FRESHWATER FISH FAUNA OF RIVERS OF SOUTHERN WESTERN GHATS, INDIA

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Abstract. This paper provides information on the diversity of freshwater fish fauna of six river systems of Southern Western Ghats. The fishes were collected using cast net, dip net, gill net and drag net from various streams and rivers. There are about 31 sites in which a total of 64 species belonging to 6 orders, 14 families and 31 genera were recorded. Among them the order Cypriniformes was dominant with 3 families' 18 genera and 49 species (76.6%) compared to other orders. Principal component analysis and cluster analysis were performed to express the contribution of the variables and its influence on the species diversity. Interestingly, of the 31 sites Thunakadavu stream, Gulithuraipatti, Athirappalli, Naduthotam, Nadathittu, Mullaithodu, Thonanthikla, Noolpuzha and Sinnaru exhibited high variations in species diversity. Nearly fifteen species were found to be threatened to the Western Ghats. *Garra periyarensis* and *Cirrhinus cirrhosus* are known to be vulnerable and *Hemibagrus punctatus* is Critically Endangered because of various anthropogenic activities. The study clearly indicates that certain timely measures has to be taken immediately to protect the fishes in Southern Western Ghats.

Keywords: Southern Western Ghats, Water Quality, Species Diversity, Endemic, threats, Conservation.

1. INTRODUCTION

The Western Ghats of India is a UNESCO World Heritage Site and is one of the eight "hotspots" of biological diversity in the world. It is also called as "The Great Escarpment of India". The range of Western Ghats runs from north to south along the western edge of the Deccan Plateau, and separates the plateau from a narrow coastal plain, called Konkan, along the Arabian Sea. A total of thirty nine world heritage sites which includes national parks, wildlife sanctuaries and reserve forests. Among them twenty were in Kerala, ten in Karnataka, five in Tamil Nadu and four in Maharashtra adds fame to the Western Ghats. The Western Ghats of India has a rich freshwater fish fauna with a high level of endemism (Dahanukar *et al.*, 2004). However, current knowledge a major part of this fauna is threatened by human activities and invasive species (Dahanukar *et al.*, 2004). Thus, knowledge of the diversity and distribution of the fish fauna is essential for designing and implementing

conservation strategies. However, data on the fish fauna of the Western Ghats have limitations as most of the rivers have not been surveyed extensively and checklists for individual rivers are not available.

History of the Indian freshwater fishes is way back to Hamilton (1822) on the fishes found in the river Ganges and its tributaries. The documentation and listing of the fishes from different part of India was carried out mainly by Jerdon (1848). A comprehensive and authoritative account on the freshwater fishes has been provided by Day (1865 – 1878). The further investigations on the freshwater fishes of India especially the Western Ghats was initiated by Hora (1921; 1937; 1938; 1941; 1942; 1949) and he enunciated the Satpura Hypothesis. Silas (1951) listed 25 fish species from Anamalai hills and 10 species from Neliampathi hills. His study extended the distribution of several species earlier known only from the central division of the Western Ghats to the southern division beyond the Palghat gap. These led to the new descriptions, enlisting with elaborate discussions on the endemism and other zoogeographical relevance and several new taxa have been added from Kerala during this period. Studies on the endemic fishes from various streams and rivers in the Western Ghats mountain ranges have been compiled. Fish diversity in selected streams in northern Karnataka (Arunachalam *et al*,. 1997); Central Western Ghats (Arunachalam 2000) have been reported. Manimekalan (1998) has described a new species *Glyptothorax davissinghi Manimekalan* and *Das* (Pisces: *Sisoridae*), a new cat fish from Nilambur in the Nilgiri Biosphere, South India. Manimekalan (1997) made a new recorded of *Schismatorhynchus (Nukta) nukta* (Sykes) (Pisces: Cyprinidae) from Moyar river. Arunachalam *et al.,* (2005) reported a new fish species *Neolissocheilus wynaadensis* from the Karnataka part of Western Ghats. Arunachalam (2007) have reported *Psilorhynchus amplicephalus*, a new species from Balishwar river of Assam, India. Earlier Biju *et al.,* (1996) has recorded *Puntius filamentous* (Val.) and *Puntius melanampyx* (Day) in Orukomban and Thelikal during the survey from December 1996 to May 1997. Manimekalan (2002) has rediscovered the critically endangered air breathing cat fish *Clarias dayi* hora (Pisces: *Claridae)* from Mudumalai Wildlife Sanctuary. Recently Arunkumar *et al*., (2015) has recorded nearly 37 species from Cauvery river system. Considering the above facts the present work documents freshwater fish fauna of Southern Western Ghats, especially from Bhavani River System, Moyar River System, Chalakudy River System, Periyar River System, Cauvery River System and Nugu River System.

2. METHODOLOGY

2.1 Collection and Identification

Fishes were collected using cast net, dip net, gill net of different mesh size ranging from 8mm to 22mm and drag net from various streams and rivers of Southern Western Ghats. At most care was taken not to damage the species while collecting. A total of 5 specimens from each species were collected and fishes were photographed before it was preserved in formalin so that the fishes can be photographed with original colour. Further the specimens were preserved in 10 per cent formalin for smaller samples and for larger samples formalin has been injected into the abdominal cavity so that the internal organs are well preserved for further taxonomic studies. The specimens were tagged and the reference numbers were given for specimen identification and transported to Lab. The species were identified based on the key given by Talwar and Jhingran (1991), Menon (1992) and Jayaram (1999, 2010). Holotype and paratypes of species were examined in Zoological Survey of India, Southern Regional station, Chennai and Kolkata for confirmation of species. Voucher specimens have been

made for each species and deposited at the Biodiversity and DNA Barcoding Lab, Dept. of Environmental Sciences, Bharathiar University.

2.2 Physico-chemical Analysis of the Water Quality at Sampling Sites

Water samples were collected from all the sampling stations during post-monsoon (February to June), depth of 10cm. Water quality analyses such as pH, conductivity, turbidity, total dissolved solids (TDS), resistivity, salinity, dissolved oxygen (DO), and water temperature were done as per the regulations of APHA 1995, respectively. Field analysis of the samples was done using portable water analyzer (X tech, Nagman Instruments Electronics, India) (Gurumurthy and Tripti, 2015; Thomas *et al.*, 2015; Anushiya and Ramachandran, 2015).

2.3 Analysis

To quantify species diversity, a number of indices have been followed. To measure the species diversity (H) the most widely used Shannon index (Shannon and Weaver, 1949), Evenness index (E) (Pielou, 1975), and Dominance index (D) (Simpson, 1949) were used. Similarity coefficients of the fish community were calculated by using Jaccard index (Southwood, 1978). The species abundance and their relative frequencies were subjected to cluster analysis, a complete linkage cluster dendrogram was drawn based on Pearson correlation. The contribution of the variables and its influence for the species diversity has been analyzed using Principal Component Analysis (Wills, 2005). The above statistical analyses were performed using SPSS (version 21), XLSTAT, and Biodiversity Pro software's.

3. RESULTS AND DISCUSSION

Fish Fauna were surveyed from the streams and rivers of Southern Western Ghats. Collection sites were selected based on the earlier faunal distribution published in literature. The Western Ghats is a mountain range that runs almost parallel to the western coast of Indian peninsula. The study sites and its characteristics are recorded and presented in Table 1 and Fig 1, 1a. In the present work a total of 31 sites of six river systems of Southern Western Ghats were studied of which a total of 64 species belonging to 6 orders, 14 families and 31 genera were recorded (Table. 2). Among them the order Cypriniformes was dominant with 3 families' 18 genera and 49 species (76.6%) compared to other orders. (Fig.2, Fig.7).

3.1 Fish Species Density, Abundance, and Distribution

Among the 31 sites high species diversity was recorded at Sinnaru of Cauvery River system (H'- 1.268) and low diversity was recorded at Thunakadavu tunnel of Chalakudy River System recorded (H'- 0.357) (Table: 3, Fig: 3). The maximum species diversity was recorded in Sinnaru of Cauvery River system (S – 21) and the minimum was recorded at Puliyarkutti 3rd bridge and Thunakadavu tunnel of Chalakudy River System and Sorrakottaodai of Periyar river system (S – 3), (Table: 3, Fig: 4). The maximum species abundance 152 was recorded at Naduthottam of Periyar river system and lowest 16 was recorded at Sorrakottaodai of Periyar river system and Belikoondu of Cauvery river system (Table: 3, Fig: 5). The maximum dominance index (D - 21.346) was recorded at Sinnaru of Cauvery river system and lowest (D- 2.121) was recorded at Thunakadavu tunnel of Chalakudy river system (Table: 3).

3.2 Species composition

Species similarity between the sites was very low among 31 sites of six river systems. Cluster analysis exhibited similar species composition between the sites (Table: 4, Fig: 6). Totally 5 clusters were grouped which clearly demonstrate the similarity of species composition among the sites. The cluster group separation is based on the following reasons – 1. Due to the rare species forms, 2. Due to low water temperature and 3. Prevalent human disturbances.

3.3 Water Quality:

Water Quality parameters were recorded and presented in table 2.6. It is found that the parameters value lies in the IS: 10500 Permissible limits. (Table: 6) (BIS 2012). The selected sites of Western Ghats has water pH ranging from 6.5 to 8.5. A pH of 9 was recorded at Kadapilliyarthittu of Cauvery river system and 7.2 was recorded at various sites like Anjurily, Athirapalli, Urilikal. Minimum conductivity value 27.8mS was recorded in Chalakudy river system and maximum conductivity value 85.2mS recorded in Noolpuzha of Nugu river system. Total dissolved solids (TDS) are a measure of inorganic salts dissolved in water. This dissolved solid comes from both natural and human sources. Mitchell and Stapp (1992) have suggested that changes in TDS concentrations can be harmful. If TDS concentrations are too high or too low, the population of aquatic life can be limited. Thenkasithodu of Periyar river system witnessed a low value of TDS content as 13.7 mg/l and Urilikal of Chalakudy river system recorded a high value of TDS as 51.9mg/l. A minimum Resistivity value of 2.58 was measured at Kadapilliyarthittu of Cauvery river sysyem and a maximum 45.6 was measured at Thenkasithodu of Periyar river system. A high level of DO of 6.11mg/l was recorded at Thenkasithodu of Periyar river system and low DO of 0.63 mg/l was recorded at Belikoondu of Cauvery river system. Arunkumar *et* al., (2015) recommended that the lowest DO recorded at sampling sites is due to organic-rich domestic waste let into the river by the tourists in the river system. Maximum water temperature (33.6°C) was recorded at Pillapara of Chalakudy river system and minimum water temperature (18.9°C) was noted at Thenkasithodu Periyar river system.

3.4 Habitat Structure

Stream habitat was measured in dimensions like length, width, depth, substratum and current. Large proportions (> 50%) of the habitat sampled included very shallow water (< 1 centimeter). Typically, such areas are not habitable by fishes and most fish concentrate in dispersed pools indicating that habitat measures in up-stream areas should be restricted to the pools themselves (Gorman, 1978).

