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Morphometric Characterisation of Freshwater Clam (*Egeria radiata*) in Three Geographic Locations of South-South Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author UUJ designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors EVI and UUJ managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Egeria radiata is a freshwater clam endemic in some large water bodies in West Africa where it serves the native communities as source of protein, income, etc. Studies on characterisation of exploited species can provide information helpful in predicting their availability, especially in the future. This research engaged nine morphometric traits of the species collected from three different geographic locations in south-south Nigeria – Itu, Southern Ijaw, and Burutu. Statistics used in the analyses were ANOVA, PCA, Coordinate plots of PCs and Hierarchical cluster analysis. Five traits were identified as primary sources of variations. Southern Ijaw samples were peculiar while Itu and Burutu samples were statistically similar. Although environmental influence seems to interact with physiological processes to effect the changes in shell parameters, they are not reliable in this case because the populations were not properly distinguished based on the nine shell-expressed traits engaged in the study. Involvement of molecular technique will, however, give clearer information on the characterisation of the species in the populations of study.

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1. INTRODUCTION

Freshwater clam (*Egeria radiata*) is a bivalve species that belongs to the Phylum Mollusca, Class Bivalvia, Order Veneroida, and Family Donacidae to which it is the only freshwater species [1]. It is among the organisms found along the coastal lagoons and mangrove swamp of West Africa [2]. The species also forms the basis of artisanal fishery in larger freshwater bodies such as Volta River in Ghana, Cross River in Nigeria and Sanaga River in Cameroon; providing employment to several communities therein [3]. In Nigeria, *Egeria radiata* is a very common bivalve species found almost throughout the coastal regions [4,5,6]; its internal structures are shown in Fig. 1. It spawns and develops in freshwater only. However, if transferred into the stagnant water like dams, it will still grow but may not reproduce, and the meat would be less palatable [7]. Therefore, its success is threatened by over-harvesting and dam construction, which modifies the natural habitat of shellfish in general by siltation [8].

Egeria radiata is heavily exploited in the areas where it is abundant [9], that is, it is fished above the level of its optimum yield. In Itu Local Government Area of Akwa Ibom State, it is heavily harvested by artisanal fishermen except between July and November when the water level is high. This act puts pressure on the very young members of the species and can lead to the extinction of the stock if conservation measures are not applied. A number of environmental factors which influence shell properties of bivalve species include water quality, depth, turbulence and current, quality of phytoplankton, type of sediment, amongst others [10].

Daniel and James et al. [3] suggested that in order to avoid extinction of clams, strategies should be made, with the help of community leaders, which prevent the landing of clams less than 50 mm (corresponding to a four-year old clam). The authors also put forward the idea of integrating young clams into the culture system of tilapia by local farmers since clam may not need special feeding, but depend on the phytoplankton and other wastes in their habitat. In such case, any catch less than the recommended harvested size can be sent to the culture system, a practice that can increase the income of the fish farmer. However, fishermen in Ghana have discovered a way of ensuring the availability of this species; which is, the transplanting (or transfer) of young clams to new 'beds' upstream so as to allow them to grow bigger before harvesting [7,9]. Though traditional and less efficient, this practice presents the need for conservation of the species with modern facilities in the regions of its availability. More research on the species would, therefore, make way for scientifically based approaches for its conservation.

