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The Diversity of Reef Fish in Ulee Kareung waters, Bireuen District Indonesia

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Abstract. *Indonesia has abundant underwater natural resources, including coral reefs. Among coral reef ecosystems, reef fish make an important contribution to supporting the sustainability of underwater life. The more diverse reef fish in an ecosystem, it shows the healthier the condition of the coral reef ecosystem. The objective of the study was to investigate the diversity of the reef fish community including abundance, diversity, evenness, and dominance index in Ulee Kareung waters, Simpang Mamplam Sub-district, Bireuen District, Indonesia. We used a visual census technique (VCT)-belt transect by using a 50-meter transect and 3 times repetition at three observation stations. Each station had 2 depth categories such as shallow waters (3-5 m) and deep water (7-10 m). Results of the study found a total of 2094 individuals that consisted of 19 families and 59 species. The abundance value of reef fish ranged from 321 ind/ha - 610 ind/ha. The diversity index (H') ranged from 2.80 to 3.16. The evenness index (E) ranged from 0.79 to 0.88 and the dominance index (C) ranged from 0.06 to 0.10. Hence, it can be concluded that ulee kareung waters have a medium level of fish diversity.*

Keywords: *Bireuen, fisheries management, reef fish, diversity*

Citation

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INTRODUCTION

Located on the equator, Indonesia is one of the countries that has a wealth of megabiodiversity in the world (Putra et al., 2021). One of Indonesia's natural resources is coral reefs. The diversity of coral reefs in Indonesia ranks highest compared to the three of the world's 17 "mega-diverse" countries (Keong, 2015). On the other hand, coral reefs are known as the important ecosystem for other organisms (Aldyza & Afkar, 2015). This is indicated by the diversity and abundance of fish associated with coral reef ecosystems (Fadli et al., 2020). Coral reefs function as a place to lay eggs, a place to find food as well as a nursery

for living organisms in the ecosystem. Due to their low mobility, corals serve as a place of survival and protection for reef-related organisms including reef fish (Rudi & Fadli, 2012). The life cycle of reef fish cannot be separated from the connectivity of coral reef ecosystems with other ecosystems, such as seagrass ecosystems serves as a spawning ground, nursery or enlargement, a place to forage, and shelter (Olds et al., 2013; Wibowo et al., 2016). Moreover, the relationship between reef fish and coral reefs is very close, therefore the presence of reef fish in a coral reef area decreases when there is the destruction of their habitat (Hartati & Edrus, 2017).

Indonesia is famous for its fish diversity after Brazil (Muchlisin et al., 2017; Rizwan et al., 2017). Meanwhile, located at the tip of the island of West Sumatra, Aceh is well-known as the province with the longest coastline in Indonesia which produces a wealth of abundant natural resources including flora and fauna (Putra et al., 2018; Muhammadar et al., 2019; Putra et al., 2020; Muhammadar et al., 2020;), and in particular coral reef ecosystems (Fadli et al., 2012; Ulfah et al., 2017). It is known that the richness of coral reef ecosystems has direct and indirect impacts and environmental services for local communities, especially in the fisheries and marine ecotourism sectors (Bagindo et al., 2016).

Information about coral reef ecosystems, especially reef fish communities in Aceh Province is still limited. Moreover, there is no scientific information that can determine the potential diversity of reef fish species in the waters of Ulee Kareung, Bireuen Regency, Indonesia. Several studies on fish diversity have been carried out in several areas in Aceh Province (Batubara et al*.,* 2017; Rizwan et al., 2017; Nasir et al., 2017; Edrus & Hadi, 2020; Ulfah et al., 2020;). On the other hand, several studies on the ecophysiology and feasibility aspects of reef fish in Aceh have also been carried out (Muhammadar et al., 2018; Herry et al., 2019). However, the work of investigating the diversity of reef fish in Bireuen district is still not conducted yet. Therefore, efforts need to be made to further investigate the potential of reef fish in the waters of Ulee Kareung, Bireuen Regency by conducting an assessment of the community structure and diversity of reef fish species, so that the data can be used further as a source of sustainable and better fisheries management.

