Diversity of Gastropods and Bivalves in mangrove ecosystem rehabilitation areas in Aceh Besar and Banda Aceh districts, Indonesia

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Abstract. This study was conducted in mangrove rehabilitation area on May to November 2011. The objective of the present study was to evaluate the diversity of Gastropods and Bivalves based on the different level of vegetation age of mangrove. Sampling were conducted on 1 x 1 m^2 of square transects. We recorded 14 species of Gastropods and 5 species of Bivalves with abundance of 371 individuals/m^2 and 28 individuals/m^2, respectively. The highest abundance of Gastropod was found on 4 years vegetation age on *Cerithidae cingulata* (150 individuals/m^2), while the highest abundance of Bivalves was found on 3 years vegetation age on *Pedalion isognomum* (8 individuals/m^2). In conclusion, the condition of community structure post tsunami was unstable.

Key Words: mangrove, rehabilitation, community structure, Gastropods, Bivalves.

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Introduction

Mangrove forests are a typical forest ecosystem growing along the coast or estuaries and they are affected by the tide and flow with a wide variety of environments throughout the tropical and sub-tropical regions (Nybakken 1992; Aksornkoae 1993). Mangrove plays an important role in the lifecycle of various aquatic organisms such as fishes, shrimps and mollusks especially for spawning, nursery and feeding grounds (Pramudji 2001). Mangrove as a feeding ground contributes to the habitat complexity and diversity of the macrofauna associated in mangrove ecosystem, while crustaceans and mollusks are the dominant macrofauna in this ecosystem (Hutchings & Saenger 1987; Sasekumar 1974). The macrofauna diversity and abundance may reflect biological indicators of changing habitat in mangrove ecosystem (Macintosh *et al* 2002).

The past tsunami in late 2004 has destroyed and reduced the mangrove ecosystem in Aceh coastal zone and it resulted in a negative impact on mangrove biota for example Gastropods and Bivalves. According to Dewiyanti (2005) *Rhizopora apiculata*, *R. stylosa* and *Avicennia marina* were the dominant species of mangrove pre tsunami in Ulee Lheue coastal, Banda Aceh city. Furthermore, Dewiyanti (2005) reported that there were 22 species of Gastropods and 17 species of Bivalves occurred before tsunami in mangrove area of Ulee-Lheue where the most dominant families were Cerithidae and Isognomonidae for Gastropods and Bivalves, respectively.

The changes of mangrove forest from the stable vegetation pre tsunami to the newly vegetations covered by sapling and seedling certainly caused a serious impact to the biotic life in changing of community structures in relation to abundance and diversity. Most of Bivalves, not only were consumed by the local people, but also were used as a commercial alternative livelihood of local people to increase their income. Gastropods and Bivalves are generally benthos organism and they are regularly used as bio-indicators of aquatic healthy. Gastropods and Bivalves can produce a billion of larvae in the form of meroplankton that sustains the biotic population and they have a role in food chain. The observation of Gastropods and Bivalves populations in mangrove ecosystem is important to evaluate their condition in the post tsunami rehabilitation program in Aceh where the new communities have begun to form. Hence, the objective of the present study was to assess the species composition of Gastropods and Bivalves in mangrove rehabilitation area post tsunami based on the different level of vegetation age.

Material and Methods

The study was conducted in the area of mangrove rehabilitation in Banda Aceh and Aceh Besar districts, Indonesia. The study was conducted for six months from May to November 2011. The mangrove vegetation in the study areas are the newly formed vegetation post mangrove rehabilitation program. Five sampling sites (10 m x 10 m) were selected by stratified random sampling method with dividing the study areas into several layers or strata based on characteristics of the different planting age. According to field assessment, there were five levels of mangrove vegetation age found at study area i.e. from 1 year old to 5 years old. Every site was a representative of mangrove age level where site one was representative of one year old and situated in Deah Glumpang village (05°33'42.3" N, 95°17'35.7" E), site two was representative of two years old and situated in Lampageu village (05°33'08.2" N, 95°14'13.9"E), site three was representative of three years old and located in Deah Glumpang village (05°33'34.3" N, 95°17'21.0" E), site four was representative of four years old and located in Lamnga village (05°37'01.6" N, 95°23'46.6" E), and site five was representative of five years old and occurred in Lamnga village (05°36'35.8" N, 95°19'25.6" E) (Figure 1).

