Chapter-5

Diversity and distribution of ichthyofauna

5.1. Introduction

Analysis of fish community structure is widely considered as an integrative indicator of the ecological state of water bodies. The aspects of fish community that contribute to the community structure are the species composition, abundance and species diversity (David et al., 1969; Sutin et al., 2007). Structural comparisons of fish communities among months are indicative of the ecological state or ecological changes. Fish diversity is the useful barometer to assess the real state of purity of water (Banaerji and Singh, 1979; Salaskar and Yeragi, 2004). Database on fish biodiversity is very essential as a decision making tool and will fulfil the obligation on the part of India under conservation on biological diversity (Jhingran et al., 1989; 1992; Khan et al., 1996; Kharat et al., 2003). Species diversity is a feature that is unique to the community level of biological organization. Higher species diversity is conceived to indicate a more complex and healthier community for a greater variety of species allows for more species interaction, hence greater system stability and indicates good environmental condition. A community is said to have high species
diversity if many nearly equal by abundant species are present. If a community has only a few species and if only a few species are very abundant, then the species diversity is low (Brower and Zar 1984).

The number of endemic species of warm water is about 544 and most of them occur in the Western Ghats. There is a serious decline of many species in different freshwater ecosystems endangering its very existence, thus warranting adequate conservation of the fishes. The proportion of global threatened fresh water fishes is about 33%. At least 790 species of fishes are threatened with extinction and, 627 of these are native to freshwater (World Conservation Monitoring Centre, 1990).

The ichthyofauna of a reservoir represents the faunal diversity of the parent river system. Noss (1990) and Ramakrishnah (1994) described many instances in which the dams acted as sanctuaries of ichthyofauna. Though Pechiparai dam is situated at the southern tip of the Western Ghats, it is considered as a hotspot of various Ichthyofauna. World conservation monitoring centre has identified Western Ghats as one of the important fresh water biodiversity hotspots. It is recognized as one of the 25 biodiversity hotspots of the world. Protected areas of this dam (reserved forest) play an important role in the conservation of fresh water fishes, but there is a need to identify and assess the
conservation value of these areas in relation to biogeographical diversity of fish population and the habitat characteristics of fish communities. Owing to anthropological factors, fish diversity has begun to decline. However, only a very few studies of fresh water fish diversity have been carried out in this regard.

Complete qualitative faunistic inventories of fish fauna have been made in relatively recent past elsewhere (Jhingran and Sugunan, 1990; Marques et al., 1997; Hasson et al., 1998; Ganasan and Hughes, 1998; Rao et al., 1999; Ricciardi and Rasmussen 1998; Ajithkumar et al., 1999; Nair, 2000; Kurup, et al., 2001, Kurup; and Ranjeet 2002; Bijukumar and Sushama, 2001; Jayaraj et al., 2001; Ahmed and Singh, 1992; Allen and Lord 2004; Ziliukas, 2005; Kurup and Manojkumar, 2001; Sutan et al., 2005; Sutin, et al., 2007). The present study aimed at establishing the fish diversity prevalent in the Pechiparai dam, which is one of the mandates to implement conservation strategies in planning and management for sustainable fisheries, enrich ichthyofauna abundance and conservation of natural fish resources.

5.2 Materials and Methods

The daily fish catch and the number of units under each species per catch was recorded with the assistance of Tamil Nadu State Fisheries Department (Inland) to assess the fish diversity in
the dam during 2004 and 2005. Gillnets with mesh size ranging from 8.0 to 26.0 cm were used for fishing. The fish samples were also collected from the landing centres of State Fisheries. The fishes collected were preserved in 5% formalin, after carefully recording the colour and the other external features. The standard keys of Jayaram (1981, 1999), Jhingran (1992) and Yadav (2002) were used for the identification.

