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Research Article

Morphometric variation and species density of Nerita (*Neritidae: Gastropoda*) in the coastal waters of Ambon Island, Indonesia

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ABSTRACT

Nerita is one of the species with high diversity in the coastal waters of Ambon Island. With this high diversity, the way to assess the length of various Nerita species is through a morphometric study. Meanwhile, density studies are useful for knowing the number of each of these diverse Nerita species. The purpose of this study was to identify the Nerita species to calculate the density and morphometrics. This research was conducted in an intertidal area in two locations, namely Seri and Tawiri villages. The morphometric characteristics of Nerita consist of shell length, shell width, aperture length, spire height, columella length, aperture length, and lip thickness. The density calculation refers to the density formula. The results showed that there were 9 species of Nerita, namely *N. polita, N. chamaeleon*, *N. patula*, *N. exuvia*, *N. maxima*, *N. squamulata*, *N. albicilla*, and *N. planospira. N. polita* has the highest density value (41.33 ind/m^2) while *N. patula* (0.04 ind/m^2) has the lowest density value. Morphometric analysis shows that there are variations in shell size among these species. Shell morphometric variations can be used as a reference for studying the phenetic diversity of Neritaidae in Ambon Island waters.

Keywords: Ambon Island, density, morphometric, Neritidae

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INTRODUCTION

The coastal waters of Ambon Island are generally divided into Outer Ambon Bay and Inner Ambon Bay waters and are productive waters because they are rich in biological resources. In the coastal areas of Ambon Island, you can find various types of unique ecosystems, such as mangrove ecosystems, brackish swamps, estuaries, seagrass, and seaweed as well as various kinds of aquatic biota such as mollusks (Supusepa, 2013; Leiwakabessy, 2016; Rumahlatu and Leiwakabessy, 2017). One class of the mollusk phylum is gastropods and is the most important part of the coastal water ecosystem because it is a key organism (Key role organisms) in studying environmental changes (Gazeau et al., 2013; Salampessy et al., 2015). Azizi et al. (2018) said that intertidal organisms such as mollusks are organisms that are often used as indicators in studying environmental changes because they are easily accessible, relatively slow-moving (sessile organisms), and abundant.

Nerita is one of the many gastropod genera that is widespread in the coastal waters of the island of Ambon. (Haumahu and Uneputty, 2018) added that the genus Neritidae is found in tropical and sub-tropical waters and usually inhabits the intertidal zone. Liline et al. (2020) reported that the nerita species found in the Latuhalat, Hutumuri, and Suli areas were *Nerita maxima* Gmelin, 1791*; Nerita grossa* Linnaeus, 1758; *Nerita costata* Gmelin 1791; *Nerita albicilla* Linnaeus, 1758; *Nerita* plicata Linnaeus, 1758; *Nerita chamaeleon* Linnaeus, 1758; *Nerita spengleriana* Récluz, 1843.

Several studies have shown that the genus Nerita uses certain mechanisms to adapt to extreme environmental changes in the intertidal zone (Weiskittel et al., 2009; Leung et al., 2019). Morphometrics are intended to measure important body parts in animals, so that the size range is known, in each growth phase in each animal species, so that the information for taxa determination becomes more complete and accurate. The important value contained in morphometry is to know more deeply about species, estimate age and sex and know body weight and size. Nerita's morphometric information on the coastal waters of Ambon Island is still minimal, therefore it is necessary to conduct a study on this matter. Echem (2017) reported that Nerita ablicilla has a heavy shell mass compared to other species so that it can survive in extreme environments. Kawai (2020) reported that the Gastropod Nerita plicata, originating from the islands of Rarotonga and Aitutaki, is widely distributed in the intertidal zone, showing shell color polymorphism that is influenced by the substrate.

