Community structure of gastropods and bivalves associated in mangrove ecosystem at Pusung Cium Island, Seruway, Aceh Tamiang

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Abstract. The purposes of the present study were to analyze the community structure of gastropods and bivalves as well as to analyze the relationship between the abundance of gastropods and bivalves within mangrove density in Pusung Cium Island, Seruway, Aceh Tamiang Regency. The research was conducted from October to November 2019. The method used in determining the location of the research station was Stratified Random Sampling based on the density of mangrove vegetation, the station 1st, 2nd, 3rd were dense, medium, and rare categories, respectively. There were 4.67 ind/m² consisted of 3 species for bivalves class and 143.33 ind/m² species of gastropods class consisted of 41 species. The highest abundance was in station three, and the highest gastropods species abundance was Littorina angulifera (51.33 ind/m²) and Saccostrea cucculata (1.33 ind/m²) for bivalves class. Biological indices showed that the diversity index of gastropods and bivalves was high and ranged from 4.24 to 2.35, evenness and dominance indices were ranged from 0.44 to 0.79 and 0.20 to 0.21. Furthermore, the distribution pattern of gastropods and bivalves were uniform, random, and clumped. The correlation between the density of mangrove and abundance of gastropods-bivalves was weak and moderate and there was no significant correlation between the density of mangrove and abundance of biota aquatic (gastropods and bivalves) where Psig>0.05. In conclusion, the community structure of gastropods and bivalves was in stable condition showed by high diversity index, moderate evenness index, and low dominance index.

1. Introduction

The mangrove forest is a most productive ecosystem dominated by several species of mangrove that can grow in salty waters and tidal areas along the coastal area [1]. Mangrove functions as spawning, nursery, and feeding ground become a suitable habitat to economical types of aquatic biota i.e. shellfish, snail, fish, shrimp, and crab. The mangrove ecosystem is rich in organic matter and nutrient content [2] derived from litter and it can support the organism life not only macrofauna but also microfauna. Moreover, the mangrove ecosystem support the life of the aquatic biota in coastal and marine areas significantly [3]. Molluscs (gastropods and bivalves) have significantly contributed to the ecological mangrove function among the organism especially in food web, as bioindicator and they can function as biomonitor [4; 5; 6; 7]. Gastropods dan bivalves as macrozoobenthos are good bioindicator in measure the health of aquatic ecosystems [8]. Studies on the community structure macrozoobenthos in Indonesia have been reported by several research particularly in Gastropods and bivalves. A previous study done by [9]
reported that 14 species of gastropods and 5 species of bivalves in mangrove rehabilitation, Aceh Besar and Banda Aceh, 15 species of gastropods in Padang [10].

The gastropods is an organism who living above the ground and they movement influenced by tidal and they interact well with their environment [11]. Gastropods periodically migrate downwards at low tide for feeding and upwards at high tide to avoid predation and water immersion due to tidal action [12]. Furthermore, bivalves class is a passive organism attached in mangrove root or buried its self in the substrate. Bivalves have a significant role in linking the mangrove detritus at the base of the food web to higher consumers of the trophic level [13]. The role of bivalves not only filtering activities ecologically repair the water quality [14] but also they can be consumed by humans.

Aceh Tamiang Regency has ± 22,900 ha of mangrove area [15]. Based on field observation, the mangrove vegetation is exploited by local people for charcoal and land conversion to agriculture land and residence. The abundance and biodiversity of mangrove ecosystem in Aceh Tamiang will decrease because of anthropogenic impact. Increasing human destructive activities become a negative impact and significantly affects organisms who live in mangrove ecosystem [16]. The detail data of aquatic biota in particularly gastropods and bivalves are left unexplored in Pusung Cium Island. Immediate action is needed to maintain the abundance and species richness of Molluscs as the important element of the mangrove ecosystem. Hence, it is very crucial to analyze the community structure of gastropods and bivalves, and distribution pattern, as well as to analyze the relationship between the density of gastropods and bivalves within mangrove density in Pusung Cium Island, Seruway, Aceh Tamiang Regency.