Fish production, composition, fish diversity and related factors during different months were analyzed. The diversity indices such as Margalef richness (D), Pielou's evenness (J'), Brillouin (H), Fisher (FI), Shannon-Weiner (H') and Simpson indices (SI) were applied to the data generated from Ichthyofauna samples of Pechiparai dam. Cluster analysis based on Bray-Curtis similarity index was performed on monthly abundance of Ichthyofauna. Diversity Indices and Bray-Curtis Cluster analysis were carried out using Primer software version 5. Correlation analysis was made between monthly ichthyofaunal abundance and hydrobiological parameters. Student's-t test was used to compare the ichthyofaunal abundance of the two years. The status of each species, whether threatened or endemic, was assigned based on International Union for Conservation of Nature and Natural Resources (NBFGR, 1998) and Kurup et al. (2001).
5.3 Results

In the present investigation, 27 fish taxa belonging to 20 genera and 8 families were recorded and the species wise representations of each family are furnished in table 5.1 and 5.2. The percentage composition of ichthyofauna at family level is given in fig. 5.1. Among the 10 families of fish fauna, Cyprinidae contributed about 72% to the fishery, followed by Cichlidae 18%, Hemiramphidae 8%, Belonidae 1%, Bagridae 1% and the remaining families contributed below 1% during the study period.

In total, 27 fish taxa were recorded during the study period. Among the fishes, Family Cyprinidae comprised of *Cirrhinus riba*, *Cyprinus carpio*, *Catla catla*, *Rasbora daniconius*, *Puntius sarana*, *P. filamentosus*, *P. tito*, *P. amphibius*, *Danio aequipinnatus*, *Cirrhinus mrigala*, *Garra mullya*, *Labeo rohita*; Family Cichlidae includes *Etroplus maculates*, *E. suratensis* and *Oreochromis mossambicus*, Family Channidace consists of *Channa marulius*, *C. punctatus*, and *C. striatus* Family Siluridae of *Ompok bimaculatus*, *Wallago attu* and *Silurus wynaadensis*, Family Blenniidae comprised of *Salarias fasciatus*, Family Hemiramphidae consisted of *Zenarchopterus dispar*, Family Belonidae included *Xenentodon cancila*; Family Heteropneustideae was represented by *Heteropneustes fossilis*; Family Bagridae by *Mystus aor* and Family Cyprinodontidae by *Aplocheilus lineatum*. 
The percentage composition of fish fauna at species level is shown in fig. 5.2. Among the taxa, *Puntius filamentosus*, *Zenarchopterus dispar*, *Oreochromis mossambicus*, *P. sarana*, *Xenentodon cancila*, *P. ticto*, *Cirrhinus mrigala* and *Mystus aor* were the most frequently encountered taxa throughout the period of study. During the study, *P. filamentosus* was the dominant species (30%), followed by *Z. dispar* (24%), *O. mossambicus* (19%), *P. sarana* (13%), *X. cancila* (4%), and *P. ticto* (3%).

The Ichthyofauna collected during the present study consisted of native fishes, alien fishes and exotic fishes. Most of these fish fauna are commercial food fish and ornamental fishes. Temporal variation in the fish fauna abundance during 2004 and 2005 is shown in fig. 5.3. The number of fishes per month recorded during 2004 ranged between 3297 (October) and 20870 (March) and during 2005, it was from 3407 (December) to 15638 (March).

During 2004, the ichthyofauna in this dam supported the minimum species of 17(November) and the maximum of 22 taxa (September) and during 2005, the number of species ranged from 17 (August) to 21 (March, April, September and November). During the period of study, fish species abundance was comparatively high during the summer period and the lowest was during the northeast
monsoon seasons (Fig. 5.4). The student's-t test between the annual ichthyofaunal abundance of two years did not show significant variation. The ichthyofauna abundance showed a significant (P<0.05) positive correlation with precipitation and zooplankton abundance during the period of investigation (Table 6).

The fish yield from the dam during 2004 ranged between 407.650 (December) and 3424.60 kg (March) and during 2005 it ranged from 428 (January) to 1978 kg (March).

The temporal and seasonal variation in fish diversity indices was generally higher during the onset of southwest and northeast monsoon seasons (Fig. 5.5, 5.6 and 5.7). The richness index (D) during 2004 varied from 1.96 (November) to 2.46 (October) and during 2005 it was observed to range between 1.78 (August) and 2.44 (November). One way ANOVA between different seasonal richness did not show any significant variation.