Because the genus Nerita can survive in environments that experience fluctuations in environmental changes, it is very important to identify and study shell morphology. This was carried out as an initial step to determine changes in the morphological size of the genus Nerita in the coastal waters of Ambon Island. Morphometric studies are important because, in addition to the things that have been described above, the results of this study are also the first step to finding out genetic information, namely morphological characteristics (Safitri and Palupi, 2017). Furthermore, the results of this study will be implicated in learning biology in the form of aquatic ecology teaching materials. Based on the description above, this research is very important to do to know the morphometric variation, density, and diversity index of Nerita (*Neritidae: Gastropoda*) in the coastal waters of Ambon Island and its implications for Biology learning.

METHODS

Research sites

This research was conducted in an intertidal area from July to August 2020. The research locations were the coastal waters of Seri Village (3045'01 "S 128010'04" E) and Tawiri Village (3039'31 "S 128012'33" E) (Figure 1 Determination of the research location based on purposive sampling technique with the following criteria: 1) Consideration of oceanographic conditions (environmental factors), 2) the type of substrate where the organism is located, and 3) the ease (accessibility) factor in sampling.

Figure 1. Map of the site location

Sampling procedure

Measurement of environmental parameters (temperature, salinity, and pH) was carried out directly at the research location. Meanwhile, Nerita's samples were drawn from two research locations. Each research location consists of three transects, where there are five quadrants measuring 1x1 m^2 so that one location consists of 15 quadrants. Nerita samples were sampled to identify and calculate the density. Furthermore, to measure the morphometric samples of Nerita, they were collected freely so that the number of samples was fulfilled. The sample results were then stored in plastic that had been labeled and put in an ice box.

Identification, density, and morphometrics

The identification of the types of snails Nerita uses books containing a collection of pictures of the types of snails (gastropods) (Linder, 1979; Dharma, 1992), and guidelines for the identification of gastropod dichotomous from the coastal waters of Ambon island compiled by Leiwakabessy (1999). Nerita morphometric data were measured using calipers. The morphometric variation used consists of 6 variables, namely (1)Shell length

(SL),(2)Shell width (SW), (3)Spire height (SH),(4)Length of aperture (AL), (5) Internal width of aperture (AW) (6) Columella Length (CL)

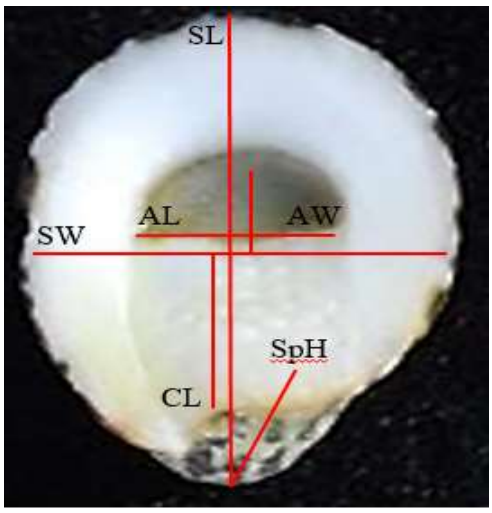

Figure 2. Nerita shell morphometrics (Haumahu and Uneputty, 2018; Supusepa, 2013)

Density

The individual density is obtained by the following equation:

$$D = \frac{N}{S}$$

Note:

D : Density of individuals in the population
N : Number of individuals
S : Areal area (m^2)

Data analysis

The data collected were analyzed descriptively and quantitatively to explain the results of density and morphometric measurements of Nerita in the coastal waters of the Island of Ambon.

RESULTS AND DISCUSSION

Environmental Physical-Chemical Factors

Environmental physicochemical factors measured in this study were temperature, salinity, and pH (degree of acidity). The results of measurements of environmental physical and chemical factors (temperature, salinity, and pH) at the two research stations in the coastal waters of Ambon Island can be seen in Table 1.