2. Material and Methods

2.1. Study Site
The present study was conducted in mangrove ecosystem in Pusung Cium Island, Aceh Tamiang (figure 1) for 2 months starting from October to November 2019. Stratified Random Sampling was the method applied to determine the sampling location. In total, three stations have been established in the study area based on the density of vegetation with three replication. Station 1 was representative of dense mangrove vegetation, station 2 was medium and station three was rare mangrove vegetation. The coordinates of station 1, 2 and 3 were 4°24’6.31” N, 98°17’4.98” E, 4°23’46.42 ” N, 98°17’7.21” E, and 4°23’25.08 “ N, 98°17’11.65E, respectively. Identification of gastropods and bivalves was carried out in marine biology laboratory, Marine and Fisheries Faculty. Substrate characteristics were carried out at soil laboratory, Agriculture Faculty, Universitas Syiah Kuala.

2.2. Sampling method
2.2.1 Biota Sampling
Gastropods and bivalves were taken using 1m x 1m square transect in 100 x 100 m². Gastropods as epifauna were found on the mangrove trees (stems, leaves, twigs) and the substrate surface. The bivalves as infauna in substrate mangrove were taken using soil shovel, then sieved using a benthos sieve. Biota samples were sorted and preserved in a bottle sample containing 70% alcohol and then labeled. The identification of gastropods and bivalves have been done in Marine Biology Laboratory, Faculty of Marine and Fisheries based on [17; 18; 19].

2.2.2 Measurement of Physical, chemical of water and Substrate
Physical and chemical water parameters measured directly in the observation area, these parameters were included temperature, pH, salinity, and dissolved oxygen. The soil surface sampling was taken using a shovel and soil sample was put into a plastic bag for further transport to soil laboratory to analyze the texture of the substrate and organic carbon content. Substrate texture is grouped based on the percentage of sand, clay, and dust. Calculation of organic carbon content using the Walkey and Black method, then categorized based on the percentage, which is very low if the carbon content is <1.00; low (1-2.00); moderate (2.01-3.00); and height (> 5.00) [20]. The organic carbon was analyzed based on
Schumacher [21] and the compositions of substrate were examined based on standard pipette method [22; 23]. Furthermore, texture of substrate was gained by using textural triangle [22; 23].

![Figure 1. Map showing the research location](image)

2.2.3 Measurement of mangrove vegetation
Mangrove vegetation was collected in 10m x 10m² square transect. Observation of the number of individual and species were limited by tree category. Identification of mangrove species identified based on [24].

2.3. Data Analysis
Abundance of gastropods and bivalves were calculated using the formula as below [25] :

\[ D_i = \frac{n_i}{A} \]

Where, \( D_i \) is abundance of gastropods and bivalves (individuals/m2); \( n_i \) is the number of individual each species (individuals), \( A \) is sampling area (m2).

The Shannon index of diversity (\( H' \)) is a measure of species weighed by the relative abundance. Shannon index of diversity (\( H' \)) was calculated using the formula as below [25]:

\[ H' = - \sum_{i=1}^{S} P_i \log_2 P_i \]

Where, \( H' \) is diversity index, \( P_i \) is the proportion of individuals in the-ith species. Shannon index was used to indicate diversity of fauna at different sampling sites. Evenness index was calculated by using the formula as follows below [26]:

\[ (E) = \frac{H'}{\log_2 S} \]

Where \( E \) is Evenness index, \( H' \) is diversity index, \( \log_2 = 3.32193 \), and \( S \) is the number of species. Dominance index was calculated by using the formula as follows below [26]:

\[ D = \sum_{i=1}^{S} \left( \frac{n_i}{N} \right)^2 \]

Where \( D \) is Dominance index, \( n_i \) is the number of individual each species, \( N \) is total individual Distribution pattern (Morisita index) was calculated by using the formula as follows below [26]:

\[ Id = n \frac{\sum X^2 - N}{N(N-1)} \]
Where $I_d$ is morisita index, $n_i$ is the number of individual each species (individuals), $N$ is total individual in each plot, and $\sum X^2$ : Total individual in all sampling location.

Pearson correlation analysis is one of the statistical analysis techniques used to find the relationship between mangrove density and abundance of gastropods and bivalves using IBM SPSS Statistics software or commonly called PAWS (Predictive Analytic Software).