J' (evenness) index varied from 0.43 (September) to 0.70 (November) during 2004 and the ensuing year the observed range was from 0.34 (October) to 0.536 (February). Seasonal evenness did not show any significant variation.
The minimum and the maximum values of $H$ (Brillouin index) recorded during 2004 were 1.34 (September) and 1.97 (November) respectively. During 2005, $H$ index ranged from 1.03 (October) to 1.60 (November). Seasonal Brillouin index showed a significant variation.

$F_I$ index (Fisher) was observed to vary between 2.13 (February) and 2.99 (October) during 2004 and during 2005, it was from 2.17 (February) to 2.96 (November). Fisher's index for the different seasons did not show any significant variation.

Shannon-Weiner diversity ($H'$) index ranged from 1.35 (September) to 1.98 (November) during 2004 and from 1.04 (October) to 1.61 (November) during 2005. Shannon-Weiner index for the different seasons showed a significant difference.

Simpson index (SI) was observed to vary between 0.61 (September) and 0.82 (November) during 2004 and the range of variation was from 0.52 (October) to 0.70 (February) during 2005. Simpson index for the different seasons showed a significant difference (Table 4). There was a temporal and seasonal relationship found between the standing crops during the study period (Fig. 5.8 and 5.9).
Bray-Curtis similarity matrix revealed that diversity indices varied considerably between different months (Fig 5.10). As for the species richness and abundance, month-wise clustering during 2004 at 50% similarity level portrayed two groups. Month wise similarity clustering observed were high density groups (7 sub groups) and low density groups (3 sub groups). The maximum species count was observed during March and the minimum was during October. The cluster analysis of ichthyofauna according to their abundance and richness revealed the closest percentage of similarity existed between June - July, October - November, August - December and February - May during 2004. During 2005, month-wise clustering comprised of three groups at 80% similarity level. First group with 7 sub groups and second and third have only one sub group each (Fig. 5.11). The species count was at its maximum during March and the minimum was observed during December. The cluster analysis of ichthyofauna according to their abundance and richness revealed the closest percentage of similarity exists between February - May, January - June, November - December, July - September and March - April.

Of the 27 taxa identified from this dam, 15 were food fishes while 12 were ornamental. Among them, 22 species were wild native species of this dam. As per International Union for Conservation of Nature and Natural Resources categorization
(NBFGR, 1998; Kurup, et al., 2001), one species (S. wynaadensis) is critically endangered, two species (W. attu and H. fossilis) are vulnerable, two species (C. marulius and C. punctatus) are nearly threatened with low risk and the remaining 22 taxa are low risk of least concern (Table 5.3).

5.4 Discussion

The mean species evenness index for the four different seasons could be arranged in the ascending order as inter monsoon season (0.478) → southwest monsoon (0.496) → summer season (0.516) → northeast monsoon season (0.562). Evenness index is known to range between 0 and 1.0, representing a situation in which all species are equally abundant (Magurram, 1988; Sparre et al., 1989; Sreenivasan, 1992; Sugunan, 2000). This index observed the maximum during northeast monsoon and the minimum was during inter monsoon season. The evenness index recorded in the present study was below one. The maximum diversity can also be taken as a measure of evenness of a population (Pielou, 1975). According to Taege et al. (1993) and Venugopal (1993) and Hosetti (2002), Shannon – Weiner index is moderately sensitive to sample size and places more weightage on richness, i.e., if there are rare species recorded the index tend to have higher value. The Shannon-Weiner diversity is based on its combination of taxa richness and equatorially distributed
abundance of individuals (Zhong and Power, 1996; Sivaramakrishnan, 1996).

In the present study similarity index of Margalef (1968; 1972), was applied to assess the richness of the ichthyofauna existing among different seasons. With respect to species richness index, northeast monsoon season registered the highest value and the lowest was either in inter monsoon or in summer season. High richness may be due to the favourable hydrobiological conditions coupled with low transparency. The low richness during inter monsoon and summer season may be due to higher water temperature coupled with high transparency.

