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THE SPATIAL TRENDS IN THE COMMUNITY STRUCTURE OF GASTROPOD ASSEMBLAGES THE COASTAL AREA OF TOMIA ISLAND, WAKATOBI MARINE NATIONAL PARK, INDONESIA

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ABSTRACT

Gastropod is one of among the most important taxa of marine benthic that plays ecological role for the ecosystem stability in the coastal area. This study was aimed to elucidate the spatial trends in the community structure of gastropod that assemblages the coastal area of Tomia Island, Wakatobi Marine National Park, Southeast Sulawesi, Indonesia. Two transect lines were placed perpendicularly to the coastline for observation the species and their individuals number of gastropod. Data were analyzed quantitatively for determining the importance value index, diversity index, evenness index, similarity index and ordination pattern. High species number of gastropod was found at the coastal area of Tomia Island, which represented by 23 species gastropod at open beach, and 26 species gastropod at unopen beach, respectively. The diversity index and Evenness Index were estimated as 2.44 bit and 0.78 at open beach, and 2.64 bit and 0.81 at unopen beach respectively. The *Conomurex luhuanus* was the most dominant gastropod at open beach, while the *Strombus gibberulus* was the most dominant gastropod at the unopen beach. Most of values of similarity index (SI) of gastropod among stands at the open beach were higher than those of at the unopen beach, indicating high similarity species composition of gastropod among sites at the open beach. Ordination pattern of gastropod both at the open and unopen beaches created 4 groups, while the degree of similarity of among stands decreased as increasing the distance of the stands. Therefore, spatial trends of the community structure of gastropod assemblages the coastal area of Tomia Island seems to associated with the spatial heterogeneity.

INTRODUCTION

Wakatobi Marine National Park (WMNP) is one of among the most popular Marine Parks in Indonesia, while Tomia Island becomes the main target for the foreigner researchers and tourisms due to its marine potentiality. High biodiversity resource potential, in terms of both species and uniqueness have verified in the WMNP, and are very interesting for researchers and tourisms activity, while the coastal area of Tomia Island supports an unique marine biodiversity, such as coral reef, fishes and snails, etc. It is known that organisms of gastropod are among the most popular benthic at the coastal areas of the world. However, the organisms in gastropod taxa provide food source not only for other marine organisms but also for human, and therefore, some species might have threatened due to over exploitation as well as habitat destruction of the coastal region. Many studies revealed that various environmental factors such as depth, tidal height, time of exposure, and type of sediment influence the distribution and abundance of benthic organisms at intertidal region (e.g. Brown and Mc Lachlan, 1990; Dittmann, 2000; Lizarralde, 2002; Veloso *et al*., 2003). Many other important environmental factors such as food availability, larval dispersal and settlement, intra and interspecific competition, and predation also influence community structure of benthic community in the intertidal area. Some experimental studies have demonstrated that biological interactions, such as predation and competition, affect the benthic community structure by acting on recruitment, survival, or migration of organisms (e.g. Brenchley, 1982; Thrush *et al.*, 1992; Knox, 2000). Other studies showed that benthic communities

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fluctuate in a cyclic pattern over time, because of the characteristics of the life cycle of the species, as well as of the influence of temporal fluctuations of abiotic factors, such as environmental temperature or salinity (Day *et al*., 1989; Das Neves *et al.,* 2008). However, little information is known regarding benthic invertebrates of coastal area of Tomia Island, knowledge of which is important for conservation and sustainable management of the Island. Ecological studies of benthic organisms such as gastropod inhabiting at the intertidal environments of Tomia Island are necessary to generate baseline information that contributes for management this coastal area, which is permanently influenced by anthropogenic activities including recreation and commercial fisheries, as well as urban development. This study was aimed to analyze the spatial trends in the abundance and community structure of gastropod that assemblages the coastal area of Tomia Island.

MATERIALS AND METHODS

Study site

The present study was carried out at the coastal area of Tomia Island, Wakatobi Marine National Park, which is located at the $05^0 46$, 826'S and $123^0 55$, 524'E (Figure 1). The beach conditions are composed by hard rock and sand. There are some seagrass growth along the study site, such as *Cymodocea rotundata, Cymodocea serulata, Enhalus acoroides* dan *Halophila minor*.

