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Fish biodiversity in coral reefs and lagoon at the Maratua Island, East Kalimantan

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ABSTRACT

Madduppa HH, Agus SB, Farhan AR, Suhendra D, Subhan B. 2012. Fish biodiversity in coral reefs and lagoon at the Maratua Island, East Kalimantan. Biodiversitas 13: 145-150. Fishes are one of the most important biotic components in the aquatic environment. They are filling different habitats, including coral reef and lagoon. This study aims to (i) assess biodiversity in coral reef and lagoon in Maratua Island, East Kalimantan, and (ii) compare the fish community indices (Shannon-Wiener diversity, Evenness, and Dominance) between the coral reef and lagoon. A total of 159 fish species of belonging to 30 families were observed during five visual census of the study period. The number of species on coral reefs is higher (121 species) than in the lagoons (47 species). Relative abundance (%) of each species also varied and did not form a specific pattern. However, a clear cluster between the coral reef and lagoon habitats from fish relative abundance based on multivariate analysis and dendogram Bray-Curtis Similarity was revealed. The Evenness index value (E) ranged from 0.814 to 0.874, the dominance index (C) ranged from 0.023 to 0.184, and the Shannon-Wiener diversity index (ln base, H') ranged from 1.890 to 4.133. Fish biodiversity in coral reefs was higher (H'= 3.290±0.301) than in the lagoon (H' = 2.495±0.578).

Key words: diversity index, Maratua Island, lagoon, fish visual census, reef fishes

INTRODUCTION

Fishes are one of the most important biotic components in the aquatic environment. They fill a very specific habitat by meeting a variety of waters substratum. Several studies have mentioned the importance of glittering fish communities in ecosystem processes through trophic relationships with other biotic components (e.g. Carrasson and Cartes 2002). Coral reefs are used by fishes as a territorial (Robertson et al. 1976), a feeding ground (Reese 1981), as a place to hide (Hixon 1991), and as a reproduction and spawning ground (Wootton 1992). Fish reach their high biodiversity in coral reef ecosystem (Allen and Werner 2002), especially in Indonesia (Allen and Adrim 2003). Indonesian coral reefs harbour more than 2000 fish species (Allen and Adrim 2003). Consequently, Indonesia has been declared as the centre of marine biodiversity (Allen 2008; Allen and Werner 2002).

Lagoon ecosystem is one of shallow water ecosystems that are separated by barrier islands or coral from larger water systems, which is characterized by predominant sand substratum (Hutomo and Moosa 2005). Sedberry and Carter (1993) states that due to differences in characteristics of the substrate between coral reef and lagoon area, the fish community will be different in terms of composition, relative abundance and biomass. In addition, lagoon surrounded by a coral reef may have similar to the biota of coral reef ecosystem, because corals may grow on hard substrate at its leeside with a variety of coral lifeforms (Hutomo and Moosa 2005).

Maratua Island, one of the islands in Derawan Islands, has a land area of 384.36 km^2 and sea area of 3735.18 km^2, which is fringed with coral reefs, lagoon and uplifted atoll (Tomascik et al. 1997). Geographically the island is situated on a peninsula north of Berau seas (02°15'12" N and 118°38'41" E). Maratua's climatic conditions in the region are affected by the rainy season (October-May) and dry season (July to September). Oceanographic factors influenced the seasonal movement of currents and Indonesian Trough Flow (Arlindo) from the Pacific to the Indian Ocean through the Straits of Makassar (Wyrtki 1961). These conditions create an environment that supports a high biodiversity of marine organisms, especially in fish.

However, documentations of the biodiversity of marine organisms such as fish in Maratua Island are poorly known. The island's coral reefs are threatened by many anthropogenic pressures like other Indonesian reef system that potentially lead many organisms to extinction. Therefore, this study aims to (i) assess fish biodiversity at the coral reefs and lagoons in Maratua Island, East Kalimantan, and (ii) compare the fish community indices between the reef and lagoon.

MATERIAL AND METHODS

Study sites and periods

The reef fish communities on the island of Maratua were observed at the two stations on the reef slope (Maratua 1, and Maratua 2) and three stations for the lagoon (Tanjung Duwata, Karang Bentukan, and Buar) (Figure 1). The study was conducted on 27-28 November 2005 and November 13 to 14, 2006 (Table 1).

