). The linear model of z on variables z_i, fitted independently showed that 0.0%, 29.60% and 44.59% are the variability explained by latitude $(r = 0.248)$, altitude $(r = 0.5771)$ and distance from the sea $(r = 0.6893)$. The best model for predicting fish abundance is that of z on z_2 and z_3 and its interaction effect. The fitted function is

$z = 0.7616 + 0.5821\,z_2 - 0.1850\,z_3 - 0.8151\,(z_2 * z_3)$ and this could explain 55.69% of the spatial variability in the fish abundance, $F\,(3,16) = 8.9624$. The relative importance of the model factors is (altitude * distance from the sea) > altitude > distance from the sea: The model in which all the three factors and their interaction effects are considered is inferior to this model stating that in future studies only altitude and distance from the sea are to be taken as the directly measured variables.

40. Pamba river system-Pre-monsoon 2002

During Pre-monsoon season, the model for standardized Y, $Y' = \frac{Y - \overline{Y}}{\sigma_Y}$ on standardized $\log_{10}$ transformed X_i's, $z_i = \frac{X_i' - \overline{X_i}}{\sigma_{X_i}}$ where $X_i' = \log_{10}(X_i + 1)$ is the optimal model form. The best model obtained in this season is the simple linear multiple regression of Y' on z_i's, $i = 1, 2, 3$ alone. The model equation is

$Y' = -0.1167 \times 10^{-1} + 0.2241\, z_1 - 0.5865\, z_2 + 1.0966\, z_3$ and explained about 26.76% of the station wise variation in the fish species abundance, $F(3, 16) = 3.3113, (p < 0.05)$. The linear models of Y' on z_i alone could explain only 0.0% for latitude $(r = 0.1965)$, 14.24% for altitude $(r = 0.4330)$, and 25.51% for distance from the sea $(r = 0.5425)$ whereas the two factors and their interaction models could not predict the fish species abundance with prediction efficiency more than 23.28% (for latitude and distance from the sea as the input factors). This shows that distance from the sea is the most important factor as given by the relative importance in the best model; distance from the sea > altitude > latitude.

41. Pamba river system-monsoon 2002

During monsoon season the best model is that z on z_i's, $i = 1, 2, 3$, and their first order interaction effects. The fitted equation is,

$$z = 1.00256 + 0.0852\, z_1 + 0.5439\, z_2 - 0.7182\, z_3 + 0.9899\,(z_1 * z_2) - 0.4067\,(z_1 * z_3) - 1.0610'(z_2 * z_3)$$

explaining about 29.54%, $F(6, 13) = 2.3274, (p < 0.05)$. The model factors are arranged according to their contribution in the model as (Alt. * dist.) > (Lat. * Alt.) > distance from the sea > altitude > (Lat.* dist) > latitude. No other model is significant to predict fish abundance in this season (p>0.5) other than the simple linear multiple regressions made of z on z_i's, which explained only 2.4% and the one on z_2 and z_3 which explained only 6.7%. This implies that interaction effects are near influential than the single parameter effects during monsoon seasons in this river system.

42. Pamba river system-Post-monsoon 2002

During post-monsoon period, the model fitted is that for z on z_i's as in monsoon season. The best predictive model is that of z on $z_1 - z_3$ and their first order interactions. The model equation is

$$z = 0.2916 + 0.1859\, z_1 + 0.01186\, z_2 + 0.6727\, z_3 + 0.1054\,(z_1 * z_2) \\ - 0.3619\,(z_1 * z_3) - 0.3210\,(z_2 * z_3)$$

explaining about 80.50% of the variation in fish abundance, $F(6, 13) = 14.0741, (p < 0.01)$. The model factors are ranked according to their contribution as distance from the sea > (latitude * distance from the sea) > (altitude * distance from the sea) > latitude > altitude > (latitude * altitude). In this case, simple model of z on $z_1 - z_3$ alone explained 66.61% whereas single factor models explained 0.0% for latitude ($r = 0.1995$), 46.44% for altitude ($r = 0.7019$), and 62.90% for distance from the sea ($r = 0.8054$) and the two factor and their first order interaction models could explain at least 56.29% (latitude and altitude) and a highest of 79.64% (latitude and distance from the sea) justifying the efficiency of the best model.

43. Pamba river system- Pre-monsoon 2003

During pre-monsoon season, the model is fitted for z on $z_i, i = 1, 2, 3$. The best model is that of z on z_2 and z_3 and its interaction effects. The equation is $z = 0.4092 + 0.7373\, z_2 + 0.4382\, z_3 - 0.4380\,(z_2 * z_3)$ explaining about 45% of the spatial variation in fish abundance, $F\,(3, 16) = 6.1811,\ (p < 0.01)$. The model of z on z_i' alone could explain 41.48%. In the optimal case, the order of importance of the factors is distance from the sea (X_3)> (distance from the sea * altitude) > altitude (X_2). In the case of simple linear model, the same status is being retained. In the case of single factor models, the variability explained are 0.0% for latitude $(r = 0.0409)$, 29.14% for altitude $(r = 0.5734)$, and 43.92% for distance from the sea $(r = 0.6847)$. The other two factor models and three factor models could extract about 21 % to 43.2% variation in the fish abundance. This implies that distance from the sea followed by its interaction with altitude and latitude are the habitat factors controlling fish abundance during pre-monsoon season in Pamba river system.

44. Pamba river system- Monsoon 2003

During monsoon season, the model is fitted for Y' on z_i'. The best model is that of Y' on $z_1 - z_3$ and its interaction of order one. The model equation is

$$Y' = 1.0316 + 0.3341\, z_1 + 0.6134\, z_2 - 0.5666\, z_3 - 0.7276\,(z_1 * z_2) + 1.0331\,(z_1 * z_3) - 1.0916\,(z_2 * z_3)$$

explaining 27.77% of the spatial variation in fish abundance, $F\,(6, 13) = 2.2173,\ (p < 0.05)$.The order of importance of the factors is (

altitude * distance from the sea) > (latitude * distance from the sea) > (latitude * altitude) > altitude (X_2)> distance from the sea (X_3)> latitude (X_1). The model of Y' on $z_1 - z_3$ alone could explain 24.01% retaining the order of importance as distance from the sea > altitude > latitude. The model of Y' on z_1, z_2, z_3 separately showed about 0% for latitude $(r = 0.2204)$, 4.67% for altitude $(r = 0.3112)$, and 15.95% for distance from the sea $(r = 0.4514)$.The two factor models could not explain more than 19.83% (altitude, distance from the sea) showing the importance of interaction of latitude with other two factors.

45. Pamba river system- Post-monsoon 2003

During post-monsoon season, the model is fitted for z on $z_i's$. The best model is that of z on altitude and distance from the sea (X_2 and X_3). The fitted equation is $z = 0.5627 + 0.006388\, z_2 + 0.5601\, z_3 - 0.6022\,(z_2 * z_3)$ explaining 76.69% of the spatial variation in fish abundance, $F\,(3,16) = 21.839$, $(p < 0.01)$. The order of importance of the factors is (altitude * distance from the sea) > distance from the sea > altitude. In the case of z on $z_1 - z_3$ alone, about 69.28% of the variation could be extracted. The order of importance is as in the optimal case, distance from the sea > altitude > latitude. The model of z on z_1, z_2, z_3 separately showed 0.0% in the case of latitude $(r = 0.0044)$, 39.56% in the case of altitude $(r = 0.6538)$, and 63.74% in the case of distance from the sea $(r = 0.8104)$. Further, this analysis emphasized the insignificance of latitude in controlling the fish abundance as is reflected in the three factor model, where only 73.57% of the spatial variation could be extracted. On the other hand, altitude and distance from the sea together with their interactions could explain more.

46. Kallada river system- Monsoon 2001

In this case, the model fitted is that standardized $Y\,(Y')$ on standardized $\log_{10}$ transformed $X_i\ (z_i)$. The one with the individual effects of the input factors viz. latitude(X_1), altitude $(X_2)$and distance from the sea (X_3) is

$Y' = -0.135144\times10^{-4} + 0.1629\,z_1 + 0.4419\,z_2 - 0.3639\,z_3$ and this could explain only 1.624% of the variation in fish abundance, $F\,(3,14) = 1.0936, (p < 0.25)$. Altitude > latitude > distance from the sea is the order of importance. The model fitted to predict Y from the input factors independently could explain only 2.19% for latitude $(r = 0.2818)$, 2.19% for altitude $(r = 0.2817)$ and 0.00% for distance from the sea $(r = -0.0755)$. The best one is determined as the one with input factors as latitude $(X_1)$and distance from the sea (X_3) is,

$Y' = 0.04387 + 0.2734\,z_1 - 0.001746\,z_3 - 0.3619\,(z_1 * z_3)$. This could explain only 6.04% of the variations in the fish abundance over the stations, $F\,(3,14) = 1.3646, (p < 0.10)$. The model factors were graded as (latitude * distance from the sea) > latitude > distance from the sea.

47. Kallada river system- Pre-monsoon 2002

In this river system in all the three seasons of this year, the model is fitted for standardized Y,

$Y' = \frac{Y - \overline{Y}}{\sigma_Y}$ on standardized $X_i, X_i' = \frac{X_i - \overline{X_i}}{\sigma_{X_i}}, i = 1, 2, 3$. The best model for pre-monsoon season is that of Y' on X_1', X_2' and its interaction effects. The equation is,

$Y' = -0.1844 - 0.2435\, X_1' + 0.6983\, X_2' + 0.4465\, (X_1' * X_2')$ explaining 8.59% of the spatial variation, $F\,(3, 14) = 1.5326, (p < 0.10)$. The order of importance of the model factors could be given as altitude > (altitude * latitude) > latitude. All the other combinations were inferior to these models, since the linear correlations of abundance with latitude $(r = -0.00565)$, altitude $(r = 0.3654)$, and distance from the sea $(r = 0.2210)$ were not significant $(p > 0.05)$. This implies that in the Kallada river system during pre-monsoon season, there are other biotic and abiotic factors also which are controlling the fish abundance.

48. Kallada river system- monsoon 2002

During monsoon season, the best model is that of Y' on X_1' to X_3' and their first order interactions. The equation is,

$$Y' = -0.3646 - 0.003626\, X_1' + 0.7087\, X_2' - 0.2112\, X_3' + 0.71169\, (X_1' * X_2') - 0.29405\, (X_1' * X_3') + 0.19650\, (X_2' * X_3')$$

explaining about 11.30% of the spatial variations in the fish species' abundance, $F\,(6, 11) = 1.3606, (p < 0.10)$. The order of the importance of the factors could be given as Lat * Alt. > altitude >Lat. * Dist. > distance from the sea > Alt. * distance from the sea > latitude. The model of Y' on X_2' and X_3' and Y' on $X_2' * X_3'$ follows next (V.E.=10.56%). Other factor models were all failures $(p > 0.05)$.

49. Kallada river system-Post-monsoon 2002

During post-monsoon season of 2002, the best model is that of Y' on X_1'-X_3' and their first order interaction effects. The fitted equation is

$$Y' = -0.1366 + 0.3411\,X_1' + 0.4623\,X_2' + 0.2337\,X_3' + 0.6281\,(X_1' * X_2') - 0.3806\,(X_1' * X_3') - 0.06096\,(X_2' * X_3')$$

which could explain 48.72% of the variation over stations for the total fish species abundance $F\,(6, 11) = 3.6923, (p < 0.05)$. The order of importance of the factors is (Lat. * Alt.) > altitude > (Lat. * Dist.) > latitude > distance from the sea > (Alt. * Dist.). The model of Y' on X_1'-X_3' without interaction effects could explain 38.87% of the variation whereas single factor models could explain, 32.05% for latitude ($r = 0.6004$), 28.50% for altitude ($r = 0.5719$), and 3.90% for distance from the sea ($r = 0.3091$). The two factor models could not explain more than 43.85 % of the variations. Further , this analysis shows that the effect of lat. * Alt interaction is almost same as that of lat.*distance from the sea interaction, along with effect of altitude in the former case and along with the effect of distance from the sea on the latter case. (V.E.~ 43% approximately in both models).

50. Kallada river system- Pre-monsoon 2003

During pre-monsoon season, the model is fitted for Y' on $X_i', i = 1, 2, 3$ and the best model obtained is that of Y' on X_1', X_2' and its interaction effect. The equation is

$Y' = -0.3367 - 0.2699\,X_1' + 0.8819\,X_2' + 0.8476\,(X_1' * X_2')$ explaining 30.37% of the variability in fish abundance, $F\,(3, 14) = 3.4720$, $(p < 0.05)$. The order of importance is altitude > (altitude * latitude) > latitude. The model including distance from the sea also and its interaction effects could explain only 29.81% and the factors are ranked as (latitude * altitude) > altitude > (latitude * distance from the sea) > latitude > (altitude * distance from the sea) > distance from the sea. Since the introduction of distance from the sea into the model has decreased the efficiency, the two factor model could be considered as the optimal one. The one factor models on latitude ($r = 0.0239$), altitude ($r = 0.3504$), and on distance from the sea ($r = 0.1397$) are not significant (p>0.05).

51. Kallada river system- Monsoon 2003

During monsoon season, the model fitted is that of Y' on $X_i', i = 1, 2, 3$. The best model obtained is that of Y' on X_1', X_2', X_3' alone. The equation is

$Y' = -0.1144 \times 10^{-5} + 0.30133\, X_1' + 0.5779\, X_2' - 0.5447\, X_3'$ explaining 22.73% of the spatial variation in fish abundance, $F\,(3, 14) = 2.6672$,(p<0.05). The order of importance of the factors is altitude > distance from the sea > latitude. The model of Y' on X_i', alone could give 12.30% for latitude ($r = 0.4178$), 5.15% for altitude ($r = 0.3276$), and 0.0% for distance from the sea ($r = -0.0902$). The two factor models could extract a maximum of 14.62% (altitude and distance from the sea). Since the extracted information is < 50%, it could be inferred that there are other habitat factors which have a better influence over the fish abundance in this season in Kabbini.

52. Kallada river system- Post-monsoon 2003

During post-monsoon season, Y' on X_i' is the form used for modeling. The best model is that of Y' on X_1', X_2' and its interaction. The equation is

$Y' = -0.2059 - 0.1301\,X_1' + 0.7269\,X_2' + 0.5183\,(X_1' * X_2')$ explaining 12.90% of the variation in fish abundance $F\,(3,14) = 1.8390$. The order of importance is altitude > (latitude * altitude) > latitude. Also it is to be stated that even though this model expalined the highest, the additional factor latitude contributes only insignificant amount since the model of Y' on $X_2'\,(r = 0.4158)$ alone could explain 12.12% $F\,(1,16) = 3.3448$,($p<0.05$). The other single factor models are not significant because the linear correlations of abundance with latitude $(r = 0.1243)$ and distance from the sea $(r = 0.2351)$ are not high, ($p<0.05$).

4.4. Discussion

Understanding the spatial and temporal scale of ecological processes is fundamental to interpret patterns in the environment (Levin, 1992). Tropical warm water rivers are dynamic (Welcomme, 1979; Hamilton and Lewis, 1987; Lewis *et al.*, 2000) and fish assemblages within different habitats may differ substantially among seasons affecting the communities (Saint-Paul *et al.*, 2000; Arrington, 2002; Lewis *et al.*, 2001; Layman *et al.*, 2005). The present results arrived at on the basis of a three-year study on the spatio-temporal pattern of fish abundance and assemblages in six major river systems of Kerala undoubtedly establish its highly dynamic and diversified nature and strongly corroborates with those results of similar studies in tropical streams conducted elsewhere.

The 3-way ANOVA analysis revealed significant temporal and spatial scale interactions (between seasons, between locations) in all the six major river systems of Kerala, which indicated the predominant role of temporal scale in controlling the assemblage structure. Table 4.7 shows the comparison of the three-way ANOVA results between river systems. Adamsque *et al.* (2004) while assessing the spatial, seasonal, and annual variation in fish assemblages in streams of northwestern Mississippi reported high temporal variability at the individual species level, and no species were classified as 'stable'. Pflieger and Grace (1987), Gido *et al.* (1997) and Onorato *et al.* (2000) based on the studies on the long term changes in large river systems reported that fish communities have indicated considerable changes in both species structure and composition as a function of cyclic seasonal hydrological changes. The species abundance was observed to be highly varied among species and among locations during the present study, indicated by the highly significant species-species and station-station interactions ($p<0.005$). Fish assemblages were observed to be highly varied following seasonal hydraulic variations and no two seasons were recorded similar in fish abundance as indicated by significantly high season-species interactions ($p<0.05$). However, the season-station interaction was presumably low and not significant (except in Pamba and Kabbini river systems during 2001) which showed that the variation in species abundance pattern of locations followed a definite seasonal trend.

The results of the Bray-Curtis similarity studies in the six river systems showed the highly diversified pattern of similarity over spatial and temporal scales. The number of clusters formed, number of species co-existed in each cluster and number of locations based on which the clusters formed were different between seasons, years, river systems and also between the locations with the temporal changes in environment. Poff and Allan (1995) observed that the seasonal hydrological variability can shift assemblages toward dynamic patterns of dissimilarity over space and time, more significantly in colonizing assemblages of large streams. Pegg and McClelland (2004) and Jowett and Duncan (1990) are of the opinion that the variability of water level caused by summer and monsoon was a factor that discriminated between species assemblages in tropical river systems. Glova *et al.* (1985) suggested that the frequency of rainfall might account for differences in abundance pattern in a study of braided Canterbury rivers of West Africa. The variation in species abundance and the resultant assemblages in the present study were more similar between the pre-monsoon and post monsoon periods and quite significantly dissimilar during monsoon periods. The number of clusters formed were generally high during pre monsoon and post-monsoon seasons indicating high habitat heterogeneity in the heterogeneous environmental conditions which lead to very distinct and localized species assemblages. The results of this study also corroborate with the findings of Schlosser (1982) who reported that on an ecological time scale, high diversity may be observed in heterogeneous environments caused by naturally repeating process at spatio-temporal scales. According to Moss (1973) and Abele (1976), the indifferent environmental conditions along a river stretch can increase species diversity at any one sampling time as a result of the presence of many species, some just becoming established, some at their population peaks and colleagues in decline. The immediate and disruptive effects of monsoon floods on individual fish and fish communities are well known (Ross *et al.* ,1985; Schlosser, 1985; Meffe and Minckley, 1987; Bain *et al.*,1988; Boulton and Lake, 1992). Monsoon increase the homogenization of the environments (Poff and Allan,1995) or rather, the environments start to respond to regional factors in an independent way and fauna heterogeneity increases to the extent the environments are isolated when the water recedes in the pre and post monsoon periods. In the present study, the clusters formed were relatively low in numbers during monsoon. However, the monsoon clusters contained large number of species because of the high homogeneity in the environmental conditions.

The situation where a large number of clusters represented in a season, with limited number of species in each cluster and assembled based on abundance at a few locations indicated the high habitat diversity and distinct and specific species assemblages as in Periyar and Chalakkudy river systems. While a large number of species having high relative abundance assembled based on a single or two locations as in Pooyamkutty of Periyar and Chalakkudy and Athirapally locations of Chalakkudy river system assumed high significance of these locations to be elevated as aquatic sanctuaries. Clusters where the species grouped based on a single location with low relative abundance when compared to other species represented in the particular season indicated the rarity and habitat affinity of the species.

Thannikudy and Mlappara of Periyar, Orukombankutty of Chalakkudy, Muthanga of Kabbini, Walakkad of Bharathapuzha river system abound many rare and threatened species and therefore these regions deserve top priority for conservation. The high relative abundance of a species in a specific cluster and in the particular season indicated the dominant nature over the other species. *Puntius filamentosus*, *Danio malabaricus*, *Barilius gatensis* and *Garra mullya* showed high relative abundance in almost all the six river systems studied.

Fish assemblage structure at (and within) the landscape scale also could be influenced by species interactions (Buhrneim and Fernandez, 2003). Jackson *et al.* (1992) and Oberdorff *et al.* (1998) suggested that inter-specific interactions are the major force structuring fish assemblages, the magnitude of which depend on the frequency and magnitude of environmental variations. No consistency was noted for a majority of species assemblages in the present study and most of them showed high temporal variation between seasons and years. However, some significantly repeated positive associations between species belonging to the same family (Cyprinidae) were found which corroborates with Linfield (1985) who reported that cyprinids in English streams are extremely mobile, aggregating widely because of the high similarities in feeding and breeding behaviors. The consistency of an assemblage in all the seasons and all the years of a river system indicated the general hardiness of the species against harsh environmental variations, similar habitat requirements of its species and high inter-species associations (Onorato *et al.,*. 2000). Minns (1990) examined species distribution by catchment and map sheet and established the co-occurrence of brown trout and blue-gilled bully by exemplifying a number of ecological similarities between them. The species that are abundant and have wide distribution are most stable and dominant (Casatti *et al.*, 2003). In the present study, the dominance of a few species with high relative abundance and co-existence was observed between the river systems, seasons and years. Fisher and Grimm (1991) opined that the periodic floods can limit species dominance (by preventing the formation of dominant species) and only a few species in streams showed dominancy while majority are far below the average relative abundance. Sheldon (1968) and McAllister *et al.* (1986) reported that in any species-rich fauna, most species are rare, and stream fishes are no exception. Bhat (2003), based on the study on fish fauna of north Western Ghats reported that the abundance distribution of the species across sites sampled, shows a typical left skew, means that most of the fish species are relatively rare, while a few species dominate an area in terms of their abundances. The assemblages between *Puntius filamentosus* and *Danio malabaricus* in Periyar river system, *Puntius filamentosus* and *Danio malabaricus*, *Barilius gatensis* and *Garra mullya* in Chalakkudy, *Danio malabaricus*, *Barilius gatensis* in Kabbini, *Garra mullya* and *Danio malabaricus* and also *Puntius filamentosus* and *Barlius gatensis* in Pamba, *Puntius filamentosus, Rasbora daniconius, Barilius gatensis* and *Garra mullya* in Kallada were showed high consistency throughout the study period. Bhat (2003) reported the dominance of *Puntius jerdoni, P. filamentosus, P. amphibius, Danio aequipinnatus,* and *Rasbora daniconius* in north western Ghat rivers. The results also corroborate with those of Fisher and Grimm (1991) who reported three sets of consistent species assemblages throughout the study with high relative abundance in Texas streams. Adamsque *et al.* (2004) could not observe a single dominant species in semi-arid Brazilian stream and during each hydrological phase, different sets of species were emerged showing their dominance. However, it is worth stating that the semiarid seasonal environmental changes are drastic and are highly dissimilar from those of the tropical river systems. Except a few associations as evident from the co-existance of *Tetradon travancoricus* and *Osteobrma bakeri* during the monsoon season in Periyar, the clusters which showed season specificity were generally bare minimum. Gehrke (2001) reported distinct seasonal clusters of species in the montane, inland and coastal rivers of New south Wales (Australia). Clusters of species which were repeated in dry seasons (pre-monsoon and post monsoon) included those between *Osteochilus longidorsalis* and *Puntius denisoni* in Periyar, *Schisura semiarmatus* and *Acanthocobitis botia* and *Puntius carnaticus* and *Osteochilus nashi* in Chalakkudy, etc. indicated their periodic co-existence at the incidence of suitable environmental condition besides high similarity and specificity in habitat requirements. Gehrke (2001) also reported such periodic occurrence of species assemblages in new south Wales river systems. Relatively large number of clusters and also periodically repeating clusters can be considered as an index of distinct habitat based assemblages for the stream (Pegg and McClelland, 2004). In the present study, Periyar and Chalakkudy river systems depicted the highest number of repeating clusters and showed high habitat diversity. Kabbini river system followed Periyar and Chalakkudy and the others, Bharathapuzha, Pamba and Kallada were at the lower side of the spectrum. Bhat (2003) explicitly illustrated the rarity for a majority of Western Ghat species. This study also implied both rarity in abundance and restricted range for the species. Most species were geographically restricted and numerically rare in the present study. Matthews (1998) has reported that the abundance of a few species and rarity of the bulk is the common feature of tropical streams and followed a lognormal frequency distributions (Loubens, 1970 and Sheldon, 1998). Highly habitat specific clusters (100% relative abundance in a particular location) represented in a single season of all the three years and also showed very low relative abundance included species such as *Lepidopygopsis typus*, *Crossocheilus periyarensis*, *G. micropogon periyarensis* in Periyar, *Puntius jerdoni* and *Esomus thoramoicos* of Chalakkudy, *Silurus wynaadensis* and *Glyptothorax annandalie* and *Labeo kontius* and *Kantaka brevidorsalis* in Kabbini. The conservation of these species is highly imperative to sustain its natural populations.

The influence of habitat diversity and availability on the composition of riverine fish communities is well known (e.g. Sheldon, 1968; Gorman and Karr, 1978; Evans and Noble, 1979; Lake, 1982) with the greatest species diversity occurring in areas offering the greatest variety of habitats. The high percentage of endemism and rarity observed for a majority of Western Ghat stream fishes further indicated the existence of distinct habitat-linked assemblages (Dahanukar *et. al.*, 2004; Bhat, 2003, 2004). The Bray-Curtis analysis conducted to explore the pattern of similarity over space along a time scale showed more similarity between different locations of the river system in different seasons. The similarity in habitat structure at different locations caused the similarity in fish assemblages within them and the temporal shift/seasonal changes had more or less similar effects for these habitats and assemblages. Mac-Arthur (1964), Matthews (1998), Gorman and Karr, (1978); Schlosser, (1982) and (1987) correlated longitudinal changes in stream habitats to stream fish assemblages and undoubtedly proved the relation of stream gradient with habitat structure and fish assemblage. The present investigation on altitudinal segregation of locations based on which the species were grouped revealed the remarkable similarity in clustering pattern for the species at distinct altitudinal ranges. The pattern of clustering was observed to be highly similar between pre monsoon and post monsoon periods simply because of the high similarity over space or in other words, high similarity between the different habitats and species within different locations. These results agree with Bhat (2003) who reported that the regions in the same altitudinal regime (and river gradient) are more similar to each other due to the similar habitats than regions in different altitudinal regimes in north Western Ghat rivers. The extremely heterogeneous environmental conditions during off-monsoon periods produced several distinct microhabitats and habitat specific fish assemblage clusters at the upstream of the rivers whereas the relatively homogeneous low land areas presented a vast uniform habitat and low number of clusters. According to Horwitz (1978) and Peres-Neto *et al.* (1995), upstream locations are hypothesized to demonstrate more structured assemblages, whereas downstream sites though have a larger catchment area and reduced hydraulic effects, present only low diversified assemblages. Remarkably, the pre monsoon and post monsoon seasons especially in Periyar and Chalakkudy represented clusters more of higher altitudes which showed that the habitat heterogeneity and resultant assemblage patterns were pronounced at the upstream during these seasons. Schlosser (1987) termed the distinct small-bodied habitat specific species groups as "colonizing assemblages" which are able to re-colonize stream reaches periodically in composition and abundance even in high temporal variability and added that colonizing assemblages are characteristic of diversified headwater streams. The monsoon flood waters limit and destroyed the distinct habitat based assemblages at the high altitudes while the resultant homogeneous environment caused species assemblages to scatter resulting in limited clusters representing wide altitudinal ranges especially of the low-altitudinal zones. However, the scattered fish assemblages become localized and the species return to their specific habitats when the floodwaters recede (Schlosser, 1987). Matthews (1990) predicted that a study encompassing all seasons or multiple years might show an increased temporal relative to spatial component of variation. The overall clustering pattern in the present study showed comparatively less intern-annual variability than the seasonal variability which further justifies the existence of distinct and repeating species assemblages in the river systems whose pattern of variation (with the hydrological cycles) showed remarkably high similarity over space than time. The high seasonal variability observed could be better explained following Schlosser (1982) and Adamsque *et al.* (2004) who opined that, temporal variability tends to be high in warm water streams however; within-stream assemblage similarity was not consistently related to season. Species abundance dissimilarity was often higher seasonally than annually, consistent with a period of change in monsoon and a return to similar species compositions in pre and post monsoons. The results also corroborated with Pegg and McClelland (2004) who reported more temporal and less spatial variation for individual species in the upper Roanoke river, Virginia. Gido *et al.* (2002) observed extremely high levels of temporal variability in assemblages within the same region of Mississippi suggesting that it is characteristic of highly diversified streams. Despite substantial temporal variability, fish assemblages maintained characteristics unique to each stream during the present study, as evidenced by clustering patterns and the processes in fish assemblages were not synchronized even in neighboring river systems. Adamsque *et al.* (2004) observed that spatial differences between the different river systems in Brazil are also varied over time, which showed lack of synchrony in catch/hr. of individual species. Gehrke (2001) reported that the substantial difference in stream size may be responsible, in part, for the lack of synchrony in species abundance as found in Buckhorn and Hotopha creeks and Cypress and Hotopha creeks in new south Wales despite their proximity. The differences in hydrology both at the locations and in more distant parts of the stream network, may have contributed to the lack of correlation in the species abundance between river systems.

The present observation on higher similarity for the pattern of assemblages over space is further confirmed from the MDS analysis of grouping of locations. The results showed that clusters of locations were more based on their altitudinal similarity and can be more or less differentiated into those representing upper, middle and lower stretches. Generally, the highly diversified river systems such as Periyar and

Chalakkudy exhibited more of, distinct clusters in the pre monsoon and post monsoon seasons and the other river systems more or less presented a uniform pattern. The altitude or the altitudinal range which is more repeating throughout the seasons and also years of a particular river system should be given high priority of conservation since they encompass a large number of distinct species assemblages. Pooyamkutty of Periyar, Athirapally of Chalakkudy, Dhoni and Cheerakkuzhi of Bharathapuzha, Begur of Kabbini, Nilakkal of Pamba and Thenmaladam of Kallada river systems were demarcated as regions of high biodiversity accordingly.

Seasonal sampling resulted highly diversified species community structure patterns in the six river systems studied. The present study results showed high resemblance to that of Amazonian lakes (Saint-Paul *et al.*, 2000, Silvano *et al.*, 2000) and rivers (Goulding *et al.*, 1988) where a distinct seasonal pattern for community structure was reported. The seasonal changes were more similar between the years than the river systems. In General, the species diversity recorded highest during off-monsoon periods than monsoon period and in most cases, post monsoon season was better productive. With respect to the species concentration, monsoon period was emerged as the period of highest value in majority of the river systems. This is because of the clustering of species having high abundance at the downstream of the river system where the disturbances of monsoon are relatively low. In this case, the number of species may high or small but a few species dominate in abundance with large number of individuals, resulting in low evenness values. Species evenness showed a more or less uniform pattern and this index can be taken as a better indicator of the community for comparison followed by species diversity index, both having the least spatial variation in the three-year study period. However, species evenness was high during monsoon season in Kallada and Bharathapuzha river systems. Spatial variation in species richness was least during monsoon in most of the years in different river systems. It was already explained that the monsoon floodwaters wash away the species to concentrate at downstream leaving the bulk of the locations at the middle and upper stretches relatively similar low abundance values. On the whole, the study indicated more or less distinct pattern for community structure for each river system during each hydrological cycle (pre-monsoon, monsoon and post-monsoon), which exhibited low inter-annual variability.

Fish communities in rivers are structured typically by complexity of habitat, environmental variables and periodic phenomena, such as low-flows and floods and associated shifts in water and habitat quality for the fishes (Gorman and Karr, 1978; Fausch *et al.*, 1984; Cowx and Welcomme, 1998). Responses to low flow periods have been recognized as one of the most important factors in structuring stream fish communities (Resh *et al.*,1988; Poff and Ward, 1989; Fausch and Bramblett, 1991). Studies on assemblage stability and diversity in warm water, upland streams (Freeman *et al.*, 1988; Matthews, 1990) and also in Black Creek, Mississippi, a Coastal Plain, blackwater stream (Ross *et al.*, 1987) also reported that the low-water periods lead to speciation and diversity. Gido *et al.* (1997) observed that species richness was highest during late summer-early autumn when discharge was low and temperature was declining and in April before spring runoff in San Juan river. Casatti (2005) reported that the highest species richness was found either during the rising of wet season or after the recession of flood-waters for the stream habitats. He argued that floods increase the homogenization of the environments in relation to their limnological characteristics whereas the off monsoon periods increases the habitat diversity of the system by the formation of several localized microhabitats and thereby increase species diversity. Dry season sampling in the river and lagoon habitats netted the highest number of species and individuals, as has been reported for other Amazonian lakes (Saint-Paul *et al.*, 2000, Silvano *et al.*, 2000) and rivers (Goulding *et al.*, 1988). Poff and Ward (1990), Stanley and Fisher (1992) and Lobon-Cervia *et al.* (1993) were of the opinion that during the drying phase, the fish community are more stable than the other phases and diversity remained higher than the monsoon phase.

The results of the present study agree with studies attributing shifts in fish assemblages to longitudinal changes in stream habitats in tune with the periodic disturbance regime and colonizing assemblages of perennial streams as reported by Gorman and Karr (1978). Horwitz (1978), Schlosser (1982), Welcomme (1987), Rahel and Hubert (1991), Paller (1994) and Poff and Allan (1995) in different tropical upland streams. The majestic presence of Western Ghats fashioned a very characteristic climatic ecology at south-West India in such a way that the streams and rivers receives rainfall throughout the year which keep the water level not to fall below a limit in summer periods (relatively small, between March-May) and at the same time the peculiar slope of the Western Ghats hills (the relatively small higher elevation region, the large steep and sloping zone and small, plainer coastal zone) reduce the duration of flood in monsoon (Bhat, 2003., Dahanukar *et* *al.*, 2004). Unlike in the Braziline semi-arid streams and tropical and neo-tropical streams that have a considerable dry and wet periods, the streams of southern Western Ghats remain perennial and have relatively low harsh effect of summer on its communities. The fish assemblages were able to recover and recolonize in a relatively short time after the monsoon floods recede. Horwitz (1978) and Peres-Neto *et al.* (1995) opined that in perennial tropical waters during summer, because of the presence of definite and permanent fluvial pool-riffle habitats interconnecting the various other macro and microhabitats along the river gradient, the species diversity remained high. He added that permanent macro-habitats such as deep pools probably act as a store of meta-populations supplying fishes for intermittent streams and other microhabitats at the upstream. Adamsque *et al.* (2004) observed the perennial nature of waters as an important factor in the resilience of the community which lacks the semi-arid Brazilian streams.

As already evident from the clustering and their temporal and special similarity pattern, the temporal variation in species community structure in the different river systems were considerably high. One of the possible reasons might be the strong and varied influence of monsoon. In Kerala, there are two regular inundation periods, one stronger south-west monsoon between June to August and the other, the relatively weak north-east monsoon between September to November and therefore, the river systems will be flooded twice in a year, strongly affecting the stability of fish communities, which is more prominent in the higher altitudes. Ross *et al.* (1985) and Schlosser (1990) experienced that streams with frequent and intense disturbances have greater temporal variability in their fish communities than do streams with lower levels of disturbance. The present results agree with Minckley *et al.* (1986) and Poff and Ward (1989) who reported that when viewed from a disturbance perspective, fish communities might be expected to have comparatively high temporal variability owing to the intermittent and heavy discharge and conversely, habitat heterogeneity may enhance their stability and reduce variability (Townsend 1989; Sedell *et al.*, 1990; Yount and Niemi 1990; Pearsons *et al.*, 1992). However, as Gido *et al.* (2002) observed in San Juan river that only one facet of the complex array of biotic and abiotic factors influenced the structure and stability of the fish community.

The river systems showed greater similarity in community structure during off monsoon periods. This might be due to the remarkable similarity in habitat structure along a river gradient as already explained elsewhere in the major river systems of Kerala. The results also support the existence of deep-rooted habitat based species assemblages of river systems of Kerala. The pattern of connectivity between geographically close environments is fundamental to their high similarity (Agostinho *et al.*, 2000) which is proved to some extend during the present study. The significant similarity pattern in community structure between Periyar and Chalakkudy river systems might be due to their high proximity and interconnection at the lower stretches. In both the river systems, similarity of the fish communities among sites was typically highest during off monsoon seasons and generally declined during monsoon periods. However, the significant variation in community structure between the river systems (mainly Periyar and Chalakkudy with other river systems) were also noticed which might be due to the presence or absence of specialized macro and microhabitats which influenced in structuring specific assemblages.

The Kabbini river system, which flows eastwards was found distinct for its highly different species diversity and distribution pattern (explained in Chapter 2). On the other hand, Bharathapuzha, Pamba and Kallada river systems were not exhibited distinct altitude-based habitat heterogeneity which further supports the MDS and Bray-Curtis similarity studies for these river systems. In addition, substantial difference in river size, differences in hydrology and also historical and evolutionary processes might also be responsible, in part, for the lack of synchrony in community structure between the different river systems. Studies elsewhere (Pflieger and Grace,1987, Ross *et al.*, 1985, Richards and Host, 1994; Johnson and Gage, 1997; Richards *et al.*, 1996, Thompson and Hunt 1930; Kuehne 1962; Sheldon, 1968; Horwitz, 1978, Wiley and Mayden, 1985, Leopold *et al.*, 1964; Richards, 1982) have well proved this. The development of geographical information system (GIS) tools would be allowing more sophisticated questions to be asked about how community composition in a stream is related to its physical setting at a variety of scales (McDonnell, 2000) in future.

The multiple regression analysis carried out in the six river systems for predicting the spatio-temporal pattern of species abundance showed a much complex picture. Biggs *et al.* (1990) reported elevation as the most important riverine variable, influencing directly to flow, water quality, periphyton and benthic invertebrates in New Zealand streams. Elevation and distance from the sea are appeared to limit the distribution of diadromous species (Jowett, 1992). Stream size along with the altitude and latitude of the area were the primary predictor of richness and density, a common finding in other similar studies (Horwitz, 1978; Welcomme, 1985; Rahel and Hubert, 1991). Angermeier and Karr (1983) reported that species composition in the Etowah streams of Panama was strongly linked to reach-level variation in stream slope, latitude of the area, bed texture and bed mobility. However, the main drawback found in these research works were that they were based on single factor effects and depended on linear regression models for species prediction. Miller *et al.,* 1988 found a lack of concordance in variable importance among the different approaches of multivariate prediction, which indicated the necessity of taking different combinations of variables to predict species occurrence. According to the author, it is difficult to generalize the importance of individual variables because multiple variable interactions were implicitly accounted for the more accurate prediction. Rather than strictly sticking to the individual factor effects of the variables, the present study gives more emphasis on the interaction effects of the variables. At the same time, the means were sought to explain the species abundance and assemblage at a location with the help of minimum number of variables. Allan and Flecker (1993) opined that with the limited financial resources to devote for surveying streams and a large number of fishes in need of protection, scientists should seek for ways to predict the patterns with minimum number of variables.

The predictive capacity of the models found extremely varied between the seasons, years and also between the river systems and the effects of individual parameters found selective to each river system. The highest percentage of variability using the three-factor model was explained in Pamba river system. (80.5%, during post monsoon season of 2002) while it was lowest (up to a maximum of 50%) in Kabbini river system, Generally, the highest percentage of variability could be explained during post monsoon season followed by premonsoon. This is mainly due to the segregation of species assemblages in to specific habitats at distinct altitudinal zones during off monsoon seasons. The monsoon floods on the other hand, destroy the specific habitat-species assemblages and cause mixing up of species where the prediction at a place became difficult. However, in Periyar river system during all the years, the percentage of explained variability were higher during monsoon season which showed that more than these listed parameters, a large number of biotic and abiotic parameters also to be considered in order to define and predict the highly complex habitat species assemblages of river systems like Periyar.

