# Spatial Distribution and Gastropod Associations Based on Tawiri and Tanjung Tiram Mangrove Habitat in Ambon, Maluku, Indonesia

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***Abstract***

*Ambon Island is an area that has the potential for a mangrove ecosystem. Ambon Island has a unique bay covered with mangroves. When viewed from the topography, Ambon Bay is divided into Outer Ambon Bay and Inner Ambon Bay, which are separated by a narrow and shallow threshold. Tawiri has five species of mangroves, and Tanjung Tiram has three species of mangroves. The density of mangroves as the main constituent of the ecosystem greatly influences the existence of associated biota, namely gastropods themselves. Gastropods have an important role in the food chain cycle in the mangrove ecosystem. This research was conducted in August–September 2023 in the Tawiri (Outer Ambon Bay) and Tanjung Tiram (Inner Ambon Bay) mangrove areas. Data collection for gastropods and mangrove ecosystems used quadrat transects, while for organic materials they used sediment cores. The association between gastropods and mangroves was analyzed using correspondence analysis (CA). The research results show that Tawiri has seven families and 10 species of gastropods. Tanjung Tiram has 3 families and 5 species of gastropods. Gastropod species at both study locations were divided into three different size classes for each location. Gastropods at each research location were found to be closely associated with mangroves because mangroves provide sufficient food sources for gastropod life. The results of this research can be useful for providing the latest data regarding the distribution of gastropods and mangroves in Tawiri and Tanjung Tiram.*

***Keywords:*** *Gastropods; Mangrove; Tanjung Tiram; Tawiri.*

## INTRODUCTION

Mangrove ecosystems has unique vegetation where their growth depends on tidal conditions and salinity, and they generally grow well on mud substrates that are rich in organic matter. As a form of adaptation, mangrove species have a specific root system that is adaptive to existing environmental conditions (Norris *et al*. 2019). Mangrove ecosystems in the coastal region have high productivity and biodiversity. Mangrove ecosystems have all the potential to be developed, both economically and ecologically (Koch *et al*., 2009; Buncag *et al*., 2019). Physically, the mangrove ecosystem serves to protect the coast from tidal waves, abrasion, and erosion. Aside from that, mangrove eould play an ecological function as a place for spawning grounds, nursery grounds and feeding grounds for various marine organisms (Sheaves *et al*., 2016; Marley *et al*., 2020). Mangrove ecosystem are a comfortable habitat for various types of marine and terrestrial fauna. Mangrove detritus is known to be a food source for decomposers in the food chain like macroinvertebrates such as crabs and gastropods (Kristensen *et al*., 2008). Various invertebrate species are known to be associated with mangrove, but molluscs are the most context of species richness, biomass and density (Li *et al*., 2012). The distribution of gastropods is strongly influenced by biotic and abiotic factors. Biotic factors consist of predators, life cycles, and food sources (Peng *et al*., 2017; Abdelhady, 2018). The existence of various activities that occur in the mangrove ecosystem will change the condition of the mangrove environment and the vulnerable to pollution (Ernanto *et al*. 2010). The occurrence of changes in the mangrove ecosystem has an impact on benthic orgnisms that live in mangrove ecosystems such as gastropods and bivalves (Saleky *et al*., 2016).

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Ambon Bay is located on Ambon Island, which is split into two parts, called the Outer Ambon Bay and the Inner Ambon Bay, due to the existence of a peninsula inside the bay. The outer part (Tawiri) has an open-water character, whereas the inner part (Tanjung Tiram) poka area is more protected from waves (Noya, 2016). Studies on gastropods in the Ambon Island and Ambon Bay area are have been carried out several times. For example, Kalay *et al*. (2022) examined the dominance of basic sediment in relationship with the density of gastropods and bivalvia in Tawiri coastal waters Ambon Island, Pietersz *et al*. (2022) found the distribution of gastropods based on the type of mangrove in the Waiheru Village area, Kho *et al*. (2020) examined the Morphometric variation and species density of Nerita in the coastal waters of Ambon Island, Indonesia. Based on the explanation above, it is necessary to conduct research on the distribution of gastropods species and conditions in mangrove ecosystems on Tawiri and Tanjung Tiram Ambon which aims to identify the distribution of gastropods species and association relationships with mangrove ecosystems, where these two locations have different characteristics to know the condition of mangrove ecosystems in both locations.

## MATERIAL AND METHODS

The research was conducted in the mangrove ecosystems of Tawiri and Tanjung Tiram (Poka area) in Agustus until September 2023. To collect the data on mangrove vegetation, we used a line transect 100 meters pointing towards land with plots of 10x10 meters for all categories of mangrove, where the distance between transects is 30 meters Rahman *et al*. (2020). In Tawiri there were 20 mangrove plots obtained, and 13 plots were obtained for Tanjung Tiram.

