Morphological Variability in White and Black-White Clams From Amal Beach, Tarakan: A Comparative Analysis

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ABSTRAK

Morphological characteristics are crucial for understanding the biology and ecology of marine species like clams. In this study, we aimed to investigate and compare the morphological differences between white and black-white clams using various morphometric measurements. To ensure accurate and reliable data, we examined 13 morphological traits, including shell length (SL), shell height (SH), shell width (SW), umbo length (UL), ligament length (LL), anterior length (AL), posterior length (PL), length of cardinal tooth (LCT), length of posterior adductor scar to anterior adductor scar (LPAS), pallial line scar to ventral margin anterior (PVM), adductor scar width scar (AW), posterior adductor scar width scar (PW), and an additional character of pallial sinus open scar (PS) shape for their normality and homogeneity. Our findings showed that most of the data followed a normal distribution according to the Shapiro-Wilk test, but there were some exceptions. Shell Width (SW), Length of Cardinal Tooth (LCT), Length of Posterior Adductor Scar to Anterior Adductor Scar (LPAS), Posterior Adductor Scar Width (PW), and Pallial Sinus Open Scar (PS) did not follow a normal distribution. This might be due to factors like different sample sizes, outliers, or a limited number of samples. Also, variables like Posterior Length (PL), Anterior Length (AL), Adductor Scar Width (AW), and Pallial Line Scar to Ventral Margin Anterior (PVM) were non-homogeneous. We found that white clams had moderate morphological variability with values below 30%, while black-white clams showed inconsistent variability, with some values above 30%. An independent sample t-test was performed on four variables: SL (Shell Length), SH (Shell Height), LL (Ligament Length), and UL (Umbo Length). The results indicated no significant morphological differences between white and black-white clams for these measured traits. This finding suggests that the morphological characteristics examined in this study are not influenced by the shell color differences between the two clam groups. For future studies, we suggest increasing sample sizes, using alternative testing methods more tolerant to data non-normality, and addressing factors causing data heterogeneity.

Keywords: Ecology, clams, morphological traits, morphometric measurements

Introduction

The Veneridae family of clams, commonly known as kerang kapah, represents a vital culinary delicacy for the inhabitants of Tarakan City, particularly in the Amal Beach region. Over the past decade, a significant decline in the daily catch of these clams has been observed, falling from 200-300 kg to nearly half of that amount (Wiharyanto *et al.*, 2013; Jabarsyah and Arizono, 2016). This decline in production has had adverse consequences on the natural population of Veneridae clams, raising concerns about their potential extinction. It is crucial to understand the taxonomy and biodiversity of these clams, particularly within the context of Indonesia's rich and diverse ecosystem, to develop appropriate conservation strategies.

Previous research has attempted to characterize the Veneridae clams found along Amal Beach in Tarakan City. Jabarsyah and Arizono (2016) reported the presence of four distinct types of Veneridae clams in the area. Meanwhile, Herliantos *et* *al* (2012) conducted a morphological analysis of one specific type of Veneridae clam, examining only three shell characteristics: thickness, length, and height. However, this limited scope of morphological analysis is insufficient to provide a comprehensive understanding of the morphometric characteristics of Veneridae clams. In contrast, Torii *et a*l (2010) examined ten morphometric characteristics of clams, while Hamli *et al* (2016) studied Meretrix spp. using twelve distinct measurements.

One particular type of Veneridae clam exhibits two unique patterns, one featuring a solid white coloration and the other displaying a black emblem surrounding the white region. These clams are hypothesized to represent a morphospecies, given their distinct color variations. This study aims to conduct a more comprehensive morphometric analysis of these morphospecies Veneridae clams, utilizing twelve distinct morphological measurements. The data obtained will be analyzed using an independent t-test to determine the significance of the observed variations and to provide a robust understanding of the morphometric diversity within this species. This comprehensive morphometric assessment will not only contribute to our understanding of the taxonomy of Veneridae clams but also inform the development of effective conservation strategies to protect these valuable organisms from potential extinction.