Fisher's index registered the highest during the northeast monsoon season. The lowest value was registered invariably during the summer season. According to Ricker (1975), Rao (1990), Sakhre (2000) and Hosetti (2002) the sensitivity of this index depended on the small sample size and gave more importance to richness. This is in close agreement with the observations made by Margalef (1963) that disturbance in standing crop often lead to a reduction in diversity. In this dam, the high primary and secondary production has not been channelized to fish production leading to low index value.
Brillouin index did not show a definite pattern and the values remained high during northeast monsoon season of 2004. During 2005, the higher index was registered in summer season. This index usually describes a known population and places more emphasis on species richness and moderately sensitive to sample size. According to Talwar and Gebre (1989) and Hosetti (2002), Brillouin index could also give misleading information owing to its dependency on sample size.

Shannon-Weiner index, the most commonly accepted index, is based on both the number of species present and the relative abundance of each species (Murthy, et al., 1986; Zargar and Ghosh, 2006). Shannon-Weiner index became more useful, while comparing two or more sites (Hosetti, 2002). It could also be used to compare two annual data collected in a particular study area. In the study the values of Shannon - Weiner index recorded during the four different seasons of Pachiparai dam differed significantly between 2004 and 2005. The index of the Ichthyofauna ranged from 1.35 to 1.98 during 2004. In the year 2005, the recorded range was from 1.09 to 1.61. According to Margalef (1972), Nath and Shrivastave (1993) and Mukherjee, (2000) the Shannon – Weiner index would normally range from 1.5 to 3.5 with the values rarely exceeding 4.5. Moyle (1949), and Moyle and Leidy (1992) confirmed that if the underlying distribution was log normal,
$10^5$ species could be needed to give a value of $n > 5.0$. In the present study, during 2004, the average value of this index recorded were 1.56 (inter monsoon), 1.6 (summer), 1.65 (southwest monsoon) and 1.95 (northeast monsoon). However, during 2005 the highest seasonal mean value (1.47) was recorded during the summer season, the northeast monsoon season ranked second (1.392) followed by southwest monsoon (1.29) and inter monsoon seasons (1.25). Abiotic factors appeared to be responsible for the change of community structure in the reservoir and subsequent reduction in diversity value (Lal et al., 1982). Johnson (1999) reported that Shannon-Weiner diversity index values calculated for the fishes occurring in the streams and rivers of the Western Ghats of South India were also below 1.5.

The data collected in the present study affirmed that the Simpson index was heavily weighed towards the most abundant species in the sample and less sensitive to species richness. It was moderately sensitive to sample size also. Simpson index recorded the highest seasonal mean during either summer or northeast monsoon seasons. The oscillation in the values was quite moderate as the index depended on the species abundance of the study area. The pattern of variation in Simpson index followed that of Nair et al. (1981), Mod and Panicker (1985), Magurran (1988) and Mayer (1990).
From the data gathered in this study on the fish catch of the dam, some similarities could be drawn. During both the years, maximum number of fishes was caught during the latter phases of monsoon and prior to the onset of southwest monsoon seasons. The fish harvest registered the lowest value during the latter phase of northeast monsoon season (secondary monsoon season). Of the 27 fish taxa recorded in the dam, *Puntius filamentosus*, *P. sarana*, *P. ticto*, *Oreochromis mossambicus*, *Zenarchopterus dispar*, *Xenentodon cancila*, *Cirrhinus mrigala* and *Mystus aor* were observed commonly in the dam. *Labeo rohita* was encountered only in few months. Similar conditions were prevalent in the case of *Catla catla* also. According to the earlier reports on Indian freshwater fish fauna of Ahirrao and Mane (2000), Yadav (2002), Kurup *et al.* (2001), and Zultan *et al.* (2005) the native fish species of this dam have been identified as *Salarias fasciatus*, *Etroplus maculates*, *E. suratensis*, *Wallago attu*, *Ompok bimaculatus*, *Hemiramphus dispar*, *Xenentodon cancila*, *Rasbora daniconius*, *Puntius sarana*, *P. filamentosus*, *P. ticto*, *P. amphibius*, *Danio aequipinnatus*, *Gyarra mulluya*, *Heteropneustes fossilis*, *Channa marulius*, *C. punctatus*, *C. striatus*, *Mystus aor* and *Aplocheilus lineatum*. It warrants mention here that though the Indian major carps *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* have been introduced into the dam, *C. mrigala* alone seemed to contribute considerably to the fishery,
followed by *L. rohita*. The State Fisheries Department has started to introduce *C. carpio* in large quantities. However, it does not contribute a significant portion to the total fish yield. It is not known to why *C. mrigala* grow very well when compared to common carp, which also is a bottom feeder. The inconsistency of the availability of certain stocked fishes could also be attributed to uncertainty in the stocking of fingerlings and self-assertion by these fishes in the changed exploitative regime (Sreenivasan, 1979; 1990; Gobinath and Jeyakrishnan, 1984; Selvaraj, 1994; Lorenzen, 1995). Considering the above observation, the omnivorous taxa like *Puntius filamentosus, P. sarana, P. ticto*, and *Oreochromis mossambicus* found perennially in the dam. This reveals that the dam could be used preferably for farming fresh water prawns and commercially important omnivorous fishes.