Gastropods data sampiling area was delineated by a 1x1 meter plot within each 10 x 10 meter plot of mangrove vegetation. We collected the gastropods on the substrate (soil, mangrove trunks, and leaves) by handpicking. Gastropods collected in each quadrant were put into a plastic sample and labeled. The collected gastropods are brought to the laboratory for analysis. In the laboratory, the gastropods collected were washed, then put back into labeled plastic, which is filled with 70% alcohol. The Identification of gastropods was done by using the book " Indonesian Shells I & II by Dharma (1988 & 1992). Sample sediment for Total Organic Matter Using a sedimen corer with a 5 cm diameter, and 1cm length, and 10 cm depth. Sedimen were put into plastic samples, labeled, and then analyzed in the soil laboratory of Udayana University for Total Organic Matter.

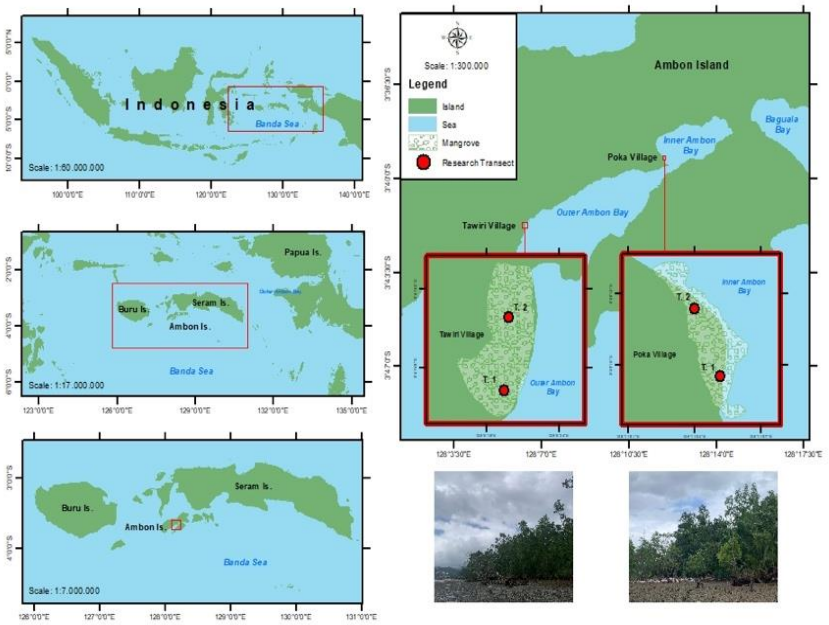


**Figure 1.** A map of sampling sites, Tanjung Tiram (Poka area) and Tawiri

## RESULT AND DISCUSSION

The composition of mangrove species in Tawiri includes *Sonneratia alba*, *Aegiceras floridum*, *Schyphiphora hydrophyllacea*, *Rhizophora apiculata*, *Avicennia rumphiana*. In Tanjung Tiram, the mangrove composition includes *Sonneratia alba*, *Rhizophora apiculata* and *Aegiceras floridum*. Mangrove species in Tawiri was dominated by *Sonneratia alba* tree category with the highest density (0.36 ind/m2, and in Tanjung Tiram they were dominated by *Rhizophora apiculata* the saplings category with the highest density (0.29 ind/m2). *Sonneratia alba* is one of the true mangrove species that is adaptive to environmental changes. True mangrove have some mechanism to deal with the saline environment, even Aegiceras has salt gland. In species without salt gland, the adaptive traits in those mangrove species is ultrafiltration by root and salt excretion via root and leaf senescence which is a major mechanism in *Sonneratia* and Rhizophoraceae (*Bruguiera, Ceriops, Rhizophora*). In Tawiri, the highest density value is represented by Sonneratia alba because this mangrove species can adapt to high salinity and is often found in areas directly facing the open sea (Wintah *et al*., 2022). In Tanjung Tiram, the highest density value is represented by the species Rhizophora apiculata, which is a mangrove species that grows in groups in swamps that are submerged in high tide, as well as muddy waters and river estuaries (Retraubun *et al*., 2022).

