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Length – Weight Relationships of *Anodontia edentula* from Mangrove Habitats of Surigao City, Philippines

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Abstract

The study was conducted to assess the length-weight relationships of *Anodontia edentula* from mangrove habitats of Surigao City, Philippines. A total of 180 individual clam species used to determine the relationships of shell length (SL), shell height (SH), and shell width (SW) with the total weight (TW) and soft-tissue weight (STW). The paired variables on SL-TW, SH-TW, SL-STW, and SH-STW showed positive allometric growth with b-values ranging from 3.1484 to 3.3798. The relationship of the shell width to the total weight (b=2.6402) and shell width to soft-tissue weight (b=2.7684) showed a negative allometric pattern indicating the growth in shell width is faster than its weight. It implies that the larger the species, the smaller its soft tissue. The highest correlation values recorded were in SH – TW (r2=0.9372), and SH – STW (r2=0.8701) relationships denote that shell height is a good weight growth estimator for A. edentula from the mangrove habitats of Surigao City, Philippines. Further studies along this line may be conducted for the conservation, management, and production of *A. edentula* species.

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Introduction

Mangroves play ecological importance to the ecosystem and an economic significance to coastal communities. They are essential in stabilizing and protecting shorelines from erosion as their root systems help induce current velocities and hold sediments (Selvam and Karunagaran, 2004; Yahya *et al.*,2018). They provide suitable refuge for various fishes and shellfishes (Ellison, 2012; Mendoza *et al.*, 2019). Fisheries products from mangroves are essential for food security and income. Popular among these species are crustaceans and bivalve mollusks like *Anodontia edentula* (Primevera *et al.*, 2002).

Anodontia edentula Linne 1758, a mangrove clam species, is locally known as *"imbao"* (Ryan, 2000) or "*libo-o*" (in Surigaonon dialect) belonging to Class Bivalvia, Order Veneroida, and Family Lucinidae (WoRMS, 2019). It inhabits 30 – 90 cm deep in the muddy bottom of mangrove areas or adjacent mudflats (Adan, 2000).

It is widespread in the Philippines (Poutiers, 1998; Primevera *et al.*, 2002), and is ample in Visayas and Mindanao (Adan, 2000). It is one of the highly – prized shellfishes, which motivates fishermen to exploit the resources by widespread harvesting that has reportedly damaged mangrove stands (Walters, 1995). With the destruction and over-exploitation of mangroves that serve as home, the mangrove clam *A. edentula* declined in numbers (Dela and Junelyn, 2004; Enriquez *et al.*, 2017). According to Garcia (1986), *A. edentula* and other Philippine bivalves of higher market value have become less available.

In the Northeastern part of Mindanao lies Surigao City, where some of its coastal areas covered with mangrove ecosystems providing habitats for mangrove clam species, *Anodontia edentula*. Locals collected these species as an essential source of food and livelihood. However, despite its attractive market value, some local middlemen and market vendors complained about the decreasing clam sizes and numbers. Collectors also whined on the physically grueling and risky ways of collecting (i.e., locating clams with bare feet, then digging them with bare hands) with a small catch.

With the economic importance of *Anodontia edentula*, the use of length–weight relationship (LWR) is essential in generating useful information for the assessment of the growth and production of species (Aban *et al.*, 2017). Allometric relationship established through shell measurement is a nondestructive and straightforward method in estimating biomass and total flesh production (Ross and Lima, 1984). To evaluate soft-tissue growth in bivalve, the robustness between shell morphology and soft – tissue weight should be established (Gimin *et al.*, 2004). Evaluation of relative (allometric) growth provides useful information to understand the development of organisms, as well as to aid in the management of fishery – exploited species (Turra *et al.*, 2018). At present, a sufficiently fine scale of the biological data of *A. edentula* inhabiting the mangrove areas of Barangay Nabago is not yet available.

Thus, this study aimed to assess the length–weight relationship of *Anodontia edentula* from the mangrove habitats of Surigao City using the paired variables, such as (1) shell length and total weight; (2) shell height and total weight; (3) shell width and total weight; (4) shell length and soft tissue weight; (5) shell height and soft tissue weight; and, (6) shell width and soft tissue weight to provide baseline information of *A. edentula* growth pattern for management and conservation of the said bivalve species.