Table 1. Information on data collection for each site

Sites	Geographical position N	Geographical position E	Study period
Coral reefs:			
Maratua 1	2° 16' 51.806"	118° 33' 45.003"	13-11-2006
Maratua 2	2° 15' 42.705"	118° 33' 26.999"	14-11-2006
Lagoons:			
Tanjung Duwata	2° 9' 50.809"	118° 38' 45.014"	27-11-2005
Karang Bentukan	2° 7' 8.309"	118° 42' 23.888"	27-11-2005
Buar	2° 12' 14.387"	118° 37' 12.515"	28-11-2005

Data collection

The location of the study sites were determined initially by snorkeling and observing the coral reef conditions and representative areas (3-7 meters depth). Data obtained by the method of fish visual census along 50 m transect line (English et al. 1997). A total of two transects were laid on coral reefs, and three transects on lagoon. The fish transect lines are straight and follow the depth contour. The basic unit of data collection for the fish visual census was 50 m x 5 m (250 m^2). The procedure was to wait for at least 10 minutes before surveying reef fish species (Halford and Thompson 1994), and the approximate time of fish census was up to 60 minutes for each transect. The SCUBA observer swims slowly along transect and recording fish encountered within 2.5 m on both side and 5 m above transect. After data collection, reef fish identification was confirmed by using several fish identification books, i.e. Allen (2000) and Lieske and Myers (2001).