Material and Methods

Sampling site: A specific variety of Veneridae clam (Fig. 1), gathered from two distinct locations at Amal Beach was transported to the laboratory for morphological and morphometric examination. The internal organs were extracted from each specimen, leaving only the shells for the morphological analysis.

Attributes of Morphology and Morphometric Analysis

In this study, we examined 24 individuals each of white clam and black-white clam. The morphological structures were identified based on the work of Hamli *et al* (2016). We analyzed a total of 13 shell features, including shell length (SL), shell height (SH), shell width (SW), umbo length (UL), ligament length (LL), anterior length (AL), posterior length (PL), length of cardinal tooth (LCT), length from posterior adductor scar to anterior adductor scar (LPAS), distance from pallial line scar to ventral margin anterior (PVM), adductor scar width (AW), posterior adductor scar width (PW), and an additional characteristic of the pallial sinus open scar (PS) shape.

Statistical analysis

Morphological characteristics were analyzed using an independent samples t-test to assess the significance of observed differences in morphological measurements between the two clam types (WC and BWC). Before conducting the independent sample t-test, data normality and homogeneity of variance tests were performed. The Shapiro-Wilk test was used to test data normality. Data were considered normally distributed if the significance value $p > 0.05$. The Levene test was used to determine data homogeneity. Data were considered homogeneous if the significance value $p > 0.05$. The coefficient of variation was also determined to gauge the extent of data variation from the mean. The null hypothesis in this analysis is that there are no significant differences in morphological measurements between the two clam groups. If the analysis results show a p-value lower than the predetermined significance level ($p < 0.05$), the null hypothesis will be rejected, indicating significant differences in morphological measurements between the two clam groups. Statistical analysis was processed using SPSS version 25 software.

Result and Discussion

Descriptive Statistic

The Shapiro-Wilk normality test results showed that most data were normally distributed. However, some variables had a non-normal distribution with p-values below 0.05. These variables included LPAS and PS for white clams, and SW, LCT, and PW for black-white clams (Table 1). The abnormal data might be due to different sample sizes, outliers, and a limited number of samples. Although the Shapiro-Wilk test is capable of disregarding data non-normality in larger samples, its performance declines in smaller samples (n<50) (Razali and Wah, 2011). Given that a primary requirement for conducting an independent samples t-test is the normal distribution of data, variables SW, LCT, LPAS, PW, and PS were not included in the subsequent independent samples t-test phase to ensure data quality.

Tabel 1. Descriptive Statistic of Morpometric Variables: S.D: standard deviation; CV: coefficient of variation.

Variables	Group					
	WC			BWC		
	Mean value (±SD)	CV	p value	Mean value (±SD)	CV	p value
SL	43.48±9.65	22.19	0.982	47.08±9.11	19.35	0.191
SH	35.15±7.42	21.11	0.827	38.61±8.62	22.32	0.557
SW	25.53±5.23	20.49	0.682	27.23±8.07	29.63	0.015*
LL	9.81±1.86	18.96	0.664	12.33±2.91	23.59	0.615
PL	36.55±7.04	19.26	0.286	38.70±10.30	26.61	0.053
AL	26.24±6.32	24.09	0.374	32.68±10.12	30.97	0.257
UL	34.37±10.90	31.71	0.083	36.86±8.69	23.58	0.616
LCT	15.53±3.72	23.95	0.913	19.04±6.93	36.40	0.001*
LPAS	24.67±5.83	23.63	0.039*	25.12±5.48	21.82	0.290
PW	7.68±1.46	19.01	0.715	8.67±5.54	63.90	0.002*
AW	6.82±1.82	26.69	0.269	6.82±3.48	51.03	0.276
PVM	9.91±2.11	21.29	0.479	9.01±3.96	43.95	0.588
PS	9.55±1.85	19.37	0.038*	9.82±3.79	38.59	0.059

*data exhibits non-normal distribution

Based on the coefficient of variation (CV) values, the morphological data distribution for WC is classified as moderate, with values ranging below 30%. The coefficient of variation is a measurement tool that illustrates the extent to which data variations correspond to the average value. Moderate CV values indicate that differences among WC samples are relatively uniform and not too far from their average value. This suggests that the morphological characteristics of WC exhibit relatively controlled variation (Sokal & Rohlf, 2012). On the other hand, the morphological characteristics of BWC exhibit an inconsistent data distribution, with some values exceeding 30% (Limpert et al., 2001). These higher CV values indicate that the variation among BWC samples is greater compared to WC.

