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Species density and shell morphology of gold ring cowry (*Monetaria annulus*, Linnaeus, 1758) (Mollusca: Gastropoda: Cypraeidae) in the coastal waters of Ambon Island, Indonesia

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Abstract. *Latupeirissa LN, Leiwakabessy F, Rumahlatu D. 2020. Species density and shell morphology of gold ring cowry (*Monetaria annulus*, Linnaeus, 1758) (Mollusca: Gastropoda: Cypraeidae) in the coastal waters of Ambon Island, Indonesia. Biodiversitas 21: 1391-1400.* The purpose of this research was to examine environmental factors, species density, and the shell morphology of *Monetaria annulus*. The samples were collected by using the line transect method at 6 research stations. The data of the environmental factors (temperature, salinity, and pH of seawater) as well as species density of *M. annulus* were collected with in-situ technique, while the shell morphology of *M. annulus* was measured at Laboratory of the Deep-Sea Research Center, Indonesian Institute of Sciences (LIPI) Ambon. The results of the measurements of the environmental factors in the coastal waters of Ambon Island showed some fluctuations in the measurement values. The seawater temperature ranged between 29.78-30.05 ºC, the salinity of seawater ranged from 32.12-32.33‰, and the pH of the seawater ranged from 8.34-8.49. The density of *M. annulus* at the research stations from the highest to the lowest was at Tanjung Tiram station, Suli station, Seri station, Hutumuri station, Halong station, and Latuhalat station ($0.27 > 0.24 > 0.23 > 0.19 > 0.14 > 0.12$ ind/m^2). The results of the measurement of the shell morphology showed many variations in the size and shape of the shell of *M. annulus* with a total number (N) of 294 individuals. The length, the width, and the height of the shell, the length of the blotches, the width of the blotches, and the total weight of *M. annulus* from each research station were significantly different ($p<0.005$). These results indicate that the differences in the shell morphology of *M. annulus* at each research station were influenced by waves, the strength of the currents sea waves, and the different substrate of water. In addition, the variation of shell morphology can be a reason for characterization in the taxonomy of the Cypraeidae family.

Keywords: Density, environmental factors, *Monetaria annulus*, shell morphology, taxonomy

INTRODUCTION

Gastropods are one of the classes in mollusk phylum that are widely distributed in various aquatic ecosystems with number of species reaching 100.000 (Ruppert et al. 2004; Strong et al. 2008). There were 30 species found in Tanjung Jara, Terengganu beach, Peninsular Malaysia (Baharuddin et al. 2018), 11 species were found in Northeast Algeria (Belhiouani et al. 2019), 15 species were found in the mangrove ecosystem of Lubuk Kertang village, North Sumatra (Manullang et al. 2018), and 65 species were found in the waters of Ambon Island, Indonesia (Rumahlatu and Leiwakabessy 2017). In addition, the distribution of gastropods in aquatic ecosystems is influenced by environmental factors such as temperature, salinity, pH, marine oxygen, organic matter content, and the composition of the substrate making up the waters (Pyron and Brown 2015; Dmitrović et al. 2016; Bula et al. 2017; Rumahlatu and Leiwakabessy 2017; Sahidin et al. 2018; Yunita et al. 2018).

One of gastropod species found in the coastal waters of Ambon Island is *Cypraea annulus* and commonly known as the Gold Ring Cowry (Laimeheriwa 2017; Laimeheriwa et al. 2018a, 2018b). In the classification system, *C. annulus* is also known as *Monetaria annulus* (Meyer 2003; WoRMS Editorial Board 2015). Tissot (1984) explained that the shell morphology of *Monetaria annulus* is smooth, slippery, having small spots and colorful. The high diversity of shell morphology is thought to be due to genetic, geographic, ecological and sexual dimorphism variations. To understand the evolution *M. annulus*, explanation for the mechanism and geographic variation of shell morphology of this species is necessary. Renaud's (1976) reported that different shell morphologies are influenced by different habitats. The shells of *M. annulus* can be prominently found in the substantial zone, whereas fine shells in the intertidal zone. This species is distributed from the tropics to the temperate regions, in the Indo-western Pacific and lives on rocky, muddy and sandy beaches at a depth of 2 m (Villamora and Yamamoto 2015).

The waters of Ambon Island, Indonesia, has a high potential of marine biological resources, because it has various types of marine life and diverse ecosystems, including coral reefs with various species of fish (Limmon et al. 2017; Limmon et al. 2018), seagrass (Irawan and Nganro 2016), sea urchins (Silahooy et al. 2013; Tuapattinaja et al. 2014; Setyastuti et al. 2018), and gastropods (Rumahlatu and Leiwakabessy 2017). Foin (1989) reported that different aquatic environments can affect the thickness of the shell of the genus Cypraeidae. Meanwhile, Irie (2006) also reported that macro and even micro geographical differences can affect the morphology of *M. annulus* shells. Therefore, a study of density and measurement of shell morphology can provide information on the taxonomy of the Cypraeidae family, which is to assist in the preparation of *M. annulus* species on phylogeny trees. The aims of this study were to determine the density and measure the morphology of *M. annulus* shells which includes the length, width and height of the shell; the length and width of the blotch, and the average weight of *M. annulus* at six different stations in Ambon Island waters.

