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Finfish diversity of trawl landings at Pamban therkuvady in south-east coast of India

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The present research provides detailed information on the yearwise distributional patterns of fishes landed by trawl at Pamban therkuvady based on fortnightly samplings from September 2007 to April 2012. A total of 244 species belonging to 75 families under 18 orders were recorded. Quantitatively, *Karalla dussumieri* and family Leiognathidae dominated while by number of species, the family Carangidae contributed maximum with 20 species. The fish landing were the maximum during 2011-12 and was the minimum during 2008-09. Biodiversity studies were made using PRIMER 6 software. Different indices of conventional diversity as well as that of taxonomic distinctness based on dominance plot, dendrogram and funnel plots of delta+ and lambda+ are presented and discussed.

[**Keywords:** Biodiversity, Fishes, AbundanPce, Gulf of Mannar, India]

Introduction

Trawl landings form a major share among the landings of mechanized sector in India. Tamil Nadu being one among the top three marine fish producing states in India, which is situated in the south-east coast, accounted for trawl landings to the tune of 54% of the total landings of Tamilnadu, which was about 88% of the mechanized catch. The Gulf of Mannar Marine Biosphere Reserve, located along Tamilnadu coast extends from Rameswaram to Tuticorin (Lat 8° 55′ - 9° 15′ N and Long 78° 0′ - 79° 16′ E), in a stretch of 140 km supports a wide spectra of flora and fauna of taxonomic and economic importance. Earlier studies from Gulf of Mannar (GOM) gave an insight into trawl fishing in the vicinity of Mandapam[1], sciaenid fishery[2], silverbellies[3], biology and fishery of *Leiognathus dussumieri*[4], catfish landings by pair trawlers at Rameswaram[5], fishery, biology and stock assessment of *Nemipterus delagoae* off Tuticorin[6], brief description on fish and fisheries[7], perches[8], flatfishes[9], dorab fishery[10] and elasmobranch fishery resources[11]. These works from GOM are concentrated on different groups in different periods and a systematic study based on regular collections on all the groups together upto species level was not undertaken so far from this region. Pamban therkuvady is one of the major fish landing centres in this stretch where trawlers operating in GOM land their catches. Hence an attempt was made here to study the diversity of all the finfishes landed by trawl at Pamban therkuvady.

Materials and Methods

Fortnightly samples were collected from Pamban therkuvady (Lat. 09° 16′ 17.92″ N and Long. 79° 12′ 08.34″ E), landed by trawls from GOM, for a period of five years from September, 2007 to April, 2012. For sampling, stratified multistage random sampling developed by Central Marine Fisheries Research Institute (CMFRI) was followed. The area of the GOM under the Indian EEZ is about 15000 sq. km., where commercial fishing takes place in about 5500 sq. km. Trawl fish landings at Pamban therkuvady is seasonal (September-October to April) as the GOM becomes rough during April to September. The landings at this centre include that of the coral reef area also using Roller madi which is a specially designed trawl net with rollers attached to the foot rope. During January-April, pair trawling was also being carried out and landed at this centre. The fishes landed were identified upto species level using standard books[12-14]. The weight as well as numbers of each species landed was recorded. Specieswise, familywise, monthwise and yearwise catch data was generated and analysed for proper interpretation of the data.

Conventional diversity indices like H' (log e), Shannon diversity index[15]; d, Margalef's richness index[16] and J', Pielous evenness index[17] were applied to compare the fish diversity between years. To compare the diversity between the years, dominance plot was drawn[18-19] by ranking the species in decreasing order of abundance. The data were fourth root transformed before the computation of diversity indices, similarity and cluster analysis. The similarity in species composition was studied by calculating the Bray-Curtis coefficient[20]. The similarity matrices were constructed using the Bray-Curtis similarity measure and the similarity is 100% if the two samples are totally similar while it is 0 if the two samples are totally dissimilar. In the cluster analysis, the Bray-Curtis similarity was used to construct the map[19]. New diversity indices have statistical support to compare the biodiversity within different years and it can be derived by using Δ, taxonomic diversity index; Δ^+, average taxonomic distinctness index and Phi+, average phylogenetic diversity index[19]. Unlike most other diversity measures, the average taxonomic distinctness, Delta$^+$ (Δ^+) and the variation in taxonomic distinctness, Lambda$^+$ (λ^+) are widely applied to presence/absence data which are preferred over the conventional indices. These indices do not involve systematic bias of low sample size which is considered to be a desirable property for any index. These measures can be used to compare faunas of different years and decline in Δ^+ has been suggested as a measure of stress in a system. Also, Δ^+ is the measure of mean path length through the taxonomic tree connecting every pair of species and λ^+ is the variance of these pairwise path lengths which reflects the unevenness of the taxonomic tree. To find out the deviation from the normal distribution and to test the variance between the samples Δ^+ and λ^+ values were used for plotting the 95% funnel plots. All the univariate and multivariate analyses for the diversity profile were done using the PRIMER (v.6) software[21].

