# Species composition, density and dominance of arboreal mangrove molluscs on the Paradiso beach of Kupang city, Indonesia

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**Abstract**. The purpose of this study is to determine the species composition, dominance and density of arboreal molluscs in the Paradiso mangrove forest area of Kupang. This research uses transect method. Transects are drawn perpendicular to the shoreline, from the lowest tide to the highest tide. Mangrove trees that are exactly in line transect or about 2 meters from the transect line are used as data collection plots. In each tree is set 3 levels of height, ie 0.0-1.0 m, 1.1-2.0 m and 2.1-3.0 m. Mangrove molluscs found in each level are recorded and the number of individuals counted. The environmental parameters measured were the dissolved oxygen, pH, temperature, and salinity. Data on the individuals number of each species were analyzed to determine the density and dominance of mangrove molluscs. The results showed that in the mangrove forest area were found 7 species of arboreal molluscs belonging to 2 classes, namely gastropods and bivalves. *Littorina scabra* is a species of mangrove molluscs with the highest density and dominance compared to other species.
**Key Words**: arboreal mollusc, density, dominance, *Littorina scabra,* mangrove forest.

**Introduction**. The magrove forest has an ecological, economic, aesthetic and recreational role. The ecological role of mangrove forests is related to the benefits of sheltering various species of marine life, such as crustaceans, molluscs, fish, birds and certain mammals such as monkey. In addition, mangrove forests also role as spawning and childcare and child protection and a place to get the food for marine organisms. Another ecological role is to protect the coast from waves, tsunamis and abrasions. The mangroves ecological function for organisms is as nursery grounds, feeding ground and spawning ground (Nybakken 1992; Pramudji 2001).

The economic role is related to the utilization of mangrove forest as a source of building materials and firewood (Zulkarnaini & Mariana 2016) and support to off-shore fisheries (Sathirathai 1998), places for mangrove crabs cultivation (Mirera & Mtile 2009; David 2009; Shelley & Lovatelli 2011; Karim et al 2017) and place of honey (Gani 2001; Da Luz & Barth 2012). In addition, an attractive arrangement of the mangrove ecosystem can contribute to the economic improvement of people living around the coastal areas as it can function as beach tourism (Wati et al 2016).

The aesthetic and recreational aspect, the natural beauty of the beach with the green mangrove forest gives the feel of beauty and comfort that is the main attraction for the community to use it as a place of tourism, recreation while studying for students, teachers, lecturers and other community groups (Ahmad 2009; Susiloningtyas et al 2017).

Regarding its role from the ecological aspect, mangrove forest is inhabited by various species of marine biota. Besides marine biota, mangrove ecosystem is also inhabited by terrestrial biota (Nagelkerken et al 2008; Bosire et al 2008) and transitional biota. Whereas transitional fauna occupy areas with hard substrate (soil) or mangrove roots as well as on soft substrate (mud) (Duke 2001; Duke & Schmitt 2015). Kustanti et al (2014) suggest that the fauna of mangrove forest consists of various species of mangrove crabs and other invertebrates. One group of invertebrates that live in the mangrove forest is a molluscs. Two dominant mollusc classes in the area of mangrove forest are bivalves and gastropods.

Molluscs are one of the dominant invertebrate groups in the mangrove community and are thought to play an important ecological role in the structure and function of mangrove systems (Nagelkerken et al 2008). Molluscs form an important link in food chain from primary to tertiary level leading to fish production and also an edible source for coastal population (Jaiswar & Kulkarni 2005). Bivalve and gastropod are considered as the main molluscs of mangrove forests and comprise an important trophic component of detritus-based food webs (Kabir et al 2014). Slim et al (1997) reported that most of the molluscans are deposit feeders that scrap organic particles from the surfaces. Thus their detritivorous habit aid nutrient release and flow in the mangal by processing mangrove litter.

