

Short Communication

PATTERNS OF RELATIVE GROWTH IN TROPICAL NERITIDS, *NERITA UNDATA*, BASED ON OPERCULUM ANALYSIS

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ABSTRACT

Growth is one of the important events in the life history of an organism beside reproduction. The objective of the present study was to evaluate the possibility of using the operculum to determine the growth pattern of tropical neritids (*Nerita undata*). Shell and operculum dimension were measured using a vernier caliper to the nearest 0.01mm. The results showed that there was a relationship between operculum dimensions (length and width) and shell, and it was also shown allometric growth pattern. The study also indicated the relationship between operculum dimension and the shell parameters.

Keywords: Operculum, Shell, Allometric

INTRODUCTION

Growth is one of the important events in the life history of an organism beside reproduction. Growth in snails is usually determined by measuring the shell linear increment which is then converted to somatic growth. This conversion was done by using the relationship between body (tissue) weight and shell size (Hughes, 1986). Knowledge of organisms growth is crucial in understanding their life history.

There have been few studies on seasonal patterns of growth rate of the Neritidae for temperate and tropical species. Kolipinski (1964) (cited in Mieskiewicz, 1980) studied the growth rate of the Atlantic *Nerita* species in Florida (i.e. *N. peloronta*, *N. tessellata*, *N. versicolor* and *N. fulgurans*) and concluded that the Florida species grew rapidly during summer. In contrast, the growth rate of *N. albicilla* in Heron Island, Australia, was faster in the cooler seasons of fall and winter (Frank, 1969). He also found differences between species, with *N. polita* grew faster and having a shorter live than *N. albicilla*.

Several techniques have been used to study the growth rate of the Neritidae. Following age cohorts through the population in time was used to

measure growth of *Nerita atramentosa* (Underwood, 1975). Whilst, Mieskiewicz (1980) used mark-recaptured methods and the relationship between shell length and width to study the growth rate and growth patterns of six tropical *Nerita* species namely *N. chamaeleon*, *N. plicata*, *N. polita*, *N. undata*, *N. albicilla*, and *N. costata*.

Analysis of the opercula has been a useful method to estimate the individual growth rate of some gastropods species. This is the case when the operculum exhibits the growth mark (striae) in the inside of the operculum and growth rings on the outside of the operculum. These striae and rings had been shown to correspond to the age of individuals in some species (e.g. Sire and Bonet, 1984; Cupul-Magana and Torres-Moye, 1996; Chen and Soong, 2002). However, most of the authors did not always verify the periodical formation of all the rings and this led to serious underestimate of ages (Geffen, 1987 cited in Cupul-Magana and Torres-Moye, 1996). In this case, what the rings represent was probably unclear in term of the time of formation (e.g. annual or daily) and the cause of the formation (e.g. environmental factors).

A part from the shell parameters, it may be possible to use the operculum dimensions to

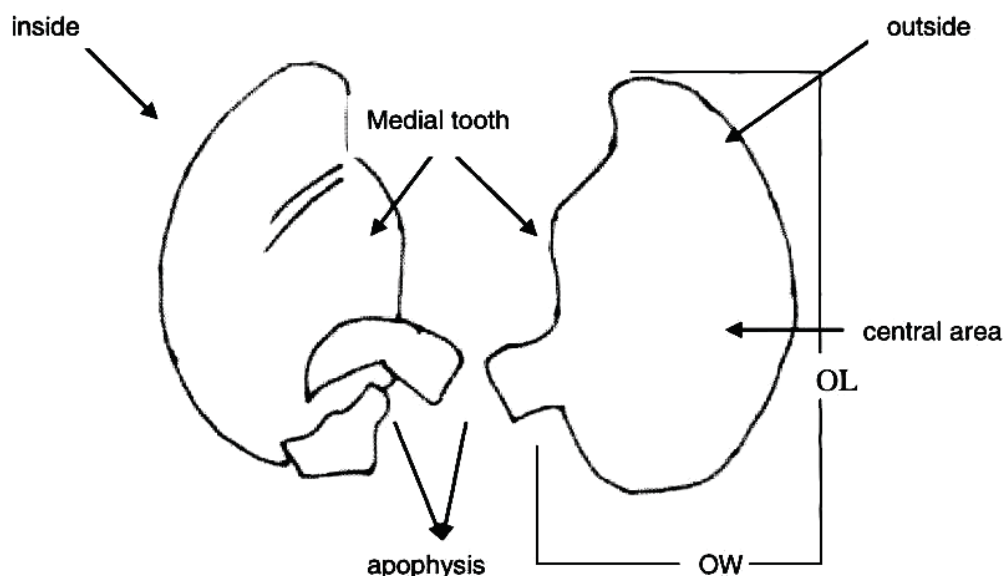


Figure 1. General structure of the operculum of *Nerita* spp. OL: operculum length; OW: operculum width