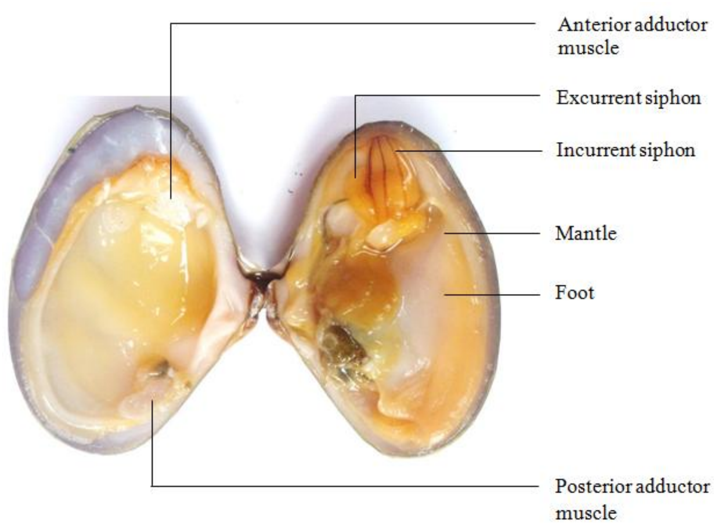

Fig. 1. Internal anatomy of clam

Morphometry is a simple yet useful criterion based on external features and is very useful in the segregation of intra and interspecific groups of populations. So far, researches related to morphometric characterisation of *Egeria radiata* are not available. This is probably because the species is common in West Africa where research is still at a relatively low level. Few researches on *Egeria radiata* are morphologically based and limited to growth studies [1,3,10,11]. However, in the coastal regions of Asia where other clam species inhabit and play useful role both industrially and as a source of protein, researches had been carried out to uncover their genetic structure at the population level in order to use the information for the making of management and conservation decisions. Our research was carried out to assess the geographic variation in morphometric traits of *Egeria radiata* in the three different populations of the south-south region of Nigeria. Since morphology of species is the outcome of genetic and environmental influence, it is believed that this research will provide substantial information necessary for management of this species in Nigeria.

2. MATERIALS AND METHODS

2.1 Sample Collection

A total of 120 mature *E. radiata* samples were collected from freshwater bodies in three different locations of south-south Nigeria. The locations are beaches of Itu Local Government Area of Akwa Ibom State (4°35'N, 8°25'E), Southern Ijaw Local Government Area of Bayelsa State (4°42'N, 5°58'E), and Burutu Local Government Area of Delta State (5°21'N, 5°30'E) (Figs. 2a and 2b). Collection was done between 21st and 23rd May 2016 and the samples were sustained in labelled nylon bags within the range of room temperature.

