



DIVERSITY OF MANGROVE GASTROPODS IN AREA OF THERMAL WATER NORTH KONAWE DISTRICT, INDONESIA

Hilda Ayu Melvi Amalia¹, Armadi Chairunnas²

¹Department of Tadris Biology, Faculty of Tarbiyah and Teacher Science, State Islamic Institute of Kendari, Indonesia

²Department of Biology, Faculty of Mathematics and Natural Sciences, University of Nahdlatul Ulama Southeast Sulawesi, Indonesia

*Surel penanggung jawab tulisan: hildaayumelvi@gmail.com

Article History

Received: 03 June 2023. Received in revised form: 14 Oktober 2023.

Accepted: 24 Oktober 2023. Available online: 04 November 2023.

Abstrak. Gastropoda sebagai kelas terbesar dari filum moluska terdiri dari hewan yang memiliki kisaran toleransi yang luas sehingga dapat hidup di lingkungan dengan tingkat stres yang sangat tinggi. Pada penelitian ini, gastropoda memiliki habitat yang unik dimana ekosistem mangrove dilewati oleh air panas dari sumber air panas Wawolesea sebelum mengalir ke laut. Penelitian ini bertujuan untuk mengidentifikasi taksa gastropoda di kawasan ekosistem mangrove air panas Wawolesea Sulawesi Tenggara, mengukur keanekaragaman gastropoda, dan mengukur kelimpahan gastropoda. Jenis penelitian ini adalah deskriptif kualitatif dengan menggunakan metode kuadran untuk koleksi gastropoda. Faktor lingkungan yang diukur dalam penelitian ini adalah intensitas cahaya, suhu udara, kelembaban udara, kelembaban substrat, pH air, salinitas air, dan suhu dalam substrat. Semua faktor lingkungan tersebut kemudian dianalisis untuk melihat hubungannya dengan keanekaragaman dan kelimpahan gastropoda. Hasil penelitian menunjukkan bahwa terdapat 5 ordo, 11 famili, dan 22 genera. Indeks keanekaragaman menunjukkan bahwa keanekaragaman di lokasi penelitian tergolong tinggi dengan nilai $H' = 3,02$; $Di = 0,054$; $Dmg = 4,14$; $P = 0,96$; $DMn = 0,077$. Kelimpahan tertinggi ditunjukkan oleh taksa Potamididae (genus Cerithidea, Terebralia, Rhinocoryne, dan Telescopium), yaitu 31,47% dan terendah adalah taksa Cypraeidae (genus Callistocypraea), yaitu 3,29%. Faktor lingkungan yang secara langsung mempengaruhi keanekaragaman gastropoda adalah pH, salinitas, dan suhu.

Kata Kunci: Kelimpahan, Mollusca, Potamididae, Sulawesi Tenggara.

Abstract. Gastropods as the largest class of the phylum molluscs consist of animals that have a wide range of ecological tolerances so that they can live in environments with very high levels of stress. In this study, gastropods have a unique habitat where the mangrove ecosystem is passed by thermal water from a hot spring called Wawolesea before flowing into the sea. This research aimed to identify Gastropod taxa in area of thermal water Wawolesea mangrove ecosystem of Southeast Sulawesi, to measure the diversity of gastropods, and to measure the abundance of gastropods. This type of research was a qualitative descriptive using the quadrat method for gastropod collections. The environmental factors that measured in this study were light intensity, air temperature, air humidity, substrate humidity, water pH, water salinity, and temperature in the substrate. All environmental factors were then analyzed to see their

relationship with gastropod diversity and abundance. The results showed that there were 5 orders, 11 families and 22 genera. The biological index shows that the diversity at study site was high with the following values $H' = 3.02$; $D_i = 0.054$; $D_{mg} = 4.14$; $P = 0.96$; $DM_n = 0.077$. The highest abundance was shown by the Taxa Potamididae (genus Cerithidea, Terebralia, Rhinocoryne, and Telescopium), which was 31.47% and the lowest was the taxa Cypraeidae (genus Callistocypraea), which was 3.29%. Environmental factors that directly affect gastropod diversity are pH, salinity, and temperature.

Keywords: Abundance; Mollusca; Potamididae; Southeast Sulawesi.