Independent sample t-test

Based on the homogeneity test, several variables were found to exhibit non-homogeneous (heterogeneous) variations. Data homogeneity is determined by the p-value, where data is considered homogeneous if $p > 0.05$. Heterogeneity in data can result from various factors. Some primary causes of data heterogeneity include inconsistent measurement errors among samples, which can lead to data non-homogeneity (Zar, 2010). Therefore, it is crucial to ensure consistent and accurate measurement procedures in research to obtain reliable data.

Tabel 2. Examination of morphologic aspects

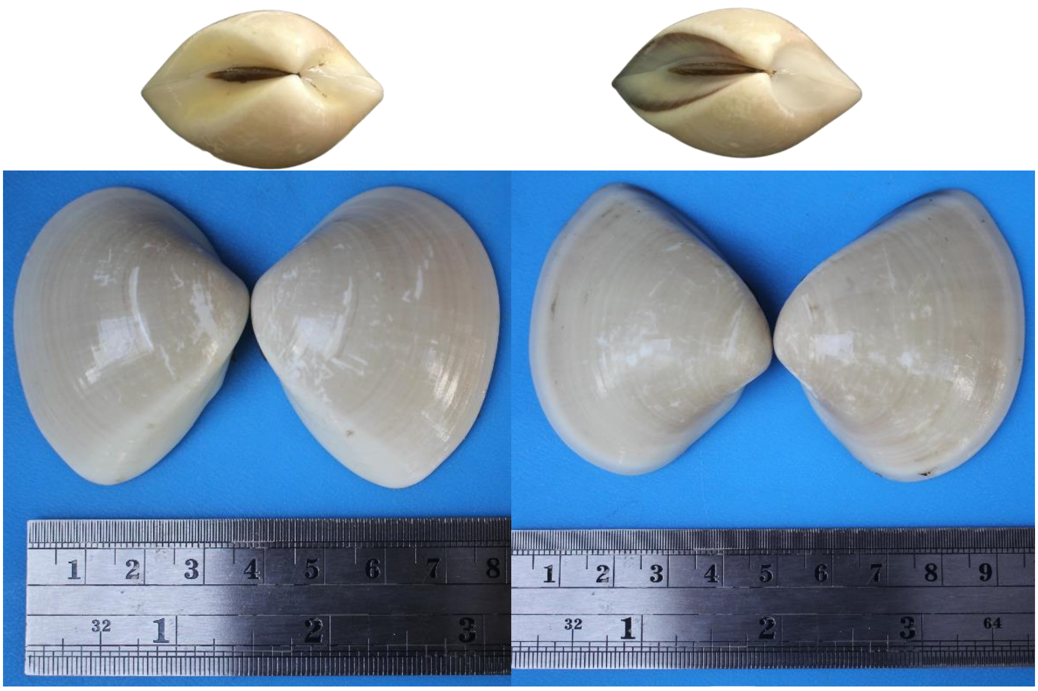
Variable	Group		Independent Samples Test		
	KP	KB			
	Mean±SD	Mean±SD	Levene’s test	p-value	t
SL	43.48±9.65	47.08±9.11	0.989	0.192	-1.326
SH	35.15±7.42	38.61±8.62	0.432	0.143	-1.491
SW	25.53±5.23	27.23±8.07*	0.339	0.391	-0.867
LL	9.81±1.86	12.33±2.91	0.090	0.001***	-3.577
PL	36.55±7.04	38.70±10.30	0.039**	0.405	-0.841
AL	26.24±6.32	32.68±10.12	0.011**	0.011***	-2.644
UL	34.37±10.90	36.86±8.69	0.234	0.386	-0.875
LCT	15.53±3.72	19.04±6.93*	0.071	0.034***	-2.186
LPAS	24.67±5.83*	25.12±5.48	0.761	0.786	-0.273
PW	7.68±1.46	8.67±5.54*	0.003**	0.403	-0.844
AW	6.82±1.82	6.82±3.48	0.001**	0.998	-0.002
PVM	9.91±2.11	9.01±3.96	0.027**	0.329	0.987
PS	9.55±1.85*	9.82±3.79	0.055	0.762	-0.305