3.5 Substratum Types

For the present study, the fish species diversity, habitat quality assessments of the river systems have been taken as the major criteria. The results exhibit that the study area is well flourished with flora and fauna. It proves that habitat provides the perfect level of food, shelter suitable for the fishes and other aquatic organisms. The habitat assessment of the study area says that there are four habitat types (pool, riffle, run and glide) with six substratum type (Fine sand, debris, Silt, Bedrocks, Gravel, Rubbles and boulders). The shore line is also sandy border rigid with rocks which makes up a good habitat for the aquatic organisms. Moreover the water quality, substratum type and vegetation provide a good and healthy habitat and high food resource availability

which plays a major key role for species diversity. The river habitat is utilized by the tribal people for catching the fishes for their source of protein food. In the present study, in regard to the substratum types like Rubble and Boulders were the dominant with 80% in Mullaithodu of Periyar river system. Anjurily of Periyar river system gravel was the dominant substratum representing 70%. Moreover substratum types like sand and silt are equally represented in all the study sites. Debris is the biological matter that occupies the stream habitat as a major part in providing good shelter and feeding habitat for the fishes. Mostly the bottom feeders like *Garra, Nemachelius, Travanchoria* use these debris and bed rock substratum as their habitat in a total stream channel with all other substratum types. Nadathittu of Cauvery River, Naduthotam of Periyar River, Kovaikutralam of Bhavani River and Thunakadavu of Chalakudy river system have their base substratum as natural bedrock, which provides them a strong rigid bottom.

Stream width and volume were high at Belikoondu of Cauvery river system (80 m, 80000 m^3) followed by Nadathittu (70m, 42000m^3), Kadapilliyarthittu (75m, 11250m^3), Kallampalayam (13m, 10400m^3), Noolpuzha (25m, 10250m^3). The lowest stream width and volume were recorded at Thellikal (4m, 400m^3). Among the 31 sites very fast flowing water was noted at Nellithurai, Thunakadavu tunnel and Belikoondu. Fast flow and Moderate flow water was noted in most of all the river systems. Slow flow of water in the channels was recorded at Thenkasithodu, Kadapilliyarthittu, Oorpannikaham and Urilikal.

3.6 Ecological Structures Influence Characterizations

Principal component analysis was used to illustrate the influence of the variables and its importance for the ecological structure of the river system and the fish species. The various habitat characteristics like water quality, channel morphology, and the substratum type influencing the species distribution. Factors like Altitude (6.940), Area (21.449) and Volume (58.428) influence the species diversity (Table.7). All other characters play a supportive role to express the variations among the study sites. Based on the contributions study sites like Belikoondu, Kallampalayam, Sorrakottaodai, Anjurily, Thenkasithodu, Belemeenthurai, Kovaikutralam, Naduthotam, Nadathittu, Kadapilliyarthittu and Sinnaru exhibits more variations. The results obtained concludes that altitude plays a major role in species diversity and species abundance, which supports the proposed the theory that diversity changes with altitude on mountain sides, being lowest at higher elevations (Colinvaux, 1930). The present finding supported the above theory as the results expressed that species diversity and abundance is low at high altitudes. Among the 31 sites, high species diversity was recorded at Sinnaru of Cauvery River system (H'- 1.268) because of the altitude, area of the channel and the volume of flow as well. The maximum species diversity was recorded at Sinnaru of Cauvery River system (S – 21), due to the channel flow, altitude and the submerged substratum types with muddy water flow. The maximum species abundance 152 was recorded at Naduthotam of Periyar River system due to the low area of the channel and the maximum percentage of the rocky boulder substratum. The maximum dominance of species (D – 21.34) was recorded at Sinnaru of Cauvery River system influenced by the vast channel area. Rest of the sites was low due to the less percentage of influence made by the habitat structures.

Rajan (1955) has studied the fishes of Moyar river system and has reported 48 species. Manimekalan (1998) has reported 38 species form Mudumalai wildlife sanctuary. Manimekalan has stated that species like *Labeo dero, Puntius mudumaliensis, Schimatorhynchus nukta, Devario neilgherriensis, Crossochelius latius latius, Clarias dayi, Gambusia affinis* were restricted to Moyar river system. Also *Clarias dayi* a critically

endangered species has been recorded by Manimekalan (2002). *Puntius carnaticus* and *Danio aequpinnatus* was recorded as common species of Moyar river system. Rajan (1955) and Mukerjii (1931) has studied the headwaters of Bhavani river and reported species like *Travancoria elangata, Barilius canarensis, Rasbora caveri, Garra menoni, Silurus wynaadensis* were restricted to the river system. *Puntius filamentosus, Puntius melanampyx, Puntius carnaticus, Barilius gatensis, Danio aequpinnatus, Rasbora daniconius* were very common in Bhavani River System. Arunkumkar *et al*., (2015) has recorded nearly 37 species from Cauvery river system. Among several fish species, the only *Garra gotyla stenorhynchus* is reordered as one of the endangered species in Grand Anicut Cauvery, which is locally consumed (Murthy *et al*., 2015). But *Garra gotyla stenorhynchus* is still under least concern status of IUCN.

Silas (1951) in his faunal account discusses the extension of range of *Salmostoma acinaces* (*Chela argentea* Day), *Barbodes carnaticus* (*Barbus* (*Puntius*) *carnaticus*), *Osteochilus* (*Osteochilichthys*) *thomassi* and *Batasio travancoria* and lists 2 endemic species described by Herre viz. *Homoloptera Montana* and *Glyptothorax housei.* Silas further reported 5 species from the Cochin part of the anamalai hills viz. *Barilius bakeri, Puntius denisoni, Travancoria jonesi, Noemacheilus triangularis* and *Batasio travancoria. Punitus bimaculatus* earlier considered as a juvenile of *Puntius dorsalis* has been collected from Anamalai hills. Interestingly this species is found to be the most dominant *Puntius* species in the hill ranges of the Eastern Ghats especially Javadi hills. *Puntius punctatus* earlier considered as a synonym of *Punitus ticto* has been kept as a separate species and both these species have been collected from Anamalai hills (Menon, 1999).

The Periyar River originates near moolavaigae and reaches the Mullai Periyar Reservoir located in the premises of Periyar Tiger Reserve which is one of the biodiversity rich zone in Southern Western Ghats (Silas 1950, 1952; Kurup *et al.*, 2004). Earliest studies on the fish fauna of the PTR dates back to 1948 when Chacko (1948) listed 35 species from the Periyar Lake, including the critically endangered small scaled *Schizothoracin Lepidopygopsis typus*. Later Menon and Remadevi (1995) described Hypselobarbus *kurali* from streams adjoining the Periyar river raising the total number of fish species to 38. In the present study 64 species were collected from 31 study sites of six river systems of southern Western Ghats. Species like *Puntius melanampyx, Puntius carnaticus, Puntius amphibious, Puntius fasciatus, Puntius mahecola, Devario aequipinnatus, Garra mullya, Travancoria jonesi, Nemacheilus guntheri* were commonly found in all the six river systems (Fig:7).

Smith (1990) has stated that habitat selection of the fishes is influenced by the body structure, food and shelter and by physiological process. Moreover the fish analyses the characters of the rivers and streams and further they respond to the characters and helps themselves for the survival of the fittest. Hence it is reliable that the Micro and Macro habitat plays a key role in the morphology and physiological characters and modifications of the species. The fish prefers the habitat based on the nature of the rivers or stream substratum type where the muddy bottom with debris is records for high species richness of the bottom feeders. Odum (1945) well stated that the flow of the water in the channel is an important factor controlling the distribution of fishes, the species like *Barilius, Hypselobarbus, Puntius, Travancoria, Rasbora* and *Tor* prefers fast flow. The nature of the substratum and the flow rate seem to be more or less closely interrelated in governing the distribution of the fishes. This induces the dominance of the cyprinid species to be well flourished in all the river systems, of the Southern Western Ghats. It is clear that ecological structure plays a key role in representing River Systems of Southern Western Ghats which is flourished with rich species diversity and abundance.

Conservation of India's vast and diverse aquatic genetic resources is essential to maintain ecological as well as socio-economic equilibrium. Fisheries and aquaculture have a promising role to play in social development by providing nutritional security for the Indian population and contributing to the economic advancement of farmers and fishery workers. The concept of fish conservation is not new to India. The fishing was prohibited during the third Chatturmass (July- October) to protect the pre-spawning brood stock and young ones. King Ashoka's prohibition period extends up to the middle of November. Renowned fisheries taxonomist Francis Day drew the attention of the Government of India to large scale slaughter of fish fry and fingerlings and pleaded urgent conservation measures. After persistent pressure, the Indian Fisheries Act was enacted in 1897. The destructive fishing methods, creation of 'fixed engines' (dams, weirs etc.) for catching fish and use of small sized nets were banned by the law. The main threats impacting freshwater biodiversity in the Western Ghats include pollution (urban and domestic pollution ranking as the worst threats followed by agricultural and industrial sources of pollution), residential and commercial development, dams and other natural system modifications, invasive species, agriculture and aquaculture, energy production and mining (IUCN). The anthropogenic perturbations to fresh water systems over the past years have escalated to enormous proportions and it is estimated that about 3000 species will become extinct within the next 20 to 30 years (Das, 1994; Prasad, 2010).

The threat to the endangered fish species from our aquatic ecosystem can be minimized by employing both preventive and protective measures. The preventive measures may include removal of causative factors and provision of suitable legislation. The protective measures would include identification of suitable areas to declare as sanctuaries and develop new technologies for the protection of the genetic resources of threatened and vulnerable fish species. Keeping this in view, the present investigation highlights some of the main causative factors of decline *Tor* species and some remedial measures for preserving the fish population. Degradation of aquatic systems, indiscriminate fishing of brood fish and juveniles, anthropogenic intervention, use of explosives, poisons and intrusion of exotic species are the major possible factors noticed in the present study which causes the depletion of fish population in the study area. Several authors have observed that fish population has recorded a sharp decline in Indian rivers due to the indiscriminate fishing of brood stock and juveniles, fast degradation of aquatic ecosystems and construction of dams, barrages, weirs, etc. Many factors have been noticed during the present study which affects the fish population adversely. Indiscriminate fishing of brood fish and juveniles, use of explosives, poisons and electrocution are some of the major possible factors the causes of depletion of fish in Indian waters.

The tribal fishermen have more preference towards fish species because of its large size and medicinal properties. The use of different types of plant products for fishing was observed among the tribes, which will kill all the fishes including young ones. *Croton tiglium* L., *Gnidia glauca* (Fresen) Glig., *Acasia instia, Acasia torta, Hynocarpus pantandra* are some plants which can be used as fish poison for catching fishes. The parts of the plant (leaves, stem, bark, fruits and seeds) and the whole plants are used as fish poison. This method can be applicable only in stagnant water which leads to mass poisoning (Ambili, 2013). Dynamiting is a common practice seen among the tribals and its frequent used in stagnant rock pools and deep water body. In this method all the fishes available, from juveniles to adults, in the spot will be affected. Dynamiting is practiced by the tourists who visit the places illegally. Use of explosives, poisoning, electrocutation and use of small sized nets etc. are some other fishing methods which affects the population adversely (Ambili, 2013).