1. INTRODUCTION

Mangrove ecosystems are a type of ecosystem that is commonly found in coastal areas and is a combination of marine and terrestrial ecosystems (Hamsiah et al., 2023). Mangrove ecosystems have broad functions from several aspects such as economic and ecological aspects. Economic functions include being used as a means of recreation, producing household and industrial needs, and producing seeds. Ecological functions include preventing coastal abrasion, absorbing carbon dioxide (CO₂), and habitat for various types of organisms (Nanlohy & Masniar, 2020). One of the organisms whose habitat is in the mangrove ecosystem is gastropods.

Gastropods as the largest class of the phylum molluscs consist of animals that have a wide range of ecological tolerances so that they can live in environments with very high levels of stress (Suratissa & Rathbayake, 2017). Diversity and abundance of gastropods are positively correlated with the number and diversity of true mangrove community saplings, but negatively correlated with the number and diversity of associated mangrove trees. This is in accordance with the results of research by Putri et al. (2015), who found the distribution of gastropods in the mangrove sapling area is more numerous and evenly distributed than the mangrove tree area. Young leaves of sapling plants may be a good food source for mangrove gastropods, or saplings are an excellent habitat for these fauna (Delfan et al., 2021).

Previous studies related to gastropods diversity in mangrove ecosystems have been conducted by Hulopi et al. (2022) and Ashuri et al. (2022). Hulopi et al. (2022) revealed that there are 16 type of species found in the mangrove ecosystem of the coast of Passo Ambon. Gastropods that are found abundantly are *Terebralia sulcata*. In contrast to the study of Hulopi et al. (2022), Ashuri et al. (2022) only found 9

species of gastropods in the coastal mangrove ecosystem of Situbondo Regency, East Java, Gastropods that were found abundantly were *Pirenella cingulata*.

This study was different from previous studies where the condition of the mangrove ecosystem has its own uniqueness. The uniqueness was that all thermal water coming out from area of thermal water passed through the mangrove ecosystems before emptying into the sea. This research aimed to identify and measure diversity of gastropods taxa in the Wawolesea mangrove ecosystems of North Konawe District.

2. METHODS

The sampling of gastropods was carried out in all areas of thermal water in the mangrove ecosystem, in Wawolesea District, Southeast Sulawesi Province (Figure 1).