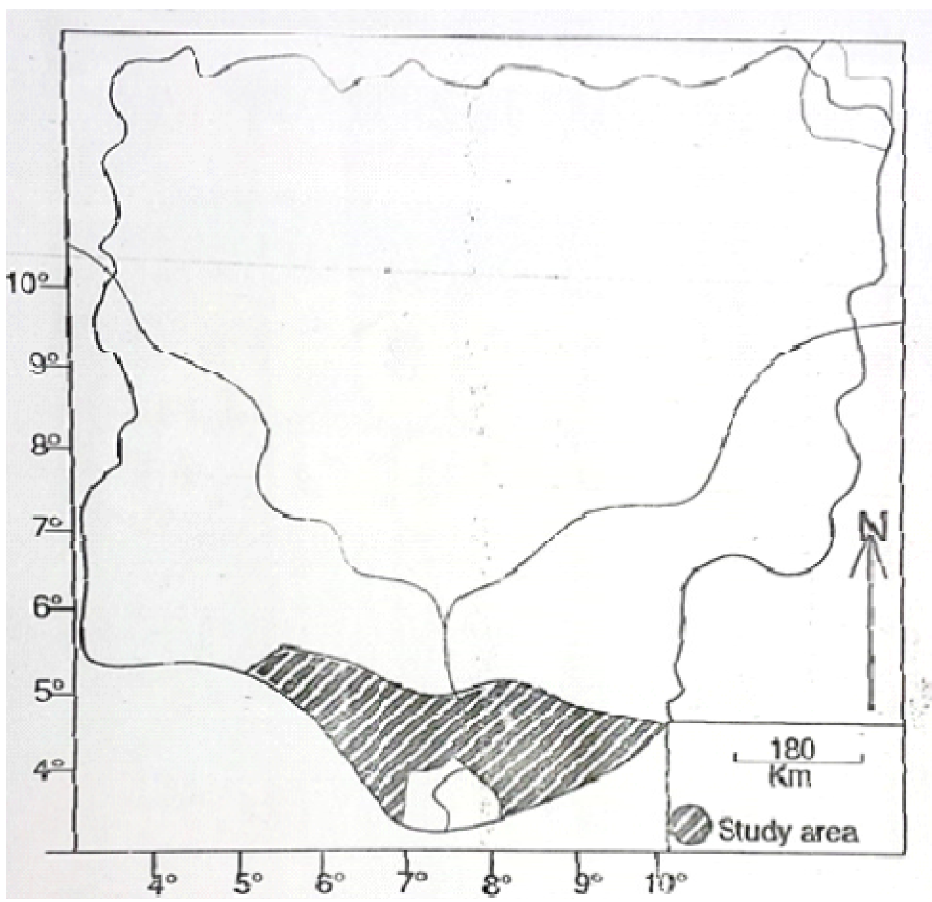

Fig. 2a. An outlined map of Nigeria showing study area

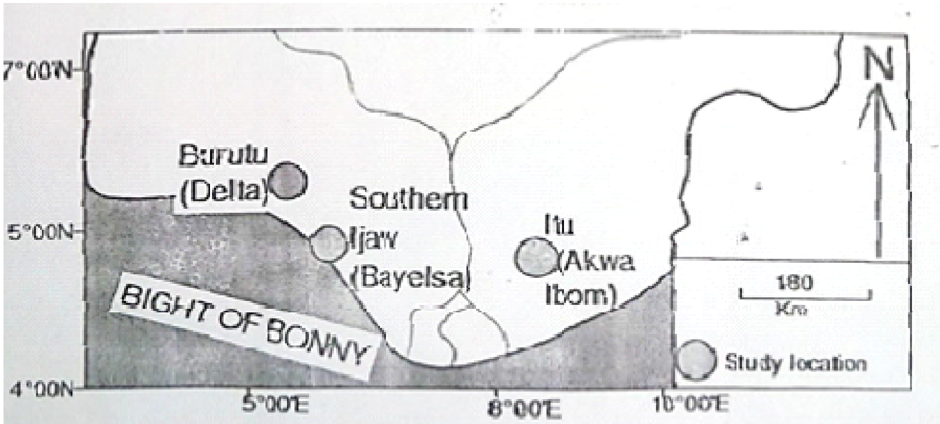

Fig. 2b. Outlined map of Nigeria showing the locations of study

2.2 Morphometric Measurements

A total of nine shell-expressed characters were measured on 40 samples per location with the aid of vernier calliper which gave the dimensions up to the nearest 0.1 mm. The nine characters used in the analyses are length (L), width (W), height (H), posterior length (PL), anterior length (AL), ligament base length (LL), anterior adductor muscle scar length (AAMS), posterior adductor muscle scar length (PAMS), and anterior-posterior adductor muscle scar distance (AP) (Fig. 3). Since it was difficult to obtain samples of exactly the same size, the adjustment formula below was applied to eliminate the size effects.

$$AC_i = Log_{10}OC_i - [\beta \times (Log_{10}TL - Log_{10}MTL)]$$

AC_i = adjusted measurement for a particular character on the i^{th} specimen, OC = original measurement of that character, β = common within-group regression coefficient of $Log_{10}OC_i$ on $Log_{10}TL_i$, TL_i = total length of i^{th} specimen, and MTL = overall mean total length [12].

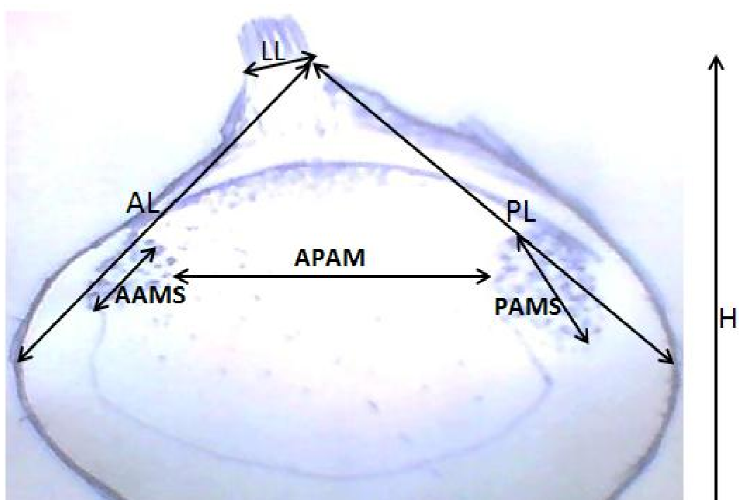

Fig. 3. Expressed characters used in morphometric analyses: L (length); H (height); PL (posterior length); AL (anterior length); LL (ligament base length); AAMS (anterior adductor muscle scar length); PAMS (posterior adductor muscle scar length); AP (anterior-posterior adductor muscle scar distance). Note that W (width), which is the maximum measurement of the sides of a closed shell, is not shown