Use of Copper Sulphate is a destructive method of fishing leads to mass poisoning of fish population. Irulas, Kurumbas and Mudugar are the tribal settlement in the Attapadi region on the banks of Bhavani river. They use the cast nets, gill nets and bamboo traps (Kooda) for fishing. Indiscriminate fishing in the Bharathapuzha made a large decline of *Tor* population. Sarkar and Srivastava (2000) noticed that because of increased anthropogenic activities, the two main species namely *Tor*. *putitora* and *Tor*. *tor* are listed under the category of endangered species and facing the high risk of extinction in the wild. Due to the proximity of human settlement, aquatic ecosystems are relatively more exposed to human influences and interventions. Besides, the industrial and urban development has altered the aquatic environment. Overfishing at various stages of life-cycle have observed more in human settlement area and this causes the spectacular changes in the environment affecting the fishery resources. Polluting the water body is also one main factor which causes the declining of the ichthyofaunal diversity (Ambili, 2013).

The pristine riverine systems along the Western Ghats have been tampered with anthropogenic activities such as dam constructions and road building which have affected the ecology and habitat of these fishes. The tourist resorts started down to Athirappally on the bank of Chalakudy river are altering the habitat by many ways. Sholayar Hydro Electric Project and Peringalkuttu Hydro Electric Project are the Hydro electric projects on the Chalakudy river. There are about 7 dams built on the river. Peringalkuthu Dam of this river prevents the local migration of *Tor* from the lower to upper stretches of the river. There are 11 reservoirs in Bharathapuzha river and Malampuzha dam is the largest one. Neyyar dam is located in the Neyyar river and the Idukki dam is located in Periyar river. The construction of dams also resulted in less water flow and affects the migration of fishes. Food availability is an important factor for the existence of fish species. MacDonald (1948) noted that Mahseer is an intermittent feeder. The vegetative matter, benthic diatoms, molluscan shells, crabs, insects, small fishes, different types of seeds and fruits have been recorded from the stomach contents of *Tor* (Dinesh *et al.*, 2010). The availability of these items varies considerably during different seasons which cause the mortality of young ones. The disruptions in the food chain also affect the species adversely. The deforestation rate all along the Western Ghats is so high and the forest areas are being transformed into agriculture practices. This type of practices was seen on the bank of most of the rivers in Kerala like Chaliyar, Sholayar, Chalakudy, Kabini, Bhavani, Periyar and Kallada river systems. Cultivation of Musa, Paddy, Cardomom, Ginger and Tea plantations are observed to be the major ones. The pesticides used in these areas are penetrating to the river system and severely affect the aquatic organism like insects, diatoms, vegetation such as phytoplanktons and even the small fishes (Ambili, 2013).

Fish population is declining rapidly hence the following immediate conservation measures will help to conserve this precious species. Awareness among the tribes is more important for conservation of fish species. Awareness can be made about the impact of using chemicals for mass poisoning, dynamiting for catching fish, avoid fishing during breeding seasons and the use of poisonous plant products for mass poisoning. Student, social workers, fishermen and local people should be educated about the importance of conservation of fish fauna in their area so that they can make awareness among the nearby people. More exclusive projects should be started with the co-operation of local people and students for protecting the fish population. Action can be taken to change the fishing profession of those who only depend on fishing for their livihood which will help to reduce the fishing pressure.

In order to conserve the fish genetic resources and provide adequate living space, shelter and habitat for valuable threatened fishes, certain areas can be declared as fish sanctuary like National Parks and Wildlife sanctuaries. Menon *et al.,* (2000) suggested that suitable segments of the rivers with fish species should be identified for establishment of 'fish sanctuaries' and such sanctuaries must be heavily stocked every year with fish fingerlings. There are two fish sanctuaries protecting the *Tor* species as a part of their religious customs, they are Aruvikara (Neyyar river) and Kulathupuzha (Kallada) in Kerala. The upstream part of Chalakudy river, Karimpuzha and Manjeeri region of Chaliyar river, a part of Bhavani up to Thavalam (Attappadi region) and selected stretches of Periyar river can be declared as fish sanctuaries. Ambili et al., (2014) has reported the presence of three species *Tor khudree, Tor malabaricus and Tor mussullah*- in the River Chaliyar. Long stretches of Cauvery river is a fish sanctuary where the Karnataka Forest Deparment (Wildlife) has leased out 14 miles of the river Cauvery to Wildlife Association of South India (WASI), which is now protecting the wildlife including fishes with more care.

Captive breeding is widely used throughout the world for a variety of endangered animals including fish (Maitland and Evans, 1994; Keshavanath *et al.,* 2006). It could be an important 'last resort' measures for endangered and endemic species, which may otherwise become extinct in the wild (Reid, 1990). Fishery Departments should take steps for breeding and caring of the endangered *Tor* species. In Kerala near Pookkode Lake and Sholayar dam, procedures for culturing the *Tor* species were attempted in hatcheries, but they could not succeed. Collection of matured brooders from interior of the forest and maintenance of water temperature are the two major problems came across. Now studies are going on to compensate the reasons for failures in *Tor* breeding. Gene banks can hold live animals or cryopreserved gametes. Gene banks can be considered as a last line of defence against species extinction. A live gene bank contributes to delisting of threatened species by captive breeding and restocking in species-specific recovery programmes. Such gene banks can contribute to recovery and utilization of genetic diversity and can be used in conservation programmes (e.g., NBFGR, India and the World Fisheries Trust, Canada) and genetic enhancement (e.g., salmon in Norway and common carp in Hungary) (Lakra *et al.*, 2007). A mini gene bank with the milt of *T. putitora* and *T. khudree* has been established by NBFGR (Ponniah *et al*., 1999a; 1999b). In India *Tor* spermatozoa cryopreservation protocols have been developed by several workers (Basavaraja and Hedge, 2004, 2005; Patil and Lakra, 2005). Fish sperm cryopreservation requires the development of species-specific protocols (Lakra *et al.*, 2006). Cryopreservation of germplasm is a very good *ex situ* strategy to conserve existing allelic diversity for future use. This technique may help to provide gametes for artificial propagation programmes in the off seasons also. Universities and Research institutes should be taken care of the cryopreservation and captive breeding of *Tor* species. Re-introduction is very essential, than the introduction, for the conservation native species. Introduction can never neutralise the problem of depletion of species. While, re-introduction (collection and protection of wild /native fishes and introduce them in to the rivers) can support a lot towards the conservation of native species. Introduction of *Tor* species in the rivers of Kerala from the other region or other river systems are making more confusions and taxonomic ambiguities and sometimes people wrongly quoting for supporting this evidence for Satpura Hypothesis (Kumar and Kurup, 2004).

Monitoring and documentation of fish stocks are significantly important to carry out regular reviews on the distribution and status of all fish species and will be possible by maintaining the registers (Koljonen and Nyberg, 1991). The documentation of genetic resources for aquaculture is also the part of the coverage of Fish

Base (Froese and Pauly, 2013). The comprehensive listing of fish species distribution and continuous monitoring of the fish species is the most critical need of protection.

4. SUMMARY AND CONCLUSION

The morphological-based fish taxonomy is more inconclusive methods that explains the micro and macro habitat which may create much impact on the phenotypical variations among the fishes. In the present study, the fishes were collected from various river systems of Southern Western Ghats like Bhavani, Moyar, Chalakudy, Periyar, Cauvery and Kabini by using different mesh size of gill nets, cast net and dip net. A total of 31 sites of six river systems of Southern Western Ghats were studied in which a total of 64 species belonging to 6 orders, 14 families and 31 genera were recorded. Cypriniformes was the most dominant order with 3 families 18 genus and 49 species (76.6%) compared to other orders. Interestingly, the sites like Thunakadavu stream, Gulithuraipatti, Athirappalli, Naduthotam, Nadathittu, Mullaithodu, Thonanthikla, Noolpuzha and Sinnaru revealed high species diversity. The results indicated that the species from Southern Western Ghats have an ambiguity taxonomy among the fish communities. The data analyses suggested that species like *P. melanampyx, P. carnaticus, P.amphibious, P. fasciatus, P. mahecola* were found to be the dominant species in the locations considered**.** Among the 31 sites, maximum diversity (H'- 1.268) was recorded at Sinnaru (altitude – 225) of Cauvery River system and minimum diversity (H'- 0.73) was recorded at Urilikal (altitude – 3238) of Chalakudy River system. The present finding supported the Colinvaux theory which expresses diversity changes with regards to elevations. The nature of ecosystem and the vegetative forest which prevails along the river systems of Southern Western Ghats are more suitable habitat for fishes. Many threats like use of explosives, poisoning and fishing of juveniles are reported against the existence of the fishes from the rivers of Southern Western Ghats. Hence, an urgent attention is needed to create awareness among local communities about the importance of the stream habitat and its fish diversity, for conserving these important resources for future generations.

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REFERENCES

Anushiya, J. and Ramachandran A.: Assessment of water availability in Chennai basin under present and future climate scenarios. Environ Manag River Bas Ecosys. pp 397-415, 2015.

APHA: Standard methods. 19th Edition. American Public Health Association Washington, D.C, 1995.

Arunachalam, M., Madhusoodanan, K., Nair, C., Vijverberg, J. and Kortmulder, K.: Food and habitat partitioning among fishes in stream pools of South Indian river. Inter J Ecol and Envi Sci. 23: 271 – 395, 1997.

Arunachalam, M., Muralidharan, M. and Sivakumar P.: *Psilorhynchus amplicephalus*, a new species from Balishwar river of Assam, India. Cur Sci. 92: 1352 – 1354, 2007.

Arunachalam, M., Sankaranaraysnan, A., Johnson, J.A., and Manimekalan, A.: Fishes of Nambiyar river, Kalakkad Mundanthurai Tiger Reserve, Tamil Nadu. J Bom Nat His Soc. 97(1): 153 – 155, 2000.

Arunachalam, M., Sivakumar, P. and Muralitharan, M.: Habitat evaluation of pristine headwater streams of Western Ghats mountain ranges, Peninsular India. New trends in Fishery Development in India. Punjab University, India, pp. 253 – 286, 2005.

Arunkumar, A A, Manimekalan, A, Manikandan, V and Velmurugan, P.: Fish species richness and habitat quality mapping with geographical information system across Cauvery River in Tamil Nadu, India. J Aridlan Agri, 1: 43-54, 2015.

Armantrout, N.B. 1990. Aquatic habitat inventory. Bureau of Land Management, Eugene District, U.S.A. pp. 32.

Ambili, TR.: Morphological and Molecular Characterization of Genus *Tor* from Southern Western Ghats, INDIA, Doctoral Thesis submitted to Dept. of Environmental Sciences, Bharathiar University, Coimbatore, September, 2013.

Ambili, TR, Manimekalan, A, Verma, MS.: Genetic diversity of genus tor in river chaliyar, Southern Western Ghats, Kerala: through DNA barcoding. J Sci, 4(4) : 206 – 214, 2014.

Biju, C.R., Raju Thomas. K. and Ajithkumar C.R.: Fishes of Parambikulam wildlife sanctuary Palakkad District, Kerala, 1996.

BIS: Indian Standard Drinking Water – Specification. Second Edition. Bureau of Indian Standards, New Delhi, 2012.

Chacko, P.I.: A survey of the fisheries of the Tungabhandra river. Proc. Indian Acad Sci. 28:166-175, 1948

Colinvaux, P.A.: Ecology congress cataloging in publication data, 1930.