Materials and methods

Study Area

Surigao City is located at the northeastern part of Mindanao with geographical coordinates of 9° 47' 02" N, 125° 29' 20" E. Based on the 2016 Surigao Ecological Profile, it has a 2, 757 hectares of mangroves areas covering mostly the coasts of the island and mainland barangays. One of the clam species inhabiting the mangrove habitats is the

Anodontia edentula and abundantly observed in barangay Nabago, per informal interview from the personnel of the Bureau of Fisheries and Aquatic Resources (BFAR) of the city. The live samples of The *Anodontia edentula* were collected by local collectors (known as “manlibo-ay”) from this barangay more or less one meter deep from the muddy substrate of its mangrove area.

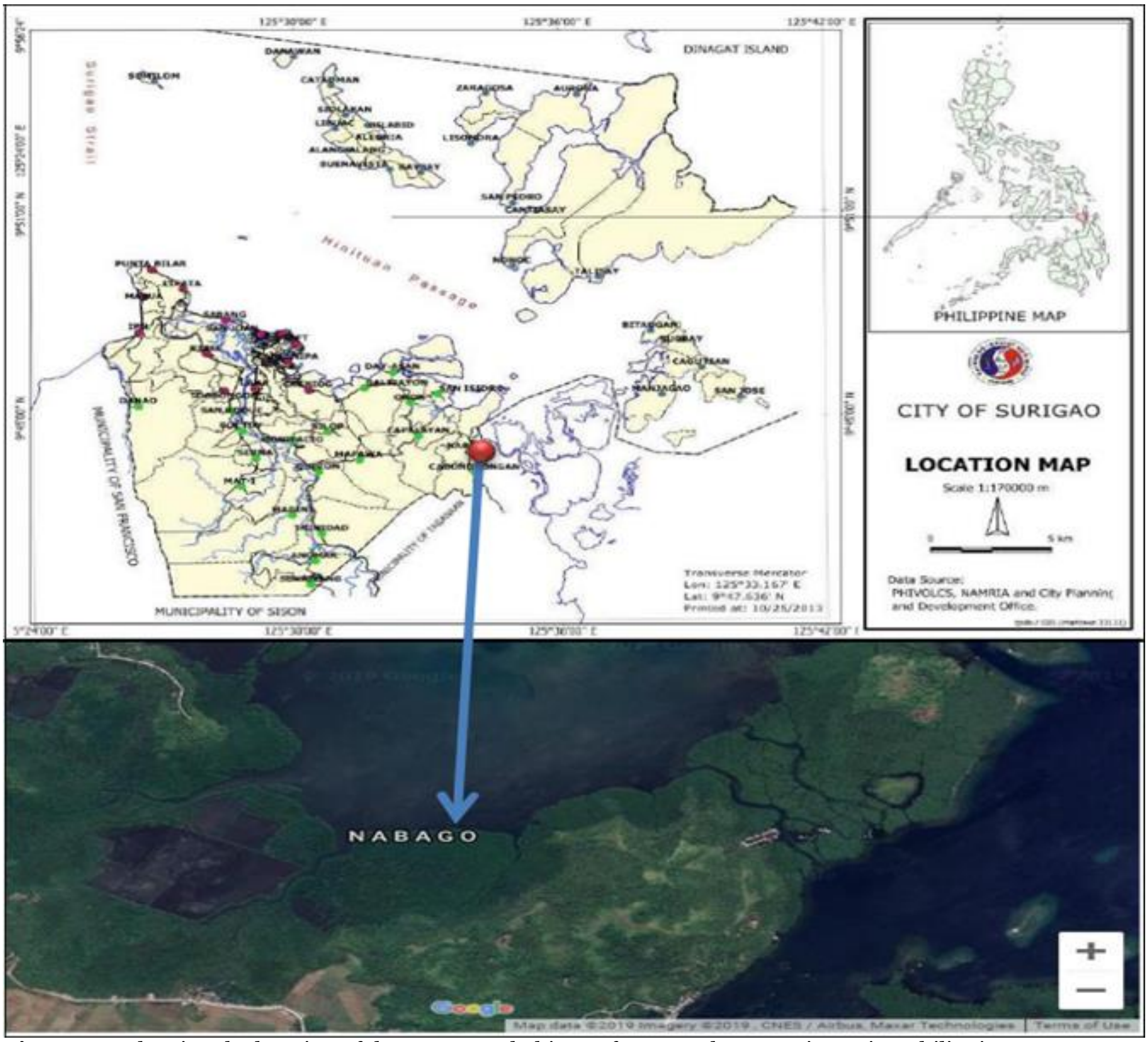

Fig. 1. Map showing the location of the mangrove habitats of Brgy. Nabago, Surigao City, Philippines.

Data collection

Live samples of *A. edentula* (Figure 2) were obtained from the local collectors of the coastal community of Barangay Nabago. The samples were left overnight with filtered seawater to clean their guts (Gimin *et al.*, 2004) and their mantle cavities from sediment particles (Yahya *et al.*, 2018). Before taking the needed morphometric measurements, specimens were cleaned by removing all the algae and dirt attached to the shell using a laundry brush. The shell length (SL), i.e., the maximum distance between the anterior and posterior margin of the shell; shell height (SH), the maximum distance from hinge to the ventral margin; and the shell width (SW), the maximum distance between two outer edges of close two valves (Ramesha and Sophia, 2015)(Figure 3) were all measured using vernier caliper at 0.05mm precision. Total weight (TW) was determined after drying the shell with a paper towel using a digital weighing balance with a sensitivity of 0.01g.

The meat of the individual sample was separated from the shell through shucking, blotted dry with a paper towel, and weighed as soft-tissue weight (STW).

Data analysis

