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COMPARATIVE ASSESSMENT OF GORGONIAN ABUNDANCE AND DIVERSITY AMONG ISLANDS WITH DIFFERENT ANTHROPOGENIC STRESSORS IN KARIMUNJAWA MARINE NATIONAL PARK, JAVA SEA

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Abstract

Gorgonians are a prominent part of coral reef fauna that changes in their abundance and diversity due to environmental changes. The present study was carried out to assess the relative abundance and diversity of gorgonian among islands with different anthropogenic stressors. The islands namely Burung, Geleang, Sambangan, and Seruni are protected areas of bird habitat, tourism area, mariculture activity, and empty, uninhabited islands, respectively. A rapid assessment of gorgonian genera was conducted by using the Roving Diver Visual Method on 4-11 March 2021. The Shannon diversity index, species richness, and evenness were computed to see the variation in the gorgonian community among islands. Results of the present study recorded 167 individuals representing 12 genera of gorgonian, which fall into 5 families namely, Ellisellidae, Plexauridae, Melithaeidae, Acanthogorgiidae and, Isididae. Of the four islands, abundance and species richness were not significantly different (F_{-value}: 4.52; p: 0.09 >0.05). Statistically, there was also no significant difference among gorgonian genera (F_{-value}: 1.01; p: 0.08 >0.05). However, the species diversity and abundance on the islands with low disturbance from various anthropogenic activities tended to increase. Monitoring is needed periodically to screen the condition of the gorgonian fauna. This study provides basic information for future monitoring due to the increasing eutrophication rate and tourism.

Keywords*: Gorgonian; Relative abundance; Diversity index; Turbidity; Karimunjawa*

Introduction

Karimunjawa National Park represents one of only seven marine national parks in Indonesia [1]. This National Park includes a group cluster of 27 coral islands that covers more than 1000km^2 of marine habitat, consisting of tropical forests, mangroves, and coral reefs [2]. The coral reefs in this national park are abundant and highly diverse, including the gorgonian octocoral. Apart from Karimunjawa's biologically significant coral reefs, the park is very important to support approximately 10.000 people, consist of fishing communities and tourists [3]. However, the island is vulnerable to environmental changes [4]. Recently, Karimunjawa National Park is threatened mainly by an anthropogenic stressor [5]. The contributing factors mainly include destructive fishing, fast-growing mariculture, and uncontrolled tourism activities

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[6]. Fishing activities in reef areas are sharply increased by using illegal methods such as the use of explosives, cyanide, and poison as well as anchoring on corals [7]. Mariculture activities such as seaweed, grouper, and scallop mariculture, are seeing faster growth than capture fisheries [8, 9]. Consequently, if not adequately managed, these activities might affect the decline of water quality. Meanwhile, the local government has been aggressively promoting Karimunjawa park tourism to create jobs and improve the economic welfare of the local community. Accordingly, tourist visits have increased sharply, on the other hand, the damage to the local reef ecosystem has also increased [6]. Hence, the problems become more sophisticated to evaluate further. This study tries to seek the problem solving within natural resources throughout on the effect of anthropogenic stressors on the diversity of gorgonian.

The Gorgonians involve the lovely sea fan and the lively sea whip that are among the most ubiquitous habit-forming species of benthic communities in the Indonesian archipelago. Gorgonians are exotic representatives of the Subclass Octocorallia, Order Alcyonacea, suborder Scleraxonians, Holaxonians, and Calcaxonians [10]. These organisms are eye-catching, various, and often major components of benthic marine environments. Besides, they are colonial suspension feeders primarily characterized by polyps bearing eight pinnate tentacles, and eight mesenteries dividing the gastrovascular cavity [4]. These organisms also provide protective microhabitats for some small invertebrates [11]. Environmental factors such as light, sedimentation, influence morphological variability in gorgonians. Nevertheless, the extremely high regional diversity and abundance of gorgonian corals result in a very limited understanding of how environmental changes affect these organisms as the human population and the gorgonian exploitation continue to increase.

