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Spatial density, size, growth and condition index of mangrove clam (*Polymesoda erosa*) in the estuarine portion of Pasak River, Sasmuan, Pampanga, Philippines

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Abstract
The assessment was conducted from September to November, 2018 to provide baseline information on the population status of mangrove clam, *Polymesoda erosa* in the estuarine areas of Pasak River, Sasmuan, Pampanga. Transect-quadrant method was employed in the collection of clam samples from the three established study sites. Results revealed that no significant variations on the spatial density, size structure, growth pattern and condition index of the mangrove clam in the study areas ($p>0.05$). Generally, the biological parameters indicate low density, unimodal to bimodal size distributions, negative allometric growth, and very low condition index which suggest poor condition of mangrove clam population in the study sites. The information derived from the condition index analysis is useful in identifying future brood stocks in the hatchery operations and future management directions to help increase clam population in the area and sustain its economic contribution.

Keywords: Spatial density, size structure, growth pattern, condition index, mangrove clam, *Polymesoda erosa*

Introduction
Philippines is endowed with vast water resources which include estuaries, rivers and swamps. The estuarine areas have sprawling mangroves playing preponderant role in coastal communities. However, mangroves varies in composition and structure as to substrate type and climatic condition [1] which provide suitable refuge for various fishes and shellfishes [2].

In the province of Pampanga located in Central Luzon, mangroves are widespread in three coastal municipalities of Sasmuan, Macabebe and Lubao. In Sasmuan, the prevalence could be linked to the presence of the Pasak River that connects the inland portion of the town to Manila Bay. The estuarine portions of the river are now receiving considerable attention. Recently, an ecotourism site and non-fishing zone was established to enhance the recruitment of fish. Also, this area aims to provide safe haven for migratory birds.

Bivalves are considered common resources in the estuarine areas of Pampanga River and its interconnected channels and creeks. These organisms especially the populations harvested in *Mangal* forests are having great importance in providing the required protein intake and income of coastal communities. The mangrove clam, *Polymesoda erosa* (Figure 1) from the family Corbiculidae is mostly preferred due to its higher meat recovery and palatability. It is a non-seasonal species widely distributed in the Indo-Pacific region which includes the Philippines [3]. The bivalve was reported to be resilient to adverse environmental condition. This characteristic of the species made it a potential candidate for growing in confinements [4]. The species were used as an indicator of heavy metals [5, 6] and organic pollutants [7]. In spite of its immense role, information regarding its biological status in the riverine system of the province is still lacking. The spatial density and other biological parameters such as size structure, growth pattern, and condition index of the clam could be important measurements to determine its biological status and level of extraction. Hence, this study was carried out in Pasak River, Sasmuan, Pampanga.

Fig 1: Mangrove Clam (*Polymesoda erosa)*

Materials and Methods
Assessment Area
The estuarine portion of the assessment area was the Pasak river located at Sasmuan, Pampanga during September to November 2018. Three stations in the estuarine portion using line transect - quadrant method in the sprawling mangrove trees of the river located at Barangay Malusac, Batang 2nd and Sto. Rosario were established (Figure 2). Coordinates of each sampling station were identified using a GPS receiver application installed in Vivo v5 android phone.

