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Diversity of invertebrate trawl bycatch off Cuddalore, Parangipettai and Pazhayar, south-east coast of India

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ABSTRACT

Invertebrate diversity along the south-east coast of India is rich and varied. Though many studies with respect to finfish bycatch resources have been carried out during yesteryears, only scanty information is available on invertebrate bycatch from tropical waters. The importance of invertebrates caught in the trawl bycatch has been recognised only recently by the scientific community, as the utility of invertebrate bycatch is manifold. The present study was undertaken to investigate and generate information on the diversity and species richness of invertebrates landed as trawl bycatch in Cuddalore, Parangipettai and Pazhayar along the south-east coast of India. The study was undertaken in the inshore waters (5- 35 m depth) of Cuddalore, Parangipettai and Pazhayar during Feb 2010 – Jan 2011. Altogether 66 species of invertebrates in Cuddalore, 75 in Parangipettai and 76 in Pazhayar were recorded during the study. The percentage composition revealed that in Cuddalore and Parangipettai, brachyuran crabs were the dominant group (37% and 46% respectively) followed by cephalopods (35% and 31% respectively), while in Pazhayar, gastropods dominanted (29%) followed by shrimps (24%) and other invertebrates were meagre. Diversity indices estimated showed variation between the regions. Shannon-Weiner diversity index ranged from 2.035 to 4.776; Margalef's richness index from 2.306 to 6.782; Pielou's evenness index varied from 0.488 to 0.957; taxonomic diversity varied from 45.08 to 83.53 and total phylogenetic diversity ranged from 733.33 to 1716.8.

Keywords: Diversity, Invertebrates, South-eash coast of India, Trawl bycatch

Introduction

Invertebrate bycatch in trawls generally comprises benthic representatives of animal taxa such as molluscs, crustaceans and echinoderms. Despite their commercial value, some of them are occasionally discarded for various reasons (Venkataraman and Wafar, 2005, Sanchez *et al*., 2007) while others go for production of fish meal/ fertiliser. In any case, the removal of benthic community components from the sea bottom and their transportation to different areas, depths, or habitats might be of particular importance for the benthic ecosystem (Concalves *et al*., 2008). Moreover, epifaunal macrobenthic communities, which are severely disturbed by certain fishing activities, play a key role in structuring demersal fish assemblages (Colloca *et al*., 2003). Macroinvertebrates especially molluscs, crustaceans and echinoderms play an important ecological role in interacting actively with other species and thereby influencing benthic community structure (Venkataraman and Wafar, 2005; Bijukumar, 2008; Wafer *et al*., 2011). Thus, the relationship between benthic invertebrate and fish communities have been set as priority issues for the development of spatial management units, if a holistic ecosystem management approach is to be promoted (Reiss *et al*., 2009).

The incidental catch of non-target species (bycatch) represents 40.4% of the total marine catch (Davies *et al*., 2009). Kelleher (2005) estimated the fishery discards at more than 7 million tonnes, of which 27% is contributed by shrimp trawl fisheries. Although bycatch is generally inevitable, it is possible to quantify the bycatch and identify the important bycatch species in order to reduce fishery discards and to effectively utilise the same (Kennelly and Broadhurst, 2002).

In recent years, there has been an increasing interest on the potentially wider impacts of commercial fishing including changes to habitats and effects on non-target species (Sanchez *et al*., 2007; Wilma Blom *et al*., 2009; Voultsiadou *et al*., 2011). Particular concern has been raised with regard to bottom trawling where intensive fishing may result in significant alterations to the benthic environment and associated communities (Alverson *et al*., 1994; Dayton *et al*., 1995). Many studies have been undertaken in this

line, which focused mainly on specific groups such as molluscs (Victor and Lazarus, 2000; Babu *et al*., 2010), crustaceans (Ajmal Khan and Jayabaskar 1999; Bijukumar *et al*., 2007) and echinoderms (Balaji *et al*., 2007; James, 2008). Howerver, information with respect to invertebrate bycatch as a whole, is meagre since attempts were not made to study and generate information in this line. Therefore, the present study was undertaken to have a thorough knowledge on the diversity of invertebrates caught in the trawls operated from three locations along the south-east coast of India.