The length-weight relationship was determined using the exponential equation: W=aLb where *W* represents the total weight/soft-tissue weight; 'a', is the intercept, representing initial growth coefficient; 'L' represents the length; 'b', is the slope, representing the relative growth rates of the variables and providing information on growth (Le Cren, 1951; Froese, 2006; Morey *et al.*, 2003). When b = 3, growth is isometric. When b is significantly different from 3, growth is allometric (positive if b>3 and negative if b<3). All the analyses of the relationships of shell dimensions to total weight and soft-tissue weight were done using the statistical package of the Microsoft Excel 2010 version.

Results and discussion

Morphometric Relationships

A total of 180 *A. edentula* clam species were collected from the mangrove habitats of Nabago, Surigao City, during the study period. The morphometric relationships between shell dimensions to total weight and soft-tissue weight of the clam were independently evaluated using non-linear regression analysis, and are graphically presented, as shown in Fig. 3 to 8.

Table 1. Summary of the Relationships between Shell Dimensions and Total and Soft Tissue Weight, and Growth Patterns of *Anodontia edentula* from Mangrove Forest of Barangay Nabago.

Variables	r	r^2	Intercept (a)	Regression Coefficient (b)	Growth (t-test)	Growth Pattern
Total Weight vs. Shell Length	0.9583	0.9184	0.0001	3.2221	b>3	allometric
Total Weight vs. Shell Height	0.9681	0.9372	0.0002	3.1484	b>3	allometric
Total Weight vs. Shell Width	0.9615	0.9244	0.0055	2.6402	b<3	allometric
Soft Tissue Weight vs. Shell Length	0.9178	0.8423	0.0000	3.3798	b>3	allometric
Soft Tissue Weight vs. Shell Height	0.9328	0.8701	0.0000	3.3228	b>3	allometric
Soft Tissue Weight vs. Shell Width	0.9204	0.8472	0.0005	2.7684	b<3	allometric

As shown on the graphical presentations, the morphometric analyses revealed that shell dimensions such as shell length, height, and width showed a positive correlation with the total weight and soft-tissue weight. The values obtained imply that there was a proportionate increase in the total weight and soft-tissue weight of *A. edentula* samples with increasing shell length, height, and weight.