MATERIALS AND METHODS

Study site

This study was conducted in April-May 2018 at the coordinate 3º37'56"S, 128º18'30"E to 3º47'38"S, 128º05'42"E in coastal waters of Ambon Island (i.e., Seri coast: station 1, Latuhalat coast: station 2, Halong coast: station 3, Tanjung Tiram coast: station 4, Suli coast: station 5, and Hutumuri coast: station 6) (Figure 1). These locations were determined as the study sites based on the preliminary observations of the appearance of *M. annulus*, because this species do not appear in all coastal on Ambon Island.

Sampling procedure and laboratory

The data of the environmental parameters (temperature, salinity, pH of seawater, and substrate) were determined using an in-situ sampling technique. Furthermore, the morphology of the shell of *M. annulus* was analyzed which covered the shell length (SL), shell width (SW), shell height (SH), blotch length (BL), blotch width (BW), total weight (TW) and the species density of *M. annulus*. A preliminary study (observation) was carried out to determine the area in the coastal waters of Ambon Island, which contains *M. annulus*. The sampling locations were determined purposively based on the habitat of *M. annulus*. The data in the field were collected using the transect method following Rumahlatu and Leiwakabessy (2017), performed at the lowest ebb tide, beginning with the determination of the area of sampling, and then apply the vertical transect lines from the highest tide limit as many as 3 transect lines (towards the sea) with the distance between one and the other transect lines 50 m. For each transect, 8 plots of 1 m^2 were prepared. The distance between one plot and the other plots was 10 m. Thus, the total transects at the six research stations were 24 transects with 144 plots.

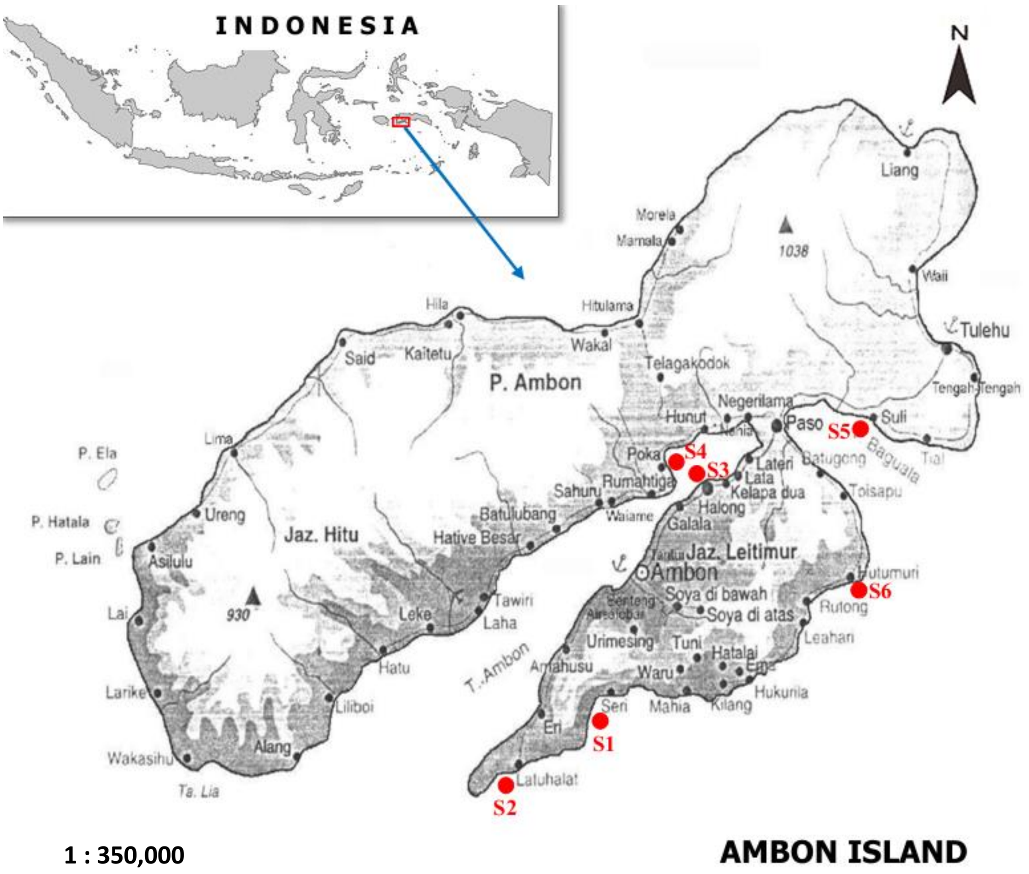

Figure 1. Study sites of *Monetaria annulus* in Ambon Island, Maluku, Indonesia. Note: S = station. S1: Seri coast, S2: Latuhalat coast, S3: Halong coast, S4: Tanjung Tiram coast, S5: Suli coast, and S6: Hutumuri coast