estimate the relative growth pattern. The objective of the present study was to evaluate the possibility of using the operculum to determine the growth pattern. I will address two questions. Firstly, can operculum dimensions be used to determine the growth pattern? Secondly, is there a relationship between operculum growth and shell length and aperture dimensions?

MATERIALS AND METHODS

General description of the operculum

The general structure of the operculum of neritids was examined by Krijnen (1997). The operculum is divided into two parts: the inside and the outside (Fig. 1). Both sides have different characteristics. The structure of the outside and inside of the operculum plays a distinctive role in determining the taxonomic status of the nerita species.

The following description is based on Krijnen (1997). The most prominent feature of the inside is the apophysis, which is a projection which locks the operculum behind the columella. Under the apophysis there is another projection (callosity) named the pseudo-apophysis. Above the apophysis there are two teeth: a medial and a lateral tooth. The inside may be bordered by a calloused outer edge. All these characters are useful to differentiate the *Nerita* species.

The description of the outside of the operculum is mainly based on the characteristic of the surface, such as granulated, smooth, distal or transversally folded strip. The surface is usually divided into two areas; central area and distal strip. These may be separated by grooves.

Samples

A total of 150 individuals was used in this study. Samples were collected from rocky shore of Leahari village, southern part of Ambon Island. The character of the operculum was also observed. The animals were transported alive to the laboratory, and kept in an aerated aquaria for a few days. The operculum was separated from the foot by leaving in warm water for 10-15 minutes. Then, it was removed by using a forceps. Its morphology was also noted. A glass slide was pre-heated using a hot plate and the operculum was attached to it by using thermoplastic glue (crystalbond) to make measurement easier.

Operculum growth

Two dimensions, the operculum length (OL) and width (OW) (Fig. 1), were measured using a vernier caliper to the nearest 0.01mm. The operculum length was measured from the anterior to the posterior end while operculum width was measured at the widest part of the operculum.

Broken, damaged and small size opercula (< 3mm) were not used in this study. Small sizes (< 3mm) were not included to avoid bias due to the assumption that small sizes grow fast with respect to the shell length. The corresponding shell length (SL), aperture length (AL) and width (AW) of the snails were also measured.

Data analysis

The relationship between operculum dimensions (OL and OW) and shell length (SL) and aperture dimensions (AL and AW) was analyzed by fitting simple linear regressions (Fowler and Cohen, 1990).

The patterns of growth were analysed by using a regression equation which was $\log y = a \log x \pm \log b$; where y is dependent variable; x is independent variable; b is constant and a is the regression coefficient (constant differential growth ratio). This equation was used to assess the allometric status (Simpson *et al.*, 1960 cited in Mieskiewicz, 1980; Gayon, 2000). A slope (b) less than 1 indicates negative allometry, while (b) greater than 1 indicates positive allometry. If a slope was not significantly different from 1, there is isometry. The slope of two-regression lines was analyzed by using student t test (Zar, 1999). Data were transformed logarithmically (\log_{10}). In this study all data were analyzed in SPSS (Statistical Package for the Social Sciences) 14 and Microsoft Excell, 1997.

RESULTS

Description of *Nerita undata*

The *Nerita* exhibit various shapes, colors and size. The body shape of this species is neritiform. The shell exterior is rough with strong spiral ribs. The spire is low. The apex is quite clearly seen. The color of shell is often brown and blackish and has grey spotted or banded color. The interior is white. The columellar is also white with 10 columellar. It consists of 4 teeth in the centre. Most of the denticles along the outer lip are weak. The aperture is white and smooth. Shell length ranged from 1.6-3.4 cm and width was 1.2-2.3 cm. The operculum is granulated on the outer side and smooth on the inner side.

The operculum is brown or blackish in color. It has a lateral and medial tooth and it also has an apophysis. The outside of the operculum has a flat surface with granulations throughout.