Results

A total of 244 species belonging to 75 families under 18 orders of 2 classes were recorded from Pamban therkuvady landing centre during the period of study (Fig. 1). Among the species landed, a maximum of 20 species were observed under the family Carangidae followed by Lutjanidae with 18 species. 70% (171 species) of the total number of species recorded were reef fishes as GOM comprised of coral reef areas to a larger extent.

Among the 244 species, *Karalla dussumieri* was found to dominate, contributing 23% of the total landings of five years at this centre, followed by *Lethrinus nebulosus* (8%), *Sardinella albella* (6%), *Sardinella gibbosa*(5%), *Pellona ditchela, Sardinella longiceps* and *Sphyraena barracuda* (4% each), *Selaroides leptolepis* and *Gazza minuta* (3% each), *Dussumieria acuta* and *Aluterus monoceros* (2% each) and the rest of the species contributed ≤ 1%. Among the landings of *Karalla dussumieri*, the maximum of 30% was contributed during 2007-08, followed by 24% in 2011-12, 21% in 2009-10, 15% in 2010-11 and a minimum of 10% was recorded during 2008-09. Among the fishes recorded, there were species categorised as Endangered (1 species - *Cheilinus undulatus*), Vulnerable (6 species - *Himantura uarnak, Rhinoptera javanica, Rhynchobatus djiddensis, Rhincodon typus, Bolbometopon muricatum* and *Hippocampus kuda*) and Near Threatened (8 species) as per IUCN.

In the present study, the familywise landings indicated that the maximum share was by the family Leiognathidae (28%) in the total trawl landings of five years, followed by Clupeidae (19%) and the rest of the families contributed less than 10% each (Fig. 2). The yearwise break-up in percentage of Leiognathidae (silver-bellies) in total fish landings at Pamban varied from 22% in 2010-11 to 34% in 2009-10.

The yearwise trawl landing of fishes at Pamban is depicted in Fig. 3. The total fish landings at Pamban by trawl fluctuated substantially between years during the period from 2007-08 to 2011-12. There was a sudden decline in the landings from 2007-08 to 2008-09 and then the fishery showed a gradual increase till 2011-12. Out of the total landings of 40272 t during five years, the maximum of 27% was landed during 2011-12 and a minimum of 12% landed during 2008-09.

The monthwise average fish landings during 2007-12 by trawls at Pamban was 1023 t. It was also observed that the reef fishes accounted for 50% by quantity and 70% by number of species of the total fish landings at this centre.

The diversity indices along with some attributes of community structure in different years are given in Table 1. The species richness (S) varied between 121 and 200, the lowest being in 2010-11 and the highest in 2007-08. There was no particular changing patternin species richness and the values fluctuated between years.