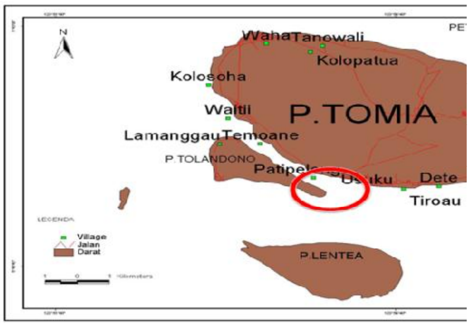


Figure 1. Map of the study site

Sampling Method

The two transect lines were placed perpendicularly to the costal line Tomia Island, i.e. Transect I (460 m length) was placed at the open beach and divided into 13 stands of $400m^2$ wide each, while transect II (360 m length) was placed at protected beach and divided into 8 stands of $400m^2$ wide each. Furthermore, five small quadrat of $1m^2$ wide each were placed purposively in each stand both at the transect I and II. The species name of gastropod and their individuals number were observed in each small quadrat of 1 m^2 wide. In addition, the substrate samples were taken from transect I and II for determining substrate type and organic content.

Data analyzed

The ecological indicators of gastropod such as, the importance value index, diversity index and evenness index were calculated in each stand. Importance value index was calculated by summation of relative density and relative frequency of each species of gastropod. Diversity index and evenness index of gastropod were estimated by using Shannon-Wienner index and evenness index (Brower *et al*., 1997). Furthermore, similarity index and ordination pattern of gastropod among stands were elucidated by using Bray and Curtis technique (Bray and Curtis, 1957)

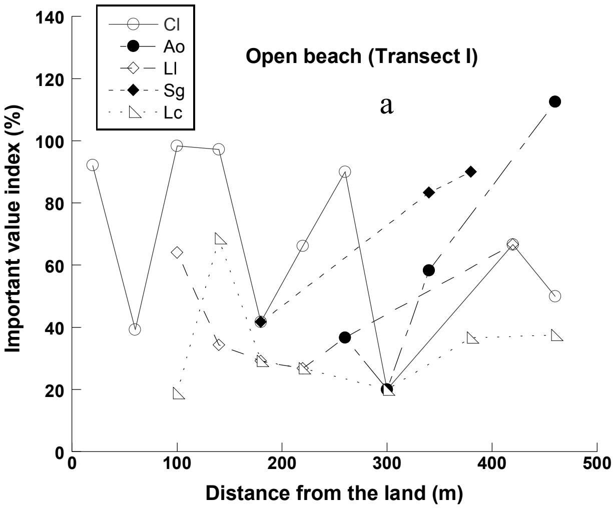
RESULTS

Species composition of Gastropod

Table 1 represents the species composition of gastropod both at the transect I and II. The number of species of gastropod at the transect I (open beach) and transect II (unopen beach) was slightly different, i.e. there existed 23 species at transect I and 26 species at transect II, respectively. The *strombidae* was the most dominant Family both at the transect I and II, which was consisted by 7 species of gastropod, while most of other families were consisted by single species of gastropod only. These trends suggested that the species of gastropod belong to the strombidae might be the most adaptable gastropod in this study site as compared to other species. However, the Shannon-Wienner Index and Evenness Index values of gastropod at transect I were estimated as 2.44 bit and 0.78 respectively. On the other hand, the Shannon-Wienner Index and Evenness Index values of gastropod at transect II were estimated as 2.64 bit and 0.81 respectively. These trends means that the community structure of gastropod at the unopen beach showed high diversity, which might be much stable than that of gastropod at open beach.