Materials and methods

Bycatch samples were collected once in a month from the trawls operated in the inshore waters (5 – 35 m depth) of Parangipettai (lat. 11º 24' N; long. 79º 46' E), Cuddalore (lat. 11^0 43' N; long. 79^0 49' E) and Pazhayar (lat. 11^0 21' N; long. 79^0 50'E), along the south-east coast of India during February 2010 to January 2011 (Fig. 1). The organisms were collected by adopting visual census method and preserved in 5-8% neutralised formalin. The morphological characters of the specimens were examined and each species was identified up to species level following standard references (Antony Fernando and Olivia Fernando, 2002; Chhapgar, 2005). Further, the data was analysed for various diversity indices using PRIMER (version 6.1.5) and ORIGIN 6.0 statistical software.

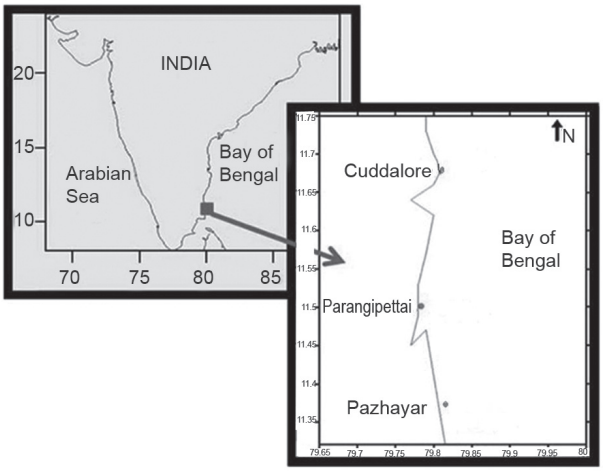

Fig. 1. Map showing the study area

Results and discussion

In the present study, nine invertebrate taxa *viz.*, cnidarians (scyphozoa), crustaceans (shrimps, brachyuran crabs, stomatopods), molluscs (gastropods, bivalves, cephalopods), and echinoderms (echinoidea, asteroidea) were recorded. Altogether 84 species were identified from the three areas, out of which 36 were gastropods, 17 bivalves, 6 cephalopods, 13 brachyuran crabs, 5 shrimps, 2 species each were stomatopods, echinoids, asteroids and 1 scyphozoan.

In Cuddalore, as many as 66 species were recorded which included 29 species of gastropods, 14 bivalves, 5 cephalopods, 7 brachyuran crabs, 5 shrimps, 2 each of stomatopods, echinoidea, one each of asteroidea and scyphozoa. In Parangipettai coastal waters, 75 species were found, of which 30 belonged to gastropods, 16 to bivalves, 6 to cephalopods, 12 to brachyuran crabs, 5 to shrimps, 2 each to echinoids and asteroides, and one scyphozoan. At Pazhayar, 76 species were encountered which consisted of 33 gastropods, 17 bivalves, 6 cephalopods, 9 brachyuran crabs, 5 shrimps, one each of stomatopod and scyphozoan, 2 each of echinoids, and asteroids (Table 1). Sakthivel (2000) reported 75 species of gastropods, 33 species of bivalves, 35 species of crabs and 15 species echinoderms in Mudasalodai and Nagapattinam coastal waters, south-east coast India. Bijukumar (2008) reported 135 species of molluscs, 72 species of arthropods, 18 species echinoderms, 10 species of porifera and cnidarians and one species each of bryozoa and sipunculida along the south-west coast of India. The results of the above said reports are in good agreement with the results of the present study as the high abundance of molluscans followed by arthropods and echinoderms were reported along the Indian coast.

When the results of species-wise distribution were viewed, *Architectonica perspectiva, Babylonia spirata spirata, B. zeylanica, Bursa spinosa, Chicoreus ramosus, Conus amadis, Ficus ficus, Harpa conoidalis, Hemifusus cochlidium, H. pugilinus, Murex tribulus, M. trapa, Natica didyma, Tonna dolium, Turritella attenuata, T. acutangula* and *Umbonium vestiarium* in gastropods; *Anadara inequivalvis, A. rhombea, Meretrix casta, M. meretrix, Paphia malabarica, P. textile, Perna indica, P. viridis, Placenta placenta* and *Saccostrea cuculata* in bivalves; *Loligo duvauceli, Octopus areolatus, Sepia aculata, Sepiella inermis* in cephalopods; *Calappa lophos, Podophthalamus vigil, Portunus sanguinolentus, Charybdis feriatus, C. hoplites* in brachyuran crabs; *Fenneropenaeus indicus, P. monodon, Metapenaeus affinis, M. dobsoni* in shrimps and *Salmasis bicolor, Astropecten indicus* in echinoderms were found to be commonly occurring species in all the three stations during the study period.