MATERIALS AND METHODS

Sampling Method

The study site was located in the waters of Ulee Kareung Village, Simpang Mamplam, Bireuen Regency, Indonesia. There were three observation locations based on the purposive sampling method, the observation locations were selected and determined to represent the waters of Ulee Kareung Village (Figure 1). We collected data using a visual census technique belt transect (VCT) for each station to assess reef fish resources (Hill & Wilkinson, 2004). Each station has 2 depth categories, namely shallow water (3-5 m) and deep water (7-10 m) as shown in Figure 2.

Reef fish were identified with reference to Fishes of the World Fourth Edition (Burke et al., 2012), and Tropical Reef Fish in the Indonesian Pacific, Tropical and Surrounding Waters (Allen et al., 2003). Some of the observed water qualities included temperature, salinity, and pH conducted after the reef fish sampling.

Data analysis

Fish Abundance

The definition of fish abundance is the number of individuals divided by the unit area of observation. Abundance can be calculated

using the formula (Odum, 1994; Rizwan et al., 2017): **K = Number of individuals/Transect**

Where, K = Abundance of fish

Diversity Index

The population of organisms in a count to analyze data on the number of individuals or genera of each form of growth in the habitat/community commonly called diversity index (H'). The diversity index commonly used is the Shannon-Weiner index (Odum, 1994, Rizwan et al., 2017; Muhammadar et al., 2021) with the formula:

$$H' = -\sum_{i=1}^{s} Pi \ln Pi$$

Where, H'=Diversity index (Shannon–Weiner)

$$Pi = \frac{\dot{n}}{N}$$

ni = Number of individuals of a species
N = Total individuals of all species

Referring to Brower et al. (1990) and Rizwan et al. (2017), the diversity index categories are:
H' <1 = Low category diversity
1 < H'≤ 3 = Medium category diversity
H '≥ 3 = High category diversity

Evenness Index

The description of the number of individuals between species in a fish community is the evenness index (E). The principle of this index is that if the distribution of individuals between species is more evenly distributed, the balance of the ecosystem will increase. The formula used refers to Odum (1994) and Rizwan et al. (2017) are:

$$E = \frac{H'}{Hmaks}$$

Evenness: E = Evenness index
H' = diversity index
H_{max} = ln SS = Number of species obtained

The range of evenness index values is 0-1. The evenness index value category refers to Kreb (1994) and Rizwan et al (2017) are:
S = Number of species obtained
0 < E 0,5: Community category depressed
0.5 <E 0,75: Community category unstable
0.75 <E 1: Stable category community

The smaller evenness index indicates the smaller evenness of the population, which means that there is a tendency of domination from one type of organism due to irregular distribution. If the evenness value is greater, indicating that the organisms are distributed evenly.

Dominance Index

The high dominance of a species over other species is indicated by a small evenness and diversity index value. The dominance index refers to Odum (1994) and Rizwan et al (2017):

$$C = \sum_{i=1}^{s} Pi^2$$

Where, C = Dominance Index
Pi = Proportion of the number of individual fish
i = 1, 2, 3, …, n

The range of index values is 0 - 1 with categories:
0 < C < 0,5= Low category dominance.
0.5< C 0.75 = Moderate dominance.
0.75< C 1.0 = High category dominance.

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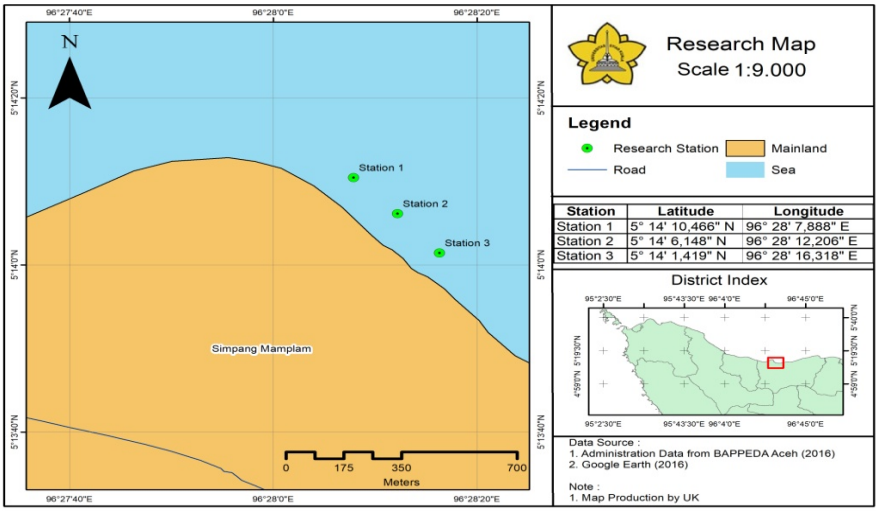

Figure 1. Map of the research location in Ulee Kareung Waters, Bireuen Regency, Aceh Indonesia.