Table 1. The species composition of gastropod at the study site

No	Family	Species	Transect I	Transect II
1		*Lambis lambis*	√	√
		Lambis chiragra	√	√
		Lambis cronata	√	√
		Strombus lentiginosus	√	√
	Strombidae	*Conomurex luhuanus*	√	√
		Strombus gibberulus	√	√
		Canarium labiatus	√	√
2		*Cypraea tigris*	√	–
	Cypraeidae	*Cypraea microdon*	√	√
3	Triviidae	*Trivia oryza*	–	√
4	Cerithiidae	*Rhinoclavis fasciata*	–	√
		Cerithium columna prodita	√	√
5	Bursidae	*Burso bubo*	–	√
6	Naticidae	*Uberella vitrea*	√	√
		Natica limbata	–	√
7	Trochidae	*Trochus niloticus*	√	√
		Trochus viridis	–	√
8	Turbinidae	*Asralium okamotoi*	√	√
		Astralium calcar	–	√
9	Angariidae	*Angaria sp*	–	√
10	Mitridae	*Mitra episcopalis*	√	–
11	Muricidae	*Chicoreus Brunneus*	–	√
12	Volutidae	*Cymbiola vespertilio*	√	–
13	Columbellidae	*Columbella scripta*	√	–
14	Nassariidae	*Nassarius coronatus*	√	√
		Nassarius aoteanus	√	–
15	Conidae	*Virgiconus flavidus*	√	√
		Virroconus coronatus	√	–
16	Mitridae	*Pusia microzonalis*	√	–
		Vexillum gruneri	–	√
		Vexillum rugosum	√	√
17	Terebridae	*Terebra sublata*	√	√
18	Ellobiidae	*Melampus luteus*	–	√
19	Bullidae	*Bulla vernicosa*	–	√



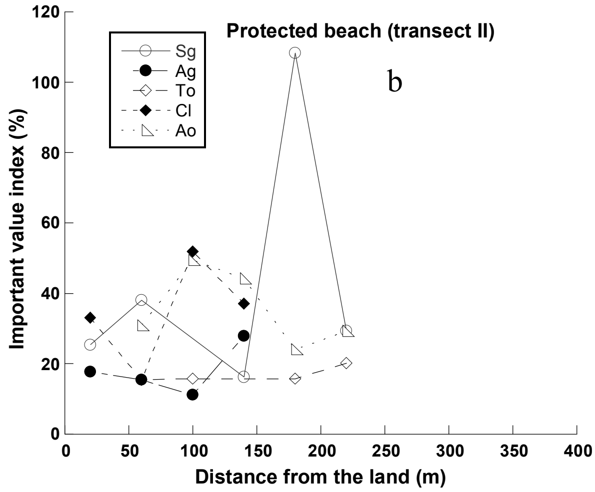
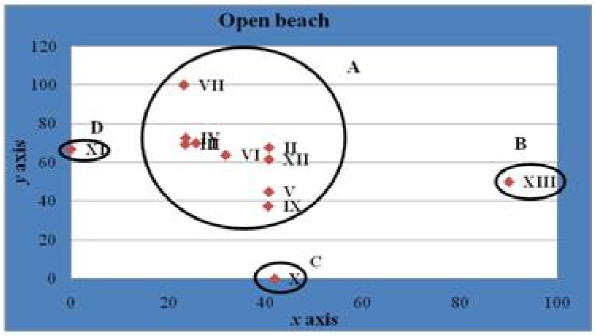


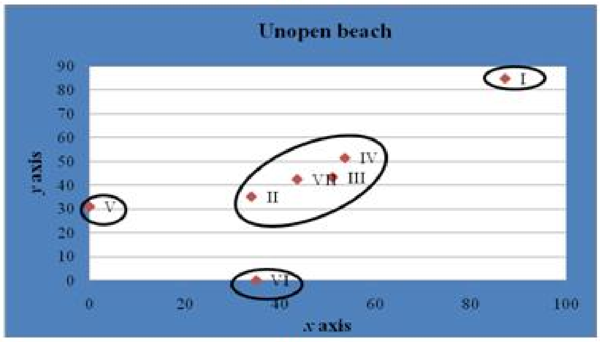
Figure 2. Spatial trend in abundance of five dominant species gastropod at open beach (transect I, upper) and un open beach (transect II, below)

