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Structure of Reef Fish Assemblages at Miang Island, East Kalimantan (Borneo)

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Abstract: Miang Island (118°0'20E-0°44'0N), located in East Kutai Regency, East Kalimantan, has an island area of 7.39 km^2 with a coastline length of about 11.73 km^2. Coral reef ecosystems can be found around the island by forming a fringing reef with an area of about ± 218.8 ha. The existence of this reef ecosystem certainly attracts a variety of biota, including reef fish. The abundance of reef fish in Miang Island has not been proven because no previous research has discussed reef fish in this region. Prioritizing conservation areas requires knowledge of the spatial distribution of fish assemblages' richness and organization. This research describes the biodiversity and community structure of reef fish assemblages in Pulau Miang at two different depths. The Underwater Visual Census (UVC) has been used for reef fish data retrieval. The results showed the abundance of reef fish at station 1 amounted to 0.45 ind./m^3, station two by 0.10 ind./m3, station three by 0.06 ind./m^3, and station four by 0.09 ind./m^3. A total of 88 species from 21 families were successfully described in this study. The abundance of reef fish is dominated by the families Pomacentridae and Caesionidae, as these two families are temperate fish, which are often found in tropical waters. Our findings may be important as primer data for managers to plan this region's future marine protected area.

Keywords: Pomacentridae, Caesionidae, habitat, competition, reef fish, remote area.

東加里曼丹島米昂島礁魚群結構（婆羅洲）

摘要: 要米昂島（118° 0'20 乙，0° 44'0 N）位於東庫台麗晶，東加里曼丹島面積 7.39 公里 2，海岸線長約 11.73 公里 2。珊瑚礁生態系統可以通過形成面積約 ± 218.8 公頃的珊瑚礁來發現。這個珊瑚礁生態系統的存在當然吸引了各種生物群落，包括珊瑚礁魚。米昂島珊瑚礁魚類的豐度尚未得到證實，因為以前沒有詳細討論過該地區珊瑚礁魚類的存在。優先保護地區需要了解魚類組合的豐富性和組織性的空間分佈。這項研究的目的是描述普勞米昂珊瑚礁魚群的生物多樣性和社區結構在兩個不同的深度。水下視覺普查（紫外线）已用於珊瑚礁魚類數據檢索。結果顯示，第 1 站礁魚的豐度為 0.45 人/立方米，第 2 站為 0.10 人/立方米，第 3 站為 0.06 人/立方米，第 4 站為 0.09 人/米 3。這項研究共成功描述了來自 21 個家庭的 88 種物種。珊瑚礁魚的豐度由波馬森特裡達和凱索尼達家族主導，因為這兩個家庭是溫帶魚，經常在熱帶水域發現。

关键词： 果蝇科，彩蝶科，栖息地，竞争，礁鱼，偏远地区。

1. Introduction

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Diversity, in general, can be determined as a condition of spreading or composing biota evenly throughout the earth, although various biota or living things are more likely to be concentrated somewhere [1]. This has happened in reef fish, which are concentrated in the coral triangle region. As many as 37% of reef fish worldwide are found in Indonesia and the Philippines. Indonesia has the highest diversity of reef fish species globally, with more than 2500 reef fish species recorded [2] and is estimated to increase to 2600 species [3]. Furthermore, there will be various hypotheses why the Coral Triangle Region, the other term is Indo-Australian Archipelago (IAA), to be the center of reef fish biodiversity?

The first hypothesis states that the IAA Region is the center of origin, which are all come from here [4]. Second, the center of overlap is a consequence of the intersection between the Indian and Pacific Oceans [5]. Third, the center of accumulation, where the number of corals that live in this aquatic area attracts various biota, including reef fish [6, 7].

Reef fish have two active roles in coral reef ecosystems. First, they can be an indicator of the health of coral reef ecosystems [8], and second, they can be used to measure the level of habitat suitability because reef fish move around to choose habitats with more suitable conditions for their life [9].

As well known that herbivorous fish can control the growth of algae (turf algae, corticated algae, tough erect algae, and foliose algae) and give a chance for coral to occupy the substrate and grow fast [10, 11]. Another function of reef fish is the certain types of reef fish in a coral reef area were accurate instructions to describe the health condition of the ecosystem. For instance, the presence of the family *Chaetodontidae*, whose life depends on the existence of corals, so the existence of this fish is usually used as a bioindicator of the health of coral reefs in general [12, 13].