Operculum growth pattern

All dimensions of operculum increased as the shell size increased (Fig. 2). There was a relationship between operculum length (OL) and operculum width (OW). *N. undata* showed a straight regression line which is evidence that the operculum length is highly associated with the operculum width (Fig. 2). This species exhibited allometric growth. The value of the slope (b) was

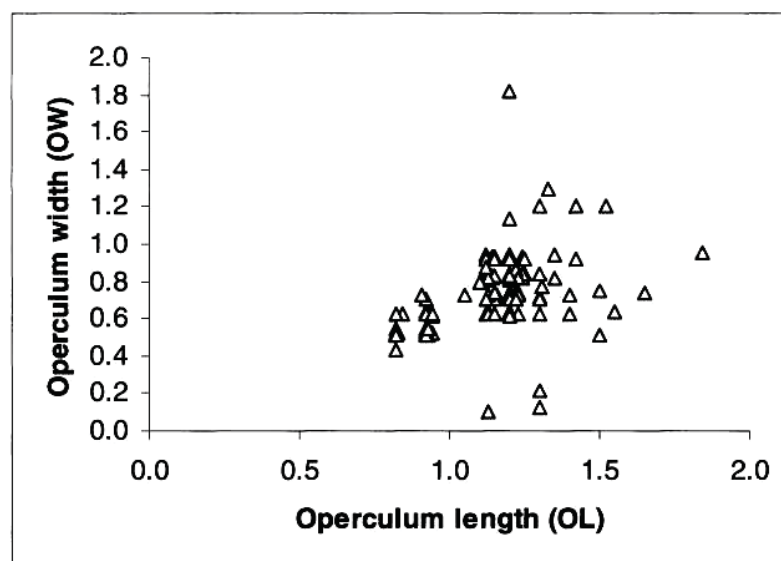


Figure 2. The relationship between operculum dimensions (OL and OW).

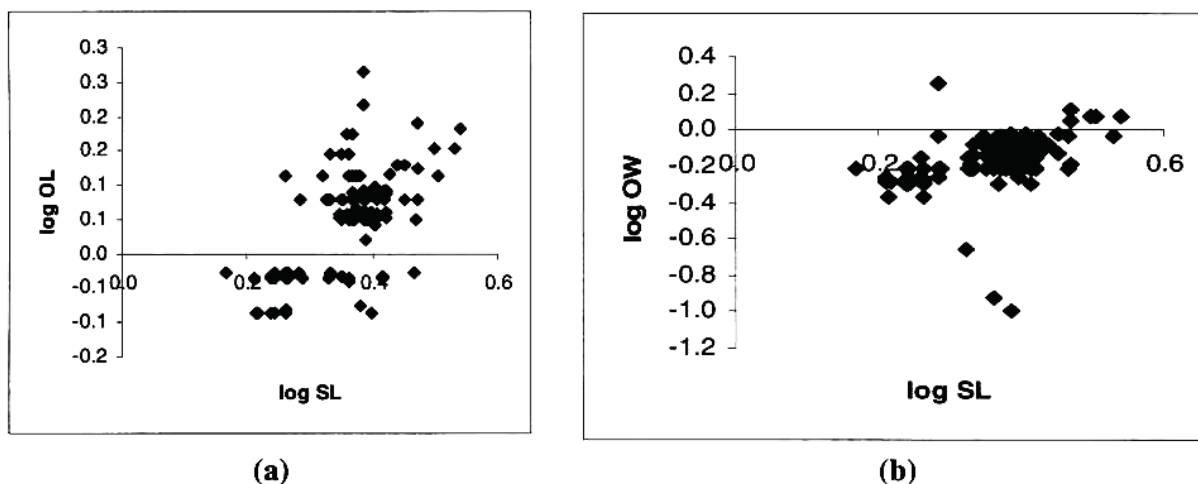


Figure 3. The relationship between shell length (SL) and operculum dimension (OL and OW)

0.471 indicating that this species showed negative allometric growth.

The first reference dimension was shell length (SL) and dependent variables were operculum length (OL) and width (OW). The result indicated that OL and OW increased moderately as shell length (SL) increased (Fig. 3) and were moderately correlated (Table 1). The slope (b) for two regression lines was significantly different ($t = -9.6670$, $df = 298$, $p < 0.001$). This suggested that the increase in shell length contributed more to the increase in operculum length rather than to the increase in operculum width.