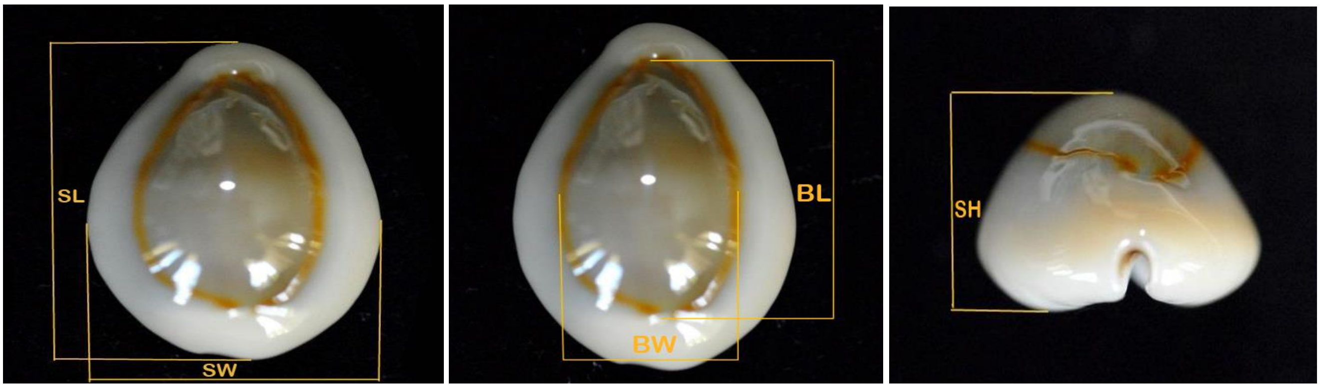

Figure 2. Parameter of the shell of *Monetaria annulus* morphology measurements

The measurements of the shell morphology of *M. annulus* were performed at the Laboratory of Deep-Sea Research Center, Indonesian Institute of Sciences (LIPI) Ambon. The morphology of were measured for shell length (SL), blotch length (BL) (Figure 2.A); shell width (SW) and blotch width (BW) (Figure 2.B); shell height (SH), (Figure 2.C) (Tissot 1984), while the total weight parameter (TW) was measured by weighing each individual of *M. annulus*.

Data analysis

The data on the environmental factors, species density of *M. annulus*, and the measurements of shell length (SL), shell width (SW), shell height (SH), blotch length (BL), blotch width (BW) and total weight (TW) were analyzed with descriptive approach. The species density of *M. annulus* was measured using the formula from Krebs (1989), as follows.

D = N/S

Where:
D: Population density
N: Number of individuals
S : Unit area (m^2)

The inferential statistics One-Way-ANOVA was used to analyze the differences in the shell morphology of *M. annulus* (shell length, shell width, shell height, blotch length, blotch width, and total weight) at each station in the waters of Ambon Island. The significant test was performed with LSD test (least significant difference), in case if the is significant difference in the inferential statistics results.

RESULTS AND DISCUSSION

Conditions of Environmental Factors

The results of the environmental factors (temperature, salinity, and pH) measurement at six research stations in the waters of Ambon Island showed fluctuations in each for environmental factors (Table 1). The water temperature ranged between 29.78-30.05 ºC, which the highest temperature was found in Hutumuri station at 30.06ºC, while the lowest temperature was at Tanjung Tiram station at 29.78ºC. According to Rumahlatu and Leiwakabessy (2017), the water temperature of Ambon Island ranged between 27.30-31.40ºC. According to Rumahlatu and Huliselan (2016), the high temperature of the seawaters of Ambon Island is greatly influenced by the heat supply from the seabed, the decomposition of household waste, and intensity of sun penetration due to seasonal changes. Irie and Morimoto (2016) reported that the gastropods of the Cypraeidae class, *Monetaria annulus* experimentally experienced shell growth between 21°C and 34°C. This condition is related to our current study (Table 1), which the temperature of seawater in the waters of Ambon has exceeded the range of temperature possible for *M. annulus* to live. However, *M. annulus* is still found in the waters of Ambon. This shows that *M. annulus* has adapted to high temperatures. This adaptation can be in the form of a change in behavior and habitat, where *M. annulus* tends to live in areas that are protected from sunlight such as coral reef, rockpool, seagrass leaves, and shelter under organic-inorganic waste. Under these conditions, *M. annulus* is able to create a micro-climate suitable for life. In addition, *M. annulus* can develop other physiological adaptations such as the presence of protective proteins (chaperons) and increase the accumulation of hemoglobin and myoglobin, which affect the ability to survive in lack of oxygen condition (Portner et al. 2007; Calosi et al. 2013).