Biological observation includes the retrieval of mangrove data and mollusks (Gastropods and Bivalves). Samples were collected using the square transects of 1 x 1 (m) into 10 x 10 (m) as a plot determined randomly in very sampling site and every plot

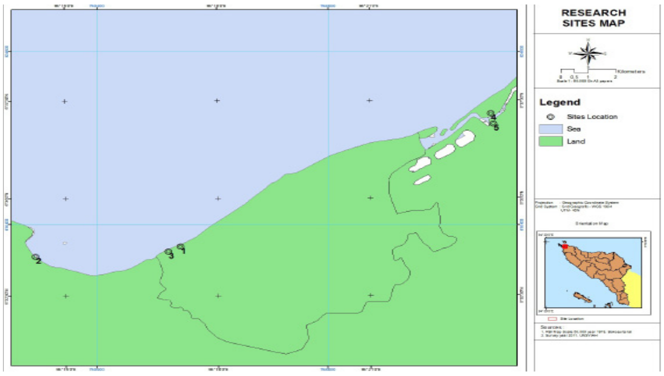

Figure 1. The map of study sites located at Banda Aceh and Aceh Besar districts.

had three square transects. Mollusk samples were collected in two ways: by collecting for epifauna and taking the substrate to a depth of 15 cm for infauna. Mollusk samples were sorted and preserved in bottle sample containing 70% alcohol. Each bottle sample was labeled with the site, date and other important information. The samples were then transported to the laboratory and identified based on Dharma (1988) and Roberts *et al* (1982) and FAO (1998). The C-organic contents were analyzed based on Schumacher (2002) and the compositions of substrate were examined based on standard pipette method (Sudjadi *et al* 1971; Van Der Pol 1983). Furhermore, texture of substrate was gained by using textural triangle according to percentage of sand, silt, and clay fraction (Sudjadi *et al* 1971; Van Der Pol 1983).

Results and Discussion

Species composition and abundance

There were 14 species of Gastropods and 5 species of Bivalves belonging to seven and four families, respectively. These results were lower compared to Macintosh *et al* (2002) who recoded 33 species of mollusks in mangrove rehabilitation area in Thailand. Gastropods and Bivalves obtained during the observation generally live on the surface of the substrate, attached to the roots, stems and leaves of mangrove trees.

The results of observation showed that Gastropods had high abundance and distribution probably due to their mobile characteristic. Gastropods are more active compared to Bivalves; they can move up and down follow the tides. According to Tee (1982) almost all Gastropods are categorized as a tree climber, moving up and down to follow the tide, for example they go down to the ground that are not flooded during low tide.

We found that total abundance of Gastropods and Bivalves was 371 individual with average density of 74 ind/m^2 and 28 individuals with average density of 6 ind/m^2, respectively (Table 1 and Table 2).

Table 1. Average of Gastropods abundance in study sites (ind/m^2)

Families/Species	Study sites					Total
	1	2	3	4	5	
Buccinidae						
Cantharus fumosus	0	0	0	1	0	1
Cerithiidae						
Cerithium patulum	7	12	9	0	0	28
Clypeomorus granosum	5	5	5	5	2	22
Clypeomorus moniliferum	0	0	4	0	0	4
Conidae						
Phasmaconus radiatus	1	0	1	0	0	2
Littorinidae						
Littorina scabra	6	4	3	3	2	18
Littorina undulata	0	1	1	0	0	2
Nassariidae						
Nassarius olivaceus	1	1	0	1	0	3
Nassarius distortus	1	2	7	4	0	14
Neritidae						
Nerita undata	1	1	1	0	0	3
Nerita planospira	2	1	1	1	0	5
Nerita. sp	1	0	0	3	0	4
Potamididae						
Cerithidea cingulata	0	0	39	150	74	263
Terebralia palustris	0	0	0	1	0	1
Total Individual	25	27	71	169	79	371
Number of Species	9	8	10	8	3	14

The higher abundance of Gastropods was obtained in study site 4 (169 ind/m^2) which was dominated by Potamididae (151 ind/m^2). These results are in agreement with Dharma (1988) who reported that mangrove forest is the most preferred habitat for families Potamididae. Moreover, Budiman (1988) explained that Potamididae had a wide geographical distribution and also found in high abundance in mangrove ecosystem. In addition, the higher abundance of Bivalves was found in study site 3 with density of 14 ind/m^2 dominated by Isognomonidae (8 ind/m^2). Overall, Ostreidae had high abundance in present study (13 ind/m^2). According to Plaziat (1984), Isognomonidae and Ostreidae are abundant in mangrove area because they have higher adaptation ability in changing environmental factors such as drought due to low tide and salinity.