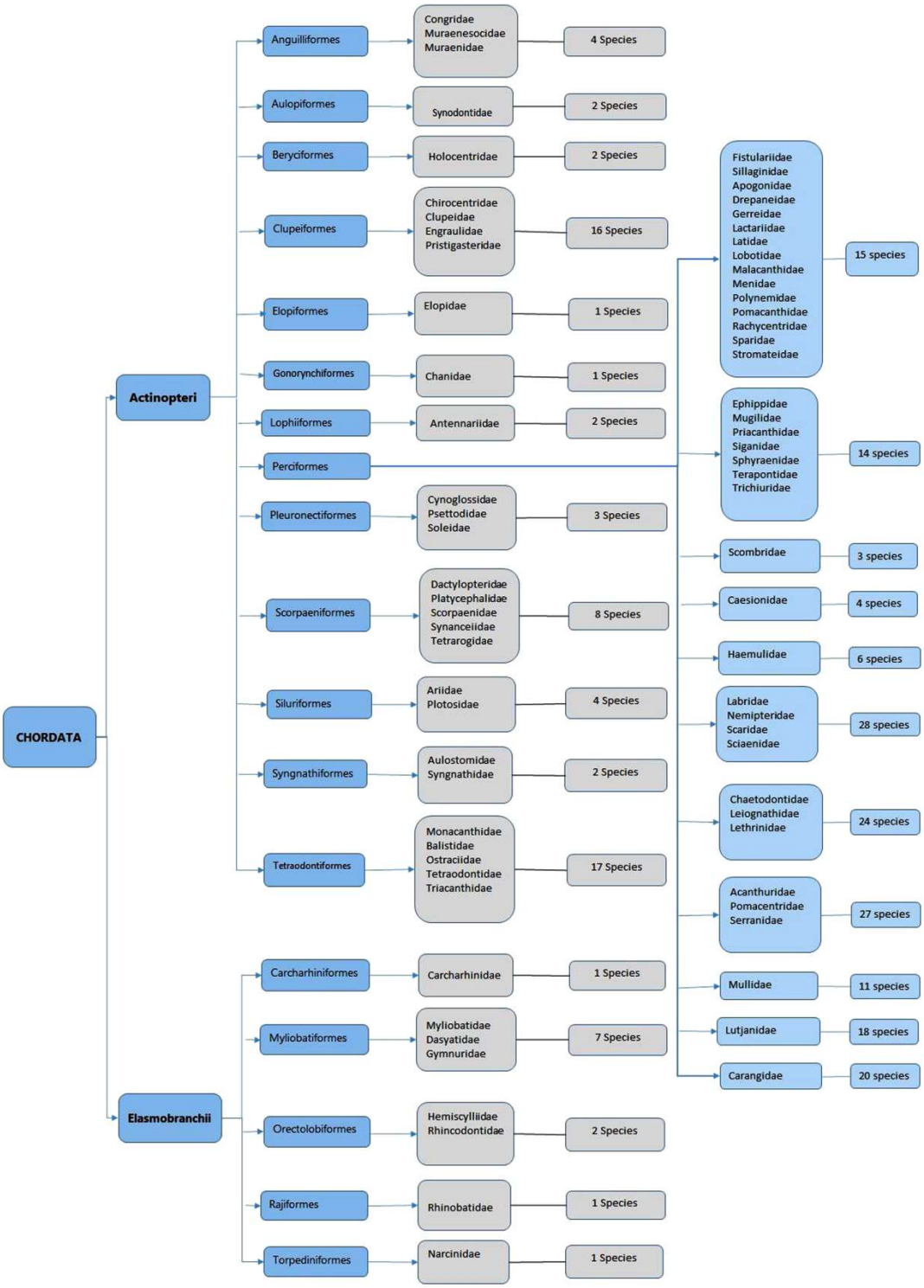

Fig. 1 — List of fish taxa landed at Pamban during the study period

The Margalef's index (d) which incorporates the number of individuals (N) and species (S) was the highest during 2007-08 (24.79) while it was minimum (15.34) in 2010-11. The equitability or Pielou's evenness index (J') which expresses the evenness of distribution of individuals among the different species did not show much variation and the values ranged from 0.91 to 0.96. In the case of Shannon-Wiener's

index (H') which is the most commonly used diversity measure, there was no considerable variation between years and it fluctuated between 4.59 and 4.85, which indicate that species composition in all the years remain almost the same. Simpson index (1-Lambda') values also support this as its values in all the years remaining the same (0.99). It is also found that the evenness was minimum when the diversity was maximum.

In the dominance plot, the curve for 2007-08, which lies on the lower side, extends further and rises slowly due to presence of more number of species when compared to rest of the years (Fig. 4). As the percentage contribution of each species is added, the curve extends horizontally along with species numbers in the x-axis, before reaching the cumulative 100%.

The similarity in species composition and abundance among different years as derived from Bray-Curtis similarity matrix during the study period is given in Table 2. The maximum similarity of 87.2% was observed between 2009-10 and 2010-11 while the similarity was found to be the minimum (77.98 %) between 2007-08 and 2010-11.