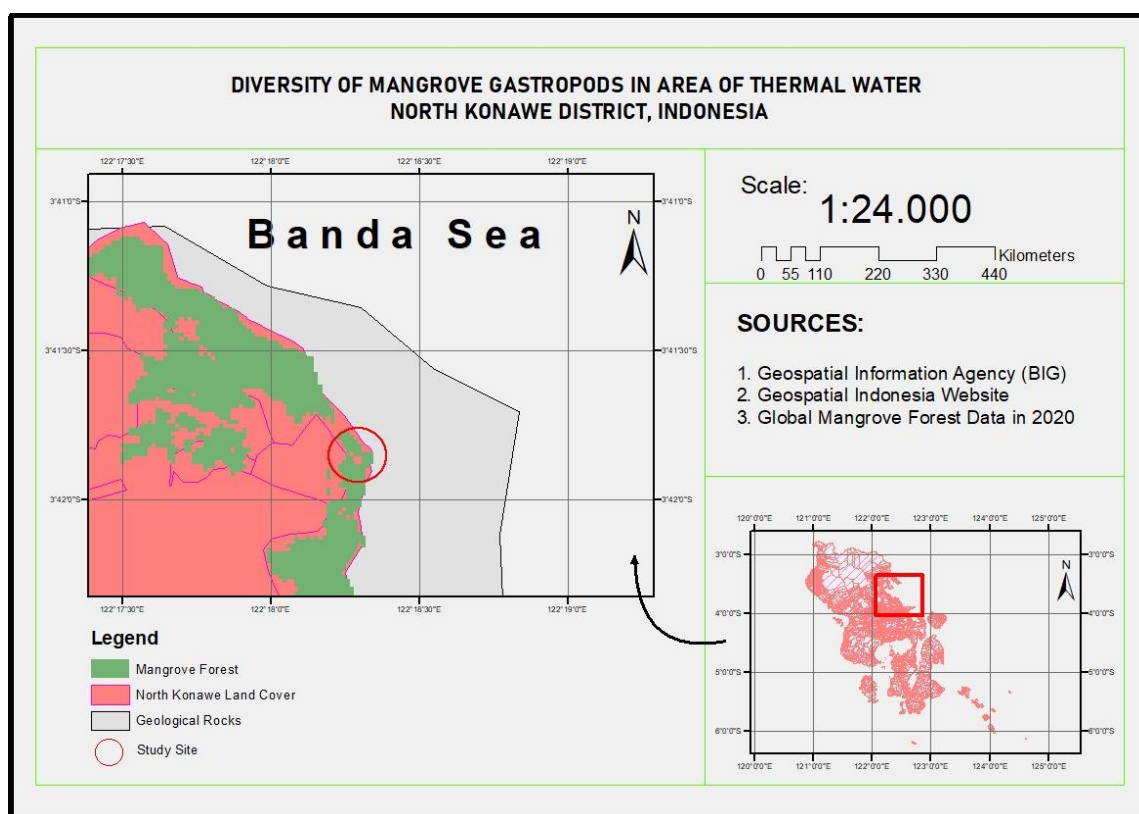


Figure 1. Study Site of Sampling Gastropods

The tools used in this research were Leica stereo microscope, GPS, electric thermometer, hand counter, lux meter, soil tester, hygrometer, saltmeter, roller meter (50 m x 50 m), soil sample ring, stakes, digital camera, sample bottle, sample box,

and tool box. The materials used in this research were gastropod samples, soil, 70% alcohol, large plastic clips, raffia, and tissue.

Gastropod sample collection was conducted four times with a two week interval. At study site, a quadrant measuring 100 m x 40 m was made to delimit the sampling points. Molluscs (gastropods) were collected in a 1 m² quadrant in a 100 m² plot that was randomly located at study site. In each plot, three quadrants were placed as sampling points. The quadrants were placed around mangrove trees that had different species characteristics. Samples of gastropods were collected in two events: directly collecting epifauna and taking substrate to a depth of 15 cm to collect endofauna. Samples obtained were placed into flip plastic, then washed and preserved using 70% alcohol in a sample bottle (Bouillon et al., 2002; Shojaei et al., 2022).

The environmental factors measured in this study were light intensity, air temperature, air humidity, substrate humidity, water pH, water salinity, and temperature in the substrate. All environmental factors were then analyzed to see their relationship with gastropod diversity and abundance (Bouillon et al., 2002; Shojaei et al., 2022).

The identification book used is a book entitled Classification and Nomenclator of Gastropod Families (Bouchet & Rocroi, 2005; Dharma & Pringgenies, 2023), which is further verified (Kartavtsev & Redin, 2019). Gastropods were described using the Shannon-Wiener diversity index (H') with the following equation:

$$H' = -\sum (P_i \ln P_i) \quad (1)$$

where P_i = Percentage number of individuals species i from total number of individuals found. Furthermore, the data were analyzed with Simpson's Index to measure dominance by the taxa found, and then the high abundance showed by the high of Menhinck's Index, Pilon's Index, and Margalef's Index. Furthermore, researchers will calculate the abundance of each genus of gastropod obtained (Bouchet & Rocroi, 2005; Dharma & Pringgenies, 2023).

3. RESULTS AND DISCUSSION

The overall mangrove gastropod community in the Wawolesea Hot Springs Mangrove Forest Ecosystem was 328 individuals at the study site. Total of 5 orders of the Gastropoda class were identified, namely the orders Mesogastropoda, Neogastropoda, Littorinimorpha, Trochida and Lepetellida. Furthermore, 11 families have been identified, namely Potamididae, Acteonidae, Babyloniidae, Muricidae, Turbinellidae, Strombidae, Cypraeidae, Calliostomatidae, Haliotidae, Naticidae, and Volutidae (Table 1).