Table 2.Average of Bivalves abundance in study sites (ind/m^2)

Families/Species	Study sites					Total
	1	2	3	4	5	
Isognomonidae						
Pedalion isognomum	1	2	8	0	0	11
Lucinidae						
Lucina sp.	1	1	0	0	0	2
Ostreidae						
Crassostrea cucullata	0	1	3	0	0	4
Saccostrea echinata	0	0	2	5	2	9
Veneridae						
Gafrarium dispar	0	1	1	0	0	2
Total	2	5	14	5	2	28
Number of species	2	4	4	1	1	5

In general, the abundance of Gastropods has increased with vegetation age increasing, for example study site 4, the vegetation of four years old had the highest abundance of Gastropods compared to other sites. We recorded that the site 4 had higher C-organic content (0.9%) compared to other sites, therefore we assumed that the higher abundance of Gastropods at site 4 probably due to higher in C-organic content. Contribution of organic matter was influenced by the litters falling in the surrounding vegetation area and would be the primarily contribution in the substrate. In addition, we also recorded that the percentage of silt and sand were higher at site 4, i.e. 15% and 83% respectively, but with lower percentage of clay (2%). According to Rangan (1996) the substrate condition influences the development of biotic communities, where muddy with a little clay is a desirable substrate for Gastropods.

The value of C-organic content in the substrate was 0.8%, 0.8%, 0.7%, 0.9% and 0.6% for sites 1, 2, 3, 4 and 5, respectively. The C-organic content recorded in the present study (post tsunami) was lower than the previous study (pre tsunami). This condition exists probably because tsunami brought out the sands from other sites into mangrove area. According to Plaziat (1984) types of substrates had strong relationship with nutrient in sediment. Sukardjo (1994) found that high quantities of C-organic matter in Tanah Grogot, East Kalimantan was from high density of trees because the fallen litter of mangrove leaves contributes significantly to the higher organic matter in the soils. Furthermore, there was a connection between the size of substrate with carbon content in the substrate and also oxygen dissolved. Sand soil enables good oxidation and it makes high oxygen content and less organic matter compared with refine soil.

The sediment examination showed that the percentage of sand, silt, and clay fractions have ranged from 82.5 to 91.0%, 5.0 to 15.0%, and 2.0 to 5.0, respectively. Percentage of sand was high probably because sampling location directly receives material brought from the sea by the current despite in mangrove area during tsunami in late December 2004. Nybakken (1992) mentioned that particle sedimentation depends on the size of the particle and current. The bigger and heavier particles will settle faster than the smaller particles and weak current will deposit material longer than the strong current. Silt fraction was higher than clay; this condition can be explained because there was a contribution of litter, especially leaves, from the mangrove vegetation.

We found that the age of vegetation did not affect the abundance of Bivalves. However, the higher abundance of Bivalves was found at study site 3 with 3 years old of mangrove. This is probably due to the higher density of mangrove (3 ind/m^2) at this site, as it had a lot of root branching used for Bivalves living on. Mangrove roots represent the area of hard substrate colonized by massive sponge, oyster (Ostreidae), and barnacle (Cannicci *et al* 2008). Moreover, Guerreiro *et al* (1996) expressed that sediment textures, tidal elevation and forest type affect the distribution of macrofauna in mangrove ecosystem.

Cerithidea cingulata was the dominant species in the study area. We assumed that this species had a good adaptation on environmental condition at these sites and therefore it won the competition for food and habitat. In addition, we found three species of native mollusks in mangrove ecosystem i.e. *C. cingulata*, Terebralia palustris and *Nerita planospira*; three facultative mollusks i.e. *Littorina scabra, C. patulum*, and *Crassostrea cucullata* and two migrant mollusks i.e. *Nerita undata* and *Clypeomorus moniliferum*.

The species richness and abundance of Gastropods and Bivalves has decreased in post tsunami. For example, at the site 1, before tsunami, the species richness of Gastropod consisted in 11 species with density of 52 ind/m^2 and they decreased to only 9 species with density of 25 ind/m^2 after tsunami. Before tsunami the Cerithiidae had high abundance; however the species composition was dominated by Potamididae after tsunami. Macintosh *et al* (2002) reported that Potamididae was one of Gastropods families which was more representative of the younger plantation, assumed as they graze the young mangrove leaves like Littorinidae and therefore, Macintosh *et al* (2002) suggested using this family as bio-indicator of ecological changes. Nevertheless, Asthon *et al* (2003) stated that young sapling leaves probably was a better food source for mangrove Gastropods evidenced by his observation that Gastropods was positively correlated with sapling species number.