Dendrogram depicted in Fig. 5 shows the results of the hierarchical clustering by using the group average linking between years during the study period. Cluster analysis is a technique in which entities are sequentially linked together according to their similarity producing a two dimentional hierarchical structure. Dendrogram revealed the separate grouping similarity in species composition and abundance of different years. The years 2009-10 and 2010-11 formed a group with the maximum similarity percentage of 87 to which the year 2011-12 got linked at 84.5 followed by 2008-09 at 83 and finally got linked to 2007-08 at 78.8% similarity.

The newly introduced biodiversity indices which measure the degree to which species or organisms in a sample are taxonomically related to each other are depicted in Fig. 6 and 7. The average taxonomic distinctness, Δ^+ was found maximum in 2009-10 and minimum in 2011-12. This indicates that the taxonomic distance between species was the highest during 2009-10 and it was found to show a declining trend in different years in the order, 2007-08, 2008-09, 2010-11 and the taxonomic diversity was found to be the lowest during 2011-12 which point

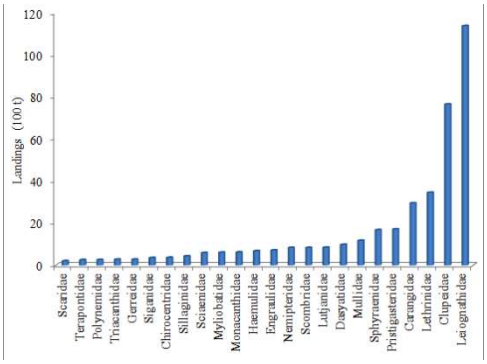

Fig. 2 — Familywise fish landings at Pamban by trawl during 2007-2012

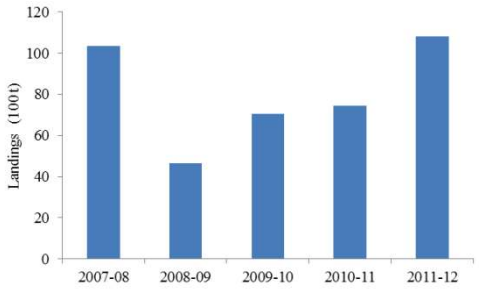

Fig. 3 — Yearwise trawl landings at Pamban during 2007-'12

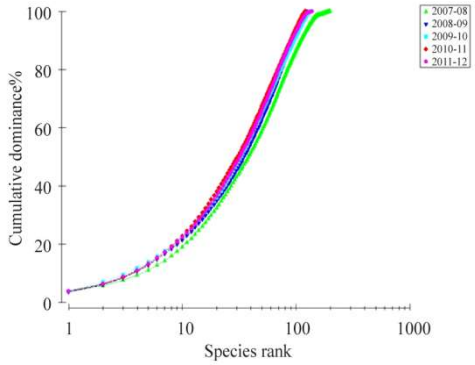

Fig. 4 — Dominance plot of fishes landed during the study period

Table 1 — Diversity indices and taxonomic attributes during the study period

	S	N	d	J'	H'(loge)	1-Lambda'	Delta	Delta+	Lambda+	Phi+
2007-08	200	3059.94	24.79	0.91	4.85	0.99	56	59.18	146.31	33.08
2008-09	130	2334.87	16.63	0.96	4.66	0.99	56.4	58.74	173.96	34.23
2009-10	137	2500.88	17.38	0.95	4.65	0.99	56.81	59.38	167.82	34.18
2010-11	121	2491.42	15.34	0.96	4.59	0.99	56.47	58.18	165.76	33.47
2011-12	139	2760.51	17.42	0.94	4.63	0.99	56.32	57.46	153.14	33.93

Table 2 — Bray-Curtis similarity of fish landings in different years during the study period

	2007-08	2008-09	2009-10	2010-11	2011-12
2007-08					
2008-09	78.22				
2009-10	78.87	83.83			
2010-11	77.98	84.29	87.20		
2011-12	79.76	80.98	84.02	84.97	

