

Statistical approaches for accurate species identification of the two blotched nerite *Nerita albicilla* and *N. originalis* (Gastropoda: Neritidae)

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ABSTRACT

The genus *Nerita* (Gastropoda: Neritidae) inhabits tropical and temperate regions, which is widely distributed in intertidal areas. Recently, it was suggested that *Nerita albicilla* was divided into the two different species with addition of *N. originalis* sp. nov. In the previous study (Park *et al.*, 2023), the morphometric data inferred from shell morphological characteristics were first employed to distinguish the two *Nerita* species from each other. To examine taxonomic significance of shell morphological differences, we have done the normality test of the nine ratios from shell morphology suggested by Park *et al.* (2023). The result revealed that only six shell morphology ratios (SW/SL, H/SL, H/SW, AL/SW, AW/SW, and AW/SL) possess appropriate normality. Through a bivariate correlation test conducted with the six ratios, we found only four ratio sets of shell morphology have little correlation- (SW/SL, AW/SL), (H/SL, AW/SL), (H/SW, AW/SL), and (AL/SW, AW/SL). With them, we performed the logistic regression and discriminant analyses. The results suggested that (H/SL, AW/SL) has the highest average percentage value (74.7%) in species identification accuracy of the two *Nerita* species. The present result indicates that the employment of statistical approaches could serve as a viable method in analyzing *Nerita* shell morphology for taxonomic use.

Keywords: *Nerita albicilla*, *Nerita originalis*, shell morphology, morphometric data, statistical analysis, logistic regression, discriminant analysis

INTRODUCTION

The family Neritidae (Rafinesque, 1815) (order Cycloneritida) are the most diverse species of Neritimorpha (Mollusca: Gastropoda), members of

which are distributed in tropical and temperate regions and exhibit remarkable habitat radiation under various conditions of salinity (from freshwater to seawater), substrata (from muddy to rocky), wave exposure (from open coast to sheltered sites), and tidal levels (Okuda and Nishihira, 2002). Among them, the blotched nerite *Nerita albicilla* (Linnaeus, 1758), which belongs to the family Neritidae, is widely distributed in intertidal areas of the Indo-Pacific, extending to the shores of East Africa in the west and reaching its eastern boundary at the Cook Islands (Crandall *et al.*, 2008).

Recently, Hong *et al.* (2023) first suggested the

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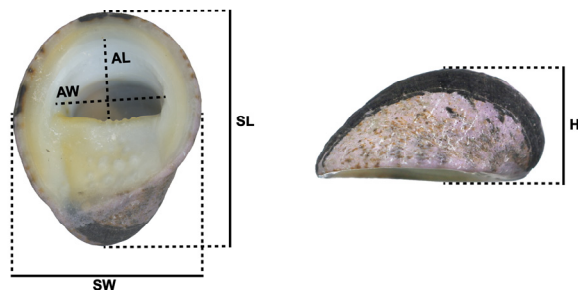


Fig. 1. Schematic representation of *Nerita originalis* S. Hong, B. Park & U. W. Hwang, 2023 with the measurements taken in the morphometrics. SL, shell length; SW, shell width; H, shell height; AL, aperture length; AW, aperture width.

possibility that *N. albicilla* can be divided into the two different species with addition of *N. originalis* sp. nov. After that, Park *et al.* (2023) reported the morphological differences between the two *Nerita* species. They compared morphological characteristics such as shell morphology and radula lateral teeth

morphology of the two species using the morphometrical analysis. However, they failed to suggest statistically reliable morphological differences. Thereby, it is needed to be adapted more appropriate statistical approaches in analyzing morphometric data sets of the two *Nerita* species. To examine the taxonomical utility of the morphometrical data set of *Nerita*, here we conducted statistical approaches with the summarized data set of shell morphological characteristics extracted from 75 individuals of *N. albicilla* (N = 48) and *N. originalis* (N = 27) used in Park *et al.* (2023).

MATERIALS AND METHODS

In this study, we statistically reanalyzed the morphometrical data extracted from the 75 individuals of *Nerita albicilla* (N = 48) and *N.*

Table 1. The results of the bivariate correlation analysis of the six different ratios inferred from morphological characteristics of *Nerita albicilla* (N = 48) and *N. originalis* (N = 27)

		SW/SL	H/SL	H/SW	AL/SW	AW/SW	AW/SL
SW/SL	Pearson Correlation	1					
	Sig. (2-tailed)						
	N	75					
H/SL	Pearson Correlation	-.510**	1				
	Sig. (2-tailed)	< .001					
	N	75	75				
H/SW	Pearson Correlation	-.874**	.861**	1			
	Sig. (2-tailed)	< .001	< .001				
	N	75	75	75			
AL/SW	Pearson Correlation	-.686**	.544**	.710**	1		
	Sig. (2-tailed)	< .001	< .001	< .001			
	N	75	75	75	75		
AW/SW	Pearson Correlation	-.703**	.573**	.732**	.691**	1	
	Sig. (2-tailed)	< .001	< .001	< .001	< .001		
	N	75	75	75	75	75	
AW/SL	Pearson Correlation	.277*	.139	-.092	0.81	.486**	1
	Sig. (2-tailed)	.016	.234	.430	.491	< .001	
	N	75	75	75	75	75	75

** Correlation is significant at the 0.001 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

The bold letters indicate the four ratios finally selected

Table 2. Percentages of correct species identification of *Nerita albicilla* (N = 48) and *N. originalis* (N = 27) using the logistic regression and discriminant analyses