Under the family Channidae, *Channa marulius, C. punctatus* and *C. striatus* occurred in the catch in unpredictable periodicity. The commercial fishes, lack of migratory space in the reservoir and due to release of water during breeding season were probably responsible for loss of fish diversity (George *et al.*, 1977; Desai and Soni 1993; Desai *et al.*, 1999). It is possible to conclude that population of these carnivore fishes plummeted possibly due to the high predatory behaviour of *O. mossambicus*, which was available in the dam round the year, and whose number was higher during
the southwest monsoon season. Its population built up and became stable during the latter phase of northeast monsoon season. The vertical distribution of dissolved oxygen and the nature of the bottom sediment should be investigated in future to assess whether the bottom water is suitable for survival for the bottom feeding fishes like _C. carpio_ and _C. mrigala_ and to maintain ecological balance.

It seems species like _P. amphibius_ and _Channa_ spp. may vanish from the dam in course of time. Though the species of _Puntius_ available in the dam were moderately commercially important, they needed to be conserved from extinction due to the introduction of exotic fishes like _C. carpio_ and _O. mosambicus_ and alien fishes like _catla, rogu_ and _mrigal_. Govind, (1963), Gulland (1978), Rao _et al._ (1999), Ahirrao, and Mane (2000) and ICUN (2000) reported that the extinction of native species in the Western Ghats is due to heavy harvest and introduction of exotic fishes. Introduction of new fauna could cause serious repercussions to the natural fish populations and the ecology of the invertible fauna (Petitjeam and Davies, 1989). Decreased food, availability accelerated cannibalism and destruction in natural breeding grounds due to modification work of the dam could also affect the fish diversity of wild species (Ganapati and Pathak, 1969; Attwell, 1970).
The checklist of phyto and zooplankton furnished in the present investigation affirmed that only chosen species registered perennially in the dam. Prevalence of chosen species of plankton may impart stress to the fish as their basic food. The health of this ecosystem could be put in a nutshell that the limiting nutrient, phosphorus always occurred in plenty.

In the conservation point of view, it is essential to maintain genetic pool rather than promoting fishes in an economic point of view. The database on population size and distribution of endangered and endemic species should be strengthened by undertaking extensive micro survey. Information regarding migration, breeding behaviour, and spawning ground of threatened fishes should be generated through extensive survey and analysis. Such database is inevitable for both ex situ and in situ conservation of the species. Brood stock maintenance centres and hatcheries should be established exclusively for indigenous and critically endangered fishes for their in situ conservation and aqua ranching to complement their natural recruitment. Introduction of any exotic or alien fishes that constitute a potential threat to native ichthyofauna should be discouraged. Introduction of *Spirulina* like cyanophytes and other essential diatoms could also supplement the food availability of this dam.
From the above investigation, it is possible to assert that the ecological state of the Pechiparai dam community is quiet good. The health of this ecosystem could be explained in nutshell as the limiting nutrient phosphorus always occurred in plenty. Based on physico-chemical and biological parameters, the Pechiparai dam can be categorized as soft and mesotrophic in nature. Considering the above observation, the dam could be used preferably for farming fresh water prawns and commercially important omnivorous fishes. If the dam is managed properly on scientific lines, fish production can be enhanced manifold and can conserve the native fauna. Further, studies need to be conducted in this regard to throw more light on the validity of the remedial measures detailed in this study.
Fig. 5.1. Fish composition (%) at family level