The seawater salinity in the observation sites is in the range between 31.12-32.33‰. The highest salinity was found in Seri station which was 32.33‰, while the lowest salinity was found in Suli station at 31.12‰. The salinity of Ambon Island waters in the rainy season ranged between 29.00-30.00‰ (Rumahlatu and Huliselan 2016), while in the dry season, salinity ranged between 32.01-32.02‰ (Rumahlatu and Leiwakabessy 2017). It means that the salinity of Ambon Island waters during the measurement was in the high range. According to Laimeheriwa (2017), salinity is one of the abiotic factors that greatly affect marine organisms including *M. annulus* in the osmoregulation process. Several types of research reported that the salinity values for the life of gastropods (*M.*

annulus) are varied. The suitable range of salinity for the life of *M. annulus* is reported between 33.67-34.97‰ (Hughes 2011), and 33.0-33.3‰ (Islami 2015). It is related to this study (Table 1), which the seawater salinity of Ambon Island waters was lower than the suitable range of salinity for the life of *M. annulus*. However, *M. annulus* was still found in Ambon Island waters. The low salinity value in this study was caused by the presence of freshwater input from rivers in the study location. According to Rumahlatu et al. (2008), the salinity of seawater is strongly influenced by the input of river flow that carries mineral salts from the mainland and the mass exchange of water from the ocean, namely the Banda Sea during the tide. Syuja et al. (2018) reported that mollusks are tolerant to salinity 30-32.67‰. This means that *M. annulus* has adapted to salinity values.

The results of the measurement of the seawater pH (Table 1) indicated that the pH of the seawater was in the range of 8.34-8.49. The highest pH was found in the Halong station, while the lowest pH was found in the Hutumuri station. Some researchers who conducted research in Ambon Island waters reported that the pH range of the waters was between 7.03-7.68 (Rumahlatu and Leiwakabessy 2017), 7.91-8.16 (Gemilang et al. 2017), 8.00-8.25 (Latuconsina et al. 2012). According to Gemilang et al (2017), terrestrial organic matter carried through rivers as well as the community activities has a significant effect on the pH values of the waters. The normal range of water pH is in the range 7.0-8.5 (Odum 1971). This means that the pH range of Ambon Island waters was very suitable for *M. annulus* to live.

Density of *Monetaria annulus*

The density of *M. annulus* at six research stations in the coastal waters of Ambon Island has fluctuated in the density value (Figure 3). The density of *M. annulus* from the highest to the lowest was Tanjung Tiram station, Suli station, Seri station, Hutumuri station, Halong station, and Latuhalat station (0.27 > 0.24 > 0.23 > 0.19 > 0.14 > 0.12 ind/m^2). The density of *M. annulus* at each research station different from each other. This was influenced by the different substrates of each station in the waters of Ambon Island, namely coral substrate (Ode 2014), coarse sand substrate, muddy sand substrate (Tuapattinaya and Rumahlatu 2019), rock and gravel substrate, coarse sand and mud substrate (Kho 2017). The highest density of *M. annulus* was at Tanjung Tiram station. This condition is due to the position of the station, which was in the Ambon Deep Bay area with the high availability of food (algae and other macrophytes). This was different from Latuhalat station, which was located in Ambon Outer Bay, where the area had a strong ocean current and the nutrient cycle is more complex, causing the availability of nutrients at this station to be less than that at the Tanjung Tiram station. The organisms having the highest density values indicate that these types of organisms have the ability to adapt to the environment they occupy so that they have high reproductive abilities (Amat et al. 2017). According to Rumahlatu and Leiwakabessy (2017), high diversity indicates the variation and density of an organism in marine waters.

On the other hand, the low density of *M. annulus* was caused by over-exploitation by people who used the shell of *M. annulus* as a traditional game tool, and the craft industry (shell-craft) (Poutiers 1998). Other factors affecting the density of *M. annulus* were extreme environmental factors (temperature, salinity, pH). These environmental factors caused the difficulties for *M. annulus* adaptation to environmental changes. Human activities also can change environmental conditions, which caused a decrease in the density value and the abundance of gastropods, as well as other ectothermic species (Gallmetzer et al. 2017). This also happened in Ambon Island water (e.g. at Halong station), where the density of *M. annulus* was quite low. The low density of *M. annulus* was also influenced by the accumulation of heavy metals Hg, Cd and Pb (Rumahlatu and Huliselan 2016; Rumahlatu et al. 2018; Rijal et al. 2014).