The advantage of interactive models over the single factor and linear regression models were well ascertained during the present study. Table 4.8 shows the comparison of the explained variability of the individual and interactive parameters. Though the three-factor models with the combined interaction effects are considered a more proficient method which substantially increase the prediction efficiency and accuracy as evident in Chalakkudy, Pamba and Kallada river systems, in a majority of the cases, the two-factor and their interaction models were observed equal or more effective and were found sufficient enough to predict the explained variability. It appears that, if the addition of a variable is not substantially increasing the prediction efficiency, considering the cost of collection of data involved, two-factors and their interaction models or even single factors (some cases) alone are sufficient to predict the variability in species abundance in different river systems at a particular time and thus save the cost and time involved in the collection of the unimportant parameters in the future studies. The possible reason observed is the insignificant importance of one/two parameter or the dominancy of either one or two parameters synchronized with the characteristics of each river system under study. The latitude has insignificant effect when taken individually in Periyar, Kabbini Bharathapuzha and Pamba where distance from the sea and altitude in their order of importance have dominant roles. Latitude has the most dominant role in Chalakkudy river system whereas latitude along with altitude have dominant roles in Kallada river system and unlike in all other river systems, the contribution of distance from the sea was found negligible. However, there are cases where the negligible individual factors also contributed substantially to the prediction by the two-factor and three-factor models. In Periyar, during monsoon of 2001, the latitude and altitude and their interaction effects was the best fitted model (explained variability 41.36%); In Kabbini, latitude along with altitude could explain up to 50% variability in post monsoon 2001 and the altitude and distance from the sea could explain 70% in post monsoon 2001 and up to 62% in monsoon 2003 in Chalakkudy river system. In Pamba, the two-factor model with latitude and distance from the sea (79.64%) could explain almost similar variability as the three-factor model (80.5%).

Altitude and distance from the sea along with their first order interaction effects were emerged as the most dominating parameters and found sufficient to explain the spatial variability in species abundance in a number of cases in different river systems which is in compliance with the results obtained in similar studies conducted else where. Schlosser (1987) used nine environmental variables for the multivariate ordination analysis, out of which altitude was found to be the most important variable (variance explained 80 %) in explaining the abundance of species. Trautman (1981) reported stream gradient as the primary factor influencing important elements of stream habitat for streams in Ohio fish assemblages (affecting pool and riffle size, bank form and sediment deposition). Hugueny (1990) in West Africa found a significant relationship between species abundance and distance to the station from mean sea level as well as an increasing river gradient. During the present study, In Periyar river system in almost all the seasons of the respective years altitude and distance from the sea and their interaction produced the best fitted models (explained variability between 18.03-50.27%). In Bharathapuzha, altitude and distance from the sea had well decisive roles in the best fitted models in monsoon and post monsoon seasons of 2002 (39.43% and 38.78% explained variability) where altitude have an individual contribution more than 90% (individual effect 34.36% and 36.71% respectively). The highest explained variability in pre monsoon and monsoon seasons (34.77% and 19.5% respectively) in 2001 in the same river system were contributed more than 90% by distance from the sea (individual effect 33.53% and 17.52% respectively). In Pamba river system, distance from the sea alone contributed to more than 85% to the best-fitted models during post monsoon seasons of year 2002 and 2003. The two-factor model with altitude and distance from the sea (76.69%) was even better than the three-factor model (73.57%) in post monsoon of 2003.

The relatively high percentage of unexplained variability observed in some seasons and river systems indicated the inefficiency of any type of models based on the present parameters to predict the explained variability at the specific period. In Periyar river system, during post monsoon of 2001, the factors and their first order interaction could explain only 6% variability and the remaining 94% unexplained might be determined by other unknown parameters. In Kabbini river system, it was found that irrespective of seasons the three-factor model failed to explain the spatial variability in species abundance. In majority of cases the predictive capacity limited to less than 20%. In Kallada, in majority of the seasons, the single factor effects explained the variability more efficiently as all the other models failed to predict the variability. The simple linear regression model and the two-factor models were also found insignificant in a number of cases. Similar results were observed in the Tagus river (Hutchison, 1993) as only 65% of the stream assemblages could be predicted by stream gradient, distance to the location and latitude. According to Briggs (1974) and Gilliam *et al.* (1993), the high percentage of unexplained variability denotes the important roles of other ecological parameters of the microhabitats, biotic relationships and also historical factors in determining the abundance distribution of freshwater fishes. Strange *et al.* (1992) reported that the biotic factors (such as those leading to endemicity) are important in explaining species abundance and/or that there are contemporary factors with a geographical variation (such as climate or topography) shaping fish communities in the study area. Pool depth, the % canopy cover and the substratum type (pebble, rock and sand) have been linked to downstream increases (Sheldon, 1968; Schlosser, 1982) in species abundance. The functional role of overhanging vegetation in determining the temperature and hydrological regime and also as a source of organic nutrients (through fallen leaves and litter) has already been documented (Lowe-McConnell, 1975). These interesting associations deserve more detailed investigations. The observed variation in predictive capacity between the river systems even though some of them such as Periyar and Chalakkudy, Kallada and Pamba shared high habitat similarity could be explained following Buhrnheim and Fernandes (2003) that the habitat heterogeneity and stream geometry are not the only factors that shape community diversity and the streams might carry unique characteristics that affect fish assemblage structure even the habitats within streams exhibited only slight variations in their physical parameters. They rightly opined that only closer examination of the streams might therefore provide insight into the causes of differences in assemblage structure among streams.

Fig.4.1. Dendrogram showing fish species clusters in Periyar river system during pre-monsoon 2001

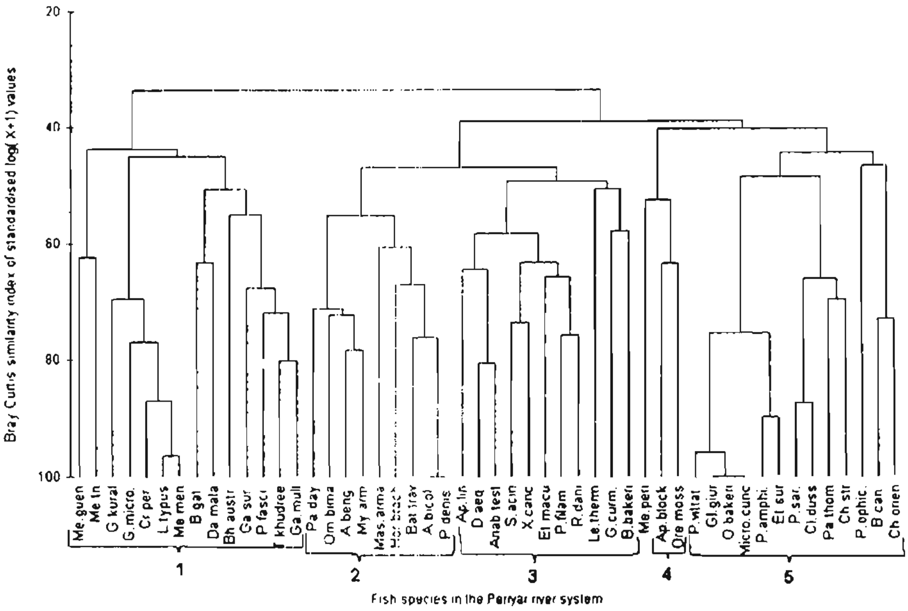


Fig.4.2. Dendrogram showing fish species clusters in Periyar river system during monsoon 2001

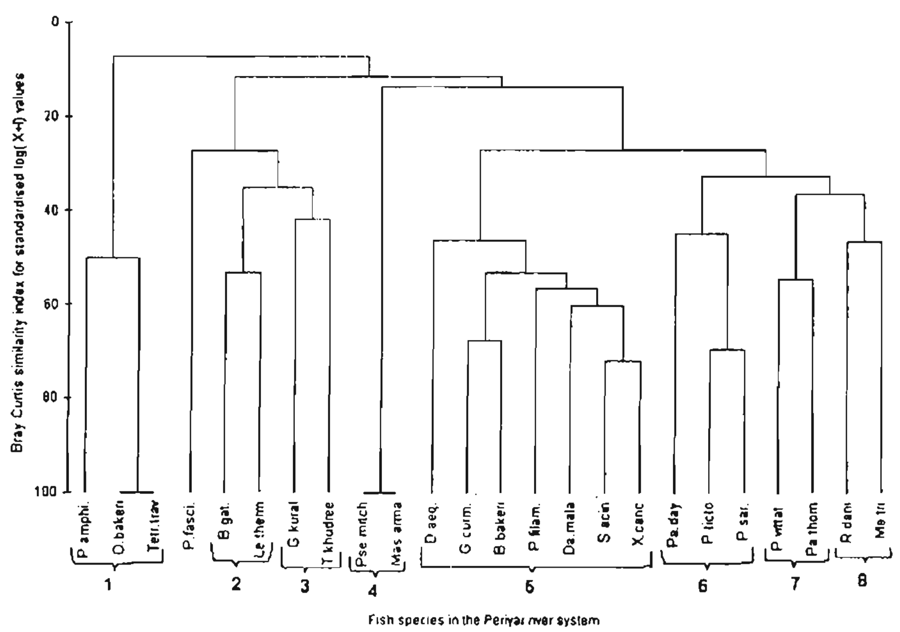


Fig.4.3. Dendrogram showing fish species clusters in Periyar river system during post-monsoon 2001

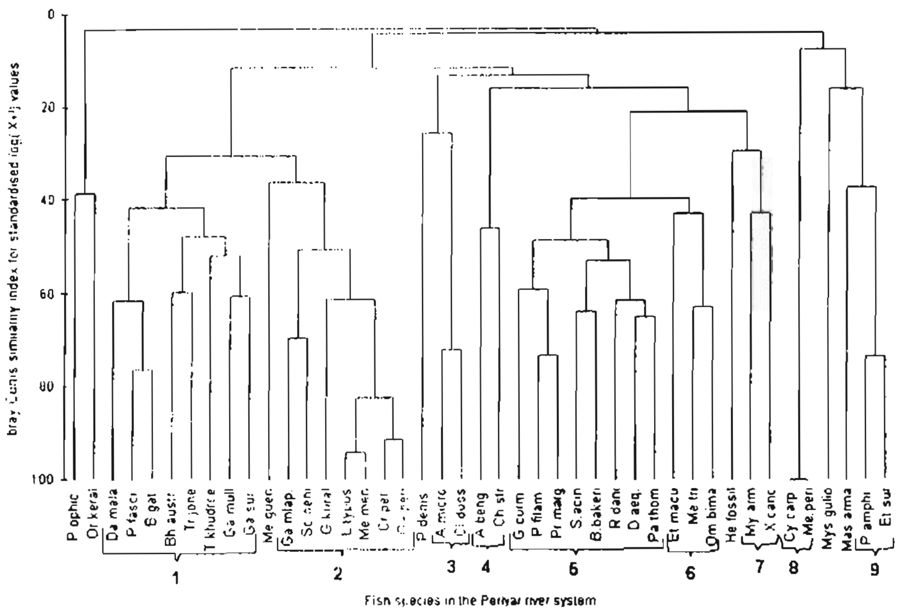


Fig.4.4. Dendrogram showing fish species clusters in Periyar river system during pre-monsoon 2002

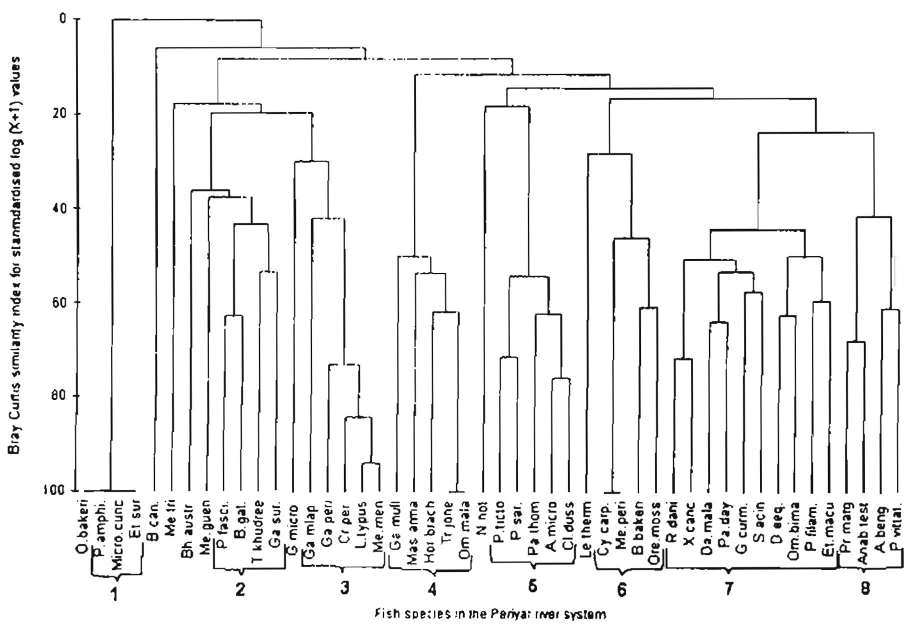


Fig.4.5. Dendrogram showing fish species clusters in Periyar river system during monsoon 2002

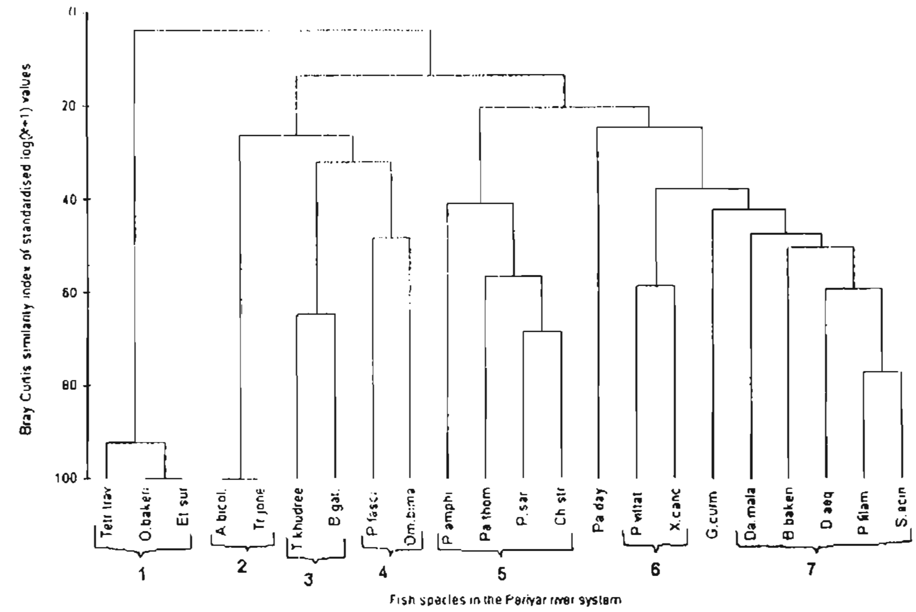


Fig.4.6. Dendrogram showing fish species clusters in Periyar river system during post-monsoon 2002

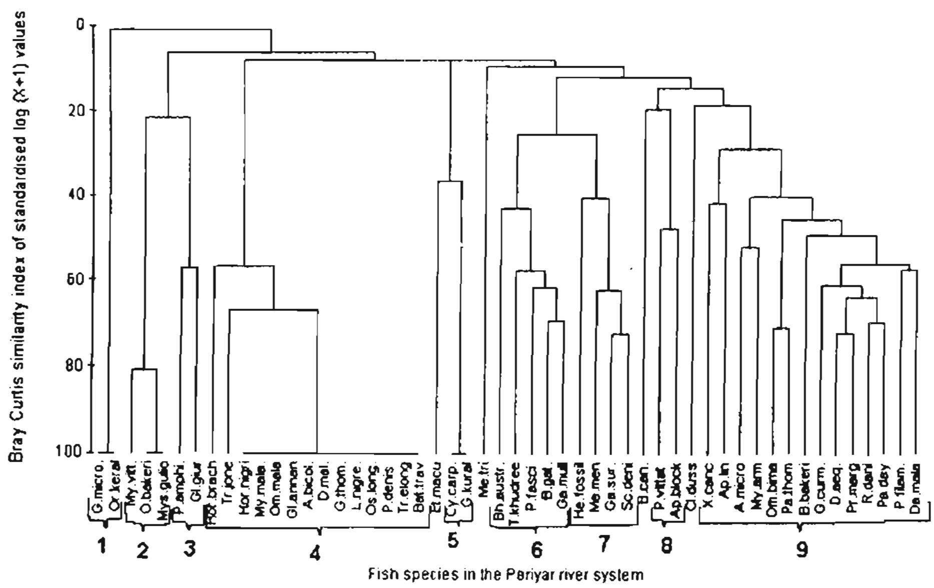


Fig.4.7. Dendrogram showing fish species clusters in Periyar river system during pre-monsoon 2003

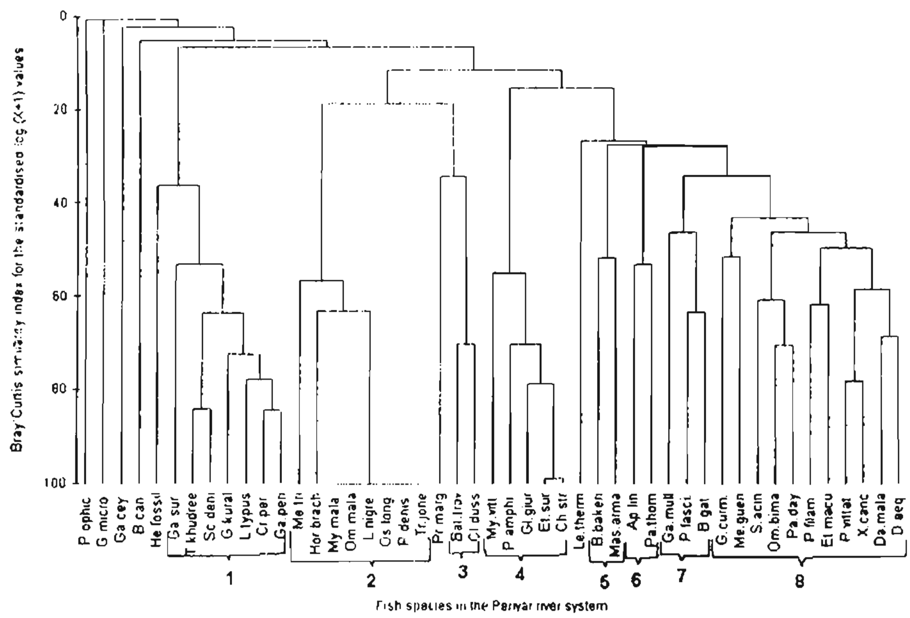


Fig.4.8. Dendrogram showing fish species clusters in Periyar river system during monsoon 2003

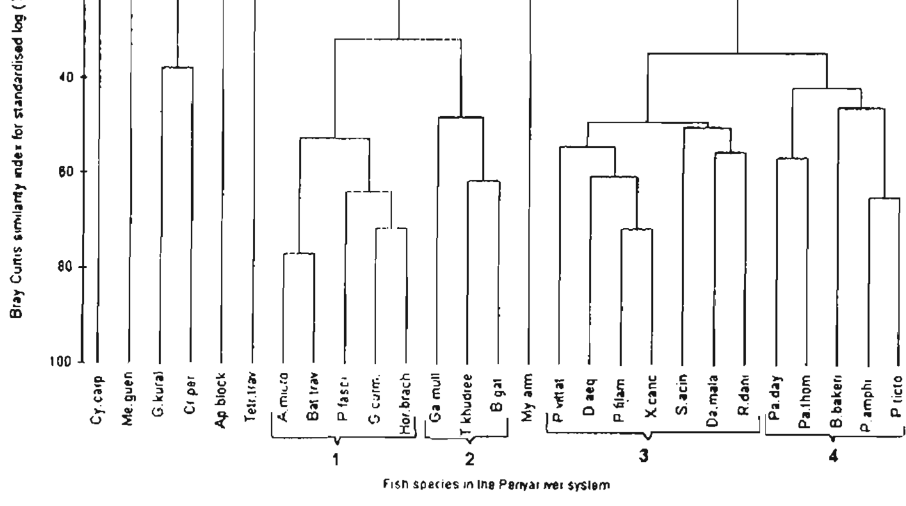


Fig.4.9. Dendrogram showing fish species clusters in Periyar river system during post-monsoon 2003

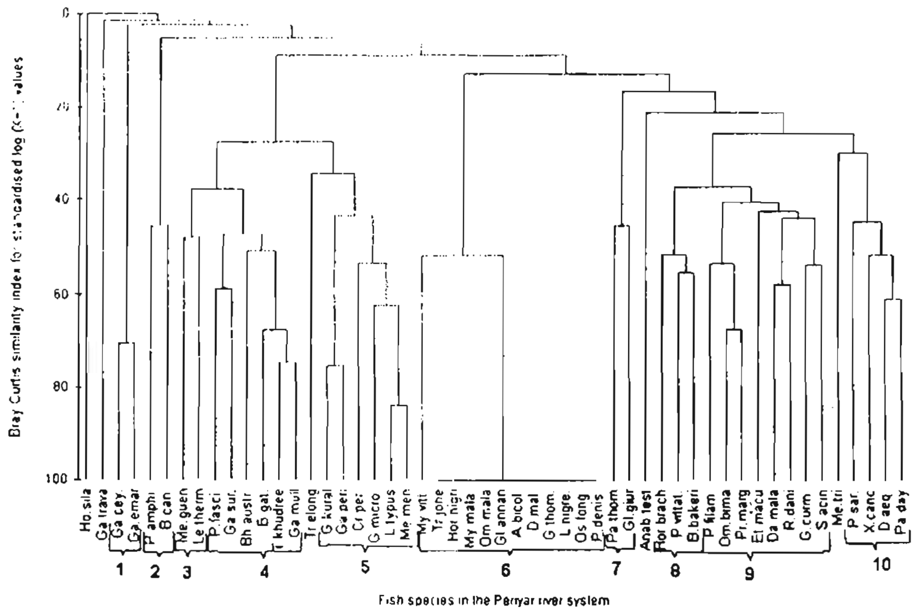


Fig.4.10. Dendrogram showing fish species clusters in Chalakkudy river system during pre-monsoon 2001

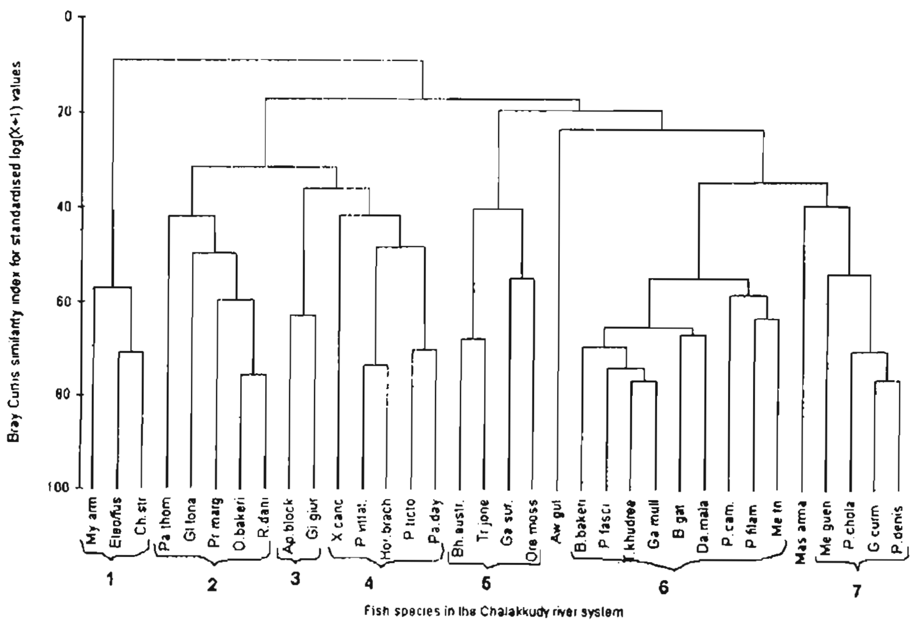


Fig.4.11. Dendrogram showing fish species clusters in Chalakkudy river system during monsoon 2001

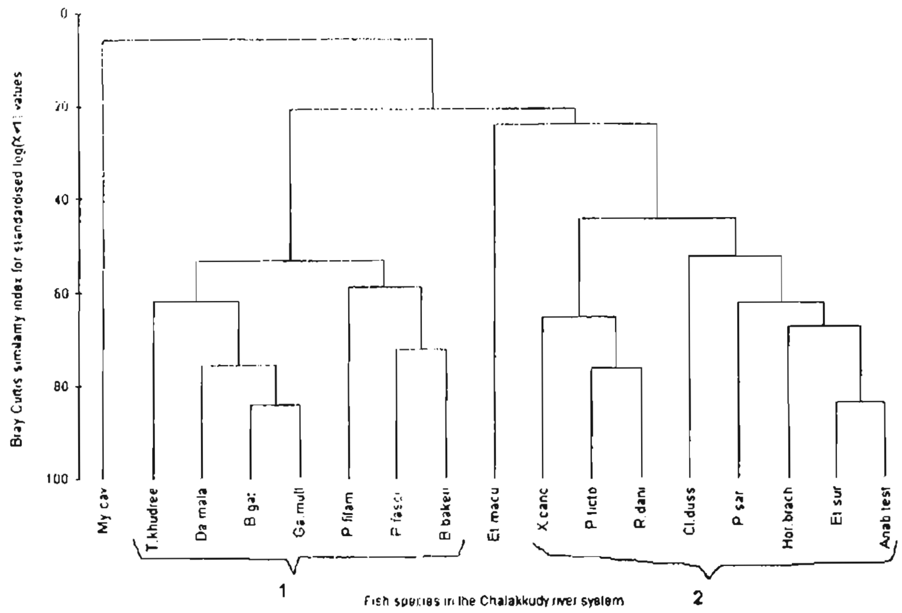


Fig.4.12. Dendrogram showing fish species clusters in Chalakkudy river system during post monsoon 2001

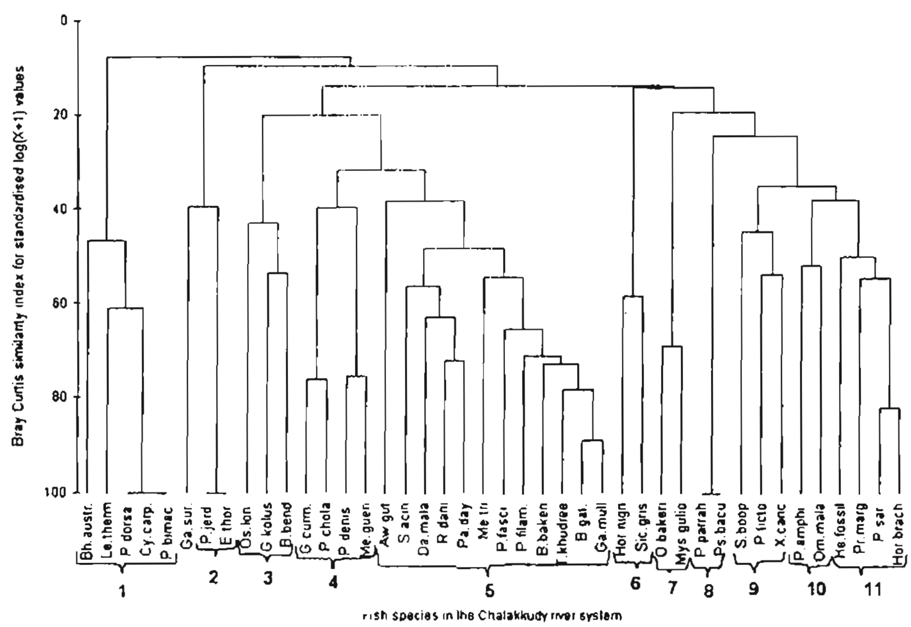


Fig.4.13. Dendrogram showing fish species clusters in Chalakkudy river system during pre-monsoon 2002

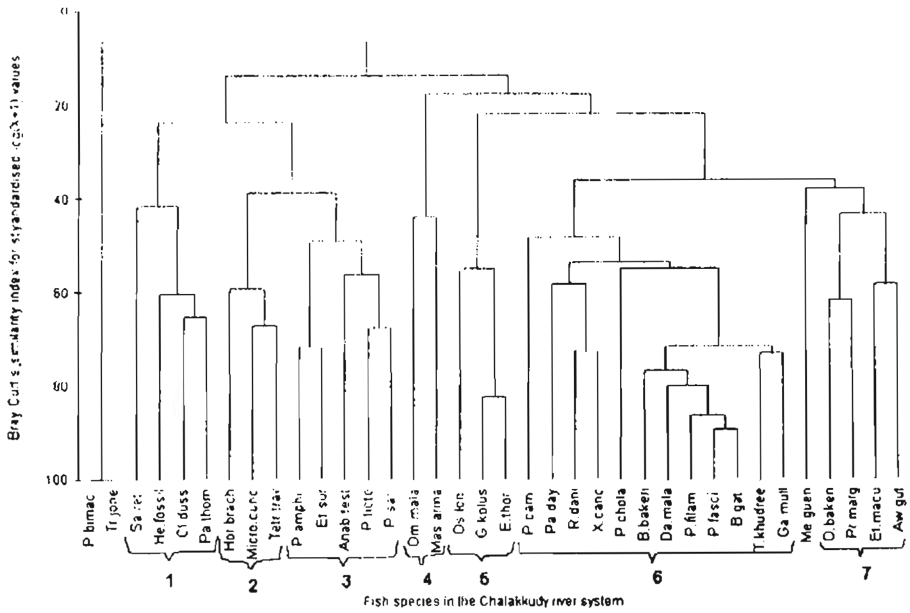


Fig.4.14. Dendrogram showing fish species clusters in Chalakkudy river system during monsoon 2002

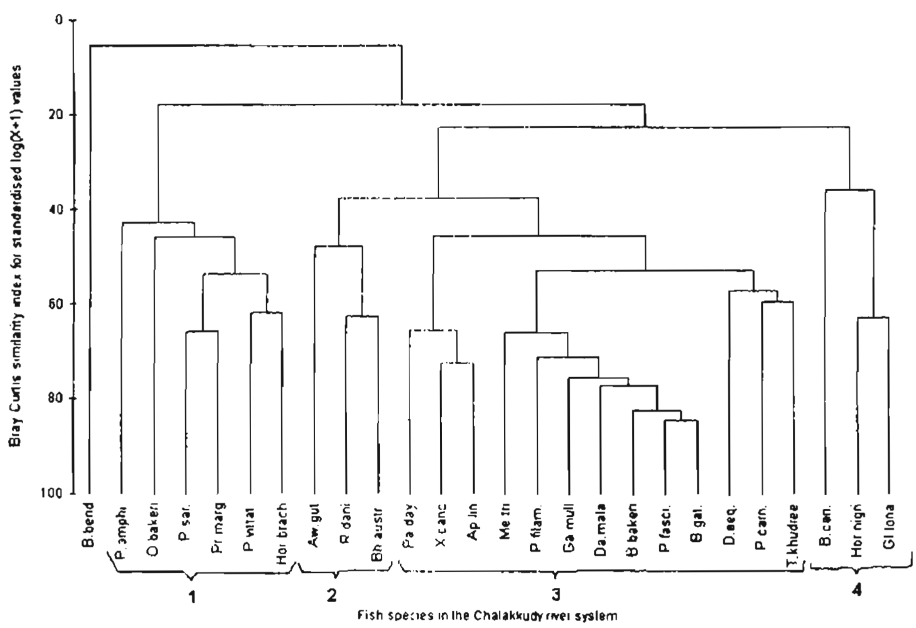


Fig.4.15. Dendrogram showing fish species clusters in Chalakkudy river system during post-monsoon 2002

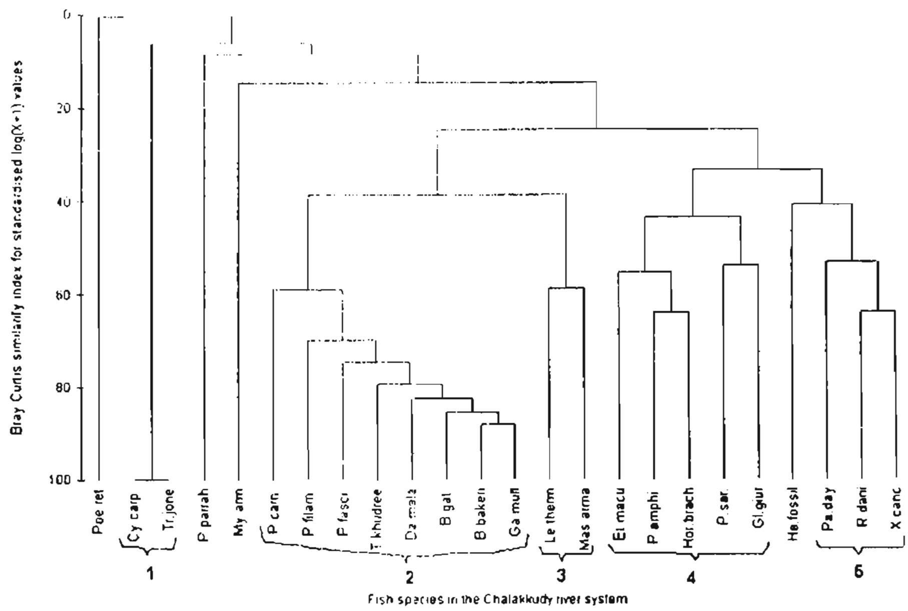


Fig.4.16. Dendrogram showing fish species clusters in Chalakkudy river system during pre-monsoon 2003

Dendrogram for species in the Chalakkudy river system during premonsoon 2003

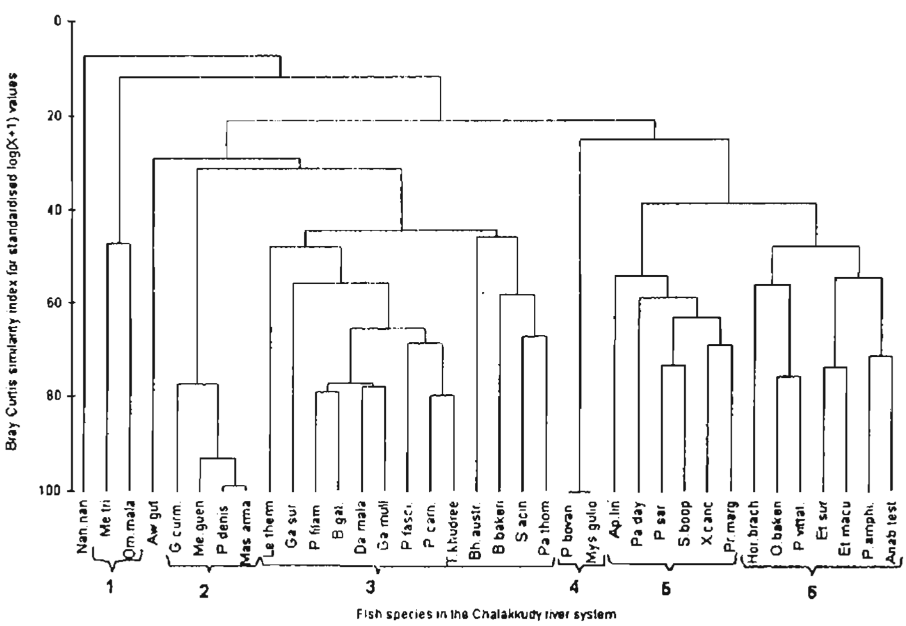


Fig.4.17. Dendrogram showing fish species clusters in Chalakkudy river system during monsoon 2003

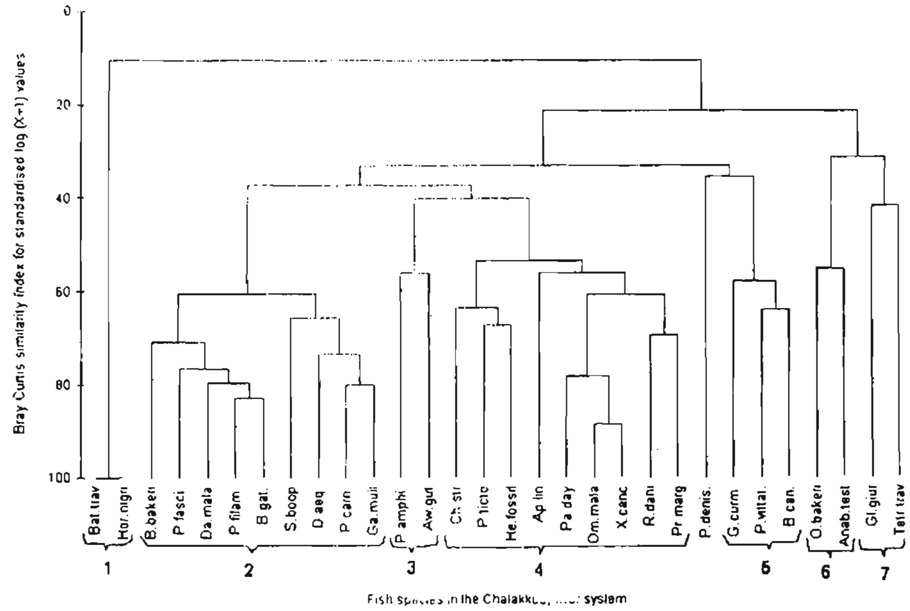


Fig.4.18. Dendrogram showing fish species clusters in Chalakkudy river system during post-monsoon 2003

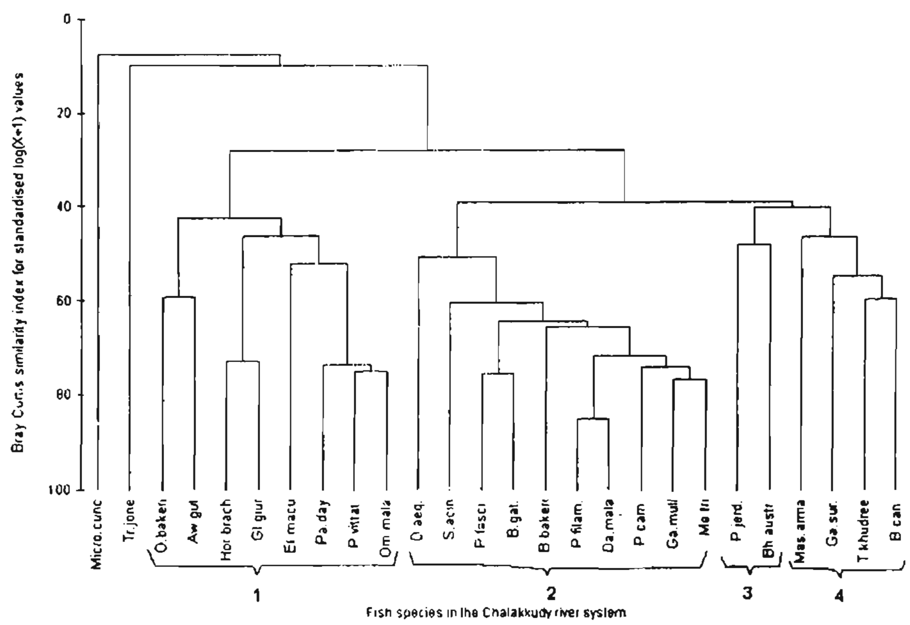


Fig.4.19. Dendrogram showing fish species clusters in Kabbini river system during pre-monsoon 2001

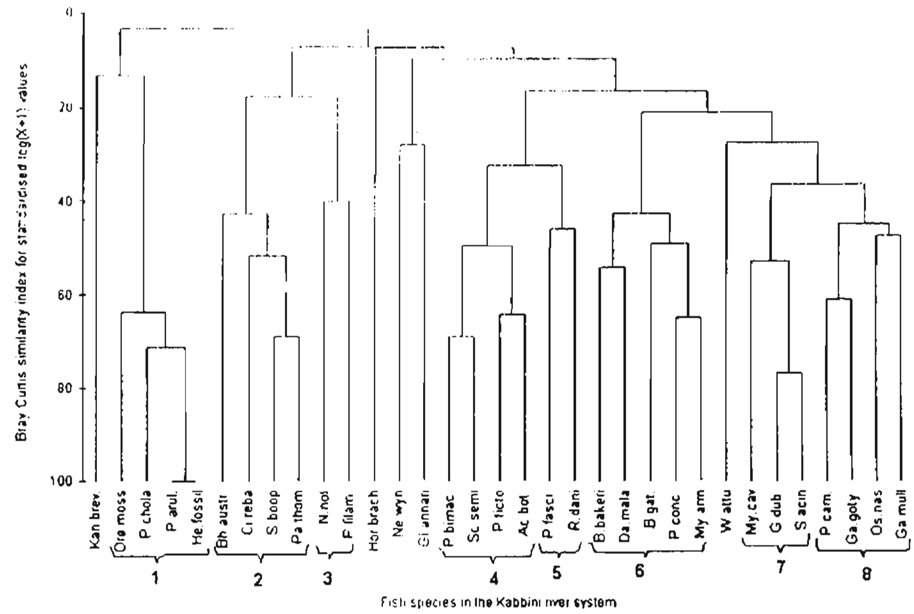


Fig.4.20. Dendrogram showing fish species clusters in Kabbini river system during monsoon 2001