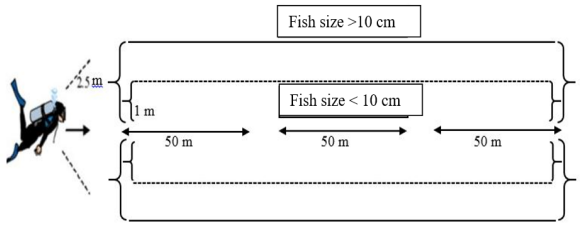

Figure 2. Fish data collection scheme

RESULTS AND DISCUSSION

The results obtained 2094 individuals consisting of 19 families and 59 species found in the waters of Ulee Kareung, Bireuen Regency (Table 1). Judging from the species composition, namely *Acanthurus aurantica-vus, Chaetodon meyeri, Chaetodon vagabun-dus, Chromis dimidiate, Dascyllus carneus, Heniochus pleurotaenia, Labroides dimidia-tus, Parupeneus macronemus, Pterocaesio tile,* and *Scolopsis bilineatus* (Table 2). The largest number of fish was found at St.2 with an average of 349 ind/ha, followed by St. 1 with an average of 290 ind/ha and St. 3 with an average of 230 ind/ha (Table 1).

The dominant fish family came from the Pomacentridae family with 882 ind, while the least known fish family came from Tetra-dontidae with only two individuals found at St. 2. There were variations in the number of families and species of reef fish obtained among St. 1, St. 2 and St. 3. It is assumed that each station has different substrates and types of coral reefs. This is in accordance with the statement of Rudi and Muchsin (2012) that the abundance and diversity of reef fish is strongly influenced by the condition of coral reefs, especially hard coral cover. When the hard-coral cover is extensive, the abundance and diversity of organism will be quite high. In addition, geological and geographical fac-tors are abiotic factors that also influence the fish diversity in an area (Paujiah et al., 2019).

Table 1. The abundance of reef fish in Ulee Kareung waters, Bireuen district (ind/ha)

Species	St. 1	St. 2	St. 3	Average
Abudefduf bengalensis	400			133
Abudefduf lorenzii		1500		500
Abudefduf vaigiensis	400		2620	1007
Acanthurus auranticavus	333	307	147	262
Acanthurus leucosternon	527	300		276
Acanthurus lineatus		420	293	238
Acanthurus nigricans		280		93
Acanthurus tristis		260	367	209
Caesio xanthonota	1100		67	389
Centropyge eibli	173	500	387	353
Cephalopholis argus		27		9
Chaetodon citrinellus			27	9
Chaetodon collare	333		133	156
Chaetodon guttatissimus	33			11
Chaetodon lunulatus	147	453		200
Chaetodon meyeri	13	527	500	347
Chaetodon punctatofasciatus	80			27
Chaetodon triangulum			53	18
Chaetodon trifascialis	93	133		76
Chaetodon trifasciatus	93		747	280
Chaetodon undulatus		267		89
Chaetodon vagabundus	93	1267	333	564
Chlorurus microrhinos		53		18
Chromis amboinensis	233			78
Chromis analis	100	633		244
Chromis caudalis	5233			1744
Chromis dimidiate	3433	3067	667	2389
Chrysiptera unimaculata			400	133
Dascyllus aruanus			133	44
Dascyllus carneus	100	3200	667	1322
Dascyllus trimaculatus	107	1300		469
Diodon holocanthus		47		16
Epinephelus aerolatus	80			27
Epinephelus macrospilos	67		40	36
Epiphelus spilotoceps		27		9
Forcipiger longirostris			27	9
Gomphosus varius	27	233	320	193
Halichoeres hotulanus			253	84
Heniochus monoceros		107		36
Heniochus pleurotaenia	27	120	33	60
Istigobius rigilius		367		122
Labroides dimidiatus	633	1333	333	767