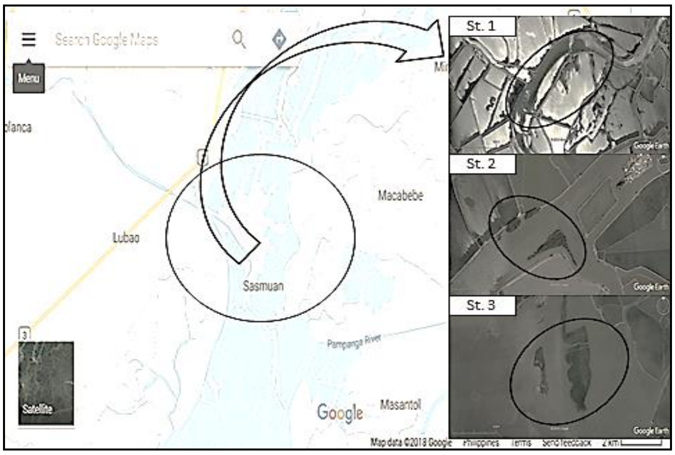

Fig 2: Location of the Study

Station	Geographic Position
St. 1	14°50'17.42"N 120°36'14.58"E - 14°50'14.00"N 120°36'8.47"E
St. 2	14°49'37.28"N 120°35'48.50"E - 14°49'40.41"N 120°35'40.95"E
St. 3	14°47'51.55"N 120°37'18.55"E - 14°48'0.08"N 120°36'57.15"E

Clam Collection and Analysis
The population density of the clam was computed using the formula, $D = ni/A$ where: D = density of the mud clam, ni = number of individuals mud clam, and A = total area sampled. Size distributions of mangrove clam were presented using shell length, shell width and total weight to determine the commonest size. Morphometric and gravimetric measurements were obtained by using Vernier caliper (1 mm sensitivity) and digital weighing balance (0.01 gram sensitivity) respectively. The growth pattern of the animal was ascertained by using the equation: $W = aL^b$ where W= weight (g), L= total length (cm), a = constant - intercept, b= growth exponent. Furthermore, the expression was adjusted to a linear function by taking the logarithm of both sides of the equation presented as: $\text{Log } W = \log a + b \log L$. The relationship between length and weight was further analyzed through the calculation of correlation coefficient as follows: $r = \sum(\log L \times \log W)/(\sum(\log L^2) \times \sum(\log W^2))^{1/2}$. Statistical significance to the isometric value (b = 3) or allometric range (negative allometry: b< 3 or positive allometry: b>: 3) was analyzed using the modified t-test with a 95% confidence interval [8] : $t = (b-3)/sb$, where t = t-test value; b = slope (regression coefficient); sb = standard error of the slope (b). Meanwhile, condition index was estimated according to the method of Rainer and Mann (1992) [9]. The following equation based on gravimetric measurements and relationships was used in the estimation of the clam's condition index: (1) $Ci = (DTW/DSW)*100$, where Ci = condition index; DTW = dry tissue weight; and DSW = dry shell weight. Dry tissue and shell weights were obtained by subjecting the individual sample to drying oven at 60°C for 48 hours. The values of condition index were also verbally interpreted according to fatness categories [10] (when $Ci \leq 2.0$ – thin, Ci = 2.0-4.0 – moderate, $Ci \geq 4.0$ – fat). Comparison of means of biological parameters among sampling stations was made using one-way analysis of variance (ANOVA) with the aid of Microsoft Excel ver. 2010.

Results and Discussion
Spatial density
The spatial density of mangrove clam in station 1 (2.30 individuals per square meter) is higher compared to other sampling stations (station 2 – 1.58 and station 3 – 1.82 individuals per square meter) (Table 1). However, analysis of variance (ANOVA) on the density variation of mangrove clam in three sampling stations failed to show any significant difference ($p>0.05$). This result suggests that mangrove clam population density did not vary among areas which could be attributed to the identical physical features of these areas. The sampling areas were characterized by dense cover of mangrove trees such as *Rhizopora*, *Avicenia* and *Bruguiera* species. These areas were also exposed to the atmosphere during low tide. According to previous accounts, this species of clam preferred to inhabit mangrove areas [3] because of its subtle nature to support the nutritional needs of various forms of organisms [11].

Table 1: Spatial differences of mangrove clam density in Pasak River.