Karimunjawa gorgonian is under rapid decline and often destroyed [6]. Different from hard corals, few studies of gorgonian were carried out in the Karimunjawa Archipelago, even in their diversity and distribution. Two articles only found in internet browsing, Rowley [12] reported 90 species of gorgonians are belonging to 38 genera and 12 families from Wakatobi Marine National Park. While Manuputy [13] recorded 17 genera from six different families in Seribu island. Conservation surveys on coral ecosystems that are currently being carried out tend to ignore the existence of gorgonian taxa due to the difficulties in the field identification [12]. However, some natural compounds of Karimunjawa gorgonians were extracted, fractionated, and elucidated for biomedical, pharmacological, and cosmetic studies [14, 15]. Hence, this study aimed to assess gorgonian abundance and diversity among islands with different anthropogenic stressors in Karimunjawa Marine National Park.

Materials and methods

Characteristic of the study area

The survey was carried out in Karimunjawa from March 2-10, 2021. Four sampling site locations were established in the study area included Burung Island, Geleang Island, Sambangan Island, and Seruni Island of Karimunjawa Marine National Park as shown in Figure 1. The Burung Island (S 05°53'27,9" E 110°20'46,2") as the name implies, Burung (Birds) has the characteristic of an island with a flock of bird's habitat. This location is a protected island for seabirds to breed. There is a site location for diving tourism. Geleang Island, tourist attracted, (S 05°52'56,0" E 110°21'29,5") is decorated with white sand beaches for snorkeling, sunbathing, and swimming. Sambangan island (S 06°35'08.5'', E 110°38'24.8'') is a maricultural farm with the cultivation of coral reefs and grouper fish. The last one, Seruni island (S 05°51'13,3" E 110°34'36,8"), is an empty, uninhabited island. Hence, the Burung, Geleang, Sambangan, and Seruni islands represent dive tourism, tourist area, mariculture activity, and no or minimum anthropogenic disturbance, respectively.

Gorgonian identification

Gorgonian identification was conducted according to A Field Key to the Identification of Zooxanthellate Octocorals [16]. These keys were designed to identify the gorgonian corals without colony collection or microscopic examination of sclerites. Several characters including colony color and branching pattern, morphology, and polyp were combined to identify the genus. To support the field key of identification, the Indonesian gorgonian book identification 'Gorgonians in Indonesian waters' [17] and the book 'Soft corals and sea fans: a comprehensive guide to the tropical shallow-water ' [18] were also be used to confirm with overcoming the problem of difficulty in identifying gorgonians in the field. In previous, several conservation surveys were conducted with a tendency to ignore gorgonian taxa mainly due to unresolved taxonomic assignments [4].