Pulau Miang (118°0'20E-0°44'0N) administratively located at Sangkulirang district, East Kutai Regency, East Kalimantan. This island has about a 7.39 km^2 area with a coastline length of about 11.73 km [14]. Pulau Miang is the name of two islands they are Pulau Miang Kecil and Pulau Miang Besar. Pulau Miang Kecil is not an inhabited island, the wide-area was 0.82 km2, and the coastline was 3.6 km. Meanwhile, Pulau Miang Besar was inhabited by 500 people that were fully dependent on fisheries activities. When local people talk about Pulau Miang, it will refer to Pulau Miang Besar, used in this research.

A fringing reef circled Pulau Miang, and in the north-western part of this island was spread some patch reef [14]. The biodiversity and potential of coral reefs on this island have not been discussed yet, since the location was in a remote area, and the high accommodation cost can be two reasons why fewer reports regarding the coral reef biodiversity on this island.

The purpose of this research is to provide an overview of the condition and biodiversity of the reef fish located on Pulau Miang as the basis of future conservation policies by the local government.

2. Materials and Methods

2.1. Study Site

This research was conducted in Pulau Miang Besar (Pulau Miang), East Kalimantan on April 28 – May 3, 2018. This location was chosen because the island has the best coral reef cover area in Sangkulirang District and is one of the best in East Kutai Regency [14]. The research location was conducted at four stations that were represented of the northern part (St.1), the western part (St.2), the eastern part (St.3), southern part (St.4) of Pulau Miang. Localities of each station were chosen by randomly based on information of local people and there was coordinate each stations: station 1 (00° 58.816' N, 117° 58.538' E); station 2 (00°43,839' N, 117°59.551' E); station 3 (00°43.901' N, 118°01.385' E); and station 4 (00°43.044' N, 118°01.172' E) (Fig. 1).

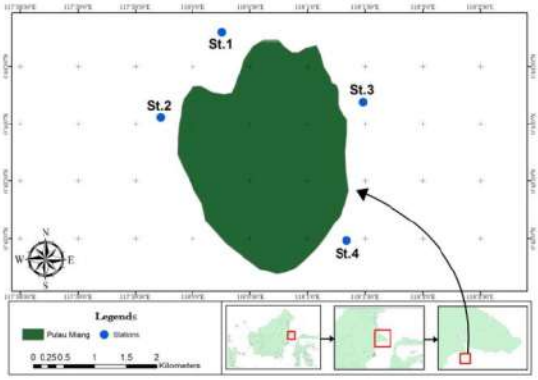

Fig. 1 The localities of the research station were marked by the blue point

2.2. Distribution of Reef Fish

This study's reef fish data collection used the UVC method (Underwater Visual Census) [15]. The 100 m-long transects have lied parallel to the shoreline in five and ten m depth than two observers were dive into right and left of the transect calculated and record the reef fish on 2.5 m right and left of transect using an underwater video camera (Canon G-16, Japan). Observer also records fish five m above transect along of transect that resulted in 100x5x5 m (2500 m^3). While recording the underwater video camera, observers also calculated the number of fish on their area in the underwater slate and estimated the fish size. All reef fish data was conducted on five and ten m depth following the contours of coral in Pulau Miang than found on those depths. Observers also photographed the reef fish to obtain good quality fish pictures for identification. All data from the underwater camera was then transferred into a computer and interpreted the fish data to an Excel file.

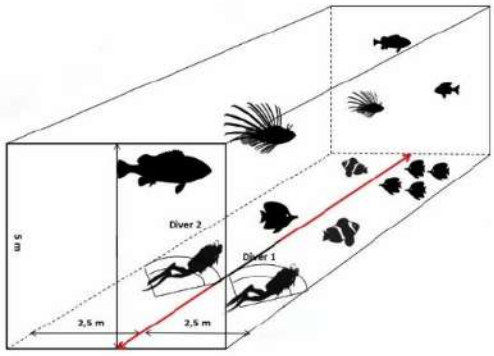

Fig. 2 Illustration of reef fish data retrieval. Fish identification

Identification of the genus of reef fish was carried out directly in the field and backed up using underwater photo documentation. The fish that had been recognized are recorded directly on the underwater slite, while some types of fish that have not been identified will be identified referring to the manual after the data retrieval is complete—identification of the species of reef fish used protocol by [2, 16].