Station	Density (ni/m^2)			Total	Average
	Period 1	Period 2	Period 3		
Station 1	2.25	1.95	2.70	6.90	2.30
Station 2	1.90	1.55	1.30	4.75	1.58
Station 3	2.05	1.60	1.80	5.45	1.82

Size Structure
Table 2 presents the unimodal to bimodal length, width and weight distributions observed in the three stations indicating variations in the ages and status of individual clam. Findings showed that bimodal distribution was observed in station 1 showing the dominance of two shell length measurements. Modal lengths of the population in this station were 50 and 60 mm. In station 2, shell length analysis also revealed a bimodal distribution with common lengths of 43 mm and 46 mm. With regard to shell length structure in station 3, only a single mode was observed on the distribution showing a peak of 59.0 mm.

Comparing the length structure of *P. erosa* in different sampling stations, it was noted that station 1 has the widest range while station 2 recorded the greatest mean shell length which could be attributed to the higher modal length observed in this station. However, analysis of variance failed to show any significant variation on the shell length among sampling stations (p>0.05) (Table 2). This infers that shell length of the species in these three stations were comparable, which are linked to the identical features and environmental condition of the areas. According to Clemente (2007) [12], shell length from 1.5 to 102 mm is predominated by size classes between 70 to 80 mm which is considered an adult population likewise, the length of more than 30 mm is already classified as adult stage or mature size shell. Analyzing the station-wise data, it can be noted that majority of the individuals collected from the three stations have already reached adult or mature stage. The dominance of this population could be due to weak fishing pressure.

The width and length of the shell is another morphometric character to determine the growth and age of the clam. Although it is an important parameter related to the soft tissue mass of the clam, this dimension is not a direct measure of body size due to different external factors that control its change. The result showed slight variation on the mean width measurement however, these figures bared no significant difference (p>0.05) among sampling stations (Table 2). As to width structure of *P. erosa* collected in station 1, a single mode was observed in the distribution with peak at 53 mm. while in station 2 and 3, the peak was noted at 50 mm having a single mode. The width of *P. erosa* among sampling stations might be caused by abiotic factors [13]. The habitat status of the clam could be a major factor on its morphometric characteristics. According to Lajtner et. al. (2004) [13], shallower habitat may produce higher shell length and shell width ratio compared to deeper habitat. The sampling stations were found to be similar in which shell width was found comparable.

Table 2: Spatial size structure of mangrove clam

Station	Sample size	Length (mm)			Width (mm)			Total Weight (g)		
		Min	Max	Mean	min	Max	Mean	Min	Max	Mean
Station 1	127	32.1	73.5	49.0	35.7	84.5	54.3	15.0	283.0	64.2
Station 2	103	29.6	65.2	47.4	32.3	70.4	52.6	16.0	114.0	59.9
Station 3	114	32.0	70.0	50.5	34.4	76.0	55.7	14.0	158.0	66.7

Weight structure of *P. erosa* in different sampling stations was also presented in Table 2 wherein two modal weights were observed in station 1 (50 g and 60 g), while in station 2 and 3, distribution is characterized by a single mode at 50 g. However, based on the analysis of variance (ANOVA), no significant difference was revealed on the weight structure collected in three established stations. The comparable weight collected in different stations could be linked to the similarity of the areas. Although not directly studied, this result could also be attributed to the reproductive state of the clam [14] in which most of the specimens had already reached maturity stage. It was observed that *P. erosa* individuals with fully-grown shells are heavier that could be due to increase in shell mass and the amount of fluid inside the shell.

Growth Pattern

As shown in Table 3, the coefficient b of the shell length and total weight relationship was 2.45, 1.86, and 2.29 for station 1, 2 and 3, respectively. However, clam in station 1 had higher b value inferring that this area is more suitable compared to other stations for clam growth. Nevertheless, the range of b values of clam is between 1.86 and 2.45 which is lower compared to the common range of b values found in *P. erosa* by Clemente (2007) [12], Sarong (2010) [15], Argente et. al. (2015) [4], and Elvira and Jumawan (2017) [16].