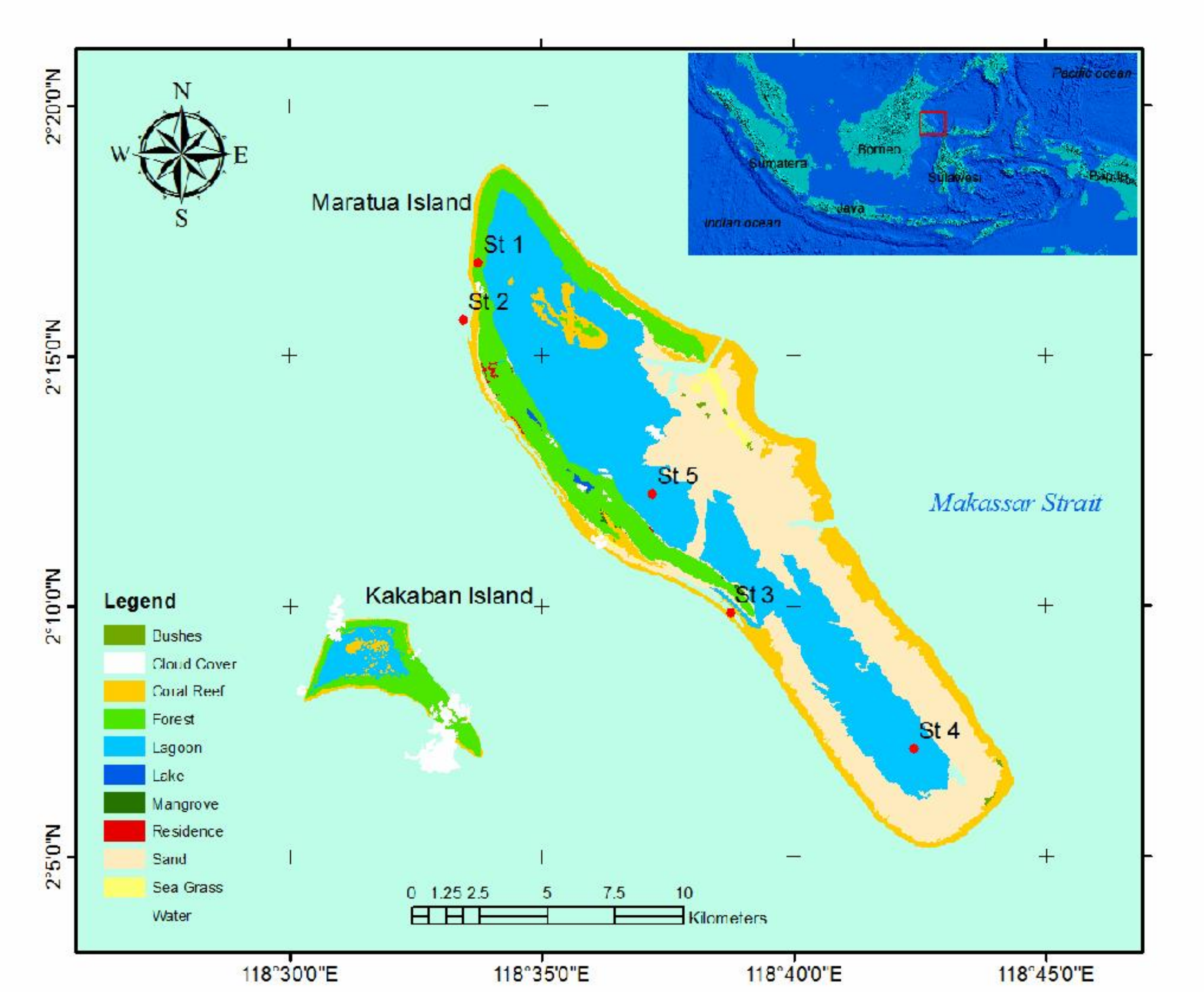

Figure 1. Map of study sites: the reef slope (station 1 and 2) and the lagoon (stations 3, 4 and 5) on the island Maratua within Derawan Islands, East Kalimantan. Insert: Maratua Island in relation to Indonesia indicated by a red box.

Data analysis

Shannon-Wiener Diversity Index (*H'*; ln basis), Evenness Index (E), and Simpson Dominance Index (C) (Odum 1971; Magurran 1988; Ludwig and Reynolds 1988; Smith 2002), as well as species richness and their relative abundance were compared among sites. In addition, functional categories (target, major and indicator) were analyzed. The target fish is individual fish that has economic value and food resources for fishermen. This group is also known as the economically important fish or fish consumption. The indicator fish is group of fish that determines the health of coral reefs. This is caused by the strong relationship between the fish and coral, such as Family Chaetodontidae. Member of chaetodonthids used coral reefs as a source of food. The major fish is fish groups that are not included in the targets and indicators. This group is generally found in large quantities and many of them are traded as marine ornamental fish. Non-metric Multidimensional Scaling (MDS) and similarity dendogram were used to visualize the differences in fish communities of the two different habitats (coral reefs and lagoons) (Shepard 1962; Kruskal 1964) by using PRIMER-5 software (Clarke and Gorley 2001). MDS was based on Bray-Curtis similarities. The quality of the MDS plot is indicated by the stress value. Values <0.2 give a potentially useful 2-dimensional picture, stress <0.1 corresponds to a good ordination and stress <0.05 gives an excellent representation (Kruskal 1964; Field et al. 1982; Clarke 1993). This approach has been widely applied to multivariate analysis of the various communities (Field et al. 1982; Clarke and Green 1988).

RESULTS AND DISCUSSION

Fish community structure

A total of 2145 individuals from 160 species of fish belonging into 30 families were observed in this study (Table 2). The number of species on coral reefs was higher (121 species) than in the lagoons (47 species). List of families that have three top species composition in coral reef areas were Pomacentridae, Labridae and Acanthuridae, while in the lagoon were Pomacentridae, Chaetodontidae, and Nemipteridae (Figure 2). These families are also mainly observed on the other coral reefs around Indonesia (Estradivari et al. 2007; Ferse 2008).

Fish abundance in the coral reef was higher (690±163 individual/250 m^2) than in the lagoon (255±92 individual/250 m^2), and relative abundance (%) of each species also varied over study sites (Table 2). A clear difference between the reef and lagoon habitats based on MDS and dendogram was revealed (Figure 3). This is similar with other study that showed differences in fish community based on the abundance of species from the results of the multivariate analysis (Madduppa et al. 2012). The presence of reef fish in the waters depends on coral health indicated by the percentage of live coral cover. It is very possible because of the live reef fish associated with the shape and type of coral as a shelter, protection and places to look for food (Madduppa 2006). Besides the health of coral, reef structure complexities have enriched reef fishes (Nybakken 1992).

Reef fish communities observed in this study were grouped into three functional categories (Table 2). The target fish families were observed in the study sites as follows: Haemulidae, Nemipteridae, Serranidae and Pomacanthidae. The target fish in the coral reef stations (40±8 species/250 m^2) were greater than in the lagoons (7±2 species/250 m^2). The presence of the target fish in the coral reef ecosystem are due to searching for food (feeding ground) or spawning and nursery. In the Philippines, many coral reef fishes are caught for the small-scale fisheries including surgeonfish, groupers, and snappers (Amar et al. 1996).

