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# Morphometric variation of ten species of *Nerita* (Molluscs: Gastropods) in rocky intertidal zone of Oma Village, Central Moluccas, Eastern Indonesia

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**Abstract**
Neritidae is a gastropod molluscs found primarily in marine habitat, as well as brackish and freshwater environment. There is limited information on Neritidae on rocky intertidal zone of Oma Village, Central Moluccas, Eastern Indonesia especially on the diversity and its morphometric variation. This research provided information on morphometric variation of the shell of *Nerita* on rocky intertidal zone of Oma Village. The fifty individual of each *Nerita* species found in this research sampling site had been measured its morphological characteristics. The result showed that there were ten spesies of Neritidae found in this reseach area. *N. albicilla* found in this study has a higher shell length, wider shell, low spire height, higher aperture length, and higher columella length compared to other nine species of *Nerita.* Spire height and aperture length were the main parameters which distinguist one species from the other species of *Nerita*.

**Keywords:** *Nerita*, gastropods, morphometric variation, rocky shore

## 1. Introduction
*Nerita* is one of the genera of gastropod molluscs in the family of Neritidae Rafisniques, 1815. Neritidae consists of 19 genera, 31 sub-genera and over 150 species [1]. Neritids show morphological polymorphic as the shell possess a wide variety of colour and patterns. The colour of Neritids shell varied between species, because of the different of environmental condition [2].

Neritidae commonly found in tropical and sub-tropical water in estuarine, marine and fresh water habitat. In the coastal zone, Neritidae usually inhabit the middle to upper intertidal zone and are known to be aggregated. Neritidae is herbivore organisms. Neritids are generally euryhaline; species of the genus *Nerita* usually closely related to marine environment [2].

Studies on shell morphology of the gastropods have been well documented. The morphology of three congeneric tropical *Nerita* was studied by Dangeubun and Uneputty (2005) [1]; Mujiono (2011) [3] on *Clithon oualaniensis*; Reisser *et al* (2012) [4] on *Cellana strigilis*; Emam *et al* (2013) [5] on *Diadora rupelli*; Acava *et al* (2013) [6] on *Buccinanops globulosus*. Some characters of the shell could be used to distinguish species. The morphological of a species varied geographically [1].

There were some species of *Nerita* has been recorded in Ambon Bay such as: *Nerita chamaeleon, Nerita polita, Nerita albicilla, Nerita plicata* and *Nerita balteata*. *N. chamaeleon, N. polita, N. albicilla, N. plicata* found in rocky shore, while *N. balteata* found in mangrove area [7, 8]

Intertidal zone of Oma Village, Central Moluccas, Eastern Indonesia is dominated by rocky substrate. Many genera of gastropods inhabit this zone such as: *Nerita, Thais, Strombus, Trochus* and *Morula*. *Nerita* is a dominant genus in this kind of substrate. The information on the shell morphology of *Nerita* in this area is still scarcely, therefore it is important to conduct this research. The objectives of the research were to analyze the difference among *Nerita* spesies based on their shell characters and to assess the shell geometry variations.

## 2. Materials and Methods
Sampels of *Nerita* were collected from two rocky intertidal zones of Oma Village, Central Moluccas namely Sila and Hitalawa rocky zone (Figure 1) in November 2017. Fifty individu

of each *Nerita* species were collected in various shell size.
The sampels of *Nerita* were collected randomly in rocky intertidal zone during low tide. Identification was followed guideline by Cernohorsky (1978) [9], Dharma (1988) [10], and Poutier (1998) [11]. Measurement of shell dimensions or characters including shell length (SL), shell width (SW), spire height (SpH), aperture length (AL), aperture width (AW), columella length (CL) and lip thickness (LT) (Figure 2). The general characters of shell measurement was followed the method by Dangeubun and Uneputty (2005) [1].