The percentage composition of invertebrates recorded in the three stations are shown in Fig. 2 - 4. In Cuddalore, brachyuran crabs were found to be the dominant group constituting 37% of the total invertebrates recorded. Cephalopods formed second dominant group with a percentage of 35%; shrimps with 10%; gastropods, echinoderms, bivalves, stomatopods and cnidarians came

Table 1. Invertebrates recorded in the trawl bycatch from the three sampling stations along the south-east coast of India

Family/Species	Cuddalore	Parangipettai	Pazhayar
Cnidaria			
Ulmaridae			
Aurilia solida	17	14	8
Shrimps			
Penaeidae			
Fenneropenaeus indicus	235	48	80
Penaeus monodon	27	20	53
Metapenaeus affinis	46	29	31
M. monoceros	35	20	12
M. dobsoni	49	27	68
Brachyuran crabs			
Calappidae			
Calappa lophos	103	61	38
Portunidae			
Charybdis feriatus	22	6	17
C. granulata	-	10	-
C. hoplites	4	9	1
C. lucifera	17	10	27
C. truncata	-	3	4
Podophthalmus vigil	8	31	31
Portunus pelagicus	25	18	-
P. sanguinolentus	52	25	37
Thalamita crenata	10	2	-
Dorippidae			
Dorippe facchino	-	4	9
Leucosiidae			
Philyra scabriuscula	-	2	1
Stomatopods			
Squillidae			
Harpiosquilla indica	15	27	53
Squilla mantis	5	-	-
Gastropods			
Architectonicidae			
Architectonica perspectiva	1	1	5
Buccinidae			
Babylonia spirata spirata	9	13	17
B. zeylanica	16	14	15
Bursa spinosa	26	13	3
B. rana	-	5	5
Conidae			
Conus amadis	1	5	5
C. inscriptus	-	4	1
C. betulinus	1	-	3
Ficidae			
Ficus ficus	13	13	25
F. gracilis	1	-	10
F. subintermedius	-	3	-
Fasciolaridae			
Fusinus longicaudatus	2	2	1

Family/Species	Cuddalore	Parangipettai	Pazhayar
Harpidae			
Harpa conoidalis	5	4	6
Melongenidae			
Hemifusus cochlidium	19	25	21
H. pugilinus	16	10	15
Turridae			
Lophiotoma indica	2	10	2
Turricula javana	3	3	8
Muricidae			
Murex ternispina	4	3	2
M. trapa	4	5	7
M. tribulus	16	10	25
M. virgineus	4	-	2
Chicoreus ramosus	26	13	3
Nassaridae			
Nassarius dorsatus	3	7	2
Natica didyma	1	6	17
N. macrochiensis	-	2	-
N. tigrina	4	6	11
Fasciolaridae			
Pleuroploca trapezium	14	7	3
Cassidae			
Phalium canaliculatum	-	-	5
Naticidae			
Rapana bulbosa	-	1	6
Tonnidae			
Tonna dolium	12	6	6
T. sulcosa	-	1	3
Turbinellinae			
Turbinella pyrum	-	-	4
Turritellidae			
Turritella turitella	6	-	-
T. acutangula	23	9	8
T. attenuata	15	8	28
Trochidae			
Umbonium vestiarium	2	12	7
Bivalves			
Arcidae			
Anadara inequivalvis	38	19	21
A. granosa	5	16	1
A. rhombea	17	-	2
Cardiidae			
Cardium setosum	7	9	13
Cucullaeidae			
Cucullea cucullata (*labiata*)	-	3	3
Ostreidae			
Crassostrea madrasensis	-	10	5
Saccostrea cucullata	3	3	7
Donacidae			
Donax cuneatus	-	3	5