Decreasing in species richness and abundance post tsunami probably due to changing in community structure of mangroves, where the density of mangrove community in pre tsunami was high than in post tsunami. The tsunami catastrophe destroyed mangrove vegetation and also disrupted community structure of biotic that lives in it. In general, the C-organic content before tsunami was also higher than after tsunami at site 1; the C-organic content before tsunami was 1.06% and it decreased to 0.8% after tsunami.

Mangrove rehabilitation program is one of the solutions to restore the mangrove ecosystem damaged due to the tsunami and later on mangrove biota including Gastropods and Bivalves will return back to this ecosystem. Ashton *et al* (2003) and Aksornkoae (1993) mentioned that anthropogenic and natural disturbance often result in diversity loss to natural ecosystem and loss of diversity have a significant effect on ecosystem functioning.

Biological indices

The diversity index (Shannon index) has varied from 0.51 to 2.95 at site 5 and site 1, respectively, with average of 2.02 indicating a low value. The evenness index (E) has varied from 0.26 to 0.85 with an average of 0.58 (Figure 2). These average values indicate that the community condition was unstable. However, the mollusk community at site 1 was relatively stable compared to other sites.

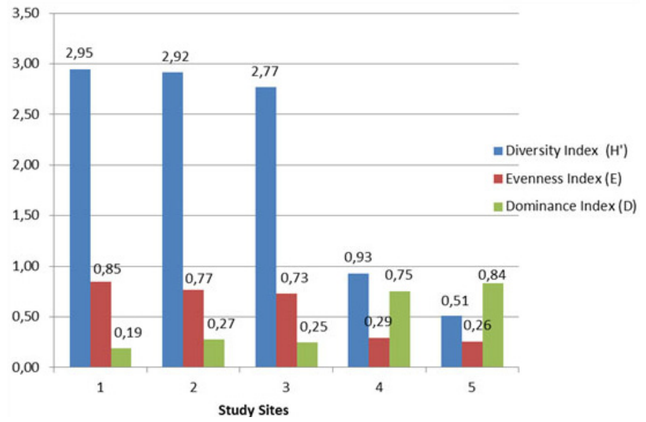

Figure 2. The diversity index (H'), evenness index (E) and Dominance index (D) according to study sites.

In addition, the dominance index (D) has ranged between 0.19 at site 1 to 0.84 at site 5 with average of 0.46 indicating a moderate value. The dominance index showed the degree of predominance of one or a few species in an ecological community. Legendre & Legendre (1983) explained that if the dominance index values obtained are between of 0.4 to 0.6 it can be categorized as moderate, above 0.6 is higher and below 0.4 is lower. The result showed that *C. cingulata* was a dominant species at sites 4 and 5, where the dominance index was higher than 0.6, indicating the dominance index at both stations were fallen into higher category. While at sites 1, 2, and 3, the dominance indices were lower than 0.4 and it was categorized into lower category. Overall, we found that the low diversity index, the unevenly distributed individuals within species and the moderate evenness and dominance showed an unstable community structure at the study sites post tsunami. Macintosh *et al* (2002) explained that high dominance of one species probably indicates a stressful environment while a higher diversity indicates a stable condition of ecosystem.

For comparison, the stability of Gastropods and Bivalves community structures in pre tsunami was in moderate category (Dewiyanti 2005). Meanwhile, the condition of community structure generally has been changed become unstable in post tsunami period.

Conclusion

Species richness of Gastropods was higher compared to that of Bivalves and the values decreased after tsunami, however their species compositions were similar between pre and post tsunami. Gastropods were dominated by Potamididae while Bivalves were dominated by Isognomonidae and Ostreidae. In general, diversity of Gastropods and Bivalves in the study areas was in lower category. The abundance of Gastropods increased with increasing vegetation age, but the age of vegetation did not affect the abundance of Bivalves, and the community structure at the present study was unstable.

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References

Aksornkoae, S., 1993. Ecology and management of mangroves. IUCN Wetlands Programe. IUCN, pp. 1-6 Bangkok, Thailand.

Ashton, E. C., Donald, J. M., Peter, J. H., 2003. A baseline study of diversity and community ecology of crab and molluscan macrofauna in the Sematan mangrove forest, Serawakm Malaysia. Journal of Tropical Ecology 19:127-142.

Budiman, A., 1988. Some aspects on the ecology of mangrove whelk Telecospium Telecospium (Linne, 1758) (Mollusca, Gastropoda: Potamididae). Treubia 29(4):237-245.