Lutjanus boutton		187		62
Lutjanus kasmira	533	267		267
Myripristis murdjan			120	40
Parapercis hexophtalma	27			9
Parapercis millipunctata			167	56
Parupeneus macronemus	107	553	187	282
Pempheris vanicolensis	1027		1000	676
Plectorhincus vittatus		320		107
Plectroglyphidodon lacrimatus	167		1480	549
Pomacanthus imperator		40		13
Pterocaesio tile	533	1307	1293	1044
Sargocentron caudimaculatum	107			36
Scarus prasiognathos	67			22
Scolopsis bilineatus	533	227	300	353
Scolopsis temporalis		80		27
Siganus guttatus		93		31
Zanclus cornutus	173	813	467	484
Individual total	290	349	230	290

The results showed that the dominant fish composition came from Pomacentridae (42%) with a frequency of fifty times at St. 1; fifteen times at St. 2 and fourteen times at St. 3 (Figure 3). Fish of the Pomacentridae family are the main group associated with coral reefs. This is in accordance to Nasir et al. (2017) reported that the family Pomacentridae is types of resident fish that have behaviors rarely go far from the food source and shelter. The second largest fish family after Pomacentridae is the Chaetodontidae family with a frequency of 12% presence. The Chaetodontidae family is often used as an indicator of the health coral reef ecosystems. The lowest family composition was Tetradontidae with 0.1% of the frequency of attendance (Figure 3).

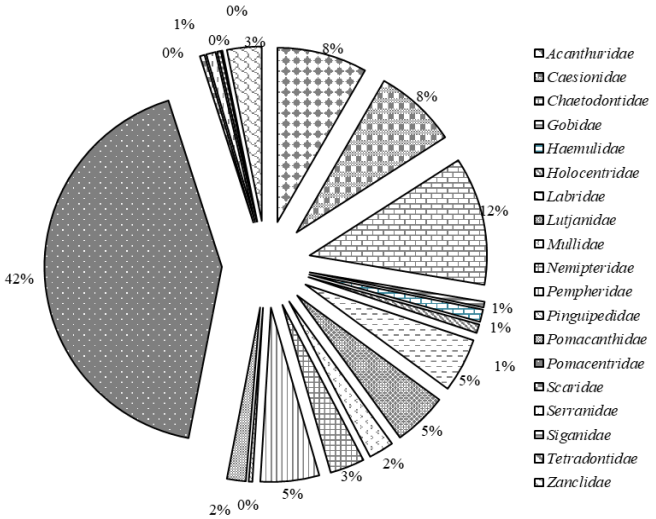

Figure 3. Percentage of reef fish composition observed in the sampling area by family.

Regarding the abundance of fish, each station has a relatively different number in both shallow and deep waters (Figure 4). The abundance of reef fish in Ulee Kareung waters is on average between 321 ind/ha - 610 ind/ha. The highest abundance of fish was at station two in shallow waters (610 ind/ha), while the lowest abundance of fish found at station three in deep waters (321 ind/ha). Based on our field observations, it was rare to find any human activity at St. 2. In contrast, many human activities such as fishing and other activities found at St. 3. Human activities have a close relationship with the status of coral reefs. This is in accordance with the Loya report (2004) which stated that local community activities can cause, directly or indirectly.

As for the fish diversity index, the results showed a range between 2.80-3.16. The highest fish diversity was at St. 2 (3.16) and the lowest was at St. 1 (2.80) (Table 3). According to Brower *et al*. (1990), the diversity index (H') > 3 classifies an area with a high distribution of individuals from each species and community at the stations. Therefore, station one is categorized in high diversity status. A community categorized as high species diversity if there are many individuals of many species that evenly distributed.. In terms of the evenness index based on data from all stations (Table 3), the evenness index in Ulee Kareung waters ranges from 0.79 - 0.88.