In addition to being found on the floor of the mangrove forest, molluscs are also found in roots and mangroves, even gastropods are also found on mangrove leaves (Imakulata 2007). The life and distribution of molluscs is influenced by environmental variations. Molluscs at the mangrove ecosystem can live as non arboreal (at surface substrate), infaunal (in substrate) and arboreal (sticking on roots, stems, and mangrove leaves), being distributed horizontally or vertically (Mujiono 2016).

The densities of mangrove mollusc species are strongly influenced by the adaptability of each species and environmental factors in mangrove forests. Species that have the ability to move to avoid predation, extreme environmental stress, mating and eating, as well as being able to crawl on the stems and roots of mangroves can survive in the mangroves. The results of Imakulata (2007) show that molluscs attached to mangrove stems and roots during low tide belong in general to the gastropod class; the results also show that gastropods attached to mangrove stems are relatively easier to remove than bivalves. Bivalves stick stronger so it is harder to let go.

In ecological studies, abundance, species composition, and species distribution are among the basic elements to analyze the structure of biological communities, which may change over time in response to disturbances (Veras et al 2013). In relation to the above explanation, this research is very important to analyze the composition of species, dominance and density of mangrove molluscs in each unit of height. This information is very important as a basis for explaining the adaptability of molluscs to survive in the dry environmental conditions (stems and leaves) beyond the reach of sea water. Beside that, the observation of gastropods and bivalves populations is important to evaluate the condition of mangrove ecosystem.

**Material and Method**. This research was conducted in mangrove area of Paradiso Beach, Kupang. Paradiso beach is overgrown by several species of mangroves that become shelter, where to find food, spawning and child care for aquatic organisms. This study was conducted for 6 months, starting from May to October 2017.

***Tools and materials.*** The tools needed in this research are meter roll, camera canon type 1200D 18-55 IS II, Professional pH Meter merk Krisbow, salinometer SA287, thermometer RI-NS1-224 and jar and stationery. The research material consisted of 70% alcohol, plastic, and raffia rope.

***Data collection technique.*** Data collection technique used transect method. In this research, there are 4 transect lines perpendicular to the coast line. Mangrove trees that pass transect line is unit or plot of data collection.

***Data collection procedure.*** This research begins with location surveys to observe the spread of the mangrove in the mangrove forest area, the height of the water surface at the highest and lowest tides, and the species of molluscs that inhabit the mangrove forest area. Next set the starting point to create a transect line. Transects are drawn perpendicular to the shoreline, from the lowest tide to the highest tide. There were 4 transects, and the distance between one transect and another was 50 meters. Mangroves trees just above the transect line or about 2 meters from the transect line is used as the mollusc data collection plot. The mangrove stem set 3 levels of height, ie 0.0-1.0 m, 1.1-2.0 m and 2.1-3.0 m. In each level the height measured the diameter of the mangrove stem to calculate the mangrove stem surface area. This surface area is used as the basis for calculating the mangrove mollusc density. Mangrove molluscs found in each level of height are recorded and counted number of each species. Specimens collected were taken to the laboratory for identification. Identification refers to Dharma (1988). Besides data on the species and number of individuals of each molluscs species, in this the environmental parameters data such as pH, temperature, salinity, disolved oxygen and mangrove species that grow in the area of mangrove forest were also taken into account. Environmental parameters are taken at two points from each transect.

***Data analysis***. Data of the species and number of individuals of each species are organized, tabulated and displayed in tables of species compositions and gafic as well as described. Data density and dominance were analyzed based on Krebs (1989) and Odum (1993).

**Results and Discussion**. Some mangrove species found in the Paradiso coastal. The dominant species is *Sonneratia alba* and the most rarer species is *Bruguiera* sp. Table 1 shows that on the area of mangrove forest were found 7 species of mangrove molluscs belonging to 2 classes, namely Gastropoda and Bivalvia. Gastropods consist of 2 orders, with 5 families, and 6 species. While the bivalve class consists only of one order, one family and one species.