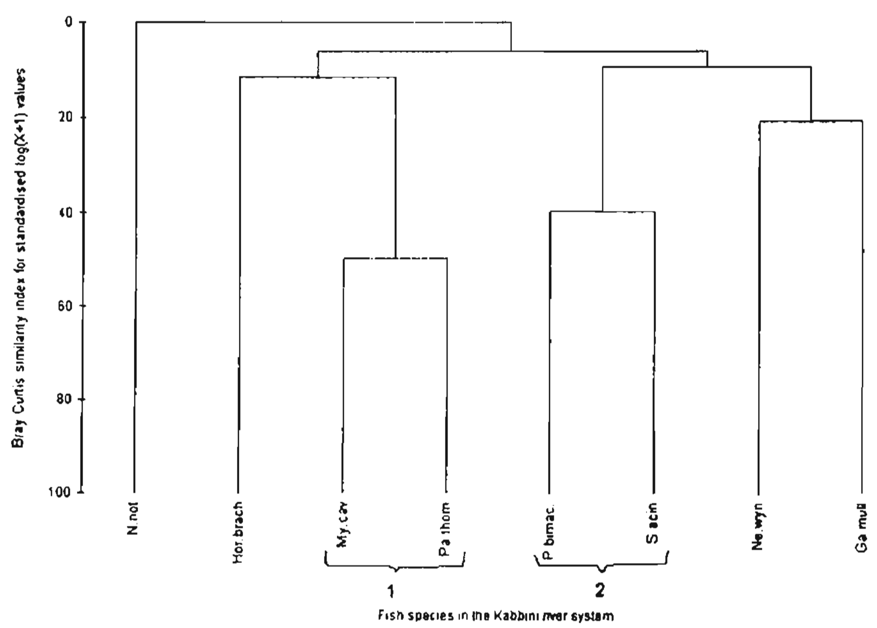


Fig.4.21. Dendrogram showing fish species clusters in Kabbini river system during post-monsoon 2001

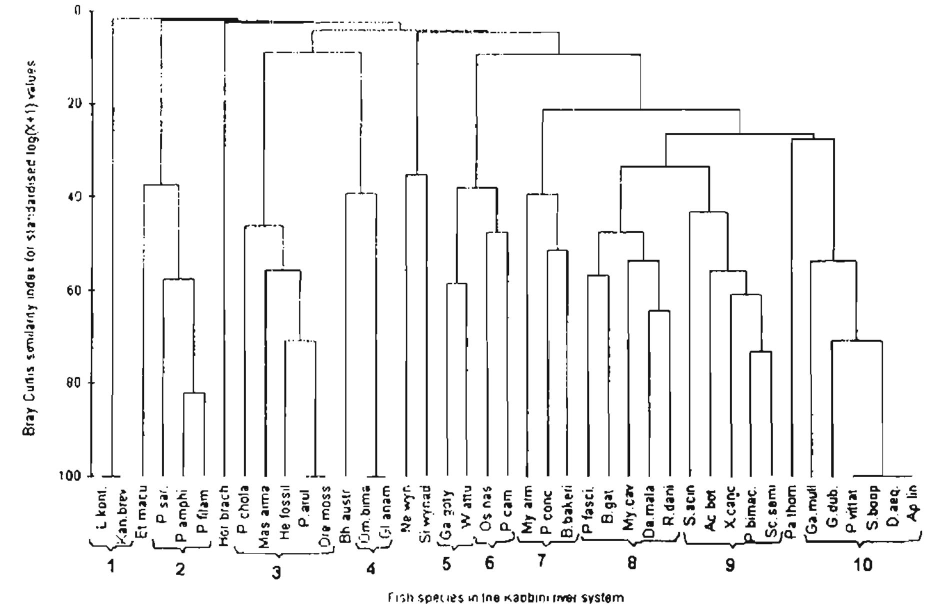


Fig.4.22. Dendrogram showing fish species clusters in Kabbini river system during pre-monsoon 2002

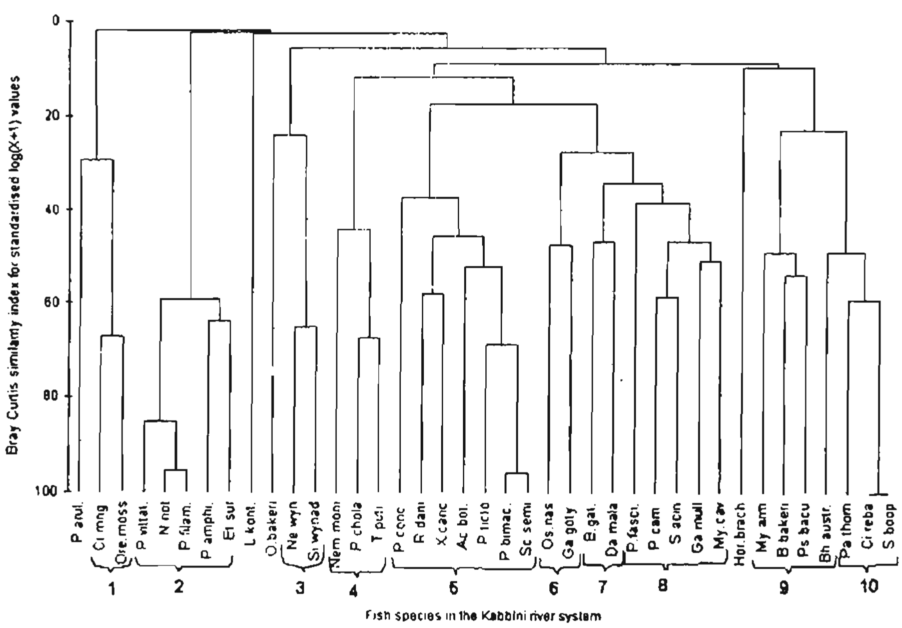


Fig.4.23. Dendrogram showing fish species clusters in Kabbini river system during monsoon 2002

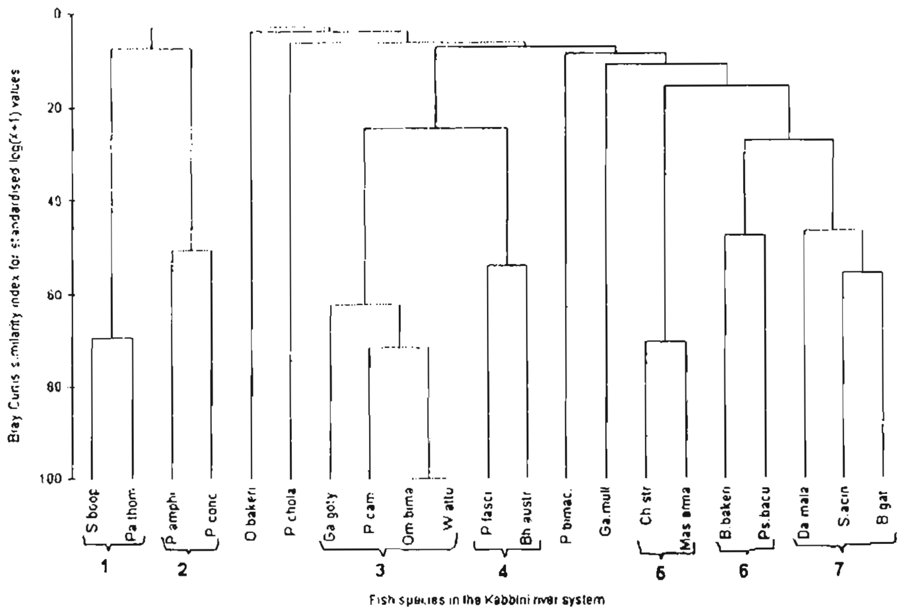


Fig.4.24. Dendrogram showing fish species clusters in Kabbini river system during post-monsoon 2002

Dendrogram for species in the Kabbini river system during postmonsoon 2002

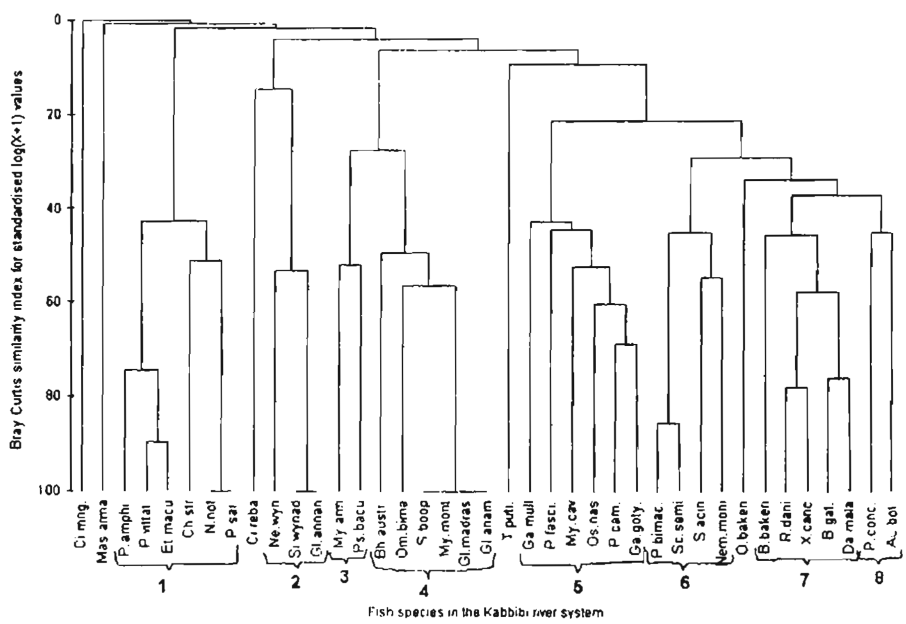


Fig.4.25. Dendrogram showing fish species clusters in Kabbini river system during pre-monsoon 2003

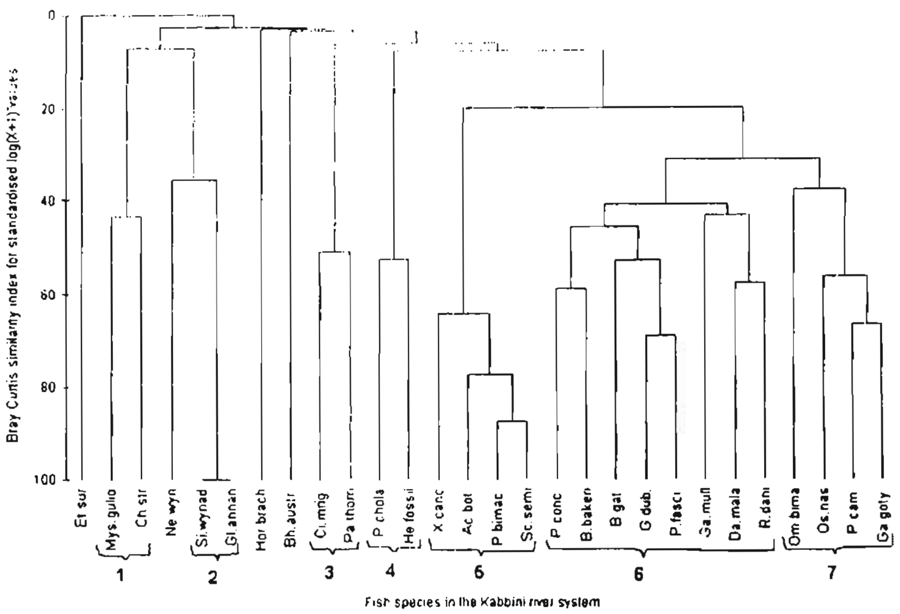


Fig.4.26. Dendrogram showing fish species clusters in Kabbini river system during monsoon 2003

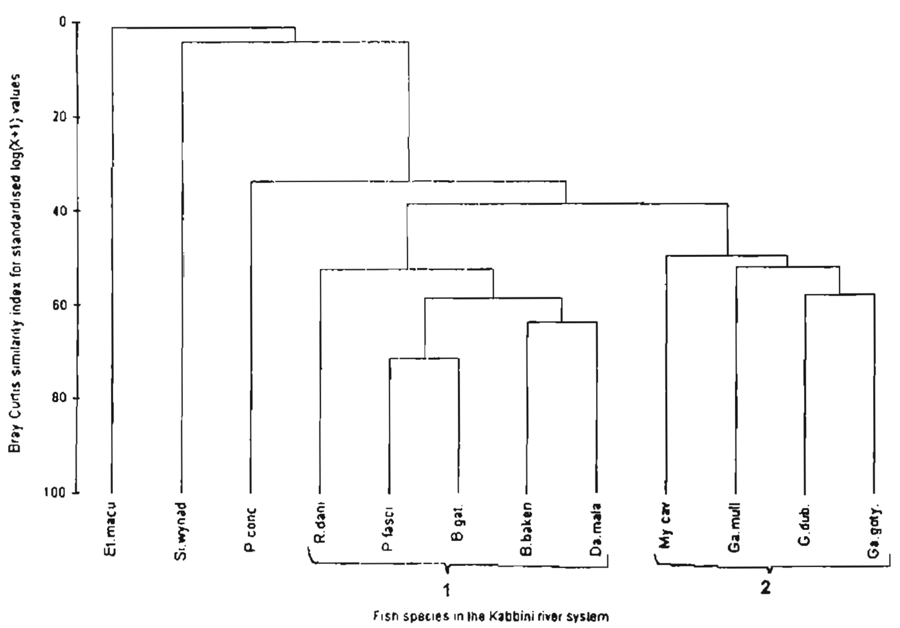


Fig.4.27. Dendrogram showing fish species clusters in Kabbini river system during post-monsoon 2003

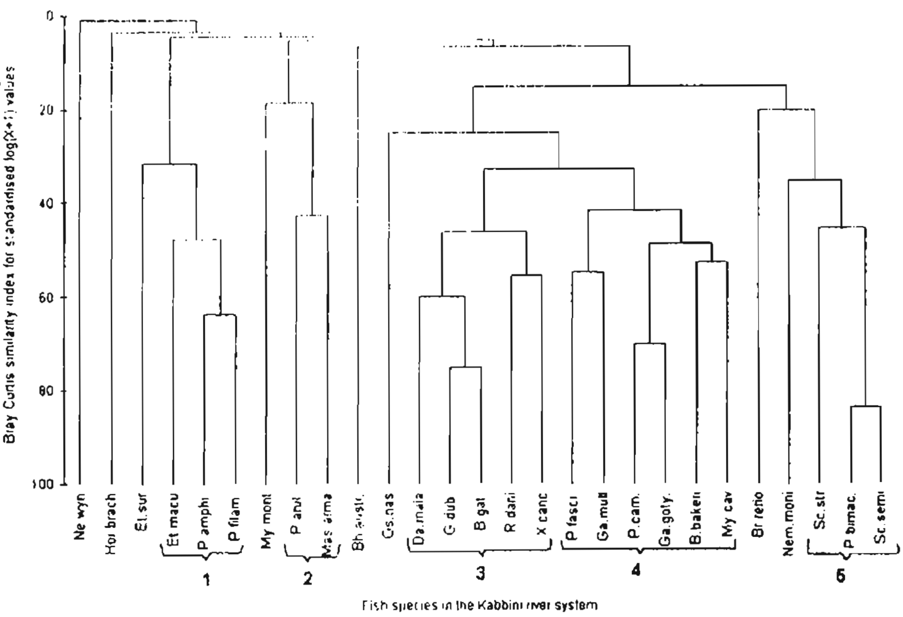


Fig.4.28. Dendrogram showing fish species clusters in Bharathapuzha river system during pre-monsoon 2001

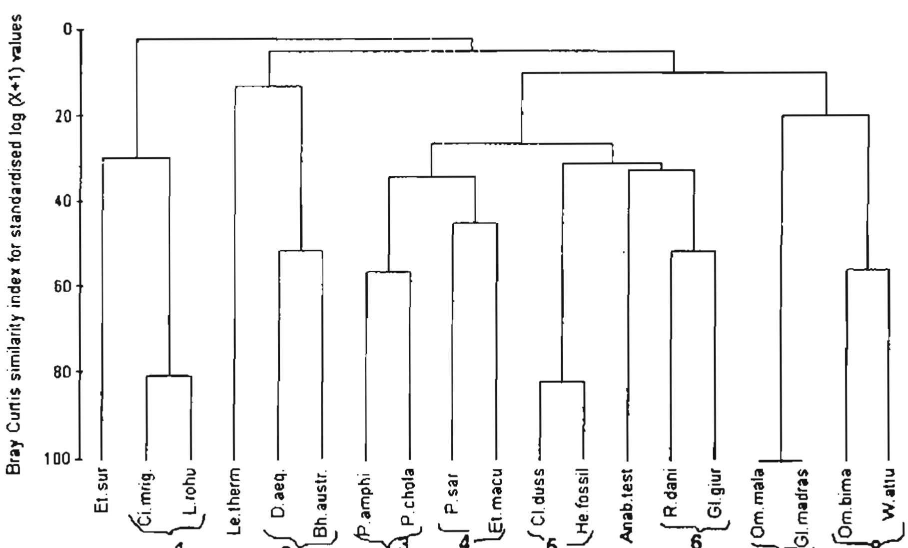


Fig.4.29. Dendrogram showing fish species clusters in Bharathapuzha river system during monsoon 2001

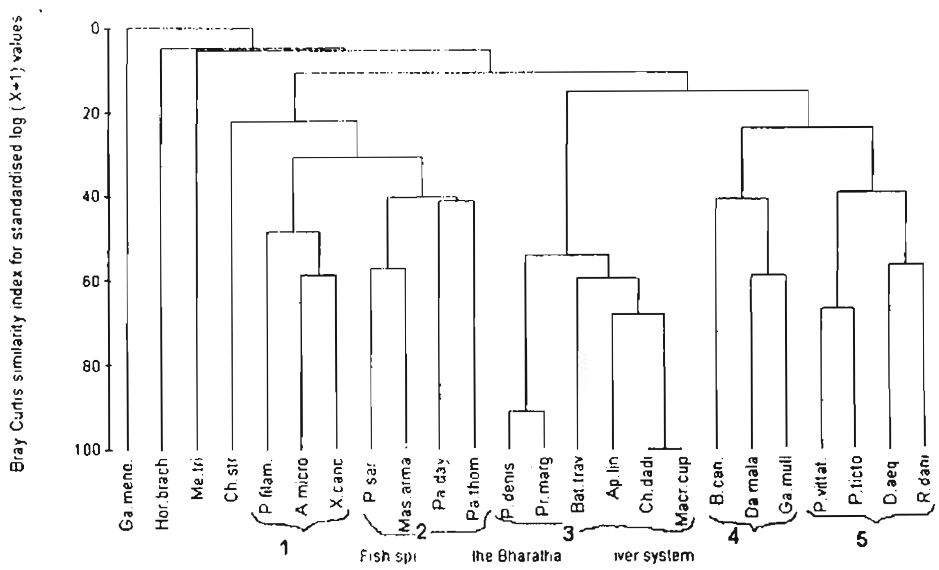


Fig.4.30. Dendrogram showing fish species clusters in Bharathapuzha river system during post-monsoon 2001

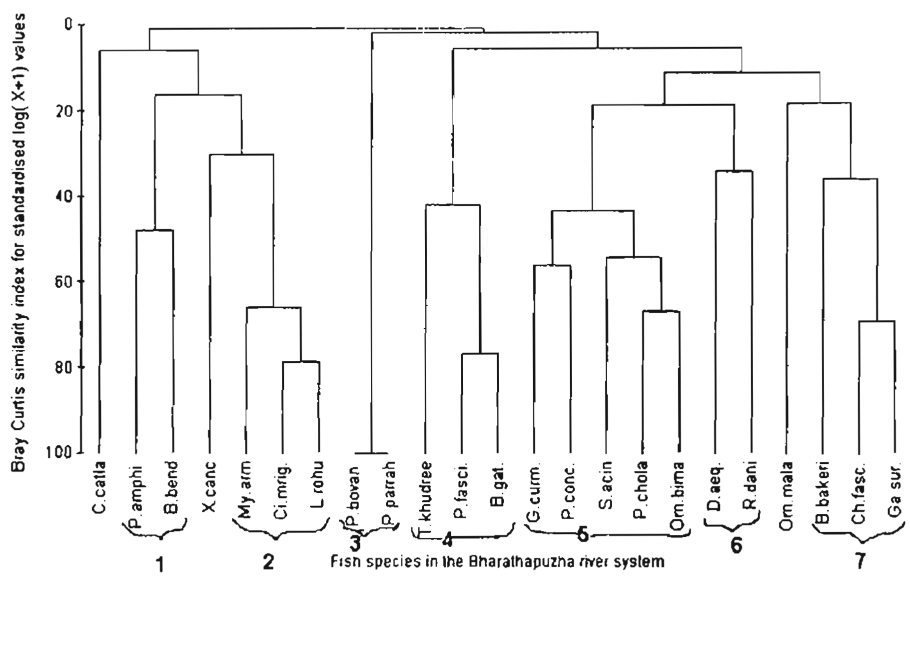


Fig.4.31. Dendrogram showing fish species clusters in Bharathapuzha river system during pre-monsoon 2002

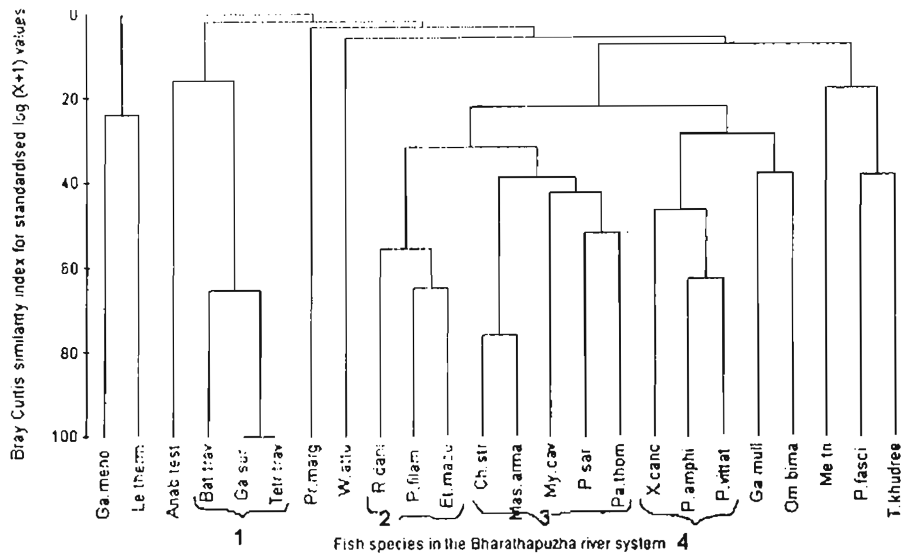


Fig.4.32. Dendrogram showing fish species clusters in Bharathapuzha river system during monsoon 2002

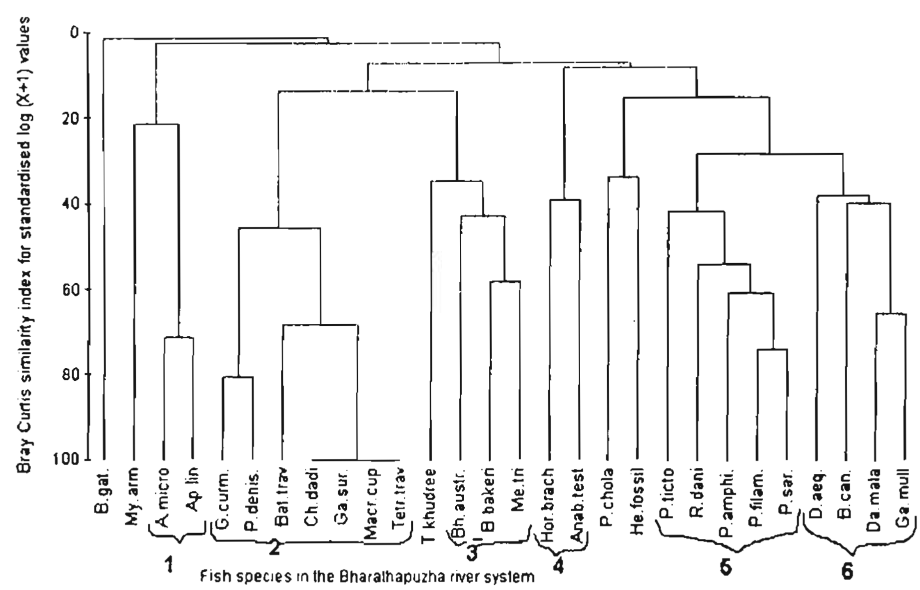


Fig.4.33. Dendrogram showing fish species clusters in Bharathapuzha river system during post-monsoon 2002

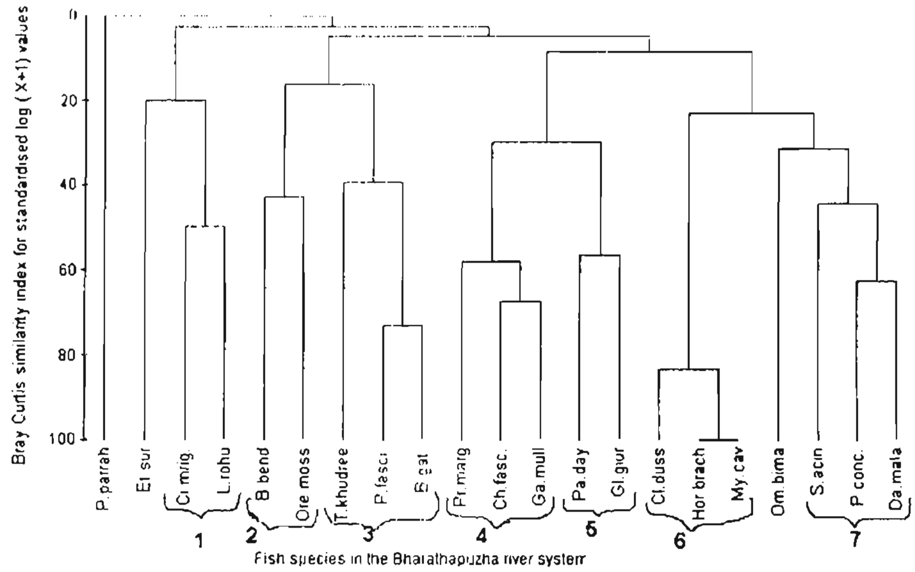


Fig.4.34. Dendrogram showing fish species clusters in Bharathapuzha river system during pre-monsoon 2003

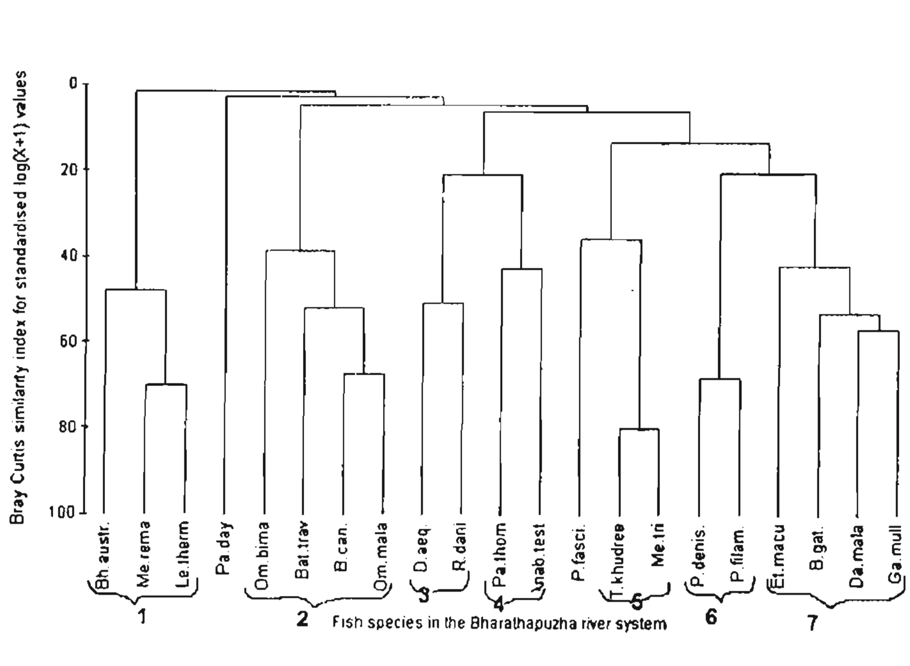


Fig.4.35. Dendrogram showing fish species clusters in Bharathapuzha river system during monsoon 2003

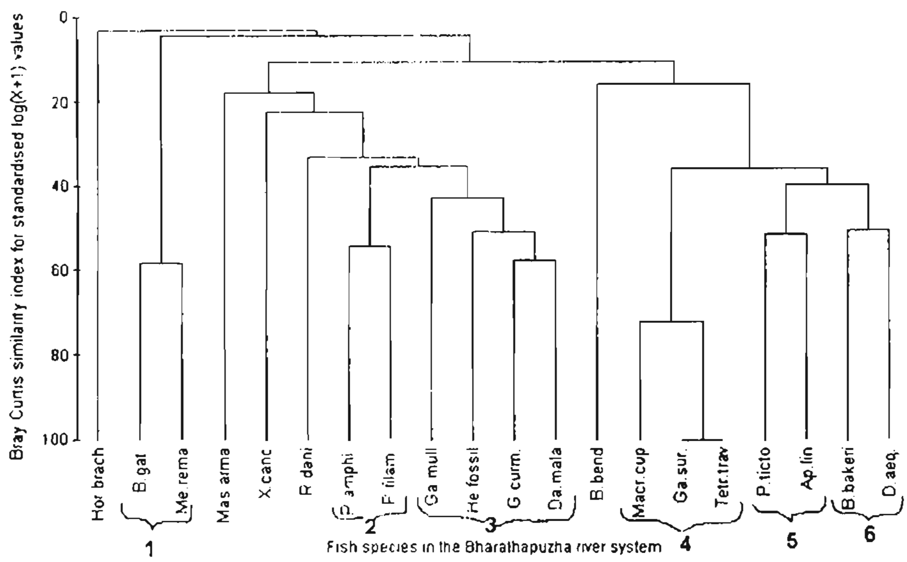


Fig.4.36. Dendrogram showing fish species clusters in Bharathapuzha river system during post-monsoon 2003

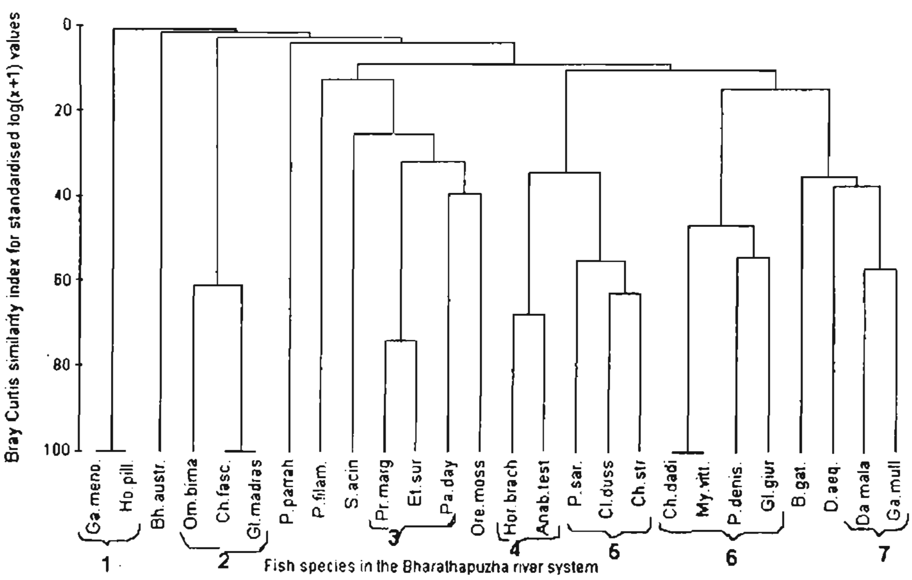


Fig.4.37. Dendrogram showing fish species clusters in Pamba river system during pre-monsoon 2001

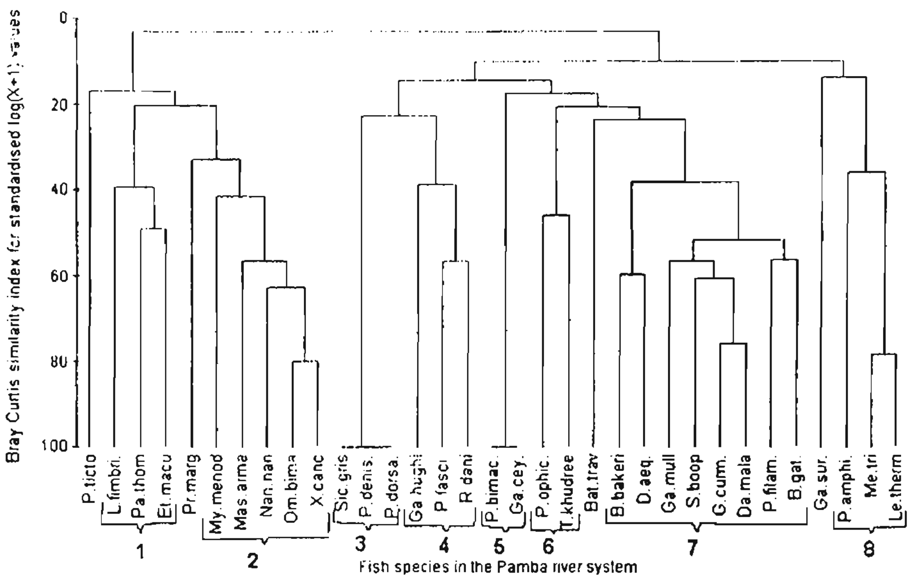


Fig.4.38. Dendrogram showing fish species clusters in Pamba river system during monsoon 2001

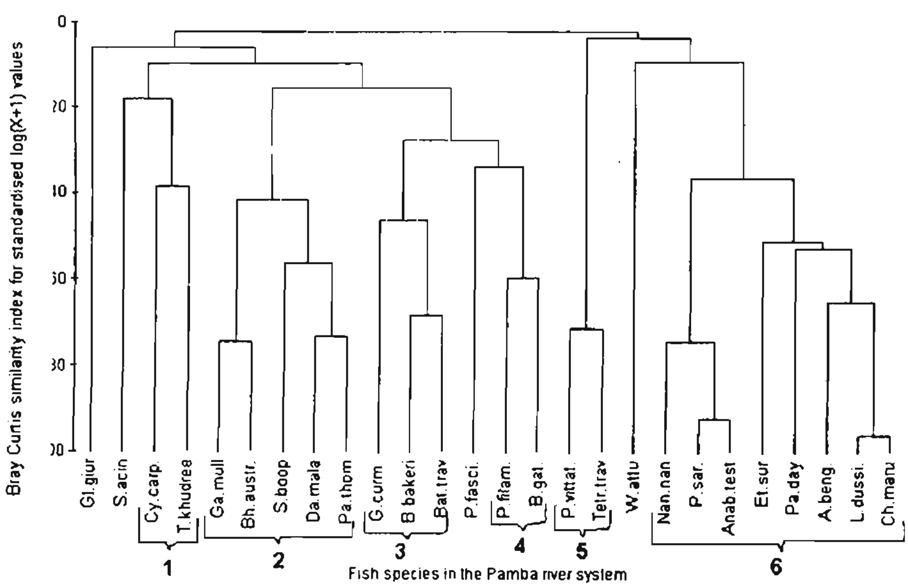


Fig.4.39. Dendrogram showing fish species clusters in Pamba river system during post-monsoon 2001

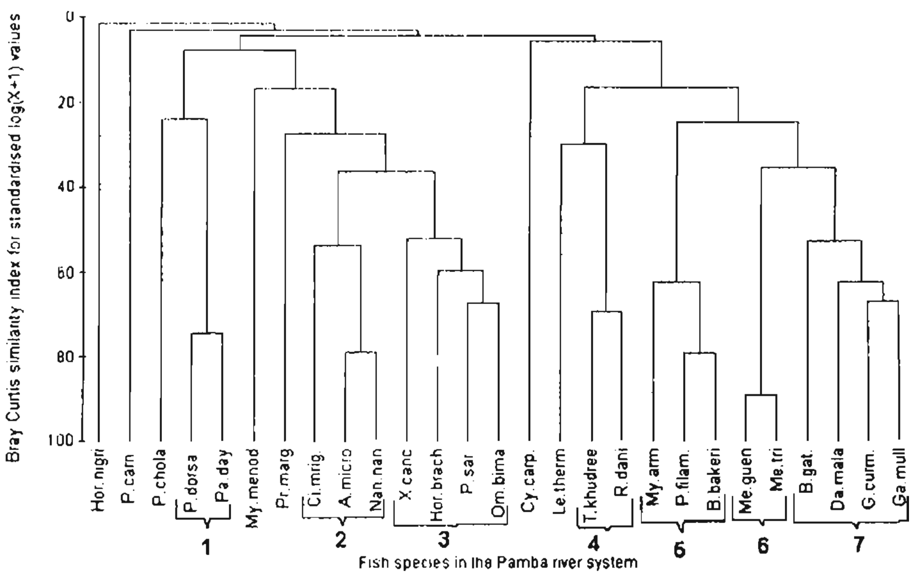


Fig.4.40. Dendrogram showing fish species clusters in Pamba river system during pre-monsoon 2002

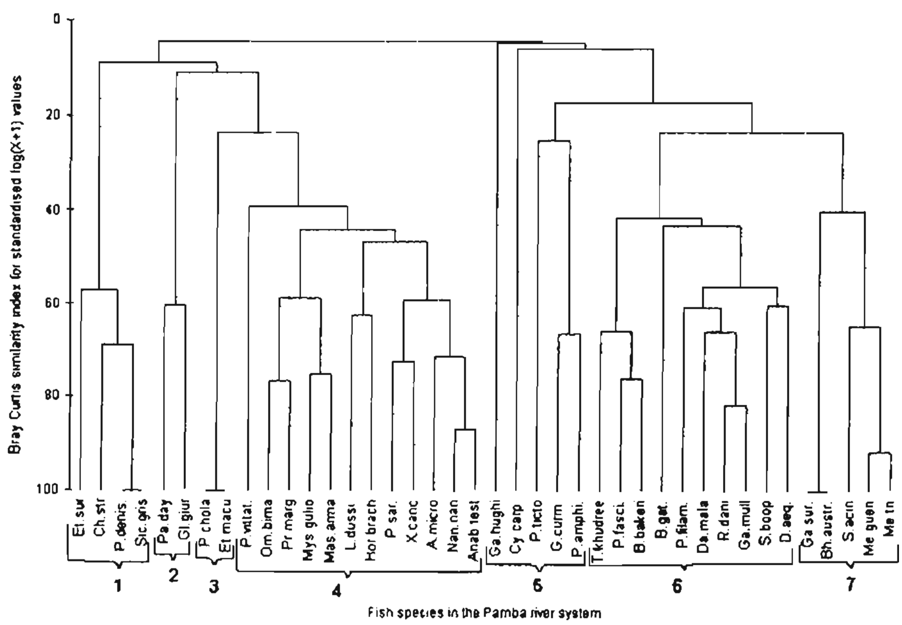


Fig.4.41. Dendrogram showing fish species clusters in Pamba river system during monsoon 2002