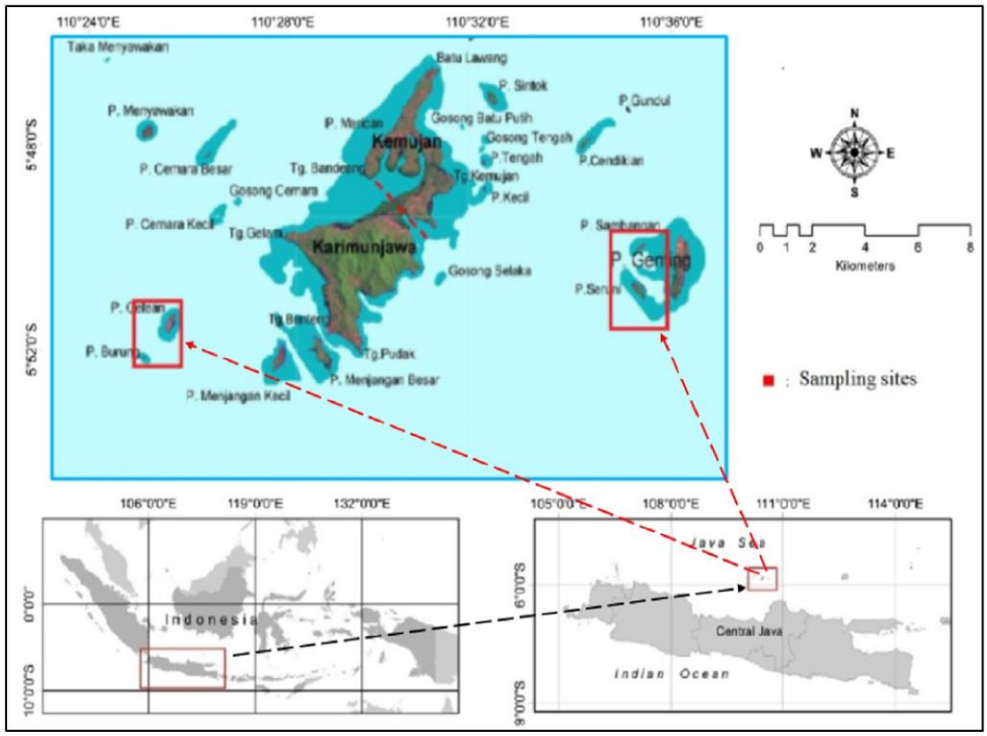

Fig. 1. Sampling site locations of Karimunjawa islands

Gorgonian abundance and diversity

The Roving Diver visual survey method was used to record data on species composition and abundance of all gorgonian [19]. This technique was used in this study due to the uncertain occurrence of gorgonian in this region. Besides, no previous studies were published from this site regarding gorgonian abundance and diversity. Specimens were documented directly from the substrate in the field by Scuba diving at each site from 3-10 March 2021. Totally 16 dives with 2 dives in every sampling site were involved. The roving diver survey technique involved four divers investigating organisms for about 45min to record all gorgonian genera in the maximum 20m in depth. The biological indexes such as species richness (SR), the Shannon index (H'), the Pielou's evenness index (J'), and the Jaccard index were used to analyze the data obtained in the field.

Results and discussion

A total of 12 genera and 5 families of gorgonians were reported from the sampling site locations (Table 1). The high number of genera was recorded from Seruni island (11) followed by Burung Island (10), Sambangan island (7), and Geleang island (4). The genus *Melithaea* was described in the highest number followed by *Ellisella, Viminella, Paraplexaura, Mopsella, Dichotella and Junceella* while *Dichotella* reported only in Burung Island (Table 2 and Figs. 2 and 3).

Table 1. Gorgonian identifications from Karimunjawa [17]

No.	Proposed family/genera	The appearance of the gorgonian	Depth (m)	Habitat
I. Ellisellidae Gray,1859:				
1.	Ellisella	Bushy colonies, long and whip-like polyps around the branches, yellow/grey color	10-14	Rubble
2.	Junceella	Whip like an unbranched colony, monomorphic, polyps around the branches, orange, pinky red	3- 5	Sediment, rubble
3.	Viminella	Whiplike colony, polyps monomorphic, and contractile, grey, yellow.	10-15	Rubble
4.	Dichotella	Dichotomously branched fans and bushes, polyps monomorphic, around the branches, upwards. brown, yellow color	12-15	Coral
II.Plexauridae Gray, 1859:				
5.	Euplexaura	Fan colony, thick branches, monomorphic, refractile polyps, yellowish-brown	4-8	Coral
6.	Rumphella	Thick bushes colony, monomorphic, have grey to brown horny axis retractile into the branch surface, brown to greenish-grey	10-12	Rubble
7.	Paraplexaura	Thickly branched colony, retractile polyps, red, orange	10-15	Coral
III. Melithaeidae Gray, 1870:				
8.	Melithaea	Colored colonies form large fans, net-like, some have multiple parallel fans. Monomorphic, small and retractile, brown	10-15	Coral
9.	Mopsella	Colonies branched densely in one parallel fan, polyps are small and retractile, pink/red color	11-15	Rubble
10.	Acabaria	A branched dichotomously, form bushes with small monomorphic polyps, retractile, red, orange color	5-7	Coral
IV.Acanthogorgiidae Gray, 1859:				
11.	Acantogorgia	Brunch colonial form, bush-like, monomorphic retractile polyps, orange, red	12-15	Coral
V. Isididae Lamouroux, 1812:				
12.	Isis	Colonies branching from internodes, bushy, polyps retractile no projecting, yellowish-brown	10-11	Coral