Table 1

Composition of mangrove mollusc species in Paradiso mangroves forest

| *No* | *Class* | *Order* | *Family* | *Species* |
|---|---|---|---|---|
| 1 | Gastropoda | Littorinimorpha | Littorinidae | *Littorina scabra* |
| | | | | *Littorina undulata* |
| | | | Potamididae | *Terebralia sulcata* |
| | | | Neritidae | *Nerita planospira* |
| | | Neogastropoda | Nassariidae | *Nassarius distorsus* |
| | | | Muricidae | *Drupella margariticola* |
| 2 | Bivalvia | Ostreoida | Ostreidae | *Saccostrea cucullata* |

Research of Mujiono (2016) from the island of Lombok West Nusa Tenggara on mangrove ecosystems found 11 families consisting of 31 species of mangrove molluscs. This results is different from the results in the area of Paradiso mangrove forest. The focus of this study is limited to arboreal molluscs, while research of Mujiono (2016) is not limited to arboreal molluscs but also includes epiphaunal molluscs. Nazim et al (2015) suggest that the dendrogram disclosed four groups at level of 81% which are described separately in the succeeding paragraphs. Group I is a group of purely gastropod species consisting of six families and six genera. These six species include *Onchidium* sp., *Bulla* sp., *Cerithidea decollata, Nerita albicilla, Pupa* sp. and *Cerithedium edule*. Group II includes three species i.e. *Clypeomorus subbrevicula, Nerita* sp. and *Terebralia bonelli* belonging to three families and three genera. Group III is the largest bivalve dominating group of all and consists of nineteen species. Twelve bivalve species showing the association between gastropods and bivalves with seven species of gastropods. Group IV consists of two important species, *Telescopium telescopium* and *Cerithedia cingulatus*. Pawar (2012) reported that gastropods found in the mangrove ecosystem of Uran Navi Mumbay consists of six orders, 17 families and 38 species and bivalves consists of four orders, eight families and 13 species. Irma & Sofyatuddin (2012) found 14 species of gastropods and 5 species of bivalve in mangrove ecosystem rehabilitation area in Aceh Besar and Banda Aceh district, Indonesia. Species and species composition are found to be different among mangrove ecosystems. This is due to differences in environmental conditions.

Kottè-Mapoko et al (2017) found 34 species of mangrove molluscs in the mangrove forest of Cameroon central coast.

***Density of mangrove molluscs***. The results of the data analysts of density and dominance of mangrove molluscs are shown in Table 2.

Table 2

Density and dominance of mangrove molluscs at Paradiso Beach Kupang

| *No* | *Type* | *Density per level height (m)* | | | *Average density* | *Dominance* |
|---|---|---|---|---|---|---|
| | | *0.0-1.0* | *1.1-2.0* | *2.1-3.0* | | |
| 1 | *Littorina scabra* | 0.090554 | 0.002652 | 0.001516 | 0.031574 | 0.292817 |
| 2 | *Littorina undulata* | 0.013640 | 0.000379 | 0.001137 | 0.005052 | 0.007496 |
| 3 | *Terebralia sulcata* | 0.009472 | 0.007578 | 0.001137 | 0.006062 | 0.010794 |
| 4 | *Nerita plasnospira* | 0.018566 | 0.001516 | 0.002273 | 0.007451 | 0.016309 |
| 5 | *Nassarius distorsus* | 0.006062 | 0.001137 | 0.000758 | 0.002652 | 0.002066 |
| 6 | *Drupella margariticola* | 0.000758 | 0.000379 | 0.001516 | 0.000884 | 0.000230 |
| 7 | *Saccostrea cucullata* | 0.012124 | 0.001137 | 0.000758 | 0.004673 | 0.006414 |
| | Total | 0.151176 | 0.014778 | 0.009095 | 0.058348 | 0.336126 |

The density of mangrove mollusc in Paradiso beach is 0.175 individual $m^{-2}$ [obtained from the total individual (462) divided by the total area of the surface circumference of the mangrove stem (2639.3 $m^2$)]. According to Table 2, mollusc species with highest average density is *L. scabra* with a density value of 0.032 individual $m^{-2}$. While the species with the lowest average density is *D. margariticola* with density values of 0.00088 individual $m^{-2}$.