Dahanukar, N., Raut, R. and Bhat, A.: Distribution, endemism and threat status of freshwater fishes in the Western Ghats of India. J Biogeo, 31 (1): 123-136, 2004.

Das, P.: Conservation and Management of cold water fish genetic resources. In: Coldwater, *Aquaculture and Fisheries* (Eds.) Singh, H.R. and Lakra, W.S. Narendra Publishing House, Delhi. pp. 337-339. 1994.

Day, F.: On the fishes of Cochin, on the Malabar Coast of India. Part II. Anacanthini. Proc Zool Soc Lon. 1: 286 – 318, 1865.

Day, F.: Monograph of Indian Cyprinidae. Parts 1-3. J Proc Asi Soc Ben. 40(1871): 95 – 143, 1871.

Day, F.: The fishes of India; being a natural history of fishes known to inhabit the seas and fresh waters of India, Burma and Ceylon. 4th ed. New Delhi, pp. 778,1878.

Gurumurthy G.P. and Tripti M.: Geochemical perspectives on river water of the tropical basins, Southwestern India. Environ Manag River Bas Ecosys. Heidelberg: Springer International Publishing. p. 329-53, 2015.

Hamilton - Buchanan, F.: An Account of the Fishes of River Ganges and its Branches. George Ramsay and Co., London. pp. vii and 405, 1822.

Hora, S.L.: Notes on fishes in the Indian Museum on a new species of Nemacheilus from the Nilgiri Hills. Rec Ind Mus. 22: 19 – 21, 1921.

Hora, S.L.: Notes on fishes in the Indian Museum, on three collections of fish from Mysore and Coorg, South India. Rec Ind Mus. 39: 5 – 28, 1937.

Hora, S.L.: Homalopterid fishes from Peninsular India. Rec Ind Mus. XLIII: 211 – 232, 1941.

Hora, S.L. and Misra, K.S.: Fish of Deolali, Part: III. Journal of Bombay Natural History Society. 40: 20 – 38, 1938.

Hora, S.L.: Satpura hypothesis of the distribution of Malayan fauna and flora and flora of peninsular India. Proc Nat Inst Sci Ind. 15: 309 – 314, 1949.

Jayaram, K.C.: The Freshwater Fishes of the Indian Region. Nerendra Publishing House, New Delhi. pp. xxvii and 551, 1999.

Jayaram, K.C.: The Freshwater Fishes of Indian Region, 2nd edition. Narendra Publications, New Delhi. pp. 119, 2010.

Jerdon, T.C.: On the freshwater fishes of southern India. Mad J Lit Sci. 15 (1848): 141 – 149, 1848.

Kurup, B.M., Radhakrishnan K.V. and Manojkumar T.G.: Biodiversity status of fishes inhabiting rivers of Kerala (S. India) with special reference to endemism, threats and conservation measures. Proceedings of the Second Large Rivers Symposium, Phnom Penh, Kingdom of Cambodia. pp. 163 – 182, 2004.

Manimekalan, A. and Singh.D.F.: New record of *Schismatorhynchus (Nukta) nukta* (Sykes) (Pisces: Cyprinidae) from Moyar river, extends its range to Tamil Nadu. J Bom Nat His Soc. 94(1): 170 – 171, 1997.

Manimekalan, A.: Fishes of Mudumalai Wildlife Sanctuary, South India. J Bom Nat His Soc., 95(3): 431 – 443, 1998.

Manimekalan, A. and Das, H.S.: *Glyptothorax davissinghi* (Pisces: Sisoridae) A new cat fishes from Nilambur in the Nilgiri Biosphere, South India. J Bom Nat His Soc. 95(1): 87 – 91, 1998.

Manimekalan, A. and M. Arunachalam.: Rediscovery of critically endangered air birthing cat fish *Clarias dayi hora* (Pisces:Claridae) from Mudumalai Wildlife Sanctuary, Tamil Nadu. J Bom Nat His Soc. 99(1): 129-131, 2002.

Menon, A.G.K., and Rema Devi, K.: *Puntius sharmai*, a new cyprinid fish from Madras. J Bom Nat His Soc. 89: 353 – 354, 1992.

Menon, A.G.K. and Rema devi, K.: *Hypselobarbus kuali* (pisces: Cyprinidae) a new large barb from the south western rives of peninsular India. J Bom Nat His Soc. 92: 489 – 393, 1995.

Menon, A.G.K.: Check list - Fresh water fishes of India. Rec Zool Sur Ind, Occasional Paper. 175: 1 – 366, 1999.

Mukerji, D.D.: On a small collection of fish from the Bhavani river (S.India). J Bom Nat His Soc. 35(1): 162 – 171, 1931.

Murthy KR, Dhanakumar S, Sundararaj P, Mohanraj R and Kumaraswamy K.: GIS-based modified SINTACS model for assessing groundwater vulnerability to pollution in Vellore District (Part of Palar River Basin), Tamil Nadu, India. Environ Manag R Bas Ecosys, 429-53, 2015.

Odum, H.T.: Primary production in flowing water. Limno Ocea, 1: 102 – 117, 1945.

Pielou, EC.: Ecological Diversity. New York: Wiley, 1975.

Prasad, G.: Status and impacts of exotic fresh water fishes in Kerala. (In: *conservation of Fishes in Kerala, India*. (eds. Sonnenschein, L. and Benziger, A.) World Aquarium and conservation for the ocean foundation, USA. pp. 294, 2010.

Rajan, S.: Notes on collection of fish from the headwaters of the Bhavani river, South India. J Bom Nat His Soc. 53: 44 – 48, 1955.

Shannon, C.E. and Weaver. W.: The mathematical theory of communications. Urbaba, University of IIinois Press, 1949.

Silas, E.G.: On a collection of fish from Travancore. J Bom Nat His Soc. 48: 792 – 795, 1950.

Silas, E.G.: On a collection of fish from the Annamalai and Nelliampathi hill ranges, Western Ghats, with a note on its zoogeographical significance. J Bom Nat His Soc. XLIX: 470 – 481, 1951.

Silas, E.G.: Fishes from the high ranges of Travancore. J Bom Nat His Soc. 50: 323 – 330, 1952.

Simpson, G.G.: Measurement of diversity, Nature. 136. pp. 688, 1949.

Southwood T R.: Ecological Methods. London: Chapmam and Hall, 1978.

Talwar, P.K. and Jhingran, A.G.: Inland fishes of India and adjacent countries. Vol. I, Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi, pp. 541, 1991.

Thomas J, Joseph S, Thrivikramji K. P.: Hydrogeochemical drivers and processes controlling solute chemistry of two Mountain River basins of contrasting climates in the Southern Western Ghats, India. Environ Manage River Bas Ecosys. pp 355-396, 2015.

Table 1: Study site and its Habitat characteristics

Site Number	Study site	Latitude	Longitude	Altitude	Forest type in Tropical Region	Stream order	Stream Width (m)	Stream Depth (m)	Area (m^2)	Volume (m^3)	Mean velocity* (m/sec)
Moyar River System											
1	Gulithuraipatti	11°33'20.4984"N	76° 59' 16.1016" E	312	Thorn forest	4	10	6	1000	6000	4
2	Kallampalayam	11° 31' 25.3992" N	77° 0' 16.4016" E	300	Thorn forest	4	13	8	1300	10400	4
3	Belemeenthurai	11° 36' 39.9996" N	76° 47' 38.0004" E	520	Dry deciduous	4	19	1.75	1900	3325	4
Chalakudy River System											
4	Orukomban range	10° 22' 53.6016" N	76° 39' 21.3984" E	450	Dry deciduous	4	6	0.5	600	300	3
5	Thenmudiparai	10° 24' 51.9984" N	76° 36' 10.5012" E	510	Dry deciduous	5	25	1.5	2500	3750	3
6	Baghapallam	10° 24' 57.6" N	76° 43' 21.3996" E	748	Dry deciduous	5	8	0.5	800	400	3
7	Thellikal	10° 27' 34.2" N	76° 43' 48.7992" E	840	Dry deciduous	4	4	1.0	400	400	3
8	Puliyarkutti 8^{th} bridge	10° 23' 39.6996" N	76° 40' 8.1984" E	527	Dry deciduous	4	19.2	1.2	1920	2304	3
9	Puliyarkutti 3^{rd} bridge	10° 23' 52.5984" N	76° 40' 51.3012" E	512	Dry deciduous	4	37	1.5	3700	5550	3
10	Thunakadavu stream	10° 25' 44.1012" N	76° 46' 4.6992" E	510	Dry deciduous	4	13.6	0.5	1360	680	3
11	Thunakadavu tunnel	10° 20' 9.3012" N	76° 34' 40.6992" E	520	Dry deciduous	5	15	10	1500	15000	5
12	Urilikal	10° 19' 54.1992" N	76° 53' 57.3" E	3238	Dry deciduous	2	7	1.5	700	1050	2

13	Athirappalli	10° 18' 15.3598" N	76° 34' 0.0012" E	202	Semi evergreen	4	8	3	800	2400	4
14	Pillapara	10° 17' 23.82" N	76° 32' 21.84" E	267	Semi evergreen	4	5	2	500	1000	4
Bhavani River System											
15	Kovaikutralam falls	10° 56' 20.1516" N	76° 41' 21.0084" E	560	Semi evergreen	2	5	1.2	500	600	4
16	Nellithurai	11° 17' 0.3012" N	76° 53' 6.9" E	380	Thorn forest	4	27	1.1	2700	2970	5
Periyar River System											
17	Oorpannikaham	9° 28' 58.1016" N	77° 16' 47.7012" E	884	Evergreen	4	12	2.1	1200	2520	2
18	Valukuparai	9° 28' 49.4004" N	77° 17' 35.0988" E	869	Evergreen	4	7.5	0.3	750	225	3
19	Melaparai	9° 26' 24.7992" N	77° 18' 24.5988" E	965	Evergreen	4	11	4.2	1100	4620	3
20	Naduthotam	9° 26' 5.1" N	77° 18' 48.0996" E	950	Evergreen	4	7.5	0.3	750	225	3
21	Ummikuppamthodu	9° 28' 20.6004" N	77° 14' 57.0984" E	943	Evergreen	4	5	3.0	500	1500	4
22	Sorrakottaodai	9° 28' 45.4008" N	77° 15' 32.7996" E	879	Evergreen	4	7	1.5	700	1050	3
23	Mullaithodu	9° 31' 58.6992" N	77° 16' 15.8016" E	869	Evergreen	4	10	0.6	1000	600	3
24	Anjurily	9° 33' 46.1988" N	77° 9' 19.6992" E	912	Evergreen	4	20	5	2000	10000	2
25	Thenkasithodu	9° 30' 59.4" N	77° 7' 5.9988" E	872	Evergreen	4	11.3	0.5	1130	565	2
Cauvery River System											
26	Kadapilliyarthittu	12° 7' 18.1992" N	77° 46' 28.3008" E	1137	Dry deciduous	4	75	1.5	7500	11250	2

27	Belikoondu	12° 11' 2.1012" N	77° 43' 12.6012" E	267	Dry deciduous	4	80	10	8000	80000	5
28	Nadathittu	12° 8' 31.9992" N	77° 44' 48.9984" E	262	Dry deciduous	4	70	6	7000	42000	3
29	Sinnaru	12° 6' 54.7992" N	77° 46' 48.5004" E	225	Dry deciduous	4	55	0.5	5500	2750	3
30	Thonanthikla	12° 7' 2.3988" N	77° 46' 36.6996" E	341	Dry deciduous	4	25	1	2500	2500	4
Nugu River System											
31	Noolpuzha	11° 41' 35.0988" N	76° 23' 36.3984" E	2810	Semi evergreen	3	25	4.1	2500	10250	4

*Velocity (m/sec): 1. Very slow (<.05); 2. Slow (0.05-0.2); 3. Moderate (0.2-0.5); 4. Fast (0.5-1.0); 5.Very fast (>1).