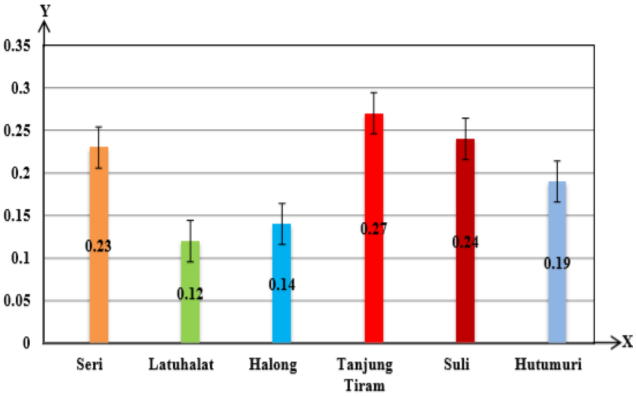

Figure 3. Density of *Monetaria annulus* in the coastal waters of Ambon Island, Maluku, Indonesia

Table 1. Physico-chemical condition (temperature, salinity, pH, and substrate) in coastal waters of Ambon Island, Maluku, Indonesia

Station		Coordinate		Physico-chemical parameters			
		Latitude	Longitude	Temperature (°C)	Salinity (‰)	pH	Substrate
1	Seri	3°45'01"S	128°10'04"E	30.02	32.33	8.38	Reef with Sand
2	Latuhalat	3°47'38"S	128°05'42"E	30.01	32.32	8.37	Reef with Sand
3	Halong	3°39'31"S	128°12'33"E	29.80	31.13	8.49	Muddy Sand
4	Tanjung Tiram	3°39'22"S	128°11'59"E	29.78	31.14	8.48	Muddy Sand
5	Suli	3°37'56"S	128°18'30"E	30.04	31.12	8.47	Gravel, Muddy Sand
6	Hutumuri	3°41'58"S	128°16'40"E	30.05	32.15	8.34	Muddy Sand

Note: * Time of measurement: in the rainy season

Table 2. Matrix of the shell morphology of *Monetaria annulus* at each station in the coastal waters of Ambon Island, Maluku, Indonesia

Shell morphology		Stations						Ambon Island
		Seri	Latuhalat	Halong	Tanjung Tiram	Suli	Hutumuri	
SL	N	58	31	34	65	60	46	294
	$\bar{x}$	18.61	19.52	17.31	15.84	16.82	13.10	16.71
	Max	23.74	22.81	23.18	21.36	20.82	17.35	23.74
	Min	14.88	14.26	13.05	11.39	10.69	10.68	10.68
SW	N	58	31	34	65	60	46	294
	$\bar{x}$	13.90	15.10	12.07	11.02	12.11	8.40	11.95
	Max	18.23	18.24	18.59	14.99	15.40	11.72	18.59
	Min	9.63	6.91	8.52	8.36	5.55	5.74	5.55
SH	N	58	31	34	65	60	46	294
	$\bar{x}$	9.27	9.68	8.70	7.88	8.37	6.30	8.29
	Max	12.13	11.43	11.25	11.33	10.31	10.41	12.13
	Min	7.05	4.96	6.09	6.01	4.45	4.42	4.42
BL	N	58	31	34	65	60	46	294
	$\bar{x}$	13.92	13.60	12.23	11.95	12.49	9.46	12,27
	Max	17.88	18.18	18.74	17.50	17.75	14.18	18.74
	Min	10.95	0.00	0.00	9.50	0.00	0.00	0.00
BH	N	58	31	34	65	60	46	294
	$\bar{x}$	9.15	9.31	7.91	7.94	8.33	6.11	8.11
	Max	12.26	12.28	11.71	12.16	11.70	9.37	12.28
	Min	6.78	0.00	0.00	5.78	0.00	0.00	0.00
TW	N	58	31	34	65	60	46	294
	$\bar{x}$	2.48	3.00	1.64	1.26	1.73	0.72	1.74
	Max	4.00	4.60	3.50	2.70	2.90	1.40	4.60
	Min	0.90	0.30	0.20	0.10	0.20	0.20	0.10

Note: N = Total number (Ind), $\bar{x}$ = Average of shell morphology (mm), Max = Maximum value of shell morphology (mm), Min= Minimum Value of shell morphology (mm)

The morphology of the shell of *Monetaria annulus* (shell length, shell width, shell height, blotch length, blotch width and total weight) in the coastal waters of Ambon Island

The shell morphology of Monetaria annulus

There are many variations for the size and shape of the shell of *M. annulus* in the waters of Ambon Island. The results of the measurement of the shell morphology of *M. annulus* (shell length (SL), shell width (SW), shell height (SH), blotch length (BL), blotch height (BH) and total weight (TW)) showed that the total number (N) of *M. annulus* was as many as 294 individuals, with the highest number found in the Tanjung Tiram station (65 individuals), while the lowest number was found at Latuhalat station (31 individuals) (Table 2).

The shell length at the six research stations is shown that the highest average value was found at Latuhalat station with 19.52 mm, while the lowest average value was found at Hutumuri station with 13.10 mm, and the average value for the coast of Ambon Island was 16.71 mm. In addition, the highest average value of shell width was found at Latuhalat station with 15.10 mm, while the lowest average value at Hutumuri station with 8.40 mm, and the average value of the shell width in the coastal waters of Ambon Island was 11.95 mm. The highest average value of the shell height was found at Latuhalat station with 9.68 mm, while the lowest average value was found at Hutumuri station with 6.30 mm, and the average value of the shell height on the coastal waters of Ambon Island was 8.29 mm (Table 2).