2.3. Data Analysis

The abundance of the number of fish found per unit of the transect was calculated using the formula that derived as:

$$Xi = ni/A \quad (1)$$

where:

Xi = Abundance of i-type fish (ind./m3)

ni = Number of i-type fish

A = Area of observation

Reef fish abundance and distribution data were analyzed descriptively using charts and tables in Microsoft Office Excel 2010 and expressed as a numerical individual per meter square [8, 17].

3. Results and Discussion

3.1. Reef Fish in Pulau Miang

The results of this research observed in total about 704 reef fish from 21 different families. The distribution of reef fish in shallow water (5 m depth) was less compared to deep water (10 m depth), in which the population was 296 and 408 fish for each depth (Fig. 3). As shown in Fig. 3 and Table 1, the population of Pomacentridae in Pulau Miang was the highest among others. Pomacentridae is unique reef fish that have territorial in the coral reef ecosystem, which had structured the benthic communities on their territory and mammals in the land territory [18]. Through their feeding habit and behavior activities, pomacentrids fish mediated the growth of algae (algal turf), influenced coral recruitment, controlled invertebrates, and other herbivorous fish [18–21]. The abundance of reef fish on deeper water might be influenced by the high cover of coral community in 10 m than shallower area. The dependency of pomacentrids to coral was studied in Lizard Island, GBR, which had the highest body mass increasing per week during their territory [22]. Total abundance of fish at a depth of 5m by 0.03 ind./m^3 and 10m by 0.04 ind./m^3.

The family *Pomacentridae* had the most abundant reef fish in Pulau Miang. It was 192 fish at a depth of 5m and 197 at a depth of 10m. Otherwise, the families of *Epiphidae* and *Cirrhitidae* had a lower abundance (Fig. 3). More than 340 species of damselfish (*Pomacentridae*) dwell primarily in coral reef habitats, and their colonies are the most visible in the coral reef environment [23]. *Pomacentriids* have been inhibited on coral reefs since 50 million years ago [6], and it was given a good role in coral reef community structure.

Moreover, scientists have reported that almost all living cycles of *Pomacentrids* through coral reef ecosystems such as larvae, settlement, adult, and recruitment. Based on diet, the *pomacentrids* fish were divided into three categories as herbivorous, planktivorous, and omnivorous. Research on 134 *Pomacentridae* fish revealed that these fish had six different types of food: phytoplankton, benthic algae, zooplankton, vagile invertebrate sessile invertebrate, and detritus [24].

The presence and role of herbivorous fish are very important to coral development and competition to win the competition with benthic fauna because carnivorous prey on algae resulted in coral can grow quickly [25]. *Pomacentrids* also play an active role in cleaning the waters because they feed on various detritus and plankton around the reef. Increasing nutrients in the water will increase the number of phytoplankton, and of course, too abundant amounts of plankton will interfere with the diet of corals that eat only nano-sized plankton [26]. As an omnivore, these fish also feed on animals living in the body of coral known as micro borer [27]. Too many holes produced micro borer in the body of corals will make the coral fragile and caused the weak structure of the coral. The presence of this fish turns out to be able to control the amount of micro borer on the body of the coral.

Two genera have dominated among other Pomacentridae in Pulau Miang. They were Chromis Viridis and Dascyllus sp. These species are closely related to branching corals, especially the genus *Acropora* [2]. They hide inside branches of *Acropora* coral in small colonies. Moreover, these fish also tag the branching of *Acropora* using chemical cues and use the correct signals for homing [28]. *Dascyllus* is also one of the genera that have many symbiotic corals. They live in small groups between the corals of *Acropora* and *Stylophora*. It was thought that there was a symbiotic relationship of mutualism between these fish and corals. Coral as a host protects fish and traps plankton so that fish do not have to come out of the coral to find food, while corals will be able to essential nutrients produced by such fish [29].