The diversity and abundance of gorgonian are important to estimate the changes in the marine ecosystem. Compared to records of Indonesian gorgonian in the previous studies, the gorgonian diversity observed in this study was lower. *S.J. Rowley* [12] has reported over 38 genera and 12 families from Wakatobi Marine National Park of East Indonesia. While Manuputy [13] recorded 17 genera from six different families in Seribu island. However, the gorgonians in these islands are still classified as moderate in terms of abundance and diversity (H':1.2-2.0, 1< H'≤ 3 = moderate diversity). The data obtained for Shannon – Weiner index (H') ranged from 1.22 to 2.0, Parlour's evenness index (J') varied from 0.81 to 0.96, and Simpson's richness index ranged from 0.72 to 0.91 (Table 2).

Table 2. The abundance and diversity of gorgonian corals in four different islands

Family/ Genera	Burung		Geleang		Sambangan		Seruni		
	n	RA (%)	n	RA (%)	n	RA (%)	n	RA (%)	Total
Ellisellidae Gray, 1859:									
Ellisella sp.	16	10.88	5	12.82	2	14.29	7	19.44	30
Junceella sp.	6	4.08	1	2.56	3	21.43	4	11.11	14
Viminella sp.	4	2.72	7	17.95	2	14.29	9	25.00	22
Dichotella sp.	16	10.88	-	-	-	-	-	0.00	16
Plexauridae Gray, 1859:									
Euplexaura sp.	-	-	-	-	1	7.14	1	2.78	2
Rumphella sp.	1	0.68	-	-	-	-	1	2.78	2
Paraplexaura	19	12.93	-	-	1	7.14	1	2.78	21
Melithaeidae Gray, 1870:									
Melithaea sp.	29	19.73	-	-	2	14.29	2	5.56	33
Mopsella sp.	5	3.40	8	20.51	-	-	8	22.22	21
Acabaria sp.	1	0.68	-	-	-	-	1	2.78	2
Acanthogorgiidae Gray, 1859:									
Acanthogorgia	-	-	-	-	1	7.14	1	2.78	2
Isididae Lamouroux, 1812:									
Isis sp.	1	0.68	-	-	-	-	1	2.78	2
Total individu		98.00		21.00		12.00		36.00	167.00
Species Richness		9.00		4.00		7.00		11.00	
Diversity index (H)		1.86		1.22		1.95		2.00	
Simpson Richness		0.82		0.72		0.91		0.85	
Evenness (J ‘)		0.88		0.81		0.96		0.87	

Note: n: no. of the individual; RA: Relative Abundance

Fig. 2. Gorgonian of Karimunjawa archipelago (Notes: *1. Ellisella sp., 2. Junceella sp., 3. Viminella sp., 4. Dichotella sp.,5. Euplexaura sp., 6. Rumphella sp., 7. Paraplexaura sp., 8. Melithaea sp., 9. Mopsella sp., 10. Acabaria sp., 11.Acanthogorgia sp, 12.Isis sp.*

Gorgonian's diversity showed no significant difference among these islands (F-value >0.05). The low gorgonian abundance observed in this study could be attributed to the relatively few islands to be assessed. However, these values showed that gorgonian octocoral in Karimunjawa was in a moderate level of species diversity with the stable community (H' value 1< H'< 3; J' 0.75-1). Hence, the more comprehensive survey covering a wider area and a fix key for field identification may reveal more species of gorgonians.