Table 1. Measurement of environmental chemical physical factors (temperature, salinity and ph) at each research station in Ambon Island Coastal Waters

Station	Temperature (^{0}C)	pH	Salinity ($^0/_{00}$)
Seri Village	27.6^{0}C - 28.2^{0}C	7.8	31 $^0/_{00}$
Tawiri Village	28.6^{0}C - 29.7 ^{0}C	7.4	30 $^0/_{00}$

Environmental factors at the two research stations show differences (Table 1). Several studies reported environmental factors in the ideal waters of Ambon Island, namely temperature 25^{0}C to 31^{0}C, pH 7-8, and Salinity 30 - 35$^0/_{00}$ (Collin and Ochoa, 2016; Rumahlatu and Leiwakabessy, 2017; Latupeirissa et al., 2020; Tebiary et al., 2022). Environmental factors of temperature, pH, and salinity in Ambon waters can support the life of gastropods in the intertidal area, one of which is Nerita.

The sea temperature of Ambon Island is strongly influenced by climatic conditions and seasons. Sea water temperature can be influenced by geothermal sources on the seabed and the decomposition of anthropogenic waste that occurs in sediments (Ebigbo et al., 2016). In addition, climate change due to global warming can increase seawater temperatures.

Sea water temperature affects the metabolic processes and physiological processes of gastropods (Hoefnagel and Verberk, 2017; Fadhlaoui and Lavoie, 2021), breeding processes (gonad formation, egg mass, and zygote size) (Collin and Ochoa, 2016b; El Khayari & Rour, 2021). An increase in temperature can trigger a physiological response from Nerita oryzarum to release antioxidant enzymes (Ambekar, 2023).

The pH value of the water is an important parameter for monitoring water quality. The pH value is influenced by several factors including biological activity, temperature, and oxygen content. The discharge of toxic waste into the waters can cause the oxygen concentration to decrease, which indirectly causes a decrease in the pH of the water. The pH value plays an important role in the interaction of heavy metals with other heavy metal ions and with other environmental factors such as the content of carbonate ions and organic compounds. (Samsi and Karim, 2019) reported that environmental factors, pH and salinity, affected the length of the shell of *N. lineata*. The salinity in the coastal waters of Ambon Island ranges from 300/00- 310/00. Salinity in water can be affected by evaporation, rainfall, and estuary areas. Salinity also affects growth and development factors as well as the osmoregulation of intertidal organisms (Rivera-Ingraham and Lignot, 2017; Gao et al., 2017). Nerita is an intertidal organism whose life is affected by salinity.

Identification of Nerita

The number of nerita found in the coastal waters of Ambon Island were *Nerita polita, Nerita chamaeleon, Nerita patula, Nerita exuvia, Nerita maxima, Nerita squamulata, Nerita albicilla, Nerita planospira,* and *Nerita plicata* (Table 2).

