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Size structure and relative growth pattern of strawberry conch (*Strombus luhuanus*) in Oma rocky shore, Central Maluku, Eastern Indonesia

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Abstract
Various substrates could be found in intertidal zone in Oma rocky shore and consisting of boulder, pebble, dead coral, coral rubble, and coarse sand. In addition, there were six species of seagrasses found in this area namely *Enhalus acoroides, Cymodocea rotundata, Halophila minor, Halodule uninervis, Thalassia hemprichii,* and *Syringodium isoetifolium. Strombus luhuanus* could be found in various habitats such as in Oma rocky shore. High intensity of utilization by local community resulted in decreasing number of this species recently. Therefore, the objectives of the research were to study size structure and growth pattern of *S. luhuanus*. Sampling was conducted by using purposive random sampling from January to June 2018. The results showed that the shell length ranged from 30.27-56.00 mm with the average 42.63 mm. The population of *S. luhuanus* was divided into juveniles and adults which the adults were pre dominant. Overall, the growth pattern of *S. luhuanus* was negative allometric both female and male. However, the females indicated both positive and negative allometric.

Keywords: Rocky shore, gastropod, allometric, growth

1. Introduction
Maluku is known as thousand islands province where has highly marine natural resources both biological resources and non-biological resources. Seagrass, algae, molluscs, echinodermata, crustaceans, and fish are biological resources whereas, some of non-biological resources such as water current, sand, and boulders Mollusc is one of the biological resources which have been utilized by coastal community in Maluku province for consume and sell especially bivalves and gastropods. Uneputty *et al.,* (2018) [1] stated that both bivalves and gastropods are highly found in interidal zone such as blood cockle (*Anadara granosa*), arch cockle (*A. antiquata*), top shell (*Trochus niloticus*), abalone (*Haliotis* spp.) and the strombidae (*Strombus* spp.).
The Strombidae has widely distribution and could be found in tropical and subtropical region (tropicopolitan). This family inhabitant various substrate such as sandy area, sand-muddy, segrass bed, coral rubble and reef flat [2]. There are 38 species respectively in Indo-Pacific region, 266 species in the Philippines and 5 species in Johor Strait [3].
The Strombidae especially for strawberry conch (*Strombus luhuanus*) has been abundantly in Maluku [4, 5, 6]. Coastal community in Oma village, Central Maluku, is always collected *S. luhuanus* as a source for protein during low tide. They always collect this species for at least 100-150 individual with various sizes. The continuous utilization without paying attention to its sustainability has been resulting in decreasing in population numbers. One of the important points to sustain this resources is bio-ecological data namely abundance, size structure, growth and reproduction. Compare to fishes, the morphometric relationship is limited for molluscs specifically for gastropod. Some studies on gastropod families have been reported for the Neritidae [7], Nassariidae [8], Cerithiidae [9], Muricidae [10] and Strombidae [1]. According to Reiss (1989) [11], the morphometric relationship was analyzed by using relative growth pattern in order to study size variation and its consequences. Therefore, the objectives of the present study were to analyze size structure and relative growth pattern of *S. luhuanus*. It is expected that the results could be used as a baseline data to formulate mangament strategies by decision makers in fisheries management.

2. Materials and Methods

2.1. Study site

The study was carried out in the coastal waters of Oma ($128^0$23'30" - $128^0$25'50"E and $03^0$37'25" - $03^0$37'50"S), Central Maluku, Eastern Indonesia from January to June 2018 (Fig. 1). Various substrates could be found in intertidal zone consisting of boulder, pebble, dead coral, coral rubble, and coarse sand. In addition, there were six species of seagrasses found in this area namely *Enhalus acoroides*, *Cymodocea rotundata*, *Halophila minor*, *Halodule uninervis*, *Thalassia hemprichii*, and *Syringodium isoetifolium.*