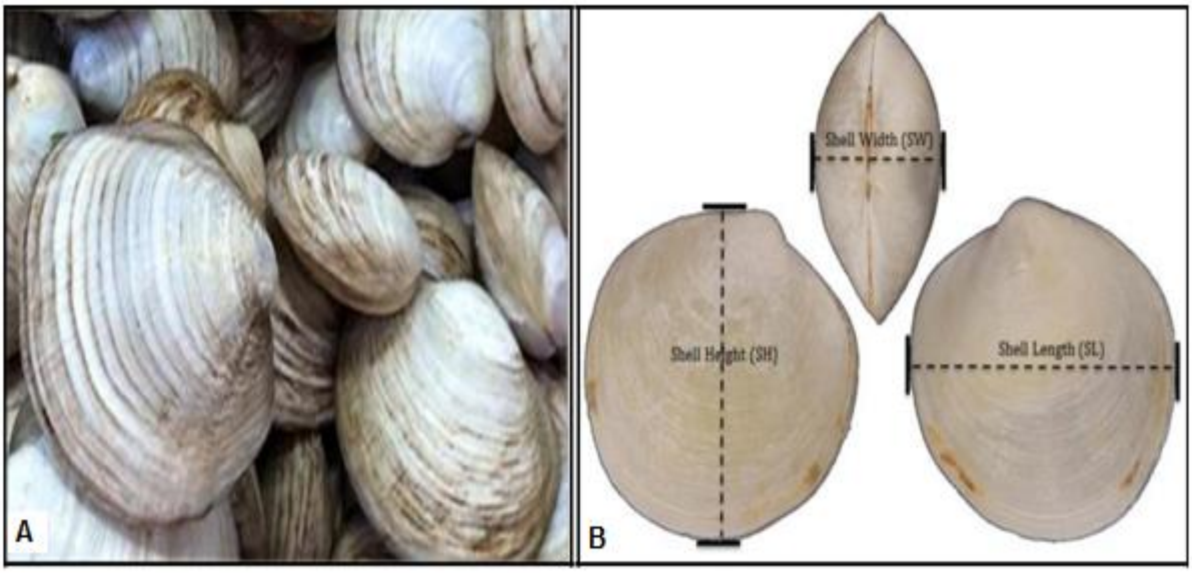

Fig. 2. A. The collected *Anodontia edentula*(Linnaeus, 1758) from mangrove habitat of Barangay Nabago. B. Measured shell dimensions of *A. edentula*.

It can be gleaned in Table 1 that among the paired morphometric variables, the value of correlation coefficient for shell length (SL) to soft-tissue weight (STW) was the highest (3.3798) with its coefficient of determination of 0.8423. It indicates that 84% of the total variation (soft-tissue weight) was accounted for the relationship with the values of the shell length.

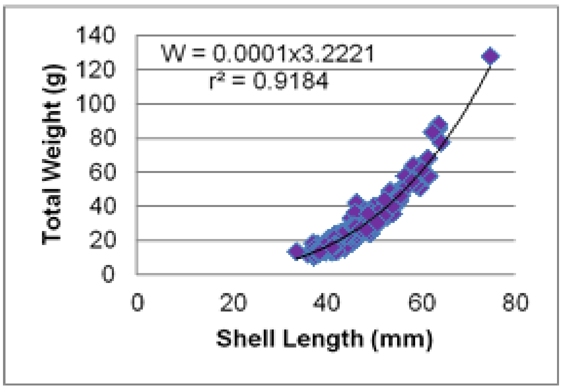

Fig. 3. Relationship between Shell Length and Total Weight of A. edentula.

This result is in contrast with the finding of Aban *et al.* (2017), where shell width has been accounted for the soft-tissue weight variation in *Psychotria viridis*. However, the overall results of the morphometric analyses showed significant relationships ($p<0.05$) between paired variables. It indicates that there was an increase in both total weight (TW) and soft-tissue weight (STW) of the *A. edentula* species as its shell length (SL), shell height (SH), and shell width (SW) increase over time.

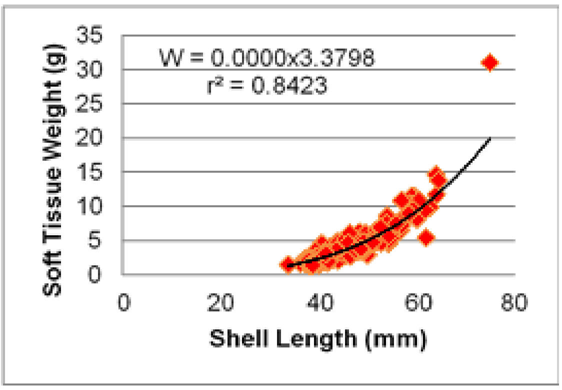

Fig. 4. Relationship between Shell Length and Soft Tissue Weight of A. edentula.