Family/Species	Cuddalore	Parangipettai	Pazhayar
Veneridae			
Katelysia opima	19	6	6
Meretrix casta	10	6	1
M. meretrix	16	2	4
Paphia malabarica	4	1	12
P. textile	3	3	12
Pectinidae			
Pecten tranquebaricus	2	1	2
Mytilidae			
Perna indica	2	8	4
P. viridis	5	7	3
Placunidae			
Placenta placenta	15	11	8
Cephalopods			
Octopodidae			
Hapalochlaena fasciata	-	7	11
Octopus areolatus	144	78	20
Loligonidae			
Loligo duvauceli	154	244	35
Sepiidae			
Sepia aculeata	18	11	3
S. pharonis	3	2	14
Sepiella enermis	3	3	11
Echinoderms			
Astropectinidae			
Astropecten indicus	3	4	3
Goniasteridae			
Stellaster incei	2	3	16
Temnopleuridae			
Salmasis bicolor	5	9	12
Salmasis virgulata	-	2	8

next in the order with percentage contributions of 6, 5, 3, 3 and 1% respectively (Fig. 2).

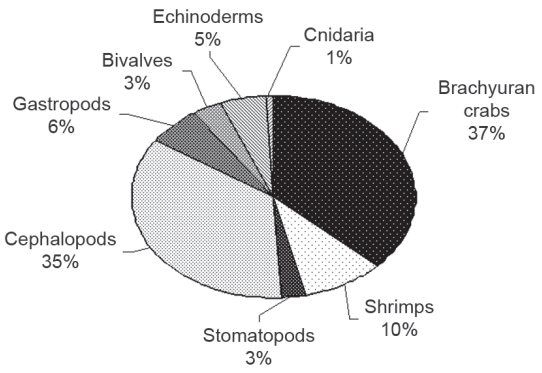

Fig. 2. Percentage composition of invertebrates recorded in trawl bycatch from Cuddalore coastal waters

In Parangipettai, as found in Cuddalore, brachyuran crabs topped the list with 46%; cephalopods ranked second with 31%; gastropods formed the next dominant group with 7%; shrimps, echinoderms, bivalves, stomatopods and cnidarians came next in the order with 6,, 4, 3, 2, and 1% respectively (Fig. 3).

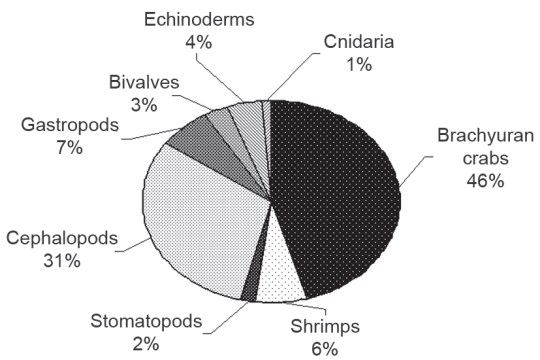

Fig. 3. Percentage composition of invertebrates recorded in trawl bycatch from Parangipettai coastal waters

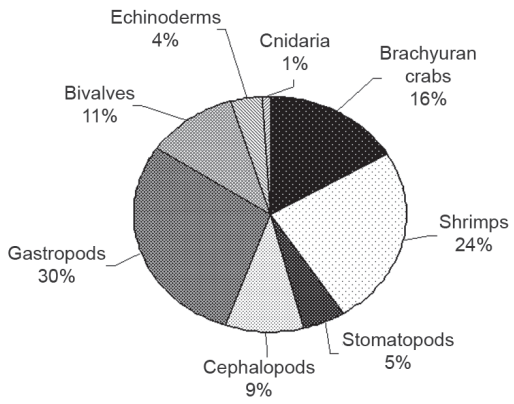

Fig. 4. Percentage composition of invertebrates recorded in trawl bycatch from Pazhayar coastal waters

In Pazhayar, gastropods emerged as dominant group (30%). Shrimps were found to be the second dominant group with 24%. Brachyuran crabs formed the third dominant group (16%). Bivalves, cephalopods, stomatopods, echinoderms, and cnidaria recorded next in the order with percentage contributions of 11, 9, 5, 4 and 1%, respectively (Fig. 4).

In the present study, molluscs (gastropods) and crustaceans (brachyuran crabs) were found to be the dominant groups. Studies done elsewhere also reported that the molluscs and crustaceans are the most important components of benthic assemblages (Bastida *et al*. 1992; Roux *et al*. 1993; Bremec and Roux, 1997; Klein *et al.* 2001; Riestra *et al*. 2006; Serrano *et al.*, 2006; Garcia Munoz *et al*., 2008). Such a preponderance of gastropods and brachyuran crabs in invertebrate samples was also reported by Venkatraman and Wafar (2005), Tissot *et al*. (2006) and Daminnidis *et al*. (2007). Recently Voultsiadou *et al*. (2011) reported that molluscs were the most diverse group (39% of the total number of species) followed by crustaceans (23%) and echinoderms (17%) in Thermaikos Gulf (North Aegean Sea).