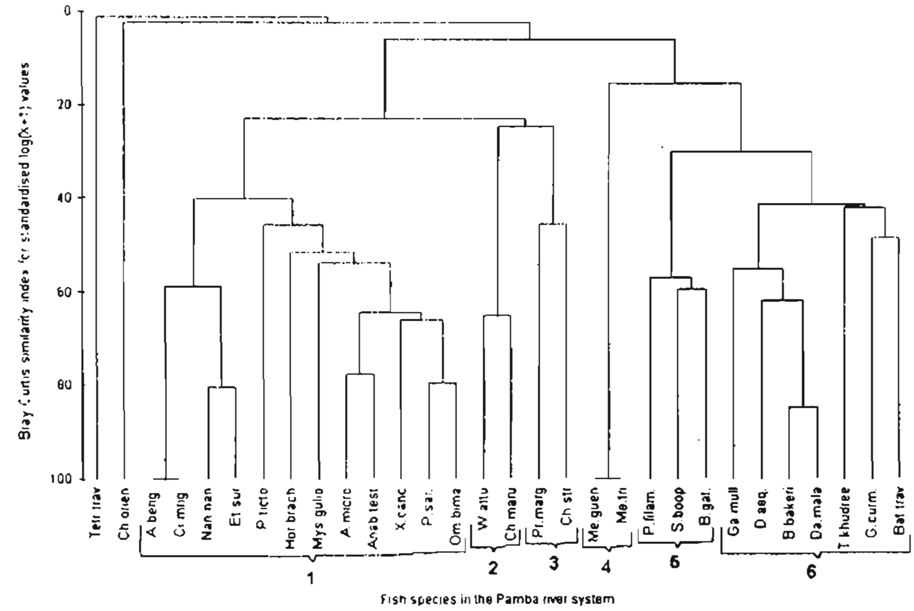


Fig.4.42. Dendrogram showing fish species clusters in Pamba river system during post-monsoon 2002

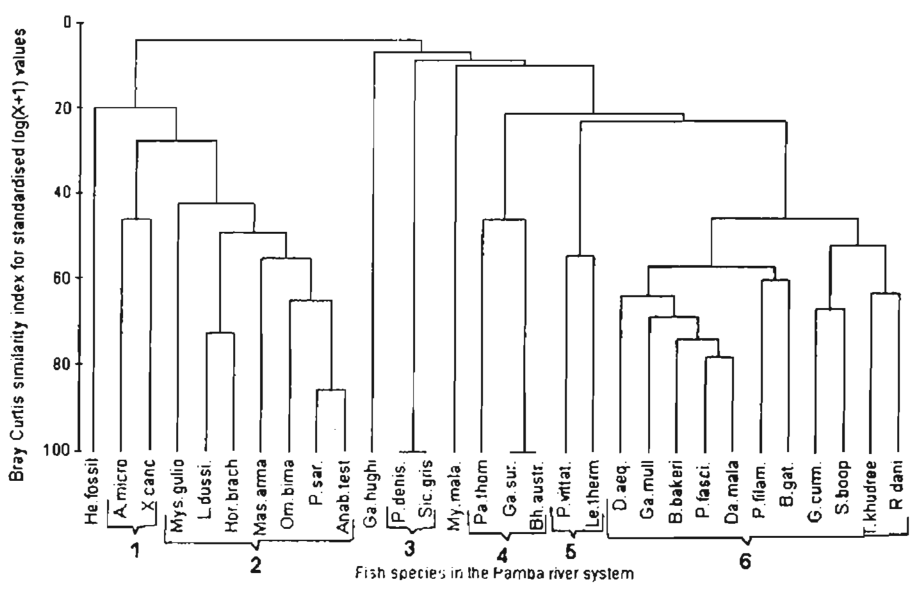


Fig.4.43. Dendrogram showing fish species clusters in Pamba river system during pre-monsoon 2003

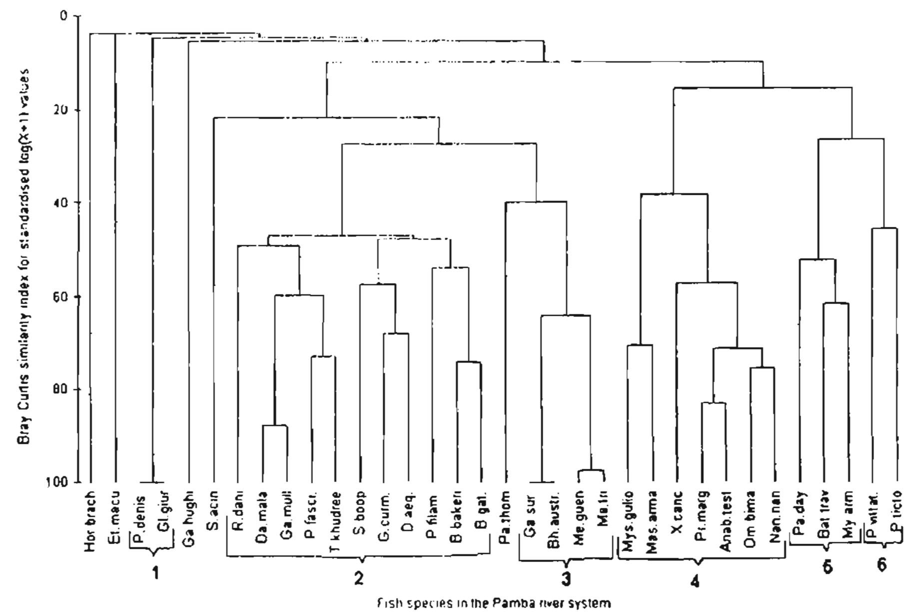


Fig.4.44. Dendrogram showing fish species clusters in Pamba river system during monsoon 2003

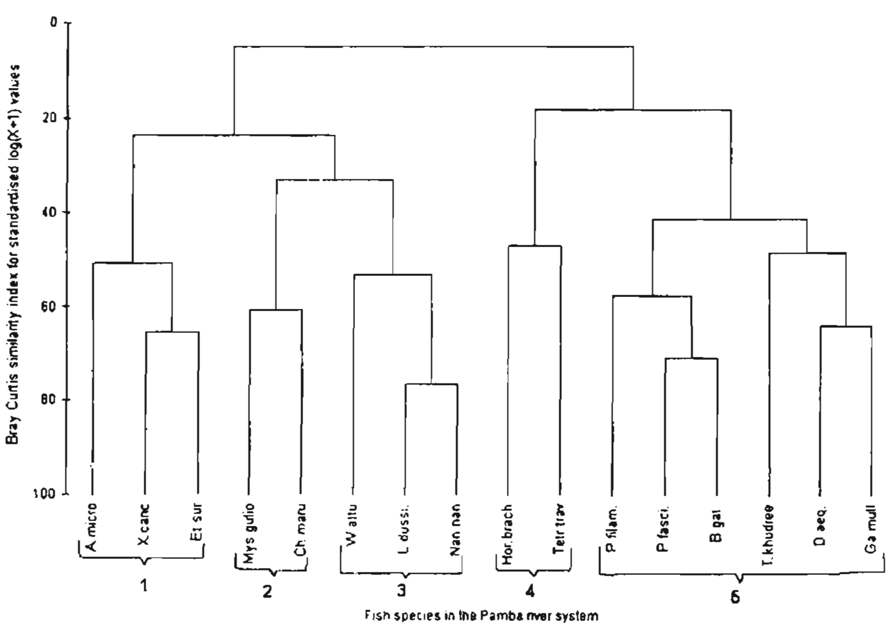


Fig.4.45. Dendrogram showing fish species clusters in Pamba river system during post-monsoon 2003

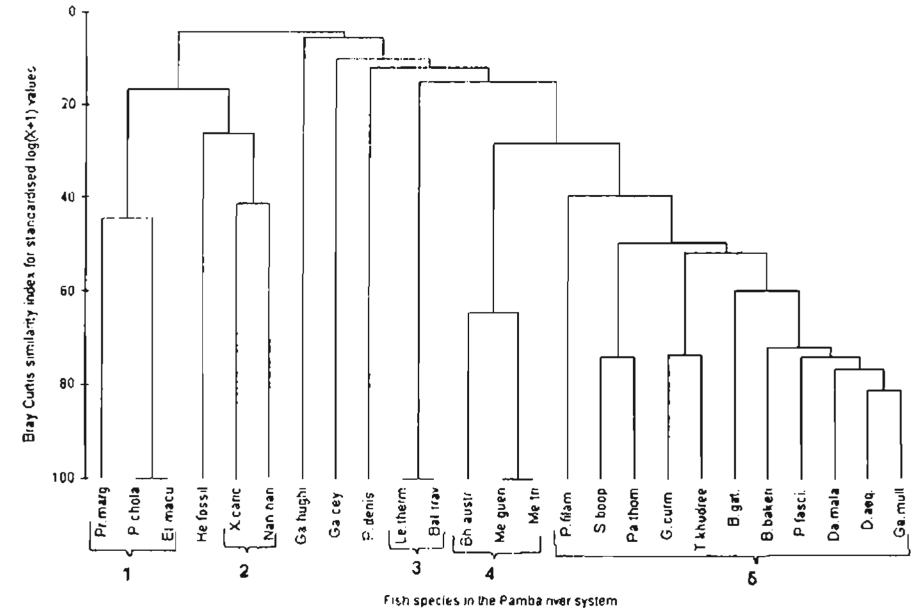


Fig.4.46. Dendrogram showing fish species clusters in Kallada river system during pre-monsoon 2001

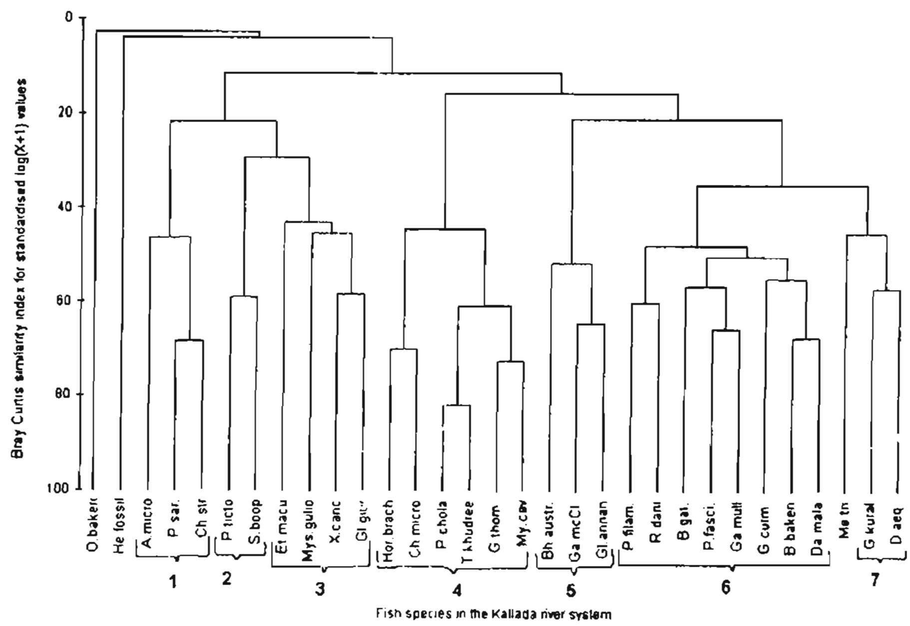


Fig.4.47. Dendrogram showing fish species clusters in Kallada river system during monsoon 2001

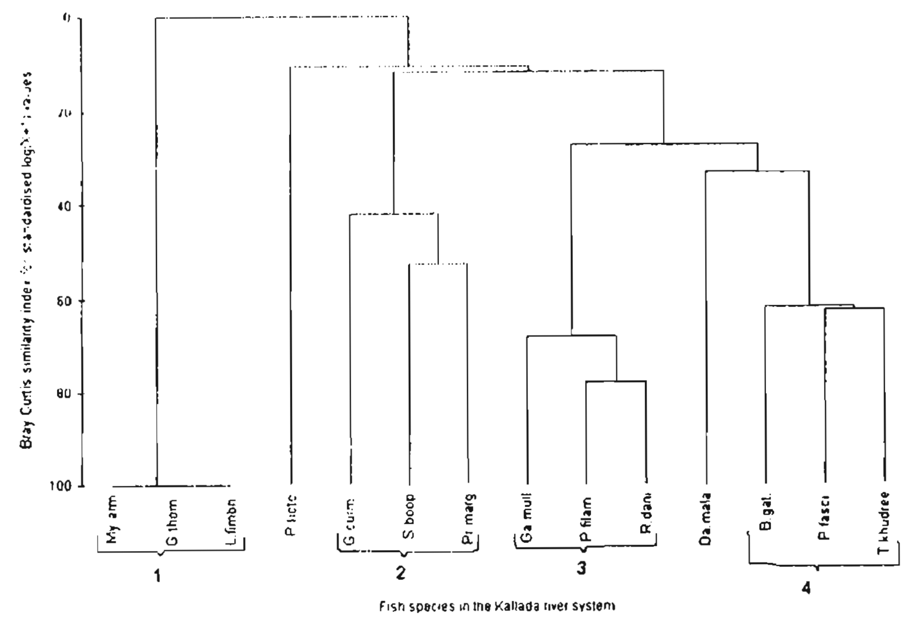


Fig.4.48. Dendrogram showing fish species clusters in Kallada river system during post-monsoon 2001

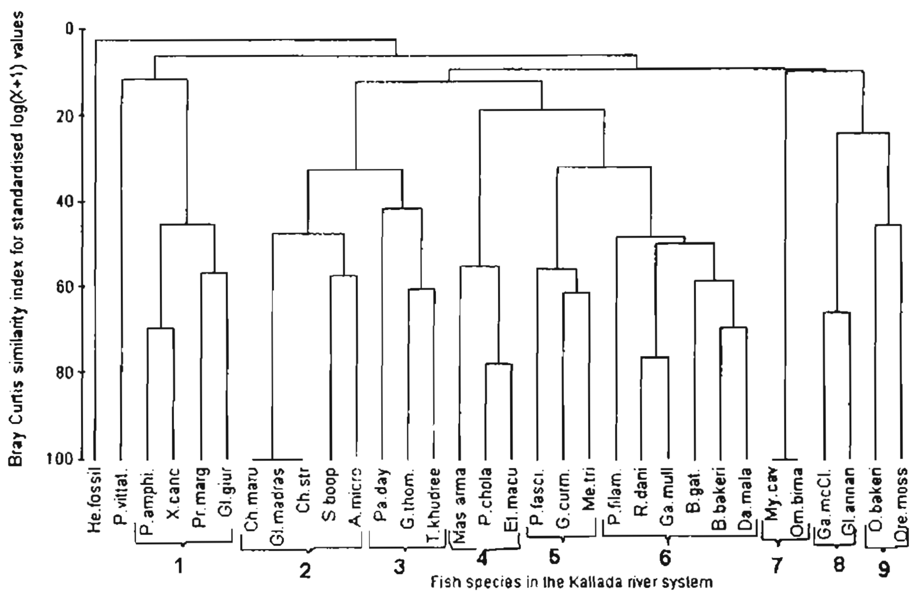


Fig.4.49. Dendrogram showing fish species clusters in Kallada river system during pre-monsoon 2002

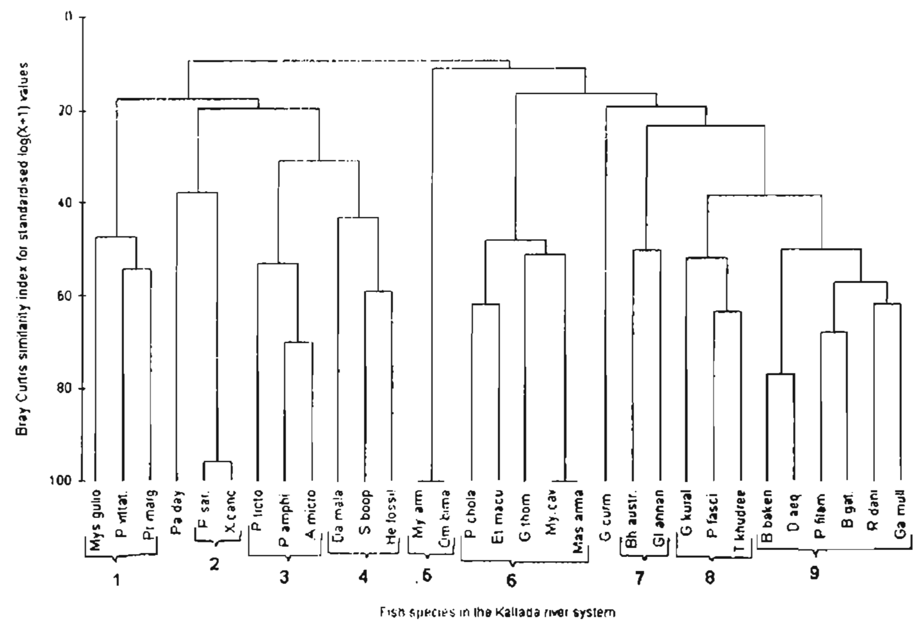


Fig.4.50. Dendrogram showing fish species clusters in Kallada river system during monsoon 2002

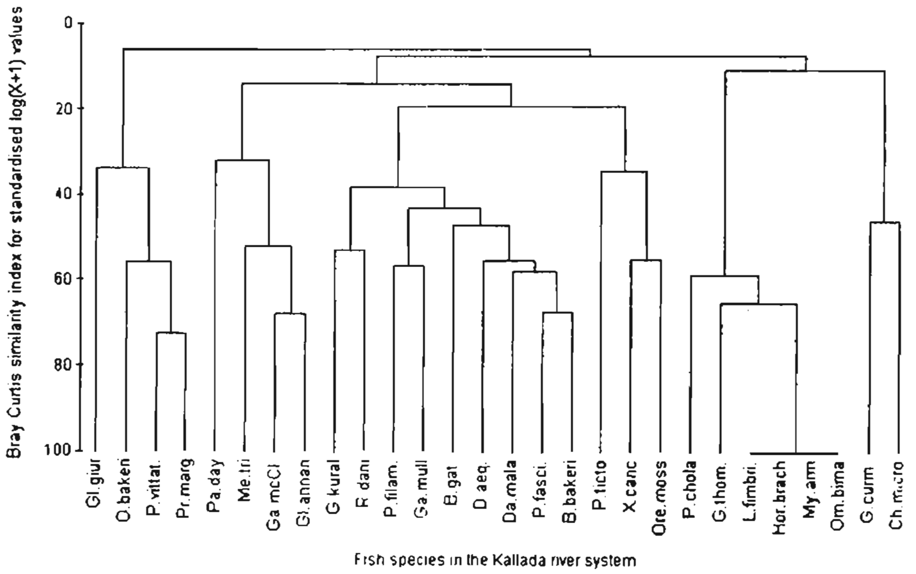


Fig.4.51. Dendrogram showing fish species clusters in Kallada river system during post-monsoon 2002

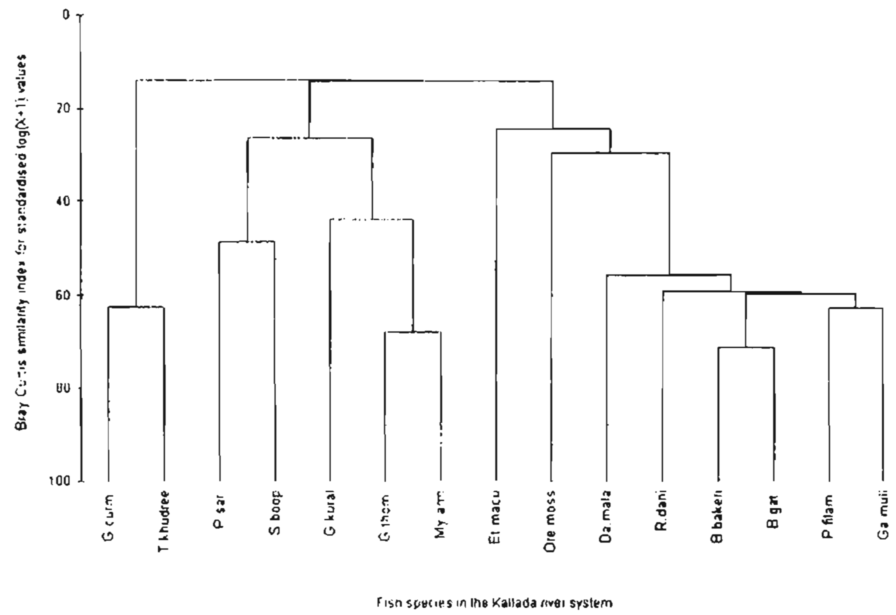


Fig.4.52. Dendrogram showing fish species clusters in Kallada river system during pre-monsoon 2003

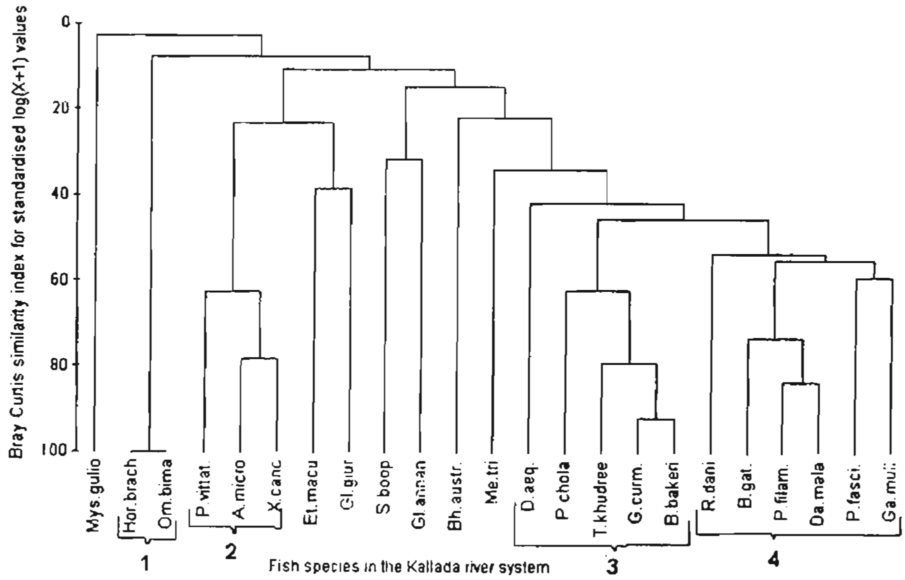


Fig.4.53. Dendrogram showing fish species clusters in Kallada river system during monsoon 2003

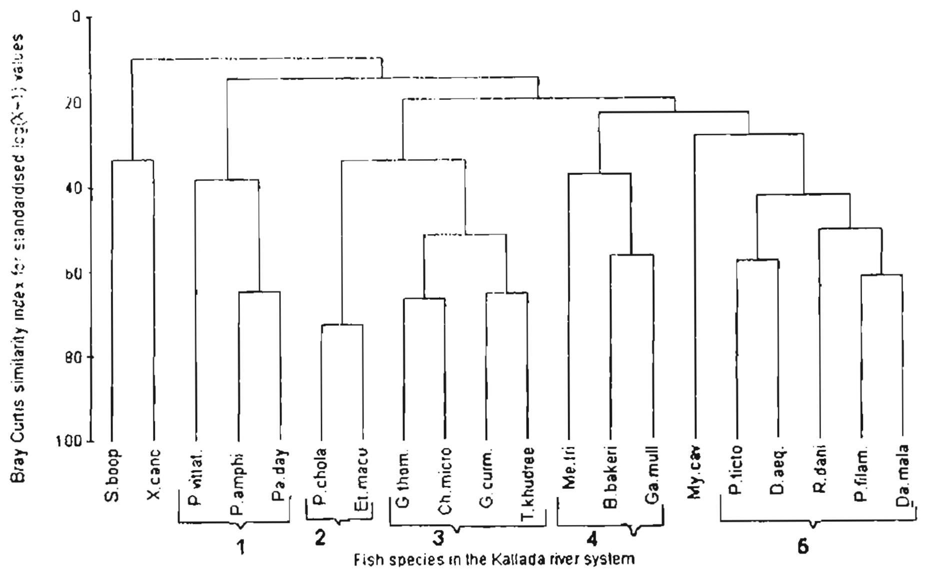


Fig.4.54. Dendrogram showing fish species clusters in Kallada river system during post-monsoon 2003

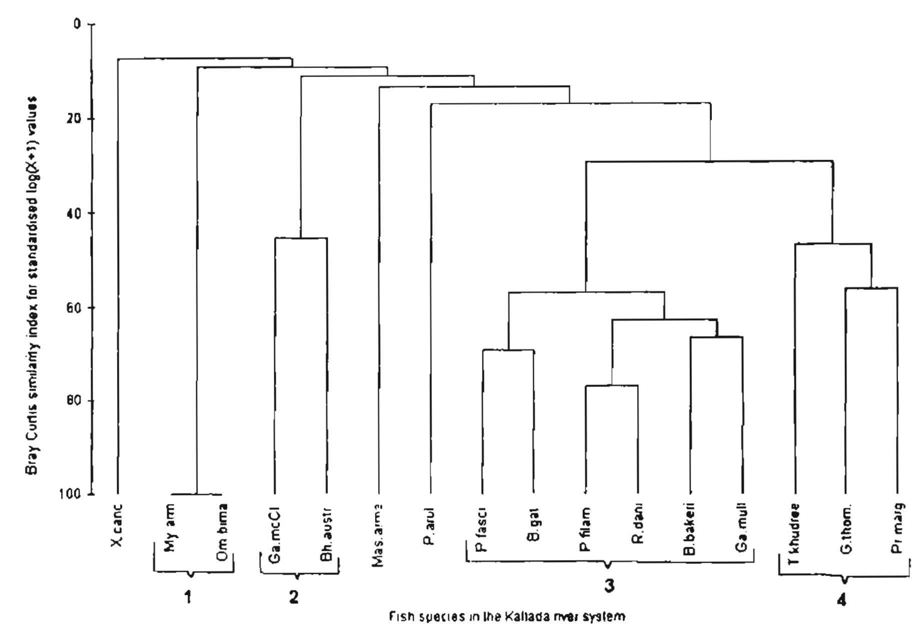


Fig.4.55. MDS analysis for stations in the Periyar river system during pre-monsoon 2001.

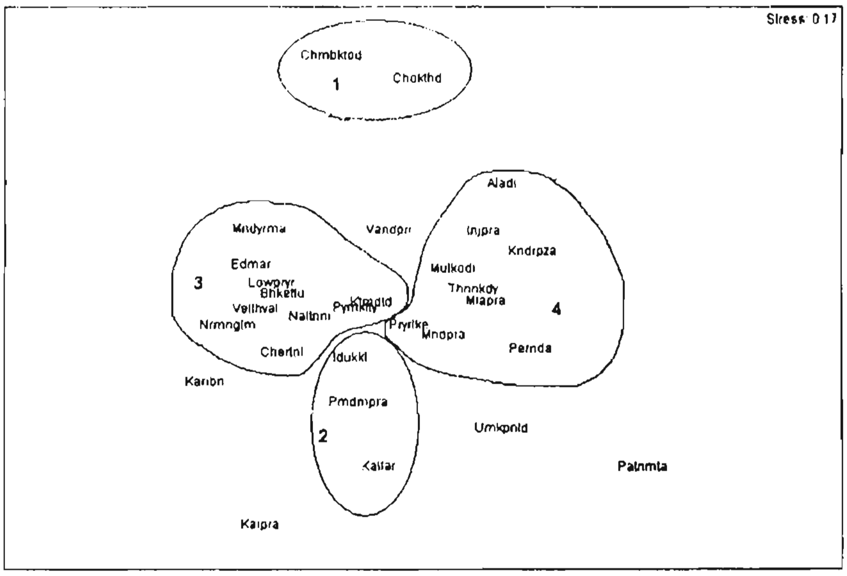


Fig.4.56. MDS analysis for stations in the Periyar river system during monsoon 2001.

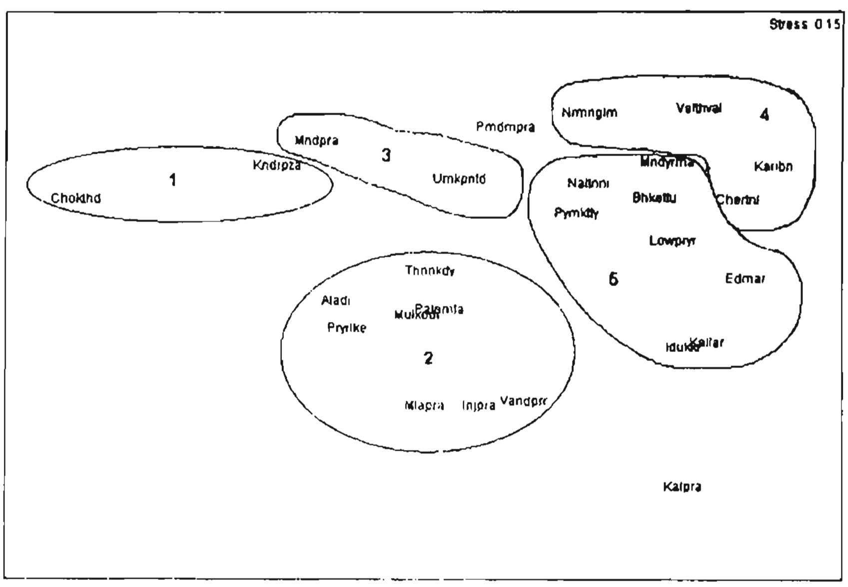


Fig.4.57. MDS analysis for stations in the Periyar river system during post-monsoon 2001.

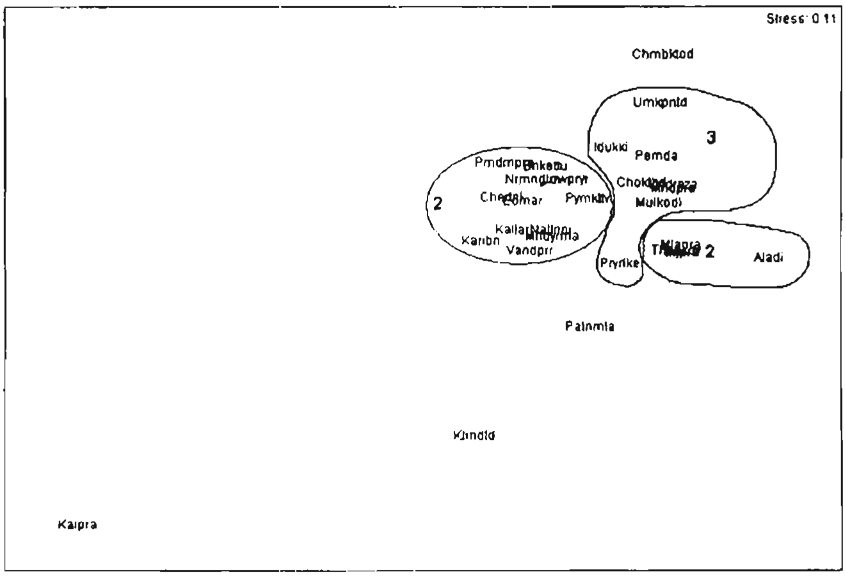


Fig.4.58. MDS analysis for stations in the Periyar river system during pre-monsoon 2002.

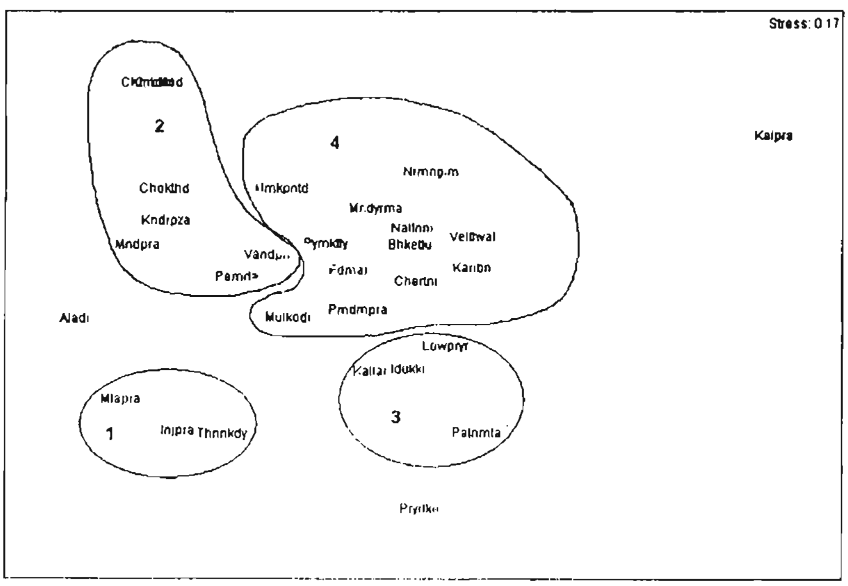


Fig.4.59. MDS analysis for stations in the Periyar river system during monsoon 2002.

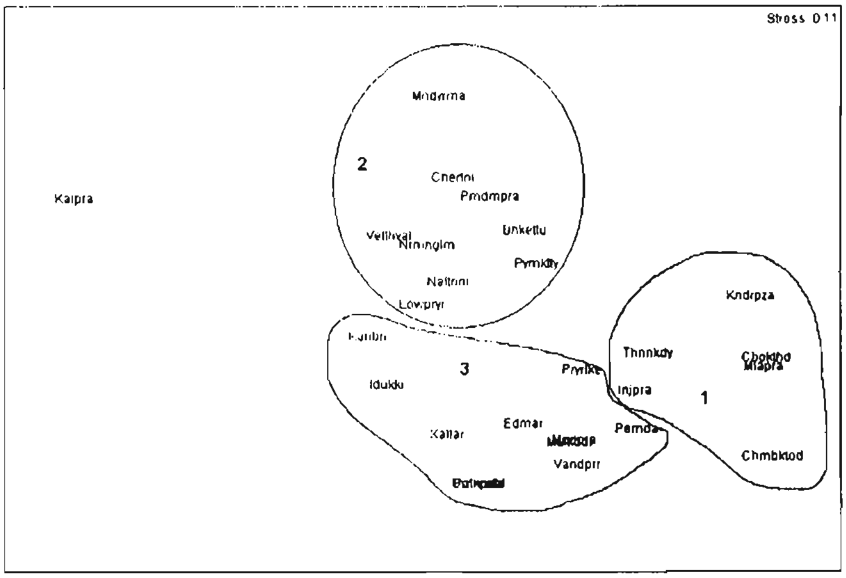


Fig.4.60. MDS analysis for stations in the Periyar river system during post-monsoon 2002.

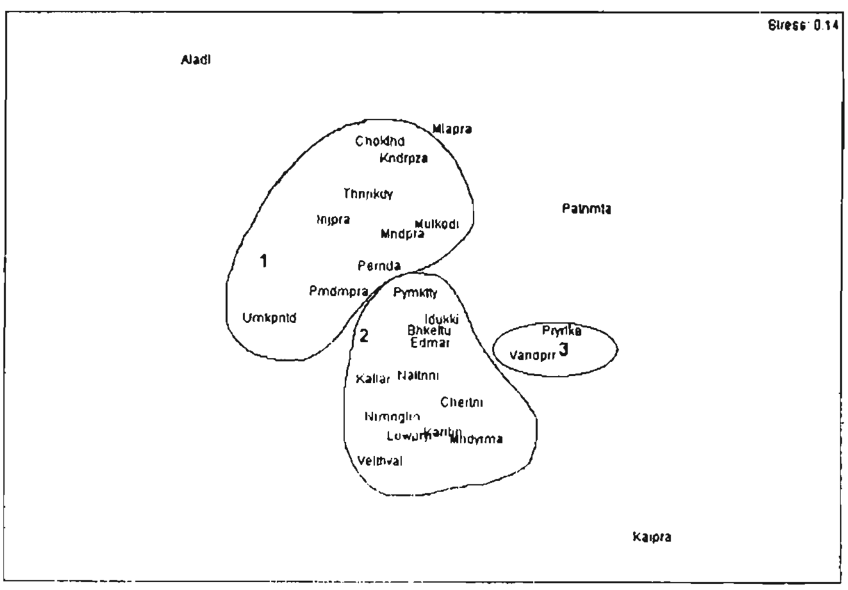


Fig.4.61. MDS analysis for stations in the Periyar river system during pre-monsoon 2003

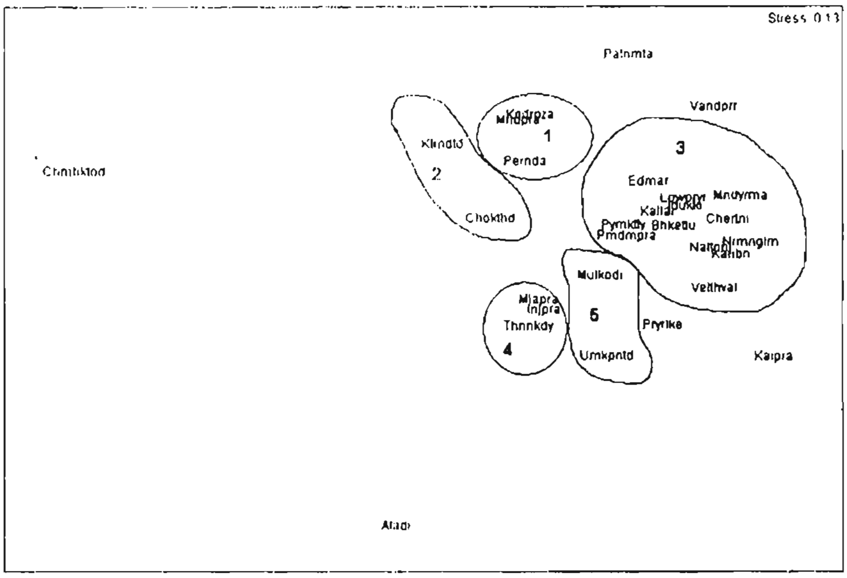


Fig.4.62. MDS analysis for stations in the Periyar river system during monsoon 2003

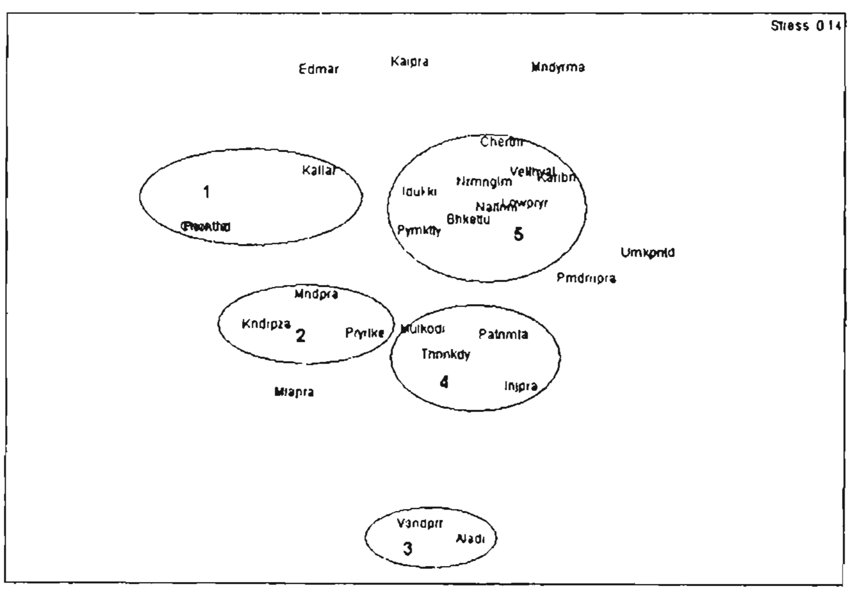


Fig.4.63. MDS analysis for stations in the Periyar river system during post-monsoon 2003.