The facts on the field show that *L. scabra* is relatively stronger to attach itself to hard substrate (mangrove stem). Colonization of this species almost on all surfaces of mangrove stems range from 0 to 3 meters. The relatively strong ability of attaching themselves on the mangrove stem helps this species to withstand waves at high tide. Other gastropod species are relatively weaker attached to mangrove stems. This low self-attachment capability causes gastropods to break loose because of strong waves. At low tide the survived species on mangrove stalks adapt themselves by closing the operculum.

The density of mangrove molluscs in each altitude unit is determined by the distribution of molluscs and the ability of attaching themselves to each altitude unit at low tide. According to Saru (2013), the species that vertically spread in the mangrove ecosystem are *Littorina scrabra, Littorina melanostoma, Littorina undulata, Cerithidea* spp.*, Nerita birmanica, Chthalmus witthersii, Murex adustus, Crassostraea cuculata, Nannosesarma minuta,* and *Clibanarius longitarsus*.

***Dominance of species (D)***. Based on Table 2, it can be concluded that the species dominance value (D) of molluscs in the Paradiso mangrove forest area is 0.336. As the D value is less than 0.4, it can be concluded that there is no dominant arboreal molluscs in the Paradiso coastal mangrove forest area. Legendre & Legendre (1983) explained that if the dominance index values obtained are between 0.4 and 0.6 it can be considered as moderate, while if the dominance index values are above 0.6, then it is it is categorized as dominant and if it goes below 0.4, it is assumed as not dominant. According to Odum (1993) that to know whether or not a community is dominated by a particular organism, this can be known by calculating the index of dominance. If the index value of dominance is close to 1, it also means that there are certain organisms dominating the waters. On the other hand, if the value goes down close to 0, then there is no dominant organism in the area. Table 2 shows each species having a dominance index less than 0.4. *L. scabra* has a dominance value of 0.293 and *D. margariticola* has a dominance value of 0.000230. This result is different from Hartoni & Agussalim's report (2013) showing that the dominant gastropods in the mangrove ecosystem down the Musi River of Banyasin Regency is *L. scabra*. This difference is due to the fact that both the research used different sample units. In this research, the sample unit is mangrove stem while the one used by Hartoni & Agussalim (2013) is the mangrove forest floor.

The results also show that the environmental conditions of mangrove forests support the growth of all species of arboreal mangrove molluscs. In the event of extreme environmental changes, only certain species that are able to adapt to the extreme environmental conditions dominate the ecosystem of mangrove forest. Macintosh et al (2002) explained that total dominance of one species probably indicates an unfriendly environment. Arboreal mangrove molluscs attach themselves to mangrove stems and can survive during low tide because they have an adaptive ability toward dry conditions. Romimohtarto & Juwana (2001) explain that the molluscs can adapt to drought because they can close their shells and use water inside the shell.

***Environmental parameters***. The environmental parameters observed in this study consist of temperature, salinity, pH and dissolved oxygen. The measurement results of environmental parameters are presented in Table 3.

Tabe 3

Environmental parameters of research location

| *No* | *Parameter* | *I* | *II* | *III* | *Average* |
|---|---|---|---|---|---|
| 1 | Dissolved oxygen (DO) (mg $L^{-1}$) | 3.2 | 3.3 | 3.5 | 3.3 |
| 2 | pH | 6.6 | 6.5 | 6.7 | 6.6 |
| 3 | Temperature ($^oC$) | 25 | 26 | 25 | 25.3 |
| 4 | Salinity ( ‰ ) | 32 | 32 | 31 | 31.6 |

Based on Table 3, it is concluded that dissolved oxygen in the mangrove environment ranges from 3.2 to 3.5 mg $L^{-1}$. The pH ranges from 6.5 to 6.7, temperatures ranges from 25 to 26$^o$C and salinity ranges from 31 to 32 ‰ .