As regards diversity indices, in Cuddalore, the Shannon–Weiner index ranged between 2.691 and 4.277 with minimum during March and maximum during June (2010); species richness from 2.306 to 5.802 with minimum during December and maximum during June (2010); evenness index from 0.594 to 0.943 with minimum during March and maximum during August (2010). The taxonomic diversity varied from 59.44 to 81.78 with minimum during June and maximum during March; total phylogenetic diversity ranged from 733.3 to 1783.3 with minimum during December and maximum during June (2010) (Fig. 5).

In Parangipettai, the Shannon–Weiner index ranged from 2.035 to 4.216 with minimum during October and maximum during February (2010); species richness from 3.175 to 5.120 with minimum during November (2010) and maximum during January (2011); and evenness index from 0.488 to 0.955 with minimum during February and maximum during July (2010). The taxonomic diversity varied from 45.08 to 81.68 with minimum during January and maximum during October and total phylogenetic diversity ranged from 883.3 to 1516.7 with minimum during July (2010) and maximum during January (2011).

In Pazhayar, the Shannon–Weiner index ranged from 3.501 to 4.776 with minimum during June and maximum during February (2010); species richness ranged from 4.039 to 6.782 with minimum during July and maximum during April (2010); the evenness index varied from 0.827 to 0.957 with minimum during December and maximum during January (2011); the taxonomic diversity varied from 69.34 to 83.53 with minimum during December and maximum during July and total phylogenetic diversity ranged from 1033.3 to 1716.7 with minimum during June and maximum during February (2010).

Among the stations, maximum (4.776) diversity was recorded in Pazhayar coastal waters compared to Cuddalore and Parangipettai. This might be due to more number of trawlers operated and also nature of the substratum which favours colonisation of more benthic invertebrates in that region. Similar findings were reported earlier by Sakthivel (2000). The Shannon diversity index values in the three areas clearly showed the diverse nature of invertebrates, so also Margalef richness index and evenness index, which is again vouching for the rich diversity. As there are only few works pertinent to invertebrate diversity, the results of the present study could not be discussed in detail.

In the dendrogram drawn through Bray–Curtis similarity, Parangipettai and Pazhayar formed a group at 99% similarity level to which Cuddalore joined at 96%. Samples collected from Parangipettai and Pazhayar were found lying closer showing more similarity in species composition and abundance than Cuddalore which was evident in species list as well (Fig. 6).

While comparing the three stations, Pazhayar and Parangipettai showed more invertebrate diversity than Cuddalore. It is also inferred that the invertebrates caught in trawlers constitute more than 70% of the total bycatch, which has become a matter of great concern among the scientific community. This can be minimised especially by mesh size regulation, particularly in bottom trawling. The results of the study also suggest that the use of certain strategies like introduction of bycatch reduction device can help to reduce the bycatch in these fisheries and efforts should be centered on the most commonly occurring and sensitive groups. Since the invertebrates play a significant