A total of 16 species of fish were found in all indicators of the study sites. Groups of fish indicators also showed a similar pattern in the area where the coral reef was higher (7±1 species/250 m^2) than in the lagoon (3±2 species/250 m^2). Due to their greatest biodiversity in coral reef ecosystems (Allen and Werner 2002) and their interdependence to the health of coral reef ecosystem (Hourigan et al. 1988), chaetodontid has been considered as a reliable way to indirectly assess the changes of a coral reef and monitor it through time (Tanner et al. 1994; Markert et al. 2003). Many members of Chaetodontidae are highly dependent on live coral polyps, and multiple studies have proven that they are corallivorous (e.g. Harmelin-Vivien and Bouchon-Navaro 1983; Pratchett 2005; Reese 1981; Birkeland and Neudecker 1981; Alwany et al. 2003; Madduppa 2006).

The major groups of fish on the coral reefs stations were higher (39±7 species/250 m^2) than in the lagoon (13±4 species/250 m^2). Function and role of the fish were not yet clear but could be as one link in the ecological system and food webs in coral reef ecosystems. Major fish species are found mainly from the family Pomacentridae.

Fish biodiversity

The Evenness index (E) value ranging from 0814 to 0874, the dominance index (C) 0023-0184 range, and the value of diversity index (H ') ranged from 1.890-4.133. Fish communities in reef areas were more diverse (H '= 3290±0301) than in the lagoon (H' = 2495±0578) (Figure 4). The value of diversity can indicate the level of stress or pressure received by the species from the environment (Lardicci et al. 1997). In the lagoon, reef fish communities in the lagoon which is located outside near reef edge (Station 3, see Figure 1) was higher in comparison with two other lagoon stations which are located in the inside (Station 4 and 5). This is similar to Hutomo and Moosa (2005) that fish communities in the lagoon near coral reefs is highly influenced by the benthic community (including corals).

Diversity of species of reef fish have a close relationship with the characteristics of the substrate in the area, such as the existence of the herbivorous fishes of the family Scaridae, because of dead coral covered with macroalgae (Madduppa et al. 2012). The fish will tend to

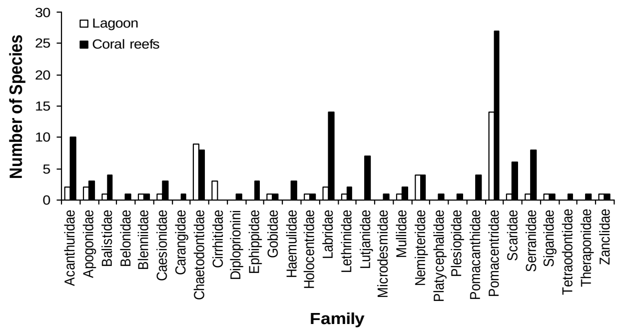

Figure 2. Comparison of the number of species of fish from each family were found among the coral reefs and lagoons

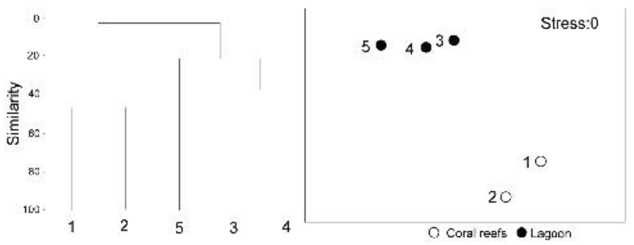

Figure 3. Multivariate analysis: (left) Bray-Curtis Similarity and (right) non-metric MDS (multidimensional scaling) of the fish community based on the relative abundance of each species per station on coral reefs (1 and 2) and in the lagoon (3, 4 and 5)