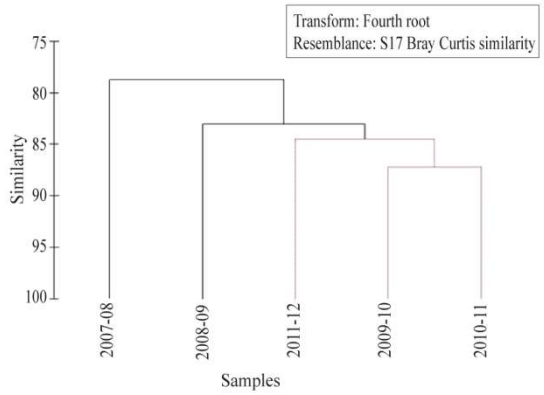

Fig. 5 — Dendrogram of fishes landed in different years

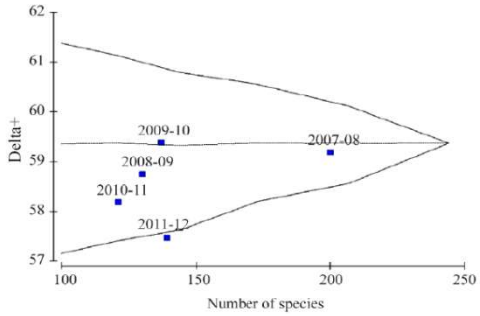

Fig. 6 — Funnel plot for average taxonomic distinctness (Δ+) showing the diversity of fishes in different years and its deviation from the normal distribution

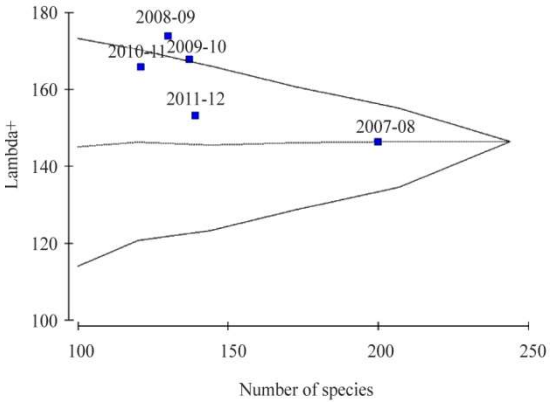

Fig. 7 — Funnel plot for variation in taxonomic distinctness (λ+) in different years

out to the availability of more closely related species during 2011-12 when compared to that of other years. Based on Δ^+ values we can classify the years into different groups namely 2007-2008 and 2009-10 having the maximum values as the first group, 2008-09, 2010-11 as the second group, 2011-12 as the third group. From the funnel plot of Δ^+against number of species (Fig. 6) this classification is visible and only 2011-12 falls outside the confidence funnel. Since the plot of 2011-12 falls very near to the expected limit and that of all other years are within the limits indicate that the taxonomic diversity in different years was almost the same.

The variation in taxonomic distinctness (λ^+) ranged between 146.31 in 2007-08 and 173.96 in 2008-09 which indicate the divergent range in taxonomic distances between pairs of species in different years (Fig. 7). Hence, the unevenness of the taxonomic tree structure was greater during 2008-09 when compared to that of other years and the same was minimum during 2007-08. But, the λ^+ for 2008-09 was not within the expected limit as that value lies outside the funnel plot. Even though the number of species was more during 2007-08, variation in taxonomic distinctness λ^+ was more during all the other years indicating the presence of more numbers at higher levels in the taxonomic tree. Average phylogenetic diversity index (Phi+) also showed the maximum during 2008-09.

Discussion

The 244 species landed by trawl at Pamban therkuvady landing centre is comparable with 223 species recorded in trawl landings at Neendakara in Kerala coast[22]. In another study conducted in the trawling grounds off Mangalore a total of 97 species were recorded[23]. Similar to the present study, the family Carangidae recorded the maximum number of species along southern Kerala also[22]. Under the family Carangidae, 20 species were recorded in the trawl landings alone at Pamban during the present study, while, from all the gears combined together the number of species observed under the family Carangidae were 57, 45, 45, 15, 27 and 26 from Tuticorin, Cochin, Mandapam, Mumbai, Karwar and Vizhinjam coasts of India respectively[24]. And from trawl landings alone, 21, 19, 18 and 15 species were observed under Carangidae from Munambam, Kalamukku, Cochin Fisheries Harbour

and Neendakara respectively along southern Kerala[22]. The second dominant family, Lutjanidae comprised of 18 species recorded during the present study was also recorded from GOM by fish trawl[25] while only 10 species were observed in trawl landings from southern Kerala[22].