One hundred and twenty *Caesionidae* fish were found in Pulau Miang. *Caesionidae* was endemic fish of the Indo-Pacific and Red Sea waters [16, 30]. The family Caesionidae usually made a group of swimming (schooling) during prey, and this incident has been found in Pulau Miang, that schooling of *Caesoniids* fish over on observers view time. The family *Caesionidae* preyed on zooplankton column of water with schooling strategi and sometimes clustered around divers in large numbers so that they almost cover the surrounding ocean scenery [2]. These fish are also known as fusiliers, which can move vertically from the sea surface to a maximum depth of 60 m around the coral reef ecosystem [31].

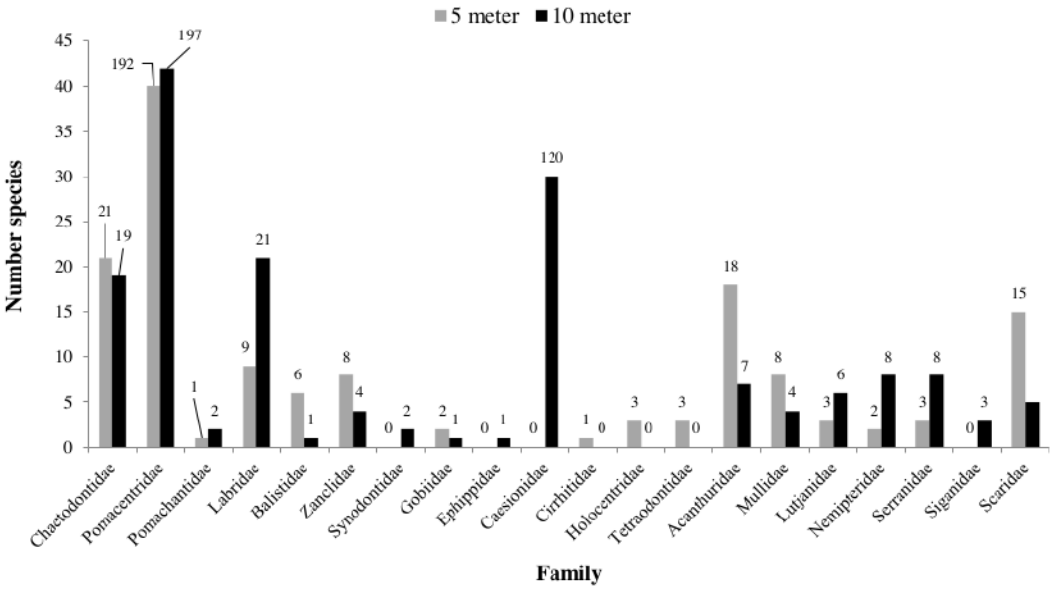

Fig. 3 Distribution of reef fish at stations at different depths

Chaetodontidae or butterflyfish are easily known due to their attractive color patterns, thin shape, and graceful swimming movements. *Chaetodontidae* is most commonly seen in large areas of living coral, usually at a depth of less than 20 m. They depend on coral reefs for shelter and their nutritional needs. Almost butterflyfish stop their foraging activity in the afternoon and hide on the reef's crevices except for the *Chaetodon* lunula that regularly eats after dark [2]. Seven species were described in this research. They were *Chaetodon lunulatus*, *C. oxycephalus*, *C. kleinii*, *C. unimaculatus*, *C. octofasciatus*, *Forcipiger flavissimus*, and *Heniochus varius*. There was no significant difference in the number of *chaetodontids* at different in five and ten m depth (Table 1; Fig. 3).

The number of *Labridae* fish found at ten m have twice the amount compared to a depth of 5 m. The most abundant from this family was *Cirrhilabrus* exquisitus (29), while the other ten species spread evenly at one individual each. *Labridae* was a large family of fish, consisting of 82 genera and 600 species of fish [32]. Most species are small, accomplishing a body length of less than 20 cm, although few achieve a mass of over 100 kg. *Labriids* occupy tropical marine and calm waters worldwide and are most common in coral reefs, dead coral algae, sand and rubble, and algae ecosystems. *Labriids* fish have diverse feeding habits such as gastropods, small bivalves, algae, and other invertebrates [30]. This fish feeding with a group surrounds living coral.

3.2. Reef Fish Distribution by Station

Reef fish have their territory. They will occupy habitats that are considered suitable for each of them. For instance, one species needs more nutrient availability in their habitat, others prefer to choose temperate environmental waters for the recruitment and post-recruitment process, and others may need combine of those factors.