Furthermore, the b values obtained are significantly different from the isometric value (b≠3) (Table 3). The findings revealed that *P. erosa* collected in three sampling stations are growing in a negative allometric pattern (b<3) which implies that the larger the species the smaller their soft tissues [17]. In addition, negative allometric growth indicates that shell length increases faster compared to the total weight of the clam. This situation may imply exposure to negative level of environmental factors and insufficient food supply. Comparing the growth pattern of clams in different sampling stations, analysis of variance (ANOVA) on the regression coefficient of clam failed to bare a significant difference (p>0.05) suggesting that individuals are probably sharing similar environmental conditions.

Table 3 presents the range of correlation coefficient (r) among sampling stations from 0.87 to 0.90. The relationship of shell length and total weight of *P. erosa* showed a strong positive correlation indicating that there was a corresponding and proportionate increase in weight with increasing shell length of the species. Moreover, determination coefficient (r^2) ranged between 0.76 to 0.81. This means that 76 to 81% of the total variation in the total weight of clam can be explained from the linear model while 24 to 19% of the total variation remained unexplained. This suggests that contribution of the shell length in the total weight of clam cannot be neglected. However, shell length as a variable is still not a good predictor of clam weight due to this large percentage of unexplained variation in the model. This result conforms to the findings of previous studies of Sarong, 2010 [15]; Argente, 2015 [4]; Elvira and Jumawan, 2017 [16] except on the findings of Clemente (2007) [12] which noted a lower value. This disagreement may be related to a distinct ecological condition of different locations.

Table 3: Growth Pattern of clam in terms of shell length and weight relationship.

Station	n	Shell Length-weight Relationship						
		r	r^2	a	b	S.E.(±95% CI of b)	t	Growth Pattern
Station 1	127	0.90	0.81	-2.37	2.45	0.10(2.25-2.66)	b≠3	(-) Allometric
Station 2	103	0.87	0.76	-1.36	1.86	0.10(1.65-2.07)	b≠3	(-) Allometric
Station 3	114	0.88	0.78	-2.10	2.29	0.11(2.06-2.51)	b≠3	(-) Allometric

As regard to the relationship of shell width and total weight of the clam, negative allometric pattern was also noted (b<3) as shown in Table 4. This means that growth in shell width is faster than the increase in the weight of clam. Highest b value was recorded in station 1 (2.51), followed by station 3 (2.50) and lowest was recorded in station 2 (1.93). However, analysis of variance showed no significant difference among sampling stations (p>0.05) which is not in conformity to the findings of Clemente (2007) [12] but is in accordance to the results of Gimin et. al. (2004) [18]. According to Currey (1988) [19], the adverse environmental conditions trigger the need for strong shells and a high capacity to live. Thus, the allocation of energy to shell growth might be higher instead of the soft organ which shifts growth into a negative allometric pattern. The condition of the environment and availability of food is still a major factor that determines the growth of an organism.

In terms of correlation between shell width and total weight, computed range was between 0.87 to 0.92 (r values) with station 1 emerged as the highest among sampling stations (Table 4). Statistical analysis, however, disclosed a strong positive relationship between these variables (p<0.01). This means that clam's total weight increases by an additional increase in its shell width. The corresponding determination coefficient (r^2) ranged 0.75 to 0.84 (r^2 values) suggesting that 75 to 84% of the total variation in terms of weight is accounted for by the linear relationship with the values of shell width.

Table 4: Growth Pattern of clam in terms of shell width and weight relationship.