- CYT - Cyprinidae
- BAG - Bagridae
- CHA - Channidae
- HEM - Hemiramphidae
- CYP - Cyprinodontidae
- BEL - Blennidae
- CIC - Cichlidae
- HET - Heteropneustidae
- BEO - Belonidae
Fig. 5.2. Species composition of ichthyofauna

- *Salarias fasciatus*
- *Oreochromis mossambicus*
- *Silurus wynaadensis*
- *Cirrhinus ruba*
- *Rasbora daniconius*
- *P. ticto*
- *Cirrhinus mrigala*
- *Heteropneustes fossilis*
- *C. striatus*
- *Etroplus maculatus*
- *Ompok bimaculatus*
- *Zenarchopterus dispar*
- *Cyprinus carpio*
- *Puntius sarana*
- *P. amphibius*
- *Garra mullya*
- *Channa marulius*
- *Mystus aor*
- *E. suratensis, Bloch*
- *Wallago attu*
- *Xenentodon cancila*
- *Catla catla*
- *P. filamentosus*
- *Danio aequipinnatus*
- *Labeo rohita*
- *C. punctatus*
- *Apocheilus lineatum*
Fig. 5.3. Temporal variation of Ichthyofauna abundance
Fig. 5.4. Seasonal abundance of Ichthyofauna

![Bar chart showing seasonal abundance of Ichthyofauna with months and series 1 data]

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Fig. 5.5. Temporal variation of diversity indices during 2004

![Bar graph showing diversity indices variation by months with different indices and months]

Diversity indices

[Graph showing diversity indices from J to D for each month]
Fig. 5.6. Temporal variation of diversity indices during 2005

![Temporal variation of diversity indices during 2005](image)

Fig. 5.7. Seasonal variation of diversity indices of fish

![Seasonal variation of diversity indices of fish](image)
Fig. 5.8. Temporal variation of standing crop

![Temporal variation of standing crop graph]

Fig. 5.9. Seasonal abundance of standing crop

![Seasonal abundance of standing crop graph]
Fig. 5.10. Cluster analysis of fish species richness and abundance during 2004
Fig. 5.11. Cluster analysis of fish species richness and abundance during 2005
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</tr>
<tr>
<td></td>
<td>Labeo rohita, Hamilton</td>
<td>LRIC</td>
<td>Food fish</td>
<td>Alien species</td>
</tr>
<tr>
<td>Heteropneustidae</td>
<td>Heteropneustes fossilis, Bloch</td>
<td>VU</td>
<td>Food fish</td>
<td>Native species</td>
</tr>
<tr>
<td>Channidae</td>
<td>Channa marulius, Hamilton</td>
<td>LRNT</td>
<td>Food fish</td>
<td>Native species</td>
</tr>
<tr>
<td></td>
<td>C. punctatus, Bloch</td>
<td>LRNT</td>
<td>Food fish</td>
<td>Native species</td>
</tr>
<tr>
<td></td>
<td>C. striatus, Bloch</td>
<td>LRIC</td>
<td>Food fish</td>
<td>Native species</td>
</tr>
<tr>
<td>Bagridae</td>
<td>Mystus aor, Hamilton</td>
<td>DD</td>
<td>Ornamental</td>
<td>Native species</td>
</tr>
<tr>
<td>Cyprinodontidae</td>
<td>Aplocheilus lineatus, Valenciennes</td>
<td>LRIC</td>
<td>Ornamental</td>
<td>Native species</td>
</tr>
</tbody>
</table>

DD-Data deficient, LRIC-Low risk least concern, LRnt-Low risk nearly threatened, VU-Vulnerable, CR-Critically endangered,