The density of gastropods found in Tawiri was 390 ind/$m^2$, consisting of 7 families and 10 species. In Tanjung Tiram, there were 258 ind/m2, consisting of 3 families and 5 species. The highest individual density in Tawiri is in the *potamididae* family at 219 ind/$m^2$, while the lowest density is in the *neritidae* family at 2 ind/m2. The *Pottamididae* family is the most often found in mangrove areas or can be called the original inhabitants of mangrove forests, and it has a high tolerance for changes in environmental conditions (Salu, 2019). This family consumes food from mangrove leaves, and usually the mangrove leaves consumed are of the Rhizophora type (Fratini *et al*., 2004). The highest individual density in Tanjung Tiram is in the *cerithiidae* family at 122 ind/m2, while the lowest is in the *potamididae* family at 25 ind/m2. The cherrythiidae family is often found in Tanjung Tiram because the number of species from this family is more dominant compared to other families in Tanjung Tiram, and this family has a fairly wide range of areas depending on environmental factors, is able to reproduce quickly, is caused by a wide distribution method, and has an area roaming in search of food sources. In other words, species from the *Cerithiidae* family are the dominant species or have a greater number of individuals because they are thought to be able to adapt and be suitable for living in that environment (Tetelepta, 2019).

The denser the mangrove root system, the more effective it will be in processing waste into high organic matter (Hogart, 2006). The distribution of gastropod species in mangrove ecosystems is influenced by various factors such as light (the main factor influencing humidity), tides, salinity, sediment texture, and mangrove vegetation type (Nagelkerken *et al*., 2008). The presence of gastropods is also influenced by mangrove density. Based on research (Ariyanto *et al*., 2018), it is stated that the higher the density of mangroves, the higher the abundance of gastropods. The

**Table 1.** Density of Mangrove Species in Tawiri and Tanjung Tiram

| Mangrove Species | Category | Ki (Ind/$m^2$) | |
|---|---|---|---|
| | | Tawiri (OAB) | T. Tiram (IAB) |
| *Sonneratia alba* | Tree | 0.36 | 0.21 |
| | Sapling | 0.11 | 0.13 |
| | Seedling | 0.32 | 0 |
| *Aegiceras floridum* | Tree | 0.01 | 0.04 |
| *Schyphiphora hydrophyllacea* | Tree | 0.01 | 0 |
| *Rhizophora apiculata* | Tree | 0.34 | 0 |
| | Sapling | 0.16 | 0.29 |
| | Seedling | 0.01 | 0.16 |
| *Avicenia rumphiana* | Tree | 0.01 | 0 |

highest average width value of gastropods in Tawiri was at station 2 at 1.57 cm (N. planospira), and the lowest average width value was at station 1 at 0.7 cm (N. niger). The highest average weight value was at station 2 at 4.11 g (T. sulcata), and the lowest average weight value was at station 1 at 0.26 g (N. niger). In Tanjung Tiram, the highest average value for width was at station 1 at 1.41 cm (T. sulcata), and the lowest average value for width was at station 1 at 0.72 cm (C. battilariaeformis). The highest average weight value at station 1 was 4.61 g (T. sulcata), and the lowest average weight value at station 1 was 0.53 g (M. margariticola). The gastropod species T. sulcata is often found at the Tawiri research location and dominates the number of individuals, while in Tanjung Tiram, C. batilariaeformis is often found at the research location and the number of individuals dominates. Gastropods require food for the formation of their shells, which contain calcium carbonate. The food that has been obtained will be filtered and selected, and food containing calcium carbonate will enter the blood plasma to form shell structures and color patterns in gastropods (Nontji, 2007).

Gastropod size classes in Tawiri are divided into three size classes, namely small size (Ki < 1.1 mm), medium size (Ki 1.2–2.5 mm), and large size (Ki > 2.6). The class size of gastropods in Tawiri ranges from 0.9 to 3.7 mm. The highest number of individuals was found in the medium size class (1.2–2.5 mm), namely 181 individuals, and the lowest number of individuals, 37 individuals, was found in the small size class (0.9–1.1 mm). Tanjung Tiram is divided into three size classes, namely small size (Ki < 1.6 mm), medium size (Ki 2.1-3.0 mm), and large size (Ki > 4 mm). The size of the class of gastropods found in Tanjung Tiram ranges from 0.6 to 4.9 mm. The highest number of individuals was found in the medium size class (2.1-3 mm) with 201 individuals, and the lowest number of individuals with 27 individuals was found in the large size class (< 4 mm). The differences in the distribution of gastropod size classes in Tawiri and Tanjung Tiram can be assumed to be influenced by the food obtained by the gastropods at each research station. According to Ariyanto *et al*. (2018) it is very possible that the size class of gastropods is influenced by sufficient food availability. The more food availability is relatively high, the size class also increases, and this is also supported by the density of mangroves at that location. The size of gastropods is greatly influenced by their eating patterns; namely, gastropods that are <40 mm long are detritus-eating gastropods (Hogart, 2006). So it can be assumed that all types of gastropods in Tawiri and Tanjung Tiram are detritus-eating gastropods with sizes ranging from 0.6 to 4.9 mm for both research locations.