Table 2: List of Freshwater Fauna recorded during the present study

S.no	Species	Distribution locations	IUCN
	Order: Cypriniformes		
	Family: Cyprinidae		
	Sub - Family: Cyprininae		
1	*Puntius melanampyx*	18	DD
2	*Puntius carnaticus*	10	LC
3	*Puntius amphibius*	4	DD
4	*Haludaria fasciatus*	11	LC
5	*Dawlinsia filamentosus*	4	LC
6	*Puntius sarana sarana*	4	LC
7	*Puntius dorsalis*	2	LC
8	*Puntius chola*	2	LC
9	*Puntius sophore*	1	LC
10	*Eechathalakenda ophicephalus*	2	EN
11	*Puntius mahecola*	7	DD
12	*Pethia conconius*	4	LC
13	*Sahyadria denisonii*	2	EN
14	*Sahyadria chalakudiensis*	2	EN
15	*Puntius sarana spirulus*	1	LC
16	*Puntius bimaculatus*	3	LC
17	*Pethia ticto*	1	LC
18	*Cirrhinus cirrhosus*	2	VU
19	*Skymatorynchus nukta*	3	EN
20	*Labeo boggut*	1	LC
21	*Labeo kontius*	1	LC
22	*Labeo ariza*	3	LC
23	*Labeo calbasu*	2	LC
24	*Labeo boga*	2	LC

25	*Hypsilobarbus curmuca*	4	EN
26	*Hypsilobarbus periyarensis*	3	EN
27	*Hypsilobarbus dubius*	6	EN
28	*Tor malabaricus*	5	EN
29	*Tor kudhree*	9	EN
30	*Osteochilus longidorsalis*	2	EN
	Sub - Family: Danioninae		
31	*Salmophasia acinaces*	1	LC
32	*Barilius gatensis*	16	LC
33	*Barilius bakeri*	10	LC
34	*Barilius barana*	2	LC
35	*Barilius bendelisis*	3	LC
36	*Devario aequipinnatus*	21	LC
37	*Rasbora daniconius*	13	LC
	Sub - Family: Oreininae		
38	*Lepiphygopsis typus*	2	EN
	Sub - Family: Garrinae		
39	*Garra mullya*	16	LC
40	*Garra surendranathi*	3	EN
41	*Garra nastuta*	1	LC
42	*Garra periyarensis*	2	VU
43	*Garra hughi*	3	EN
44	*Garra gotyola stenorynchus*	2	LC
45	*Crossochelius latius latius*	1	LC
	Family: Balitoridae		
	Sub - Family: Balitorinae		
46	*Travancoria jonesi*	8	EN
	Sub - Family: Nemacheilinae		
47	*Nemacheilus dennisoni*	2	LC
48	*Nemacheilus guntheri*	7	LC

	Family: Cobitidae		
	Sub - Family: Cobitinae		
49	*Lepidocephalus thermalis*	5	LC
	Order: Siluriformes		
	Family: Bagridae		
	Sub - Family: Bagrinae		
50	*Hemibagrus punctatus*	3	CR
51	*Mystus cavasius*	4	LC
	Family: Siluridae		
52	*Ompok bimaculatus*	1	NT
	Family: Sisoridae		
	Sub - Family: Glyptosterninae		
53	*Glyptothorax housei*	1	EN
	Order: Cyprinodontiformes		
	Family: Aplocheilidae		
	Sub - Family: Aplocheilinae		
54	*Aplocheilus lineatus*	3	LC
	Order: Synbranchiformes		
	Sub- order: Mastacembeloidei		
	Family: Mastacembelidae		
	Sub - Family: Mastacembelinae		
55	*Macroganthus pancalus*	1	LC
56	*Mastacembelus armatus*	1	LC
	Order: Perciformes		
	Sub- order: Percoidei		
	Family: Ambassidae		
57	*Chanda nama*	2	LC
	Family: Pristolepididae		
58	*Peristolepis marignata*	3	LC
	Sub- order: Labroidei		

	Family: Cichlidae		
59	*Oreochromis mosambica*	1	NT
60	*Etroplus suratensis*	3	LC
61	*Etroplus maculatus*	2	LC
	Sub- order: Gobioidei		
	Family: Gobiindae		
	Sub - Family: Gobiinae		
62	*Glossogobius guiris*	1	LC
	Order: Mugiliformes		
	Sub- order: Belonoidei		
	Family: Belonidae		
63	*Xenetodon cancilia*	3	LC
	Family: Hemiramphidae		
64	*Hyporhamphus limbatus*	2	LC

* EX – Extinct; EW – Extinct in the Wild; CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; LRlc – Low Risk least concern; LRcd – Low Risk conservation dependent; DD – Data Deficient.

Table 3: Indices of diversity of fishes respective to altitudes of six river systems

Sampling Locations	Altitude	Diversity (H')	Evenness (E)	Abundance	Richness (S)	Dominance (D)
Moyar River System						
Belemeenthurai	520	0.841	0.932	19	8	8.55
Gulithuraipatti	312	0.769	0.769	62	10	5.016
Kallampalayam	300	0.62	0.686	38	8	3.316
Chalakudy River System						
Urilikal	3238	0.734	0.869	131	7	4.598
Thellikal	840	0.805	0.843	32	9	5.701
Baghapallam	748	0.617	0.793	36	6	3.728
Puliyarkutti 8th bridge	527	0.879	0.921	39	9	7.8

Thunakadavu tunnel	520	0.357	0.748	42	3	2.121
Puliyarkutti 3rd bridge	512	0.401	0.841	17	3	2.429
Thunakadavu stream	510	0.864	0.864	68	10	6.026
Thenmudiparai	510	0.74	0.875	59	7	4.833
Orukomban range	450	0.711	0.842	49	7	4.576
Pillapara	267	0.718	0.923	25	6	5.769
Athirappalli	202	1.01	0.936	52	12	11.143
Bhavani River System						
Kovaikutralam falls	560	0.722	0.928	40	6	5
Nellithurai	380	0.757	0.896	29	7	5.639
Periyar River System						
Melaparai	965	0.798	0.944	19	7	7.773
Naduthotam	950	1.019	0.915	152	13	9.936
Ummikuppamthodu	943	0.527	0.678	41	6	2.384
Anjurily	912	0.537	0.768	19	5	3.054
Oorpannikaham	884	0.767	0.849	27	8	5.4
Sorrakottaodai	879	0.465	0.976	16	3	3.243
Thenkasithodu	872	0.638	0.668	100	9	3.327
Valukuparai	869	0.91	0.954	28	9	9.947
Mullaithodu	869	1.045	0.968	48	12	12.966
Cauvery River System						
Kadapilliyarthittu	1137	0.8	0.886	37	8	6.055
Thonanthikla	341	1.069	0.909	46	15	11.129
Belikoondu	267	0.625	0.804	16	6	3.75
Nadathittu	262	1.198	0.921	77	20	15.481
Sinnaru	225	1.268	0.959	75	21	21.346
Nugu River System						
Noolpuzha	2810	0.946	0.946	78	10	8.938

Table 4: Species composition among the 31 sites

Cluster no	Cluster between	Study sites
1	1 - 4	Thunakadavu stream, Baghapallam, Kallampalayam, Thunakadavu tunnel
2	5 -7	Thenmudiparai, Orukomban range, Gulithuraipatti
3	8 - 28	Melaparai, Valukuparai, Belemeenthurai, Anjurily, Oorpannikaham, Nellithurai, Belikoondu, Kadapilliyarthittu, Sorrakottaodai, Puliyarkutti 3rd bridge, Mullaithodu, Kovaikutralam falls, Puliyarkutti 8th bridge, Sinnaru, Nadathittu, Thonanthikla, Thellikal, Pillapara, Athirapalli, Noolpuzha, Ummikuppamthodu
4	29	Naduthotam
5	30	Thenkasithodu
6	31	Urilikal

Table 5: Distribution and abundance of fishes of six river systems

Species	Collection sites																														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**
Puntius melanampyx				4	6	12	7	10	5	11		32	5	2	5			2	2			5	4	5	2						10
Puntius carnaticus	1	1	5				1		2	6																4		9	5	2	
Puntius amphibius	1	2					1																						2		
Haludaria fasciatus								5	10	5		13			15		1	1		2		4	5								15
Dawlinsia filamentosus	1																											5	2	5	
Puntius sarana sarana	15	1														10													6		
Puntius dorsalis	1	1																													
Puntius chola	7	15																													
Puntius sophore												11																			
Eechathalakenda ophicephalus																				19	26										
Puntius mahecola											25		8	5		5										4	3	3			
Pethia conconius																										10	1	3	4		
Sahyadria denisonii													5	5																	
Sahyadria chalakudiensis													1	1																	
Puntius sarana spirulus																3															
Puntius bimaculatus												10													2						10
Pethia ticto		1																													

Cirrhinus cirrhosus																													6	2	
Skymatorynchus nukta																2													3		5
Labeo boggut																														1	
Labeo kontius																														2	
Labeo ariza																										1			1	2	
Labeo calbasu																											1	1			
Labeo boga			2													1															
Hypsilobarbus curmuca																	1						7	1							2
Hypsilobarbus periyarensis																		2		10			3								
Hypsilobarbus dubius			1																1	15							1	3	3		
Tor malabaricus																				17			2					2	4	3	
Tor kudhree					2		2										5	3	2	10								2	3	4	
Osteochilus longidorsalis																				5											4
Salmophasia acinaces																												4			
Barilius gatensis	4		4	18	11		3	5		5			5		4	3		2		20	4		5		20						10
Barilius bakeri				2	8			2					2		5	5	2			15					21						8
Barilius barana								2		5																					
Barilius bendelisis																										2		3	3		
Devario aequipinnatus	11	15	2	5	7	14	4	6		23	15	47	5	5	6				2	10	2				47			10	2	3	
Rasbora daniconius				7	3		1					14	4					4		2	5			10	1			2	7	5	
Lepiphygopsis typus																	10			25											
Garra mullya	20	2		12	22	4	11	3		7			8	7									2	2		2		3	4	11	