Distribution of abundance

The distribution of abundance of gastropod at the transect I is described by Table 2. Most of gastropod at open beach showed few important value index. The *Conomurex luhuanus* only had important value index nearly 50%, while most of other species had important value index less than 10 %. However, five species of gastropod only had important value index 10-20 %. Figure 2a shows the spatial distribution in abundnace of five dominant species of Gastropod at transect I. The *Conomurex luhuanus* was the most dominant gastropod from the near the land site and the middle area. This result stands for that *Conomurex luhuanus* might be as a key species for maintaining the stability of gastropod community near the land until the middle sites at the transect I. On the other hand, *Lambis cronata* and *Astralium okomotoi* were dominant at the distances of 420 m and 460 m from the land, while their important value index were estimated as 90% and 112.5%, respectively. This means that these species might play an important role for maintenance the stability of gastropod community near the sub tidal zone. Table 3 describes the distribution of abundance of gastropod at transect II. It shown that *Strombus gibberulus* was the highest important value index (34.31%), indicating its superiority. The three other gastropods such as *Asralium okamotoi*, *Angaria sp* and *Canarium labiatus* had the same value of IVI that is 22.45% , while other species showed lower important value index. However, the only six species or 23% of gastropod had important value index more than 10%, while around 77% species gastropod had important value index less than 10% indicating inferiority of gastropod. Figure 2b describes spatial trend in abundance of gastropod at transect II.

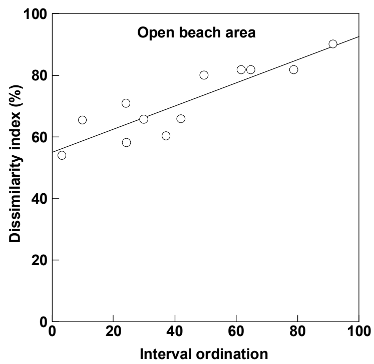


(a)



(b)

Figure 3. Ordination pattern of *Gastropod* community at the open and unopen beaches in the Coastal area of Tomia Island Wakatobi Marine National Park



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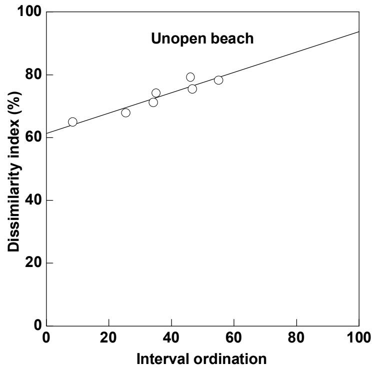

(b)

Figure 4. Relationship of interval ordination to the dissimilarity index of gastropod community at the coastal area of Tomia Island, Wakatobi Marine National Park

Table 2. Density, frequency and Important value index of gastropod at Intertidal area of Tomia Island, Wakatobi Marine National Park (Transect I or open beach)

No	Name of Species	Number of individual	Density (ind/m²)	Relative density (%)	Frequency	Relative frequency (%)	Important value index (%)
1	*Asralium okamotoi*	9	0.15	9.38	0.07	6.667	16.04
2	*Canarium labiatus*	1	0.017	1.04	0.02	1.667	2.708
3	*Cerithium columna prodita*	1	0.017	1.04	0.02	1.667	2.708
4	*Columbella scripta*	1	0.017	1.04	0.02	1.667	2.708
5	*Conomurex luhuanus*	31	0.517	32.3	0.17	16.67	48.96
6	*Cymbiola vespertilio*	5	0.083	5.21	0.08	8.333	13.54
7	*Cypraea microdon*	1	0.017	1.04	0.02	1.667	2.708
8	*Cypraea tigris lyncicrosa*	1	0.017	1.04	0.02	1.667	2.708
9	*Lambis chiragra*	5	0.083	5.21	0.08	8.333	13.54
10	*Lambis cronata*	8	0.133	8.33	0.12	11.67	20
11	*Lambis lambis*	9	0.15	9.38	0.1	10	19.38
12	*Mitra episcopalism*	1	0.017	1.04	0.02	1.667	2.708
13	*Nassarius aoteanus*	1	0.017	1.04	0.02	1.667	2.708
14	*Nassarius coronatus*	1	0.017	1.04	0.02	1.667	2.708
15	*Pusia microzonalis*	1	0.017	1.04	0.02	1.667	2.708
16	*Strombus gibberulus*	9	0.15	9.38	0.05	5	14.38
17	*Strombus lentiginosus*	1	0.017	1.04	0.02	1.667	2.708
18	*Tectus niloticus*	1	0.017	1.04	0.02	1.667	2.708
19	*Terebra sublata*	2	0.033	2.08	0.03	3.333	5.417
20	*Uberella vitrea*	1	0.017	1.04	0.02	1.667	2.708
21	*Vexillum rugosum*	2	0.033	2.08	0.03	3.333	5.417
22	*Virgiconus flavidus*	2	0.033	2.08	0.03	3.333	5.417
23	*Virroconus coronatus*	2	0.033	2.08	0.03	3.333	5.417
		96	1.6	100	1	100	200