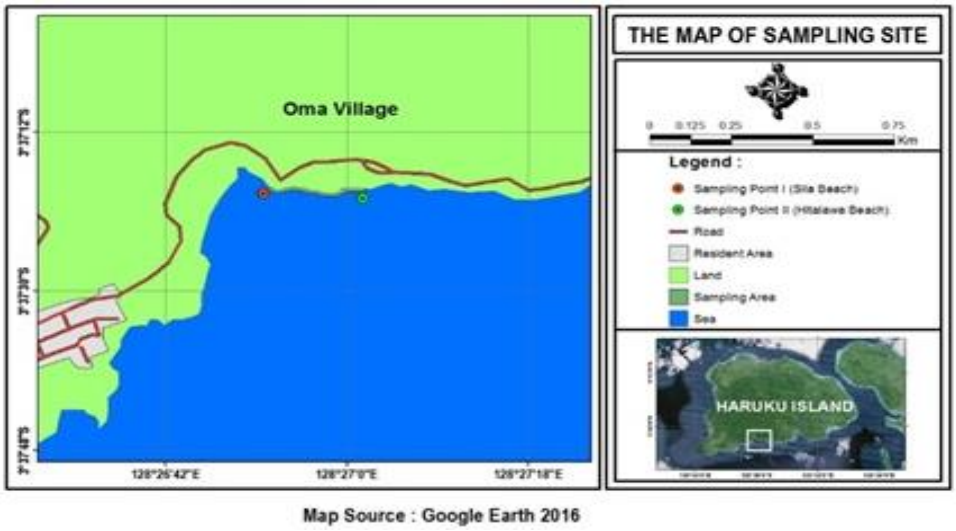


**Fig 1:** Map of study site of rocky intertidal zone of Oma Village, Haruku Island, Central Moluccas, Indonesia

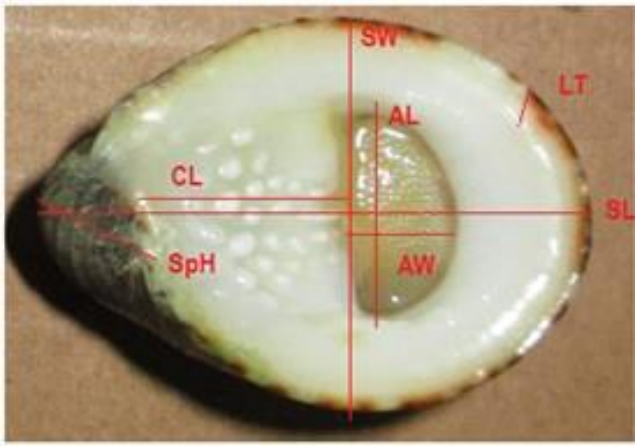


**Fig 2:** Shell dimension of *Nerita* (e.q, *N. albicilla*). SL (shell length), SW (shell width), SpH (spire height), CL (columella length), AL (internal length of aperture), AW (internal widht of aperture), LT (lip thickness)

These shell dimensions are described as follow:

1. Shell length (SL): the maximum dimension from the apex to the longest part paralel to the axis
2. Shell width (SW): the widest part of the shell
3. Spire height (SpH): distance from the apex to the last of spire whorl
4. Columella length (CL): distance from the columella fold to the tip of the columella deck.
5. Length of aperture (AL): distance from the internal part of outer lip to the furthest point of the anterior lip
6. Internal width of aperture (AW): distance from the columella fold to the internal outer lip.
7. Lip thickness (LT): distance between inner and outer lip

The morphological characteristics were measured by using digital vernier caliper to the nearest 0.01 mm. Apart from these shell dimensions, some other characteristics were observed to describe *Nerita* species such as shell surface, colour of interior and exterior shell, colour of columella deck, aperture, and operculum shape.
Shell length (SL) is the main parameter used to study variation in shell dimensions. Therefore, all the measurements were compared to SL to examine shell variation between species. The linear measurement and a combination of various ratio were then compared among these ten species of *Nerita*. The general ratio included: relative shell width (SW/SL), relative aperture length (AL/SL), relative aperture width (AW/SL), relative columella length (CL/SL) and relative lip thickness (LT/SL).
Before any statiscical analyses has been conducted, data distribution were tested for normality and homogeneity of variances. One-way Anova or nonparametric Kruskal-Wallis tests were used to analyze the different in specific morphometric parameter between groups followed by post-hoct analyses at $p<0,05$ probability level. To analyze the variation between group, a parametric canonical variate analyis (CVA) or nonparametric multidimensional scaling (NMDS) was applied by using PAST (PAlaentological STatistic) software.