Station	n	Shell Width-Total Weight Relationship						
		r	r^2	a	b	S.E.(±95% CI of b)	t	Growth Pattern
Station 1	127	0.92	0.84	-2.59	2.51	0.10(2.32-2.71)	b≠3	(-) Allometric
Station 2	103	0.87	0.75	-1.56	1.93	0.11(1.71-2.15)	b≠3	(-) Allometric
Station 3	114	0.89	0.79	-2.57	2.50	0.12(2.26-2.74)	b≠3	(-) Allometric

Condition Index

The result revealed a comparable condition index of *P. erosa* among sampling areas (p>0.05). This result could be linked to the similarities of the sampling areas. The locations were subjected to temperature, salinity and tidal fluctuations which could affect the condition index of the clam [20]. However, verbal interpretation of values showed that clams in station 1 and 3 are categorized as moderate compared to station 2 which gained an interpretation of thin (Table 5). The condition index of *P. erosa* is lower than the typical range reported by Rizal (2010) [21] which is from 3.0 to 4.0% and relatively close with those other bivalve species [20, 22, 10].

Table 5: Condition index of mangrove clam in Pasak River.

Stn.	Dry Tissue Weight (g)			Dry Shell Weight (g)			Condition Index (%)			
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Verbal Interpretation
Station 1	0.2	1.3	0.5	5.2	70.0	26.3	1.0	3.7	2.0	Moderate
Station 2	0.1	0.8	0.5	5.6	57.7	25.9	0.8	2.7	1.8	Thin
Station 3	0.1	1.3	0.4	3.5	63.0	27.1	0.9	3.9	2.1	Moderate

Conclusions

The habitat status of the clam could be a major factor on its morphometric characteristics. However, the relationship of shell length and total weight of *P. erosa* showed a strong positive correlation indicating that there was a corresponding and proportionate increase in weight with increasing shell length of the species. Furthermore, The relationship of shell width and total weight of the clam had negative allometric pattern which means that growth in shell width is faster than the increase in the weight of clam, and the larger the species the smaller their soft tissues. In addition, the condition index of the bivalve is a close measure of its reproductive development changes however, results revealed a comparable condition index of *P. erosa* among sampling areas.

Although not directly studied, the result may suggest that the clam population during the period of the assessment is exposed to unfavorable environment and insufficiency of food. Moreover, the condition index can be correlated to their very low tissue weight which resulted in a negative allometric growth. The information derived from the condition index analysis is useful in identifying future brood stocks in the hatchery operations and future management directions to help increase clam population and sustain its economic contribution.

References

1. Lovelock CE, Feller IC, McKee KL, Thompson R. Variation in mangrove forest structure and sediment characteristics in Bocas del Toro, Panama. Carribean Journal of Science. 2005; 41(3):456-464.
2. Ellison JC. Climate Change Vulnerability Assessment and Adaptation Planning for Mangrove Systems. World Wildlife Fund (WWF): Washington, DC, USA, 2012, 142.
3. Ingole BS, Naik S, Furtado R, Ansari ZA, Chatterji A. Population characteristics of the mangrove clam, *Polymesoda* (geloina) *erosa* (Solander, 1786) in the Chorao mangrove, Goa. A paper presented at the National Conference on Coastal Agriculture. Helbaticar, Old Goa, India. 2002.
4. Argente FAT, Garcia AC, Aban SM, Capinpin EFC, Bautista LM. Biology and Aquaculture Potential of the Mud Clam, *Polymesoda erosa* (Solander 1786) (Bivalvia: Corbiculidae) in Santiago River, Dagupan City, Pangasinan, Northern Philippines. A paper presented during the 1st ICoNSIE and 14th annual scientific conference of the Philippine Society for the Studies of Nature. Hotel Stotsenberg, Clark, Pampanga, 2015.
5. Edward FB, Yap CK, Ismail A, Tan SG. Interspecific variation of heavy metal concentrations in the different parts of tropical intertidal bivalves. Water Air Soil Pollution. 2009; 196:297-309.
6. Elvira MV, Garcia CM, Calomot NH, Seronay RA, Jumawan JC. Heavy metal concentrations in sediments and muscles of mud clam *Polymesoda erosa* in Butuan Bay, Philippines. Journal of Biodiversity and