Table 3. Density, frequency and Important value index of gastropod at Intertidal area of Tomia Island, Wakatobi Marine National Park (Transect II or unopen beach)

No	Name of Species	Number of individual	Density (ind/m²)	Relative density (%)	Frequency	Relative frequency (%)	Important value index (%)
1	*Angaria sp*	6	0.17	5.36	0.11	8.16	13.52
2	*Asralium okamotoi*	16	0.46	14.30	0.11	8.16	22.45
3	*Astralium calcar*	2	0.06	1.79	0.03	2.04	3.827
4	*Bulla vernicosa*	2	0.06	1.79	0.03	2.04	3.827
5	*Burso bubo*	1	0.03	0.89	0.03	2.04	2.934
6	*Canarium labiatus*	16	0.46	14.30	0.11	8.16	22.45
7	*Cerithium columna prodita*	4	0.11	3.57	0.06	4.08	7.653
8	*Chicoreus Brunneus*	3	0.09	2.68	0.06	4.08	6.76
9	*Conomurex luhuanus*	3	0.09	2.68	0.06	4.08	6.76
10	*Cypraea microdon*	2	0.06	1.79	0.03	2.04	3.827
11	*Lambis chiragra*	5	0.14	4.46	0.09	6.12	10.59
12	*Lambis cronata*	1	0.03	0.89	0.03	2.04	2.934
13	*Melampus luteus*	1	0.03	0.89	0.03	2.04	2.934
14	*Nassarius coronatus*	2	0.06	1.79	0.03	2.04	3.827
15	*Natica limbata*	1	0.03	0.89	0.03	2.04	2.934
16	*Rhinoclavis fasciata*	3	0.09	2.68	0.06	4.08	6.76
17	*Strombus gibberulus*	27	0.77	24.10	0.14	10.2	34.31
18	*Strombus lentiginosus*	2	0.06	1.79	0.06	4.08	5.867
19	*Tectus niloticus*	1	0.03	0.89	0.03	2.04	2.934
20	*Terebra sublata*	1	0.03	0.89	0.03	2.04	2.934
21	*Trivia oryza*	6	0.17	5.36	0.11	8.16	13.52
22	*Trochus viridis*	1	0.03	0.89	0.03	2.04	2.934
23	*Uberella vitrea*	2	0.06	1.79	0.03	2.04	3.827
24	*Vexillum gruneri*	1	0.03	0.89	0.03	2.04	2.934
25	*Vexillum rugosum*	1	0.03	0.89	0.03	2.04	2.934
26	*Virgiconus flavidus*	2	0.06	1.79	0.03	2.04	3.827
		112	3.2	100	1.4	100	200

Table 4. Similarity and dissimilarity indexes of gastropod community at open beach

IS/ID	1	2	3	4	5	6	7	8	9	10	11	12
1	-	80.36	44.58	53.98	73.77	61.57	55	85	89.2	83.81	61.27	75
2	19.64	-	80.36	80.36	80.36	73.66	80.36	85	100	100	80.36	80.36
3	55.42	19.64	-	38.16	65.6	65.39	59.17	80.6	100	85.9	51.28	70.3
4	46.02	19.64	61.84	-	64.58	53.57	46.43	85	100	81.67	58.1	65.63
5	26.23	19.64	34.4	35.42	-	69.49	75	80	79.17	67.71	75	71.88
6	38.43	26.34	34.61	46.43	30.51	-	60.27	80	86.61	79.91	63.39	68.3
7	45	19.64	40.83	53.57	25	39.73	-	85	81.67	100	57.5	65.83
8	15	15	19.4	15	20	20	15	-	90	85	90	80
9	10.8	0	0	0	20.83	13.39	18.33	10	-	64.58	85.42	70.83
10	16.19	0	14.1	18.33	32.29	20.09	0	15	35.42	-	81.67	81.67
11	38.73	19.64	48.72	41.9	25	36.61	42.5	10	14.58	18.33	-	75
12	25	19.64	29.7	34.38	28.13	31.7	34.17	20	29.17	18.33	25	-