Garra surendranathi													6										6		3						
Garra nastuta																	3														
Garra periyarensis																		4					2								
Garra hughi																		5	5		2										
Garra gotyola stenorynchus																											2	4			
Crossochelius latius latius																	1														
Travancoria jonesi						1		5							5		4	5	4		2				2						
Nemacheilus dennisoni			1																3												
Nemacheilus guntheri						4	2	1		1													4		2						4
Lepidocephalus thermalis				1									2							2			3					7			
<u>Hemibagrus</u> punctatus			2																									1	3		
Mystus cavasius			2																										1	2	10
Ompok bimaculatus													1																		
Glyptothorax housei						1																									
Aplocheilus lineatus												4										7	5								
Macroganthus pancalus																													2		
Mastacembelus armatus																														1	
Chanda nama										3																			7		
Peristolepis										2	2													1							

marignata																															
Oreochromis mosambica	1																														
Etroplus suratensis																									10	8	1			
Etroplus maculatus																									4		10			
Glossogobius guiris																												5		
Xenetodon cancilia																											2	2	2	
Hyporhamphus limbatus																											2		1	

***Collection site number as in Table 1.**

Table 6: Water quality of 31 study sites of six river systems

Sampling Locations		pH	Conductivity (mS)	TDS (mg/L)	Resistivity (KΩ)	DO (mg/L)	Water temperature (°C)
Moyar River System							
Belemeenthurai	520	8.4	59.2	37.7	16.4	1.3	24.5
Gulithuraipatti	312	8.4	57.8	20.37	24.2	3.5	23.8
Kallampalayam	300	7.9	45.2	28.5	21.9	2.5	24.1
Chalakudy River System							
Urilikal	3238	7.2	78.7	51.9	12.9	1.4	24.1
Thellikal	840	8.8	59.2	37.7	16.4	1.3	24.5
Baghapallam	748	8	57.8	38.0	16.8	2.4	21.7
Puliyarkutti 8th bridge	527	7.79	27.8	18.0	34.8	5.4	23.5
Thunakadavu tunnel	520	5.9	38.3	28.3	22.2	5.09	21.4
Puliyarkutti 3rd bridge	512	7.79	27.8	18.0	34.8	5.4	23.5
Thunakadavu stream	510	5.9	38.3	28.3	22.2	5.09	21.4
Thenmudiparai	510	8	45.2	28.5	21.9	2.5	24.1
Orukomban range	450	7.5	33.9	26.5	22.4	3.5	23.4
Pillapara	267	7.6	34.0	19.5	29.9	0.89	33.6
Athirappalli	202	7.2	35.2	47.5	3.97	0.73	32.7
Bhavani River System							
Kovaikutralam falls	560	7.5	31.3	20.1	32.3	3.2	22.5
Nellithurai	380	7.3	30.3	20.3	31.5	2.3	25.5
Periyar River System							
Melaparai	965	9	44.7	28.8	22.5	1.3	26.1
Naduthotam	950	7.5	46.2	30.4	20.6	0.7	25.9
Ummikuppamthodu	943	7.7	64.9	43.2	17.1	1.2	24.8
Anjurily	912	7.2	21.5	13.6	47.5	4.86	19.2
Oorpannikaham	884	8.3	50.3	32.3	20.0	1.2	24.8
Sorrakottaodai	879	8	34.2	21.9	29.5	1.1	23.1

Thenkasithodu	872	5.2	22.0	13.7	45.6	6.11	18.9
Valukuparai	869	7.7	66.9	43.8	15.1	0.7	24.8
Mullaithodu	869	8.1	78.6	51.4	12.5	0.9	24.2
Cauvery River System							
Kadapilliyarthittu	1137	9.6	39.1	26.3	2.58	0.72	30.5
Thonanthikla	341	9.2	39.5	26.3	2.65	3.11	30.2
Belikoondu	267	9.4	39.8	26.3	2.63	0.63	32.7
Nadathittu	262	9.4	39.8	26.3	2.63	0.63	32.7
Sinnaru	225	9.2	39.5	26.3	2.65	3.11	30.2
Nugu River System							
Noolpuzha	2810	7.32	85.2	51.7	11.8	3.62	23.2

Table 7: Contribution of the variables (%) after Varimax rotation for Habitat characters.

Variables	D1	D2
Altitude	6.940	45.277
pH	0.849	0.147
Conductivity (mS)	0.424	0.002
TDS (ppm)	0.568	0.031
Resistivity (KΩ)	0.715	0.075
DO (mg/L)	0.900	0.180
Salinity (ppt)	0.923	0.196
Water temperature (°C)	0.695	0.069
Rubble & Boulders	0.676	0.060
Gravel	0.740	0.098

Sand	0.764	0.127
Silt	0.884	0.167
Derbies	0.828	0.120
Bedrock	0.714	0.037
Stream order	0.885	0.170
Stream Width (m)	0.819	0.155
Stream Depth (m)	0.909	0.196
Area (m2)	21.449	20.245
Volume (m3)	58.428	32.473
Mean Velocity (m/sec)	0.891	0.177