Other morphometric characters which were used as reference dimension include the aperture dimensions; aperture length (AL) and aperture width (AW). Operculum dimensions were dependent variables. There was a high correlation

between AL and operculum length (OL) and the correlation was significant (Fig 4; Table 1). On the contrary, aperture length (AL) and operculum width (OW) showed a weak correlation (Fig 5; Table 1). The slope (b) for the two regression lines (aperture length against operculum dimensions) differed significantly ($t = -10.411$, $df = 298$, $p < 0.001$). This indicated that operculum length grew faster as the aperture length increased. There was a weak correlation between AW and OL (Fig 5a; Table 1). In contrast, there was a high correlation between AW and OW (Fig 5b; Table 1). The slope (b) was also significantly different between the two regressions line of the aperture width and operculum dimensions ($t = -8.3151$, $df = 298$, $p < 0.001$). This also showed that the operculum width grew faster than the operculum length with respect to aperture width.

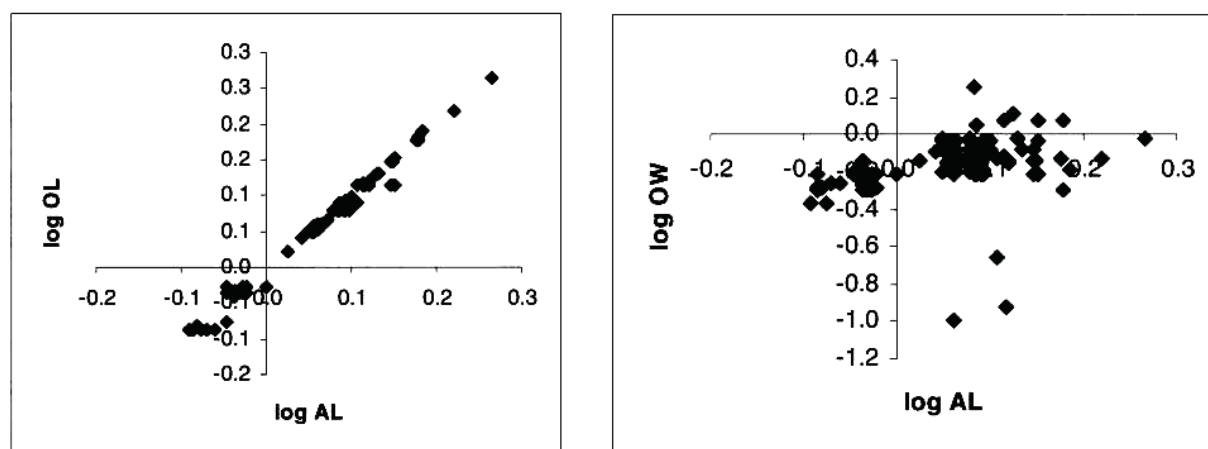


Figure 4. The relationship between aperture length (AL) and operculum dimension (OL and OW)

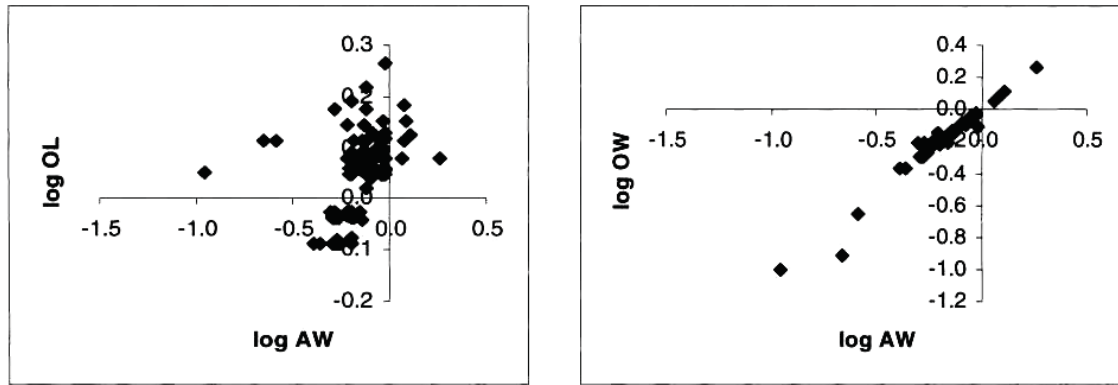


Figure 5. The relationship between aperture width (AW) and operculum dimension (OL and OW).