The data of this research (Table 2) reveal that the length, width, and height of the shell of *M. annulus* at Latuhalat station were the largest of all, while the *M. annulus* at the Hutumuri station contained the smallest shell size of *M. annulus*. The length of the shell of *M. annulus* is largely determined by the waves and strong currents of sea waves (Tissot 1984), as well as the presence of pollutants in the waters (Primost et al. 2015). The characteristic size of the shell of *M. annulus* at Hutumuri station was relatively smaller than the shell size at the other stations. This might be caused by the adaptation to the sandy substrate environment (Sälgeback and Esavazzi 2006; Vermeij 2017; Yamamori and Kato 2018). The relatively small body size of the *M. annulus* living in the sandy substrate is probably helped the *M. annulus* for camouflage and survives from the predators or humans. In addition, the substrate at the Latuhalat and Seri stations was in the form of coral reefs. This caused *M. annulus* with large size to have more possibilities to survive. Large body size allows the *M. annulus* to camouflage with the corals as its life substrate, so the predators cannot easily detect the presence of *M. annulus*. This species also will tend to adapt its color and lifestyle with the substrate or its habitat (Troscianko et al. 2013). The size of the shell of *M. annulus* is also influenced by the geographical location and physical factors of the waters (Tissot 1984; Stafford et al. 2015; Saleky et al. 2016). Both Seri and Latuhalat stations were located at the Outer Ambon Bay, so the *M. annulus* in this location had a similar ratio of shell length and shell width.

The shape of the shell of *M. annulus* was more globular than that of the *M. annulus* at the other stations. At the geographical conditions with open area waters, the shape of the gastropod shells will be more globular than the shells found in semi-open areas or in protected areas (Trussell 1997; Verhaegen et al. 2019). This condition plays a role to reduce the strength of current and ocean waves so that the *M. annulus* does not easily come off the substrate.

In addition, the blotch length at the six research stations (Table 2) has the highest average value at the Seri station with 13.92 mm, while the lowest average value was at the Hutumuri station with 9.46 mm. The blotch width dimension at the six research stations (Table 2) have the highest average value at the Latuhalat station with 9.31 mm, and the lowest average value at the Hutumuri station with 6.11 mm. The total weight at the six research stations (Table 2) showed that the highest average value was found at the Latuhalat station with 2.48 g while the lowest value was found at the Latuhalat station with 3.00 g while the lowest average value was found at Hutumuri station with 0.72 g.

Blotches are a circular ring-shaped structure on the shell of *M. annulus*, which are used as a growth parameter for *M. annulus* and the diagnostic character of the Cypreadea group (Renaud 1976; Laimeheriwa 2017). The largest blotch length (BL) and blotch width (BW) (Table 2) were found at Seri station and Latuhalat station, with the blotch length (13.92, 13.60), and blotch width (9.15, 9.31). The smallest blotch was found at the Hutumuri station with the length and width was 9.46 and 9.37, respectively. The relatively small size of the blotches at Hutumuri station was caused by the relatively small size of the shell of *M. annulus* at this station. Laimeheriwa (2017) explains that the blotch starts to appear when *M. annulus* is at the development stage of almost adult (sub-adult) with a shell size of about 15.00-18.99 mm. This was different from the results found in the study site. At the Hutumuri station, *M. annulus* was found with relative smaller size shells, and already had blotches. The results of this study indicate that the size of the blotches depends on the size of the shells, but the size of the shells of *M. annulus* is also determined by other environmental factors such as substrate, habitat, pH, water depth (Chiu et al. 2003), velocity of ocean currents (Trussell 1997; Minton et al. 2008), predatory and population density (Crowl and Schnell 1990). This means that in this study, the size of the shell was influenced by the substrate where *M. annulus* lived. It can be concluded that the shell weight of *M. annulus* is largely determined by the length, width, and height of the shell (SL, SW, SH). The weight of the shell tends to follow the trend from SL, SW, SH measurements found at Latuhalat and Seri stations. The size of SL, SW, SH of *M. annulus* is larger than the size found at the other stations. This condition may also tend to have a higher shell weight, whereas the size of the SL, SW, and SH found at Hutumuri station is smaller because the weight of the shell is also smaller than at the other stations.

Difference in length, width, and height of shell, blotch length and width of Monetaria annulus

The results of the statistical analysis (ANOVA) on the shell length, shell width, shell height, blotch length, blotch width, and total weight of *M. annulus* (Table 3) are shown the significance value was 0.000, which was smaller than the α 0.05 ($p<0.05$). It means that there was a difference in the shell length, shell width, shell height, blotch length, blotch width, and total weight of *M. annulus* at the six research stations in the coastal waters of Ambon Island. Furthermore, since the results of the One-Way-ANOVA showed a very significant effect, 0.05 LSD test was performed (Tables 4, 5, 6, 7, 8 and 9), which revealed the differences in the average of the shell length, shell width, shell height, blotch length, blotch width, and total weight of *M. annulus* at six observation stations in the coastal waters of Ambon Island.