2.3 Statistical Analyses for Morphometric Traits

Univarite analysis of variance (ANOVA) was performed on the data in order to evaluate the significant difference among the means of the nine morphometric characters on the samples from the three locations of study. To achieve this, lengths (L) from the three populations (each population serving as the factor or group) were subjected to ANOVA. Same was done for the remaining eight morphometric characters. The Tukey HSD post-hoc test was performed on characters which showed a significant difference in order to have a clear idea of which population is different from the other in terms of the character in consideration. Principal component analysis (PCA) was used for multivariate analysis in this study. Hierarchical cluster analysis (HCA) based on Euclidean distance was also used as a means of measuring the morphometric distance between the populations, and the Ward's method was used as a clustering algorithm. In a nutshell, HCA generates a dendogram (tree diagram) which is a visual display of the grouping of the samples based on their statistical relatedness, and can as well give an idea of their genetic status. All statistical analyses for morphometric data were carried out using SPSS version 20 and Microsoft Excel (2010).

3. RESULTS

3.1 Morphometric Traits Analysis of Variance

Morphometric traits in *Egeria radiata* were estimated and subjected to analysis of variance. Results showed that five traits differed significantly ($p<0.05$) when samples from the three populations were compared: width, height, posterior length, anterior adductor muscle scar length and posterior adductor muscle scar length. For the height, anterior length, ligament base length and anterior adductor muscle scar length, there were no significant difference ($p>0.05$) among the morphotypes (Table 1).

3.2 Principal Component Analysis

Principal component analysis (PCA) was also conducted on the three populations based on the nine morphometric traits. Three components were extracted, which cumulatively contributed 60.21 percent to the total variability observed in the three *Egeria radiata* populations; principal component one (PC1) contributed 33.83 percent, PC2 contributed 14.24 percent while PC3 contributed 12.14 percent to the variability. The trait that had the highest communality is the height (0.701) followed by the width (0.688). In PC1, total length, width, height and anterior length (0.820, 0.743, 0.734 and 0.585) contributed highly while for PC2 posterior length, ligament base length as well as anterior adductor muscle scar length (0.732; 0.706; 0.632) contributed meaningfully. Furthermore, in PC3, only posterior adductor muscle scar length and anterior posterior muscle scar distance (0.739; 0.620) contributed significantly to the variability (Table 2).

3.3 Coordinate Plots

The principal component coordinates revealed that there were no much variability observed among the *Egeria radiata* obtained from three populations as there were no clear separation of morphotypes, especially when PC2/PC3 and PC1/PC3 were plotted. However, coordinates PC1/PC2 showed slight cluster separation; especially samples collected from Southern Ijaw as those collected from Itu and Burutu were merged together (Fig. 4).

3.4 Hierarchical Cluster Analysis (HCA)

Using the nine (9) morphometric traits, hierarchical cluster analysis was carried out based on Euclidean distance using Ward's linkage method. The dendogram revealed four (4) clusters. Importantly, the clustering pattern was not based on population as members were mixed up on the same clusters. However, the third cluster to the right of the dendogram is dominated by samples of Ijaw population (Fig. 5).

4. DISCUSSION

Up until now, researchers have done few works on *Egeria radiata*, thus, little knowledge about it is available. This research has, however, shed more light on this species in Nigeria. The nine morphometric traits selected for this study prove effective as revealed by ANOVA results, which showed significant difference in five traits across the populations of study – width, height, posterior length, anterior adductor muscle scar length, and posterior adductor muscle scar length. Furthermore, these five traits showed high value in their respective principal components. They must have, therefore, constituted high percentage of the between-population differences obtained during analyses.

Table 1. Morphometric traits in *Egeria radiata* from the three locations of study

Parameters(cm)	Itu	Southern Ijaw	Burutu
Total length	7.690±0.122[a]	7.565±0.110[a]	7.731±0.099[a]
Width	3.736±0.047[ab]	3.593±0.066[a]	3.840±0.056[b]
Height	5.059±0.094[b]	5.550±.079[a]	6.081±0.086[b]
Anterior length	4.336±0.075[a]	4.182±0.058[a]	4.286±0.058[a]
Posterior length	5.641±0.092[b]	5.334±0.083[a]	5.529±0.072[ab]
Ligament base length	0.962±0.037[a]	1.003±0.036[a]	0.946±0.034[a]
Anterior adductor muscle scar length	1.674±0.029[c]	1.464±0.029[a]	1.577±0.019[b]
Posterior adductor muscle scar length	1.395±0.027[b]	1.245±0.021[a]	1.316±0.022[ab]
Anterior posterior muscle scar distance	5.107±0.088[a]	5.103±0.084[a]	5.112±0.068[a]