3. Result and Discussion

3.1. Bivalves and gastropods composition

The composition of gastropods is higher than bivalves with a value of 97% (Figure 2). In detail, there were 3 species from bivalves within 14 individuals while the gastropods consisted of 41 species (458 individuals). Gastropods have high composition presumably because they are more active than bivalves and they can adapt well in various substrate type [8]. Furthermore, gastropod is one of Molluscs class that has a very wide distribution in mangrove ecosystem due to high adaptability [27]. The total number of gastropods species in the study area is higher compared with the result found by Dewiyanti and Karina [9] found 14 species, Baderan et al. [28] found 21 species, and Yolanda et al. [10] recorded 15 species of gastropods in mangrove ecosystem. There is a significant correlation between the number of mangrove vegetation with litter mangrove production, these litter contributes material organic in this ecosystem then will stimulate detrivore to eat [29]. The number of mangrove forest can affect the presence of gastropods [30]. Furthermore, gastropods have a considerable pattern of adaptation with changes in environmental factors caused by tides rhythmic, they will match their activity with the tidal phase [31]. Rangan [43] stated that the condition of the substrate affects the development of gastropods community where the substrate consisting of mud and sand with a little clay is a substrate that is favored by gastropods, in the study area consisted of sand, dust and clay fraction with the value 81-85%, 5-10%, and clay 5-11%, respectively.

![Figure 2. Gastropods and Bivalves Composition in Study Area](image)

The bivalves composition was 3%, its assumed because they are not more active than gastropods, sessile and limited in mobility [8]. Bivalves found immerse themselves in the substrate, and they were very depending on substrate characteristics. Bivalves are suspension feeders and they gain nourishment by filtering suspended particles, they need a suitable environment to support their life.

3.2. Gastropods and Bivalves Abundance

The results for gastropods and bivalves abundance are summarized in table 1 and table 2. Gastropods were generally found on the soil surface, attached to the leaves, stems and roots of mangroves, while bivalves usually found immerse in the mangrove soil. Gastropods that attached to the stems because mangrove stems are strong, thick and stable, and also easy to movement [32].

The highest abundance of gastropods was at station 3 followed by station 1, and 2 which was 75.3 ind/m$^2$, 44 ind/m$^2$, and 24.9 ind/m$^2$. It presumably because station 3 contained the organic carbon higher
than station 1, and 2 even though in a low category because organic carbon content <1 [20]. C-organic contents in station 1, 2, and 3 were 0.77, 0.63, and 0.17, respectively. Basically, organic material is a source of food for gastropods that comes from parts of plants i.e. leaves that fall in the forest and then accumulate in the mangrove ecosystem [33]. Station 3 has a suitable salinity value for the gastropods life, where the average of salinity in station 1 was 27.5 ppt, station 1, and 2 was 21.2 ppt and 30.3 ppt. Furthermore, water salinity and temperature fluctuated can lead to mortality of young animal snails and their eggs [34].