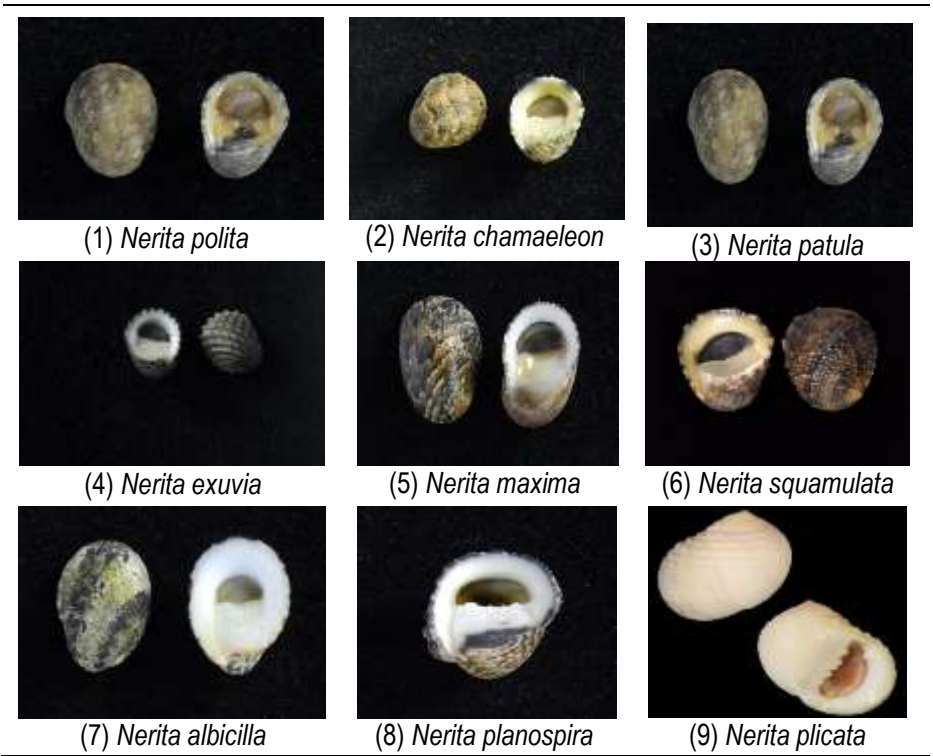

Figure 3. Nerita in the coastal waters of Ambon Island

Several studies reported that Ambon Island is a suitable habitat for nerita life such as *Nerita patula*, *Nerita chamaeleon*, *Nerita polita*, *Nerita albicilla*, *Nerita exuvia*, *Nerita maxima*, *Nerita costata*, *Nerita undata*, and *Nerita plicata* (Kalay and Lewerissa, 2022; Haumahu and Uneputty, 2020).

The special characteristics of each species of nerita are *Nerita polita* which has a smooth and black outer shell and a black operculum, *Nerita chamaeleon* has a shell that tends to be rough and grayish in color, the operculum is creamy brown in color, the lips are serrated with a light cream color. *Nerita patula* has shells of various colors, the operculum is brownish yellow and has a black pattern, and has small bumps on the shell. *Nerita exuvia* has a black outer shell with white spots and a groove that is more clearly visible following the rotation of the shell, the operculum is cream-colored and the inner shell is white.

Nerita in the coastal waters of the island of Ambon is generally the same on each coast, but several types are not present in the two research statistics. *N. polita*, *N. chamaeleon*, *N. patula*, *N. exuvia* are the Nerita groups found in the two research stations while *N. maxima*, *N. squamulata*, *N. albicilla*, *N. planospira*, and *N. plicata* are only found on the coast of Seri village. These differences are caused by environmental and substrate conditions as well as environmental physicochemical factors that support Nerita's presence.

Density of Nerita

The results of the calculation of the density of Nerita at the two research locations in the coastal waters of the island of Ambon can be seen in Table 3 and Table 4.

Table 2. The density value of Nerita in the coastal waters of Tawiri

No	Species	D (ind/m^2)
1	*Nerita Patula*	22.52
2	*Nerita chameleon*	1.90
3	*Nerita exuvia*	1.47
4	*Nerita polita*	41.33

Table 3. The density value of Nerita in the coastal waters of Seri

No	Species	D (ind/m^2)
1	*Nerita Patula*	0.04
2	*Nerita chameleon*	0.61
3	*Nerita squamulata*	0.52
4	*Nerita polita*	7.52
5	*Nerita maxima*	0.66
6	*Nerita albicilia*	0.19
7	*Nerita planospira*	0.09

The highest density value at Tawiri village station was *Nerita polita*, which was 41.33 ind/m^2 and the lowest density value was *N. chameleon* with a value of 1.9 ind/m^2 (Table 3). While the highest density value at Seri village station was *Nerita Polita* 7.52 ind/m^2 and the lowest density value was *N. Patula* which was 0.04 ind/m^2 (Table 3).

The two research stations are located in outer Ambon Bay but have different water conditions. Tawiri Station has a sandy and rocky substrate and experiences moderate waves. On the other hand, Seri Station has a sandy and rocky substrate but gets hit by strong waves. This is shown by the Seri station having species richness but a small number of individuals. This statement supports the results of the research of (Weiskittel et al., 2009), which found that sea snails in the Neritidae family are abundant in the intertidal zone and conditions of extreme temperature, drought conditions, and in areas with strong waves conditions.