Means followed with same superscript along horizontal array indicate no significant difference (p>0.05)

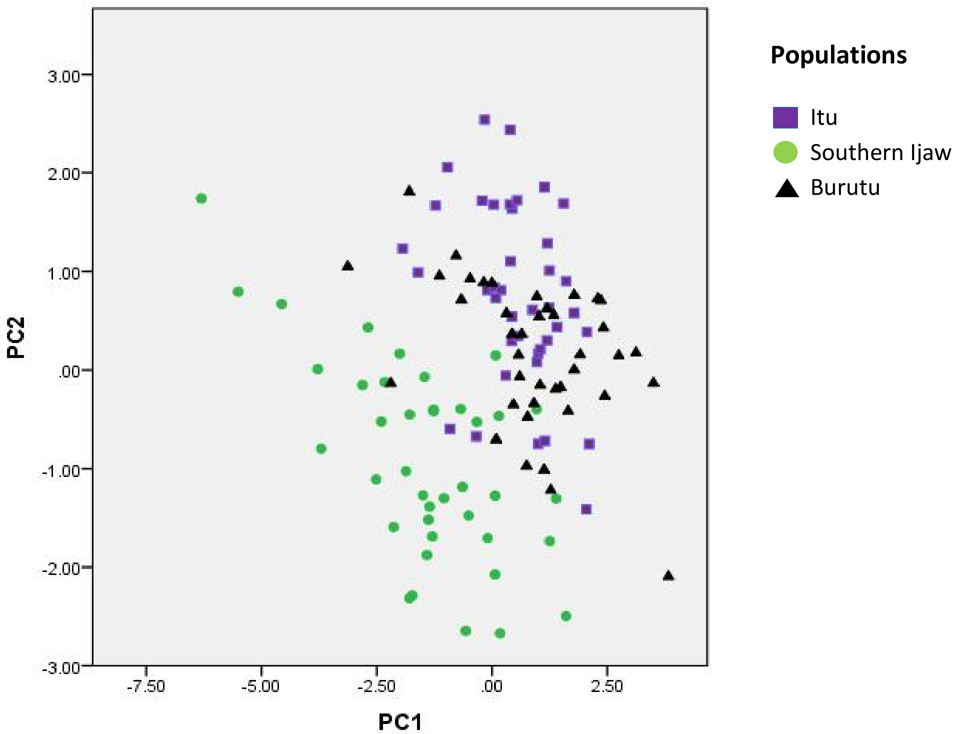

Fig. 4. Coordinate plot of the first two axes of principal component on *Egeria radiata* from the three populations of study based on the nine morphometric traits

Table 2. Principal component analysis of the nine morphometric traits in pooled samples of *Egeria radiata* from the three populations of study

Morphometric traits	PC1	PC2	PC3	Communality
Total length	0.820	-0.021	-0.121	0.626
Width	0.743	0.372	-0.101	0.688
Height	0.732	0.124	0.210	0.701
Anterior length	0.585	0.518	-0.124	0.522
Posterior length	0.261	0.732	0.042	0.596
Ligament base length	0.218	0.706	0.201	0.623
Anterior adductor muscle scar length	-0.054	0.632	-0.350	0.606
Posterior adductor muscle scar length	0.086	-0.264	0.739	0.587
Anterior posterior muscle scar distance	-0.146	0.249	0.620	0.468
		Components matrix		
Eigen value	3.045	1.281	1.093	
Proportion of variation (%)	33.833	14.238	12.139	
Cumulative variation (%)	33.833	48.070	60.209	