To confirm the significance of morphometric relationship using the coefficient b (=, < or >3), a t-test (Huxley and Teissier, 1936; Sokal and Rohlf, 1987) with a confidence level of 95% was applied. As disclosed in Table 1, the 'b' values for SL-TW, SH-TW, SW-TW, SL-STW, SH-STW, and SW-STW relationships were 3.2221, 3.1484, 2.6402, 3.3798, 3.3228 and 2.7684, respectively. These values were significantly different to 3.0, which conferred the statement of Gayanilo and Pauly (1997) that the growth of the organism proceeds in a 'different' dimension differing from the cube of the length.

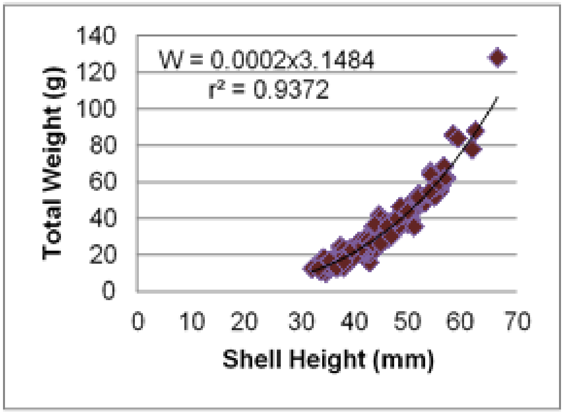

Fig. 5. Relationship between Shell Height and Total Weight of A. edentula.

Moreover, the slope values for paired morphometric variables, SL-TW, SH-TW, SL-STW, and SH-STW were greater than 3.0, but for SW-TW and SW-STW were less than 3.0. It means that *A. edentula* from mangrove areas of Nabago are growing in positive allometric way considering the shell length and height variables but negatively allometric for shell width.

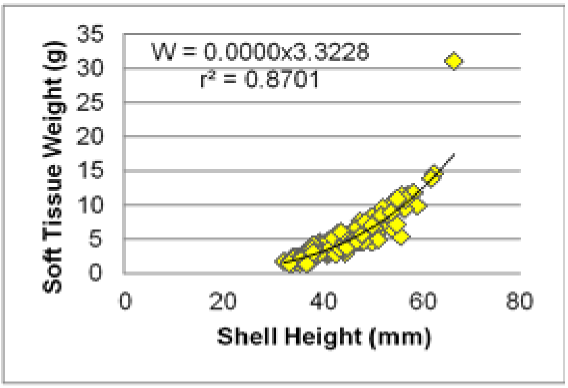

Fig 6. Relationship between Shell Height and Soft Tissue Weight of A. edentula.

This result implies that the rate of increase in shell length and height indirectly proportional to the rate of increase in total weight and soft-tissue weight but inversely proportional to the shell width. However, based on the result of the morphometric analysis, the 'b' value of the shell length (ranging from 2.6402 to 3.3798) against the total weight and soft-tissue weight conformed to the observation of Wilbur and Owen (1964) that most mollusks have a slope between 2.5 and 4.5 and that, variation in the meat content of bivalve mollusks depends upon the variation in physiological and environmental variables.

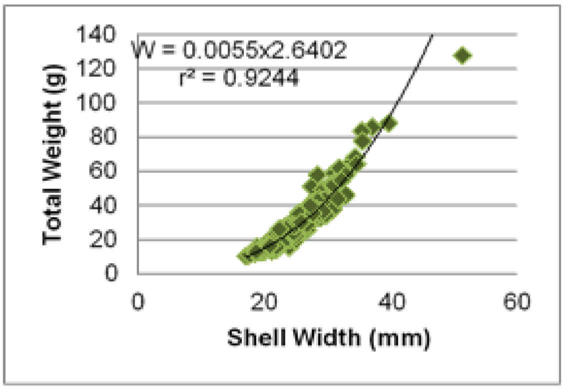

Fig. 7. Relationship between Shell Width and Total Weight of A. edentula.