Fig.4.64. MDS analysis for stations in the Chalakkudy river system during pre-monsoon 2001

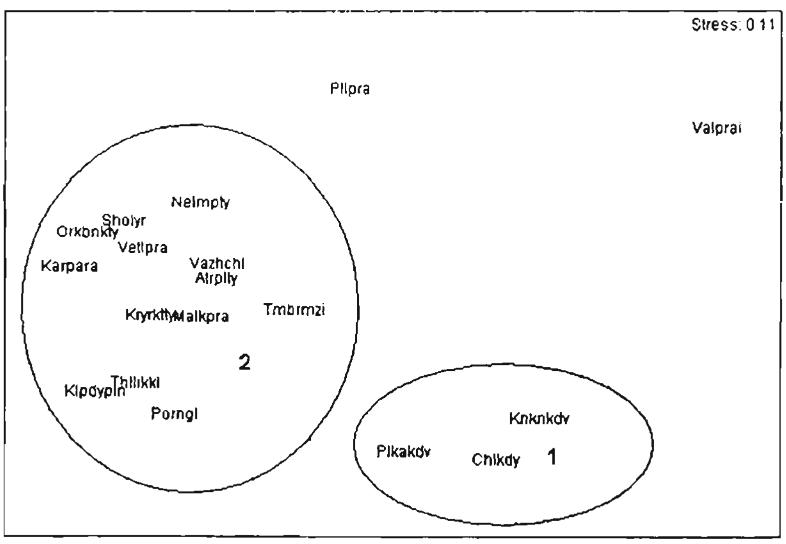


Fig.4.65. MDS analysis for stations in the Chalakkudy river system during monsoon 2001

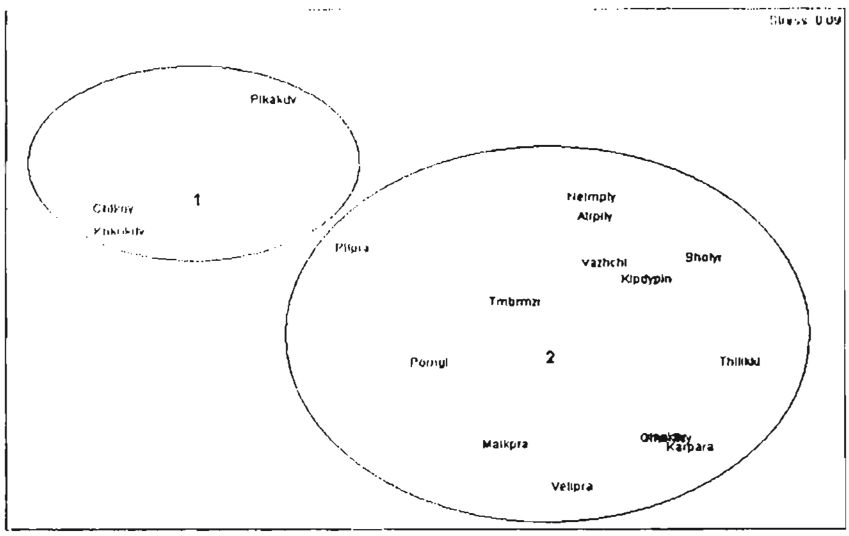


Fig.4.66. MDS analysis for stations in the Chalakkudy river system during post-monsoon 2001

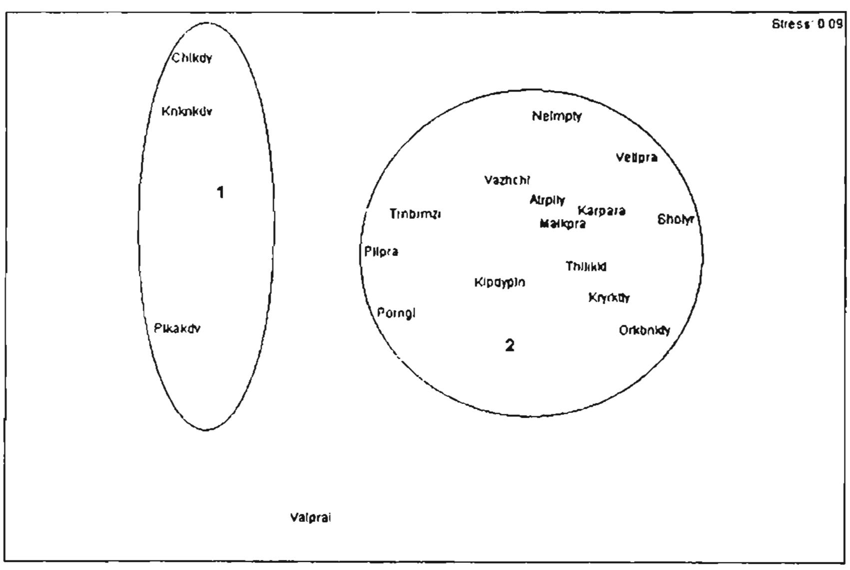


Fig.4.67. MDS analysis for stations in the Chalakkudy river system during pre-monsoon 2002

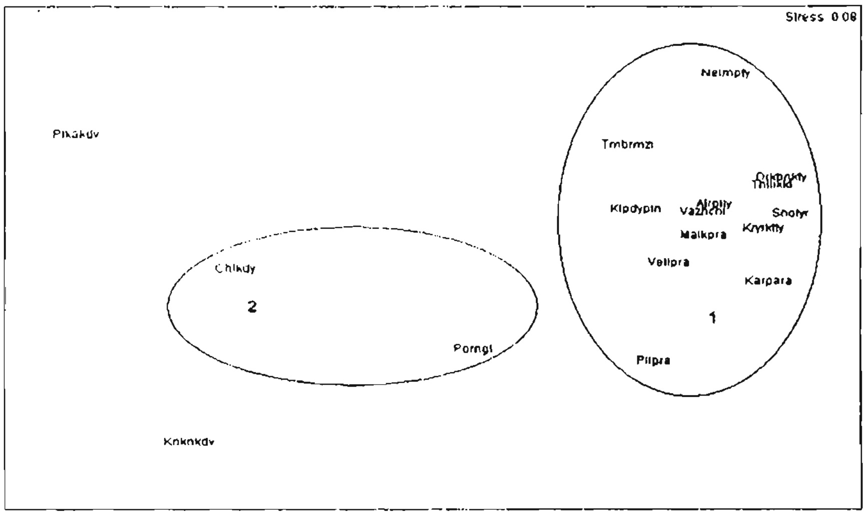


Fig.4.68. MDS analysis for stations in the Chalakkudy river system during monsoon 2002

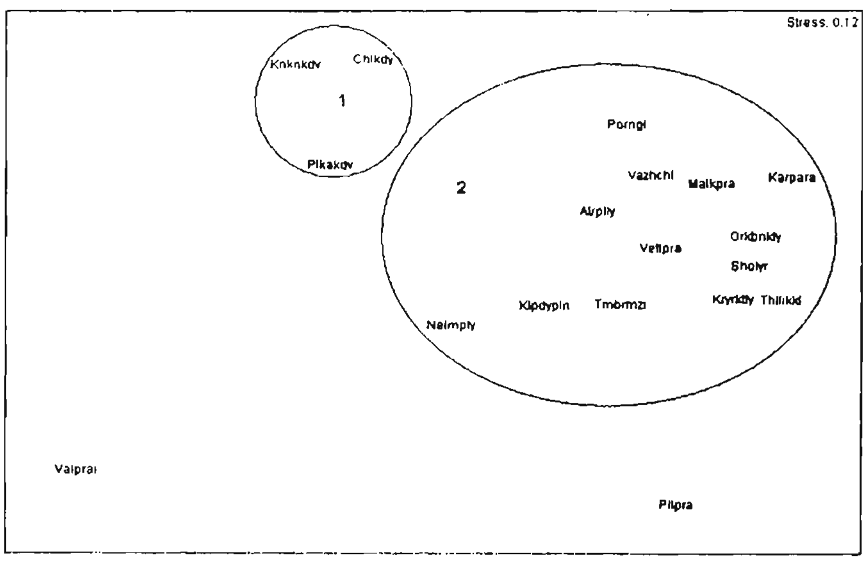


Fig.4.69. MDS analysis for stations in the Chalakkudy river system during post-monsoon 2002

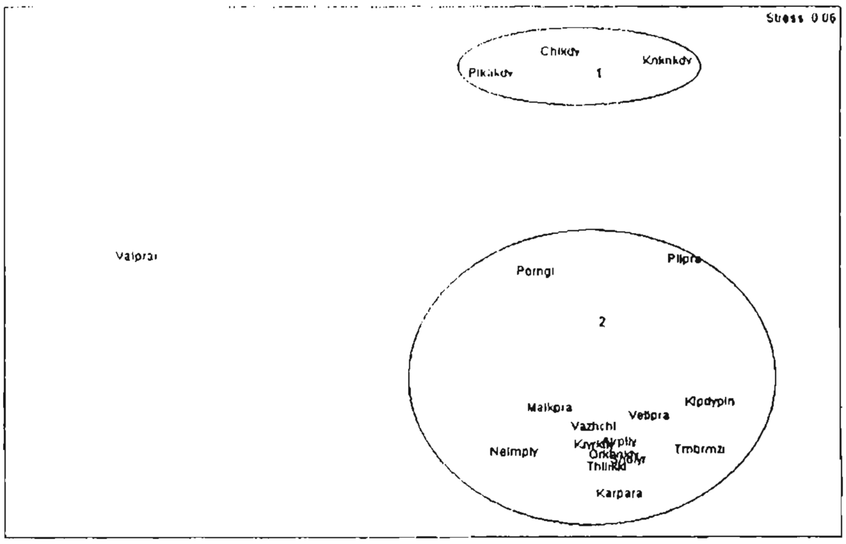


Fig.4.70. MDS analysis for stations in the Chalakkudy river system during pre-monsoon 2003

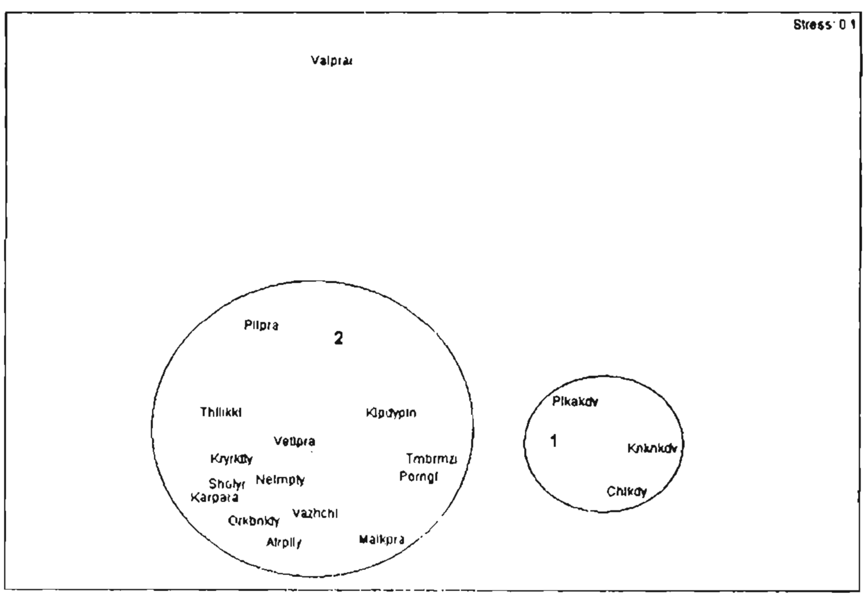


Fig.4.71. MDS analysis for stations in the Chalakkudy river system during monsoon 2003

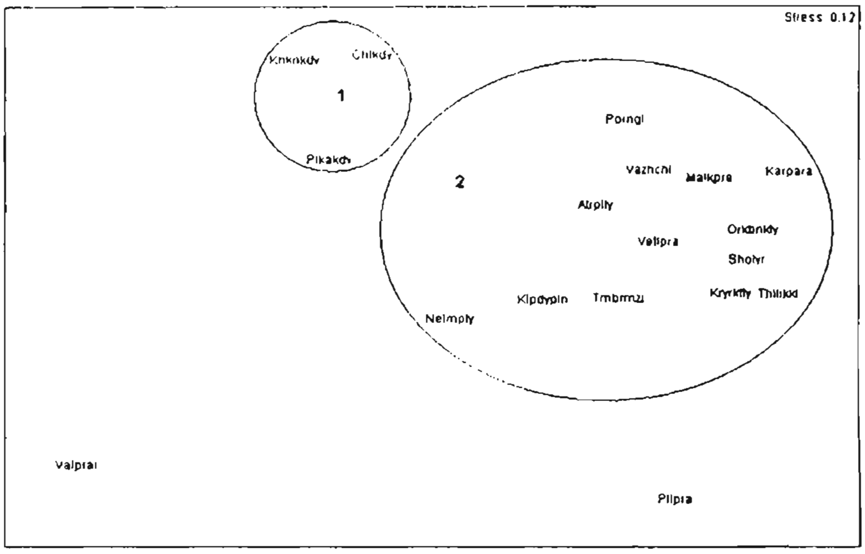


Fig.4.72. MDS analysis for stations in the Chalakkudy river system during post-monsoon 2003

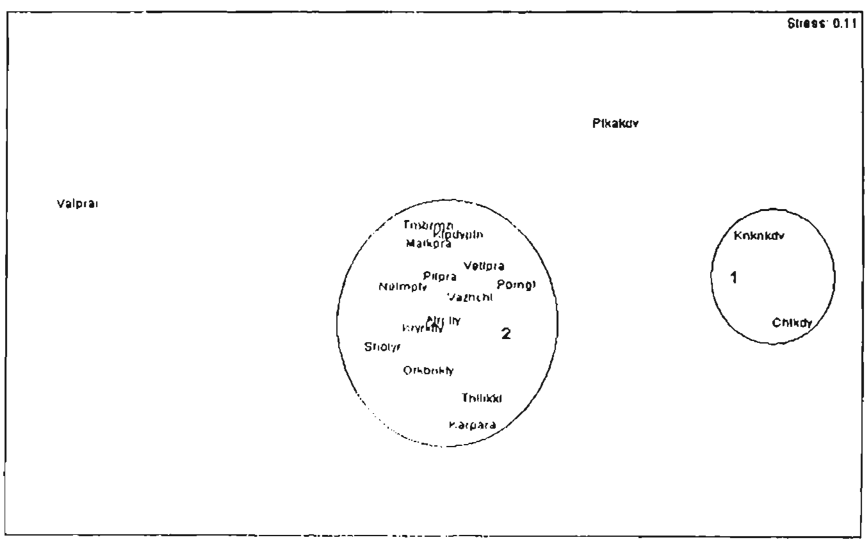


Fig.4.73. MDS analysis for stations in the Kabbini river system during pre-monsoon 2001

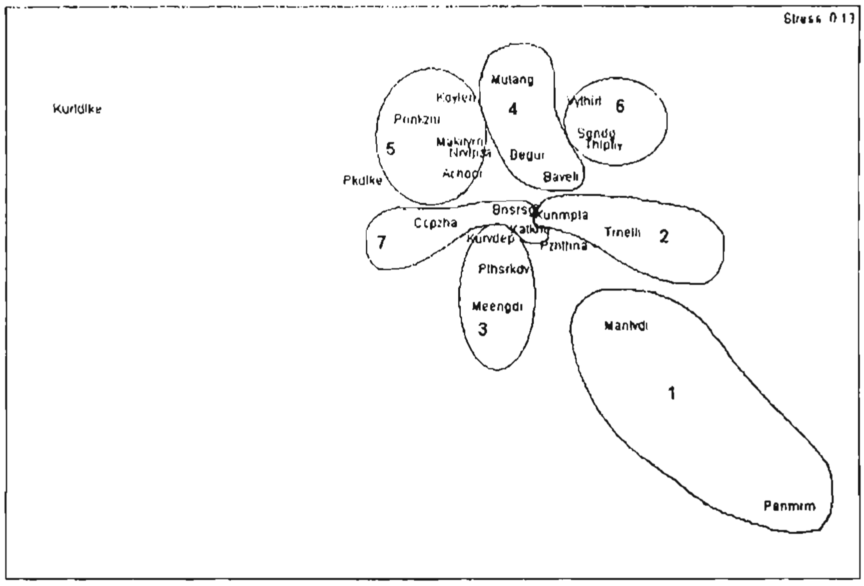


Fig.4.74. MDS analysis for stations in the Kabbini river system during monsoon 2001

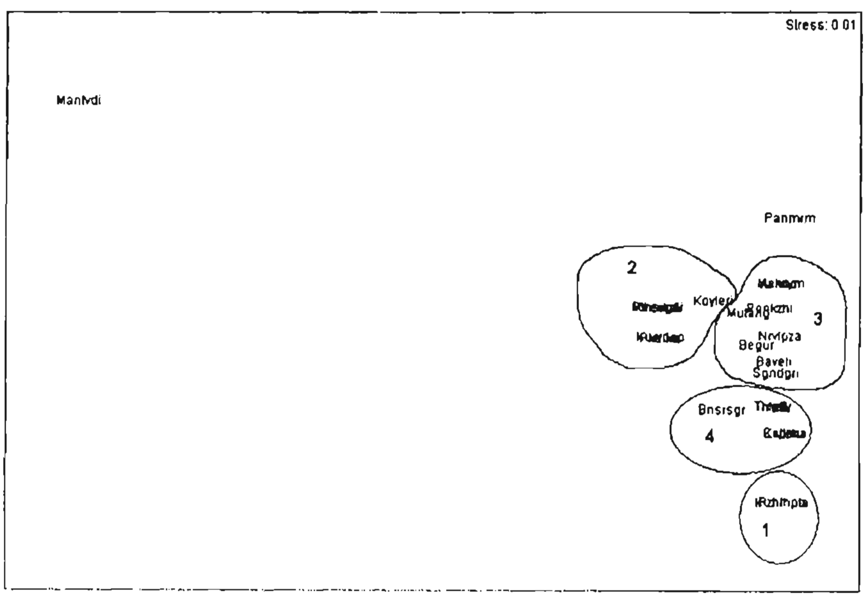


Fig.4.75. MDS analysis for stations in the Kabbini river system during post-monsoon 2001

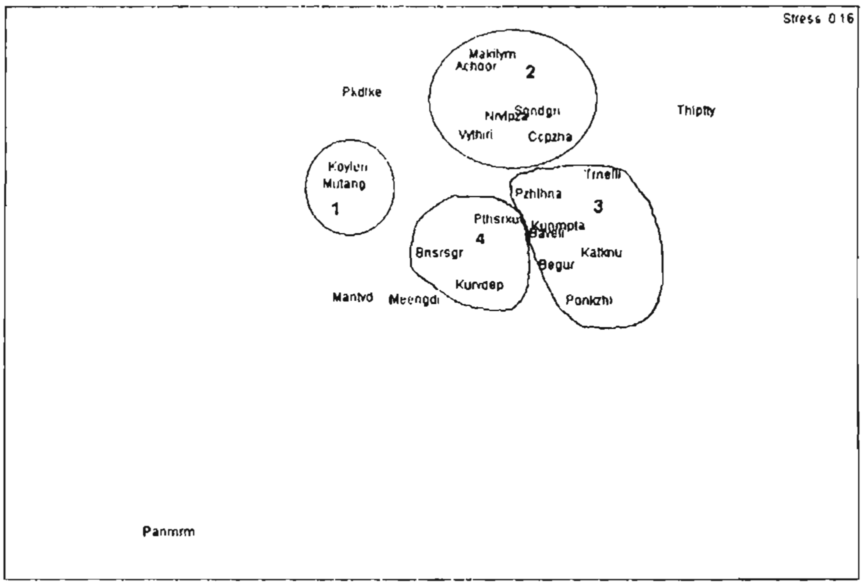


Fig.4.76. MDS analysis for stations in the Kabbini river system during pre-monsoon 2002

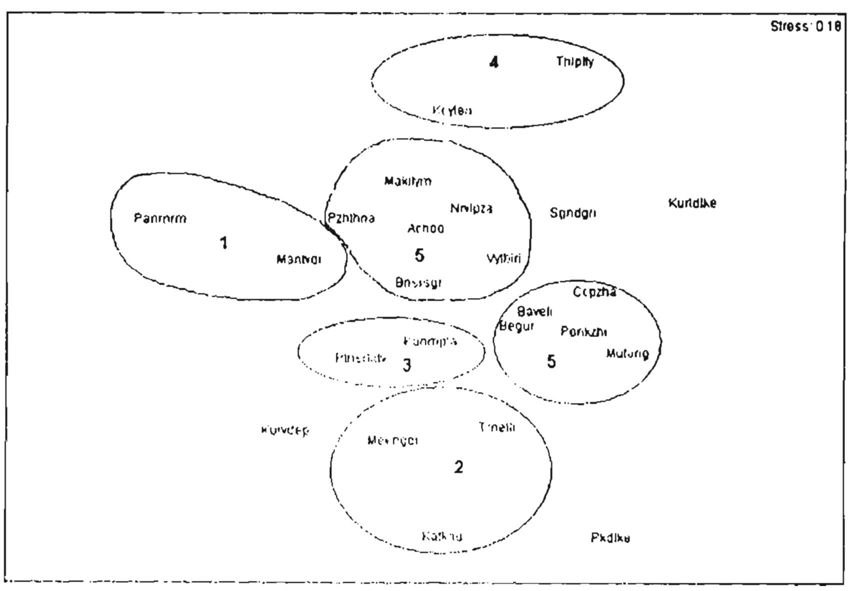


Fig.4.77. MDS analysis for stations in the Kabbini river system during monsoon 2002

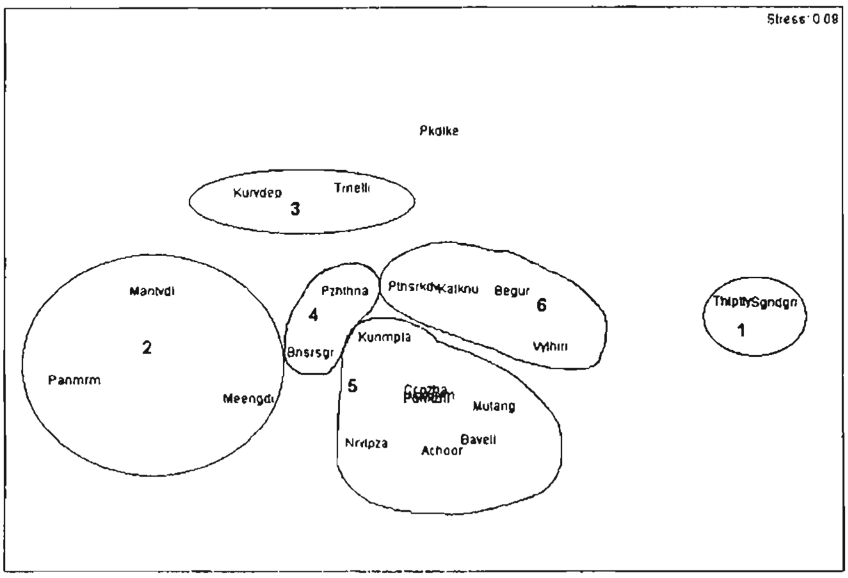


Fig.4.78. MDS analysis for stations in the Kabbini river system during post-monsoon 2002

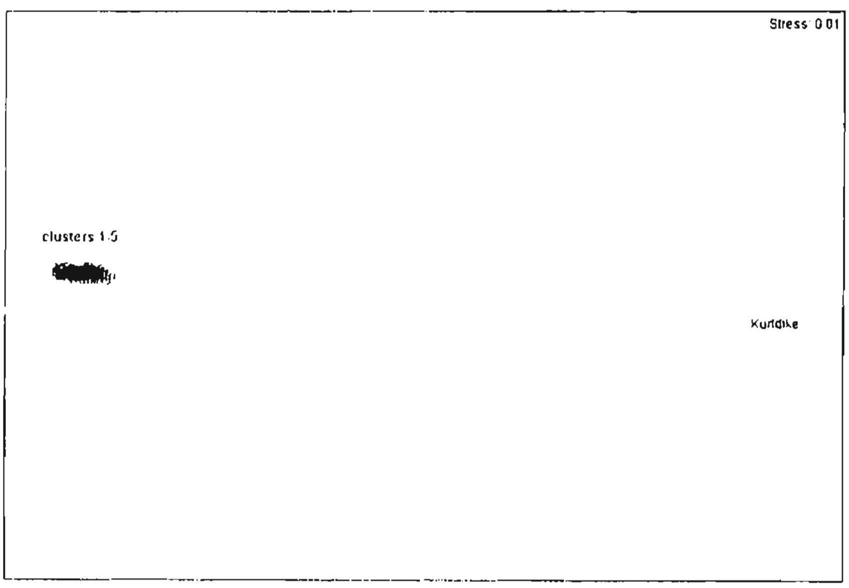


Fig.4.79. MDS analysis for stations in the Kabbini river system during pre-monsoon 2003

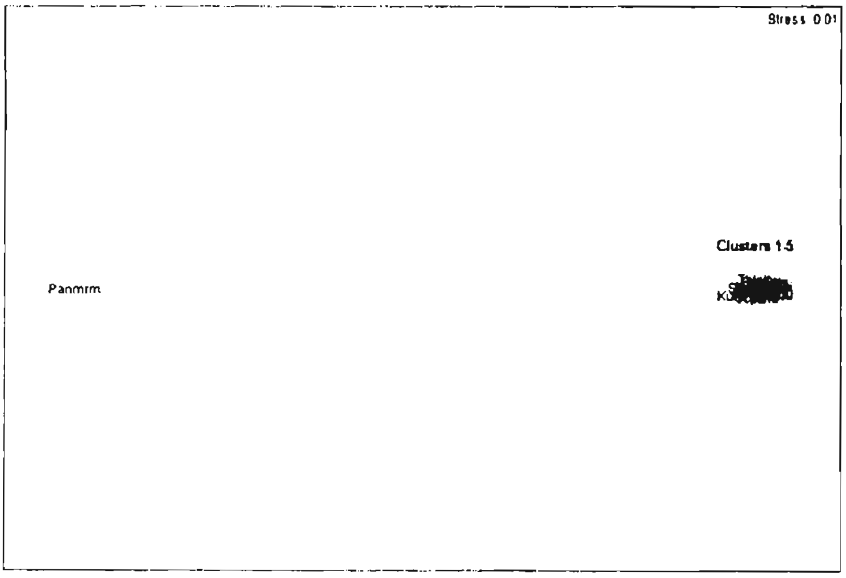


Fig.4.80. MDS analysis for stations in the Kabbini river system during monsoon 2003

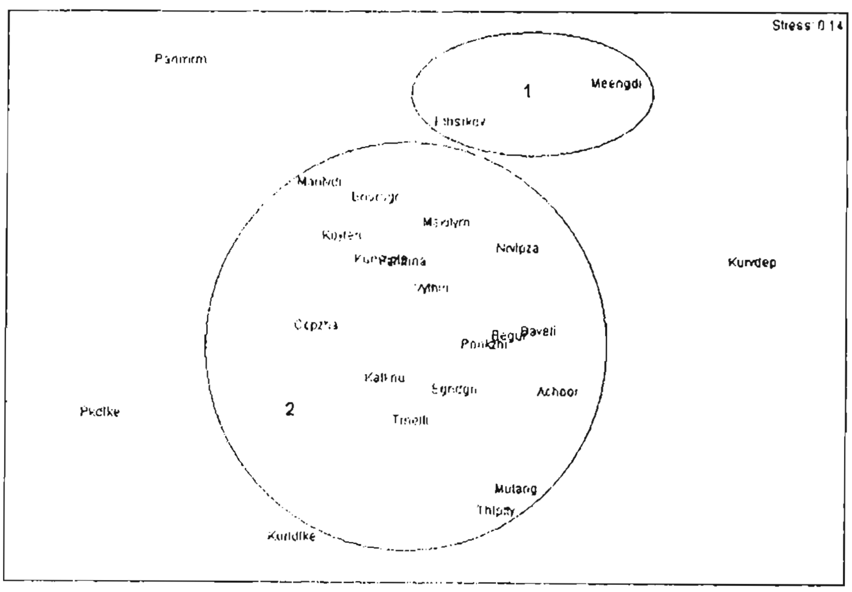


Fig.4.81. MDS analysis for stations in the Kabbini river system during post-monsoon 2003

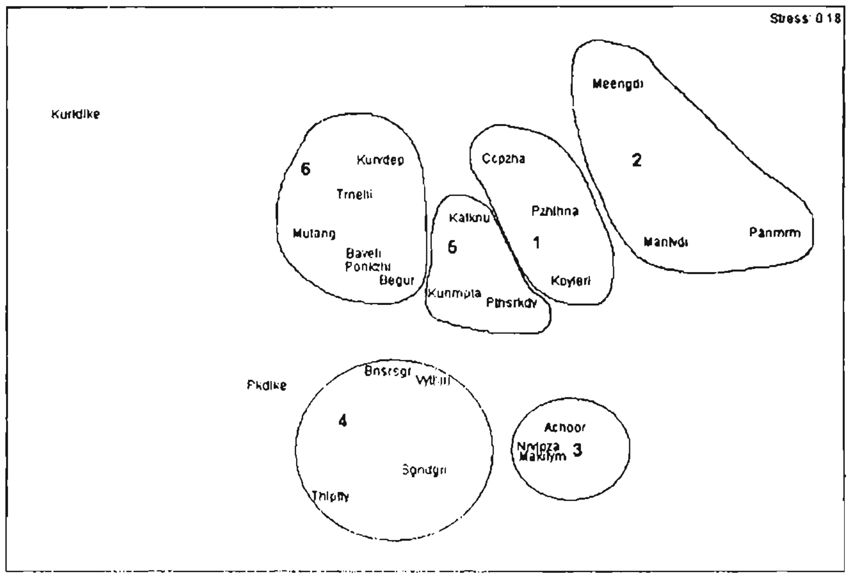


Fig.4.82. MDS analysis for stations in the Bharathapuzha river system during pre-monsoon 2001

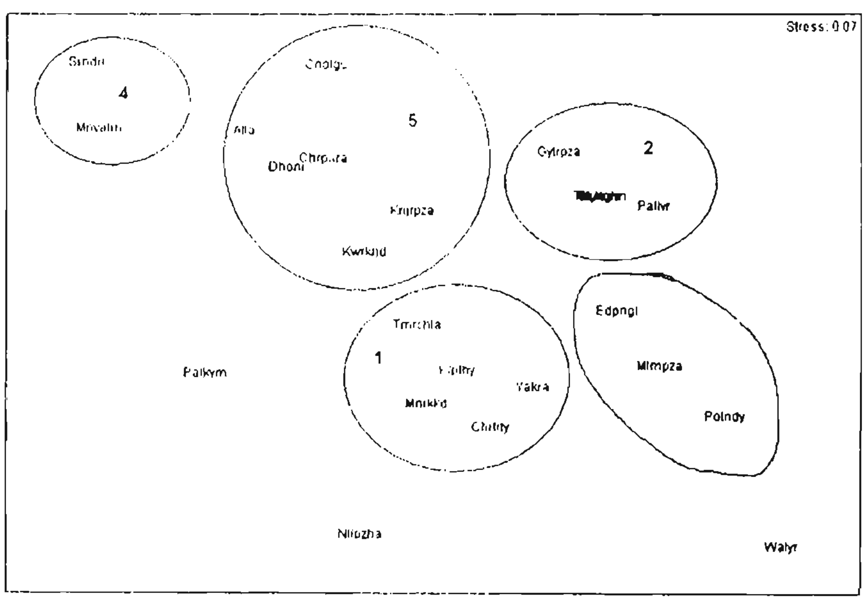


Fig.4.83. MDS analysis for stations in the Bharathapuzha river system during monsoon 2001

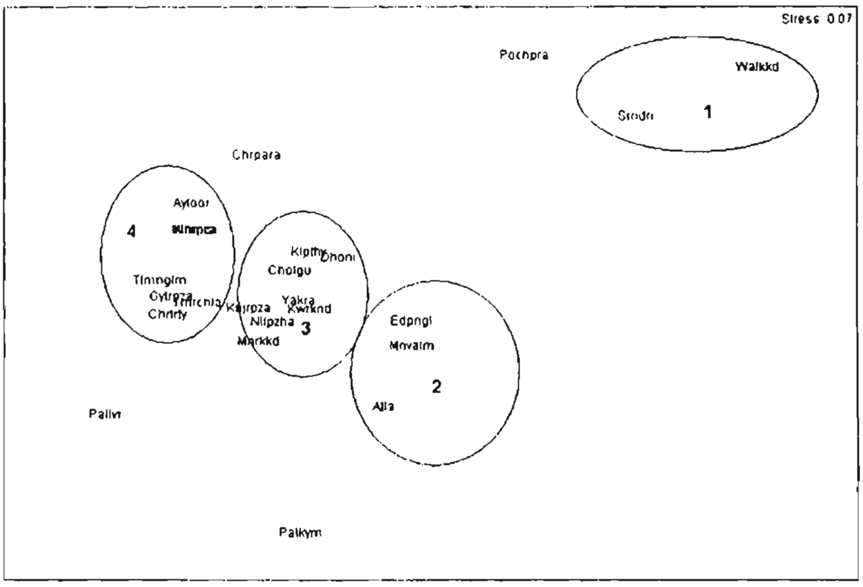


Fig.4.84. MDS analysis for stations in the Bharathapuzha river system during post-monsoon 2001

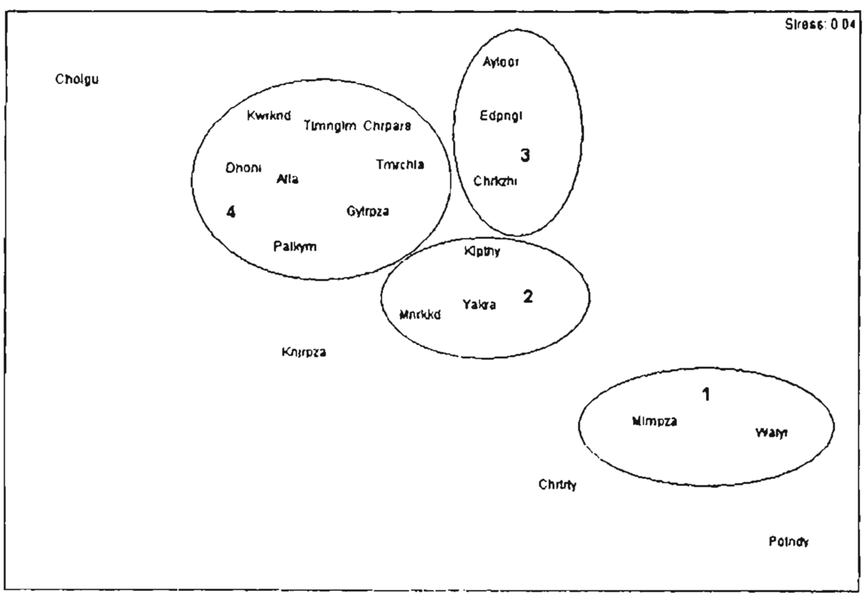


Fig.4.85. MDS analysis for stations in the Bharathapuzha river system during pre-monsoon 2002

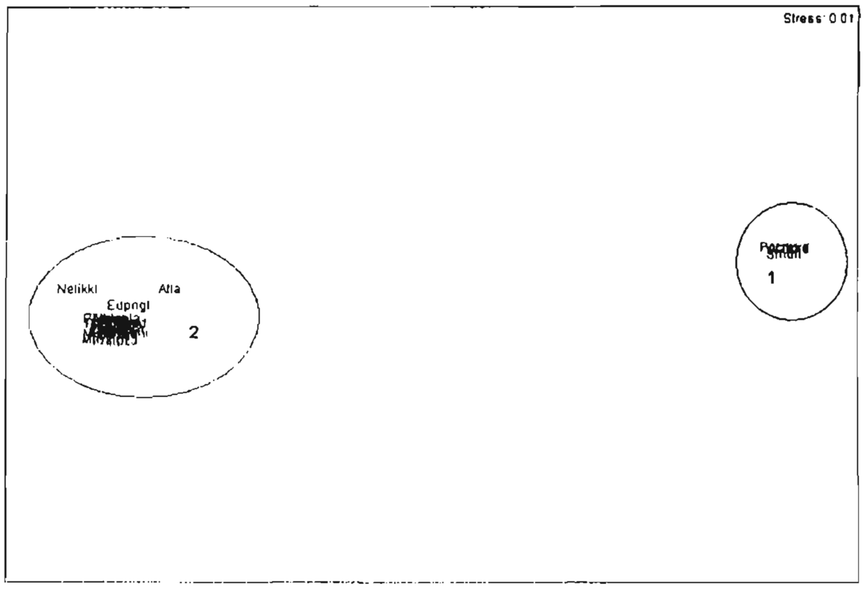


Fig.4.86. MDS analysis for stations in the Bharathapuzha river system during monsoon 2002

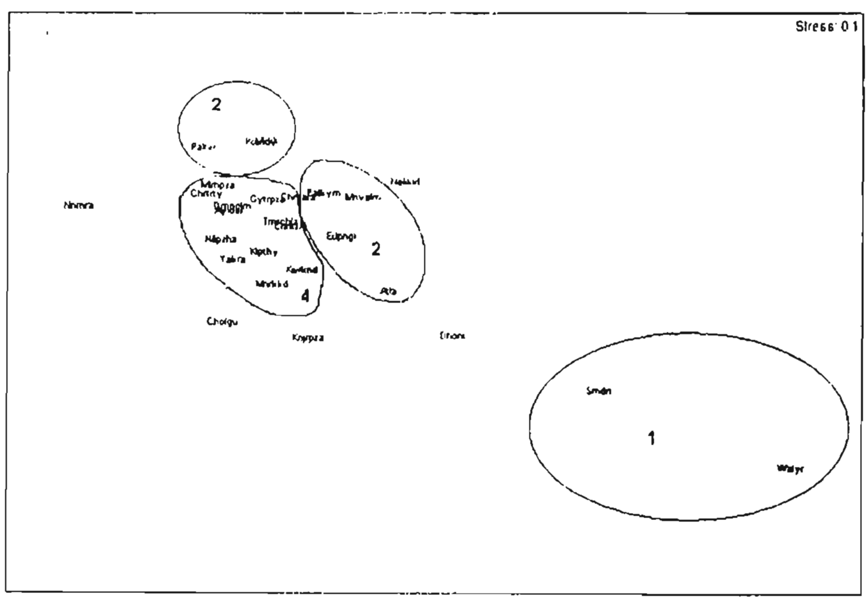


Fig.4.87. MDS analysis for stations in the Bharathapuzha river system during post-monsoon 2002

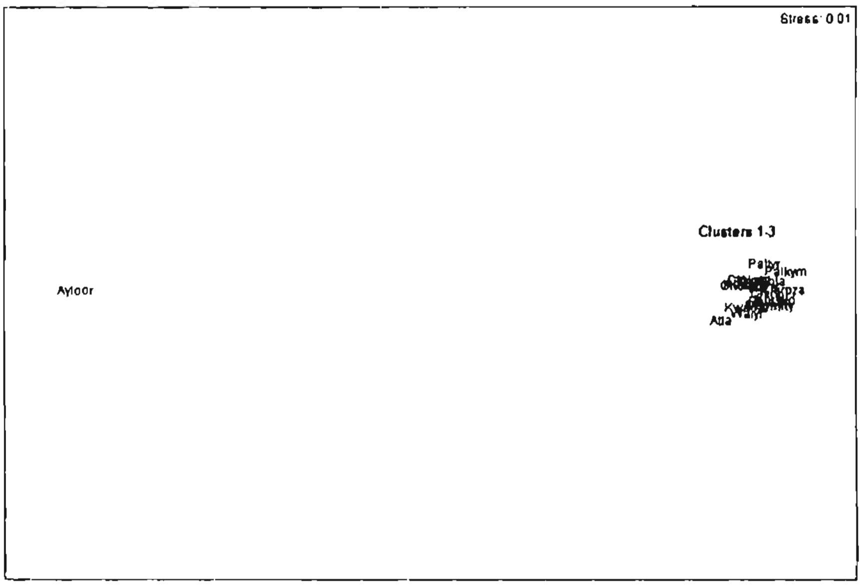


Fig.4.88. MDS analysis for stations in the Bharathapuzha river system during pre-monsoon 2003