Table 1. The abundance of gastropods (ind/m²) at each sampling location

| No | Species                | Station 1 |       | Station 2 |       | Station 3 |       | Total  |
|----|------------------------|-----------|-------|-----------|-------|-----------|-------|--------|
|    |                        | SS R S L  | SS R S L | SS R S L |       |          |       |        |
| 1  | Bolinus brandaris      | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 2  | Cassidula angulifera   | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 3  | Cerithiodeopsis        | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 4  | Chicoicaps capucinus    | 1.3 0 0 0 | 0 0 0 0 | 0.3 0 0 0 | 0.3   | 1.3       |       |        |
| 5  | Cerithidea cingulata   | 0.7 0 0 0 | 0.7 0 0 0 | 0.7 0 0 0 | 0.7   |           |       | 0.7    |
| 6  | Cerithidea quadrata    | 0.3 0 0 0 | 0.3 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 7  | Cerithidea quoyii      | 0.7 0 0 0 | 0.7 0 0 0 | 0.7 0 0 0 | 0.7   |           |       | 0.7    |
| 8  | Chdrupella marginicola  | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 9  | Chdrupella cassidula    | 0.7 0 0 0 | 0.7 0 0 0 | 0.7 0 0 0 | 0.7   |           |       | 0.7    |
| 10 | Chdrupella angulifera   | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 11 | Chdrupella quadrata    | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 12 | Chdrupella quoyii      | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 13 | Chdrupella marginicola  | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 14 | Chdrupella angulifera   | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 15 | Chdrupella quadrata    | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 16 | Chdrupella quoyii      | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 17 | Chdrupella marginicola  | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 18 | Chdrupella angulifera   | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 19 | Chdrupella quadrata    | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 20 | Chdrupella quoyii      | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 21 | Chdrupella marginicola  | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 22 | Chdrupella angulifera   | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 23 | Chdrupella quadrata    | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 24 | Chdrupella quoyii      | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 25 | Chdrupella marginicola  | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 26 | Chdrupella angulifera   | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 27 | Chdrupella quadrata    | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 28 | Chdrupella quoyii      | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 29 | Chdrupella marginicola  | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 30 | Chdrupella angulifera   | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 31 | Chdrupella quadrata    | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 32 | Chdrupella quoyii      | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 33 | Chdrupella marginicola  | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 34 | Chdrupella angulifera   | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 35 | Chdrupella quadrata    | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 36 | Chdrupella quoyii      | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 37 | Chdrupella marginicola  | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 38 | Chdrupella angulifera   | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 39 | Chdrupella quadrata    | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 40 | Chdrupella quoyii      | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
| 41 | Chdrupella marginicola  | 0 0 0 0   | 0 0 0 0 | 0.3 0 0 0 | 0.3   |           |       | 0.3    |
|    | Total                  | 18.3 5.7 13.7 6.3 4.0 1.3 9.3 10.3 1.1 23.8 37.7 12.7 144.2 |
|    | Total each station     | 44 24.9 75.3 144.2 |

Note: SS (soil surface), R (root), S (stem), L (leaf)
Table 2. The abundance of bivalves (ind/m$^2$) at each sampling location

| No | Species                     | Station 1 | Station 2 | Station 3 | Total |
|----|-----------------------------|-----------|-----------|-----------|-------|
| 1  | *Isognomon ephippium*       | 0.7       | 0         | 0         | 0.7   |
| 2  | *Saccostrea cucullata*      | 1.3       | 1.7       | 0.7       | 3.7   |
| 3  | *Solen cylindraceus*        | 0.3       | 0         | 0         | 0.3   |
|    | Total                       | 2.3       | 1.7       | 0.7       | 4.7   |

The highest abundance of gastropods species found was *Littorina angulifera* with a total of 51.33 ind/m$^2$, particularly in station 3. *L. angulifera* attached on the stems, roots and leaves, they were prefers protruding stem and root areas because they can easily move from one vegetation to another. Littorinidae family was the most commonly found in mangrove ecosystem. This is in line with Tapilatu and Pelasula [35] reported that Littorinidae family is gastropods that are associated with mangrove vegetation by attaching in leaves in order to consume the leaves as mangrove component. This is supported by Masni et al. [36] who explained that the facultative gastropod group is from the Littorinidae family, which can be found in large numbers both inside and outside the mangrove ecosystem. Littorinidae which lives dominantly in mangrove habitats can adapt well from fluctuating estuary waters, food, and protecting themselves from predators [32].

In the bivalves class, the highest abundance species found was *Saccostrea cucullata* with a total of 3.7 ind/m$^2$ found at all stations particularly attached on the mangrove root. This species to be able to live in mangrove forests because it can ability to adapt in tidal activity. According to Plaziat [37], Isognomonidae and Ostreidae are abundant in mangrove areas because they have higher adaptation ability in changing environmental factors such as drought due to low tide and salinity. Moreover, *S. cucullata* is one of the native macrozoobenthos species that remains in mangrove forests, easy and widely found [38]. The abundance of *S. cucullate* was highest in station 1 because of mangrove density.

Mangrove density in station 1, 2, and 3 were 119, 96, and 85 ind/m$^2$, respectively.

3.3 Biological Indices of gastropods and bivalves

Diversity index ($H'$), Evenness (E), and Dominance (C) are index studies that are often used to estimate community stability based on biological components. In detail, the biological indices of gastropods and bivalves show in table 3.