*data exhibits non-normal distribution
**data demonstrates non-homogeneity
*** data shows significant differences

Data heterogeneity can be attributed to external influences or outliers as well. Outliers represent values that significantly deviate from the central distribution, which can affect statistical analysis (Barnett and Lewis, 1994). In such situations, applying methods like the IQR (interquartile range) or z-score to detect and address outliers might be necessary to enhance data quality and analysis. Moreover, natural variation is often exhibited by data collected from the same population (Whitlock and Schluter, 2009). This emphasizes the need to comprehend the sources of variation in data and take into account their impact on statistical analysis. Such understanding helps researchers interpret analytical outcomes and minimize the likelihood of analytical error. Based on the outcomes of normality and homogeneity tests, four variables were found to meet the criteria for further analysis, which include SL (Shell Length), SH (Shell Height), LL (Ligament Length), and UL (Umbo Length).

The conducted analysis revealed no significant differences between white and black-white clams regarding the variables SL (Shell Length), SH (Shell Height), LL (Ligament Length), and UL (Umbo Length). The independent sample t-test demonstrated p-values for the variables SL, SH, LL, and UL higher than the established significance threshold ($p > 0.05$). This indicates no significant differences in shell size, shell height, ligament length, and umbo length between the two clam types. The analysis evaluating morphological differences between white and black-white clams, focusing on the variables SL (Shell Length), SH (Shell Height), LL (Ligament Length), and UL (Umbo Length), found no significant differences in these variables between the two clam types (Zhang *et al.*, 2018).

The absence of significant differences in the variables SL, SH, LL, and UL suggests that white and black-white clams possess similar morphological characteristics concerning shell size and shape, as well as ligament and umbo structures. Thus, shell color differences do not affect the morphological aspects measured in this study. These results align with previous studies that also found no significant morphological differences between white and black clams (Herliantos *et al.*, 2012).



a **b**

Fig1. Samples used in this study: a) White Clam (WC) and b) Black-White Clam (BWC)

From these findings, we can conclude that white and black clams exhibit similar morphological characteristics, which may influence our understanding of the relationship between morphological variation and phenotypic differences within the Veneridae family. These results can also provide valuable information for practitioners, such as the fishing industry or conservation efforts, to identify and manage clam resources effectively. Some limitations may affect the interpretation of these results, such as a limited sample size or potential measurement errors. Future research can address these limitations by employing larger samples and more accurate measurement techniques. Additionally, further studies may need to assess other factors potentially influencing morphological variation, such as environmental or genetic factors.

Conclussion

This study investigated morphological differences between white and black-white clams using 13 morphometric measurements. The findings revealed similar morphological characteristics between the two clam groups, suggesting that shell color does not influence the examined traits. However, some data did not follow a normal distribution or were non-homogeneous, which could be due to factors like sample size, outliers, or limited samples. These results provide valuable information for practitioners, such as the fishing industry and conservation efforts.

Limitations of the study include limited sample size and potential measurement errors. Future research should address these limitations by increasing sample sizes, using alternative testing methods, and considering factors causing data heterogeneity. Additionally, further studies may explore other factors potentially influencing morphological variation, such as environmental or genetic factors. To more accurately differentiate between the clams, future research could also employ DNA barcoding techniques as a complementary method to morphological assessments. This approach will help to reveal any potential genetic differences between the clam groups, providing a more comprehensive understanding of their biological distinctions.

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Conflict Of Interest

Except for one author who functions as the editor-in-chief of the journal to which this manuscript is being submitted, the authors declare that there are no conflicts of interest associated with this study. To ensure the integrity and impartiality of the peer review and editorial process, this author has not participated in any aspect of evaluating or deciding the manuscript. All other authors have actively contributed to the research's preparation, execution, and reporting. The Research and Community Service Institution of Borneo Tarakan University's funding has had no impact on the research's integrity, data analysis, or interpretation of the results.

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