## 3. Results and Discussion

### 3.1 Spesies composition of *Nerita* found in rocky intertidal zone of Oma Village, Central Moluccas.

Ten species of *Nerita* were found in rocky intertidal zone of Oma Village namely *Nerita albicilla, Nerita undata, Nerita chamaeleon, Nerita costata, Nerita exuvia, Nerita maxima, Nerita polita, Nerita patula, Nerita signata* and *Nerita plicata* (Figure 3). Uneputty (1991) [7] found some species of *Nerita* in Ambon Bay surrounding waters i.e. *N. chamaeleon, N. polita, N. albicilla, N. plicata, and N. balteata*. Besides that, Dangeubun dan Uneputty (2005) [1] found *N. albicilla, N. chameleon* and *N. polita* in intertidal zone of Latuhalat, Ambon. Supusepa (2011) [8] also found *N. albicilla, N. plicata, N. polita, N. squamulata* and *N. patula* in intertidal zone of Ambon Bay, Ambon. The species diversity of *Nerita* found in this study was higher compared to the other sampling site in Moluccas province. This was because the substrate of the research sites supported the occurrence of these *Nerita*.


**Fig 3:** (1) *N. albicilla* Linneaus, 1758; (2) *N. chaemaleon* Linneaus, 1758; (3) *N. costata* Gmelin, 1791; (4) *N. exuvia* Linneaus, 1758; (5) *N. maxima* Gmelin, 1791; (6) *N. patula* Recluz, 1841; (7) *N. plicata* Linneaus, 1758; (8) *N. polita* Linneaus, 1758; (9) *N.signata* Lamarck, 1922; (10) *N. undata* Linneaus, 1758

**3.2 Morphometric variation on *Nerita* shell.**

The results of statistic univariate analysis on morphometric variation of shell from ten species of *Nerita* were shown in Table 1. It was stated before that shell length is the main parameter to asses shell growth of *Nerita*. Therefore, *Nerita* gastropods can be clasified into three categories based on shell length, namely juvenile (< 5mm), young (5-10 mm) and adult (>10 mm) [1]. The results of this study indicated that only *N. undata* had these three categories. Whilst *N. albicilla*, *N. chamaeleon* and *N. exuvia* were found in adult phase and did not have juvenile and young phases. This was because shell length of *N. undata* found >10 mm.

The average shell length (SL) showed that *N. albicilla* had shell length higher than other nine species of *Nerita* found in rocky intertidal zone of Oma Village (24.74 mm ± 3.40) (Table 1). It means that *N. albicilla* was longer than the others species. According to Poutier (1998) [11], maximum shell length of *N. albicilla* is 3.5 cm, commonly to 2.5 cm. On the other hand, size variation of shell length of *N. plicata* was lower compared to the other species.

There were three species of *Nerita* which have higher variation of shell width than other *Nerita* species, namely *N. albicilla, N. costata* and *N. polita* (Table 1). However, *N. chamaeleon, N. patula* and *N. exuvia* have average variation of shell width lower than the other species of *Nerita*. Overall, *N. polita* has the lowest width compare to other species of *Nerita*. Table 1 also showed that average size of shell width of *N.albicilla* was higher than the others *Nerita* species. It can be concluded that *N. albicilla* was wider than others species of *Nerita* found in this study. Dangeubun and Uneputty (2005) [1] found variation of this shell dimension of *N. chamaeleon* was higher than *N. albicilla* and *N. polita* in intertidal zone of Latuhalat, Ambon. This condition showed that the variation of shell dimension differed geographically. Tan and Clement (2008)[2] also found the shell width of *N.costata* varied between 13-37 mm. They also found shell width of *N. polita* varied between 17-40 mm.