As in the present study the dominance of *Karalla dussumieri* among different species of silverbellies in trawl fish landings at Pamban was also reported in a study conducted during 1996-2000[26]. In a trawling survey also the dominance of *Leiognathus dussumieri* (now valid as *Karalla dussumieri*) in GOM was observed which is similar to the present observation[27]. It was also found that silverbellies dominated in the total catch followed by lesser sardines, sciaenids, *Pellona*, rays, carangids, etc.[27] while during the present study, the abundance were in the order silverbellies, clupeids, lethrinids, carangids, etc. Hence, a notable change in the composition of fishes in GOM was noticed during the past several years.

Dominance of silverbellies in GOM was recorded by earlier workers also[1,27]. While analysing the trawl landings in GOM for the past ten years (1997 - 2006), it was evident that silverbellies dominated in all these years as per the records from National Marine Fisheries Data Centre (NMFDC) of CMFRI. In another study, silverbellies was found to be the most abundant constituent followed by clupeids in the trawl fishery of Tamilnadu during 1985-2000[28]. Hence, the dominance of silverbellies in trawl landings is not restricted to Pamban landing centre alone but it was true for the GOM ecosystem and the entire state of Tamil Nadu.

While analysing the share of silverbellies in total landings, it was observed that during 1964-65, the catches of the Indo-Norwegian project vessels had 90.8% silverbellies from GOM[29] while, 82.1% of silverbellies was recorded in a trawling survey conducted by *Cadalmin II* during 1977-80[27]. Apart from the trawling surveys, the analysis of trawl landings from GOM during 1995-2012 collected from NMFDC of CMFRI indicated no particular trend in the share of silverbellies in trawl landings and it was found to fluctuate between 10.78% in 2009 and 36.97% in 2006. At Pamban, the share of silverbellies was found to be in the range of 17.8 - 30.2% out of the total fish landings by trawl during 1996-2000[26] and during the present study, silverbellies contributed 22-34%. This indicates a fluctuating trend in the share of landings of silverbellies in total fish catch. Also, the share of silverbellies in trawling surveys was found to be higher than that from the landings and this may be due to the unaccounted quantities of silverbellies as discards by trawls.

The sudden decline in total fish landings in 2008-09 during the present investigation can be due to the incidence of an algal bloom in GOM during October, 2008[30]. Since the intensity of the algal bloom was very high causing death of a large number of fishes in that area, the revival in fishery was very slow and this may be the reason for the gradual increase in landings and attaining normalcy in 2011-12. If such an outburst of algal bloom was not there, the landings would not have affected that much and it would have been almost steady. Here, it is significant to note that in GOM, there is a self-imposed ban on fishing by nature during June to September as this region of the sea remains rough during this period. Also, there exist a closed fishing season of 45 days from 15th April. Hence, in effect, fishing will not take place nearly 6 months per year and the ecosystem will get enough time to replenish the stock and keep the ecosystem in balance.

The present work revealed the qualitative, quantitative and biodiversity aspects of the trawl fishery at Pamban therkuvady landing centre in a regional perspective. The occurrence of many threatened species as per the IUCN categorisation point out to the need for adopting conservation measures. These data have a direct application on important matters such as fisheries administration, planning and conservation. More concerted studies encompassing environmental variables have to be carried out to arrive at more meaningful conclusions.

Conclusion

In this study, the abundance of trawl landings at Pamban landing centre indicate the availability of 244 species with maximum contribution by *Karalla dussumieri* under the family Leiognathidae and maximum diversity by the family Carangidae. The landings were almost steady except for a decline in 2008-09 due to algal bloom and time taken for its recovery. The conventional biodiversity indices did not show much variation between years. The taxonomic distinctness also indicates that they are within the expected limits and does not show much variation from the normal distribution. But, the availability of endangered and vulnerable species in the landings is of great concern. Since such a systematic study is conducted for the first time, this can act as a baseline for the managers to implement

proper planning and conservation measures in the long-term scenario in Gulf of Mannar.

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