Table 3. Biological indices of gastropods and Bivalves in study area

| Biological indices | H'  | Category | E   | Category | C   | Category |
|-------------------|-----|----------|-----|----------|-----|----------|
| Station 1         | 4.24| High     | 0.79| High     | 0.20| Low      |
| Station 2         | 2.35| Moderate | 0.44| Moderate | 0.40| Moderate |
| Station 3         | 2.88| High     | 0.54| Moderate | 0.21| Low      |
| Average           | 3.16| High     | 0.59| Moderate | 0.27| Low      |

The diversity index ($H'$) of gastropods and bivalves have an average of 3.16. The result indicated that the diversity of gastropods and bivalves is in the high category according to the Shannon-Wienner diversity index. High diversity of fauna because in the research area has health mangrove, so it can allow gastropods and bivalves to live by utilizing mangrove litter as a source of food. Similarly, Putra [30] statement that mangrove litter has an important role as organic material which is the basis of the food chain. High or low level of diversity is not only influenced by sediment conditions but also several environmental parameters that can support the survival of any associated fauna in mangrove ecosystem [39]. The evenness index (E) has an average of 0.59 with moderate criteria. The highest E value was found at station 1 (0.79) while the lowest value was found at station 2 (0.44). The high E index due to the distribution of individuals in each species is relatively the same or no species dominated. Krebs [26] categorized that if 0.4 E > 0.6 means high category. In the study area recorded that the dominance value was low, it means that no particular species dominate and the community structure was in stable.
condition proven by high diversity, and low dominance of particular species. Legendre and Legendre [40] explained that if the dominance index values obtained are between 0.4 to 0.6 it can be categorized as moderate, and below 0.4 was low.

The Morisita index (Id) is used to determine the distribution pattern of gastropods and bivalves. The Morisita index analysis showed that the distribution patterns of gastropods and bivalves were clumped, random and uniform. There were 16 species found as uniform distribution pattern i.e. Saccostrea cucullata, Solen cylindraceus, Bolinus brandaris, Cassidula angulifera, Cerithideopsis californica, Cerithidea obtusa, Cerithidea rhizophorarum, Clithon oualaniense, Drupella margariticoila, Nassarius corniculus, Nassarius olivaceus, Natica tigrina, Nerita insculpta, Nerita polita, Notocochlis gualteriana, Pirenella incise. Nerita undata is the only one species found as random distribution pattern. This uniform distribution pattern is rarely found in natural populations that are close to conditions where thinning occurs due to competition between individuals that encourages the same division of living space [41]. Judging from this random distribution pattern, reproductive activity will be low and the presence of gastropods and bivalves in the wild will be neither strong nor weak [42]. The rest species (27 species) have clumped distribution pattern that indicate the species are always present in groups, and very rarely seen separate or scattered.

**Table 4.** The correlation between mangrove density and gastropods-bivalves abundance

| Aspect                     | Mangrove density (tree category) | Mangrove density (sapling category) | Mangrove density (seedling category) |
|----------------------------|---------------------------------|-------------------------------------|--------------------------------------|
| Pearson moment correlation | -233                            | -152                                | -262                                 |
| Psig                       | .547                            | .695                                | .495                                 |

Table 4 explained the correlation between mangrove density and gastropods-bivalves abundance, there was no significant correlation between the density of mangrove and abundance of biota aquatic (gastropods and bivalves) where Psig>0.05. The pearson moment correlation informed that the correlation between density of mangrove and abundance of gastropods-bivalves was negative.

**4. Conclusion**

Species diversity and abundance of gastropods was higher compared bivalves class, gastropods were dominated by *L. angulifera* whereas bivalves dominated by *S. cucullata*. Gastropods was found not only in the soil surface but also attached on roots, stems, and leaves of mangrove. Bivalves found immerse in the soil and attached on mangrove roots. Community structure of gastropods and bivalves in Pusung Cium Island, Seruway, Aceh Tamiang was in stable condition showed by high species richness, moderate in evenness index, and low dominance index. The Morisita index analysis showed that the distribution patterns of gastropods and bivalves were clumped, random and uniform. There was no significant correlation between the density of mangrove and abundance of biota aquatic (gastropods and bivalves) where Psig>0.05.

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