Table 1. Total number of Mollusc family collected from Wawolesea mangrove ecosystem

No.	Family	Species	Ind
1	Potamididae	<i>Cerithidea</i> sp.1	18
		<i>Cerithidea</i> sp.2	16
		<i>Terebralia</i> sp.1	36
		<i>Terebralia</i> sp.2	16
		<i>Rhinocoryne</i> sp.	8
		<i>Telescopium</i> sp.	15
2	Acteonidae	<i>Acteon</i> sp. 1	10
3	Babyloniidae	<i>Babylonia</i> sp.	6
		Genus of babyloniidae	8
4	Muricidae	Genus of muricidae	9
5	Turbinellidae	<i>Vasum</i> sp.1	5
		<i>Vasum</i> sp.2	14
		<i>Vasum</i> sp.3	7
6	Strombidae	<i>Canarium</i> sp.	26
		<i>Laevistrombus</i> sp.	18
		<i>Dolomena</i> sp.	11
7	Cypraeidae	<i>Callistocypraea</i> sp.	9
8	Calliostomatidae	<i>Calliostoma</i> sp.1	21
		<i>Calliostoma</i> sp.2	24
9	Haliotidae	<i>Haliotis</i> sp.	14
10	Naticidae	<i>Polinices</i> sp.	12
		Genera of naticidae	8
11	Volutidae	<i>Amora</i> sp.	17
TOTAL OF IND			328

Biological Indeks

H'	Di	Dmg (4,14) DMn (0,077)	P (0,96)
(3,02)	(0,054)		

Description: H'= Shannon-Wiener Index; Di= Simpson's Index; Dmg= Margalef's Index; DMn= Menhinick's Index; P= Pielou's Index.

Identification of mangrove gastropod communities was carried out up to the genus level, and then the genus was given a sequence number based on differences in their respective morphological structures. The most abundant genus in Family Potamididae was *Cerithidea* sp. 1 (Figure 2). Genera of the Family Potamididae were found namely *Cerithidea* sp. 1, *Cerithidea* sp. 2, *Terebralia* sp.1, *Terebralia* sp. 2,

Rhinocoryne sp., and *Telescopium* sp.. one genus of the family Acteonidae was *Acteon* sp. 1; there were two genera of the family Babyloniidae, it were *Babylonia* sp. and genus of Babyloniidae, genus of Babyloniidae was only identified up to the family level; the family Muricidae was only identified up to the family level, and the genus of the taxa was marked with *genus of Muricidae*; the genera of the family Turbinellidae were *Vasum* sp. 1, *Vasum* sp. 2, and *Vasum* sp. 3. Furthermore, the genera of the Strombidae family were *Canarium* sp., *Laevistrombus* sp., and *Dolomena* sp.; the genus of the Cypraeidae family was *Callistocypraea* sp.; the genera of the Calliostomatidae family were *Calliostoma* sp. 1 and *Calliostoma* sp. 2; the genus of the Haliotidae family was *Haliotis* sp.; the genera of Naticidae family was *Polinices* sp. and the genus of the taxa marked with *genus of Naticidae*; and the genus of volutidae family was *Amora* sp.. Thus, the number of genera that found were 22 genera.



Figure 2. *Cerithidea* sp. 1 (Source: Personal documentation)

The diversity index shows that the Shannon-Wiener Diversity of Gastropods at study site is high which is 3.02 (Table 2). The diversity index was inversely proportional to the dominance index, the results showed that the dominance index at study siteshowing a value of 0.054. A high dominance index was a parameter that there was a species or genus that has a much more abundant than other species. Margalef's index as an index that explains species richness in a community shows that study site was. high with values of 4.14. This was directly proportional to the value of the diversity index in this study. Furthermore, the Menhinick index as an index explaining the relative abundance of a taxon showed that study site with values of 0.077. Pielou's index as an index explaining the relative abundance of a taxon showed that the evenness of species in study site was high with values of 0.96. Thus all biological indices showed high results in study site except Simpson's index. The

high diversity found can be caused by Indonesia's favorable geographical location so that it becomes one of the biodiversity points or commonly referred to as the coral triangle (Heery et al., 2018).