The dimension of spire height (SpH) (Table 1) showed that *N. signata, N. plicata* and *N. costata* had higher variation of SpH compare to another *Nerita* species. Meanwhile, *N. albicilla* and *N. exuvia* had lower variation of SpH. This result indicated that *N. albicilla* and *N. exuvia* had the lower spire compared to the others species of *Nerita*. However, average size of SpH of *N. albicilla* was the lowest one (4.33 mm ± 1.40). This meant that *N. albicilla* had a low spire.

The highest average size of columella length (CL) (Table 1) from these ten *Nerita* species found in our study was on *N. albicilla* (8, 23 mm ± 2.785). On the other side, *N. costata* had the lowest CL (4.27 mm ± 1.23). The highest variation of CL was found on *N. albicilla* and the lowest was on *N. exuvia.* This meant that the columella of *N. albicilla* wider than others species. According to Poutier (1998) [11]; Dangeubun & Uneputty (2005) [1], *N. albicilla* is the species from the genus of *Nerita* which has columella deck wide and flat.

*N. albicilla* had the highest average size of aperture length (AL) (Table 1) which was 11.09 mm ± 2.69. This meant that *N. albicilla* has the longest aperture length compare to the others species of *Nerita*. However, *N. costata* had the lowest aperture length (7.07 mm ± 2.07). The aperture length of *N. albicilla* from intertidal zone of Latuhalat, Ambon was varied from 4.20-11.30 mm (average 7.44 mm ± 0.90) [1]. Our result showed that *N. albicilla, N. costata,* and *N. polita* had higher variation of aperture length compared to other *Nerita* species found in this sampling area.

*N. albicilla* has the highest variation of aperture width compare to others species of *Nerita* in this study (Table 1). Average size of aperture width (AW) was higher on *N. albicilla* (5.31 mm) and the lowest was on *N. costata* (3.02 mm). Dangeubun and Uneputty (2005) [1] reported that average size of aperture length of *N. albicilla* was higher than *N. polita* and *N.chamaeleon* found in intertidal zone of Latuhalat, Ambon.

The highest average size of lip thickness (LT) (Table 1) was found on *N. albicilla* (3.64 mm) and the lowest was on *N.*

*patula* (0.90 mm). However, the result of this study showed that variation of lip thickness of *N. chamaeleon* was higher compare to another *Nerita* species, and its variation was lower in *N. patula.* Generally, it can be concluded from Table 1 that *N. albicilla* found in this study has a higher shell length, wider shell, low spire height, higher aperture length, and higher columella length.

**Table 1:** Shell dimension of 10 spesies of *Nerita* found in intertidal zone of Oma village. Paranthese is Mean ± Standard Deviation