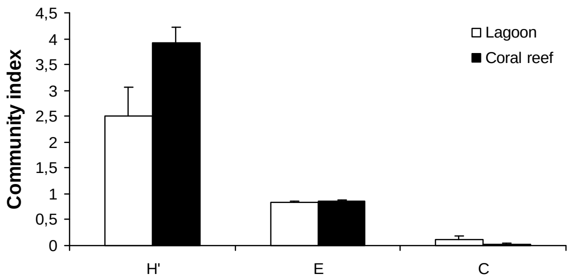

Figure 4. Comparison of reef fish community index values between the lagoon and reef slope are seen from the value of Shannon-Wiener diversity (H '), Evenness (E), and Dominance (C)

cluster in certain forms of corals and generally have limited movement compared to other invertebrates that have the same size cite. Because the reef fish communities have a close relationship with the coral reefs as a habitat, so that if a high percentage of dead coral will cause a significant decrease in the number of fish species and individuals associated with coral reefs cite. The current study observed that some fishes found in a specific habitat, but many species were found in more than one habitat. Generally each species has specific habitat preferences (Hutomo 1986), and they have two different interaction mode in coral reefs: direct interaction (e.g. as a refuge from predators or prey, interactions in search of food the relationship between corals and fish that live on the reef biota, including algae) and indirect interaction due to reef structure and hydrology and sediment (Choat and Bellwood 1991).

Table 2. List of taxa, number of individual (±SE individual/250 m^2), species richness (±SE species/250 m^2), fish categorical function (±SE species/250 m^2, T=Target, M=Major, I=Indicator), and relative abundance (%) for each species at each site (1 and 2 = reef slope, 3-5 = lagoon).

Taxa (family/species)	Category	Relative abundance (%) 1	2	3	4	5
Acanthuridae						
Acanthurus auranticavus	T	1.3	-	-	-	-
Acanthurus gahhm	T	0.8	2.3	-	-	-
Acanthurus leucocheilus	T	0.8	-	-	-	-
Acanthurus leucosternon	T	0.1	1.1	-	-	-
Acanthurus lineatus	T	-	0.4	-	-	-
Acanthurus thompsoni	T	0.8	2.1	-	-	-
Naso annulatus	T	0.2	0.2	-	-	-
Naso brevirostris	T	-	0.2	-	-	-
Naso lituratus	T	0.4	-	-	-	-
Naso sp.	T	-	-	1.9	6.4	-
Paracanthurus hepatus	T	-	-	11.3	-	-
Zebrasoma scopas	T	2.2	2.1	-	-	-
Apogonidae						
Apogon cavitienis	M	-	-	-	21.3	-
Apogon cookie	M	-	-	5.8	-	-
Apogon doederleini	M	2.7	4.0	-	-	-
Apogon kauderni	M	-	1.3	-	-	-
Sphaeramia nematoptera	M	0.5	0.8	-	-	-
Balistidae						
Balistapus undulatus	M	-	0.2	-	-	-
Balistoides viridescens	M	0.1	-	-	-	-
Odonus niger	M	-	-	3.0	-	-
Pseudobalistes flavimarginatus	M	-	5.1	-	-	-
Pseudobalistes fuscus	M	1.6	0.2	-	-	-
Belonidae						
Strongylura incisa	M	1.1	-	-	-	-
Meiacanthus vittatus	M	0.1	-	0.3	-	-
Caesionidae						
Caesio cuning	T	0.1	0.2	-	-	-
Caesio lunaris	T	0.1	0.2	-	-	-
Caesio teres	T	0.1	-	-	-	-
Caesio xanthonota	T	-	-	0.3	-	-
Carangidae						
Gnathanodon speciosus	T	-	0.2	-	-	-
Chaetodontidae						
Chaetodon auriga	I	-	-	0.6	-	-
Chaetodon collare	I	-	-	0.8	-	-
Chaetodon collare	I	-	-	0.3	0.9	-
Chaetodon decussatus	I	-	-	-	0.6	-
Chaetodon decussatus	I	-	-	0.8	-	-
Chaetodon ephippium	I	-	-	2.2	-	-
Chaetodon guttatissimus	I	0.4	0.2	0.6	-	-
Chaetodon melapterus	I	0.2	0.2	-	-	-
Chaetodon meyeri	I	0.6	0.6	-	-	-
Chaetodon rafflesi	I	-	0.2	-	-	-
Chaetodon trifascialis	I	0.1	-	-	-	-
Chaetodon trifasciatus	I	0.2	2.3	-	-	-
Chaetodon vagabundus	I	0.1	-	-	-	-
Chelmon rostratus	I	-	-	0.3	-	-
Hemitaurichthys polylepis	I	1.3	0.4	-	-	-
Parachaetodon ocellatus	I	-	-	12.9	-	-
Cirrhitidae						
Paracirrhites arcatus	M	-	-	-	9.7	-
Paracirrhites forsteri	M	-	-	6.3	2.7	31.5
Paracirrhites nisus	M	-	-	-	2.4	-
Diploprionidae						
Diploprion bifasciatum	M	-	0.6	-	-	-
Platax orbicularis	M	4.1	-	-	-	-