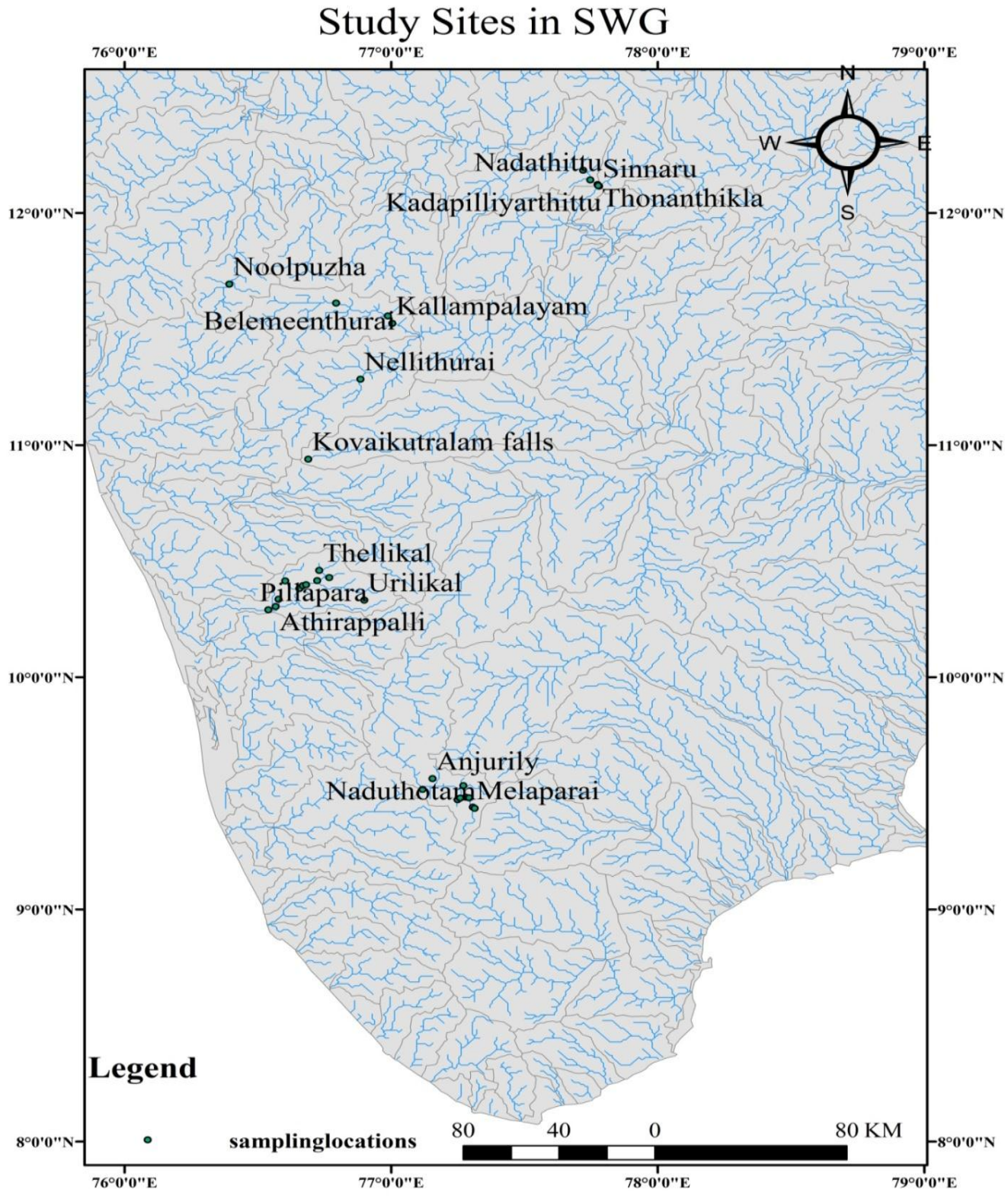

Fig 1: Collection location of six river systems

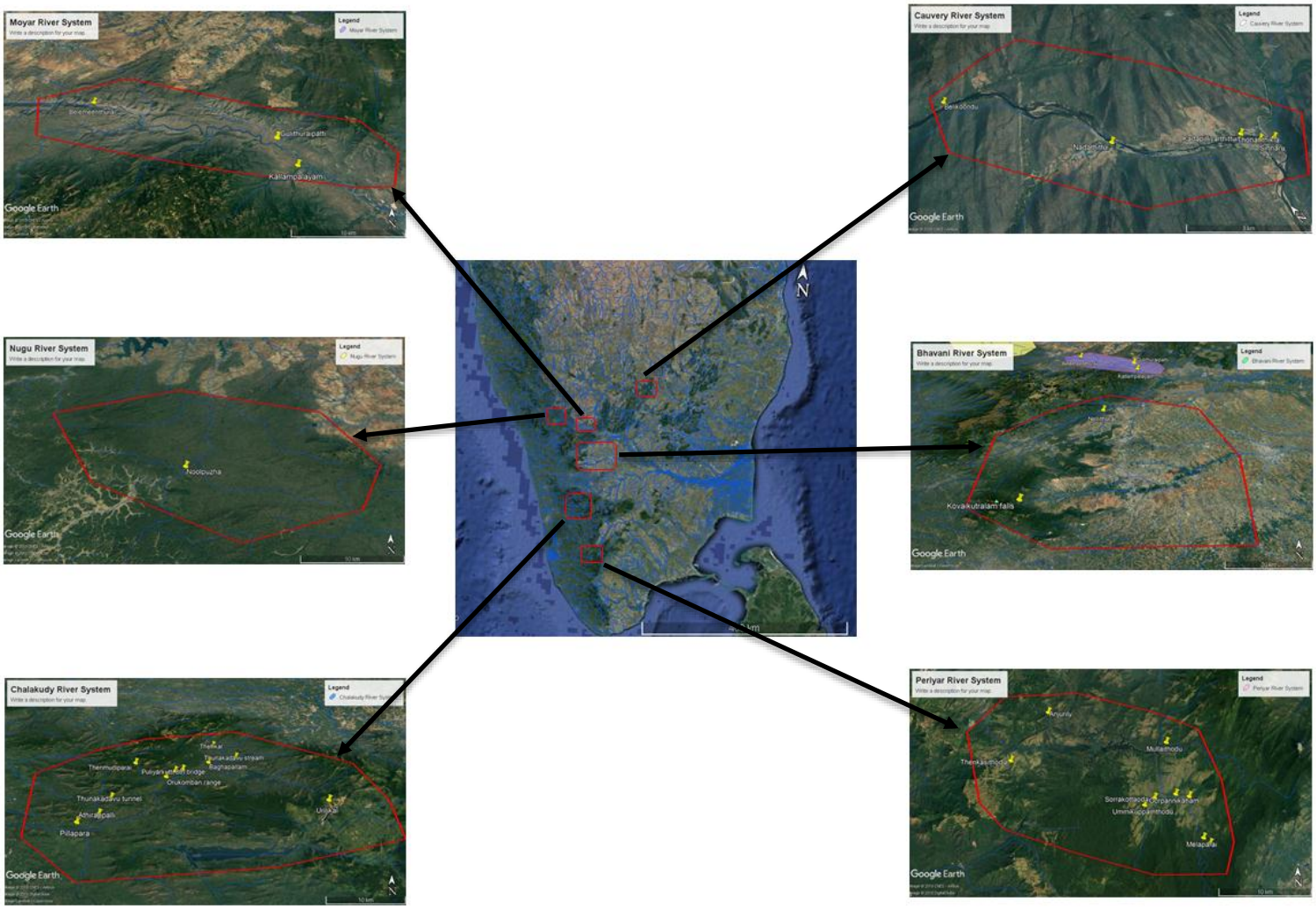

Fig 1a: Collection location of six river systems

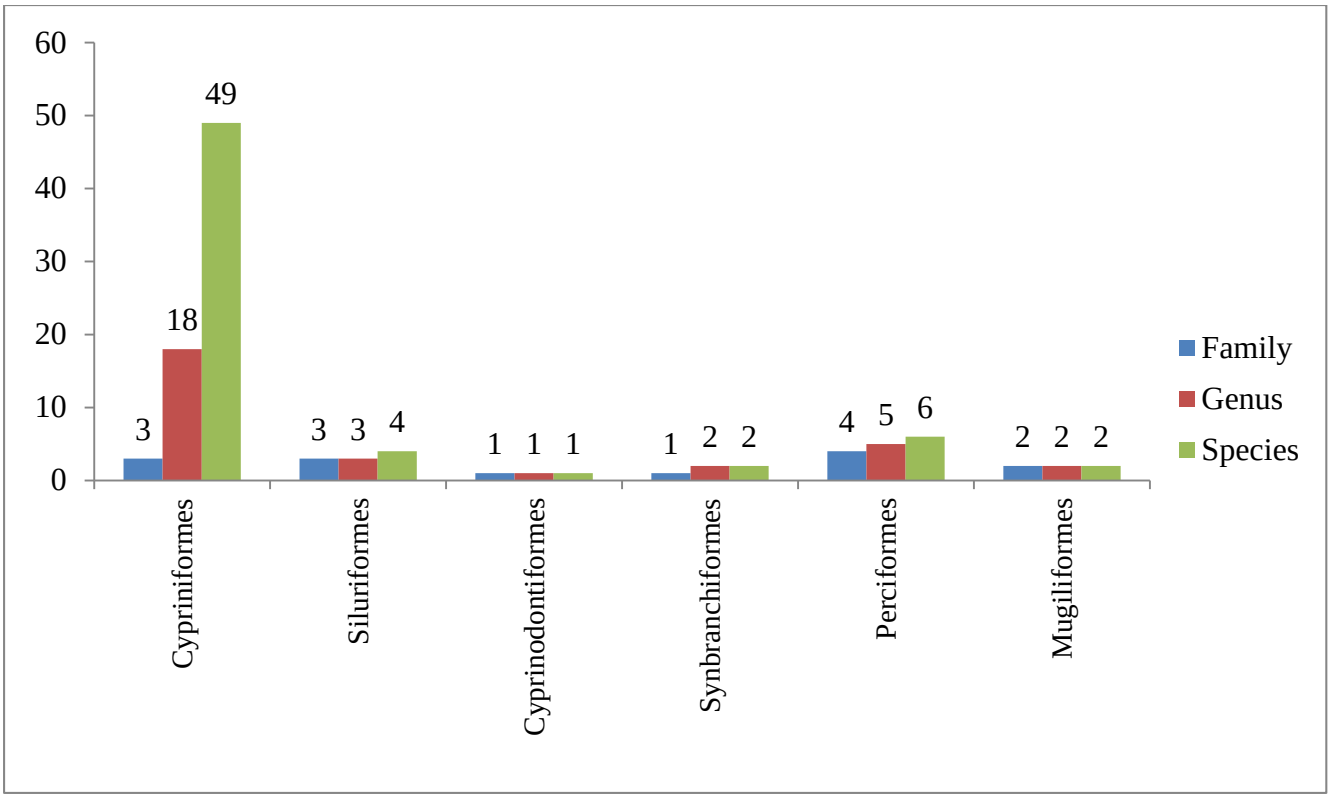

Fig. 2. Representation of fishes orders among the six river systems

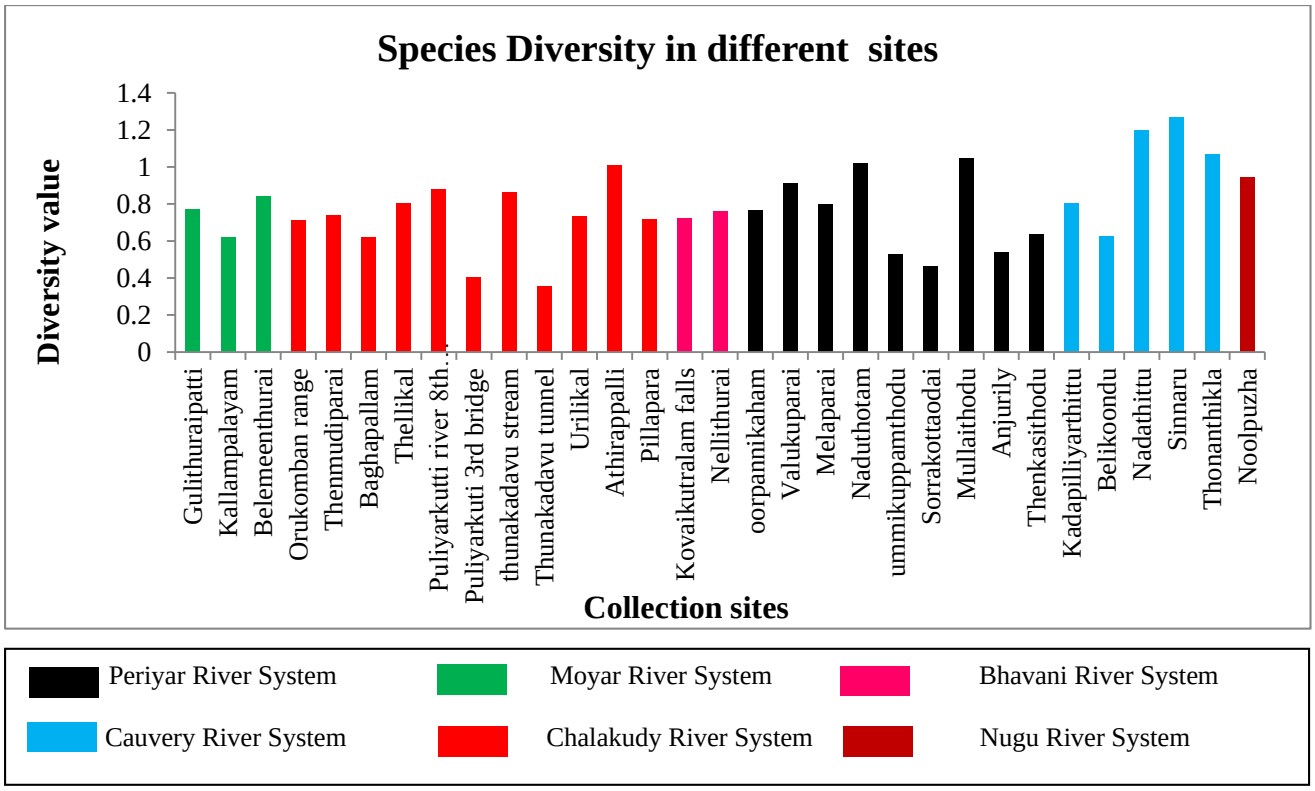

Fig 3: Species diversity among 31 sites