Table 5. Similarity and dissimilarity indexes of gastropod community at unopen beach

IS/ID	1	2	3	4	5	6	7
1	-	82.05	78.25	74.98	87.31	84.81	100
2	17.95	-	77.85	67.83	71.06	74.16	100
3	21.75	22.15	-	64.85	86.11	79.19	100
4	25.02	32.17	35.15	-	85.86	84.56	100
5	12.69	28.94	13.89	14.14	-	75.4	100
6	15.19	25.84	20.81	15.44	24.6	-	100
7	0	0	0	0	0	0	-

It showed that *Strombus gibberulus* had high important value index nearly in each stand, except at the distance of 100 m and of 260 m from the land area or at stand 3 and stand 7. Its important value index ranged from 16.23 in the stand 4 up to 108.33 at stand 5. On the contrary, *Asralium okomotoi* showed higher important value index at stand 3 and stand 4, while *Canarium labiatus* showed its high important value index at stand 3. These two species likely play an important roles for maintenance the stability of gastropod community at beach near the sub tidal zone.

Similarity Index

The values of similarity index of gastropod among stands at transect I (Table 4) were estimated to be low. Most of the Similarity Index (SI) values among stands were less than 50%. The higher SI values among stands were found between stands 1 and 3, stands 3 and 4, and stands 4 and 7, i.e. SI among those stands were estimated as 55.42, 61.84 and 53.57 %, respectively. However, many SI values of gastropod among stands were less than 20% even SI some stands was 0, indicating low degree similarity of gastropod among stands in the present study. This result suggested that the species composition of gastropod at open beach showed its differences from the near the land site to the open sea or sub tidal zone. The values of Similarity Index (SI) of gastropod among stands at transect II (Table 5) were found to be lower as compare with SI at the transect II. There was no values of similarity index among stands in this transect more than 50%, indicating low degree similarity. The only SI among stand 3 and 4 was estimated to be 35.15%, even the values of SI among stand 7 and other stands were completely zero means that the gastropod composition of stand 7 was completely different with the other stands. Therefore, the species composition of gastropod at the transect II was different from the land site to the open sea.

Multidimension Pattern of Gastropod

Multidimension pattern of gastropod at the present study site was elucidated by ordination technique analyses. Figure 3 showed the multidimension pattern of gastropod both at transect I and II. The ordination pattern of gastropod at the transect I (Fig. 3a) performs 4 group, i.e. (1) Group A was consisted for nine stands including stands I, II, III, IV, V, VI, VII, IX and XII; (2) Group B was consisted by the stand VIII only; (3) Group C was consisted by the stand X only; and (4) Group D was created by the stand XI only. Statistical analysis showed that dissimilarity index (DI) of gastropod among stands in this site increased significantly as increasing in Interval Ordination (IO) ($P < 0.01$; Fig. 4b). These trends realized that the degree of dissimilarity of among stands increased as increasing the distance of the stand. The ordination pattern of gastropod at the transect II (Fig. 3b) could also divided into 4 groups, though the distribution of stands in each group was different trend as compared to the grouping at the transect I. These groups were: (1) Group A was consisted for stand I only; (2) Group B was couple four stands, i.e. stands II, III, IV and VII; (3) Group C was represented for stand VI only; and (4) Group D was created by the stand V only. Statistical analysis showed that Dissimilarity Index (DI) of gastropod among stands in the transect II increased significantly as increasing in Interval Ordination (IO) ($P < 0.01$; Fig 4). This means that the degree of dissimilarity of among stand at the transect II increased as increasing the distance of the stand.