Table 1. The linear regression equation of shell parameters and operculum dimension for *Nerita undata* (* = $p < 0.05$; - = negative allometric)

Shell parameters (mm)	Equation	Correlation Coefficient (r)	SE	t	p	Allometric status
Shell length with						
OL	$\log y = 0.601 \log x - 0.166$	0.616	0.054	9.56	*	-
OW	$\log y = 0.852 \log x - 0.458$	0.413	0.063	5.53	*	-
Aperture length with						
OL	$\log y = 0.995 \log x - 0.0035$	0.995	0.007	119.39	*	-
OW	$\log y = 0.723 \log x - 0.189$	0.341	0.063	4.429	*	-
Aperture width with						
OL	$\log y = 0.202 \log x + 0.0804$	0.397	0.122	5.28	*	-
OW	$\log y = 1.059 \log x + 0.003$	0.983	0.024	66.05	*	I

DISCUSSION

The operculum

The results showed that the operculum is half moon shaped and calcified. A thick calcified operculum was found to be the most common in *Nerita* species (Hughes, 1971). Even though evaporation was an important factor in maintaining the body temperature of *N. tessellata*, it was

doubtful that heavy calcification of the operculum played a role in reducing water loss (Lewis, 1963; Hughes, 1971). The operculum functioned probably to protect the snails from predator such as crabs (Hughes, 1971).

The operculum of the family Neritidae could be used to distinguish each species. As an example, it was quite difficult to distinguish *Nerita polita* and *N. maxima* except through their operculum, and compared to other families of

mollusks, the operculum of the Neritidae occupies an important position in taxonomy (Krijnen, 1997). In addition, the features of the operculum of tropical Neogastropods in Ambon Bay, Eastern Indonesia was examined by Uneputty (1989) who found that they could be used to differentiate the family and genera within the order Neogastropods.

Allometric growth in the operculum

The results of the present study showed that there was a relationship between operculum length (OL) and operculum width (OW). The species showed a positive correlation between operculum dimensions (OL and OW). This suggested that the operculum width increased as the increase of the operculum length. The similar results were also shown for *N. chamaeleon* (Uneputty, 2004).

The allometric growth pattern was also shown in the relationship between shell parameters and operculum for *N. undata*, *N. polita* and *N. albicilla* showed the same pattern in which the shell parameters (SL and AL) have more influence on the increase of operculum length than operculum width (Uneputty, 2003). However, *N. undata* also showed a pattern that the operculum width increased with respect to aperture width. *N. polita* and *N. albicilla* had a similar pattern because it might be related to the shell shapes (Uneputty, 2003). The shape of *N. polita* was more ball-like and flat apex while *N. albicilla* was dorso ventral with flat apex as well. The finding in this study was similar to the pattern shown by the *Littorina* species (Reid, 1996). The allometric relationship (shell breadth and height) of the *Littorina* species altered from positive to negative allometry. During their life span allometric relationship might vary and this was a common pattern for gastropods (Vermeij, 1980). Even though few studies on the growth of *Nerita*'s operculum were available for comparisons, the use of the operculum in the present study to determine growth pattern is still useful. It was shown in this study that the operculum dimensions of species *Nerita undata* could also be used to determine the allometric growth beside the shell dimensions such as shell length and shell width. In several studies, shell length or shell height was commonly used to estimate the growth in mollusks (e.g. Ross and Lima, 1994; Bailey and Green, 1988; Mieskiewicz, 1980).

The concept of allometric relationship has been discussed, particularly the meaning of the formula for allometric growth. The history of the concept of allometry has been described in details by Gay on (2000). This concept had been applied to understand the relative growth pattern of the organisms. In gastropods, the allometric growth caused a major intrinsic confusion in taxonomical studies (Chiu *et al.*, 2002). This is because of difficulties in identification based on overlapping morphological boundaries in related species specifically in juveniles (Valovirta and Vaisanen, 1986). In addition, this concept also brought in difficulties in intraspecific comparisons of the shell shapes and its perception by the users. The perception relied on the variable measured such as size (i.e. height or body weight) or a multidimensional factor (Sundberg, 1988; Palmer, 1990). Gould (1966) stated that the allometric relationship in gastropods was determined genetically and subjected to adaptive modification. Several studies also showed that environmental factors could also influence the allometric relationship (e.g. Palmer, 1990; Boulding and Hay, 1993).

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