Cannicci, S., Damien, B., Sara, F., Thomas, J. S., Joachim, O., Farid, D. G., 2008. Faunal impact on vegetation structure and ecosystem function in mangrove forests: a review. Aquatic Botani 89:186-200.

Dewiyanti, I., 2005. Structure of mollusca community (Gastropods and Bivalves) with its associates in mangrove ecosystem at Ulee-Lheue, Banda Aceh. Nad [Struktur Komunitas Moluska (Gastropoda dan Bivalvia) Serta Asosianya Pada Ekosistem Mangrove Di Kawasan Pantai Ulee-Lheue Banda Aceh NAD]. Jurnal Natural 5(2):12-16.

Dharma, B., 1988. Indonesian shells [Siput dan Kerang Indonesia]. 111 pp., Sarana Graha, Jakarta.

FAO species identification guide for fishery purposes, 1998. The living marine resources of the Western Central Pasific: Volume 1 Seaweeds, corals, bivalves and gastropods. Carpenter K. E., Niem V. H (eds), pp. 1-686. Food and Agriculture Organization of the United Nations, Rome, Italy.

Guerreiro, J. S., Freitas, P., Pareira, J., Paula, J., Macia, A., 1996. Sediment macrobenthos of mangrove flats at Inhaca Island, Mozambique. Cah Bio Mar 37:309-327.

Hutchings, P., Saenger, P., 1987. Ecology of mangroves. Heatwole H (ed), 388 pp., University of Queensland Press, St. Lucia, Australia.

Legendre, L., Legendre, P., 1983. Numerical Ecology. 337 pp., Elsevier Scientific, Publishing Company, New York.

Macintosh, D. J., Ashton, E. C., Havanon, S., 2002. Mangrove rehabilitation and intertidal biodiversity: a study in the Ranong mangrove ecosystem Thailand. Estuarine, Coastal and shelf Science 55:331-345.

Nybakken, J. W., 1992. Marine Biology: an ecological approach [Biologi Laut, Suatu Pendekatan Ekologis]. Translated by: M. Eidman, D. G. Bengen, Koesoebiono, M. Hutomo dan Sukristijono, pp. 363-375, PT Gramedia, Jakarta.

Plaziat, J. C., 1984. Mollusk distribution in the Mangal. Hydrobiology of the Mangal, pp. 111-143, Dr W. Junk Publishers, The Hague.

Pramudji, P., 2001. The role of mangrove forest ecosystems as habitat for marine organisms [Ekosistem Hutan Mangrove dan Peranannya Sebagai Habitat Berbagai Fauna Akuatik]. Oseana 26(4):13-23.

Rangan, J., 1996. Community structure and typology of Gastropods on mangrove forest zone, Kulu district, Minahasa, North Sulawes [Struktur dan Tipologi Komunitas Gastropoda pada Zona Hutan Mangrove Perairan Kulu, Kabupaten Minahasa, Sulawesi Utara]. Program Pasca Sarjana, IPB, Bogor, Indonesia.

Roberts, D., Soemodihardjo, S., Kastoro, W., 1982. Shallow water marine molluscs of North-West Java, pp. 143, P3O – LIPI, Jakarta.

Sasekumar, A., 1974. The distribution of macrofauna on a Malayan mangrove shore. Journal of Animal Ecology 43:51-69.

Schumacher, B. A., 2002. Methods for determination of total organic carbon (TOC) in soils and sediments. In: Ecological Risk Assessment Support Center Office of Research and Development (ERASC), pp. 23, US Environmental Protection Agency.

Sudjadi, M., Widjik, I. M., Soleh, M., 1971. Soil analysis guidance: the soil fertility [Penuntun Analisa Tanah: Bagian Kesuburan Tanah]. pp. 166, Bogor Soil Research Institute, Bogor, Indonesia.

Sukardjo, S., 1994. Soils in the mangrove forests of the Apar Nature Reserve, Tanah Grogot, East Kalimantan, Indonesia. Southeast Asian Studies 32(3):385-398.

Tee, G. A. C., 1982. Some aspect of the mangrove forest at Sungai Buloh, Selangor II. Distribution patternand population dynamic of tree dwelling fauna. Mal Nat J 35:267-277.

Van Der Pol, F., 1983. Analytical methods of the service laboratory for soil, plant and water analysis: part 1 methods for soil analysis. Soil Science and Agrochemestry Devision, Koninklijk Instituut Vor De Tropen, Amsterdam, Mauritskade. pp. 110.

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