DISCUSSION

The present study showed the variety in the distribution and community structure of gastropod that assemblages the coastal area of Tomia Island, Wakatobi Marine National Park, Indonesia. High species number of gastropod was found at the coastal area of Tomia Island, which represents 23 species at open beach, and 26 species at unopen beach, respectively. The *Conomurex luhuanus* was the most dominant gastropod at open beach, while the *Strombus gibberulus* was dominant at unopen beach. The similarity index of among sites of gastropod both at open beach (transect I) and unopen beach (transect II) as described by Tables 4 and 5 showed that the Similarity Index (SI) of Gastropod among stands at transect I (Table 4) was low because most of SI values among stands were estimated less than 50%. The higher SI values of gastropod at transect I was found only for SI between stands I-II, III-IV, and stands IV-VII, i.e. SI values among these stands were estimated as 55.42, 61.84 and 53.57 %, respectively. However, many SI values of gastropod among stands were estimated less than 20% even SI values some stands were zero, indicating the less similarity degree of Gastropod among stands in this site. This result suggested that the species composition of gastropod at open beach showed its differences from the near the land site to the open sea or sub tidal zone. The Similarity Index (SI) among stands of gastropod distributed at transect II or unopen beach (Table 5) was found to be lower as compare with SI gastropod at the transect I or open beach. There was no stand having more than 50% of similarity index at unopen beach, indicating their less degree similarity or high dissimilarity. The only SI among stands III and IV was estimated as 35.15%, even the SI values of paired stand VII to other stands were estimated as zero, it means that the species composition of gastropod at stand VII was completely different from the other stands. These results realized that spatial trends in community structure of gastropod varied across unopen beach gradient.

Multidimension pattern of gastropod community at the study site was elucidated by ordination technique analyses. The ordination pattern of gastropod both at transect I and II showed that the ordination pattern of gastropod at the transect I (Fig. 3a) could divided into 4 groups, i.e. (1) Group A was consisted for nine stands including stands I, II, III, IV, V, VI, VII, IX and XII; (2) Group B was performed by stand VIII only; (3) Group C was formed by stand X only; and (4) Group D was created by stand XI. However, ordination pattern of gastropod at the transect II (Fig. 3b) could also divided into 4 groups, though the distribution of stands in each group was different trend as compared to the grouping at the transect I. These groups were: (1) Group A was consisted for stand I only; (2)

Group B was couple four stands, i.e. stand II, III, IV and VII; (3) Group C was represented for stand VI only; and (4) Group D was appear for stand V only. Statistical analysis showed that Dissimilarity Index (DI) of gastropod among stands (Fig. 5) in this site both at open and unopen beaches increased significantly as increasing in Interval Ordination (IO) ($P < 0.001$). This means that the degree of similarity of among stand decreased as increasing the distance of the stand. These spatially heterogeneity might be correlated to the environmental condition of the beach, such substrate types costal area of Tomia Island, Wakatobi Marine National Park. Gastropod community showed less similarity degree among stands because they responded to the different sets of substrate types, which influenced the community structure of gastropod in the Tomia Island. For species that have limited dispersal abilities, distance or a spatial component are expected to be important structuring factors in gastropod similarity, which would result in assemblages from sites close together being more similar than assemblages other substrate types.

Many previous studies revealed that distance between sites can be a function of differences in spatially explicit environmental variables (Borcard *et al*., 1992; Harrison *et al*., 1992; Ohmann and Spies 1998). The present result was clearly found a significant association between distance and community structure of gastropod both at open and unopen beaches, because it showed higly significant relationship between interval ordination and dissimilarity index for this three taxon. Many previous studies realized that pattern in beta diversity can differ among Taxa due to community-wide differences in dispersal ability and other taxon-specific factor (Reyers *et al*., 2000). Pattern in community structure of organisms in many taxa have been affected by not only distance between sample stands but also environmental variables (Ellingsen and Gray 2002; Clearly *et al*., 2004). Biotic factors, such as human disturbance might had been the other factor that reduce the individual number and the species number of benthic community at the coastal marine. Species on Gastropod are frequently collected by people for consumption, which might has strong impact on their abundance and distribution. However, interaction among species gastropod becomes biological control for the community stability, while the association with distance itself may also be due to distance-dependent environmental variable.

Conclusion

The present result was clearly found a significant correlation between stands distance and community structure of gastropod assemblages the coastal area of Tomia Island, Wakatobi Marine National Park, Indonesia. The unopen beach showed more high diversity gastropod as compared to the open beach. Spatial trend of gastropod in this area seems to associated with the spatial heterogeneity as it showed by multidimension analyses.

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