The abundance of gastropods in the Wawolesea mangrove ecosystem was dominated by Potamididae taxa at 31.47% followed by Strombidae 14%, Calliostomatidae 13.34%, Turbinellidae 9, 22%, Naticidae and Haliotidae which amounted to 5.76%, Babyloniidae 4.77%, Acteonidae 4.61%, Volutidae 3.95%, Muricidae 3.78%, and in the last place Cypraeidae 3.29%. This was in line with the results of research by Pape et al. (2008) which stated that Potamididae, especially Terebralia, was the gastropod that most dominant in mangrove ecosystems that had sandy sediments, this was influenced by high distribution and good foraging ability so that it can maintain its population numbers. In line with this, Irma and Sofyatuddin (2012) found the Potamididae Family as the most abundant family in rehabilitated mangrove forests, but in contrast to the results of the study, the most abundant genus found was Cerithidea. The Potamididae family was the only family that exclusively lived in mangrove ecosystems where all taxa only live in mangrove ecosystems (Pape et al., 2008; Printrakoon et al., 2008; Jamabo & Chinda, 2010; Moruf & Lawal-Are, 2015). The Potamididae family was highly dependent on mangroves and therefore has potential as an indicator of mangrove health status (Penha-Lopes et al., 2010; Zvonareva et al., 2015).

Environmental factors measured at the study sites showed light intensity with a range of 441-1988 cd $p > 0.05$ which was classified as high range. High light intensity affects the temperature of the air and substrate as a gastropod habitat (Karim et al., 2021), air temperature in this study site was on range of 32.1 - 35,90°C $p > 0.05$. The variation in water temperature due to the time of measurement were done in the morning and also during the day. Air temperature affected gastropod metabolism, the higher the temperature, the higher metabolic rate of gastropods increase. Gastropods can perform metabolic processes optimally in the temperature range between 25-35°C (Suwondo et al. 2006; Piranto, 2019). Air humidity with a range of 24-35.6% $p > 0.05$. Air humidity with a range of 24-35.6% was low, this was because the mangrove ecosystem was flowed by thermal water from the Wawolesea hot springs so that it will increase the air temperature. High air temperature causes low

air humidity. According to Fitri & Hernawan (2022), low air humidity does not directly affect the distribution of gastropods.

Substrate humidity with a range of 69-77% $p>0.05$. This value was classified as moderate humidity and was due to the Wawolesea mangrove ecosystem always being inundated with water. Water pH with a range of 7.8 - 8.8 mg/L $p>0.05$. The pH of this seawater was classified as alkaline because the Wawolesea mangrove ecosystem was in open waters directly connected to the Banda Sea. According to Magdalena et al. (2019), gastropods can live in the pH range of 5.7-8.4. Water salinity with a range of 7.8-8.7 mg/L $p>0.05$. The salinity obtained from this study was relatively low due to the presence of fresh water from Wawolesea hot springs that enter the mangrove ecosystem. This low salinity was still within the tolerance range that supports the life of gastropods. This was in accordance with research conducted by Sandewi et al. (2019), that high salinity was negatively correlated with gastropod diversity. Water temperature with a range of 37.8-39,6⁰C $p>0.05$. This value was relatively high, because at the time of measurement it was near noon and the Wawolesea mangrove ecosystem was very close to the hot spring area. High temperatures can affect gastropod metabolism (Dinata et al., 2022).

4. CONCLUSION

The conclusion that can be drawn from this research was that the diversity of gastropods in the Wawolesea mangrove ecosystem included 22 Genera, 11 Families, and 5 Orders which were classified as high. Gastropod abundance in Wawolesea mangrove ecosystem was directly proportional to the diversity value obtained, where Potamididae taxa that consisted of genera *Cerithidea* sp.1, *Cerithidea* sp. 2, *Terebralia* sp.1, *Terebralia* sp. 2, *Rhinocoryne* sp., and *Telescopium* sp. was the most abundant gastropod family. Environmental parameters such as temperature range of 12.8-14.10⁰C and salinity with a range of 8.6 to 31.3 mg/L can be an implication of diversity and abundance Potamididae family. This research can be continued to the next stage, considering that it still had limitations in research data, especially the utilization of gastropods in the wawolesea mangrove ecosystem as alternative food for residents, as well as the structure of mangrove communities in the wawolesea mangrove ecosystem, Southeast Sulawesi Province.

5. ACKNOWLEDGEMENTS

The authors would like to thank the Ministry of Religious Affairs for funding this research through the KEMENAG LITABDIMAS programme.