| Parame-ter (mm) | *N. albicilla* | *N. chamaeleon* | *N. costata* | *N. exuvia* | *N. maxima* | *N. patula* | *N. plicata* | *N. polita* | *N. signata* | *N. undata* | F/H | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SL | 18,8-33,8 (24,34±3,40) | 14,49-20,20 (21,97±2,17) | 6,73-25,13 (15,83±4,31) | 11,33-27,48 (22,52±3,03) | 7,43-27,17 (18,79±5,07) | 9,02-21,02 (16,94±2,16) | 8,66-20,2 (15,38±2,92) | 5,63-22,63 (16,86±4,21) | 9,02-22,66 (18,40±3,79) | 4,02-23,09 (16,38±4,67) | 35,83 | 1,227E-48 |
| SW | 14,32-28,12 (18,81±2,56) | 12,08-20,42 (16,84±1,51) | 5,17-19,88 (12,27±3,43) | 8,66-20,03 (17,44±2,14) | 4,18-20,19 (14,70±3,86) | 6,32-15,74 (12,28±1,74) | 6,64-18,18 (12,34±2,66) | 4,09-16,2 (12,16±3,25) | 7,00-16,33 (13,65±2,66) | 6,11-17,41 (12,91±2,91) | 40,54 | 6,456E-54 |
| SpH | 1,94-9,6 (4,33±1,40) | 5,96-11,85 (8,91±1,50) | 2,01-10,49 (5,36±1,84) | 3,54-9,02 (6,61±1,12) | 2,48-10,32 (4,96±1,34) | 3,00-9,72 (6,94±1,29) | 1,67-13,15 (4,85±1,72) | 1,82-8,82 (5,58±1,69) | 3,00-10,97 (8,07±1,97) | 2,15-8,19 (5,46±1,49) | 45,69 | 1,953E-59 |
| CL | 3,55-20,4 (8,23±2,785) | 4,91-10,56 (7,98±1,26) | 1,43-8,23 (4,27±1,23) | 3,09-7,88 (5,94±0,93) | 2,86-11,54 (6,31±1,50) | 2,89-8,66 (6,29±1,21) | 2,95-9,11 (5,78±1,45) | 2,28-7,79 (4,93±1,26) | 1,88-8,30 (5,76±1,474) | 2,7-10,05 (5,43±1,69) | 31,23 | 3,553E-43 |
| AL | 7,94-21,77 (11,09±2,69) | 7,83-15,3 (10,58±1,58) | 2,72-12,01 (7,07±2,07) | 4,56-12,88 (10,67±1,47) | 3,73-13,11 (8,44±1,66) | 4,26-9,98 (7,96±1,27) | 3,83-10,47 (7,32±1,72) | 0,62-11,08 (7,79±2,12) | 3,07-10,37 (7,82±1,69) | 4,06-11,15 (7,09±1,81) | 36,37 | 3,081E-49 |
| AW | 2,41-15,02 (5,31±2,28) | 1,65-7,53 (4,95±1,11) | 1,01-5,79 (3,02±0,95) | 2,25-6,98 (4,05±0,81) | 2,5-9,3 (4,88±1,13) | 2,14-7,21 (4,92±1,05) | 1,51-5,43 (3,19±0,89) | 1,69-5,99 (4,22±1,08) | 1,74-5,79 (3,96±0,99) | 1,78-6,41 (3,92±1,16) | 20,31 | 4,132E-29 |
| TB | 0,97-9,85 (3,64±1,47) | 0,97-3,27 (2,13±0,56) | 0,24-3,55 (1,49±0,81) | 0,91-3,39 (2,38±0,50) | 0,73-3,55 (2,08±0,75) | 0,44-1,7 (0,90±0,34) | 0,52-4,19 (1,97±0,81 | 0,21-3,19 (1,80±0,71) | 0,65-3,19 (2,06±0,65) | 0,3-3,0 (1,52±0,71) | 41,38 | 7,784E-55 |
| SW/SL | 0,71-0,82 (0,77±-0,07) | 0,71-0,84 (0,760±0,45) | 0,704-0,924 (0,768±0,24) | 0,68-0,88 (0,771±0,04) | 0,542-0,951 (0,784±0,56) | 0,65-0,80 (0,73±0,43) | 0,67-0,981 (0,79±0,88) | 0,676-0,874 (0,75±0,77) | 0,680-0,841 (0,75±0,38) | 0,650-0,99 (0,83±0,82) | 93,99 | 2,569E-16 |
| SpH/SL | 0,09-0,31 (0,176±0,79) | 0,27-0,52 (0,42±-0,23) | 0,212-0,503 (0,333±0,32) | 0,22-0,44 (0,30±0,61) | 0,124-0,45 (0,271±0,35) | 0,31-0,59 (0,40±0,68) | 0,19-0,44 (0,30±5,34) | 0,13-0,44 (0,34±-0,56) | 0,283-0,563 (0,45±-0,68) | 0,17-1,02 (0,34±4,12) | 292,8 | 8,629E-58 |
| CL/SL | 0,19-0,607 (0,32±2,07) | 0,28-0,46 (0,37±0,12) | 0,19-0,393 (0,274±0,32) | 0,173-0,38 (0,27±0,30) | 0,243-0,501 (0,35±0,30) | 0,26-0,535 (0,36±0,55) | 0,29-0,48 (0,37±0,37) | 0,214-0,425 (0,30±0,48) | 0,19-0,478 (0,32±0,11) | 0,183-1,376 (0,33±5,50) | 173,9 | 9,419E-33 |
| AL/SL | 0,34-0,69 (0,44±1,37) | 0,383-0,640 (0,478±0,69) | 0,241-0,54 (0,457±-,81) | 0,362-0,56 (0,45±-3,63) | 0,34-1,09 (0,45±3,63) | 0,340-0,574 (0,47±-0,31) | 0,314-0,59 (0,48±-0,32) | 0,033-0,61 (0,48±-2,70) | 0,30-0,56 (0,43±0,19) | 0,22-1,72 (0,43±5,303) | 39,85 | 8,083E-06 |
| AW/SL | 0,13-0,459 (0,20±2,46) | 0,09-0,33 (0,22±-0,10) | 0,125-0,266 (0,192±0,10) | 0,11-0,31 (0,18±0,97) | 0,20-0,59 (0,25±1,92) | 0,14-0,422 (0,30±-0,14) | 0,122-0,291 (0,21±0,04) | 0,18-0,35 (0,26±-0,04) | 0,146-0,292 (0,21±0,09) | 0,088-0,846 (0,25±3,80) | 176,6 | 2,536E-33 |
| LT/SL | 0,05-0,43 (0,14±2,81) | 0,05-0,14 (0,10±-0,45) | 0,03-0,155 (0,089±0,03) | 0,07-0,17 (0,11±0,78) | 0,06-0,18 (0,11±0,36) | 0,03-0,09 (0,05±0,24) | 0,05-0,255 (0,13±0,17) | 0,03-0,151 (0,10±-0,59) | 0,058-0,160 (0,11±-0,56) | 0,02-0,161 (0,10±-0,11) | 195,7 | 2,652E-37 |