Platax pinnatus	M	0.4	-	-	-	-
Platax teira	M	0.1	-	-	-	-
Gobiidae						
Gobi sp.	M	1.1	-	-	-	-
Istigobius nigroocellatus	M	-	-	1.4	-	2.7
Haemulidae						
Plectorhinchus sordidus	T	0.2	-	-	-	-
Plectorhinchus flavomaculatus	T	0.7	-	-	-	-
Plectorhinchus chaetodonoides	T	0.2	7.8	-	-	-
Holocentridae						
Myripristis amaena	T	-	-	-	3.3	-
Sargocentron caudimaculatus	T	1.5	0.4	-	-	-
Labridae						
Bodianus mesothorax	T	0.1	0.4	-	-	-
Cheilinus fasciatus	T	-	0.6	-	-	-
Cheilinus oxycephalus	T	0.2	-	-	-	-
Cheilinus trilobatus	T	0.1	-	-	-	-
Choerodon zamboanga	T	0.1	-	-	-	-
Choerodon anchorago	T	0.1	-	-	-	-
Gomphosus caeruleus	T	0.1	0.9	-	-	-
Gomphosus varius	T	0.8	-	-	-	-
Halichoeres hortulanus	T	1.6	0.2	-	-	-
Halichoeres melanurus	T	0.8	-	-	-	-
Halichoeres ornatissimus	T	0.5	0.2	-	-	-
Halichoeres purpurascens	T	-	-	1.9	0.9	-
Labroides dimidiatus	M	1.4	-	0.8	-	-
Thalassoma grammaticum	M	0.8	4.2	-	-	-
Thalassoma lunare	M	2.9	-	-	-	-
Lethrinidae						
Gymnocranius griseus	T	0.1	0.2	-	-	-
Monotaxis grandoculis	T	0.1	-	0.3	-	-
Lutjanidae						
Lutjanus decussatus	T	2.6	-	-	-	-
Lutjanus ehrenbergii	T	-	0.2	-	-	-
Lutjanus fulviflamma	T	-	0.4	-	-	-
Lutjanus kasmira	T	-	0.9	-	-	-
Lutjanus quinquelineatus	T	1.9	0.2	-	-	-
Lutjanus semicinctus	T	0.1	-	-	-	-
Lutjanus vitta	T	-	0.2	-	-	-
Microdesmidae						
Ptereleotris evides	M	0.1	0.4	-	-	-
Mullidae						
Parupeneus bifasciatus	M	-	-	4.4	4.0	-
Upeneus sp.	M	0.6	0.4	-	-	-
Upeneus vittatus	M	0.5	0.4	-	-	-
Nemipteridae						
Parascolopsis eriomma	T	-	-	1.1	1.5	9.6
Pentapodus caninus	T	-	-	7.2	0.6	-
Pentapodus trivittatus	T	1.5	4.7	-	-	-
Scolopsis bilineatus	T	-	-	-	3.3	16.4
Scolopsis ghanam	T	-	-	-	0.6	-
Scolopsis lineatus	T	0.1	-	-	-	-
Scolopsis margaritifer	T	2.1	2.5	-	-	-
Scolopsis trilineatus	T	1.6	-	-	-	-
Platycephalidae						
Thysanophrys arenicola	M	5.6	-	-	-	-
Plesiopidae						
Calloplesiops altivelis	M	-	0.2	-	-	-
Pomacanthidae						
Centropyge eibli	M	5.5	4.0	-	-	-
Centropyge multispinis	M	6.3	8.2	-	-	-
Centropyge nox	M	3.4	-	-	-	-
Pygoplites diacanthus	T	3.6	3.0	-	-	-
Pomacentridae						
Abudefduf sexfasciatus	M	-	-	2.5	21.3	-
Abudefduf vaigiensis	M	0.9	-	2.5	4.6	6.8
Amblyglyphidodon curacao	M	0.5	2.1	-	-	-
Amphiprion ocellaris	M	-	-	-	-	9.6
Amphiprion sandaracinos	M	-	-	10.2	-	-
Chrysiptera unimaculata	M	-	0.2	-	-	-
Chromis analis	M	-	1.3	-	-	-
Chromis atripectoralis	M	0.4	0.2	-	-	-
Chromis delta	M	0.1	0.2	-	-	1.4
Chromis dimidiate	M	0.4	0.2	-	1.2	-
Chromis nitida	M	0.2	-	-	-	-
Chromis verater	M	0.6	1.7	-	-	-
Chromis viridis	M	-	-	0.6	1.5	4.1
Chrysiptera cyanea	M	-	-	-	1.2	-
Chrysiptera hemicyanea	M	-	-	1.4	2.1	-