Growth Pattern

In this study, the positive allometric growth pattern considering the shell length and height against total weight conforms to the findings of the studies on the LWR of bivalves species conducted by Petteta *et al.*, (2019), Perez and Santelli (2018), Yahya *et al.*, (2018), Turra *et al.*, (2018), Elvira and Jumawan (2017), Ramesha and Sophia (2015), Miley *et al.*, (2012) and on the study of Park and Oh (2002). The 'b' values obtained by these authors varied from 3.006 to 3.490. According to Perez and Santelli (2018), this particular allometric growth is known to infaunal burrowing bivalves, and the resulting adult morphology is present in representatives of several groups like Carditidae, Crassatellidae, Veneridae, and Trigoniidae.

As shown in Table 1, the relationship of shell width to the total weight (b=2.6402) and shell width to soft-tissue weight (b=2.7684) of *A. edentula* has a negative allometric growth pattern (b<3). This means that the growth in shell width is faster than the increase in the weight of the mangrove clam. This result is in accordance with the findings of Mendoza, *et al.* (2019) and Gimin, *et.al* (2004) on their study on *Polanisia erosa*. According to Currey (1988), the adverse environmental conditions trigger the need for strong shells and a high capacity to live.

The allocation of energy shell growth is higher instead of the soft organ that shifts growth into a negative allometric pattern (Mendoza *et al.*, 2019).

Furthermore, there are certain factors like the reproductive state, density, physical and biological variables of the habitat that are known to affect the growth of bivalves and can change the allometry between the shell and the flesh (Gimin *et al.*, 2004).

The growth and shape of the shell are usually influenced by both environmental like temperature, depth, currents, wave exposure, and sediment and biological factors such as predation and burrowing abilities (Gaspar *et al.*, 2002; Gimin *et al.*, 2004; Babei *et al.*, 2010 and Turra *et al.*, 2018).

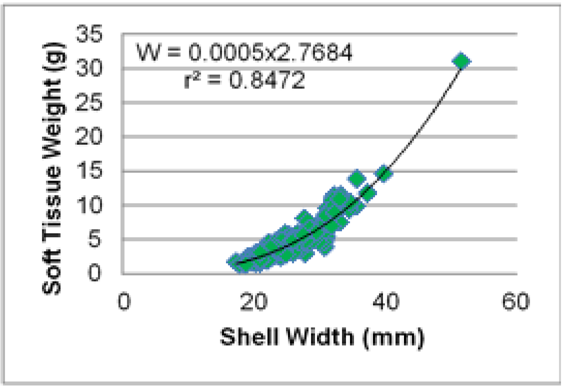

Fig. 8. Relationship between Shell Height and Soft Tissue Weight of A. edentula.

The allometric growth pattern of *A. edentula* from the mangrove habitat of Barangay Nabago indicates that the clam species, although not directly considered in this study, is affected by those factors affecting its condition.

With the various well – documented studies on shell morphometries and allometries of bivalve species from the different regions of the Philippines and the world, this LWR of mangrove clam *A. edentula* can be a valuable reference for the assessment and monitoring on the growth of this species either in its natural or cultured habitats.

Conclusion

The paired morphometric variables in describing the growth of *A. edentula* showed strong correlations indicating that there was a corresponding increase in the weight of the mangrove clam species with its increasing shell length and height. However, the relationship of the shell width to total weight and soft-tissue weight had a negative allometric pattern, which means that the growth in shell width is faster than its weight. Thus, the larger the species, the smaller its soft tissue. The highest correlation values recorded were in SH – TW (r2=0.9372) and SH – STW (r2=0.8701) relationships. It suggests that shell height is a good weight growth estimator for *A. edentula* from the mangrove habitat of Barangay Nabago, Surigao City. The results of this study may provide baseline information that can be an essential reference for the fisheries and conservation agencies of the local government of Surigao City for the successful management and production of the clam species. Further studies may be conducted along this line using *A. edentula* collected from other mangrove habitats not only from the coastal barangays of Surigao City but in the whole province of Surigao del Norte.

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Statement of Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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