	Percentage Correct (%)	
	<i>N. albicilla</i>	<i>N. originalis</i>
(SW/SL, AW/SL)	79.2 / 68.8*	51.9 / 66.7
(H/SL, AW/SL)	87.5 / 75.0	51.9 / 74.1
(H/SW, AW/SL)	83.3 / 72.9	59.3 / 74.1
(AL/SW, AW/SL)	85.4 / 58.3	40.7 / 63.0

*Logistic regression analysis / discriminant analysis

originalis (N = 27) made by Park *et al.* (2023). They employed five shell morphological characteristics such as SL, SW, H, AL, and AW measured using a digital micrometer (SINCON, China). Here, the following abbreviations are identically used throughout the text: SL, shell length; SW, shell width; H, shell height; AL, aperture length; AW, aperture width (Fig. 1). Based on the five morphological characteristics, nine ratios were calculated: SW/SL, H/SL, H/SW, AL/SW, AL/SL, AL/H, AW/SW, AW/SL, and AW/H. The morphological terminology was followed by Susintowati *et al.* (2018).

To examine the association between quantitative variables, with the nine ratios, we tested the normality and the bivariate correlation analyses using IBM SPSS Statistics for Windows, Version 29.0.2.0 (IBM Corp., New York) (Table 1). According to the result, we selected four ratio sets, each of which was subjected to the logistic regression and discriminant analyses to evaluate the accuracy for species identification based on morphological differences. The results of the statistical analyses are presented in a histogram.

RESULTS AND DISCUSSION

To examine taxonomic significance of shell morphological differences of *Nerita* species, we have first done the normality test with the nine ratios from shell morphology suggested by Park *et al.* (2023). The result revealed that only six shell morphology ratios (SW/SL, H/SL, H/SW, AL/SW,

AW/SW, and AW/SL) possess appropriate normality (data not shown). Based on the results of the normality test, six ratios were first selected, and then through the subsequent bivariate correlation analysis, only four ratio sets were finally selected, which are summarized in Table 1: (SW/SL, AW/SL), (H/SL, AW/SL), (H/SW, AW/SL), and (AL/SW, AW/SL).

With the four ratio sets selected finally, morphological distinctiveness for distinguishing the two *Nerita* species from each other were examined by the two different statistical methods of the logistic regression and the discriminant analyses (Table 2). In the logistic regression analysis, the accuracy of species identification of *Nerita originalis* ranges from 40.7% to 59.3%, whereas that of *N. albicilla* from 79.2% to 87.5%, indicating higher identification accuracy of *N. albicilla* than that of *N. originalis*. In the discriminant analysis, the accuracy of *N. originalis* species identification ranges from 63.0% to 74.1%, while that of *N. albicilla* from 58.3% to 75.0%.

As shown in Fig. 2, in the logistic regression analysis, overall average percentage of species identification accuracy of *N. albicilla* and *N. originalis* were 69.3% in both (SW/SL, AW/SL) and (AL/SW, AW/SL), and 74.7% in both (H/SL, AW/SL) and (H/SW, AW/SL). Overall average percentages in the discriminant analysis revealed varying accuracy values across the ratio sets: the lowest (60.0%) for (AL/SW, AW/SL), 68.0% for (SW/SL, AW/SL), 73.3% (H/SW, AW/SL), and the highest (74.7%) for (H/SL, AW/SL). On the other hand, the highest accuracy (74.7%) calculated by both the statistical analyses was

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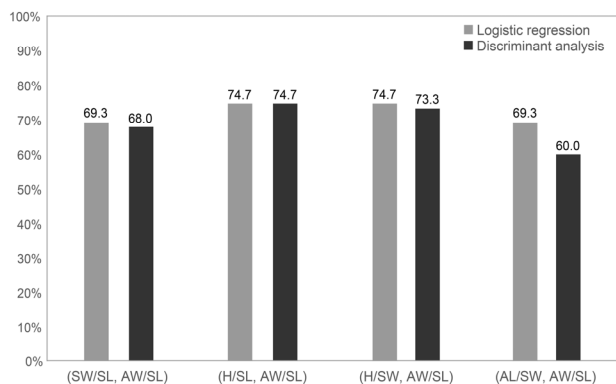


Fig. 2. The average percentage comparison of species identification accuracies shown in the two statistical approaches performed with the morphometric data inferred from 75 individuals of *Nerita albicilla* and *N. originalis*.

shown in the H/SL & AW/SL ratio set.

In the logistic regression analysis (Table 2), the species identification accuracy was distinctly lower in *N. originalis* than in *N. albicilla*. This result may be influenced by the relatively small sample size of *N. originalis* (N = 27), compared to that of *N. albicilla* (N = 48). In comparison of the two statistical approaches, the discriminant analysis rather than the logistic regression analysis demonstrated slightly higher accuracy for the species identification of *N. originalis*. In contrast, the total average of overall percentage accuracies for species identification of *N. originalis* and *N. albicilla* shown in Fig. 2 appeared higher (72.0%) in the logistic regression analysis than 69.0% in the other analysis (Fig. 2). These results strongly indicate that the employment of statistical approaches could serve as a viable method in analyzing *Nerita* shell morphology for taxonomic use.

It is known that the family Neritidae is distinctive in its frequent use of morphometric analysis through ratio calculations of morphological characteristics (e.g., Altomari *et al.*, 2021, Haumahu and Unepetty, 2018). Likewise, to identify the two brackish *Nerita* species, here we also employed statistical approaches based on the morphometric data sets. Although the present results did not provide us clearcut morphological features to identify the two *Nerita* species, it sheds light on the possibility that such statistical approaches can help the accuracy of the

Nerita species identification increased. Through further studies, the adaptation of additional statistical approaches as well as the application of molecular species identification technology are needed to be employed to resolve the problem of enigmatic *Nerita* species identification.

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