The morphometric ratio from ten species of *Nerita* found in intertidal zone of Oma Village based on one way ANOVA (Table 1) showed that all shell dimensions were significantly different ($p$<0,0001). This is because of the type of substrate which these *Nerita* were found influence their morphological development.

Chiu *et al.,* (2003) [12] stated that different habitat which is *Nerita* found will influence the morphology of species. This condition cause significant effect on shell size of marine gastropods. Tan and Clement (2008) [2] stated that shell length of *N. albicilla* varied between 19 and 32 mm and its shell width varied from 15 to 24 mm.

Multivariate ANOVA analysis (MANOVA) of linear morphological characters of ten species *Nerita* found in rocky intertidal zone of Oma Village showed significantly difference between seven shell characters. This was showed by Wilks Λ value = 0.04862, $F_{[63.\ 2732]}$ = 30.82; $p$<0.001. A CVA was shown in Table 2. A scatter plot of the CVA coefficients was presented in Figure 4, where each specimen was plotted as a point in a space of reduced dimensionally. The 95% confidence ellipses showed large overlap between morphometric of *Nerita* found in rocky intertidal zone of Oma Village. *N. albicilla* distribute toward the upper left, whilst the others nine towards the upper and lower right of the plot area.

**Table 2:** CVA loading based on correlation matrix of 7 shell linear characters of 10 species of *Nerita*. Colomns represented the 1st 2 axes of *canonical discriminant function coefficients*

| | Axis 1 | Axis 2 |
|---|---|---|
| Eigenvalue | 2,676 | 0,7898 |
| Percen (%) of variation | 55,54 | 16,24 |
| Cumulative persent (%) of variation | 55,54 | 71,78 |
| Eigenvectors: | | |
| SL (Shell length) | -0,21421 | 0,23799 |
| SW (Shell width) | -0,29282 | 0,28808 |
| SpH (Spire height) | 0,78135 | 0,4051 |
| CL (Columella length) | -0,14611 | -0,37008 |
| AL (Aperture length) | -0,17813 | 0,40209 |
| AW (Aperture width) | 0,1119 | -0,58997 |
| LT (Lip thickness) | -0,43848 | 0,22263 |

The 1st canonical discriminant function coefficient accounted for 55.54% of the variance in morphology between species of *Nerita*. The eigenvector elements showed positive and negative value indicating the CVA described differences in shape rather than size, where SpH (spire height) was the most important discriminating parameters. The second function accounted for 16.24% of total variance, where AL (aperture length) forming the most important discriminating characters. Based on this CVA analysis, it can be concluded that SpH and AL were the most important characters which discriminating these ten species of *Nerita* in rocky intertidal zone of Oma Village.