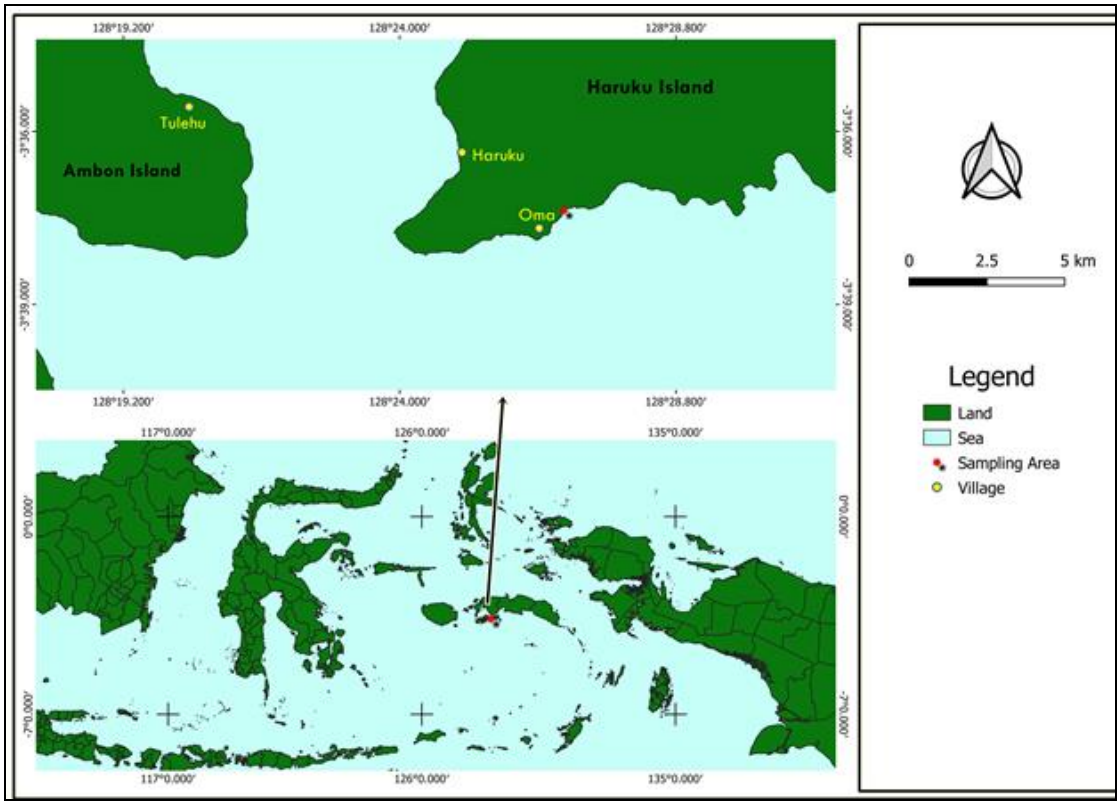

Fig 1: Study area site (red circle) in the coastal waters Oma, Maluku Province, Eastern Indonesia

2.2. Field sampling and Data analysis.

Samples were taken using purposive random sampling in the area of intertidal zone without replacement [12]. *Strombus luhuanus* were collected by using a quadrate 1 x 1 m. All individuals within a quadrate were counted and collected. Approximately more than 50 individuals were collected at each sampling time depending on their abundance. When samples were collected, the shell length and weight were measured insitu (Fig. 2). The measurements were made using a vernier calliper to the nearest 0.1 mm and weighted by using portable digital balance to the nearest 0.1g.

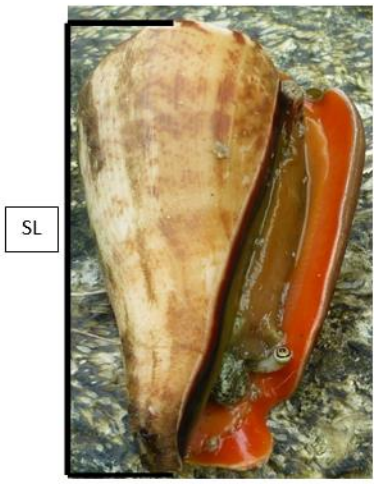

Fig 2: Measurement of Shell Length (SL)

Data was analyzed by using Microsoft Excel 2010, SPSS 12 and FISAT software. Length-weight relationship was analyzed by using power function of Pauly (1984) [13].

$$W = a L^b$$

Where: W = weight (g);
L = Total length (cm);
a = intercept;
b = slope.

3. Results and Discussion

3.1. Size structure

A total of 878 individuals of *S. luhuanus* were collected during the research. The shell length was different monthly (Table 1). It could be seen from table 1 that the shell length ranged from 30.27-56.00 mm with the average 42.63 mm. The other Strombid such as *S. canarium*, *S. urceus*, *S. marginatus*, *S.vittatus*, had large size compare to the shell length of *S. luhuanus* [3]. Otherwise, the shell length of *S. luhuanus* in this study was larger than that study reported by Wada *et al.*, (1983) [14] in Shirahama Jepang that is 36.14-37.80 mm. However, Lee *et al*., (2013)[15] found that the shell length of *S. luhuanus* in Korean waters ranged from 60-63 mm.