Chrysiptera rollandi	M	-	-	1.9	0.3	-
Chrysiptera springeri	M	0.2	-	-	-	-
Dascyllus aruanus	M	0.2	-	-	-	-
Dascyllus carneus	M	0.4	-	-	-	-
Dascyllus melanurus	M	0.9	-	-	-	-
Dascyllus trimaculatus	M	0.1	-	-	-	-
Dischistodus melanotus	M	0.1	-	-	-	-
Dischistodus perspicillatus	M	0.1	-	-	-	-
Dischistodus prosopotaenia	M	2.2	4.7	-	-	-
Hemiglyphidodon plagiometopon	M	0.4	-	1.7	-	-
Neopomacentrus azysron	M	-	-	2.8	7.0	-
Neopomacentrus cyanomos	M	-	-	8.5	-	-
Neopomacentrus xanthurus	M	-	-	0.6	-	-
Plectroglyphidodon lacrymatus	M	0.1	1.7	-	-	-
Pomacentrus alexandrae	M	-	1.3	-	-	-
Pomacentrus amboinensis	M	0.2	0.4	-	-	-
Pomacentrus brachialis	M	0.5	-	-	-	-
Pomacentrus lepidogenys	M	0.4	2.1	-	-	-
Pomacentrus milleri (juv.)	M	-	0.6	-	-	-
Pomacentrus nigromarginatus	M	0.7	-	-	-	-
Pomacentrus tripunctatus	M	1.3	0.4	-	-	-
Stegastes aureus	M	1.4	5.5	-	-	-
Scaridae						
Chlorurus microrhinos	T	0.1	-	-	-	-
Scarus globiceps	T	1.2	2.7	-	-	-
Scarus melanurus	T	-	1.7	-	-	-
Scarus niger	T	0.5	-	-	-	-
Scarus rivulatus	T	3.4	-	-	-	-
Scarus rubroviolaceus	T	0.1	0.2	-	-	-
Scarus sp.	T	-	-	-	0.3	-
Serranidae						
Cephalopholis cyanostigma	T	-	4.6	-	-	-
Epinephelus fasciatus	T	1.1	-	-	-	-
Epinephelus spilotoceps	T	-	-	0.3	-	17.8
Plectropomus leopardus	T	0.4	-	-	-	-
Pseudanthias bimaculatus	T	1.9	-	-	-	-
Pseudanthias pleurotaenia	T	2.6	-	-	-	-
Pseudanthias randalli	T	0.2	-	-	-	-
Pseudanthias squamipinnis	T	1.6	-	-	-	-
Pseudanthias tuka	T	1.1	0.4	-	-	-
Siganidae						
Siganus puellus	T	-	-	0.3	-	-
Siganus virgatus	T	0.1	1.9	-	-	-
Tetraodontidae						
Canthigaster compressa	T	0.2	0.2	-	-	-
Theraponidae						
Terapon jarbua	T	0.8	0.4	-	-	-
Zanclidae						
Zanclus cornutus	M	2.5	0.2	2.5	2.1	-
Number of individual		690	±163	255	±92	
Species richness		86	±16	22	±7	
Target (T)		40	±8	7	±2	
Major (M)		39	±7	13	±4	
Indicator (I)		7	±1	3	±2	

CONCLUSION

The study observed that the diversity of fish species in the reef slope was higher than in the lagoon. This shows that the characteristics of the habitat were instrumental in shaping the fish community. Habitats in a tropical lagoon are an important area for various fish species of coral reef ecosystems cite. Despite the complexity of the lagoon habitat characteristics are not as high in coral reef ecosystems, but also provides a location for a few juvenile fish to grow and evolve, which is also vital for the conservation of species. Therefore, management strategies and conservation of coral reef ecosystems should include a lagoon habitat as an important and integrated part.

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