The size of the length, width, and height of the gastropod shell are the main indicators to determine its growth and development (Tissot 1984; Chiu et al. 2002; Medeiros et al. 2015). The results of the analysis of One-Way-ANOVA (Tabel 3) is shown the average of length, width, and height of the shell of *M. annulus* from each of the stations was significantly different ($p<0.05$). LSD test results showed that the average length and width of *M. annulus* shells were significant at Hutumuri, Tanjung Tiram, Seri and Latuhalat stations, while Halong and Suli stations were not significant (Table 4 and Table 5). The average height of *M. annulus* shells was significant at all six stations, but the average height of shells was not significant at Tanjung Tiram and Suli, Suli and Halong, Seri and Latuhalat stations (Table 6). This insignificant difference was likely due to the geographical and environmental conditions of the stations which were relatively similar (Gustafson et al. 2014; Márquez et al. 2015). On the other hand, the main difference in the length and the width of the shell of *M. annulus* (Table 4 and Table 5) was influenced by the differences in habitat, predators, anthropogenic activity, and geographical conditions of each station (Tissot 1984; Chiu et al. 2002; Quensen and Woodruff 2003; Bourdeau et al. 2015; Rosin et al. 2018).

The length and the width of the shell of *M. annulus* in the Halong station and Suli station were not significantly different because of the protected environmental conditions and the relatively similar physical-chemical factors (currents and pH). For the morphology of *M. annulus* shell height, the results of the analysis showed that the height of *M. annulus* shell at Tanjung Tiram and Suli stations; Halong and Suli; Seri and Latuhalat are not significant. Although, Tanjung Tiram, Halong and Suli stations are in different geographical locations, namely Ambon Bay and Baguala, they have the same coast topography and substrate types. While the Seri and Latuhalat coast is in the outer bay of Ambon, have the same substrate coast topography. These relatively protected conditions cause the sizes of the length, width, and height of the shell of *M. annulus* to be relatively similar. The same environmental conditions and geographical locations made the shells of gastropods have the same structure and shape (Trussell 1997; Tissot 1984; Cazenave and Zanatta 2016; Zhao et al. 2019). In addition, variations of the shapes of gastropods shells are influenced by the body size and the sex differences (Avaca et al. 2013).

Table 3. The results of the one-way-ANOVA on the shell morphology of *Monetaria annulus*

Shell Morphology	Source of variance	Sum of Squares	df	Mean Square	F	Sig.
SL	Between Groups	1114.931	5	222.986	50.063	.000
	Within Groups	1282.794	288	4.454		
	Total	2397.725	293			
LW	Between Groups	1165.544	5	233.109	74.431	.000
	Within Groups	901.981	288	3.132		
	Total	2067.525	293			
SH	Between Groups	295.309	5	59.062	34.680	.000
	Within Groups	490.478	288	1.703		
	Total	785.787	293			
BL	Between Groups	585.038	5	117.008	10.461	.000
	Within Groups	3221.423	288	11.185		
	Total	3806.461	293			
BW	Between Groups	297.641	5	59.528	12.307	.000
	Within Groups	1393.058	288	4.837		
	Total	1690.699	293			
TW	Between Groups	144.269	5	28.854	76.470	.000
	Within Groups	108.669	288	.377		
	Total	252.938	293			

Table 4. Results of the LSD test on the differences in the shell length of *Monetaria annulus*

Station	Average	Notasi
Hutumuri	13.1065	a
Tanjung Tiram	15.8406	b
Suli	16.8248	c
Halong	17.3141	c
Seri	18.6140	d
Latuhalat	19.5216	e

Table 5. The results of the LSD test on the differences in the shell width of *Monetaria annulus*

Station	Average	Notasi
Hutumuri	8.4048	a
Tanjung Tiram	11.0275	b
Halong	12.0735	c
Suli	12.1100	c
Seri	13.9000	d
Latuhalat	15.1097	e

Tabel 6. The results of (LSD) test on the differences in the shell length of *Monetaria annulus*

Station	Average	Notasi
Hutumuri	6.4139	a
Tanjung Tiram	7.8845	b
Suli	8.3768	bc
Halong	8.7012	c
Seri	9.2726	d
Latuhalat	9.6890	d

Table 7. The results of the LSD test, the difference in the length of the blotches of *Monetaria annulus*

Station	Average	Notasi
Hutumuri	9.4696	a
Tanjung Tiram	11.9534	b
Halong	12.2368	bc
Suli	12.4945	bcd
Seri	13.6058	cd
Latuhalat	13.9278	d

Table 8. The results of the LSD test, the difference of the width of the blotches of *Monetaria annulus*

Station	Average	Notasi
Hutumuri	6.1113	a
Tanjung Tiram	7.9194	b
Suli	7.9488	b
Halong	8.3390	bc
Seri	9.1524	cd
Latuhalat	9.3123	d