Table 1: Size distribution of *S. luhuanus* during the study

Month	n (ind.)	Length (mm)		
		min	max	mean
January	75	37,34	53.04	44,35
February	206	31.86	50.65	42.34
March	49	39.90	55.86	42.21
April	162	30.27	56.00	39.95
May	121	31.86	53.15	43.30
June	154	33.45	55.20	43.64
Total	878	30.27	56.00	42.63

Monthly of shell length frequency distribution are presented in Fig 3. The population of *Strombus luhuanus* during this study indicated that it consisted of juvenile and adult individuals. The juveniles size was less than 30 mm and adult size was more than 30 mm. Generally, it could be seen that the adults were pre dominant in this population. Poiner and Caterral (1988) [16] stated that the shell length of *S. luhuanus* ranged from 35-60 mm belonged to adult individuals which having thickened outer lips. The adult category was not only determine by increment of the shell length but also by thickened outer lips. Uneputty *et al.*, (2018) [1] found that the maximum of shell length of *S. lunuanus* was 55.86 mm, the lip thickness reached 8.03 mm. Therefore, the shell lips become thickened at year 2+ from early with shell length in various size [14].

S. luhuanus would stop growing lengthwise when the outer lips thickens to several milimetres there is a slight flaring outwards of the lip (known as stromboid notch[17]. Similarly, the lip thickness of juvenile *S. pugilis* was <1.8 mm and the adults >1,8 mm [18].

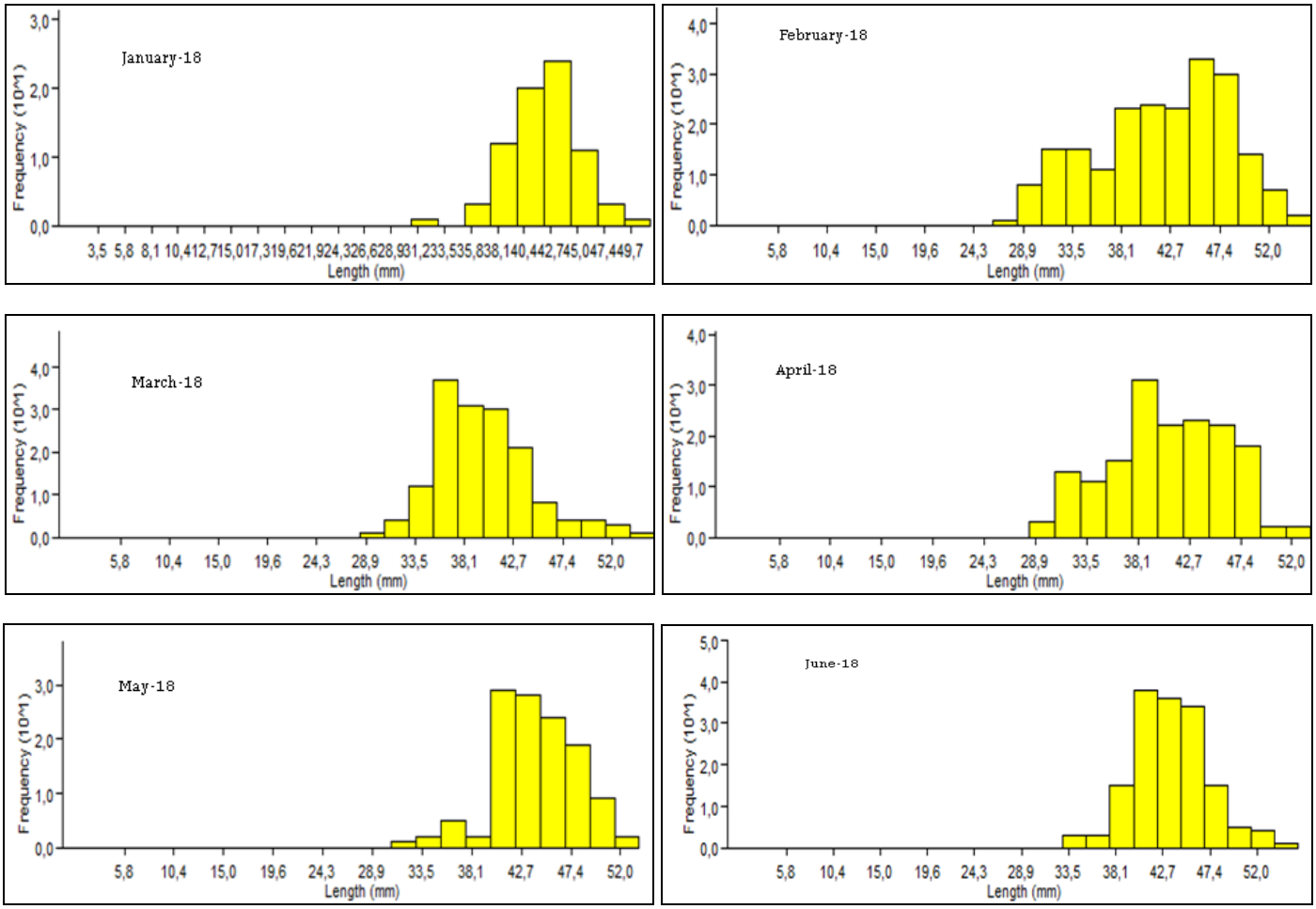

Fig 3: Size distribution of shell length (SL) of *Strombus luhuanus* from January to June 2018

3.2. Growth pattern of *Strombus luhuanus*

The growth of an organism could be measured by increment in size or weight. Beside shell geometry, shell length-weight relationship could be used to determine relative growth pattern of an organism such as macroinvertebrates [19]. The shell length-weight relationship were factors to describe changes in shell geometry and weight of an individuals. Nevertheless, this concept could be used also to indicated relative growth pattern of an organisms. Gayon (2000) [19] stated that if the slope (b) less than 3 showing negative allometric.