The high density of Nerita patula and Nerita polita is influenced by their adaptability and habitat. The results of research in Banyuwangi show that the distribution pattern of Nerita sp is clustered (Adi and Sudarmadji, 2013). This species forms colonies as a community that inhabits rocky coastal areas, especially in the middle zone to the highest of the intertidal, to the upper (supralittoral) areas which are still affected by tides. In general, the species with the highest density are the species that have the most individuals. This is presumably because the Neritapatula species adapted to environmental conditions and the availability of food at that location.

Morphometric Nerita in the coastal waters of the Island of Ambon

Morphometric is a measurement of the morphological properties of nerita which includes Shell length (SL), Shell width (SW), Spire height (SpH), Length of aperture (AL), Internal width of aperture (AW), Columella Length (CL). Nine species of nerita were found in the intertidal zone with sandy and rocky substrates, namely *Nerita polita, Nerita chamaeleon, Nerita patula, Nerita exuvia, Nerita maxima, Nerita squamulata, Nerita albicilla, Nerita planospira*, and *Nerita plicata*.

Table 5: Neritidae morphometrics in the coastal waters of Ambon Bay

Family Neritidae	**Location**		**SL**	**SW**	**SH**	**AL**	**AW**	**CL**
			(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Nerita patula	Seri	Min	13.44	10.11	6.31	6.19	3.66	2.6
		Max	19.1	15.61	5.67	9.3	4.96	4.71
		mean±SD	15.68±1.31	12.14±1.151	5.87±0.66	7.26±0.79	4.69±0.55	4.04±0.94
	Tawiri	Min	10.71	8.66	4.22	5.56	3.27	3.94
		Max	18.57	14.88	6.72	9.43	5.69	6.13
		mean±SD	14.49±2.06	11.47±1.70	5.29±0.74	7.48±1.12	4.48±0.79	5.58±0.86
Nerita Polita	Seri	Min	9.76	8.02	3.78	5.13	2.89	2.71

		Max	21.66	16.29	9.8	10.38	5.86	6.69
		mean±SD	14.47±2.15	11.42±1.51	6.20±1.13	7.26±1.041	4.29±0.76	3.94±0.83
	Tawiri	Min	9.25	8.57	4.24	5.25	2.88	3.62
		Max	17.26	9.83	5.13	6	3.83	4.39
		mean±SD	12.05±1.47	8.89±0.95	4.67±0.46	6.02±0.57	3.71±0.42	4.44±0.59
Nerita exuvia	Seri	Min	8.58	7.54	2.84	3.91	2.49	2.27
		Max	16.57	14.71	5.69	8.54	4.27	6.1
		mean±SD	12.43±1.56	11.04±1.29	4.39±0.61	6.13±0.82	3.21±0.49	4.10±60.83
	Tawiri	Min	8.06	7.43	3.54	4.56	2.89	2.89
		Max	23.78	19.73	10.39	11.3	6.31	8.86
		mean±SD	14.04±3.69	11.85±3.12	5.34±1.71	6.88±1.84	3.75±1.02	5.16±1.53
Nerita chamaleon	Seri	Min	10.32	9.72	4.2	5.01	3.2	2.73
		Max	25.01	22.92	13.89	8.34	8.11	8.09
		mean±SD	16.01±3.36	14.85±2.92	6.74±1.81	8.55±1.69	5.03±1.11	4.61±1.36
	Tawiri	Min	7.53	6.27	2.96	4.16	2.36	1.71
		Max	15.44	11.51	5.47	7.24	4.76	4.16
		mean±SD	12.13±1.61	9.95±1.32	4.45±0.58	6.31±0.88	3.97±1.28	3.44±0.57
Nerita plicata	Seri	Min	8.43	8.23	5.22	4.94	2.71	4.2
		Max	16,45	12.82	9.57	8.1	3.59	7.24
		mean±SD	10.07±2.77	11.40±1.64	7.836±1.52	6.75±1.27	3.13±0.62	6.37±1.70
Nerita albicila	Seri	Min	6.94	5.74	2.42	2.63	1.79	2.07
		Max	14.35	12.96	4.63	5,81	3.47	5.15
		mean±SD	13.73±3.92	12.00±3.31	4.741±1.35	5.02±1.75	3.30±0.82	5.08±1.71
Nerita squamulata	Seri	Min	10.03	9.78	4.69	5.05	3.37	3.48
		Max	19.52	8.86	4.24	4.93	2.99	2.99
		mean±SD	12.42±1.71	10.29±0.94	4.57±0.45	5.91±0.81	3.71±0.41	3.60±0.71
Nerita maxima	Seri	Min	14.3	12.42	6.58	8.77	5.05	4.07
		Max	23.92	18.07	10.99	11.11	6.95	6.51
		mean±SD	18.97±2.47	14.81±1.85	8.33±1.08	9.20±1.04	5.35±0.88	5.41±1.11
Nerita planospira	Seri	Min	11.13	10.69	3.18	6	3.39	4.62
		Max	17.28	15.15	4.14	7.4	3.88	6.86
		mean±SD	13.26±1.21	12.42±1.13	4.04±0.51	6.43±0.54	3.52±0.33	5.29±0.61