If referring to Krebs (1989), it can be concluded that the evenness index in the waters of Ulee Kareung belongs to the stable category which shows evenly distributed species at each station. Regarding the dominance index, it is obtained that the dominance index in Ulee Kareung waters ranges from 0.06 to 0.10 (Table 3). Based on the reference of Odum (1994), it can be concluded that Ulee kareung waters are categorized as low dominance. The low dominance index refers to the group of species that have less significant influence or control over the other organism in its ecological community. Then, because of less numerical advantage, the low dominance tends to be influenced by other species or groups of organisms.

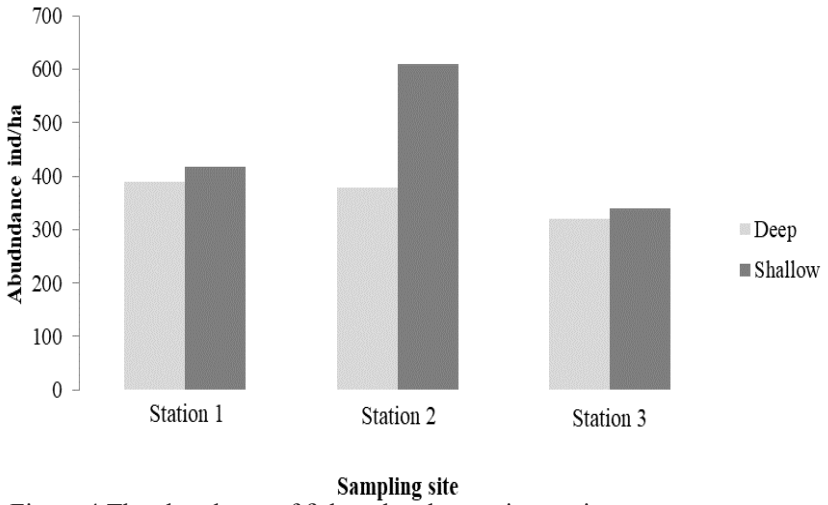

Figure 4.The abundance of fish at the observation station.

Table 2. Index of diversity, evenness and dominance in the study area

Community Structure	Station 1	Category	Station 2	Category	Station 3	Category
H' (Diversity index)	2.8	currently	3.16	tall	2.95	currently
E (Evenness index)	0.79	stable	0.88	table	0.87	stable
C (Dominance Index)	0.1	low	0.06	low	0.07	low

The physical and chemical properties of waters are sufficiently essential to know as they directly or indirectly affect the life of the organisms in a coral reef ecosystem (Nasir et al., 2017). With regard to water quality parameters, we have measured several parameters including temperature, salinity, and degree of acid-base (pH) (Table 4). We obtained temperature values ranging from 28.3 - 29.3°C. This is in accordance with Tucker Jr. (2012) statement in his book that the ideal temperature range for fish survival is between 25°C - 32°C. The pH values obtained from each station ranged from 7.4 - 7.7. This result is also within tolerance as stated by Tucker Jr. (2012) that marine waters generally have a relatively stable pH and a narrow range, the pH value range is between 7.6 - 8.3. In terms of salinity, we measured the salinity of all stations which ranged from 29 - 30‰. Nybakken (1992) suggested that the optimal salinity of marine waters generally ranges from 30‰ - 35‰, from the references it is evident that the salinity was still in an optimum range.

Table 3. Water quality parameters on the study site

Water Quality Parameters	Unit	Station			Range
		1	2	3	
Temperature	°C	28.7	29.3	28.3	28.3 - 29.3
pH	-	7.7	7.48	7.41	7.41 - 7.7
Salinity	°/oo	29.6	30	30	29.6 – 30

CONCLUSION

We concluded that the level of fish diversity in Ulee Kareung waters, Bireuen district has a relatively moderate diversity of reef fish. While the level of evenness shows in a relatively stable category. However, the level of dominance shows a low level of dominance. It is expected that there will be further researches on the structure of the reef fish community and other biotas which aims to obtain additional and comparative data so that it can be used as a basis for determining policies in the management and establishment of community-based marine protected areas so that coral reef ecosystems can be maintained in a sustainable manner.

AUTHOR CONTRIBUTION

D.F.P. and M.N. supervised all the process and wrote the manuscript, M.R.S. carried out the experiment, S.P. and I.S. helped supervise the project and E.M.F. support the writing.

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CONFLICT OF INTEREST

There is no conflict of interest during the research work.

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