4. REFERENCES

- Ashuri, N. M., Wirawan, I., Larasati, K. D., Jasmine, B. O., Supriyadi, S., Anshory, M. I., ... & Oktafitria, D. (2022). KEANEKARAGAMAN GASTROPODA DI EKOSISTEM MANGROVE PESISIR KABUPATEN SITUBONDO, JAWA TIMUR. *Biology Natural Resources Journal*, 1(1), 15-23. <https://doi.org/10.55719/Binar.2022.1.1.15-23>
- Bouchet P. and J-P Rocroi, 2005, Classification and Nomenclator of Gastropod Families, *Malacologia*, Vol 47(1-2): 1-397.
- Bouillon, S., Koedam, N., Raman, A., Dehairs, F., 2002. Primary producers sustaining macro-invertebrate communities in intertidal mangrove forests. *Oecologia* 130, 441-448.
- Delfan, N., Shojaei, M. G., & Naderloo, R. (2021). Patterns of structural and functional diversity of macrofaunal communities in a subtropical mangrove ecosystem. *Estuarine, Coastal and Shelf Science*, 252, 107288. <https://doi.org/10.1016/j.ecss.2021.107288>
- Dharma, B., & Pringgenies, D. (2023). Differences in shell morphology of the species *Rochia nilotica* (Linnaeus, 1767) and *Rochia maxima* (FCL Koch, 1844)(Gastropoda: Tegulidae). *Jurnal Moluska Indonesia*, 7(1), 36-42. <https://doi.org/10.54115/jmi.v7i1.82>
- Dinata, H. N., Henri, H., & Adi, W. (2022). Analisis Habitat Gastropoda pada Ekosistem Lamun di Perairan Pulau Semujur, Bangka Belitung. *Jurnal Ilmiah Sains*, 49-59. <https://doi.org/10.35799/jis.v22i1.37694>
- Fitri, N., & Hernawan, H. (2022). Indeks Ekologi Gastropoda sebagai Bioindikator Tingkat Pencemaran Air Tawar Situ Bangendit. *Jurnal Life Science: Jurnal Pendidikan dan Ilmu Pengetahuan Alam*, 4(2), 47-56. <https://doi.org/10.31980/jls.v4i2.2350>
- Hamsiah, H., Asmidar, A., & Kasmawati, K. (2023). Keanekaragaman dan Pola Sebaran Fauna pada Ekosistem Mangrove Di Pesisir Labakkang Kabupaten Pangkep Sulawesi Selatan. *JURNAL ILMIAH WAHANA LAUT LESTARI (JIWaLL)*, 1(1), 1-9.
- Heery, E. C., Hoeksema, B. W., Browne, N. K., Reimer, J. D., Ang, P. O., Huang, D., Fries, D. A., & Todd, P. A. (2018). Urban coral reefs: Degradation and resilience of hard coral assemblages in coastal cities of East and Southeast Asia. *Marine pollution bulletin*, 135, 654-681. <https://doi.org/10.1016/j.marpolbul.2018.07.041>
- Hulopi, M., de Queljoe, K. M., & Uneputti, P. A. (2022). KEANEKARAGAMAN GASTROPODA DI EKOSISTEM MANGROVE PANTAI NEGERI PASSO KECAMATAN BAGUALA KOTA AMBON. *TRITON: Jurnal Manajemen Sumberdaya Perairan*, 18(2), 121-132. <https://doi.org/10.30598/TRITONvol18issue2page121-132>