A total of 421 individuals of *S. luhuanus* were used in the study which consisting of 211 males and 210 females. The main reference was shell length (SL) as independent variable and weight (W) as dependent variable. The weight ranged from 2.15-30.62 g for female whereas 5.84-26.6 g for male. Generally, *S. luhuanus* showed negative allometric growth pattern both for female and male during the study. It was indicated by the value of slope (b) which is b < 3 (Table 2). The shell length-weight relationship was strong and the correlation value (*r*) was 0.92 for female and 0.84 for male.

Moreover, table 2 also indicated that all the males showed negative allometric growth pattern with b value < 3. It means that length increment is faster than weight [13, 20].

The correlation (*r*) value ranged from 0.118-0.926. It indicated weak to very strong relationship between shell length and weight. The contribution of length to weight indicated by coefficient of determination (R^2) ranging from

1.4-85.8% respectively. On the contrary, the females also showed negative and positive allometric. In other words, the females not only indicated that in certain month increment in weight is faster than length but also showing length increment is faster than weight. Coefficient of determination (R^2) for female ranged from 9.0-91.8% respectively.

Table 2: Length-weight relationship of *S. luhuanus*

Month	Sex	$W = a L^b$	R^2	Growth pattern
January	Female	$Y= 0.006L^{1.606}$	0.366	Negative allometric
	Male	$Y= 0.002L^{2.299}$	0.799	Negative allometric
February	Female	$Y= 0.001L^{2.422}$	0.090	Negative allometric
	Male	$Y= 3.522L^{0.429}$	0.014	Negative allometric
March	Female	$Y= 4E\text{-}07L^{4.531}$	0.824	Positive allometric
	Male	$Y= 0.003L^{2.186}$	0.760	Negative allometric
April	Female	$Y= 4E\text{-}05L^{3.393}$	0.918	Positive allometric
	Male	$Y= 0.000L^{2.844}$	0.858	Negative allometric
May	Female	$Y= 5E\text{-}05L^{3.305}$	0.886	Positive allometric
	Male	$Y= 0.011L^{1.885}$	0.569	Negative allometric
June	Female	$Y= 8E\text{-}05L^{3.211}$	0.882	Positive allometric
	Male	$Y= 0.000L^{2.949}$	0.799	Negative allometric
Overall	Female	$Y= 0.007L^{2.981}$	0.839	Negative allometric
	Male	$W= 0.0013L^{2.455}$	0.712	Negative allometric

Allometric growth pattern as also shown by other gastropod such as *Littorina* spp. [21] which shell length gave more contribution than shell width to the weight i.e also changing from positive to negative allometric. Allometric growth could be varied in the life time of a species and it was general relative growth pattern for the gastropods [22].

Allometric growth for gastropod caused intrinsic confusing in taxonomy specifically for juvenile size [23]. In addition, this concept was quite difficult to compare intraspecific relationship based on shell shape due to measured variables (i.e length or weight) or other multidimesional scale [24, 25]. Nevertheless, this concept is still used and the perceptions of it depended on users [21]. Allometric relationship for gastropods was determine by genetic and adaptive modified subject [26].

The growth of *S. gigas* has affected by season associated with water quality and nutrients available [27]. Nevertheless, according to Wada *et al.*, (1983) [14], the growth rate depended on season. For example, the shell length most significant increased during summer but scarcely increased in winter time. Even though no studies on the relative growth pattern of *S. luhuanus* based on shell length-weight relationship were available for comparisons, the present study to determine growth pattern is still useful.

4. Conclusions

Totally, there were 878 individuals of *S. luhuanus* were collected during the research. The shell length was different monthly. Overall, the shell length ranged from 30.27-56.00 mm with the average 42.63 mm. Based on the shell length, the population of *Strombus luhuanus* consisted of juvenile and adult individuals. The shell length was less than 30 mm for juveniles and for adult size was more than 30 mm. In general, it could be seen that the adults were pre dominant in this population. The weight ranged from 2.15-30.62 g for female whereas 5.84-26.6 g for male. Generally, *S. luhuanus* showed negative allometric growth pattern both for female and male during the study. However, the males indicated negative allometric growth pattern but the females also had both negative and positive allometric.

5. Acknowledgement

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