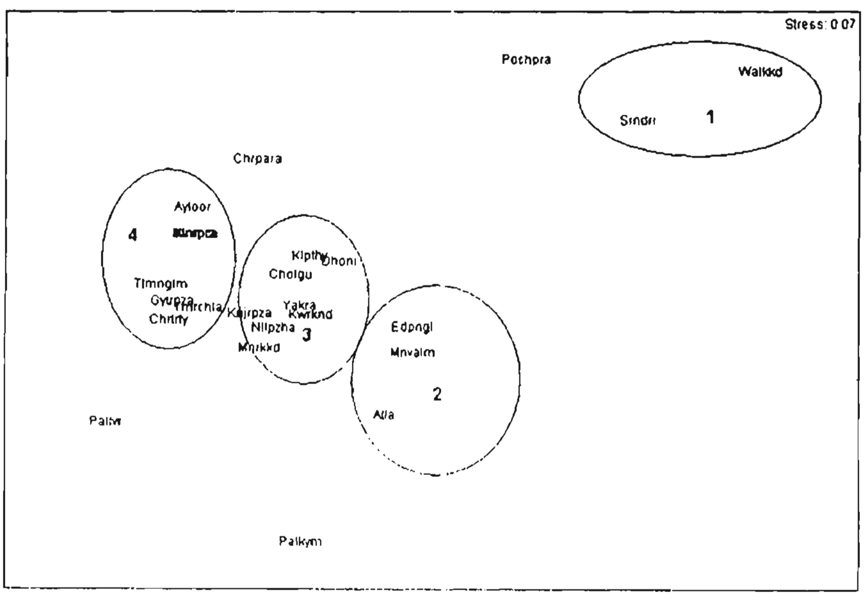


Fig.4.89. MDS analysis for stations in the Bharathapuzha river system during monsoon 2003

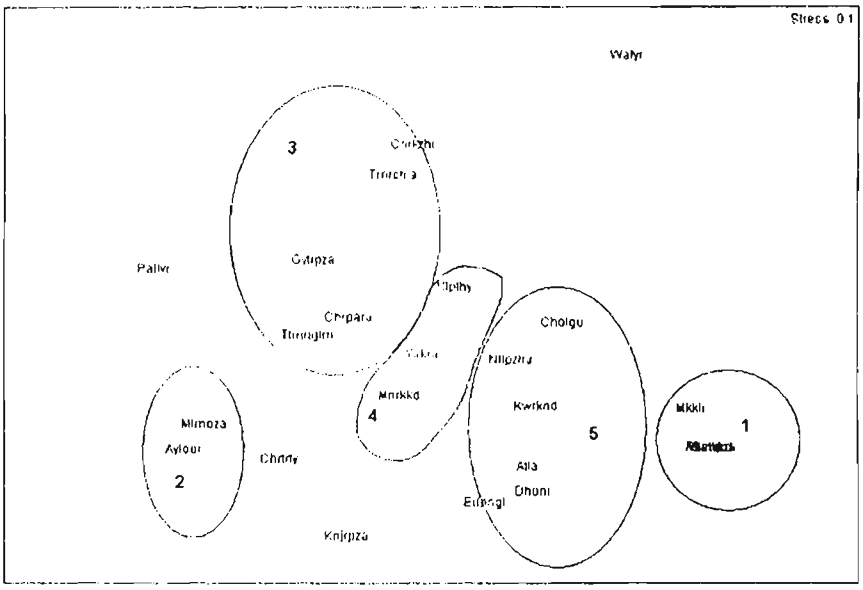


Fig.4.90. MDS analysis for stations in the Bharathapuzha river system during post-monsoon 2003

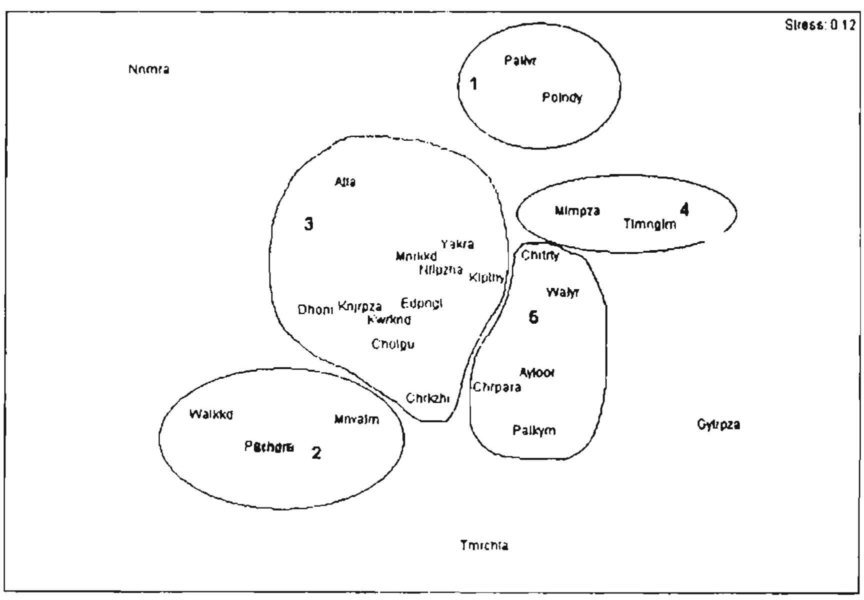


Fig.4.91. MDS analysis for stations in the Pamba river system during pre-monsoon 2001

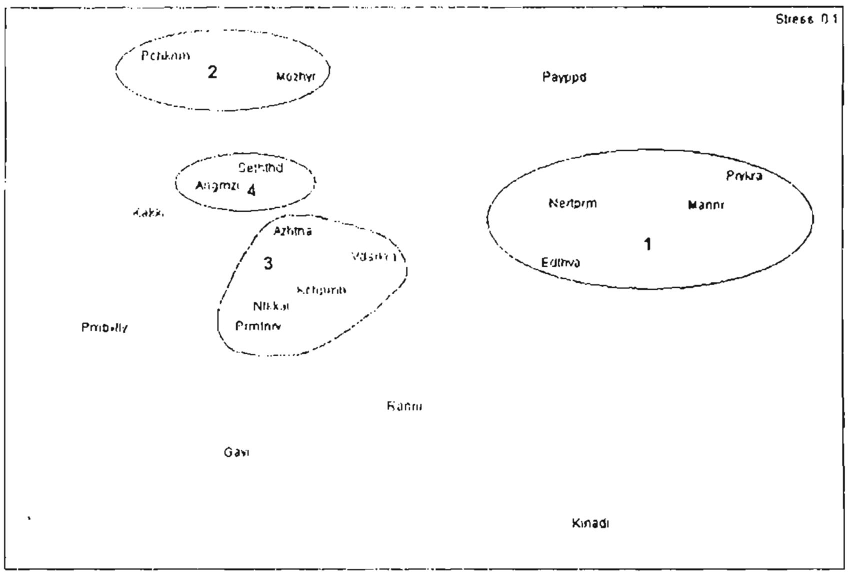


Fig.4.92. MDS analysis for stations in the Pamba river system during monsoon 2001

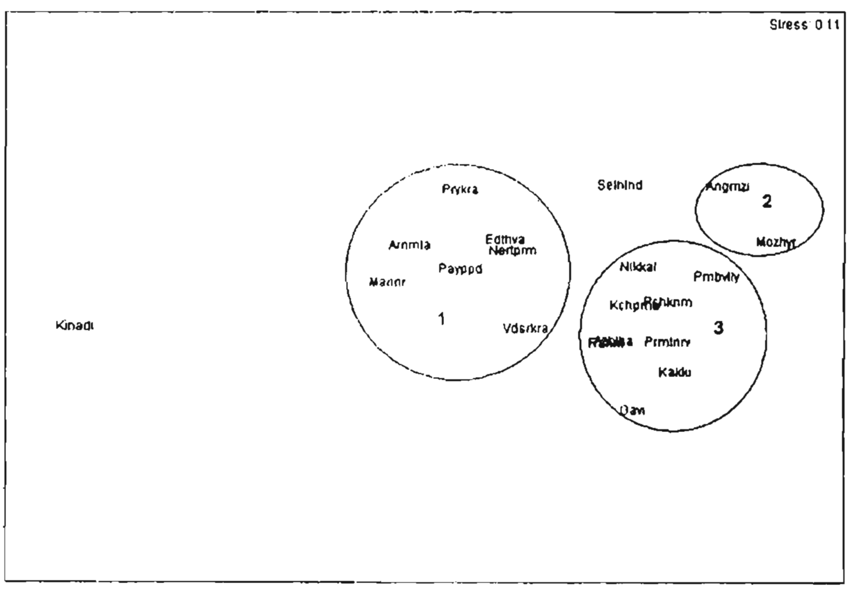


Fig.4.93. MDS analysis for stations in the Pamba river system during post-monsoon 2001

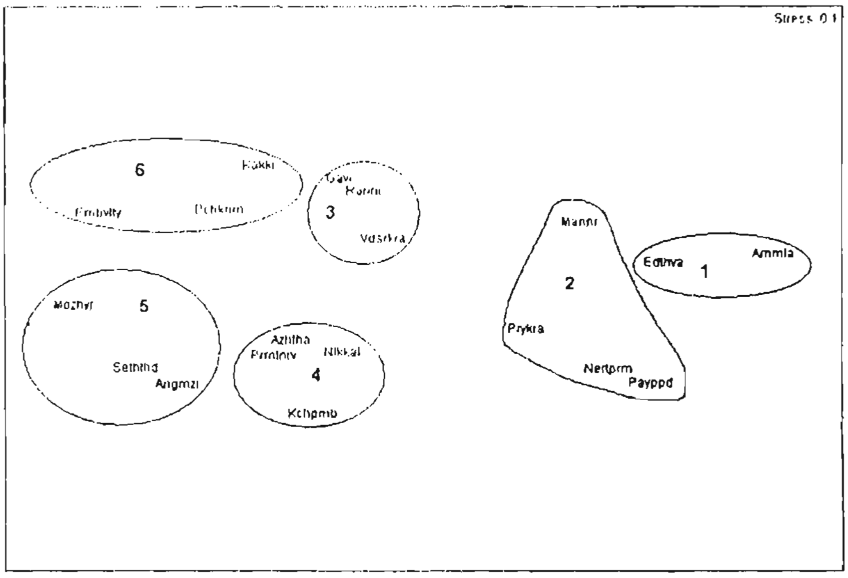


Fig.4.94. MDS analysis for stations in the Pamba river system during pre-monsoon 2002

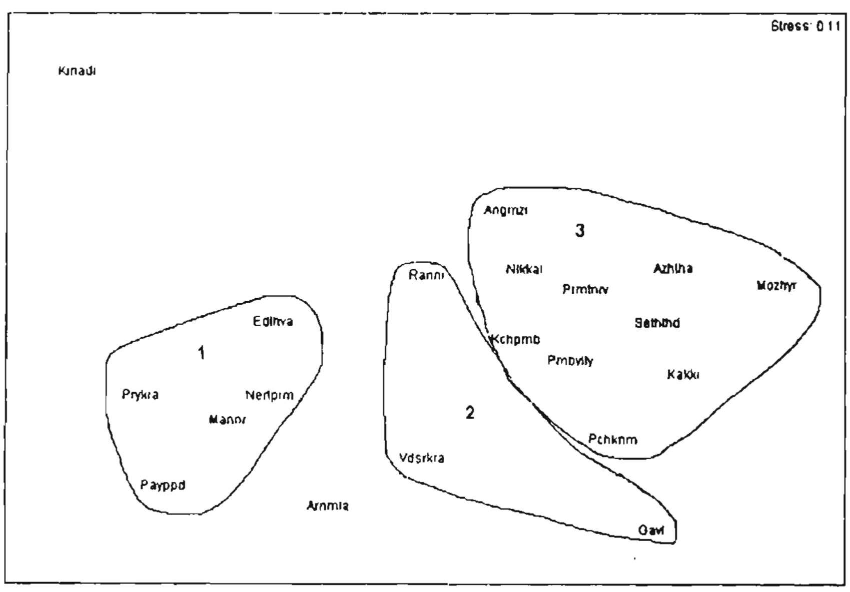


Fig.4.95. MDS analysis for stations in the Pamba river system during monsoon 2002

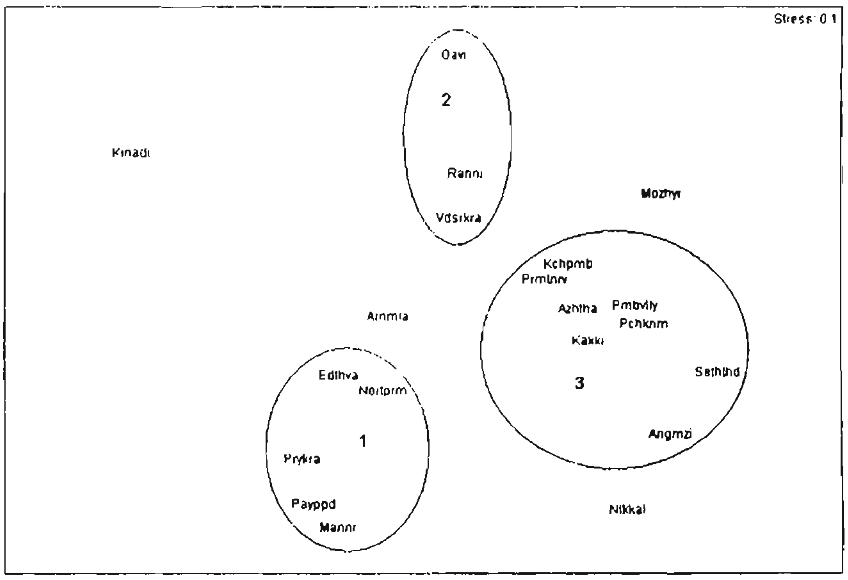


Fig.4.96. MDS analysis for stations in the Pamba river system during post-monsoon 2002

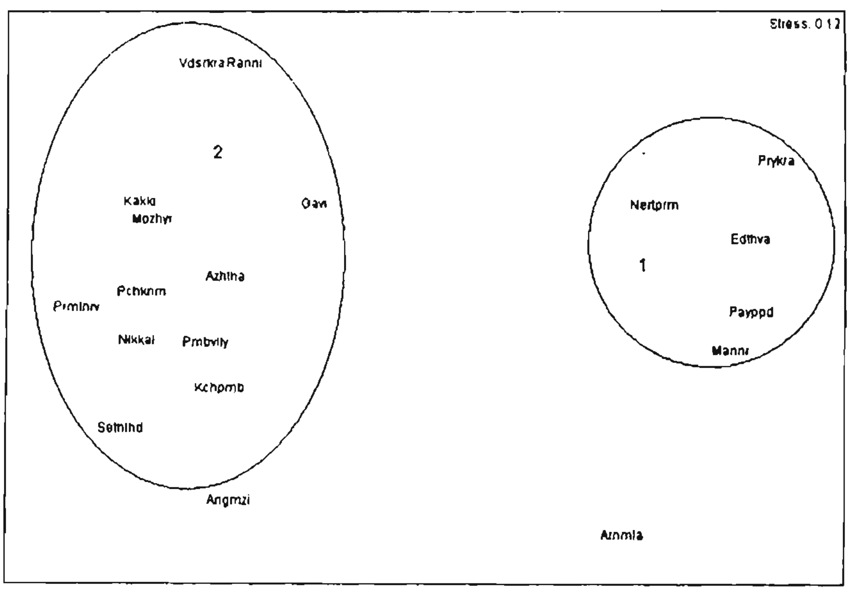


Fig.4.97. MDS analysis for stations in the Pamba river system during pre-monsoon 2003

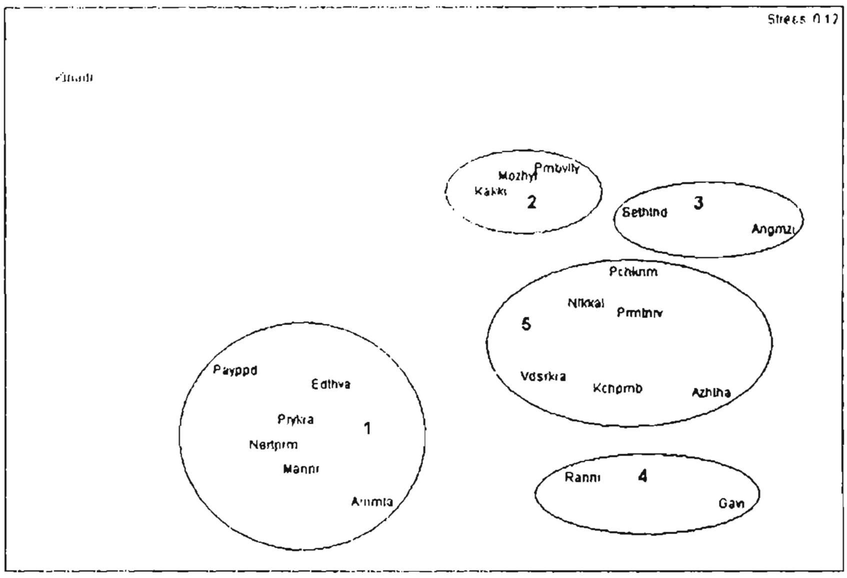


Fig.4.98. MDS analysis for stations in the Pamba river system during monsoon 2003

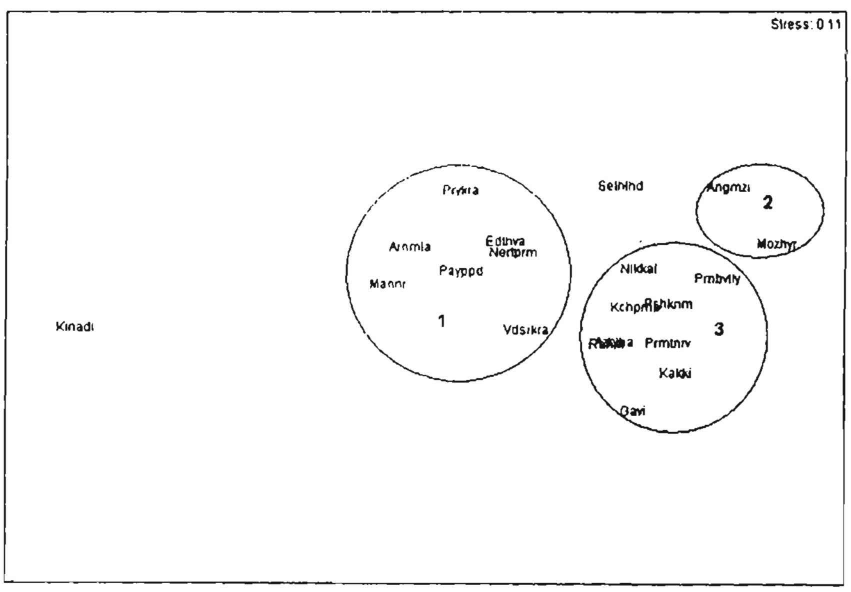


Fig.4.99. MDS analysis for stations in the Pamba river system during post-monsoon 2003

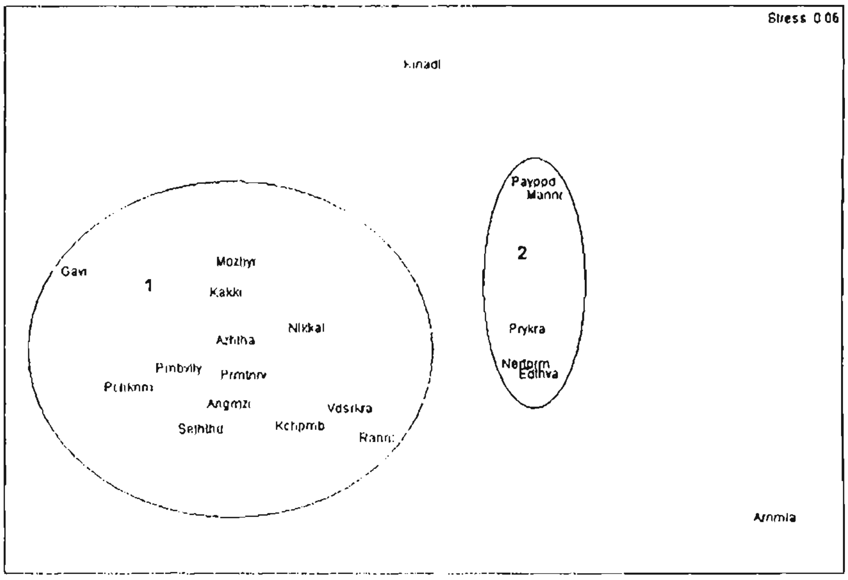


Fig.4.100. MDS analysis for stations in the Kallada river system during pre-monsoon 2001

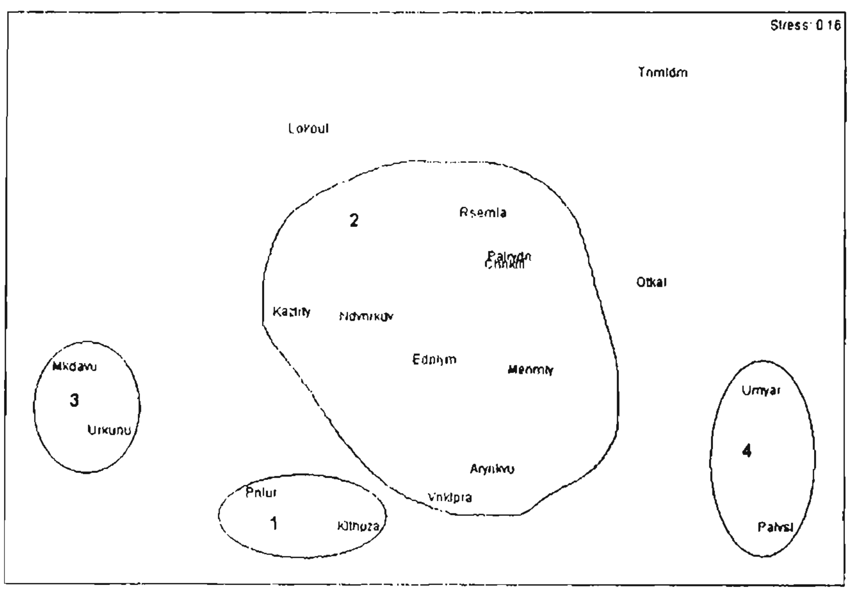


Fig.4.101. MDS analysis for stations in the Kallada river system during monsoon 2001

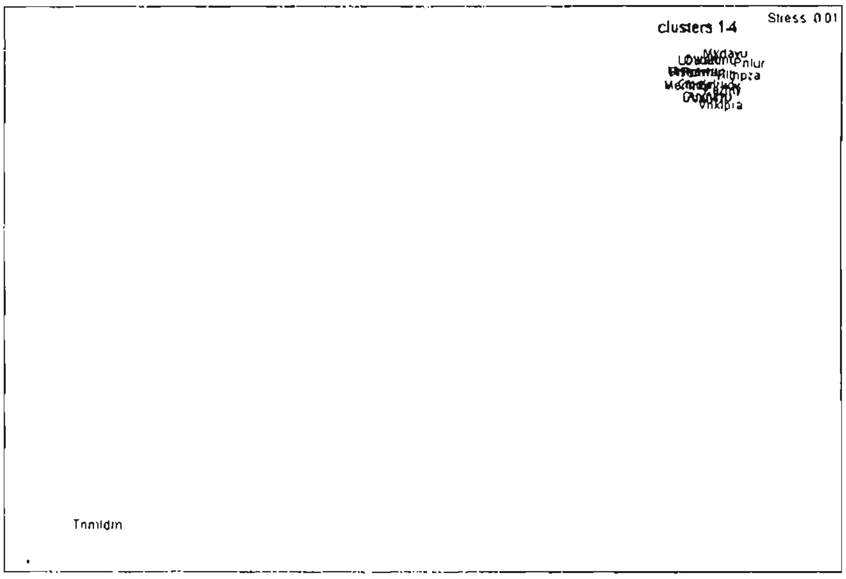


Fig.4.102. MDS analysis for stations in the Kallada river system during post-monsoon 2001

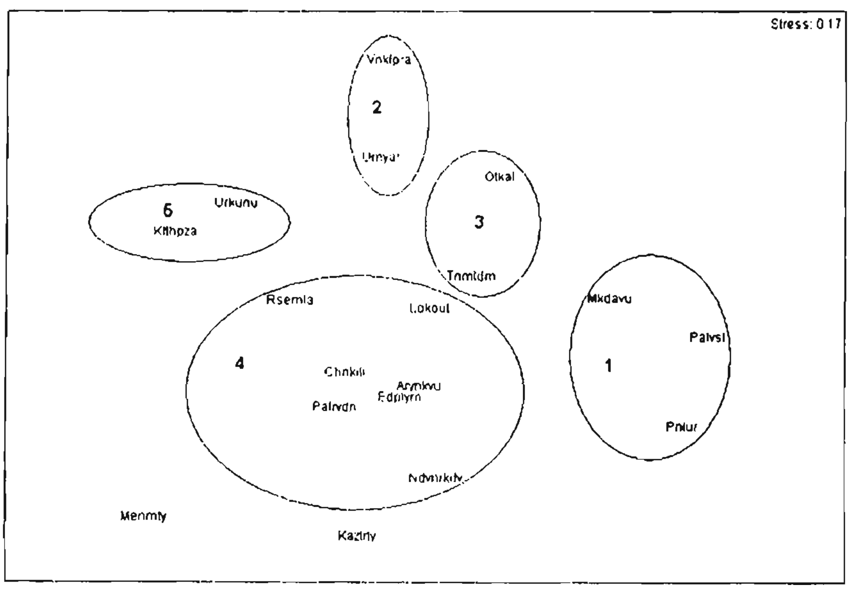


Fig.4.103. MDS analysis for stations in the Kallada river system during pre-monsoon 2002

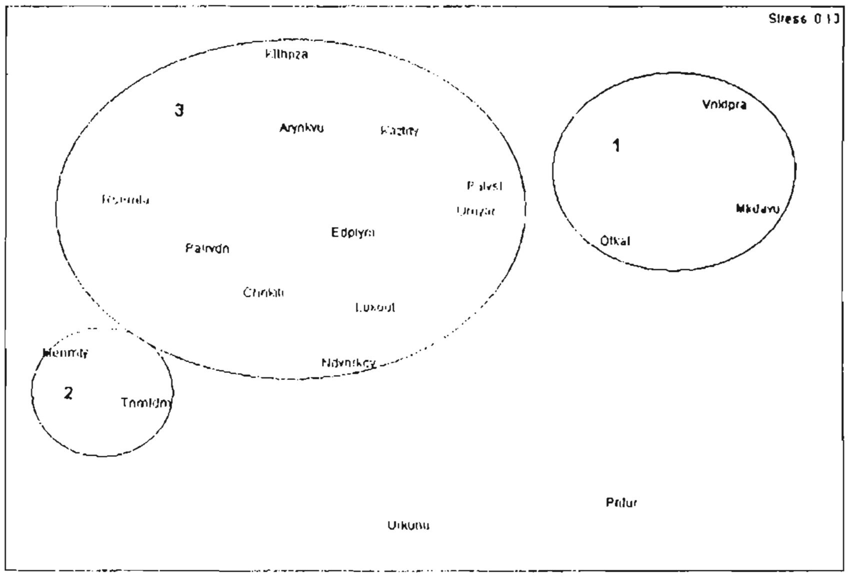


Fig.4.104. MDS analysis for stations in the Kallada river system during monsoon 2002

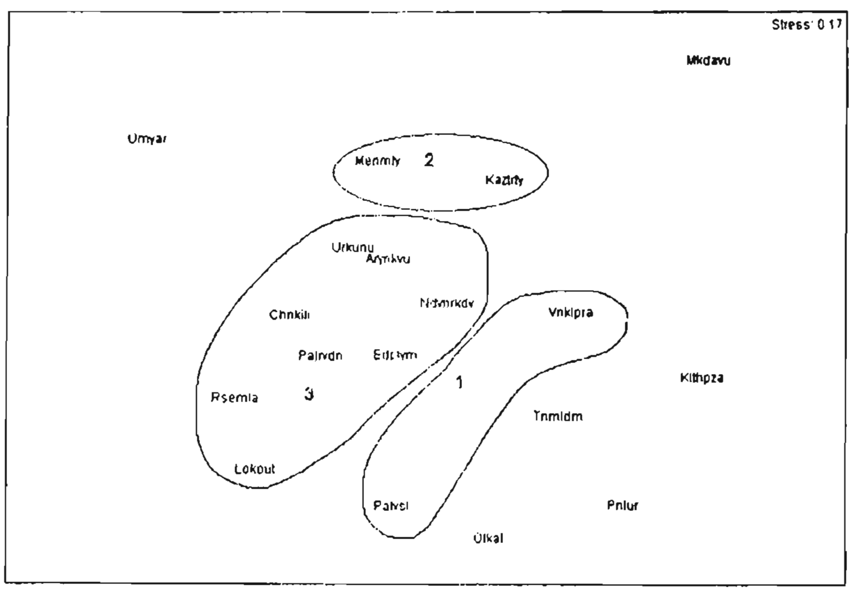


Fig.4.105. MDS analysis for stations in the Kallada river system during post-monsoon 2002

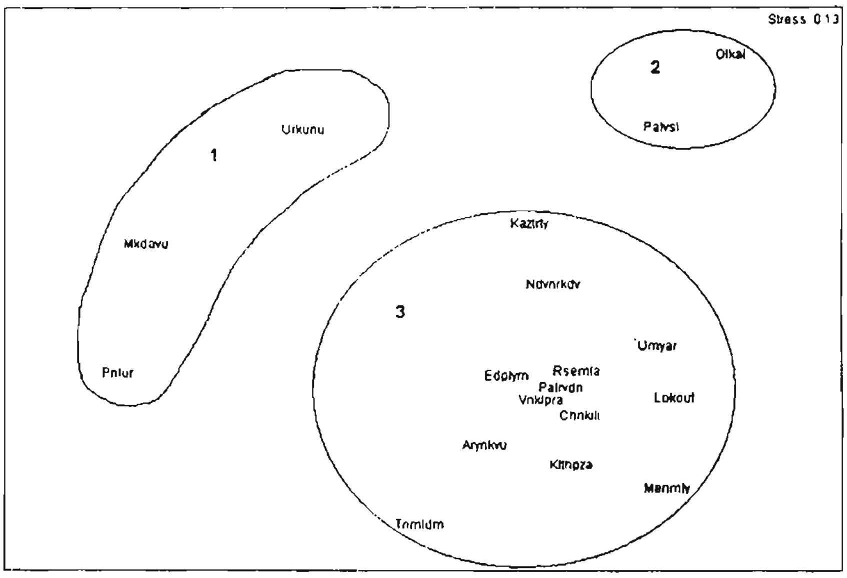


Fig.4.106. MDS analysis for stations in the Kallada river system during pre-monsoon 2003

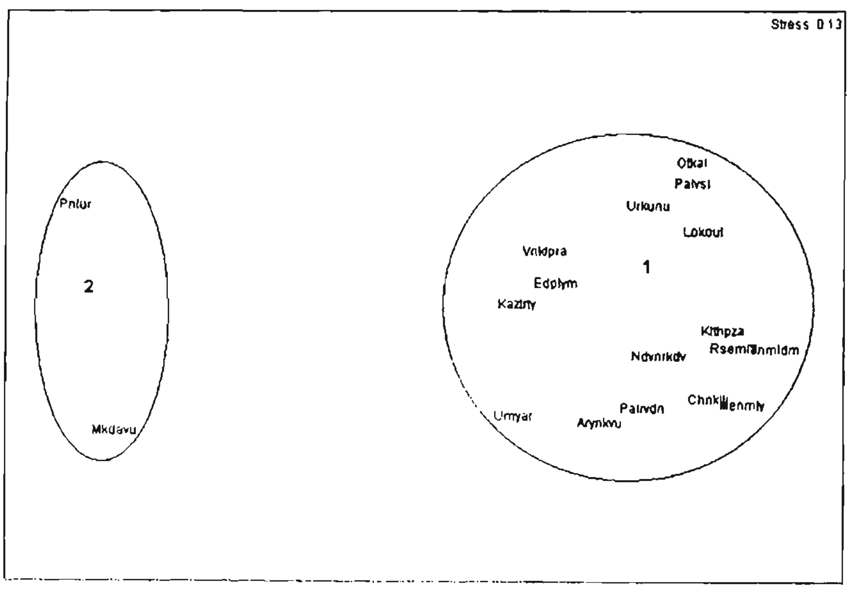


Fig.4.107. MDS analysis for stations in the Kallada river system during monsoon 2003

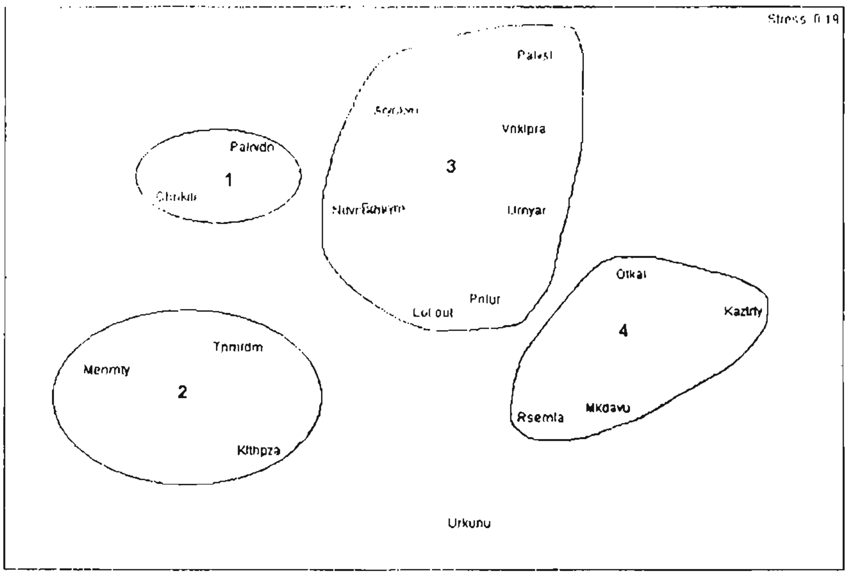


Fig.4.108. MDS analysis for stations in the Kallada river system during post-monsoon 2003

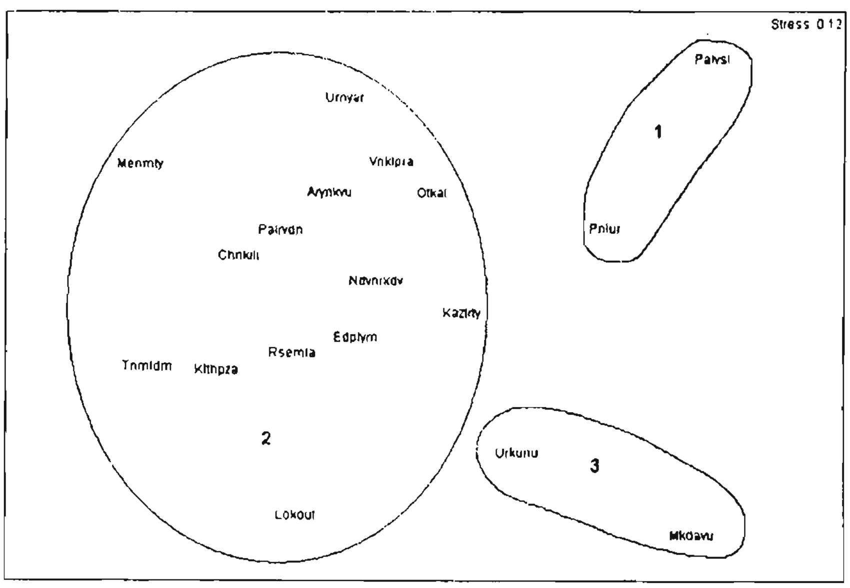


Table 4.1.Three-way ANOVA for comparing between seasons, species and stations in different river systems

Periyar river system-2001					
Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	113.6	2	56.801	9.9949	**
Between stations (B)	1576.7	28	56.31	7.6995	**
Between species ©	11207	62	180.75	24.715	**
AB linteraction		56	13.952	1.9077	
BC interaction		1736	16.842	2.3028	*
AC interaction		124	19.532	2.6707	*
Error	25393	3472	7.3135		
Periyar river system - 2002					
Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	74.706	2	37.353	14.479	**
Between stations (B)	1259.4	28	44.978	5.45	**
Between species ©	22331	68	328.4	39.792	**
AB linteraction		56	10.921	1.3233	
BC interaction		1904	16.295	1.9745	
AC interaction		136	16.25	1.969	
Error	31427	3808	8.2529		
Periyar river system - 2003					
Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	32.761	2	16.381	2.8562	*
Between stations (B)	1751.2	28	62.544	10.906	**
Between species ©	16283	66	246.71	43.02	**
AB linteraction		56	9.965	1.7359	
BC interaction		1848	20.561	3.5853	*
AC interaction		132	11.738	2.0468	*
Error	21195	3696	5.7346		
Chalakkudy - 2001					
Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	68.541	2	34.2705	2.0273	*
Between stations (B)	2363.47	17	139.027	8.2242	*
Between species ©	41451.7	58	714.685	42.2773	**
AB linteraction		34	18.1372	1.0729	
BC interaction		986	36.878	2.1815	*
AC interaction		116	32.341	1.9131	*
Error	33336	1972	16.9047		
Chalakkudy - 2002					
Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	49.905	2	24.953	2.4335	*
Between stations (B)	1576.9	17	92.76	9.046	**
Between species ©	36907	52	709.75	69.215	**
AB linteraction		34	12.908	1.2588	
BC interaction		884	29.321	2.8594	*
AC interaction		104	27.004	2.6334	*
Error	18130	1768	10.254		
Chalakkudy - 2003					
Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	36.56	2	18.28	2.0745	*
Between stations (B)	1423.4	17	83.727	9.5018	**
Between species ©	27120	49	553.46	62.81	**
AB linteraction		34	12.848	1.458	
BC interaction		833	20.171	2.2891	*
AC interaction		98	29.422	3.339	*
Error	14680	1666	8.8117		

Continued…………..

Table 4.1 Continued........

Kabbini - 2001					
Source	**Sum of squares**	**dof**	**MSS**	**F ratio**	**Remarks**
Between seasons (A)	143	2	71.721	8.5406	**
Between stations (B)	744	23	32.351	3.8524	**
Between species ©	440	44	100.01	11.91	**
AB linteraction		46	25.81	3.0736	**
BC interaction		1012	18.663	1.627	
AC interaction		48	31.079	3.701	**
Error	16997	2024	8.3975		
Kabbini - 2002					
Source	**Sum of squares**	**dof**	**MSS**	**F ratio**	**Remarks**
Between seasons (A)	151.8	2	75.898	16.3609	**
Between stations (B)	801	23	34.826	7.509	**
Between species ©	5480	48	114.17	24.617	**
AB linteraction		46	5.1873	1.1185	
BC interaction		1104	12.518	2.6991	**
AC interaction		96	15.279	3.29	**
Error	10241	2208	4.6379		
Kabbini - 2003					
Source	**Sum of squares**	**dof**	**MSS**	**F ratio**	**Remarks**
Between seasons (A)	15.741	2	7.8704	1.3054	
Between stations (B)	1810.5	23	78.717	13.056	**
Between species ©	7022	37	189.79	31.477	**
AB linteraction		46	6.4198	1.0648	
BC interaction		2701	19.947	3.3083	**
AC interaction		74	21.46	3.5593	**
Error	10262	5402	6.0293		
Bharathapuzha - 2001					
Source	**Sum of squares**	**dof**	**MSS**	**F ratio**	**Remarks**
Between seasons (A)	149.7	2	74.85	18.9768	**
Between stations (B)	223.49	28	7.9818	2.0236	**
Between species ©	1798.7	53	33.937	8.6042	**
AB linteraction		56	3.2917	0.83455	
BC interaction		1484	5.0679	1.2849	
AC interaction		106	13.681	3.4687	*
Error	11707	2968	3.9443		
Bharathapuzha - 2002					
Source	**Sum of squares**	**dof**	**MSS**	**F ratio**	**Remarks**
Between seasons (A)	370.26	2	185.13	44.9759	**
Between stations (B)	254.4	28	9.0858	2.2074	*
Between species ©	3441.1	53	64.926	15.773	**
AB linteraction		56	5.6729	1.3782	
BC interaction		1484	5.2437	1.2739	
AC interaction		106	32.797	7.96778	*
Error	12217	2968	4.1162		
Bharathapuzha - 2003					
Source	**Sum of squares**	**dof**	**MSS**	**F ratio**	**Remarks**
Between seasons (A)	38.4275	2	19.2137	3.2554	**
Between stations (B)	704.697	27	26.1	4.4221	**
Between species ©	9488.36	48	197.674	33.4924	**
AB linteraction		54	7.4792	1.2673	
BC interaction		1296	17.7045	2.9997	**
AC interaction		96	27.0921	4.5903	**
Error	15298.1	2592	5.9021		

Continued.............