- Irma, D., & Sofyatuddin, K. (2012). Diversity of Gastropods and Bivalves in mangrove ecosystem rehabilitation areas in Aceh Besar and Banda Aceh districts, Indonesia. *Aquaculture, Aquarium, Conservation & Legislation*, 5(2).
- Jamabo, N., & Chinda, A. (2010). Aspects of the ecology of *Tympanotonus fuscatus* var *fuscatus* (Linnaeus, 1758) in the mangrove swamps of the upper Bonny River, Niger Delta, Nigeria. *Current Research Journal of Biological Sciences*, 2(1), 42-47.
- Karim, W. A., Anggo, S., & Soden, H. J. (2021). Keanekaragaman Jenis Gastropoda di Hutan Mangrove Desa Ranga-Ranga Kecamatan Masama Kabupaten Banggai. *Bioscientist: Jurnal Ilmiah Biologi*, 9(2), 445-454. <https://doi.org/10.33394/bioscientist.v9i2.4259>
- Kartavtsev, Y. P., & Redin, A. D. (2019). Estimates of genetic introgression, gene tree reticulation, taxon divergence, and sustainability of DNA barcoding based on genetic molecular markers. *Biology Bulletin Reviews*, 9, 275-294. <https://doi.org/10.1134/S2079086419040042>
- Magdalena, W., Kushadiwijayanto, A. A., & Putra, Y. P. (2019). Struktur Komunitas Siput Laut (Kelas: Gastropoda) di Pesisir Dusun Karang Utara, Pulau Lemukutan. *Jurnal Laut Khatulistiwa*, 2(2), 72-78.
- Moruf, R. O., & Lawal-Are, A. O. (2015). Growth pattern, whorl and girth relationship of the periwinkle, *Tympanotonus fuscatus* var *radula* (Linnaeus, 1758) from a tropical estuarine lagoon, Lagos, Nigeria. *International Journal of Fisheries and Aquatic Studies*, 3(1), 111-115.
- Nanlohy, L. H., & Masniar, M. (2020). Manfaat Ekosistem Mangrove Dalam Meningkatkan Kualitas Lingkungan Masyarakat Pesisir. *Abdimas: Papua Journal of Community Service*, 2(1), 1-4. <https://doi.org/10.33506/pjcs.v2i1.804>
- Pape, E., Muthumbi, A., Kamanu, C. P., & Vanreusel, A. (2008). Size-dependent distribution and feeding habits of *Terebralia palustris* in mangrove habitats of Gazi Bay, Kenya. *Estuarine, Coastal and Shelf Science*, 76(4), 797-808. <https://doi.org/10.1016/j.ecss.2007.08.007>
- Penha-Lopes, G., Kristensen, E., Flindt, M., Mangion, P., Bouillon, S., & Paula, J. (2010). The role of biogenic structures on the biogeochemical functioning of mangrove constructed wetlands sediments—a mesocosm approach. *Marine Pollution Bulletin*, 60(4), 560-572. <https://doi.org/10.1016/j.marpolbul.2009.11.008>
- Piranto, D., Riyantini, I., Agung, M. U. K., & Prihadi, D. J. (2019). Karakteristik sedimen dan pengaruhnya terhadap kelimpahan gastropoda pada ekosistem mangrove di Pulau Pramuka. *Jurnal Perikanan Kelautan*, 10(1).
- Printrakoon, C., Wells, F. E., & Chitramvong, Y. (2008). Distribution of molluscs in mangroves at six sites in the upper Gulf of Thailand. *The Raffles Bulletin of Zoology*, 18(18), 247-257.
- Putri, L., Yulianda, F., & Wardiatno, Y. (2015). Mangrove zonation and its associated macrozoobenthos in Pantai Indah Kapuk, Jakarta. *International Journal of Bonorowo Wetlands*, 5(1), 29-43. <https://doi.org/10.13057/bonorowo/w050104>
- Sandewi, N. P. D., Watiniasih, N. L., & Pebriani, D. A. A. (2019). Keanekaragaman Gastropoda di Pantai Bangklangan, Kabupaten Karangasem, Bali. *Current Trends in Aquatic Science*, 2(2), 63-70.
- Shojaei, M. G., Farahani, M. M., Abtahi, B., Delfan, N., Naderloo, R., & Kourandeh, M. B. (2022). Sources partitioning in the diet of the mudskipper *Periophthalmus*

- waltoni in an arid mangrove system: Evidence from stable isotope analysis. *Food Webs*, 31, e00234. <https://doi.org/10.1016/j.fooweb.2022.e00234>
- Suratissa, D. M., & Rathnayake, U. (2017). Effect of pollution on diversity of marine gastropods and its role in trophic structure at Nasese Shore, Suva, Fiji Islands. *Journal of Asia-Pacific Biodiversity*, 10(2), 192-198. <https://doi.org/10.1016/j.japb.2017.02.001>
- Suwondo, E. F., & Sumanti, F. (2005). Struktur komunitas gastropoda pada hutan mangrove di pulau sipora kabupaten kepulauan Mentawai Sumatera Barat. *Jurnal Biogenesis*, 2(1), 25-29.
- Zvonareva, S., Kantor, Y., Li, X., & Britayev, T. (2015). Long-term monitoring of Gastropoda (Mollusca) fauna in planted mangroves in central Vietnam. *Zoological studies*, 54(1), 1-16. <https://doi.org/10.1186/s40555-015-0120-0>