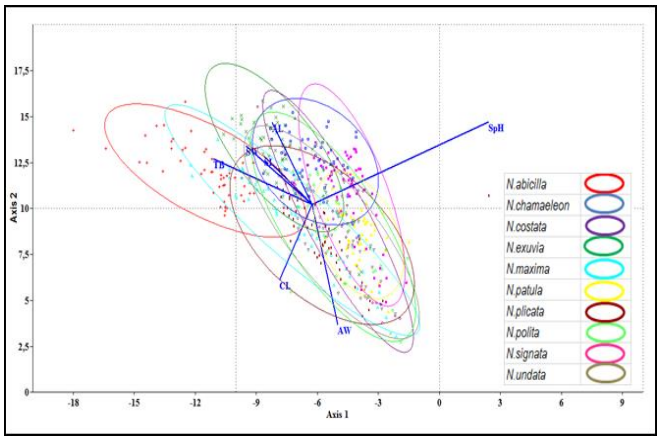


**Fig 4:** *Scatter plot*of the 1st 2 axes of the CVA and its 95% confidence ellipses. Data point represent individual discriminat function scores of the linear mesurement data of 10 species of *Nerita.* SL, shell length; SW, shell width; AL, aperture length; AW, aperture width; SpH, spire height; CL, columella length; TB, lip thickness.

A nonparametric multivariate (NMDS) analysis was applied to compare each of six linear measurement parameters to SL (shell length) parameter (Table 1). This analysis showed that there was a highly significant difference between all shell characters (Kruskal-Wallis, $p$<0,001). The scatter plot of this analysis was presented in Figure 5 based on Bray-Curtis similarity coeficient. The 95% ellipsess howed that *N. albicilla* distributed toward the lower left of the curve, whilts the other nine species showed the morphological overlap between individual within and between populatian. Non-parametric MANOVA (NPMANOVA) analysis showed that there was a significantly different between morphological characters of these ten *Nerita* species found in this research (NPMANOVA, $F$ = 22,64, $p$ = < 0,0001). This NPMANOVA showed that there were at least one morphological character of *Nerita* significantly differed from at least another one.

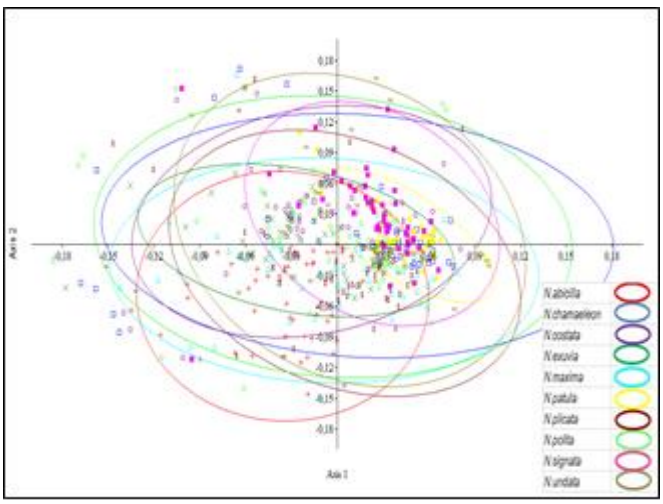


**Fig 5:** The scatter plot of the 1st 2 axes of the NMDS and its 95% confidence ellipses.

## 4. Conclusions

Ten species of Neritidae found in rocky intertidal zone of Oma coastal water, Central Moluccas, Eastern Indonesia. *Nerita albicilla* differs from the other nine species based on its linear morphology characteristic. All Neritid gastropods found in our study were significally different in its shell shape rather than its size.

## 5. Acknowledgements

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