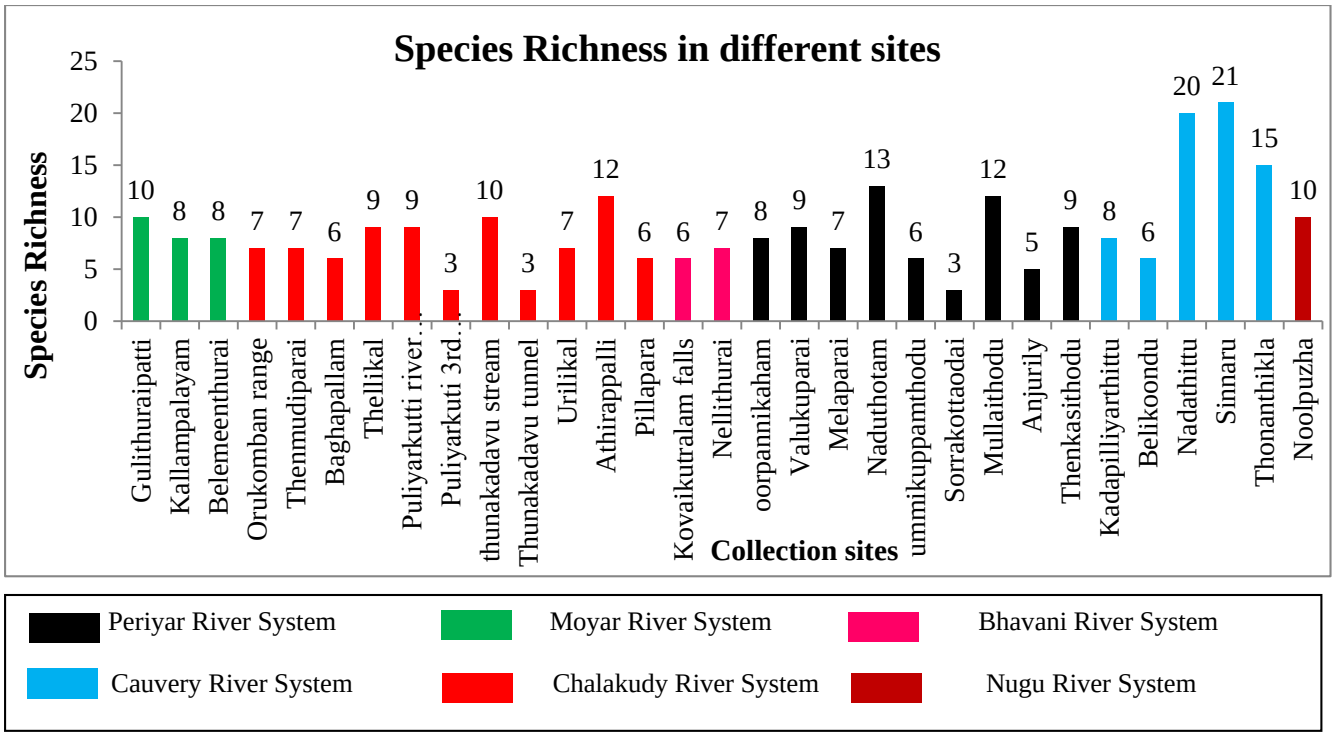

Fig 4: Species richness among 31 sites

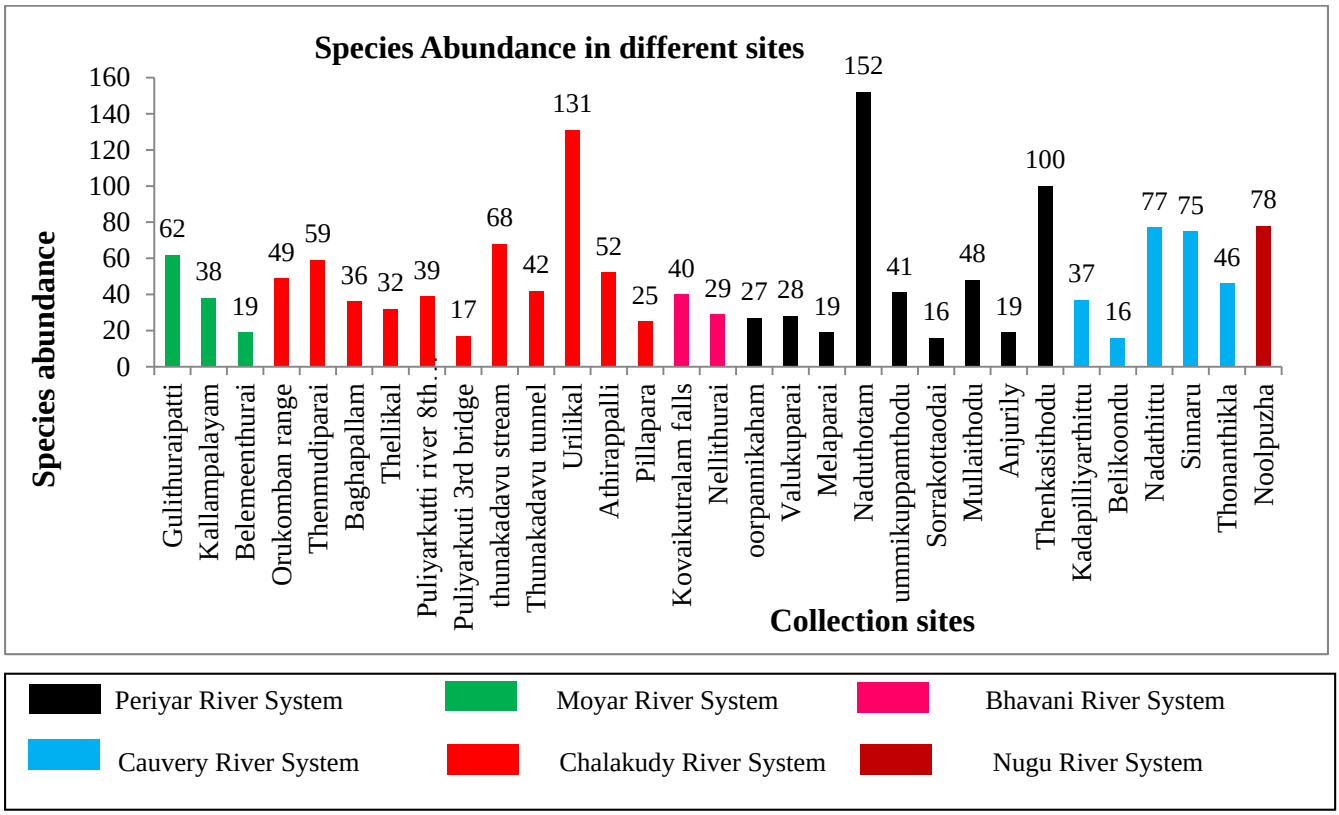

Fig 5: Species abundance among 31 sites

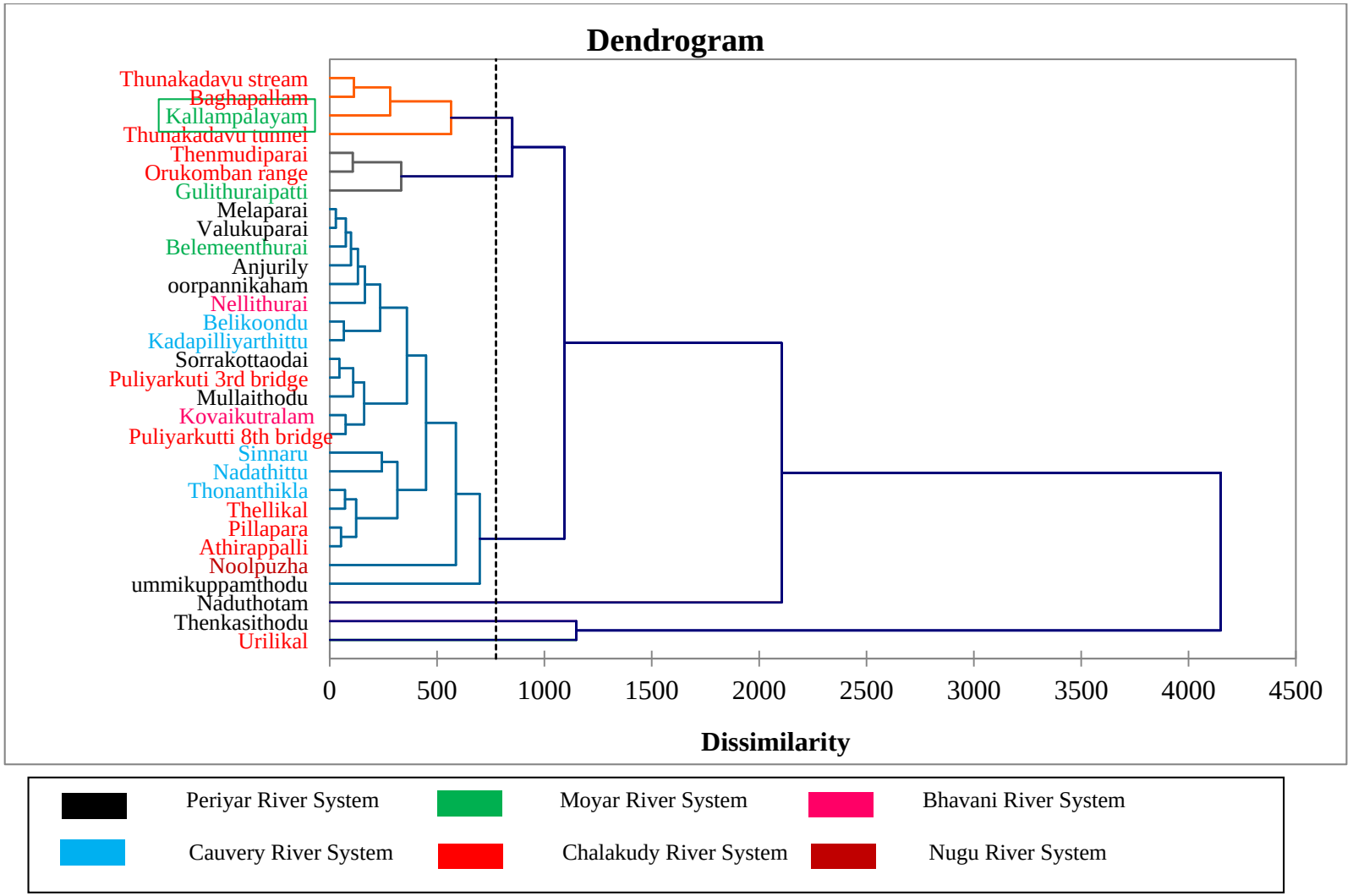

Fig 6: Cluster dendogram expressing the dissimilarity

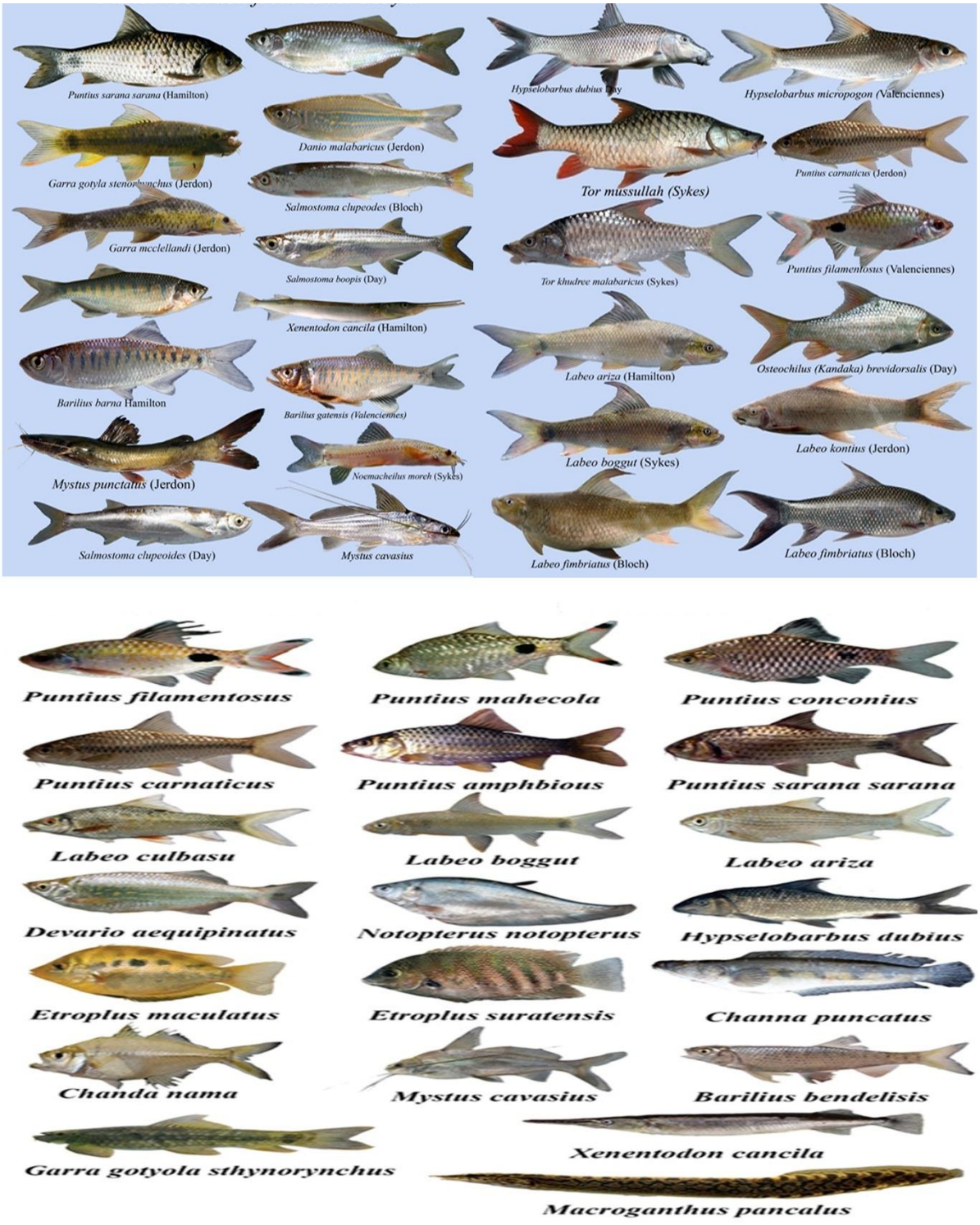

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Fig. 7: Fishes collected from various water bodies of SWG