Table 4.1 Continued.......

Pamba - 2001					
Source	**Sum of squares**	**dof**	**MSS**	**F ratio**	**Remarks**
Between seasons (A)	32.153	2	16.077	1.5685	
Between stations (B)	524.2	19	27.589	2.6917	*
Between species ©	4128	56	73.714	7.1918	**
AB linteraction		38	9.4655	9.2349	**
BC interaction		1064	16.357	1.5958	
AC interaction		112	27.818	2.7171	*
Error	21812	2128	10.25		
Pamba - 2002					
Source	**Sum of squares**	**dof**	**MSS**	**F ratio**	**Remarks**
Between seasons (A)	22.418	2	11.209	1.6163	**
Between stations (B)	1296.5	19	68.238	9.8397	**
Between species ©	13642	50	272.84	39.344	
AB linteraction		38	8.8092	1.2703	
BC interaction		950	20.531	2.9606	*
AC interaction		100	17.794	2.5658	*
Error	13176	1900	6.9349		
Pamba - 2003					
Source	**Sum of squares**	**dof**	**MSS**	**F ratio**	**Remarks**
Between seasons (A)	417.41	2	208.71	2.46.4	*
Between stations (B)	2140.8	19	112.67	9.6586	**
Between species ©	9956.2	43	231.54	19.849	**
AB linteraction		38	13.979	1.1983	
BC interaction		817	25.554	2.1906	*
AC interaction		86	38.226	3.2769	*
Error	19061	1634	11.665		
Kallada - 2001					
Source	**Sum of squares**	**dof**	**MSS**	**F ratio**	**Remarks**
Between seasons (A)	128.64	2	64.32	20.9136	*
Between stations (B)	421.49	19	24.793	8.0617	**
Between species ©	4645.7	50	113.31	36.844	**
AB linteraction		38	3.9921	1.2981	
BC interaction		950	12.347	4.0145	**
AC interaction		100	9.1337	2.9699	*
Error	4287.3	1900	3.0755		
Kallada - 2002					
Source	**Sum of squares**	**dof**	**MSS**	**F ratio**	**Remarks**
Between seasons (A)	14.381	2	7.1904	1.7756	
Between stations (B)	673.85	17	39.639	9.7836	**
Between species ©	6942.4	38	182.7	45.093	**
AB linteraction		34	4.883	1.2052	
BC interaction		646	11.941	2.9473	*
AC interaction		76	8.8832	1.6496	
Error	5234.6	1292	4.0515		
Kallada - 2003					
Source	**Sum of squares**	**dof**	**MSS**	**F ratio**	**Remarks**
Between seasons (A)	123.13	2	61.566	1.1874	
Between stations (B)	856.67	17	50.392	9.1133	**
Between species ©	7027	33	212.94	38.509	**
AB linteraction		34	9.773	1.7674	
BC interaction		561	17.864	3.2307	*
AC interaction		66	29.786	5.3868	**
Error	6204.3	1122	5.5296		

* = calculated F is significant at 5% level ($p<0.05$)

** = calculated Fis significant at 1% level ($p<0.01$)

Table 4.2. Seggregation based on altitude for species culsters obtained from dendragram in Bray-Curtis similatiy studies

Periyar river system - 2001

Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
Pre-monsoon	1	13	478-916	Monsoon	1	3	4	Post-monsoon	1	8	478-1044
	2	8	478		2	2	478-916		2	7	1044
	3	11	78-1359		3	2	916-1044		3	2	180
	4	16	478-1359		4	2	78		4	2	702
					5	7	78		5	8	478-1359
					6	3	116-160		6	3	180
									7	2	160-212
									8	2	916
									9	2	116

Periyar river system - 2002

Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
Pre-monsoon	1	3	4	Monsoon	1	3	4	Post-monsoon	1	2	1208
	2	4	478-1044		2	2	478		2	3	4
	3	5	1044		3	2	478-1359		3	2	116
	4	5	478		4	2	775		4	14	478
	5	5	116		5	4	116		5	3	916
	6	4	916		6	2	160-241		6	5	870-1029
	7	10	78		7	6	78-478		7	4	1029
	8	4	78						8	2	241

Periyar river system - 2003

Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
Pre-monsoon	1	6	1029-1044	Monsoon	1	5	478	Post-monsoon	1	2	518
	2	8	478		2	3	478-988		2	2	212
	3	2	608		3	7	112-160		3	2	689-1029
	4	5	4		4	5	116		4	6	870-1029
	5	2	116-478						5	6	1108
	6	2	116-775						6	12	478
	7	3	78-1044						7	2	180
	8	11	478-1359						8	3	78-478
									9	8	78-478
									10	4	116

Chalakkudy river system - 2001

Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
Pre-monsoon	1	3	21	Monsoon	1	7	104-205	Post-monsoon	1	5	1002
	2	5	205		2	8	16-24		2	2	498
	3	2	24						3	3	498
	4	5	24						4	4	104
	5	4	1002						5	12	
	6	9	104						6	2	46
	7	4	205						7	2	16
									8	2	24
									9	3	16-205
									10	2	16-46
									11	3	24-38

Chalakkudy river system - 2002

Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
Pre-monsoon	1	4	38	Monsoon	1	6	16	Post-monsoon	1	2	1002
	2	3	24		2	3	104-743		2	8	104-549
	3	5	16-24		3	13	205		3	2	46-104
	4	2	104		4	2	205		4	5	16
	5	3	549						5	3	21-411
	6	12	104								
	7	4	205								

Chalakkudy river system - 2003

Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
Pre-monsoon	1	2	46	Monsoon	1	2	46	Post-monsoon	1	8	16
	2	4	104-205		2	9	104-743		2	10	104-205
	3	13	104		3	2	21-743		3	6	104
	4	2	24		4	9	16-38				
	5	6	24		5	3	24-743				
	6	3	16-205		6	2	16				
					7	2	21				

Continued.....

Table 4 2 continued

Kabbini river system - 2001

Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
Pre-monsoon	1	4	714	Monsoon	1	2	714-769	Post-monsoon	1	2	946
	2	4	769		2	2	718-772		2	3	676
	3	3							3	4	714
	4	4	718						4	2	769
	5	2	702-718						5	2	783
	6	5	682-769						6	2	761-796
	7	3	691-783						7	2	674-769
	8	4	783-796						8	5	712-731
									9	5	718-772
									10	6	772

Kabbini river system - 2002

Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
Pre-monsoon	1	2	796	Monsoon	1	2	769	Post-monsoon	1	6	676
	2	5	684		2	2	674		2	3	794
	3	2	794		3	4	783		3	2	702-769
	4	36	905		4	2	731		4	5	769
	5	2	718		5	2	682		5	6	783
	6	2	783		6	2	682-769		6	4	718
	7	5	682-783		7	3	712-946		7	5	716-722
	8	5	783						8	2	716-718
	9	3	682-769								
	10	3	769								

Kabbini river system - 2003

Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
Pre-monsoon	1	2	676	Monsoon	1	5	718-761	Post-monsoon	1	3	676
	2	2	794		2	4	783-905		2	3	718
	3	2	731						3	5	714-722
	4	2	714						4	6	783
	5	4	718-772						5	3	714
	6	8	783								
	7	3	783-796								

Bharathapuzha river system - 2001

Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
Pre-monsoon	1	2	84	Monsoon	1	3	47-62	Post-monsoon	1	2	18
	2	2	161-218		2	3	47-113		2	3	212
	3	2	161-207		3	6	161		3	2	118
	4	2	18-286		4	3	212-222		4	3	161
	5	2	64-286		5	4	218-1249		5	5	286
	6	2	47-286						6	2	135
	7	2	241						7	3	161-286
	8	2	18								

Bharathapuzha river system - 2002

Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
Pre-monsoon	1	3	135	Monsoon	1	2	18	Post-monsoon	1	2	84
	2	3	118-286		2	7	135		2	2	18
	3	5	286		3	4	607		3	3	161
	4	3	47-70		4	2	286		4	3	135
					5	5	118-242		5	2	18-135
					6	4	161		6	3	286
									7	3	64-70

Bharathapuzha river system - 2003

Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
Pre-monsoon	1	3	892	Monsoon	1	4	135	Post-monsoon	1	2	1249
	2	4	241		2	2	18-222		2	3	241
	3	2	222		3	4	64-70		3	2	212
	4	2	242		4	3	135		4	2	286
	5	2	607		5	2	70-135		5	3	64-286
	6	2	47		6	2	135-607		6	4	70
	7	4	67-112						7	2	286-342

Continued.....

Table 4.2 continued.....

Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
Pamba river system- 2001											
Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
	1	3	8		1	2	824		1	2	85
	2	5	8		2	5	48		2	3	8
	3	3	85		3	3	149		3	4	18
	4	3	816		4	2	48-1001		4	2	168-816
Pre-monsoon	5	2	1001	Monsoon	5	2	4	Post-monsoon	5	3	149
	6	2	824		6	4	38936		6	2	48-133
	7	2	133-188		7	5	8		7	4	48-149
	8	5	85-1001								
	9	3	133								
Pamba river system - 2002											
Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
	1	4	85		1	12	8		1	2	8
	2	2	9		2	2	8		2	7	8
	3	2	18		3	2	7		3	2	85
Pre-monsoon	4	10	133-149	Monsoon	4	2	48	Post-monsoon	4	3	48
	5	2	48		5	3	48-1001		5	6	168
	6	10	48		6	7	133		6	11	149
	7	5	133								
Pamba river system - 2003											
Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
	1	2	85		1	3	7-18		1	3	18
	2	11	149		2	2	8		2	2	18
Pre-monsoon	3	5	48	Monsoon	3	3	8	Post-monsoon	3	2	168
	4	7	18		4	2	149		4	3	48
	5	3	149		5	6	48		5	11	48-168
	6	2	4								
Kallada river system - 2001											
Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
	1	3	218		1	3	124		1	4	216
	2	2	201-216		2	3	218		2	5	218
	3	4	216		3	3	201-241		3	3	124-218
	4	7	124		4	3	226		4	3	89
Pre-monsoon	5	3	274	Monsoon				Post-monsoon	5	3	229
	6	8	218						6	6	241
	7	2	216-332						7	2	124
									8	2	274
									9	2	19
Kallada river system - 2002											
Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
	1	3	216		1	3	25		1	2	229
	2	2	218		2	3	282		2	2	218
	3	3	19-25		3	9	332		3	3	124
	4	3	25-201		4	3	19		4	6	218-332
Pre-monsoon	5	2	124	Monsoon	5	6	124	Post-monsoon			
	6	5	89		6	2	218				
	7	2	274								
	8	3	229								
	9	6	212-332								
Kallada river system - 2003											
Season	C	S	Altitude	Season	C	S	Altitude	Season	C	S	Altitude
	1	2	124		1	3	25		1	2	124
	2	3	19		2	2	89		2	2	282
Pre-monsoon	3	5	124-332	Monsoon	3	4	218	Post-monsoon	3	6	212-332
	4	6	229-332		4	3	229		4	3	124-218
					5	5	212-216				

C - No. of clusters

S - No. of species in the cluster

Table 4.3. Seasonal comparison based on Bray-Curtis similarity indices of stations in MDS analysis for different river systems

Periyar river system									
	2001			2002			2003		
	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
C	5	5	3	4	3	3	5	5	5
R*	5 (5,2)	5 (8,2)	1(12,1)	4(11,2)	3 (11,1)	2 (12,1)	4 (3,6)	5 (9,2)	3 (8,2)
							3 (13,1)		1 (3, 6)
Chalakkudy river system									
	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
C	2	2	2	2	2	2	2	2	2
R*	2 (13,2)	2 (14,1)	2 (14,1)	1 (13,2)	2 (14, 1)	2 (14,2)	2 (14,2)	2 (13, 3)	2 (14,2)
		1 (3,5)	1 (3,4)	2 (2,6)	1 (2,8)		1 (3,5)	1 (3,7)	1 (2,7)
Kabbini river system									
	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
C	7	4	4	6	6	5	5	3	6
R*	5 (5, 2)	3 (8,1)	3 (7,2)	6 (5,2)	5 (8,1)	3 (6,1)	4(3,7)	3(10,1)	3(3,6)
			4 (3,3)	3 (2,4)		1(2,3)	5(4,3)		6(6,1)
Pamba river system									
	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
C	4	2	6	2	3	2	5	3	2
R*	2(5,3)	1(14,1)	4(4,3)	1(4,4)	3(8,2)	1(12,1)	1(6,2)	3(7,2)	2(5,1)
						2(5,3)	5(6,3)		
Bharathapuzha river system									
	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
C	5	4	4	3	4	5	4	3	5
R*	2(6,1)	2(5,1)	4(8,1)	2(10,1)	4(13,1)	5(6,1)	3(8,1)	3(9,1)	5(5,1)
	5(6,1)						4(7,1)		4(2,3)
Kallada river system									
	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
C	4	4	5	3	2	3	2	4	3
R*	No big clusters	2(5,1)	4(7,1)	2(2,4)	2(2,2)	3(13,1)	1(16,1)	3(7,1)	1(2,7)
	all contain 2	4(2,1)	5(2,3)	3(10,1)					3(2,7)
	stations								

C No.of clusters of stations obtained

R* Major cluster (No. of stations, no. of species based on which the stations are clustered)

Table 4.4. Seggregation based on altitude for locations obtained in MDS analysis for the different river systems

Periyar river system - 2001

Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
Pre-monsoon	1	1359	Monsoon	1	870-1359	Post-monsoon	1	78-608
	2	608-702		2	860-1208		2	1028-1208
	3	78-1378		3	988-1023		3	518-1359
	4	518-988		4	116-243			
	5	916-1208		5	78-702			

Periyar river system - 2002

Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
Pre-monsoon	1	1209-1108	Monsoon	1	870-1359	Post-monsoon	1	518-1359
	2	518-1378		2	78-478		2	78-478
	3	112-702		3	116-1023		3	860-916
	4	78-984						

Periyar river system - 2003

Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
Pre-monsoon	1	518-988	Monsoon	1	518-1359	Post-monsoon	1	1029-1108
	2	1359		2	870-988		2	1023-1359
	3	78-478		3	860-1208		3	518-1359
	4	1029-1108		4	884-1108		4	4-212
	5	984-1023		5	78-702		5	78-718

Chalakkudy river system - 2001

Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
Pre-monsoon	1	16-24	Monsoon	1		Post-monsoon	1	16-24
	2	46-1002		2			2	46-1002

Chalakkudy river system - 2002

Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
Pre-monsoon	1	46-1002	Monsoon	1	16-24	Post-monsoon	1	16-24
	2	24-411		2	38-1002		2	38-1002

Chalakkudy river system - 2003

Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
Pre-monsoon	1	16-24	Monsoon	1	16-24	Post-monsoon	1	16-24
	2	38-1002		2	46-1002		2	38-1002

Kabbini river system - 2001

Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
Pre-monsoon	1	676-684	Monsoon	1	716-761	Post-monsoon	1	691-905
	2	761-1112		2	691-769		2	712-772
	3	682-769		3	718-946		3	716-1112
	4	783-905		4	702-1112		4	702-769
	5	691-946						
	6	704-1002						
	7	714-794						

Kabbini river system - 2002

Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
Pre-monsoon	1	676-684	Monsoon	1	731-1002	Post-monsoon	1	676-684
	2	674-1112		2	674-682		2	674-772
	3	682-761		3	769-1112		3	731-794
	4	691-1002		4	702-716		4	712-1112
	5	691-946		5	712-946		5	783-946
	6	714-1002		6	682-796			
	7	702-794						

Kabbini river system - 2003

Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
Pre-monsoon	1	676-716	Monsoon	1	676-682	Post-monsoon	1	691-716
	2	682-714		2	783-1112		2	674-684
	3	674-1112		3	676-714		3	718-772
	4	718-772					4	702-1002
	5	761-946					5	682-794
							6	769-1112

Continued.....

Table 4.4 continued.....

Bharathapuzha river system - 2001								
Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
	1	18-286		1	124-261		1	84-212
	2	47-242		2	18-118		2	47-70
Pre-monsoon	3	113-261	Monsoon	3	47-219	Post-monsoon	3	47-118
	4	892-1207		4	47-607		4	218-607
	5	161-607						

Bharathapuzha river system - 2002								
Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
	1	892-1249		1	892-1249		1	47-212
Pre-monsoon	2	47-242	Monsoon	2	113-607	Post-monsoon	2	70-286
	3	218-641		3	124-641		3	18-261
				4	64-242			

Bharathapuzha river system - 2003								
Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
	1	892-1249		1	649-1249		1	124-261
	2	113-607		2	118-212		2	892-1249
Pre-monsoon	3	47-218	Monsoon	3	47-242	Post-monsoon	3	47-607
	4	118-219		4	113-607		4	212-242
							5	18-241

Pamba river system- 2001								
Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
	1	43282		1	20911		1	38967
	2	314-816		2	133-314		2	43282
	3	48-1001		3	48-1001		3	57-762
Pre-monsoon	4	133-168	Monsoon			Post-monsoon	4	48-1001
							5	133-314
							6	188-824

Pamba river system - 2002								
Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
	1	43282		1	38936		1	48-1001
Pre-monsoon	2	48-1001	Monsoon	2	57-762	Post-monsoon	2	43282
				3	48-1001			

Pamba river system - 2003								
Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
	1	43282		1	38936		1	64-1001
	2	188-824		2	9-168		2	38936
Pre-monsoon	3	133-168	Monsoon	3	48-1001	Post-monsoon		
	4	64-762		4	64-824			
	5	48-1001						

Kallada river system - 2001								
Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
	1	216-218		1	216-218		1	121-224
	2	89-332		2	201-241		2	212-282
Pre-monsoon	3	19-212	Monsoon	3	89-282	Post-monsoon	3	25-124
	4	224-282		4	19-332		4	116-332
							5	19-218

Kallada river system - 2002								
Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
	1	25-212		1	212-224		1	19-216
Pre-monsoon	2	89-124	Monsoon	2	89-201	Post-monsoon	2	25-224
	3	116-332		3	19-332		3	89-332

Kallada river system - 2003								
Season	C	Altitude	Season	C	Altitude	Season	C	Altitude
	1	19-332		1	229-332		1	216-224
Pre-monsoon	2	121-216	Monsoon	2	89-218	Post-monsoon	2	89-218
				3	212-274		3	19-121
				4	19-121			

Table 4.5. Average value, standard diviation and coefficient of variation of community structure indices for the different river systems

River		Margalef	Simpson	Shannon	Pielou	S	N
Periyar - 2001							
Pre-monsoon	$\bar{x}$	2.1846	0.2693	2.4948	0.8104	9.9643	62.6704
	σ	1.1238	0.2075	0.9030	0.0983	5.3158	44.0503
	C.V.%	51.4400	77.5000	36.2000	12.1400	53.3500	70.2900
Monsoon	$\bar{x}$	1.2383	0.3723	1.8406	0.8407	5.6154	43.1657
	σ	0.7032	0.1923	0.7859	0.1199	3.1122	37.4655
	C.V.%	56.7865	51.6500	42.7000	14.2700	55.4300	66.7900
Post-monsoon	$\bar{x}$	2.0756	0.2751	2.4379	0.8177	9.2143	55.1761
	σ	0.9752	0.2165	0.8878	0.1429	4.6853	42.7422
	C.V.%	46.9800	78.7100	36.4100	17.4800	50.8500	77.4700
Periyar - 2002							
Pre-monsoon	$\bar{x}$	1.8144	0.3248	2.1631	0.7951	8.3448	59.3718
	σ	1.0437	0.2125	0.8549	0.0873	4.7605	45.2149
	C.V.%	57.5200	65.4100	39.5200	10.9800	57.0500	76.1600
Monsoon	$\bar{x}$	0.8943	0.4962	1.4185	0.7604	4.5556	47.4539
	σ	0.6354	0.2692	0.8558	0.2008	3.0551	38.7721
	C.V.%	71.0500	54.2600	60.3300	26.4100	67.0600	81.7100
Post-monsoon	$\bar{x}$	2.0406	0.2733	2.4099	0.8089	9.3333	58.9890
	σ	1.2390	0.1671	0.7455	0.1559	5.6091	29.7667
	C.V.%	60.7200	61.1600	31.0500	19.2700	60.1000	50.4600
Periyar - 2003							
Pre-monsoon	$\bar{x}$	1.8700	0.3200	2.2500	0.8200	8.5517	54.8600
	σ	1.1000	0.2400	0.9600	0.1100	5.3415	40.0000
	C.V.%	58.5900	76.2000	42.9500	12.9300	62.4700	72.9100
Monsoon	$\bar{x}$	1.1447	0.4527	1.6270	0.7852	5.4444	48.7576
	σ	0.7505	0.2806	0.9629	0.1389	3.7451	41.1745
	C.V.%	65.5700	61.9700	59.1800	17.6900	68.7900	85.4400
Post-monsoon	$\bar{x}$	1.9491	0.2790	2.3706	0.8429	8.7586	56.9300
	σ	1.1626	0.2048	0.8661	0.1125	5.6924	46.8200
	C.V.%	59.6500	73.4000	36.5400	13.3500	64.9900	82.2300
Chalakkudy - 2001							
Pre-monsoon	$\bar{x}$	2.0133	0.2823	2.4896	0.7472	9.7222	89.4500
	σ	0.9060	0.2140	0.6607	0.2180	4.3764	67.8667
	C.V.%	44.9900	75.8000	26.5400	29.1800	45.0200	75.8700
Monsoon	$\bar{x}$	1.5907	0.2835	2.1881	0.7875	7.1176	74.3397
	σ	0.6158	0.0775	0.3462	0.0715	1.9001	58.4320
	C.V.%	38.7100	2.7051	15.8200	9.0800	26.7000	78.6000
Post-monsoon	$\bar{x}$	2.3613	0.2314	2.7438	0.7942	11.2778	87.5344
	σ	0.8855	0.1890	0.7677	0.1602	4.1132	47.0793
	C.V.%	37.5000	81.6900	27.9900	20.1700	36.4700	53.7880

Continued......

Table 4.5 Continued.....

Chalakkudy - 2002							
Pre-monsoon	$\overline{x}$	2.5399	0.1705	2.9477	0.8329	12.1177	88.7820
	σ	0.6252	0.0722	0.4454	0.0775	3.2381	40.0964
	C.V.%	24.6200	42.3700	15.1200	9.3000	26.7200	45.1600
Monsoon	$\overline{x}$	2.0364	0.2078	2.6884	0.8444	10.0555	95.4300
	σ	0.7000	0.0992	0.6086	0.0652	3.9478	46.2500
	C.V.%	34.3800	47.6900	22.6700	7.7209	39.2600	48.4700
Post-monsoon	$\overline{x}$	1.7992	0.2409	2.5347	0.8037	9.1667	100.5873
	σ	0.4679	0.1592	0.6364	0.1193	2.5029	46.8430
	C.V.%	26.0000	66.0400	25.1089	14.8500	27.3000	46.5700
Chalakkudy - 2003							
Pre-monsoon	$\overline{x}$	2.6043	0.2056	2.9362	0.7946	12.2222	78.1921
	σ	1.0467	0.2044	0.6424	0.2089	4.8695	39.2475
	C.V.%	40.1900	99.4100	21.8800	26.2800	39.8400	50.1900
Monsoon	$\overline{x}$	2.5213	0.2044	2.7566	0.8151	11.9444	85.3660
	σ	0.9206	0.0968	0.6349	0.0886	4.8200	42.0573
	C.V.%	36.5100	47.3500	23.0300	10.8700	40.3500	49.2700
Post-monsoon	$\overline{x}$	2.2384	0.2317	2.7519	0.7698	11.0000	92.4400
	σ	0.8005	0.2136	0.6518	0.2123	4.0293	46.5000
	C.V.%	35.7600	92.1900	23.6800	27.5700	36.6300	50.3000
Kabini - 2001							
Pre-monsoon	$\overline{x}$	1.3779	0.3545	2.0441	0.7747	5.7917	30.6354
	σ	0.7240	0.2460	0.7214	0.2540	2.9337	18.4873
	C.V.%	52.5400	69.3900	35.2900	32.7900	50.6500	60.3500
Monsoon	$\overline{x}$	0.2350	0.7881	0.8831	0.4841	1.6818	22.2616
	σ	0.2571	0.1928	0.1671	0.3928	0.6464	25.0600
	C.V.%	109.4200	24.4700	18.9300	81.1500	38.4300	112.5700
Post-monsoon	$\overline{x}$	1.6382	0.2755	2.1989	0.8267	6.8261	45.4409
	σ	0.6242	0.1029	0.5308	0.1017	2.9022	53.5023
	C.V.%	38.1000	37.3500	24.1300	12.2900	42.5200	117.7400
Kabini - 2002							
Pre-monsoon	$\overline{x}$	1.5312	0.2940	2.2199	0.8100	6.5417	42.8537
	σ	0.5591	0.1797	0.5501	0.1850	2.4491	31.9138
	C.V.%	36.5100	61.1242	24.7800	22.8400	37.4400	74.4800
Monsoon	$\overline{x}$	0.7571	0.5296	1.2902	0.7001	3.2857	21.3300
	σ	0.4074	0.2239	0.4708	0.2941	1.6169	15.5728
	C.V.%	53.8200	42.2800	36.4900	42.0100	49.2100	73.0100
Post-monsoon	$\overline{x}$	1.5391	0.3500	1.8928	0.7774	6.2500	38.2782
	σ	0.9136	0.2231	0.8328	0.2020	3.1931	30.8071
	C.V.%	59.3600	63.73	44	25.98	51.09	80.48

Continued......

Table 4.5 Continued.....

Kabini - 2003							
Pre-monsoon	$\bar{x}$	1.2336	0.3730	1.8147	0.7950	5.2083	37.0292
	σ	0.6716	0.2333	0.8695	0.2087	2.9632	34.4149
	C.V.%	54.4400	62.5600	47.9100	26.2500	56.8900	92.9300
Monsoon	$\bar{x}$	0.9470	0.3940	1.8081	0.7845	4.5833	43.9767
	σ	0.4506	0.2399	0.6529	0.2552	2.1653	35.1939
	C.V.%	47.5800	60.8900	36.1100	32.5400	47.2400	80.0300
Post-monsoon	$\bar{x}$	1.2974	0.3241	2.0730	0.8261	5.7083	41.5900
	σ	0.5418	0.2127	0.6842	0.1953	2.5277	32.4987
	C.V.%	41.7600	65.6300	33.0100	23.6300	44.2800	78.1400
Bharathapuzha - 2001							
Pre-monsoon	$\bar{x}$	1.5969	0.2452	2.3388	0.8716	7.2222	52.9899
	σ	0.7679	0.1037	0.6258	0.0678	3.1911	34.9026
	C.V.%	48.0800	42.3200	26.7600	7.7829	44.1800	65.8800
Monsoon	$\bar{x}$	1.3717	0.3446	1.9388	0.8238	5.5556	32.7929
	σ	0.7849	0.1563	0.6766	0.0861	2.4787	18.9539
	C.V.%	57.2300	45.3600	34.9000	10.4600	44.6200	57.7900
Post-monsoon	$\bar{x}$	1.2425	0.3508	1.9414	0.8829	5.2778	36.3400
	σ	0.7990	0.2699	0.8959	0.0934	2.4448	28.2837
	C.V.%	64.3100	76.9700	46.1500	10.5797	46.3200	77.8300
Bharathapuzha - 2002							
Pre-monsoon	$\bar{x}$	1.5969	0.2452	2.3388	0.8716	7.2222	52.9899
	σ	0.7679	0.1037	0.6258	0.0678	3.1911	34.9026
	C.V.%	48.0800	42.3200	26.7600	7.7829	44.1800	65.8800
Monsoon	$\bar{x}$	1.3717	0.3446	1.9388	0.8238	5.5556	32.7929
	σ	0.7849	0.1563	0.6766	0.0861	2.4787	18.9539
	C.V.%	57.2300	45.3600	34.9000	10.4600	44.6200	57.7900
Post-monsoon	$\bar{x}$	1.2425	0.3508	1.9414	0.8829	5.2778	36.3400
	σ	0.7990	0.2699	0.8959	0.0934	2.4448	28.2837
	C.V.%	64.3100	76.9700	46.1500	10.5797	46.3200	77.8300
Bharathapuzha - 2003							
Pre-monsoon	$\bar{x}$	0.6043	0.6086	1.2866	0.5556	3.1667	28.6561
	σ	0.4409	0.2738	0.4556	0.3582	1.6857	19.8074
	C.V.%	72.9200	46.7856	35.4090	64.4800	53.2200	69.1200
Monsoon	$\bar{x}$	0.7695	0.4803	1.5216	0.7152	3.8750	39.6600
	σ	0.2749	0.1108	0.3041	0.0852	1.5000	18.7600
	C.V.%	35.7200	23.0700	19.9800	11.9200	38.7100	47.3100
Post-monsoon	$\bar{x}$	0.7384	0.5613	1.2811	0.6091	3.5769	36.8900
	σ	0.5154	0.2716	0.6586	0.3066	2.0035	27.5600
	C.V.%	69.7900	48.3900	51.4000	50.3300	56.0100	74.7200

Continued......

Table 4.5 Continued.....

Pamba - 2001							
Pre-monsoon	$\bar{x}$	1.6004	0.3461	1.9851	0.8331	5.8500	24.2251
	σ	0.8548	0.2223	0.8186	0.1058	2.8336	17.8500
	C.V.%	53.4100	64.2400	41.2400	12.7000	48.5100	73.6910
Monsoon	$\bar{x}$	1.1257	0.4277	1.5830	0.7720	4.4000	24.0543
	σ	0.4785	0.1737	0.5994	0.1426	1.7592	16.4028
	C.V.%	42.5100	40.6200	37.8600	18.4700	39.9800	68.1900
Post-monsoon	$\bar{x}$	1.3469	0.4367	1.5922	0.7830	4.6316	37.0200
	σ	0.8358	0.2632	0.8560	0.2376	2.2659	45.7363
	C.V.%	62.0600	60.2600	53.7600	30.3500	48.9200	123.5300
Pamba - 2002							
Pre-monsoon	$\bar{x}$	1.9283	0.2608	2.3961	0.8336	8.0500	55.3481
	σ	0.8575	0.1318	0.6675	0.0841	3.2521	43.2778
	C.V.%	44.4700	50.5400	27.8500	10.0800	40.4000	78.1900
Monsoon	$\bar{x}$	1.5019	0.3327	2.0687	0.7732	6.4500	44.6628
	σ	6.2841	1.3923	8.5965	3.2115	26.9094	187.8869
	C.V.%	418.4200	418.4600	415.5600	415.3800	477.2000	420.6800
Post-monsoon	$\bar{x}$	1.8098	0.2621	2.3646	0.8283	7.6316	52.9953
	σ	0.6283	0.1391	0.6252	0.0955	2.7530	37.0654
	C.V.%	34.7200	53.0800	26.4400	11.5300	36.0700	69.9400
Pamba - 2003							
Pre-monsoon	$\bar{x}$	1.0405	0.4814	1.4173	0.7921	3.7778	25.2151
	σ	0.7919	0.2655	0.7883	0.1635	1.7339	21.8990
	C.V.%	76.1100	55.1500	55.6200	20.6400	45.8900	86.8500
Monsoon	$\bar{x}$	1.7765	0.2787	2.2780	0.8218	7.7500	64.0914
	σ	0.7915	0.1239	0.6662	0.1011	3.6545	60.3187
	C.V.%	44.5600	44.4700	29.2470	12.3100	47.1600	94.1100
Post-monsoon	$\bar{x}$	1.3520	0.4271	1.7923	0.7677	6.1000	52.9911
	σ	0.7473	0.2861	1.0507	0.1742	3.8099	45.3873
	C.V.%	55.2700	67.0000	58.6300	22.6900	62.4600	85.6500
Kallada - 2001							
Pre-monsoon	$\bar{x}$	1.6754	0.3465	2.2519	0.7282	7.2222	40.7607
	σ	0.9428	0.2863	0.8122	0.3005	3.6065	23.0872
	C.V.%	56.2700	82.6300	36.0700	41.2700	49.9400	56.6400
Monsoon	$\bar{x}$	0.6490	0.5891	1.3616	0.5973	2.8824	18.1942
	σ	0.5403	0.3034	0.5087	0.4027	1.7636	14.8318
	C.V.%	83.2600	51.5000	37.3600	67.4200	61.1800	81.5290
Post-monsoon	$\bar{x}$	1.4781	0.3583	2.1131	0.7378	6.1667	34.7451
	σ	0.8168	0.2764	0.7127	0.2832	2.8748	24.8637
	C.V.%	55.2600	77.1500	33.7300	38.3867	46.6200	71.5600

Continued......

Table 4.5 Continued.....

Kallada - 2002							
Pre-monsoon	$\overline{x}$	1.6612	0.2747	2.3546	0.8115	7.2222	42.4425
	σ	0.6967	0.2056	0.6285	0.2190	2.9216	21.4307
	C.V.%	41.9400	74.8700	26.7000	26.9900	40.4500	50.4900
Monsoon	$\overline{x}$	1.3694	0.3332	2.0408	0.8231	5.6667	35.6132
	σ	0.8465	0.2228	0.7345	0.2174	2.9306	30.5239
	C.V.%	61.8200	66.8800	35.9900	26.4090	51.7159	85.7100
Post-monsoon	$\overline{x}$	1.0743	0.3872	1.8556	0.7737	4.8333	35.6000
	σ	0.7022	0.2468	0.6132	0.2866	2.5263	23.1472
	C.V.%	65.3700	63.0500	33.0500	37.0400	52.2700	65.0200
Kallada - 2003							
Pre-monsoon	$\overline{x}$	1.5969	0.2452	2.3388	0.8716	7.2222	52.9899
	σ	0.7679	0.1037	0.6258	0.0678	3.1911	34.9026
	C.V.%	48.0800	42.3200	26.7600	7.7829	44.1800	65.8800
Monsoon	$\overline{x}$	1.3717	0.3446	1.9388	0.8238	5.5556	32.7929
	σ	0.7849	0.1563	0.6766	0.0861	2.4787	18.9539
	C.V.%	57.2300	45.3600	34.9000	10.4600	44.6200	57.7900
Post-monsoon	$\overline{x}$	1.2425	0.3508	1.9414	0.8829	5.2778	36.3400
	σ	0.7990	0.2699	0.8959	0.0934	2.4448	28.2837
	C.V.%	64.3100	76.9700	46.1500	10.5797	46.3200	77.8300

Table 4.6. Three-way ANOVA analysis for seasonal variation in species abundance in the different river systems

Periyar river system-Premonsoon					
Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	7.8315	2	3.9158	0.5732	
Between stations (B)	1923.67	28	68.7023	10.0567	**
Between species ©	16970.1	65	261.078	38.217	**
AB linteraction		56	8.4603	1.2384	
BC interaction		1820	20.3121	2.9733	*
AC interaction		130	12.9593	1.897	
Error	24866.5	3640	6.8315		
Total		574			
Periyar river system-Monsoon					
Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	19.5952	2	9.7976	0.84227	
Between stations (B)	2712.69	27	100.47	8.6371	**
Between species ©	16517.1	38	434.66	37.3665	**
AB linteraction		54	9.6795	0.8321	
BC interaction		1026	37.6792	3.2392	**
AC interaction		76	24.0065	2.0638	*
Error	23869.6	2052	11.6324		
Total		3275			
Periyar river system-Post monsoon					
Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	19.5952	2	9.7976	0.84227	
Between stations (B)	2712.69	27	100.47	8.6371	**
Between species ©	16517.1	38	434.66	37.3665	**
AB linteraction		54	9.6795	0.8321	
BC interaction		1026	37.6792	3.2392	**
AC interaction		76	24.0065	2.0638	*
Error	23869.6	2052	11.6324		
Total		3275			
Chalakkudy river system-Premonsoon					
Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	20.3662	2	10.1813	0.7452	
Between stations (B)	1807.46	28	106.321	7.7805	**
Between species ©	29429.2	70	535.076	39.1561	**
AB linteraction		56	19.1337	1.4002	
BC interaction		1960	24.8127	1.8158	
AC interaction		140	16.9952	1.2437	
Error	25553.9	3920	13.6652		
Total		6176			
Chalakkudy river system-monsoon					
Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	141.498	27	70.749	3.6668	*
Between stations (B)	2246.38	17	132.14	6.8486	**
Between species ©	30100.2	40	752.504	39.0012	**
AB linteraction		34	24.5216	1.2709	
BC interaction		680	35.1534	1.822	
AC interaction		80	59.5549	3.0866	*
Error	26240.4	1360	19.2944		
Total		2213			
Chalakkudy river system-post monsoon					
Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	29.5244	2	14.7622	1.1516	
Between stations (B)	1687.44	17	99.2611	7.7434	**
Between species ©	41139.8	52	791.149	61.718	**
AB linteraction		34	12.378	0.9656	
BC interaction		884	25.8782	2.0188	*
AC interaction		104	54.0365	4.2154	**
Error	22663.6	1768	12.8188		
Total		2861			

Continued..........

Table 4.6 Continued.........

Kabbini river system-Premonsoon

Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	20.0414	2	10.0207	1.3277	
Between stations (B)	421.865	20	21.0933	2.7947	*
Between species ©	3919.29	46	85.202	11.2886	**
AB linteraction		40	18.9738	2.5139	*
BC interaction		920	7.57771	1.0039	
AC interaction		92	10.5014	1.3914	
Error	13887.6	1840	7.5476		
Total		2960			

Kabbini river system- monsoon

Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	1015.93	2	507.964	34.9966	**
Between stations (B)	708.778	20	35.4389	2.4416	*
Between species ©	1025.51	11	93.2279	6.423	**
AB linteraction		40	45.1626	3.1115	*
BC interaction		220	15.1861	1.0463	
AC interaction		22	52.1077	3.59	*
Error	6386.44	440	14.5146		
Total		755			

Kabbini river system- Post monsoon

Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	80.4741	2	40.2371	2.9919	*
Between stations (B)	895.614	20	44.7807	3.3298	*
Between species ©	3748.6	26	144.177	10.7208	**
AB linteraction		40	37.7864	2.8097	*
BC interaction		520	14.352	1.0672	
AC interaction		52	17.0018	1.2642	
Error	13986.3	1040	13.4484		
Total		1700			

Bharathapuzha river system-Premonsoon

Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	77.9733	2	38.9866	10.0984	**
Between stations (B)	240.303	28	8.5823	2.2229	*
Between species ©	1497.2	42	35.6477	9.2335	**
AB linteraction		56	4.2113	1.0908	
BC interaction		1176	4.3536	1.1277	
AC interaction		84	33.0933	8.5719	**
Error	9080.33	2352	3.8607		
Total		3740			

Bharathapuzha river system-Monsoon

Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	61.3257	2	30.6628	3.2405	*
Between stations (B)	1119.73	28	39.9902	4.2263	**
Between species ©	7597.32	37	205.333	21.7	**
AB linteraction		56	9.8745	1.0435	
BC interaction		1036	22.6181	2.3903	*
AC interaction		74	39.4535	4.1695	**
Error	19605.9	2072	9.4623		
Total		3305			

Bharathapuzha river system-Post monsoon

Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	335.585	2	167.793	30.9336	**
Between stations (B)	220.006	26	8.46178	1.55998	*
Between species ©	2405.95	43	55.9522	10.3151	**
AB linteraction		52	5.9836	1.1031	
BC interaction		1118	6.6849	1.2324	
AC interaction		86	48.1101	8.8694	**
Error	12128.7	2236	5.42429		
Total		3563			

Continued.........

Table 4.6 Continued.........