Table 9. The Results of LSD test, the difference in the total weight of *Monetaria annulus*

Station	Average	Notasi
Hutumuri	.727	a
Tanjung Tiram	1.267	b
Halong	1.649	c
Suli	1.730	c
Seri	2.489	d
Latuhalat	3.006	e

The results of the One-Way-ANOVA analysis on the length and the width of the blotch of *M. annulus* (Table 3) is shown the significance value was 0.000, lower than the α value of 0.05 ($p<0.05$). It means that there was a difference in the length and the width of the blotches of *M. annulus* at the six observation stations in the coastal waters of Ambon Island. Furthermore, since the results of the One-Way-ANOVA analysis showed a significant effect, the LSD 0.05 test was performed (Table 7 and Table 8). The results revealed that there was an average difference in the length and width of the blotches of *M. annulus* at the six observation stations in the coastal waters of Ambon Island. However, the average length of *M. annulus* blotches in Tanjung Tiram, Halong and Suli stations is not significant, as at the Halong, Suli and Seri stations; Suli, Seri and Latuhalat. The average width of *M. annulus* blotches at Tanjung Tiram, Suli, and Halong stations are insignificant, as well as at the Halong and Seri stations, and Seri and Latuhalat stations.

Blotches are one of the unique characteristics of Gastropod's family Cypraeidae. On the *M. annulus* species, the color of the blotches is generally golden yellow and it has ring-shaped form so that this species is generally known as "gold ring cowries*".* The results of the One-Way-ANOVA analysis (Table 9 and Table 11) revealed that the average length and width of the blotches of the *M. annulus* from each research station were significantly different ($p<0.005$), and the results of the LSD test (Table 10 and Table 12) revealed that there was a difference in the average length and width of the blotches of *M. annulus* at each research station. These results (Table 10 and Table 12) indicated that the length and the width of the blotches of *M. annulus* were not significantly different. For the difference in the length of the blotches, Seri station was different from the Latuhalat station, Latuhalat station was different from the Halong station, and Latuhalat station was different from Suli station. For the difference in the width of the blotches, Seri station was different from Latuhalat station, Halong station was different from Tanjung Tiram station, Halong station was different from Suli station, and Tanjung Tiram station was different from Suli station. The insignificant difference in each research station was due to the relatively similar geographical conditions and environmental conditions (Trusell 1997; Madeira et al. 2012). The length and the width of the blotches at Seri Station and Latuhalat station were not significantly different. The insignificant difference in the length and the width of the blotches was also found between Halong stations and Tanjung Tiram stations, between Halong station and Suli station, and between Tanjung Tiram station and Suli station. This is also in line with the results of statistical analysis on the length and width of the shell (Table 3 and Table 5). The difference in the characteristics of *M. annulus* depends on geographical, genetic, age, sex, and environmental condition factor. The variations and the distribution of characteristics are the response to the physical environment where certain species live (Jellison et al. 2016; Laimeheriwa 2017).

The difference in the total weight of Monetaria annulus

The results of the One-Way-ANOVA analysis on the total weight of *M. annulus* (Table 9) is the significance value of about 0.000, which lower than the α value of 0.05 ($p<0.05$). This indicated that there was a difference in the total weight of *M. annulus* at the six observation stations in the coastal waters of Ambon Island. Furthermore, since the results of One-Way-ANOVA showed a significant effect, the LSD 0.05 test was performed (Table 9). LSD test results show that there is a significant average difference in the total weight of *M. annulus* in the coastal waters of Ambon Island, except for Halong and Suli Stations. If the total weight is correlated with the length and the width of the shell of *M. annulus* (Table 3), it can be the longer and the wider the shell of the *M. annulus* is bigger than total weight. Das et al. (2015) explain that the shell diameter, shell height, shell total weight, and weight of an empty shell are influenced by seasonal variations. The shell which measured during the cold season showed the maximum size of shell diameter, shell height, and shell weight, while the shell during the hot season showed the normal/medium size of the shell diameter, shell height, and shell weigh, and the shell which measured during the rainy season showed the minimum size of shell diameter, shell height, and shell weight. In addition, the size, thickness, strength, and calcium content of the shell are influenced by environmental factors such as predation and pollution of heavy metals (Watson et al. 2017; Duquette et al. 2017; Jordaens et al. 2006).

In conclusion, this study was conducted to determine the density and morphology of *M. annulus* shells at six stations in the coastal waters of the island of Ambon. Six research stations namely Seri, Latuhalat, Halong, Tanjung Tiram, Suli, and Hutumuri were selected for this study. The highest density of *M. annulus* species was found at Tanjung Tiram station, while the lowest species density was found at Latuhalat station. Meanwhile, the results showed that there were differences in shell morphology (e.g. length, width, and height of the shell; the length and width of the blotch; and total weight). Shell morphology differences are influenced by geographical location, coast topography, and type of substrate.

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