The results of the analysis of organic matter content in sediments in Tawiri (50.74%) and Tanjung Tiram (58.27%) can be categorized as having high organic matter values. According to Bengen (2002), the higher the mud and clay content in the sediment obtained, the higher the organic matter content. Organic matter increases with increasing clay and clay content. Sediments rich in organic material are often supported by an abundance of benthic organisms, including gastropods, because organic material is a food source for marine biota that live on the substrate, so their dependence on organic material is very large (Abdunnur, 2002).

Gastropods have associations with different types of mangroves based on size classes and form three association groups (Figure 2). The first group explains that the small-sized N. *niger*, M. *decurtata*, C. *battilariaeformis* at station 1, large-sized L. *scabra* at station 2, medium-sized M. *margariticola* at station 3, and medium-sized C. *vulgatum* at station 4 are closely associated with *Rhizophora apiculata* mangrove. The organic material content and density of mangroves in the *Rhizophora apiculata* area have the potential to provide food for gastropods. The second group, which describes small-sized T. *sulcata*, large-sized C. *vulgtum*, medium-sized N. *polita* at station 1, medium-sized T. *sulcata* at station 2, and large-sized C. *vulgatum* at station 3, is closely associated with the *Sonneratia alba* mangrove. The third group, namely medium-sized M. *margariticola* at station 1, small-sized N. *chamaeleon*, large-sized N. *planospira* at station 2, medium-sized T. *sulcata* at station 3, and small-sized C. *battilariaeformis* at station 4, is classified as having a higher weight. (plump) compared to other gastropod species at each research station. This can be assumed if the research station provides sufficient organic material for consumption by gastropods as a source of nutrition so that the weight of the gastropod species is greater. Overall, gastropods are closely associated with the *Sonneratia alba* and *Rhizophora apiculata* mangrove types found at the research station, where these mangroves are suppliers of food ingredients necessary for gastropod life.

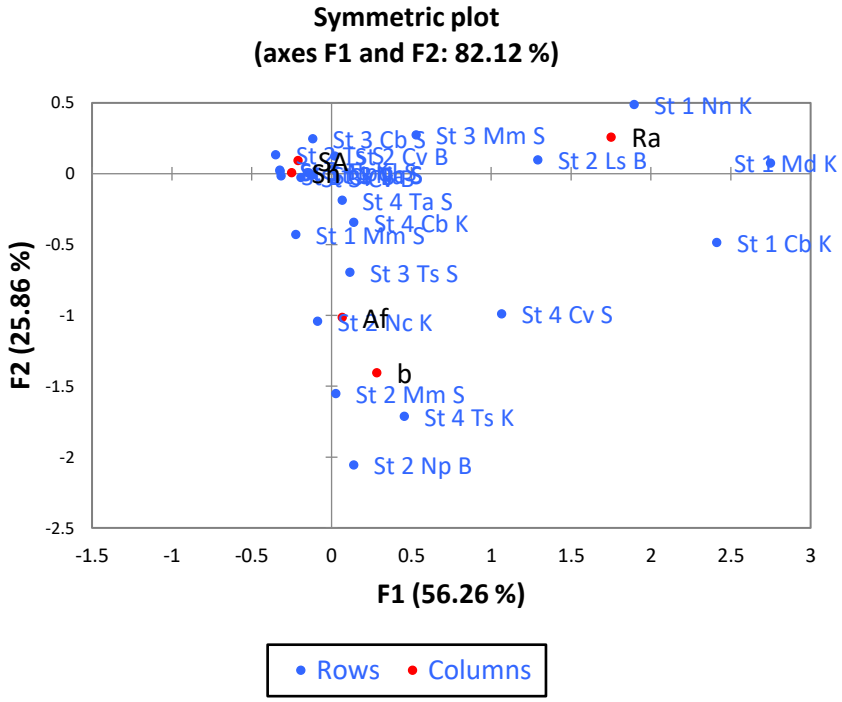


**Figure 2** Results of CA analysis between Gastropods and mangroves

## CONCLUSION

The gastropods found in Tawiri were from 7 families and 10 species, and Tanjung Tiram was found to consist of 3 families and 5 species. There are 5 species of mangroves found in Tawiri and 3 species in Tanjung Tiram. The gastropod with the gastropod with the highest abundance in Tawiri is *Terebralia sulcata*, and in Tanjung Tiram it is *Cypeomorus battilariaeformis*.The gastropod type T. sulcata in Tanjung Tiram has a greater width and weight (1.38 cm and 4.15 g) compared to that in Tawiri because the water conditions are closed and more protected compared to Tawiri, making this type of gastropod use less energy to adapt and more energy. widely used for the growth process so that the weight and width of the gastropods will increase. Each research location has three gastropod size classes, namely small, medium, and large. Gastropods at each research location were found to be closely associated with *Sonneratia alba* and *Rhizophora apiculata* mangroves because these two types of mangroves provide sufficient food sources for gastropod life.

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