Pamba river system-Premonsoon

Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	374.577	2	187.289	17.3628	**
Between stations (B)	1536.7	19	80.8788	7.498	**
Between species ©	8921.5	49	182.071	16.879	**
AB linteraction		38	17.9859	1.6674	
BC interaction		931	21.8885	2.0292	*
AC interaction		98	48.2202	4.47031	**
Error	20085	1862	10.7868		
Total		2992			

Pamba river system-Monsoon

Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	155.42	2	77.7	13.0922	**
Between stations (B)	536.004	19	28.21	4.7528	**
Between species ©	5925.64	38	155.938	26.2717	**
AB linteraction		38	9.25504	1.5592	
BC interaction		722	15.3462	2.5854	*
AC interaction		76	15.6148	2.6307	*
Error	8571	1444	5.9356		
Total		2339			

Pamba river system-Postmonsoon

Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	78.2078	2	39.1039	2.4274	*
Between stations (B)	1926.48	19	101.394	6.2941	**
Between species ©	10978.3	46	238.66	14.8149	**
AB linteraction		38	8.38148	0.5202	
BC interaction		874	26.7691	1.6617	
AC interaction		92	42.2271	2.6213	*
Error	28159.2	1764	16.1094		
Total		2819			

Kallada river system-Premonsoon

Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	41.6248	2	20.8124	3.9533	*
Between stations (B)	785.061	17	46.1801	8.7719	**
Between species ©	8600	37	232.433	44.1508	**
AB linteraction		34	6.0019	1.14006	
BC interaction		629	15.1393	2.9897	*
AC interaction		74	10.8707	2.0649	*
Error	6622.78	1258	5.2645		
Total		2051			

Kallada river system-Monsoon

Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	107.503	2	53.7515	10.9854	**
Between stations (B)	512.304	17	30.1355	6.1589	**
Between species ©	3205.2	32	100.162	20.4707	**
AB linteraction		34	7.9079	1.6162	
BC interaction		544	11.8133	2.4143	*
AC interaction		64	18.082	3.6955	**
Error	5323.56	1088	4.893		
Total		1781			

Kallada river system-Postmonsoon

Source	Sum of squares	dof	MSS	F ratio	Remarks
Between seasons (A)	0.6191	2	0.3096	0.08076	
Between stations (B)	745.291	17	43.8406	11.4377	**
Between species ©	6852.84	36	190.357	49.6627	**
AB linteraction		34	4.4845	1.1699	
BC interaction		612	14.7397	3.8455	**
AC interaction		72	14.927	3.8943	**
Error	4691.58	1224	3.83299		
Total		1997			

* = calculated F is significant at 5% level (p<0.05)

** = calculated Fis significant at 1% level (p<0.01)

Table 4.7. Comparison of three-way ANOVA results on spatio-temporal variation in species abundance between river systems

	Periyar			Chalakkudy			Kabbini			Bharathapuzha			Pamba			Kallada		
Source	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
Between seasons (A)	**	**	*	*	*	*	**	**		**	**	**		**	*	*		
Between stations (B)	**	**	**	*	**	**	**	**	**	**	*	**	*	**	**	**	**	**
Between species ©	**	**	**	**	**	**	**	**	**	**	**	**	**		**	**	**	**
AB iinteraction							**						**					
BC interaction	*		*	*	*	*		**	**			**		*	*	**	*	*
AC interaction	*		*	*	*	*	**	**	**	*	*		*	*	*	*		**

Table 4.8. Comparison of the seasons based on the explained variability of the different parameters calculated from step-up multiple regression analysis and their interaction effects

Year	Season	L	A	D	L,A,D	A,L & A*L	A,D & A*D	L,D & L*D	A,L,D & A*L, L*D, A*D
Periyar river system									
2001	Pre-monsoon		3.22	14.67	14.86		29.16*		
	Monsoon	0	27.1	26.65	29.48	41.36*			
	Post-monsoon								6*
2002	Pre-monsoon		21.1	21.12	21.22		22.12		22.22*
	Monsoon						47.37*		
	Post-monsoon	0	2.08	13.85	14.91		35.14*		28.68
2003	Pre-monsoon	0	11.7	18.23	13.82		26.84*		25.91
	Monsoon	2.03	21.5	34.98	31.46		50.27*		48.12
	Post-monsoon				2.28		18.03*		
Chalakkudy river system									
2001	Pre-monsoon	17.6	x	x	29.52	31.55			44.82*
	Monsoon	19.7	0	1.11	38.52				55.89*
	Post-monsoon	15.1	2.33	23.36	48.92		69.8		76.23*
2002	Pre-monsoon	19	0	0	37.03	32.71			59.68*
	Monsoon				32.95	32.95			48.95*
	Post-monsoon						36.15		59.08*
2003	Pre-monsoon	22.8	0	9	34.78*			23.73	26.1
	Monsoon	0	9.03	0	57.94		62.12		64.04*
	Post-monsoon	26.9	0.73	17.14	49.95				71.28*
Kabbini river system									
2001	Pre-monsoon	0.28	0	6.01	16.85			15.52*	0
	Monsoon	x	x	16.32	x	x	x	x	x
	Post-monsoon	0	31.7	13.88	23.32	49.56*			
2002	Pre-monsoon				8.89*				x
	Monsoon	3.36			16.71			17.10*	x
	Post-monsoon	0	2.87	20.44*	12.93				x
2003	Pre-monsoon				4.46				
	Monsoon			2.05					
	Post-monsoon			0.84					
Bharathapuzha river system									
2001	Pre-monsoon	2.21	24	33.53	34.77*			33.93	33.93
	Monsoon	0.7	17.1	17.52	19.5				
	Post-monsoon	0	17.6	15.57			21.23*		16.7
2002	Pre-monsoon			6.99					
	Monsoon	0	34.4	18.1	30.04	38.68			39.43*
	Post-monsoon	3.28	36.7	21.36	38.78*	38.57			35.32
2003	Pre-monsoon	0	7.26	7.84	3.34	7.08		10.08*	
	Monsoon	0	0	5.44	2.12		16.72		22.32*
	Post-monsoon				2.64				

Continued.........

Table 4.8 Continued............

Pamba river system									
Year	Season	L	A	D	L,A,D	A,L & A*L	A,D & A*D	L,D & L*D	A,L,D & A*L, L*D, A*D
2001	Pre-monsoon	0	30.7	44.97	45.53				46.56*
	Monsoon								21.81*
	Post-monsoon	0	29.6	44.59	42.17		55.69*		
2002	Pre-monsoon	0	14.2	25.51	26.76*			23.28	
	Monsoon				2.4		6.7		29.54*
	Post-monsoon	0	46.4	62.9	66.61	56.29		79.64	80.5*
2003	Pre-monsoon	0	29.1	43.92	41.48	21	45*	21	43.2
	Monsoon	0	4.67	15.95	24.9		19.83		27.77*
	Post-monsoon	0	39.6	63.74	69.28		76.69*		73.57
Kallada river system									
Year	Season	L	A	D	L,A,D	A,L & A*L	A,D & A*D	L,D & L*D	A,L,D & A*L, L*D, A*D
2001	Pre-monsoon								
.	Monsoon	2.19	2.19		1.62			6.04*	
	Post-monsoon								
2002	Pre-monsoon	x	x	x		8.59*			
	Monsoon						10.56		11.3*
	Post-monsoon	32.1	28.5	3.9	38.87				48.72*
2003	Pre-monsoon					30.37*			29.81
	Monsoon	12.3	5.15	0	22.73		14.62		
	Post-monsoon	x	12.1	x		12.9*			

* **Most fitted equation**

x **Not significant**

Chapter 5

SUMMARY AND SUGGESTIONS FOR MANAGEMENT AND CONSERVATION OF FRESHWATER FISH GERMPLASM RESOURCES OF KERALA

5.1. Summary

With the signing on the convention on biodiversity, the countries become privileged with absolute rights and responsibility to conserve and utilize their diverse resources for the betterment of mankind in a sustainable way. South-east Asia along with Africa and South America were considered to be the most biodiversity rich areas in the world (Briggs, 1974). With its variety of ecological conditions, and its position at the confluence of three biogeographic realms, (Paleartic, Afro-tropical and Indo-Malayan) the Indian subcontinent enjoys a tremendous diversity of plant and animal species (Gadgil and Meher-Homji, 1990). India, one among the mega diversity countries (Molur and Walker, 1998) occupies eighth in the world and third in Asia In freshwater fish diversity (Dahanukar *et al.* 2004). The Eastern and Western Ghats are known to have about 55% of India's terrestrial and freshwater biodiversity (Jayaram, 1999) and have a place among the 21-biodiversity hotspots of the world. 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 (Kottelat and Whitten, 1996). The tremendous potential associated with the sustainable utilization of fish germplasm resources of various river systems of Kerala for food, aquaculture and ornamental purposes have to be fully tapped for economic upliftment of fisherman community and also for equitable sharing of benefits among the mankind without compromising the conservation of the rare and unique fish germplasm resources for the future generations.

Identification, evaluation and prioritization of fishes are the important tasks required to be addressed in their conservation and sustainable utilisation. A perusal of the literature revealed that most of the previous works on freshwater fishes of Kerala were rather confined to taxonomic listing of fishes within some specific geographical areas. Given the high levels of faunal diversity and endemism reported so far, there is an urgent need to understand the fish diversity and distribution pattern of freshwater fishes of Kerala in a more comprehensive and holistic way. More over, though a number fishes have been added to faunistic list of Kerala either as new descriptions or new records, practically there is no literature is available by revalidating the species so far known from the river systems of Kerala. A river system wise database on the commercially important and potential ornamental and cultivable fishes and an assessment of their biodiversity status either as threatened or non-threatened are also still wanting. The dynamics of spatio-temporal variations in species abundance and assemblages in freshwater bodies, particularly in the case of fishes, are the emerging global issues, however, these topics are not getting priority in the Indian context. 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 for their sustainable utilisation and delineating their distribution, abundance and assemblage pattern.

The study was carried during April 2000 to December 2004. 25 major river systems of Kerala were surveyed for fish fauna for delineating the pattern of distribution and abundance of fishes both seasonally and geographically. A variety of fishing methods were employed for collection of specimens. 1:50,000 topographical maps of Survey of India and Water Atlas of Kerala (Anon, 1991) were used to trace the river system, their secondary and tertiary tributaries and pinpointing the location sites for survey. A total of 474 locations were surveyed during the study period. 6 major river systems viz. Periyar, Chalakkudy, Kabbini, Bharathapuzha, Pamba and Kallada were selected to study spatio-temporal pattern of fish abundance and assemblages. 134 locations within these river systems were surveyed repeatedly giving due representation to the pre-monsoon, monsoon and post-monsoon seasons for a period of three years (2001-2003). Different statistical packages such as PRIMER-5, PAST and SPSS-11.5 were used for different analyses.

145 freshwater fish species belonging to 12 orders, 28 families and 66 genera were described in the present study. The fishes were identified up to species level with the help of authentic keys. The families, subfamilies and genera were briefly introduced. The keys and descriptions were prepared user friendly. Except for monotypic taxa, all other taxa are following dichotomous keys. The various species under a genus are arranged and presented based on the order in which they appear in the key. But the sequence of suborders, families, sub families and genera are arranged and described according to their known phylogenitic and inter-generic affinities. Description of individual species is followed by a remarks section which deals mainly with aspects of conservation and fishery, habitat and fishing method etc. A photograph of the species in live condition is also provided.

8 fish species which are new to science were described from different

river systems of Kerala as part of the present study. Among them *Nemacheilus periarensis, Homaloptera silasi, Garra mlapparaensis, Garra travancoria* and *Garra emarginata* are the new species described from Periyar river system, *Salarias reticulates* from Chalakkudy, *Tor remadevi* from Pambar and *Garra nilamburensis* from Chaliyar river system. *Garra ceylonensis* belongs to the family Cyprinidae is a new record of fish species from Indian region which is so far known only from Sri Lankan waters. *Tor putitora, Mystus menoda, Labeo kontius and Puntius bovanicus* are new records from Peninsular region, sharing their extension on to southern part of Indian subcontinent. 14 fish species were found shared their presence in other river systems of Kerala also. Cuncurring with the studies conducted else where in the South Asian tropical waters and Western Ghats, order Cypriniformes emerged as the largest order in its numerical strength of species with 87 species followed by Siluriformes with 23 species. Family Cyprinidae was the largest family accommodating 21 genera and 67 species while the genus *Puntius* of this family accommodated the highest number with 17 species. The results of germplasm inventory and evaluation of fish species were presented both for the state and also river wise. The results of evaluation of fish species for their commercial utilization revealed that, of the 145, 76 are ornamental, 47 food and 22 cultivable. 21 species are strictly endemic to Kerala rivers. The revalidation on biodiversity status of the fishes assessed based on IUCN is so alarming that a high percentage of fishes (59 spp.) belong to threatened category which is inclusive of 8 critically endangered (CR), 36 endangered and 15 species under vulnerable (VU) category.

The river wise fish germplasm inventory surveys were conducted in 25 major river systems of Kerala. This type of investigation is practically new to the ichthyological studies of the subcontinent which is absolutely necessary for making frame work for the species, areas and river systems to be prioritised for management and conservation. The germplasm resources of the different river system were evaluated for their commercial utilization viz. ornamental, cultivable and food fishes while biodiversity assessment was done following IUCN criteria whereas nature and degree of endemism was adjudged on the basis of available literature.

While examining the nature of fish species diversity exist in the river systems based on the Jaccard's similarity coefficient, a distinct difference was noticed between east and west flowing river systems. Highest similarities in species diversity were observed between Nileswaram and Peruvamba (0.7) followed by Kuppam and Chandragiri (<0.6) while it was least between Chalakkudy and Pambar river systems. A pioneer attempt was made to establish the influence of geographical dimensions on the fish diversity of river systems and the results showed that Periyar river system showed highest species diversity (512.2) followed by Chalakkudy and Bharathapuzha. The river systems were categorised based on the index values and expressed as "excellent" or hot spots of fish diversity and 'Good', 'moderate' and 'poor'. The regions showing rich species diversity and deserving immediate protection in individual river system were demarcated. When the river systems were compared based on the river index values per km^2 of the catchment area, Tirur river system, which was one among those recorded low index value, showed highest (0.38) and is followed by Pambar

(0.29), Kuppam (0.27) and Karyangod (0.25). The large and highly diversified river system like Periyar (0.094), Bharathapuzha (0.06), Pamba (0.089), Achenkoil (0.012) have shown only low values. This is indicative of the fact that species diversity is not uniformly distributed all along the river length and there is a downstream increase or addition in species richness. Smaller river systems which are characterised by the presence of fish fauna seen in the downstream therefore are richer than the longer river systems having more diversified habitat structure.

The species diversity in terms of species richness for different river systems were plotted against the physical dimensions of the river systems such as length and catchment area, it appeared that the diversity showed a direct relationship with these parameters. Conversely, a declining trend was obtained while plotting the species diversity in the unit area of the river system against these parameters. It appears that the species richness generally increases and the unit diversity in terms of richness decreases with an increase in length and catchment area of the river system. While studying the influence of latitude on the species diversity, it appeared that the species diversity increased from north of Kerala up to central Kerala and thereafter showed a decline. Smaller river systems generally showed less diversity while it is vice versa in the case of large river systems. A zone wise comparison of species richness on the basis of 1^0 latitude revealed that highest number of fish species were found at central Kerala region (Zone III). However, the results of species diversity available per km^2 catchment area showed that zone I is the richest. While comparing the five zones with the help of Jaccard index values, two distinct clusters were emerged showing a high similarity between Zones I and V (55%) and a moderate similarity between cluster representing Zones II and IV (50%). Zone III was unique in species richness. This is another justification of area-species diversity relation as the longest river systems of central Kerala contributed heavily to the aggregation of species diversity in this region. However, the unit diversity values were highest for the northern and southern Kerala which encompassing the smallest geographical areas and the river systems having smaller length and catchment areas. The results equivocally proved that latitude has no direct bearing on the species diversity but the same is more influenced by the length and catchment area of the river system.

The regional distribution pattern of fish species in different river systems showed extreme variation in their diversity. *Puntius filamentosus* and *Rasbora daniconius* were collected from all the river systems, hence emerged as species having extensive geographical distribution. Majority of the species viz. *Puntius denisoni, Barilius canarensis, Tetradon travancoricus* and *Garra hughi* were found restricted to a few river systems while species such as *Lepidopygopsis typus*, *Cirrhinus reba*, *Osteochilus* (*Kantaka*) *brevidorsalis*, *Mesonemacheilus remadevi*, *M. pambarensis* and *Channa micropeltes* were found restricted to one or a few locations within a specific river system. The longitudinal distribution of fish species showed highly diversified pattern within the different altitude ranges. *Puntius filamentosus* and *Rasbora daniconius* were characterised by a uniform distribution in all the three stretches of the river systems surveyed whereas *Bhavania auastralis* was found more or less confined to the upper stretches of the river systems while the distribution of *Channa striatus* and *Nandus nandus* were confined to the lower reaches. The presence of critically endangered species were found extremely restricted to the upper stretches of some of the selected river systems. While comparing the fish faunal distribution in the different altitudinal zones, high resemblance were observed for the higher altitudinal zones for the major river systems followed by their middle and lower reaches. This is indicative of the high similarity associated with well-defined habitat structure especially seen at the upstream regions of the larger river systems. The similarities between the smaller river systems were not so significant which indicate the absence of well differentiated habitats in these river systems.

The abundance pattern of fish species showed highly significant difference between seasons, locations and species in all the major six river systems of Kerala viz. Periyar, Chalakkudy, Kabbini, Pamba, Kallada and Bharathapuzha. The variations in diversity and species richness in each river system over space and time are explained with the help of advanced statistical programme (PRIMER-5, SPSS-11 and PAST). The three-way ANOVA applied to test the seasonal and annual variability showed significant difference between seasons, between stations and between species invariably in all the three years ($P<0.05$) in Periyar river system. High seasonal specificity and high location specificity was observed for species in 2001 and 2003 ($p<0.05$) indicated by high significant season-species interactions (A*C) and station-species interactions. In Chalakkudy river system, seasonal variation in species abundance were very obvious, as indicated by high season-species interactions ($p<0.05$) and high station-species interaction ($p<0.05$). In Kabbini river system, seasonal differences were high during 2001 and 2002. Species abundance vary significantly in all the years ($p<0.05$) which is more obvious in the case of seasons indicated by high season-species interaction (A*C)($p<0.05$) in all the years. In Pamba river system, invariably in all the years, fish species abundance differed from location to location and also from species to species ($p<0.05$). Seasonal variations were found only during 2003 ($p<0.05$). In Kallada river system during 2002 and 2003, species abundance was not significantly different between seasons ($p>0.05$). But station wise difference was not negligible in any of the years ($p<0.05$). So also is the abundance with respect to species ($p<0.05$). In all the years species abundance varied with respect to locations ($p<0.05$).

The results based on Bray-Curtis indices showed a diversified pattern of similarity between fish assemblages of both at spatial and temporal scales. Variation in species abundance were more similar between the pre-monsoon and post monsoon seasons and quite considerably dissimilar during monsoon periods. The number of clusters formed were generally high during off-monsoon seasons indicating high habitat heterogeneity which lead to very distinct and localized species assemblages during these seasons. Species richness and abundance were generally high in locations such as Pooyamkutty of Periyar, Chalakkudy and Athirapally of Chalakkudy river system and this would indicate the necessity of protecting these regions as aquatic sanctuaries. Thannikudy and Mlappara of Periyar, Orukombankutty of Chalakkudy, Muthanga of Kabbini and Walakkad of Bharathapuzha river system were observed as regions which harbour many rare species with extremely low relative abundance. *Puntius filamentosus*, *Danio malabaricus*, *Barilius gatensis* and *Garra mullya* showed high relative abundance in almost all the seasons and years in all the river systems studied and their assemblages were consistent throughout the study period. Highly habitat specific clusters were formed by those of *Lepidopygopsis typus*, *Crossocheilus periyarensis*, *G. micropogon periyarensis* in Periyar, *Puntius jerdoni* and *Esomus thoramoicos* of Chalakkudy, *Silurus wynaadensis* and *Glyptothorax annandalie* and *Labeo kontius* and *Kantaka brevidorsalis* in Kabbini. The species can only be conserved by the preservation of these unique habitats where their occurrence is natural.

The altitudinal segregation of locations based on which the species were clustered revealed that the assemblages occupy distinct altitudinal ranges in a river system and exhibit remarkable similarity in their pattern of clustering between pre monsoon and post monsoon seasons. The overall clustering pattern showed comparatively less inter-annual variability than the seasonal variability. The results of MDS analysis also showed that clusters of locations were mostly based on their altitudinal similarity and can be more or less differentiated in to those representing upper, middle and lower stretches. Generally, the highly diversified river systems such as Periyar and Chalakkudy exhibited more of, distinct clusters in the pre monsoon and post monsoon seasons. Overall, the study confirmed that the variation in species abundance over a time period in different river systems were more similar over space than time.

While analyzing the spatio-temporal variations in community structure of the fishes in the different river systems it appeared that in Periyar river system average species richness was maximum during pre-monsoon season followed by post monsoon. On the other hand, the spatial variability for species richness was least during post monsoon period. Species concentration was maximum during monsoon followed by post monsoon. Shannon-Wiener diversity was least during monsoon while maximum during pre-monsoon. Pielou's index of evenness is found to be more or less of same uniformity in the distribution of individuals among the various fish species. In Chalakkudy river system, unlike Periyar river system, species richness was maximum during post monsoon and species concentration index was almost same in all the seasons with least values during post monsoon. But spatial variation was very less during monsoon season. Pielou's evenness index showed a steady increase from the beginning to the end of the year. Average abundance was maximum during pre monsoon and minimum during monsoon. In the Kabbini river system, during the study period from 2001 to 2003, a steady increase in the species richness was observed from the monsoon to post monsoon. Maximum concentration was observed in monsoon season while species diversity was maximum during post monsoon. Invariably in all the years, monsoon season was least productive. Species evenness followed the identical pattern of distribution of species diversity in the three years of study. Average number of species and average abundance also exhibited the same pattern of seasonal distribution. As in Periyar and Chalakkudy river systems, in Kabbini river system also, species evenness was a better index for comparison followed by species diversity index. All the three river systems showed least spatial variation in the three year study period. In Kabbini river system, pre monsoon was comparatively rich being more productive in terms of number of species and number of individuals, monsoon with higher species concentration, pre monsoon with higher diversity and highest uniformity during post monsoon period. In the Pamba river system pre monsoon appeared as the best productive season with respect to the species richness, diversity and evenness. But maximum value with respect to the concentration and average number of individuals were observed in post monsoon. In all the cases of community structure indices, values during post monsoon perlod was higher than that of monsoon and pre monsoon.

The predictive multiple regression model fitted in different seasons and years for the various river systems showed that the ecological parameters such as altitude of the location, distance from the sea and latitude have strong bearing on the spatial distribution and abundance of fishes. The predictive capacity of the different models found extremely varied between the seasons, years and also between the river systems and most interestingly, the individual parameters were found having specific effects in each river system. Generally, the highest percentage of accuracy in prediction was observed during post monsoon season followed by pre-monsoon due to the clear segregation of species assemblages at specific habitats during these periods. The advantage of interactive models, more specifically the three-factor combined interactive models over the single factor and linear regression models were well ascertained during the present study. However, when a variable is not found substantially increasing the predictive efficiency, considering the cost of collection of data involved, two-factor models or even single factors (some cases) alone are sufficient to predict the explained variability, thus helping in saving the cost and time involved in the collection of the unimportant parameters in the future studies. The main reason attributed to this is the insignificant importance/dominancy of one or two parameters in each river system under study. Altitude and distance from the sea were emerged as the most dominant parameters and their interactive effects alone were found sufficient to explain the spatial variability in species abundance in a number of cases in different river systems. The relatively high percentage of unexplained variability observed in some seasons and river systems indicated the inefficiency of any type of models based on the present parameters to predict the spatial variation in abundance during the specific season. This denotes the important roles of other ecological parameters such as biotic relationships and also historical factors in determining the abundance distribution of freshwater fishes.

5.2. Suggestions for conservation and management of freshwater fish germplasm resources of Kerala:

The following management measures are proposed based on the findings from this study which would be useful in the conservation and sustainable utilization of freshwater fish germplasm resources of Kerala:

1. Database on the freshwater fish fauna and fish biodiversity of Kerala is incomplete at present. It is felt that there is an urgency to intensify the fish sampling surveys in a systematic way in all the 44 rivers of Kerala to strengthen and revalidate the database of freshwater fishes of Kerala.
2. It is high time to resolve the taxonomic ambiguities prevailing in some of the fish groups using modern tools such as molecular systematics. Genera such as *Tor, Garra, Barils* and *Puntius* etc. requires urgent

revision in view of the intricacies and complexities involved in the identity of species of these groups.

3. The results of the present study is indicative of existence of several new fish species 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.

4. The results of fish germplasm evaluation revealed that there exist many potential endemic ornamental and cultivable fishes in Kerala. It is found imperative to utilize these species sustainably for improving the aquaculture production and aquarium trade of the country which would definitely fetch more income and generate employment. 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. Any attempt to export the ornamental fishes procured directly from the wild shall be discouraged as it may not only leads to species endangerment but also germplasm piracy.

5. As the habitat-species relationships and species interactions are found very strong in the river systems of Kerala, rather adopting single species protection plans, multi-species or community conservation plans shall be planned and implemented.

6. Adopt location specific management plans such as establishment of sanctuaries, closed seasons, mesh size regulations etc. in biodiversity

rich areas and regions harbouring a large number of endemic/ endangered fish species.

7. It is high time to declare aquatic sanctuaries at par with the sanctuaries for the wild animals in Western Ghats for conservation of endemic endangered fish germplasm resources.
8. Endangered freshwater fishes shall be brought under the purview of the wild life act. (1972, amended 1991) at par with the marine fishes. The natural breeding and nursery grounds of the endangered fish species shall be protected by declaring them as aquatic sanctuaries.
9. Establishment of broodstock maintenance centers and hatcheries exclusively for indigenous endangered fish species are also found imperative to assure preservation of fish germplasm resources of the country.
10. Regulate the human interventions in the river systems such as sand mining, ban unethical fishing practices; prevent discharge of polluted water, etc. as measures of habitat preservation of freshwater fishes.
11. Necessary steps shall be initiated for the transplantation and translocation programme on a war footing for the species which have a restricted distribution in some specific habitats and low abundance to similar other habitats within the same river system or a separate river system, and thus replenish their natural population in the wild.
12. The pioneer database generated as part of the present study on the pattern of fish species abundance and community structure based on catch per effort from the major river systems of Kerala can be well used as a role model in initiating similar studies in other river systems

also. These type of information can be passed on to the Govt. to adopt management programme to augment the fish production of those species which are getting disappeared and become sparse in abundance.

13. The research priorities can be focused on ecology of freshwater fishes to understand the complex and dynamic habitat-species assemblages and the role of ecology and geomorphology in controlling the species distribution and abundance in river systems. Sophisticated techniques such as GIS can well be utilized for such studies.

14. Lack of proper regulations and rules form a major reason for the depletion of inland fishery wealth of Kerala. Govt. of Kerala may enact Inland Fishery Regulation Act (KIFRA) at par with KMFRA at the earliest. Collective effort by State & Central Govt. agencies, Local bodies, NGOs and research communities are required for the adoption and implementation of location specific conservation and management plan.

15. Successful fish conservation on a long-term basis is mainly dependant on habitat protection which in turn can be achieved only through public awareness. Educate the fishermen community, local people, governmental and non-governmental agencies, students and the general public regarding the importance of conservation of freshwater fish fauna of the state.

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APPENDIX - I

	Periyar river system			
Sl.No.	Locations	Lattitude (^{0} E)	Altitude(m)msl	Distance from the sea(km)
1	Kaipra	76.208333	4	16
2	Bhoothathankettu	76.84166	78	56
3	Lower periyar	76.0444	112	74
4	Karimban	76.81666	116	63
5	Neriyamangalam	76.84166	160	102
6	Edamalayar	76.111	180	62
7	Cheruthoni	77.0943	212	73
8	Vellathuval	77.5833	241	62
9	Pooyamkuuty	76.9222	478	91
10	Perunda	76.86111	518	88
11	Kallar	76.888	608	78
12	Pampadumpara	76.924999	689	91
13	Idukki	76.13888	702	116
14	Mundiyeruma	77.236111	718	69
15	Nilathanni	77.077	775	83
16	Vandipperiyar	76.019444	860	141
17	Koondrappuzha	77.16944	870	92
18	Pathinalammile	77.0611	884	138
19	Periyar lake	77.0555	916	141
20	Mullakkodi	77.0333	984	162
21	Mandrappara	76.50277	988	92
22	Ummikuppanthodu	77.39166	1023	162
23	Thannikkudy	77.37499	1029	172
24	Mlappara	77.3722	1044	181
25	Injippara	77.39444	1108	196
26	Aladi	77.3888	1208	212
27	Chokkanpettythodu	77.3444	1359	231
28	Chembakavallithode	77.333	1359	241
29	Katamadithodu	77.402777	1378	243
30	Munnar	77.0333	1878	222
	Chalakkudy river system			
Sl.No.	**Locations**	**Lattitude (^{0} E)**	**Altitude(m)msl**	**Distance from the sea(km)**
1	Kanakkankadavu	76.24444	16	15
2	Pulikkalkadavu	76.24444	21	14
3	Chalakkudy	76.760444	24	14
4	Thumburmuzhi	76.06111	38	55
5	Vettilappara	76.74333	46	65
6	Athirappally	76.613822	104	69
7	Vazhachal	76.84412	205	76
8	Poringal	76.23333	411	86
9	Orukombankutty	76.563555	498	128
10	Sholayar	76.769444	512	129
11	Kuriarkutty	76.7554	524	124
12	Thellikkal	76.45112	549	124
13	Pillappara	76 663888	574	89
14	Malakkappara	76.75488	743	91
15	Kulappady plantation	76.754	781	79
16	Karapara	76.75555	996	128
17	Nelliampathy estate	76.63577	1002	136
18	Valparai	76 219111	1781	142

Continued.........

Appendix I continued.......

Kabbini river system				
Sl.No.	**Locations**	**Lattitude (^{0} E)**	**Altitude(m)msl**	**Distance from the sea(km)**
1	Meenangadi	76.222	674	124
2	Mananthavadi	76.302777	676	129
3	Puthusserikkadavu	76.23611	682	106
4	Panamaram	76.25	684	126
5	Koyleri	76.26944	691	88
6	Banasurasagar dam site	76.0888	702	118
7	C.C.Puzha	76.30277	712	82
8	Pookode lake	76.0944	714	79
9	Vythiri	76.1777	714	78
10	Pozhuthana	76.2444	716	98
11	Makkilayam	76.09444	718	136
12	Niravilpuzha	76.50555	722	135
13	Kurlode lake	76.1333	731	98
14	Sugandagiri	76.0499	731	76
15	Kunnumpotta	76.10277	761	116
16	Kuruvadeep	76.2444	769	142
17	Achoor	76.036111	772	132
18	Begur	76.0777	783	136
19	Kattikunnu	76.04999	794	89
20	Baveli	76.21666	796	152
21	Muthanga	76.39444	905	149
22	Ponkuzhi	76.39166	946	152
23	Tholpetty	76.319444	1002	149
24	Tirunelli	76.85277	1112	151
	Kallada river system			
Sl.No.	**Locations**	**Lattitude (^{0} E)**	**Altitude(m)msl**	**Distance from the sea(km)**
1	Urukunnu	77.0555	19	55
2	O ttakkal	77.11944	25	49
3	Meenmudy	77.09722	89	84
4	Lookout	77.31666	116	79
5	Mukkadavu	77.25	121	67
6	Thenmaladam	77.23055	124	86
7	Kazhuthurutti	77.1055	201	64
8	Venkalappala	77.59444	212	112
9	Neduvannurkkadavu	77.53888	212	42
10	Punalur	77.30277	216	64
11	Kulathupuzha	77.23055	218	86
12	Pallivasal	77.18611	224	92
13	Chankili	77.13888	229	94
14	Aryankavu	77.2	233	111
15	Edappalayam	77.5305	241	108
16	Rose mala	77.2444	274	118
17	Umayar	77.21944	282	114
18	Palaruvi	77.30833	332	116
	Pamba river system			
Sl.No.	**Locations**	**Lattitude (^{0} E)**	**Altitude(m)msl**	**Distance from the sea(km)**
1	Kinadi	76.11666	4	9
2	Edathuva	76.3694443	7	22
3	Mannar	77.180555	7	23
4	Payippad	77.019444	8	23
5	Prayikkara	76.95833	8	23
6	Aranmula	77.2999	9	13

Continued.........

Appendix I continued......

7	Neerettupuram	77.30555	18	21
8	Perumthenaruvi	76.9583333	48	89
9	Vadasserikkara	76.119444	57	76
10	Ranni	76.26666	64	79
11	Azhutha	76.99722	85	76
12	Angamoozhi	77.013888	133	126
13	Nilakkal	77.044	149	128
14	Seethathode	76.09444	168	131
15	Pambavalley	77.11666	188	158
16	Moozhiyar	77.09166	314	151
17	Gavi	76.22777	762	144
18	Pachakkanam	76.36944	816	146
19	Kakki	77.180555	824	162
20	Kochupamba	77.180555	1001	171
	Bharathapuzha river system			
Sl.No.	**Locations**	**Lattitude (^{0} E)**	**Altitude(m)msl**	**Distance from the sea(km)**
1	Cheruthuruthy	76.402777	18	22
2	Cheerakuzhi	76.524999	47	128
3	Mannarkkad	76.5303	47	76
4	Cholagu	76.06111	62	61
5	Yakkara	76.86944	64	69
6	Kalpatthy	76.48333	70	64
7	Walayar	76.333	84	111
8	Nellipuzha	76.774999	112	74
9	Edapungal	76.3833	113	72
10	Ayiloor	76.42777	118	131
11	Pallavoor	76.5611	124	64
12	Kanjirappuzha dam site	76.163888	135	81
13	Kawarakkundu	76.52499	161	76
14	Gayathrippuzha	76.32777	202	68
15	Malampuzha dam site	76.3277	212	72
16	Dhoni	76.0805	218	73
17	Nenmara	76.35833	219	69
18	Choorapara	76.60833	222	48
19	Palakkayam	76.6333	241	81
20	Thathamangalam	76.399	242	72
21	Pothundy	76.24722	261	89
22	Thamrachalla	76.5166	286	81
23	Atla	76.1166	607	156
24	Mukkali	76.84722	641	134
25	Neelickal	76.2722	748	145
26	Syrendri	76.30555	892	161
27	Poochippara	76.5555	945	154
28	Meenvallam	76.71944	1207	184
29	Walakkad	76.4666	1249	164

APPENDIX - II

Scientific Publications

a) Papers published

1. **Radhakrishnan. K.V** and B.M. Kurup (2002): Inland indigenous ornamental fish resources of Kerala. *Fishing Chimes* 12 (1) : 27-33.
2. B.M. Kurup 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.* Vol. 102(1).75-78
3. B.M. Kurup, T.G. Manojkumar and **Radhakrishnan. K.V.** (2006): *Salarius reticulates* (Pisces; Blennidae), a new freshwater blenny from Chalakudy river, Kerala (South India) 102 (3), 195-197
4. **Radhakrishnan. K.V.** and B.M. Kurup (2006): Extension of range of *Nemacheilus keralensis* (Rita & Nalbant) and *Puntius ophicephalus* (Raj) to river Meenachil, Kerala. (South India) 102(3), 236-237.
5. B.M. Kurup and **Radhakrishnan. K.V.** (2006): Freshwater fish biodiversity of Kerala: Status and utilisation for commercial fishing, Food security and lively hood. *Fishing Chimes* 25 (10) : 111-122.

b) Manuscripts accepted for publication

1. B.M. Kurup and **Radhakrishnan. K.V.** and Manojkumar.T.G (2004): Biodiversity assessment of freshwater fishes of Kerala with special reference to endemism, threats and conservation measures (Accepted to Second international Symposia on larger rivers, Cambodia)
2. **Radhakrishnan. K.V.** and B.M. Kurup (2002): Ornamental fish stocks of the rivers of Kerala deserve immediate protection and conservation (Paper accepted to be included in the proceedings of the sixth Indian Fisheries Forum)
3. **Radhakrishnan. K.V.** and B.M. Kurup (2004): Additions to the Fresh water fish biodiversity of Kerala (South India) (Accepted by BNHS)
4. **Radhakrishnan. K.V.** and B.M. Kurup (2004): Ornamental fish resources of Periyar river with special reference to Periyar Tiger

2. **Radhakrishnan. K.V.** and B. M. Kurup (2002): Length weight relationship of ten potential ornamental fishes of Kerala (South India):In Proceedings of the workshop on the Life history traits of fish populations for its Utilisation in conservation ;organized by NBFGR, Lucknow pp. AA-6
3. **Radhakrishnan K.V** and B.M. Kurup (2002): Food and feeding habits *of Puntius denisonii* (Day)- An endemic endangered ornamental fish of Kerala (South India).In Proceedings of the workshop on the Life history traits for the conservation; organised by NBFGR, Lucknow.ppAF-4
4. B.M. Kurup and **Radhakrishnan. K.V.** (2002): Inland indigenous ornamental fish resources of Kerala and their domestication.In Proceedings on the symposia on Breeding and maintenance of Ornamental fishes organized by MPEDA, Cochin.
5. B.M. Kurup**, Radhakrishnan K.**V. & Euphrasia C.J (2002): Length weight relationships of some of the critically endangered and endangered fresh water fishes of Kerala part of Western Ghats. In Proceedings of the workshop on the Life history traits of fish population for its utilisation in Conservation organized by NBFGR, Lucknow pp. AA-2.
6. **Radhakrishnan. K.V.** and B.M. Kurup (2005): Fish Germplasm resources of major rivers of Kerala with special reference to distribution pattern and conservation status of threatened fishes (Paper presented in the 17th Kerala Science Congress held at KFRI Peechi from 29-31 Jan.2005)
7. **Radhakrishnan. K.V.** and B.M. Kurup (2005): An account on the threatened fishes of rivers of Kerala (South India) with special reference to endemism, distribution and stock size (Paper presented in the Asian Fisheries Forum,29 November to 3rd December 2004, Penang, Malaysia)

8. **Radhakrishnan. K.V.** and B.M. Kurup (2005): Status of fish Germplasm resources of the major rivers of Kerala (Paper presented in the 3rd Asian Fisheries Forum, 4-6 Nov.2004,IARI, New Delhi)

9. **Radhakrishnan. K.V.** and B.M. Kurup (2005): Distribution and stock size of potential ornamental fishes of Kerala with special reference to sustainable issues. Paper presented at the "Sustain fish 2005" international symposium on improved sustainability of production systems and appropriate technologies for utilization,16-18th March 2005 ,Cochin, India.

10. **Radhakrishnan. K.V.** and B.M. Kurup (2005): Length weight relationships of seventy two ornamental fishes of Kerala. Paper presented at the "Sustain fish 2005" international symposium on improved sustainability of production systems and appropriate technologies for utilization, 16-18th March 2005 ,Cochin, India.

12. .**Radhakrishnan. K.V.** and B.M. Kurup (2005): Aspects of Life history traits of *Puntius denisoni* (Day), an endemic threatened ornamental fish of Kerala. Paper presented at the "Sustain fish 2005" international symposium on improved sustainability of production systems and appropriate technologies for utilization, 16-18th March 2005 ,Cochin, India.

13. B.M. Kurup and **Radhakrishnan. K.V.** (2005): Status of freshwater fish germplasm resources of Kerala. Paper presented at the "Sustain fish 2005" international symposium on improved sustainability of production systems and appropriate technologies for utilization, 16-18th March 2005, Cochin, India.

14. Euphrasia C.J., **Radhakrishnan. K.V.** and B.M. Kurup (2005): The threatened freshwater fishes of Kerala. Paper presented at the "Sustain fish 2005" international symposium on improved sustainability of production systems and appropriate technologies for utilization, 16-18th March 2005, Cochin, India.