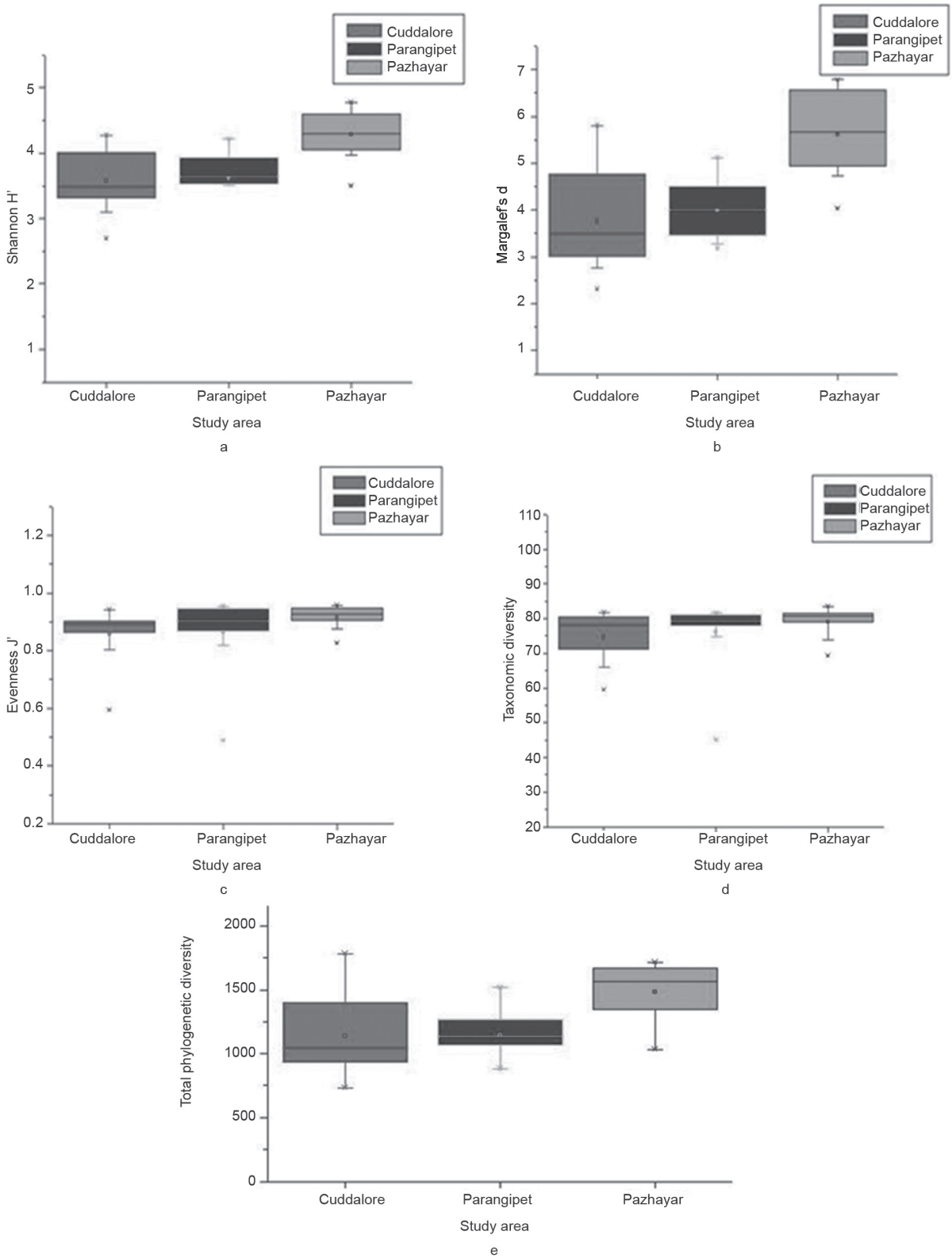

Fig. 5. Univariate measures for invertebrate trawl bycatch of Cuddalore, Parangipettai and Pazhayar coast.
a) Shannon-Weiner index, H'; b) Margalef's richness d; c) evenness J', d) Taxonomic diversity; e) Total phylogenetic diversity. *Data presented as mean (squares); ±1 SE (boxes) and ±1 SD (whiskers). Upside-down triangles: minimum; right-side-up triangles: maximum*

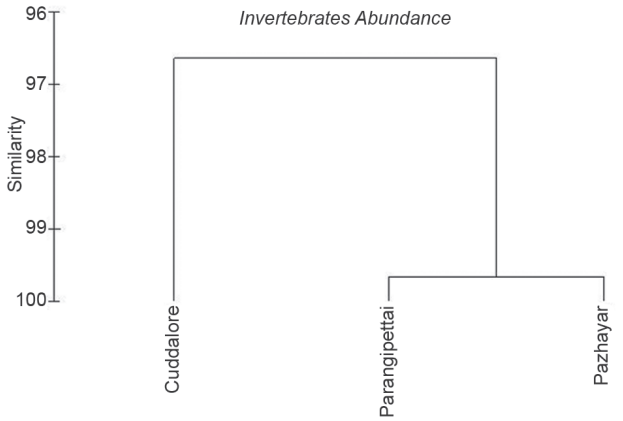

Fig. 6. Dendrogram showing similarity between three regions

role for ensuring the food security of low and middle income people, steps need to be initiated for effective utilisation of the bycatch landed.

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