The availability of prey and interspecies also greatly influence a species's habitat presence [33]. The total abundance of fish at station 1, 2, 3 and 4 were 0.45; 0.10; 0.06 and 0.09 ind./m^3 respectively. *Pomacentridae* and *Caesionidae* were the most abundant reef fish in Pulau Miang. As stated in Table 1, station one was occupied by 453 fish, station 2 was 100 fish, station 3 was 61 fish, and station 4 was 91 fish. The effect of live coral percent cover on the abundance of reef fish in

water has become an attraction of ecologists. Research on the abundance of reef fish has been conducted in Mataiva Atoll, which mentions species richness from *Chatodontidae*, *Pomacentridae*, *Labridae*, *Scaridae*, *Acanthuridae*, and *Gobidae* were significantly increasing once the coral cover raised to 5% [34]. The coral cover also has a pronounced influence on reef fish diversity, species composition, and abundance [35], and coral cover is known as a driver for reef fish biomass [36]. In this research, the live coral cover was 45% and stated as the highest percentage coral cover than other stations.

Table 1 Distribution of reef fish in Miang Island

Group of Fish	Family	Number of Fish			
		St. 1	St. 2	St. 3	St. 4
Indicator	*Chaetodontidae*	9	15	0	16
Major	*Balistidae*	6	0	0	1
	Caesionidae	120	0	0	0
	Cirrhitidae	1	0	0	0
	Ephippidae	1	0	0	0
	Gobiidae	0	0	1	2
	Holocentridae	3	0	0	0
	Labridae	10	8	7	5
	Pomacentridae	231	58	52	48
	Pomachantidae	1	2	0	0
	Synodontidae	1	0	0	1
	Tetraodontidae	3	0	0	0
	Zanclidae	10	2	0	0
Target	*Acanthuridae*	18	4	0	3
	Lutjanidae	2	7	0	0
	Mullidae	7	0	1	4
	Nemipteridae	7	0	0	3
	Serranidae	11	0	0	0
	Siganidae	1	0	0	2
Eco. Importance	*Scaridae*	11	3	0	6
Total		453	100	61	91

The number and composition of reef fish in Pulau Miang were not distributed evenly. For instance, Family *Caesionidae* was abundant in station 1 (Table 1) but not followed by three other stations. In contrast, *Pomacentridae* can be found in all stations so that the total number of this family was very high (389) (Table 1). Understanding how the pattern of reef fish distribution to their habitat is not easy because the composition of reef fish that have separated 10's meter each other has a very real difference compared to coral reef habitats that are 1000 km apart [37]. This research shows that *Caesinidae* is only found in station one, not elsewhere, even though the distance of each station is not surely far. In another possibility, during that time number of phytoplankton in station one was very abundant and attracted *Caesionidae* to feed it. Chlorophyll contained in phytoplankton was the main food of the caesiniids fish [38]. The strong current at station one at that time and carrying much phytoplankton may have also affected the presence of these fish. The research that has been carried out is temporary. It does not study the eating habits of all types of fish for a certain period, so the habitat preferences of reef fish can only be done by making estimates following the existing literature. Based on research conducted on Orpheus Island, Australia which states that among the many factors that affect the abundance of reef fish in a water area, the condition of corals as the main habitat for reef fish and the presence of food sources are the two most important factors that affect the diversity of reef fish [37].

4. Conclusion

Reef fish assemblage in Pulau Miang was composed of large species that *Pomacentridae* and *Caesionidae* dominated. *Pomacentridae* was very distributed on this island. They can be found easily in all stations. The habitat of these fish is mostly found in coral reef structures and eats epilithic algae in surround of coral that keep coral success on the competition with algae. *Caesionidae* is one important reef fish for human, most of the islander in Indo-Pacific has depended on these fish for protein sources. Reef fish abundance had a strong relationship with the coral reef ecosystem because the reef is the main habitat of these fish. Knowing the fish assemblages in this island accurately is important as the baseline and foundation of marine protected areas in the future. Decision-making based on ecology instead of the economy is a good approach to conserving the marine ecosystem. This study has a big effort and has involved many resources on it and if any collaboration in the future between local government, university, and private sector, the research will be expanded on revealed linkages of the environment to reef fish assemblages in this island.

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