Environmental Sciences (JBES). 2016; 9(3):47-56.
7. Bayene S, Wurl O, Karuppiah S, Sivasothi N, Lee HK, Obbard JP. Persistent organic pollutants in mangrove food webs in Singapore. Chemosphere. 2005; 61:303-313.
8. Lleonart J, Salat J GJ, Torres GJ. Removing allometric effects of body size in morphological analysis. Journal of Theoretical Biology. 2000; 205:85-93.
9. Rainer JS, Mann R. A comparison of methods for calculating condition index in eastern oysters Crassostrea virginica (Gmelin, 1791). J Shellfish Res. 1992; 11(1):55-58.
10. Rahim AA, Idris MH, Kamal AHM, Wong SK, Arshad A. Analysis pf condition index in *Polymesoda expansa* (Mousson, 1849). Pakistan Journal of Biological Sciences. 2012; 15(13):629-634.
11. McIntosh DJ, Ashton EC, Havanon S. Mangrove rehabilitation and intertidal biodiversity: A study in the Ranong Ecosystem, Thailand. Estuarine, Coastal and Shelf Science. 2002; 55:331-345.
12. Clemente S. Ecology and population dynamics of the mangrove clam *Polymesoda erosa* (Solander, 1876) in the mangrove ecosystem. Unpublished Thesis (Ph.D.) - Goa University, Goa, India. 2007.
13. Lajtner J, Marusic Z, Klobucar GIV, Maguire I, Erben R. Comparative shell morphology of the zebra mussel, *Dreissena polymorpha* in the Drava River (Croatia). Biologia. 2004; 59:595-600.
14. Thórarinsdóttir GG, Jóhannesson G. Shell length-meat weight relationships of the ocean quahog, *Artica islandica* (Linnaeus, 1767), Icelandic Waters. J Shellfish Res. 1996; 15(3):729-733.
15. Sarong MA, Daud AM, Wardiah W, Dewiyanti I, Muchlisin ZA. Gonadal histological characteristics of mud clam (*Geloina erosa*) in the estuary of Reuleung River, Aceh Besar District, Indonesia. Aquaculture, Aquarium, Conservation & Legislation - International Journal of the Bioflux Society. 2015; 8(5):708-713.
16. Elvira MV, Jumawan JC. Species abundance distribution of mud clam (*Polymesoda erosa*) in selected mangrove wetlands of Butuan Bay, Philippines. Journal of Biodiversity and Environmental Sciences. 2017; 11(3):1-6.
17. Udo PJ. Length-weight/girth relationship and condition factor of the periwinkle *Tympanotonus fuscatus*, (Cerithidae: Gastropoda) of the Cross River, Nigeria. International Journal of Fisheries and Aquatic Studies. 2013; 1: 26-28.
18. Gimin R, Mohan R, Thinh LV, Griffiths AD. The relationships of shell dimension and shell volume to live weight and soft tissue weight in the mangrove clam *Polymesoda erosa* (Solander, 1786) from northern Australia. NAGA, WorldFish Centre Quarterly. 2004; 27:32-35.
19. Currey JD. Shell form and strength. In E.R. Trueman and M.R. Clarke (eds.). The Mollusca: Form and Function. Academic Press, London, 1988, 183-210.
20. Mercado-Silva N. Condition index of the eastern oyster, *Crassostrea virginica* (Gmelin, 1791) in Sapelo Island Georgia – Effects of site, position on bed and pea crab parasitism. Journal of Shellfish Research. 2005; 24(1):121-126.
21. Rizal S. The Utilization of brackishwater pond for experimental test for mud clams culture, *Polymesoda erosa* (Solander, 1786) in Mahakan Delta, East Kalimatan Province. M. Sci. Thesis, Universitas Diponegor, Semarang, 2010.
22. Sahin C, Duzgunes E, Okumus I. Seasonal variations in condition index and gonadal development of the introduced blood cockle *Anadara inaequavalvis* (Bruguire, 1789) in the southeastern Black Sea Coast. Turk. J Fish. Aquatic Sci. 2006; 6:15-163.