Note: Shell Length (SL), Shell Width (SW), Spire Height (SH), Aperture Length (AL), Aperture Width, Columella Length (CL).

The results of the descriptive statistical analysis show that all Nerita species have shell lengths ranging from 10.08-18.97 mm. Therefore, all Nerita species belong to the adult category. The same result was also conveyed by (Dangeubun and Uneputty, 2005) that Nerita could be classified into three categories based on PC, namely juvenile (<5mm), young (5-10mm), and adult (>10mm). The results of the analysis showed that *N. maxima* had the highest shell length (18.97), while the lowest value was owned by *N. plicata* (10.08). The same results were also conveyed by (Haumahu and Uneputty, 2018) that *N. plicata* is the nerita with the lowest shell length compared to other types of nerita in the coastal waters of Oma village. The width of the shell is one measure that supports the length of the shell. *N. chamaleon* is a type of nerita which has the highest shell width of 14.85 while the lowest is owned by *N. polita* with a value of 8.89. *N. chamaleon* is also the species with the highest shell height of 21.17, while the lowest is *N. albicila* of 6.46. The highest spire height was owned by *N. plicata* at 7.84 while the lowest was by *N. chamaeleon* at 4.45. The results showed that the shell length was longer than the spire height. The results of the same study were also put forward by (Ali, 2017) that the overall shell length is three times longer than the spire length of each nerita member species. The highest aperture length is owned by *N. maxima* of 9.20, while the lowest is by *N. chaemaeleon* of 6.04. the highest aperture width by *N. maxima* is 5.35 while *Nerita plicata* is 3.13. the highest columela length was owned by *N. plicata* at 6.38, while the lowest was owned by *N.*

chaemaeleon at 3.44. The results showed that there were morphometric variations in Nerita species, this was also influenced by environmental conditions. Maxwell et al. (2021) explained that environmental conditions affect variations in the size of individual gastropod shells in the population. This study yielded information that has not been studied by other researchers related to Nerita species, densities and shell size variations in the waters of Ambon Island

CONCLUSION

Based on the research results, it can be concluded that there are 9 species of Nerita in Ambon Island waters. *N. polita* has the highest density value (41.33 ind/m^2) while *N. Patula* (0.04 ind/m^2) has the lowest density value. All shell morphological characters showed variations in determining phenetic diversity. The recommendation from this study is that the morphological characteristics of Nerita in Ambon Island waters can be used as a comparison for genetic analysis research.

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