*Temperature.* Table 3 shows that the water temperature ranges from 25 to 26$^o$C. The water temperature range is still within the normal range for mollusc growth. Rahmasari et al (2015) suggested that gastropods can optimally perform metabolism process in the temperature extending from 25 to 35$^o$C. Hutagalung (1988) suggests that in general the maximum temperature for the growth of benthic molluscs varies between 15 to 28$^o$C.

The effect of temperature on the growth of organisms is mainly involved in the activity of metabolic enzymes. The temperature range which is above the maximum rate can cause denaturation of enzyme proteins which in turn will affect the activity of metabolism. Hitalessy et al (2015) suggest that a temperature range exceeding the tolerance limit can lead to decreased metabolic activity, even causing death of gastropods. Water temperature at the surface is affected by meteorological conditions such as rainfall, humidity, wind speed and intensity of solar radiation (Nontji 1987). Mollusks attached to mangrove stems during low tide can adapt to temperature changes.

*Degree of acidity (pH).* The results showed that pH in the mangrove forest area ranges from 6.5 to 6.7 with average of 6.6. This pH value is still within the normal range for growth of gastropods. Rusnaningsih (2012), explains that the tolerance of gastropods to pH extends from 5 to 9. While Handayani (2006) suggests that the optimum pH for the life of marine organisms ranges from 6 to 8.

The drastic changes in pH greatly affect the activity of molluscs. A very acidic or very alkaline pH can cause denaturation of enzyme and membrane integral proteins. Denaturation causes a change in protein structure so that proteins do not function normally. This situation will affect the metabolic activity. Conditions of waters that are very acidic or very alkaline will endanger the survival of aquatic organisms, because it can cause metabolic and respiratory disorders.

*Salinity.* The results showed that salinity in Paradiso mangrove forest ranges from 31 to 32 ‰ with average of 31.6 ‰. This salinity value is still within the normal range for the life of molluscs. According to Hitalessy et al (2015), in general the species of gastropod can live in waters with salinity extending from 31 to 37 ‰. In ocean, salinity typically ranges from 34 to 35 ‰ but in coastal waters there is dillution by fresh water causing it lower from its normal value (Nontji 1987). Salinity in the environment affects the water balance of the organism through osmosis. Most of living aquatic organisms are limited in freshwater or saltwater habitats because they have limited ability for osmoregulation (Campbell et al 2010).

*Dissolved oxygen (DO).* The results showed that DO in the Paradiso mangrove forest area ranged from 3.2 to 3.5 mg $L^{-1}$ with average of 3.3 mg $L^{-1}$. The value of DO is still within the normal range for the life of aquatic organisms. The maximum DO for the life of benthic molluscs ranges from 4.5 to 6.6 mg $L^{-1}$. Effendi (2003) suggests that if the DO value is below 2.0 mg $L^{-1}$, it can cause death of organisms. DO is a basic requirement for the life of aquatic biota. The arboreal molluscs in the mangrove stems acquire DO during the tide. As being predicted, in order to maintain the adequacy of oxygen demand during the low tide, the operculum is sometime opened to absorb oxygen through the respiratory system.

**Conclusions**. Based on the results and discussion, it can be concluded into several things as follows: it is found that the 7 species of arboreal molluscs located in the Paradiso mangrove forest area can be divided into 2 classes, namely, gastropods and bivalves. Six species in the gastropod class are *Littorina scabra, Littorina undulata*, *Terebralia sulcata, Nerita plasnospira, Nassarius distortus,* and *Drupella margariticola.* The other species, that is, *Saccostrea cucullata* belongs to bivalve class. The dominance value of species is 0.336 < 0.5, indicating that there is no dominant species in the area. This result can be seen from all environmental parameters showing a normal range of value to support the life of arboreal molluscs.

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