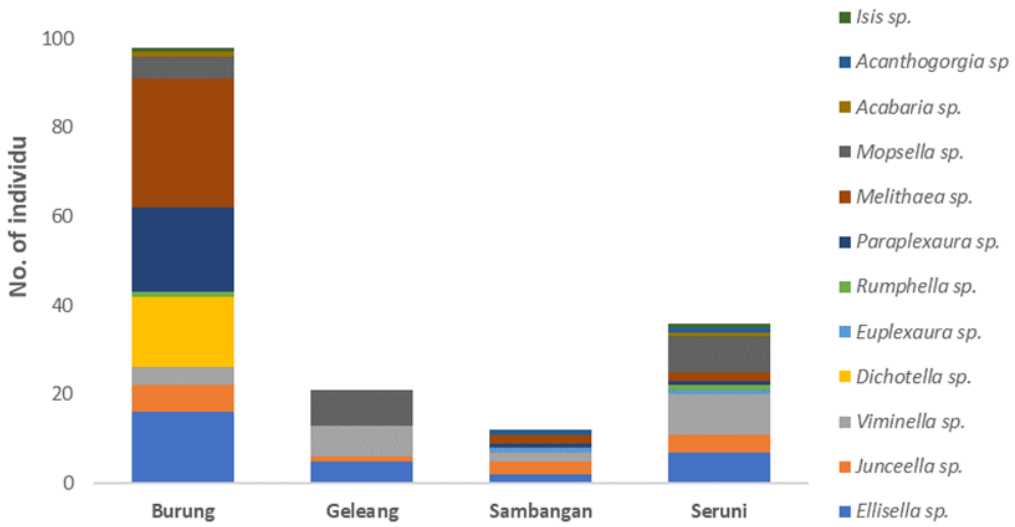

Fig. 3. Number of gorgonians covers among the Islands, Karimunjawa

General oceanographers and ecosystem ecologists are interested in the diversity of octocoral organisms due to the variety in their number of species (richness) and their relative abundance of these species (evenness). Species richness does not allow for the number of individuals of each species present. Hence, to reveal the gorgonian coral communities, a Jaccard similarity coefficient matrix of genera by island was used to analyze. The analysis results showed that the gorgonian communities on Burung Island were more similar to Seruni Island (75%), instead, Sambangan Island and Seruni Island were the least similar (36.4%) (Table 3).

Table 3. Jaccard Similarity indices between the Islands of Karimunjawa (%)

Location	Burung Island	Geleang Island	Sambangan Island	Seruni Island
Burung Island	-			
Geleang Island	40	-		
Sambangan Islannd	41.6	37.5	-	
Seruni Island	75	36.4	63.6	-

The quite similar gorgonian genera between Burung Island and Seruni Island observed in the study could be attributed to the least anthropogenic disturbance on both islands. *J. He et al* [20] found that in the less disturbed stream, functional richness increased but divergence decreased downstream. As mentioned before, Burung island is a protected area for bird habitat. It means that no one is permitted to do activity in those areas without a permission letter given by Park Management Officer. While Seruni island is uninhabited with no anthropogenic stressors.

Conclusions

Rapid assessment of gorgonian octocoral in four islands of Karimunjawa Marine Park through collecting, identifying, analyzing, and comparing gorgonian genera was carried out. The genus *Ellisella* of the family Ellisellidae was most of the genera collected. The lowest genera diversity and evenness were Geleang island. Seruni Island has the highest species diversity and evenness due to its undisturbed state relative to the three islands. The genera diversity of all the four islands shows a moderate level of diversity. To obtain the true range of the gorgonian distribution in Karimunjawa, it is necessary to conduct more intensive research using ecological parameters that are closely related to several factors influencing the gorgonian distribution. In addition, despite their abundance and ecological importance, however, it is difficult to identify octocoral gorgonian species. Hence, a fixed key for field identification used in this study is urgently needed.

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