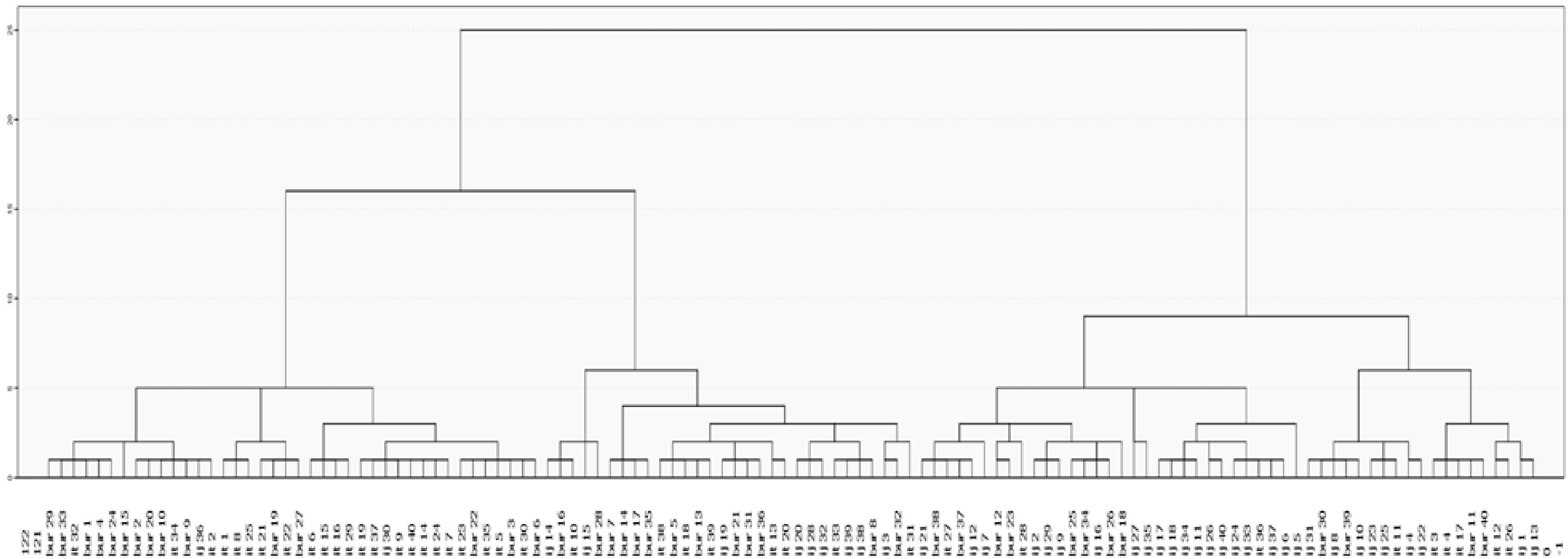

Fig. 5. Hierarchical cluster analysis based on the nine morphometric characters on *Egeria radiata* from Itu, Southern Ijaw, and Burutu
it – Itu; ij – Southern Ijaw; bur – Burutu

Further analyses of the traits revealed that Southern Ijaw samples appeared to be exclusive, while Itu and Burutu samples showed close similarity based on the traits in consideration. In other words, there was a noticeable separation of Southern Ijaw population from the other two populations which are geographically more distant but morphometrically similar. A careful look at the coordinate plot reveals that Southern Ijaw samples are distributed towards the left of the zero origin while Itu and Burutu are intermingled and shifted away from the centre towards the right. Hamli et al. [13] report that salinity, suspended solids, ferrous, and pH are among the factors that can affect bivalves in their habitat. Furthermore, [14] equipped that the structure of bivalve shell is influenced by both physiological and environmental factors: quality of phytoplankton, water quality and depth, sediment, and type of bottom (sandy or muddy). Based on these, phenotypic modulation in response to external environment and non-genetic mechanisms can lead to maintenance or variation of shell structure of species in different habitats [15]. Our outcome, which is further supported by the hierarchical cluster analysis, suggests that anthropogenic activities such as dredging, effluent discharge, use of chemicals in fishing, and crude oil spillage might be acting on these populations such that the overall effects on the morphometric traits of study are similar in Itu and Burutu populations, but take another course in Southern Ijaw population.

5. CONCLUSION

Statistical information was very useful in this research since ordinary physical examination of shapes and structures of samples did not show population-based distinction. Also, the statistics based on the nine shell-expressed traits presented a good information on the samples but not sufficient to characterise them according to their respective populations. Environmental influence, upon which this study seems to rely, appears to be a weak source of variation among the populations of *Egeria radiata* in consideration. Therefore, incorporation of molecular techniques will present a clearer distinction of the species in the three populations of study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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